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Prognosis of Emission Limits and Regulations for Vehicular Emission Pollutants in Nigeria

A. F. Oluwole[a], O. H. Joshua[b,*], O. Oyediran[a], S. Guttikunda[c], O. I. Asubiojo[b], I. I. Omoniyi[d]

[a]*SEEMS Nig. Ltd, 23B, Ixora Drive, M.K.O Abiola Gardens, Lagos.*
[b]*Department of Chemistry, Obafemi Awolowo University, Ile-Ife, Nigeria.*
[c]*Desert Research Institute, Reno, USA.*
[d]*LAMATA, Block C 2nd Floor Motorways Centre, Motorways Avenue, Alausa, Ikeja, Lagos.*

Abstract

The main purpose of this study is to propose a limit and regulation for vehicular emission in Nigeria using a prediction tool. Two (2) gas Analysers (the UEI – Automotive 5 gas fuel efficiency analyzer and Infrared Industries Inc – DC 5 gas analyzer) were used to measure concentrations of CO, CO_2, HC, NO_X, O_2 and A/F Ratio from vehicular exhaust both in the idle and motion mode. The analyzer determines the Emission Factors (EFs) in gram per kilometer of pollutants based on distance covered and fuel consumption. EFs for both new and used vehicles are, at best, as good as EURO II. But EF for CO is 3 to 4 times that of EURO II. The determined EFs were used to calculate the Emission Inventory along a chosen corridor in Lagos Metropolis. A Simple Interactive Model is applied to estimate percentage reduction on emission from various six scenarios. Optimal reduction values are obtained when emission standards are changed from EURO II to EURO V, currently in vogue in India, Egypt and Brazil. Fuel switch from gas oil to CNG gives promising results. Emission standards based on EURO IV are proposed and methods of regulation and enforcement are discussed.

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1. Introduction

Vehicular emission is one of the major contributors to urban air pollution (Ostro and Chestnut, 1998). This is particularly so in developing countries like Nigeria where there is a preponderance of old, rickety vehicles with attendant air pollution-related health problems. The problem is compounded by increasing vehicle fleets, infrastructural limitations, poor engine/emission control technologies and limited provision for vehicle maintenance practices and emission standards. A country-wide inventory of air pollutants in Nigeria has been published (Obioh et al., 1988). The same workers also carried out an inventory and emission measurements of various transport modes in Nigeria (Obioh et al., 1994). Their results showed that the transport sector contributed over 10% of the greenhouse gases nationally and is responsible for about 30% of total fossil fuel consumption annually. More recent studies have estimated the contribution of transport sector to air pollution along a major corridor in Lagos State to be around 30-45% (LAMATA, 2007, 2009).

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*Corresponding author
Email address: trjoshua247@gmail.com (O. H. Joshua)

