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Investigating the Vehicular Carbon Monoxide Concentration in the Central Region of Ogun State, Nigeria.

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Abstract: *Poor air quality has been shown to have serious adverse effects on public health. The continuous importation and usage of over-aged vehicles in Nigeria for transportation has been discovered to be a major contributor to the exhaust emission of pollutant gases especially carbon monoxide, CO which have been termed to be a silent killer of whose attendant toxicological effect have greatly affected human especially the children and elderly resulting into increasing cardio-respiratory illnesses. The exhaust emission tests conducted within the Central parts comprising six Local Government areas of Ogun State, Nigeria identifies the polluting level of some petrol-driven vehicles as compared to European standards. The average exhaust concentration was as high as 1.62% with some reaching as high as 7.67% depicting that more than 65% of vehicles tested do not meet the current international standard due to their old age.*

Keywords: *carbon monoxide, exhaust emission, over-aged vehicle, pollutant gases, transportation.*

I. Introduction

Transport is a vital part of modern life. The freedom to travel short and long distances opens the horizons for personal development and professional activities, increases the options for leisure and holidays, and allows better contact and understanding between people. To a large extent the economic development of the various regions of the world is facilitated by contemporary transport technology. Owing to its flexibility, road transport is a major transport mode, and cars are objects of desire and pride in many societies. The growth of transport has undoubtedly brought many economic and health benefits. But it has brought problems too which are now leading to environmental crisis, crisis of energy, air pollution and congestion. The air has been severely polluted in the villages, towns and cities where most of the world's population lives. Populations in an increasing number of areas are regularly exposed to air pollution, levels above limits set by the World Health Organisation [1].

Transport is a main sector which causes the environmental pollution and climate change. Emissions from transport, and especially motor vehicles, add considerably to the levels of greenhouse gases in the atmosphere [2], while it is the second-largest sector in producing global CO_2 emissions with a range of 22% [3]. Owing to the rapid increase of motor vehicles and very limited use of emission control technologies, transport emerges as the largest source of urban air pollution, which is an important public health problem in most cities of the developing world. Air pollution in developing countries accounts for tens of thousands of excess deaths and billions of dollars in medical costs and loses productivity every year [4, 5]. The World Health Organization estimated that around 2.4 million people die every year due to air pollution [6].

The US Environmental Protection Agency, (USEPA) reported that vehicle emissions account for 51% of carbon monoxide, 34% of nitrogen oxides and 10% of particulate matter released each year [7]. The emissions from the vehicles pose serious health threat to humans. It has been asserted that, in developing countries of the world, vehicular growth has been largely unchecked by environmental regulating bodies creating high levels of pollution [8].

In the city centres, especially on highly congested streets, traffic can be responsible for as much as 90-95% of the ambient CO levels, 80-90% of the NOx and hydrocarbons, and a large portion of the particulates, posing a significant threat to human health and natural resources [9].

In recent years, there has been considerable research on vehicle emissions and fumes. Pollution from motor vehicles has become an issue simply because of the steady increase both in the number of vehicles in use and the distance travelled by each vehicle each year. As a result of these increases, the use of motor vehicles now generates more air pollution than any other single human activity. It is the fastest growing source of CO_2 and in urban areas, accounts for the bulk of emissions of CO, HC, and NO_x.

United State EPA [10] defines air pollution as the contamination of air by discharge of harmful substances, which can cause health problems including burning eyes and nose, itchy irritated throat and breathing problems. With increasing concern for air toxics and climate modification caused by exhaust emissions, the need for tighter control increases in importance. According to the United Nations Environment Program (UNEP), over 600 million people are exposed annually to vehicular pollutants [11, 12]. The worst levels of pollution are seen in such urban cities as are densely populated with a low standard of living [13, 14].
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 [15, 16], since it may shorten the lifespan of exposed people especially the children and the aged.

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 [17, 18, 19].

1.1 Carbon monoxide

Carbon monoxide (CO) is one of the most common and widely distributed air pollutants. It is a colourless, odourless and tasteless gas that is poorly soluble in water. In the human body, it reacts readily with haemoglobin to form carboxyhaemoglobin. Small amounts of carbon monoxide are also produced endogenously. Carbon monoxide exposure is still one of the leading causes of unintentional and suicidal poisonings, and it causes a large number of deaths annually both in Europe and in the United States [20].