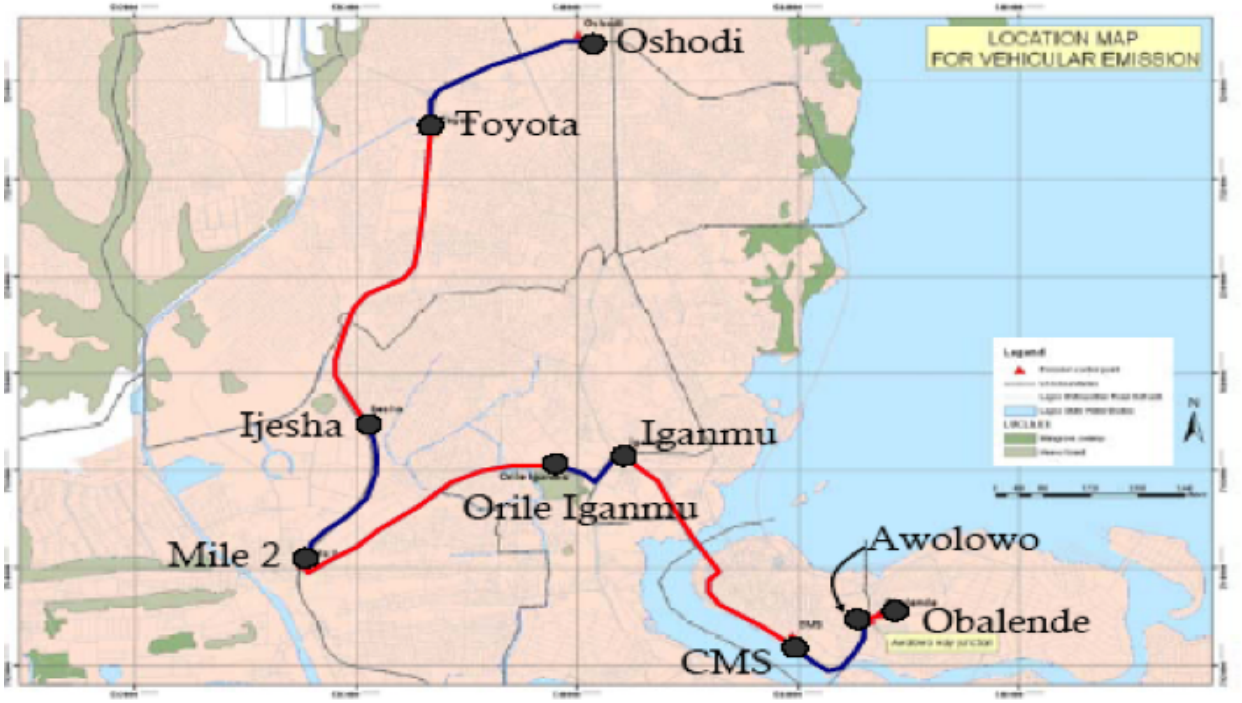


Figure 1. Study Route Map.

One of the most effective strategies for controlling emission is the setting of emission limits applicable regulations. The emission standards currently adopted by the National Environmental Standards and Regulations Enforcement Agency (NESREA) is the Euro 2. Euro 2 is one of the European emission standards that define the acceptable limits for exhaust emissions of new vehicles sold in the European Union and EEA member states (European Union, EU, 2014). Euro 2 was developed in 1996 to control vehicular emission in Europe but there is need to develop local emission standards, based on data obtained from vehicles operating on Nigerian roads.

Lagos, the erstwhile administrative capital and still the commercial capital of Nigeria, with an estimated population of 15 million inhabitants is of particular interest from pollution considerations because of its high population density, as well as its high commercial and industrial activities. Previous studies of the Lagos environment have implicated vehicular traffic as a major contributor to the air pollution load in Lagos Metropolitan (LAMATA, 2009). While emission factor measurements have been made for stationary sources (industries), none exists for mobile sources in Nigeria (LAMATA, 2007). This makes greenhouse gases inventory inaccurate. Hence, there is need for accurate emission factor measurements from which emission standards can be deduced and emission regulations set.

This study was designed to carry out an emission inventory of major vehicular pollutants in Lagos, Nigeria in order to project and propose standards and regulations for the country. The study encompasses vehicular traffic counts, vehicular emission measurements, and projection of total emission.

2. Materials and Methods

2.1. Sampling

Nine sampling locations were identified along the study route and their coordinates were determined using an Explorist 400 handheld GPS receiver. Equipped with survey plan and layout of the study site, Global Positioning System (GPS), a GIS map was used for the modeling (Figure 1). Sampling and observations were made of vehicular counting and vehicular emission testing. Field assistants were employed as enumerators and supplied with manual traffic counters for traffic count exercise. Five enumerators were stationed on each side of the road to count the different types of vehicles, viz: passenger cars including SUVs, light commercial vehicles, heavy duty trucks, urban

buses, motorcycles and tricycles. Hourly counts for each type were carried out from 7am to 6pm. Traffic counts during Monday morning rush hour and Friday evening rush hour may show exceptionally high volumes and are not normally used in analysis; therefore, counts are usually conducted on Tuesday, Wednesday, or/and Thursday (Sharma, 1994). The traffic count was performed at all nine identified monitoring sites along the corridor for 2 weeks.