1.1.1 Sources of Carbon Monoxide

The annual global emissions of carbon monoxide into the atmosphere have been estimated to be as high as 2600 million tonnes, of which about 60% are from human activities and about 40% from natural processes. Anthropogenic emissions of carbon monoxide originate mainly from incomplete combustion of carbonaceous materials. The largest proportions of these emissions are produced as exhausts of internal combustion engines, especially by motor vehicles with petrol engines. Other common sources include various industrial processes, power plants using coal, and waste incinerators. Petroleum-derived emissions have greatly increased during the past few decades [20].

1.1.2 Occurrence in air

Global background concentrations of carbon monoxide range between 0.06 and 0.14 mg/m^3 (0.05–0.12 ppm). The ambient concentrations measured in urban areas depend greatly on the density of combustion-powered vehicles, and are influenced by topography and weather conditions.
Carbon monoxide levels have a close quantitative and temporal association with the levels of other primary exhaust pollutants such as nitrogen monoxide and volatile organic compounds. In urban traffic environments, the concentrations measured inside motor vehicles are generally higher than those measured in ambient air. The carbon monoxide levels are highest in personal cars, the mean concentrations being 2–5 times the levels measured in streets or inside subway trains [20].
Traffic patterns, car model and maintenance are some of the factors that affect the carbon monoxide levels inside the cars [20].

1.1.3 Routes of exposure

Because carbon monoxide is a rather stable gas in the atmosphere, the lungs are practically the only significant route for environmental exposures.
Carbon monoxide binds readily with haemoglobin to form carboxyhaemoglobin (COHb) which can be measured in a blood sample by specific spectrophotometric or gas chromatographic methods. As a biomarker of carbon monoxide exposure, COHb is specific and closely related to the mechanisms of toxicity.
In population groups with relatively high exposures, there are people who are continuously exposed to exhaust from combustion engines at their work. Among these people are car, bus and taxi drivers, policemen, traffic wardens, and garage and tunnel workers [20].

1.1.4 Toxicokinetics

After reaching the lungs, carbon monoxide diffuses rapidly across the alveolar and capillary membranes. It also readily crosses the placental membranes. Approximately 80–90% of the absorbed carbon monoxide binds with haemoglobin, which causes a reduction in the oxygen-carrying capacity of the blood and impairs the release of oxygen from haemoglobin to extravascular tissues. These are the main causes of tissue hypoxia produced by exposures to low levels of carbon monoxide. At higher concentrations the rest of the absorbed carbon monoxide binds with other haem proteins such as myoglobin, and with cytochrome oxidase and cytochrome P-450. The binding to myoglobin might contribute to the depression of cardiac function and the impairment of skeletal muscle oxygenation, while the binding to cytochrome oxidase might affect the heart and the brain. The affinity of haemoglobin for carbon monoxide is 200–250 times that for oxygen. The organs and tissues that are mostly affected include the brain, the cardiovascular system, exercising skeletal muscle and the developing foetus [20].

Furthermore, it is well known that severe hypoxia due to acute carbon monoxide poisoning may cause both reversible, short-lasting neurological deficits and severe, often delayed, neurological damage. At a COHb level of about 10%, carbon monoxide is likely to cause headache, and at somewhat higher levels there will be also dizziness, nausea and vomiting. At a COHb level of about 40%, carbon monoxide starts to cause coma and collapse, and at 50–60% the poisonings are often lethal. The effects of carbon monoxide on cognitive performance have generally been equivocal at COHb levels of 5–20% [20].

1.1.5 Cardiovascular effects

Patients with cardiovascular disease, especially ischaemic heart disease, are expected to be particularly sensitive to carbon monoxide. Atherosclerotic narrowing of the coronary arteries and impaired dilatation mechanisms restrict blood flow to the myocardium and prevent physiological compensation for lowered oxygen delivery caused by elevated levels of COHb. In exercise, these subjects experience myocardial ischaemia, which can impair myocardial contractility, affect cardiac rate and rhythm, and cause angina pectoris. In patients with severe ischaemic heart disease, carbon monoxide poisonings have been lethal at COHb levels of 10–30%, while usual COHb levels in lethal poisonings are around 50–60% [20].

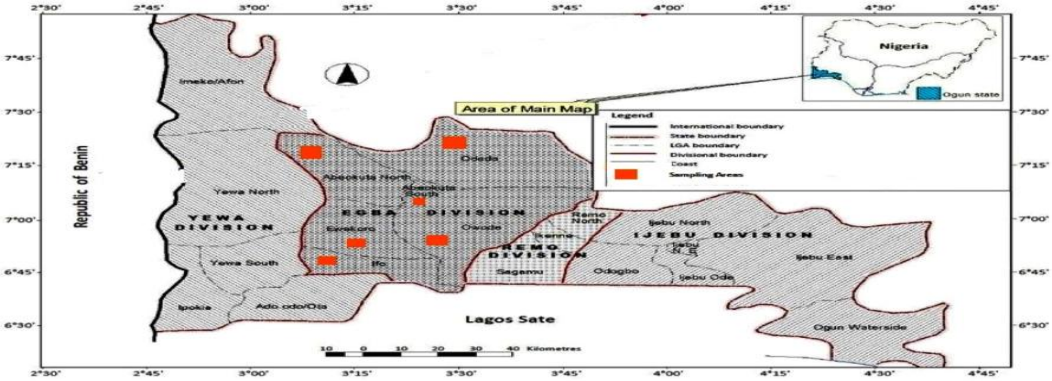
Furthermore, the pregnant mother, the foetus in utero and the newborn infant are also at high risk of adverse health effects from atmospheric carbon monoxide exposures. Maternal COHb levels are usually about 20% higher than the nonpregnant values. Carbon monoxide diffuses readily across the placental membranes, and the carbon-monoxide binding affinity of foetal haemoglobin is higher than that of adult haemoglobin [20].
Ogun State Environmental Protection Agency (OGEPA) Law, No. 2 of 2003 as amended in 2012 [21] established an Emission Control and Monitoring Regulations (ECMR) to control, regulate and supervise the enforcement of the ECMR. The Vehicular Exhaust Emission Limit by OGEPA for petrol-driven vehicle is set at 3.0% (Low Idle) for the carbon monoxide, CO, while the Euro II Limit is set at 2.5% (Low Idle), Euro III at 0.5% (Low Idle) and Euro IV at 0.3% (Low Idle).

II. Materials and Methods.

The raw exhaust emission tests on major (gasoline) vehicles used were carried out using hand-held KANE Automotive 4-Gas Analyser with detector tube, capable of measuring carbon monoxide, CO (with a specified range of 0-10% and an over range of 20% with an accuracy volume of ±5% and a resolution of 0.01%), hydrocarbons HC, carbon dioxide CO_2, oxygen O_2 and Lambda (otherwise referred to as the burning efficiency). The calibration of the analyser was performed after every test was conducted before another in an ambient air and after which the analyser was "zero checked" to return the setting to the allowable range, especially the O_2 to be 20.9-21% and the CO to 0.00%. Furthermore, the vehicles particulars such as type, make, year of manufacture and use of the vehicles were documented.

2.1 Study Area

Ogun State nicknamed "Gateway State" is a state in southwestern part of Nigeria. It borders Lagos State to the south, Oyo and Osun States to the north, Ondo State to the east and the Republic of Benin to the west. Abeokuta is the capital and largest city in the state Located on the coordinates 7°00′N 3°35′E, the state has a total area of 16,980.55 km^2 (6,556.23sq mi) and a population of 3,751,140 (according to 2006 Census and still ounting) with a density of 220/km^2 (570/sq



The Political Map of Ogun State, Southwest Nigeria.

Ogun State has emerged as one of the fastest growing business destinations in Nigeria, with several local and international businesses and factories strategically sited [22]. Infact, The Guardian Newspaper published on October 22, 2014 that the State have overtaken Lagos State in industrialisation [23]. The State, because of its proximity to Lagos State which is the largest commercial hub in Nigeria, experiences a vehicular population boom as it is the passage of heavy transport to the Northern parts of the country via Lagos-Ibadan Expressway and Eastern parts via Lagos-Sagamu-Benin Expressway.

The study was conducted in six (6) Local Government Areas including Abeokuta North, Abeokuta South, Ewekoro, Ifo, Obafemi Owode and Odeda, all within the Central region of the State, otherwise categorised as "**Egba Division**", with the vehicles randomly selected at various places including road sides, office/industrial areas, commercial parks and garages.

2.2 Experiments and Tests Conducted

The No–Load Short Tests commonly called the idle tests were used for this work. This term denotes all tests during which no external load is exerted and the vehicle operates with the transmission in neutral position. Emissions from these tests are reported in concentrated units (percent, % where 1% = 10,000ppm).

Analysis of variance (ANOVA) between models and line graph presentation of result were carried out using Statistical Package for Social Science (SPSS) Software Version 21.0 due to its complex and powerful application with the use of both a graphical and syntactical interface frequency for percentages, data coding, correlations and chi-square test, while Microsoft Excel Version 2010 was used for Bar and Pie Chart presentation of results.