2.2. Vehicular Emission Measurements

Ten (10) vehicles from each of the categories (cars, buses, trucks, motorcycles, SUVs) were randomly selected at each of the sampling sites along the corridor for emission test. The static and motion mode were considered for the emission measurement along the study route for the estimation of total emission.

Two (2) gas Analysers (the UEI – Automotive 5 gas fuel efficiency analyzers and Infrared Industries Inc – DC 5 gas analyzers) were used to measure gases while a handheld aerosol real time particulate sampler measured fine particulates. Different vehicle types were driven at nine established sampling sites along the study route with the GPS installed. The gas analyzer and particulate sampler were connected to the tail exhaust pipe to measure the concentrations of CO_2, CO, HC, NO_X, O_2, air fuel ratio, temperature and particulate matter as on-board emission measurement method for motion and static mode.

2.3. Emission Factor (E.F.) Calculation

Emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. This factor is usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e. g., grams of particulate emitted per km of vehicle). Infrared Industries Inc-DC 5 gas analyzer was used for this. The estimated fuel consumption was based on the manufacturer standards and desired distance covered were directly supplied into the gas analyser as required along with installed on-board GPS. At the end of each measurement, EF results are displayed in g/km.

Mathematically:

$$EF = \frac{Emission}{Activity\ rate} \tag{1}$$

3. Results and Discussion

3.1. Vehicular Emission Measurements

The results of the vehicular emission measurements for the various vehicle types at idling state are summarized in Table 1 . The last row in the table shows ideal values (best values) for each of the parameters.

Table 1. Summary of Emission Concentrations.

Vehicle types	CO	HC	CO_2	NO_x	NO
	%	ppm	%	ppm	ppm
Cars	0.01-9.46	1.00-5116	0.21-18.0	0.00-990	0.00-1010
Buses	0.85-8.79	1.00-2540	1.50-14.70	4.00-507	3.00-505
SUVs	0.01-2.06	1.00-765	3.10-15.3	0.00-134	0.00-420
Trucks	0.00-20.97	176-32808	5.46-5.46	30-6823	27-6555
Molue	0.02-3.40	480-790	2.20-4.70	1.0	-6.9
Motorcycles/					
Tricycles	0.01-5.00	80.0-9430	1.20-4.10	4.00-216	1.00-268
Ideal values	< 0.5	< 100	< 15	0-500	–

The hydrocarbon concentration is a measure of raw, unburnt fuel. A good value is < 100 ppm to which some of the SUVs conform but which is violated by most of the other types of vehicles. A high value of CO and low CO_2

are indicative of incomplete combustion; High value of NO_x implies faulty engine, high temperature, serious carbon build-up, over ignition timing. The value should be zero at idling state and less than 500 ppm under load. From the above table, it is evident that most of the vehicles do not satisfy ideal emission standards, the only exception being the SUV vehicles. Incidentally, most of the SUVs are the newest brands (< 10 years old) on Nigerian roads.

The ranges of emission concentration values are very wide owing to the wide disparity in the age and state of the vehicles, some of the vehicles being as old as 30 years based on the model. We have thus extracted the values for those vehicles of 0 -10 years for comparison with standard values from other countries, as shown in Table 2.

Table 2. Average of vehicular emission (idle state) for vehicular mix of age 0-10 years

Age		CO	HC	CO_2	O_2	NO_x	NO	Lamda
Years		%	ppm	%	%	ppm	ppm	constant
Cars (0-10)		0.44	200.43	12.71	3.29	141.36	138.36	1.10
Buses (0-10)		3.90	175.50	12.30	7.06	80.50	76.00	0.93
SUVs (0-10)		0.20	38.00	15.03	0.52	211.33	220.33	1.01
Trucks (0-10)		0.60	560.67	6.50	12.33	399.33	434.00	1.28
Motorcycles (0-10)		2.13	244.00	3.10	14.28	4.00	1.00	4.18
Molue (10 above)		1.99	2818.50	2.88	10.88	89.75	68.50	4.93
BRT Buses								
Marcopolo		0.02	70.00	2.50	18.83	90.00	87.00	2.40
Ashok Leyland		0.01	85.00	4.50	18.40	55.00	53.00	2.30
Ideal values		0.50	100.00	15.00	1.00	500.00		1.00
US Health &								
Safety code		1.5	150.00			350.00		
Egyptian Exhaust	A	1.2	200					
Polutant	B	2.0	400					
Concentration	C	4.5	900					

A=Cars; B=Trucks; C= Motorcycles

It can be seen that SUVs and passengers cars under 10 years comply with these other standards. This is especially true for the SUVs, a lot of which are under 5 years old. The CO, HC, O_2, NO_x levels are too high while the CO_2 levels are too low from the ideal values (best values) for the other vehicular types - buses, Trucks and Motorcycles. Lambda (λ) is a measure of air/fuel ratio with an ideal value of < 1.

The emission factors for each vehicle were obtained directly from the gas analyzer described above. They were then combined with the average age and fuel mix of the different vehicle types to obtain the effective emission factors. These are presented in Table 3 below, alongside European 1996 (EURO II) standards for comparison. The results show that the emission factors for the Nigerian vehicles are close to the EURO II standards. In Table 3, the combustion status of new vehicles are better than old vehicles based on CO and CO2 levels (i.e. the higher the CO, the lower the CO_2)

3.2. Inventory of Green House Gases Emissions along the Corridor for the Year 2008

Pollutant emissions (kg/day) at each sampling point along the corridor were calculated using the traffic count, Emission Factor and Kilometer travelled using the following equation (EPA, 1992):

$$Emission = \text{Vehicle count} \times \text{Distance} \times \text{Emission Factor (EF)} \quad (2)$$

Table 3. European Emission Standards and Measured Emission Factors.

Gasoline (Standard)	As from*	CO	HC	NO_x	
EURO I	1992	4.05	0.66	0.49	
EURO II	1996	3.28	0.34	0.25	
EURO III	2000	2.3	0.2	0.15	
EURO IV	2005	1.00	0.10	0.08	
Gasoline Measured (Lagos)		CO	HC	NO_x	CO_2
Cars:					
New		3	0.006	1.2	165.9
$> 15yrs$		7.1	0.219	0.07	22.92
$< 5yrs$		14.96	0.22	0.19	121.2
SUVs:					
New		4.84	0.01	0.40	300.75
Used		11.37	0.04	0.37	198.3
Buses:					
New		8.07	0.006	0.36	229.2
Used		112.45	0.17	0.15	107.9

The SIMS-Air model was used for the GHG Emission Inventory along the corridor (Guttikunda, 2009). This required the following inputs:

- Traffic count per day for year 2008. This is 80190 for SUVs, 296,918 for cars, 6176 for molues, 82,000 for trucks, 319,964 for tricycles/motorcycles (3WD and 2WD).
- Vehicle mix by age
- Vehicle by fuel mix

Since our measured EF for gasoline vehicles is close to EURO-II Standards, and equipment for measuring EF is only good for vehicles with spark plugs (not diesel fuelled), then EURO-II standards for diesel engines were used for the base year 2008.