III. Results and Discussion

Emission test was carried out on petrol- driven 960 vehicles. The breakdown of the number of vehicles tested by type are as follows: buses 82, cars 733, jeeps 78 and pick-ups 67, of vehicle use gives commercial as 188, organizational 181 (registered to an organisation, either public or private) and private 591, while make/brand gives BMW 8, Chevrolet 22, Ford 10, Honda 122, Hyundai 19, Infinity 2, Isuzu 7, Kia 32, Lexus 4, Mazda 52, Mercedes 17, Mitsubishi 38, Nissan 217, Opel 12, Peugeot 16, Renault 1, Rover 8, Toyota 362 and Volkswagen 11.

However, the vehicles' make/brand whose frequency were less than 20 were pruned out leaving the final number to 845 leaving Vehicle Type to 80 buses, 635 cars, 70 Jeeps and 60 Pick Ups, Vehicle Use as 172 Commercial, 162 Organisational and 511 Privates and Vehicular Make/Brand to 22 Chevrolet, 122 Honda, 32 Kia, 52 Mazda, 38 Mitsubishi, 217 Nissan and 362 Toyota.

The carbon monoxide, CO results of the tests for each vehicle using the Euro II, Euro III, Euro IV and OGEPA standards were done to determine the vehicles status. The results in Table 1.0 showed that for OGEPA limit, 701 (or 82.96%) of the vehicles passed the emission test while 144 (or 17.04%) failed, for Euro II limit, 612 (or 72.43%) passed while 233 (or 27.57%) failed, Euro III limit 280 (or 33.14%) passed while 565 (or 66.86%) failed and Euro IV limit recorded 243 (or 28.76%) passed while 602 (or 71.24%) failed as shown in Table 1 and Figure 1

Table 1: Frequency of the Emission Status of Tested Vehicles

		OGEPA Limit (3.0%)		**Euro II limit (2.5%)**		**Euro III limit (0.5%)**		**Euro IV limit (0.3%)**	
		Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
	Failed	144	17.04	233	27.57	565	66.86	602	71.24
	Passed	701	82.96	612	72.42	280	33.14	243	28.76
Total		**845**		**845**		**845**		**845**	

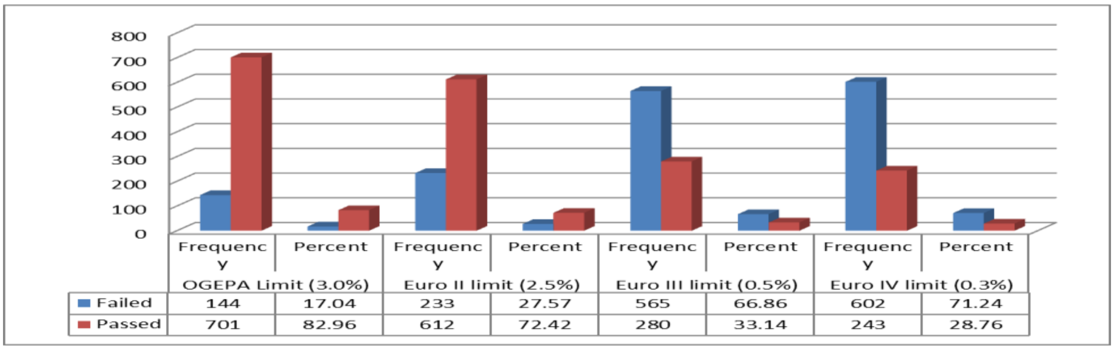


Figure 1: Bar Chart indicating the frequency of Pass-Fail Status of the Tested Vehicles

Table 1 and Figure 1 indicated the number of vehicles that failed within the tested population. It could be seen that as the limit becomes tighter from OGEPA to the Euro, especially the Euro III and IV recorded, the number of "failed" emission test increases. This could be attributed to the fact that many vehicles on Nigerian roads are either old or imported-but-used and sometimes over-aged vehicles (popularly called "tokunboh") coupled with the low maintenance culture of an average Nigerian who owns vehicle. Reference [24] stated that the general lack of maintenance culture and poor grade fuels combined with some other factors increase the polluting propensity of motor automobiles in Nigeria and which has reflected in both the public and private lives, while Reference
[25] further stated that Nigerians find it difficult to maintain their own property. Infact routine servicing of vehicles is a luxury to many car owners.