Projected traffic count for future years is obtained from the equation based on World Bank standard:

$$\text{New count} = \text{Base count} \times (1 + \text{growth rate})^{(\text{Projection year–Base year})} \tag{3}$$

Growth rates of 2%, 5%, 0%, 1.5% and 1% are assumed for SUVs, cars, *molues*, trucks/buses and motorcycles/tricycles respectively with corresponding grwoth rate in traffic count of 27%, 80%, 0%, 20% and 13% in line with World Bank policy and standards.
The results of emissions for the base year 2008 and projected year 2020 are shown in Table 4.

The model is applied to predict changes in Emission of GHG if Euro-IV standards are introduced. Table 5 gives the overview of the analysis under this scenario. The emission reductions in the GHG are given as CO_2 (24.7%), CO

Table 4. Summary of Emissions for Year 2008 and Projected Year 2020.

		4WD	Cars	Molue	Trucks	Buses	3W/2W	Total
Total	2008	80,190	296,918	6,176	82,000	197,474	222,490	885,248
Traffic	2020	101,700	533,222	6,176	98,041	236,104	250,707	1,225,950
Count	% change	26.8%	79.6%	0.0%	19.6%	19.6%	12.7%	38.5%
	Petrol	52.9	401.6	0.3	12.9	977.2	112.3	1,557
CO_2	Diesel	14.2	22.6	31.0	446.2	32.4	-	546
(tons/day)	CNG	-	-	-	-	-	-	-
	Total	67.1	424.2	31.3	459.0	1,009.6	112.3	2,104
	Petrol	722.7	5,484.8	4.3	189.7	14,383.7	1,860.0	22,645
CO	Diesel	82.1	131.2	514.8	7,397.5	536.6	-	8,662
(kg/day)	CNG	-	-	-	-	-	-	-
	Total	804.8	5,616.0	519.1	7,587.2	14,920.3	1,860.0	31,307
	Petrol	23.0	174.5	0.2	8.0	606.7	18.6	831
SO_2	Diesel	11.5	18.4	36.0	517.4	37.5	-	621
(kg/day)	CNG	-	-	-	-	-	-	-
	Total	34.5	192.9	36.2	525.4	644.3	18.6	1,452
	Petrol	82.1	623.3	7.5	331.9	25,171.4	139.5	26,356
NO_x	Diesel	49.3	78.7	900.9	12,945.6	939.1	-	14,914
(kg/day)	CNG	-	-	-	-	-	-	-
	Total	131.4	702.0	908.4	13,277.5	26,110.5	139.5	41,269

Table 5. Introducing EURO-IV Standards for Emission Reduction Mechanism.

Overview of the Analysis		4WD	Cars	Molue	Trucks	Buses	3W/2W	Total
Total Traffic	2008	80,190	296,918	6,176	82,000	197,474	222,490	
Count	2020	101,700	533,222	6,176	98,041	236,104	250,707	
	Control	101,700	533,222	6,176	98,041	236,104	250,707	
% Increase	2020	26.8%	79.6%	0.0%	19.6%	19.6%	12.7%	
from base	Control	26.8%	79.6%	0.0%	19.6%	19.6%	12.7%	
% change in	Control	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	2008	52.9	236.2	31.3	383.9	844.4	99.7	1,648
CO_2	2020	67.1	424.2	31.3	459.0	1,009.6	112.3	2,104
(tons/day)	Control	50.3	318.1	23.5	344.3	757.2	89.9	1,583
% change in	Control	-25.0%	-25.0%	-25.0%	-25.0%	-25.0%	-20.0%	-24.7%
	2008	634.6	3,127.2	431.1	5,287.9	12,402.4	1,650.6	23,534
CO	2020	804.8	5,616.0	431.1	6,322.3	14,828.5	1,860.0	29,863
(kg/day)	Control	410.6	2,624.3	146.0	2,133.9	4,196.3	930.0	10,441
% change in	Control	-49.0%	-53.3%	-66.1%	-66.2%	-71.7%	-50.0%	-65.0%
	2008	27.2	107.4	36.2	439.4	538.9	16.5	1,166
SO_2	2020	34.5	192.9	36.2	525.4	644.3	18.6	1,452
(kg/day)	Control	34.5	192.9	36.2	525.4	644.3	18.6	1,452
% change in	Control	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	2008	103.6	390.9	754.4	9,253.8	21,704.2	123.8	32,331
NO_x	2020	131.4	702.0	754.4	11,064.0	25,949.9	139.5	38,741
(kg/day)	Control	75.6	278.2	340.7	4,979.1	9,791.4	65.1	15,530
% change in	Control	-42.5%	-60.4%	-54.8%	-55.0%	-62.3%	-53.3%	-59.9%
	2008	7.8	19.7	16.2	198.3	465.1	82.5	790
PM10	2020	9.9	35.4	16.2	237.1	556.1	93.0	948
(kg/day)	Control	8.2	23.0	1.9	28.5	56.0	46.5	164
% change in	Control	-16.7%	-35.2%	-88.0%	-88.0%	-89.9%	-50.0%	-82.7%
	2008	84.2	369.0	118.5	1,454.2	3,410.7	123.8	5,560
HC	2020	106.8	662.6	118.5	1,738.6	4,077.8	139.5	6,844
(kg/day)	Control	106.8	662.6	44.8	654.4	1,286.9	139.5	164
% change in	Control	0.0%	-0.0%	-62.2%	-62.4%	-68.4%	0.0%	-57.7%

(65%), NO_x (59.9%), PM (82.7%) and HC (57.7%), an approximate improvement of 50% in the Emission Factors of the newly introduced vehicles. The scenario will yield maximum benefit.

Introduction of EURO-IV standards will call for the use of catalytic converters which can be poisoned by Pb. Hence, the gasoline has to be Lead-free as expected for Nigerian gasoline. It can also help to promote greater use of Compressed Natural Gas (CNG) in transport where all the buses are changed to CNG. Table 6 gives the emission changes as in EURO-IV standards if buses were converted from gasoline to CNG

This scenario leads to the following reduction in the emissions CO_2 (13.6%), CO (14.5%), SO_2 (44.4%), NO_X (0.4%), PM (55.9%) and HC (0.3%).

Table 7 gives the results of Emission reduction from other scenarios

4. GHG Emission Reduction

The following scenarios were examined for possible emission reduction:
Scenario 1: Change in vehicle fuel mix
Scenario 2: Banning molues and buses with 15+yrs age
Scenario 3: Increasing the number of buses
Scenario 4: Non-motorized transport (NMT)
Scenario 5: Introducing EURO IV Standard
Scenario 6: All buses to CNG

Other important proposed Regulatory reduction mechanisms include:

4.1. Fuel Quality

Fuel quality specification and engine technologies are to be looked at in unison. The Standards Organisation of Nigeria (SON) must be involved for the quality specification of gasoline and diesel. The sulphur content, especially for refined imported diesel must also be specified. For health reasons, the Benzene content which is carcinogenic is to be reduced to less than 1%. This has been achieved in countries like India since year 2000. Also, doping process of imported fuels must be strictly monitored by the Department of Petroleum Resources (DPR).

4.2. Inspection and Maintenance (I&M)

The first and most important step towards emission control for the used fleet of vehicles is the formulation of an inspection and maintenance system. Based on the measurements in this study, most showed that the concentration of CO generally exceeded the EURO-II emission standard by 300% when NO_x and HC had reasonable agreement with EURO-II. The cause is generally linked to rich fuel/air mixture.

It has been demonstrated in Egypt and India that it is possible to reduce pollution load by as much as 30 ? 40% by proper periodic inspection and maintenance (I & M). I & M measures for in-use vehicle are an essential complement to emission standards for new vehicles.

Hence, vehicle testing, engine-turning and certification programme should be established to improve fuel efficiency and air quality. Such programme must include emission testing. This is to be done annually. Government may need to collaborate with a few established workshops for this purpose.