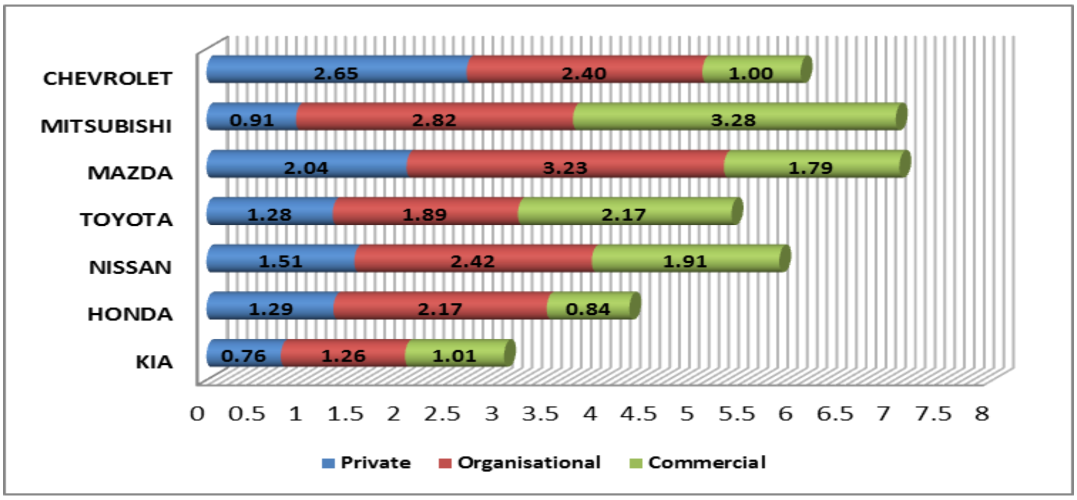


Figure 2: Bar chart showing the average CO emission by vehicle make stacked by category of use.

The Figure 2 above shows the average CO emission status of each vehicle make segregated into method of usage (private, organizational and commercial).
From the stacked bar chart above, it can be seen that Mitsubishi and Mazda vehicle makes are the top CO emitter such that these two vehicles model emitted double of what KIA model emit. Also it was evident that organizational used vehicles emit more CO than other vehicle usage, having noted that organizational Mazda is the topmost CO emitter. However, Private KIA emits the least CO.

3.1 Independence Test

In order to investigate the effect of vehicle type, vehicle make, vehicle use and year of manufacture on vehicle CO, the independence test between these variable and OGEPA scale for vehicles CO using chi-square test. The following hypotheses established the claims.

Table 2: Crosstab of Vehicle Type and OGEPA Standard

		Vehicle Type				Total
		Bus	Car	Jeep	Pick-Up	
	Failed	20	107	6	11	144
	Passed	60	528	64	49	701
Total		80	635	70	60	845

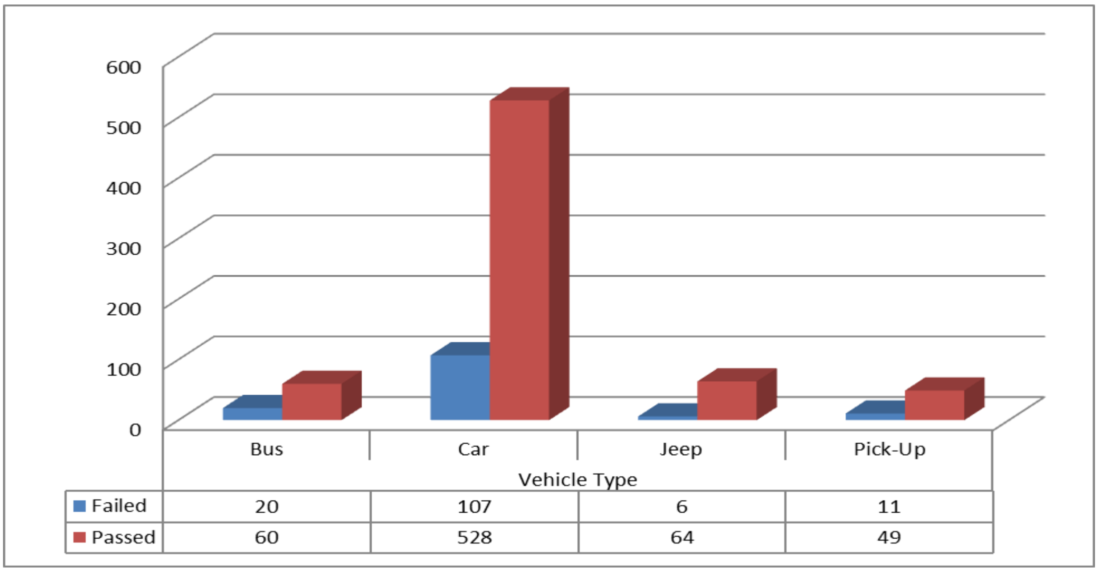


Figure 3: Bar chart indicating the relationship between Vehicle Type and OGEPA Standard

Table 3: Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.364[a]	3	
Likelohood Ratio	10.144	3	0.016
N of Valid Cases	845		0.017

a.0 Cells (.0%) have expected count less than 5. The minimum expected count is 23.79

H_o: There is no significant association between the vehicle type and its emission status.
H_1: There is significant association between the vehicle type and its emission status.

Using a Chi-Square test at degree of freedom of 3, the asymptotic significance statistic is less than 0.05 with Pearson Chi-square of 10.36 indicating that there is significant difference between the observed and expected values. Hence, it was concluded that vehicle type in the test population has an effect on its CO emission level based on OGEPA standard as seen in Tables 2, 3 and Figure 3, which will also have a more profound effect on the other tighter International standards of Euro II, III and IV.

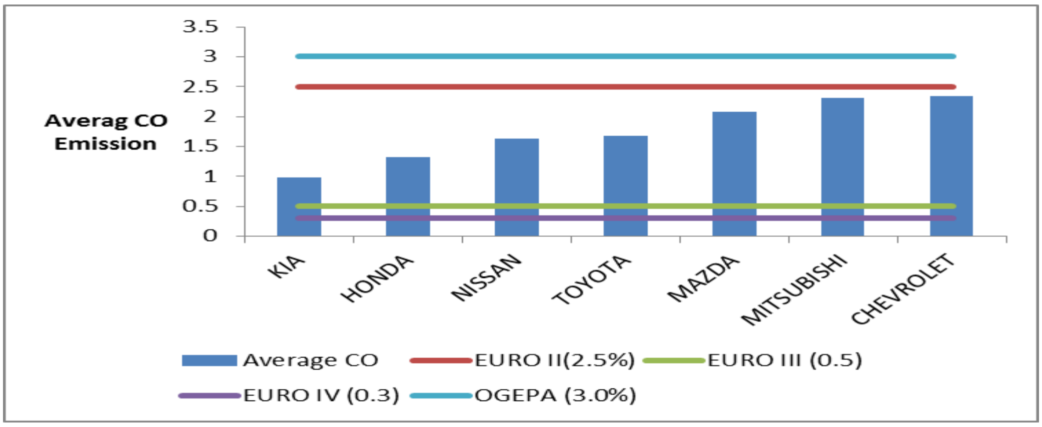


Figure 4: The average CO emission gauged with local (OGEPA) and international standards.

The Figure 4 above shows the average CO emitted by each "vehicle make" was gauged against three international standards (Euro II, Euro III and Euro IV) and one local standard, OGEPA. The figure above shows that the entire "vehicle make" failed EURO III and EURO IV standard tests, while all the vehicle makes passed EURO II and OGEPA standard test.

Table 4: Crosstab of OGEPA/Euro III Standards and Vehicles' Year of Manufacture

	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014

	OGEPA	Euro III	OGEPA	Euro III	OGEPA	Euro III	OGEPA	Euro III	OGEPA	Euro III
Passed	205	69	188	74	102	47	154	55	50	34
Failed	59	195	36	150	26	81	22	121	1	17
	264	**264**	**224**	**224**	**28**	**128**	**176**	**176**	**51**	**51**

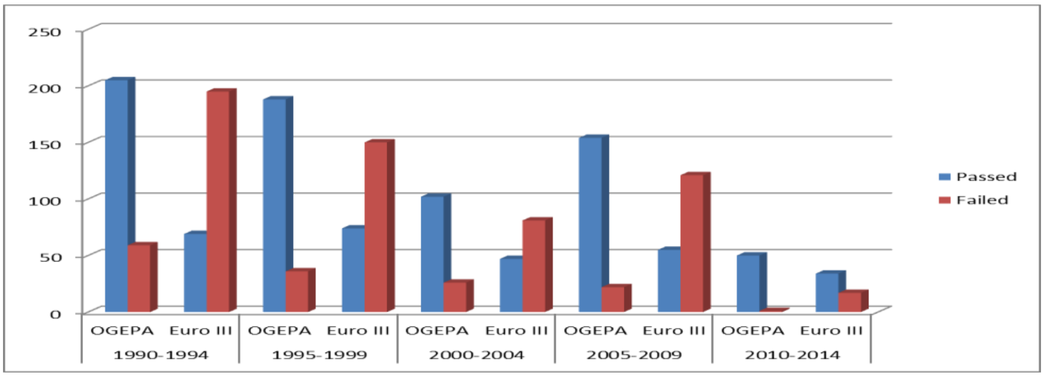


Figure 5: Correlation of the Vehicle's Year of Manufacture to the Local/European Standard

The Table 4 and Figure 5 above showed that few vehicles fail the OGEPA emission limit as compared to Euro III which has more "fail" value in the vehicle population.

Nigerian buying used cars is attributed the extent of the erosion of the average individual purchasing powers of her average citizens. This according to Reference [26] was further corroborated to the increase in population and the hardship occasioned by the Structural Adjustment Program (SAP) of the mid-eighties when it became much difficult for the average Nigerian employee, private or public, to access even the basic necessities of life (food, water, shelter) let alone save enough money to buy a brand new car or replace an old one. This scenario encouraged the quest for second-hand cars (popularly called 'tokunbohs') in Nigeria.

Table 5: Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.413[a]	4	.000
Likelihood Ratio	22.075	4	.000
N of Valid Cases	845		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 20.62

H_o: The vehicle year of manufacture and its emission status are independent.
H_1: The vehicle year of manufacture and its emission status are dependent.

At degree freedom of 4, the asymptotic significance statistics is less than 0.05 with Pearson Chi-square of 22.41 in Table 5 shows that the vehicles age and emission status are dependent, hence, it was concluded that vehicle year of manufacture has effect on its CO, indicating that the older the age of the vehicle, the more it emits carbon monoxide.

Table 6: Zero order Correlations

Control Variables		CO emission	Year of Manufacture
CO emission	Pearson Correlation	1.000	.106**
	Sig. (2-tailed)		.001
	N	980	980
Year of Manufacture	Pearson Correlation	.106**	1.000
	Sig. (2-tailed)	.001	
	N	980	980

**. Correlation is significant at the 0.01 level (2-tailed).

Preliminary analyses were further performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. The Correlation analysis showed the strength and direction of the linear relationship between CO emission and vehicle year of manufacture.

From the Table 6 above, the Pearson correlation coefficient between CO emission and vehicle year of manufacture is 0.106, indicating a positive and small correlation between CO emission and vehicle year of manufacture, with increasing year of manufacture being associated with high "CO emission". Since the P-value (0.000) is less than 0.05, it implies that the relationship is statistically significant.

Reference [27] noted that Nigeria had become an easy dumping ground for end-of-life vehicles, which were regarded in the European countries as waste that should be treated carefully. Pointing out that about

300,000 of such cars were pushed into Nigeria in 2012, she commented that "Nigeria is a huge market for end-of-life vehicles which are often smuggled from Europe or North America through over 1,400 illegal routes from Benin Republic into Nigeria and are sold for dumping prices". Furthermore, most of the vehicles, especially the commercial vehicles use cheap, fairly-used (called "tokunboh") spare parts and sub-standard plugs alongside with cheap road-side/sub-standard engine oils to lubricate their engines in addition to postponing vehicle maintenance in order to maximise profits as usually observed in many vehicular breakdown and accidents experienced on the roads. This corroborated the statement made by Reference [28] who also reported that low income levels have been an incentive to using cheaper fuel and also postponing vehicular maintenance. Such conditions result in an increase in the emissions per kilometre travelled.

IV. Conclusion

The continuous usage of imported, over-aged, used vehicles "tokunboh" for all forms of transportation in Nigeria has been the source of emission of poisonous gases especially carbon monoxide and that the attendant health effects on the people have also been on the increase. The average vehicular CO emission as seen in the study conducted is very high as compared to recent international (European) standards.

V. Recommendation

Having identified the concentration level of carbon monoxide emission and the attendance health effect of using over-aged vehicles for transportation in Nigeria, though there are transportation laws and policies in the area of vehicular exhaust emission in the country, the will power on the part of Government to enforce these laws is lacking. Also, Government should ban the importation of old vehicles especially beyond ten years while also strengthening the partnership of foreign automobiles manufacturing organisations to establish a vehicular assembling plant in the country. Furthermore, the effective implementation of modern, public transportation policies should be strengthened at all strata of Government.

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References

[1] WHO, World Health Organisation. Investing in Health Research and Development, Geneva, Switzerland. 2002.
[2] Organisation for Economic Co-Operation and Development, OECD. Strategies to reduce greenhouse gas emissions from road transport: Analytical Methods. OECD, Paris. 2002.
[3] International Energy Agency, IEA. CO_2 Emissions From Fuel Combustion Highlights. France. 2012.
[4] Faiz A, Weaver CS and Walsh PW. Air pollution from motor vehicles: standards and technologies for controlling emissions. The World Bank, Washington. 1996.
[5] Sivaloganathan S. Case report: Death from Diesel fumes. Journ Clin. Forensic Med. 5, 1998, 138–139.
[6] WHO, World Health Organization. Estimated deaths & DALYs attributable to selected environmental risk factors, by WHO Member State. Department of Public Health and Environment. 2007.
[7] United State Environmental Protection Agency, USEPA. "Mobile Source Emissions-Pollutants".<http://www.epa.gov/otaq/invntory/overview/pollutants>. 2007.
[8] Hans X and Naeher "A review of traffic-related air pollution exposure assessment studies in the developing world". Environment International. 32(1), 2006, 106-120.
[9] Saville SB. Automotive options and quality Management in developing Countries. Industrial Environment, 16(1-2), 1993, 20-32.
[10] United State Environmental Protection Agency, USEPA. National Air Quality and Emission Trends Report, United States Environmental Protection Agency, Washington DC, USA. 1994.
[11] Cacciola RR, Sarva M and Polosa R. Adverse respiratory effects and allergic susceptibility in relation to particulate air pollution: flirting with disaster. Allergy 57, 2002, 281–286.
[12] United Nations. Prospect of World Urbanization, (Population Study No. 112). New York: United Nations. 1989.
[13] Addy MW and Pietrass E. On-vehicle exhaust gas cooling in a diesel emissions control system. SAE Special Publications on diesel Combustion, Emissions and Exhaust After Treatment. 931, 1992, 191-198.
[14] Washington S, Leonard JDU, Roberts CA, Young T, Sperling D and Bottha J. Forecasting vehicle modes of operation needed as an input to model emissions model. International Journal of Vehicle Design. 20(1-4), 1998: 351-359.
[15] Bailey PD. Modelling future vehicle exhaust emission in Europe. Water, Air and Soil Pollution. 85(4), 1995, 1879-1884.
[16] Marshall JD, Riley WJ, McKone TE and Nazarott WE. Intake fraction of primary pollutants: Motor vehicle emission in the South Coast Air Basin. Atmospheric Environment. 37(24), 2003, 3455-3468.
[17] Ackerman M, Davies T, Jefferson C, Longhust J and Marquez J. Comparison of diesel and hybrid vehicle emissions by computer modeling. Advances in Transport, Urban Transport VIII: Urban Transport and the Environment in the 21sCentury: 2002, 471-480.
[18] Glen WG, Zelenka MP and Graham RC. Relating meteorological variables and trends in motor vehicle emissions to monthly urban carbon monoxide concentrations. Atmospheric Environment. 31(24), 1996, 4225-4232.
[19] Johnson L, Jamriska M, Morawska L and Ferreira L. Vehicle emissions in Australia: From monitoring to modelling, Advances in Transport, Urban Transport VI. Urban Transport and the Environment for the 21st Century. 6, 2000, 469-478.
[20] WHO, World Health Organization. "Air quality guidelines for Europe, 2nd Edition". WHO Regional Office for Europe, Copenhagen, Denmark. 2000.

[21] Ogun State Environmental Protection Agency Law, 2003. State Emission Control and Monitoring Regulation. 2012, 80-89.
[22] Ogun State of Nigeria. http://en.wikipedia.org/wiki/Ogun_State. Accessed on the 18th May, 2015.
[23] The Guardian Newspaper. Nigeria: Ogun Overtakes Lagos in Industrialisation. www.ngrguardiannews.com., Vol. 31, No.13,081, October 21, 2014.
[24] Orubu CO. Using Transportation Control Measures and Economic Instruments to Reduce Air Pollution Due to Automobile Emissions. J. Soc. Sci. 8(3), 2004, 227-236.
[25] Adeleye, SI. "Maintenance Practice in Nigeria, Policy, Budgeting and Legislative Issues", A paper presented at "Sensitization Campaign for Maintenance Culture", organised by National Orientation Agency NOA, Oyo State Directorate, Ibadan, Nigeria, 2009.
[26] Asekhame, FF and Oisamoje MD. Ban on Commercial Motorcycle Operations in Benin City, Nigeria: An Appraisal of the Benefits and Business Opportunities. Developing Country Studies. 3 (14), 2013, 10-17.
[27] Kummer, B. "End of Live Vehicles (ELV): Recycling Strategy in the EU, the Legal Background and the Risks of not Recycling ELVs in Africa." (http://nigeria.newsi.ng/news/362431-group-advocates-law-to-discourage-write-off-vehicleimportation), April. 22, 2015.
[28] Faiz A, Sinha K and Gautam S. Air Pollution Characteristics and Trends. Discussion Paper, World Bank, Washington, DC, 1994.