For implementing regulation, vehicles must obtain Emission Certification i.e. vehicles must meet prescribed set EFs Limits as well as exhaust pollutant concentrations at idle speed.

Test procedure could be adopted based on US and E.U. procedures. Proposed types are:
Idle Test: Check HCs and CO, CO_2 and O_2 coming out of the tailpipe when the car is at idle.
Steady State Test: Check HCs, NO_x, CO and CO_2 coming from the tailpipe while operating the engine under load at a specified speed.

Table 6. All the buses to CNG for Emission Reduction Mechanism.

Overview of the Analysis								
		4WD	Cars	Molue	Trucks	Buses	3W/2W	Total
Total Traffic	2008	80,190	296,918	6,176	82,000	197,474	222,490	
Count	2020	101,700	533,222	6,176	98,041	236,104	250,707	
	Control	101,700	533,222	6,176	98,041	236,104	250,707	
% Increase	2020	26.8%	79.6%	0.0%	19.6%	19.6%	12.7%	
from base	Control	26.8%	79.6%	0.0%	19.6%	19.6%	12.7%	
% change in	Control	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
	2008	52.9	236.2	31.3	383.9	844.4	99.7	1,648
CO_2	2020	67.1	424.2	31.3	459.0	1,009.6	112.3	2,104
(tons/day)	Control	67.1	424.2	31.3	459.0	720.2	112.3	1,814
% change in	Control	0.0%	0.0%	0.0%	0.0%	-28.7%	0.0%	-13.8%
	2008	634.6	3,127.2	519.1	6,345.8	12,479.1	1,650.6	24,758
CO	2020	804.8	5,616.0	519.1	7,587.2	14,920.3	1,860.0	31,307
(kg/day)	Control	804.8	5,616.0	519.1	7,587.2	10,380.0	1,860.0	26,767
% change in	Control	-0.0%	0.0%	0.0%	0.0%	-30.4%	0.0%	-14.5%
	2008	27.2	107.4	36.2	439.4	538.9	16.5	1,166
SO_2	2020	34.5	192.9	36.2	525.4	644.3	18.6	1,452
(kg/day)	Control	34.5	192.9	36.2	525.4	-	18.6	808
% change in	Control	0.0%	0.0%	0.0%	0.0%	-100.0%	0.0%	-44.4%
	2008	103.6	390.9	908.4	11,105.1	21,838.2	123.8	34,470
NO_x	2020	131.4	702.0	908.4	13,277.5	26,110.5	139.5	41,269
(kg/day)	Control	131.4	702.0	908.4	13,277.5	25,949.9	139.5	41,109
% change in	Control	0.0%	0.0%	0.0%	0.0%	-0.6%	0.0%	-0.4%
	2008	7.8	19.7	19.5	238.0	468.0	82.5	835
PM10	2020	9.9	35.4	19.5	284.5	559.5	93.0	1,002
(kg/day)	Control	9.9	35.4	19.5	284.5	-	93.0	442
% change in	Control	0.0%	0.0%	0.0%	0.0%	-100.0%	0.0%	-55.9%
	2008	84.2	369.0	142.8	1,745.1	3,431.8	123.8	5,897
HC	2020	106.8	662.6	142.8	2,086.5	4,103.1	139.5	7,241
(kg/day)	Control	106.8	662.6	142.8	2,086.5	4,077.8	139.5	7,216
% change in	Control	0.0%	0.0%	0.0%	0.0%	-0.6%	0.0%	-0.3%

Table 7. GHG Reduction Scenario through Year 2020.

Pollutant Conc.	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
		Reduction (%)					
CO (kg/day)	24,756	-8.8	-9.8	-4.1	-7.6	-65.0	-14.5
CO_2 (tons/day)	1,648	-7.6	-9.6	-4.5	-7.9	-24.7	-13.6
HC (kg/day)	5,897	0.2	-11.6	-1.1	-7.2	-57.7	-0.3
NO_x (kg/day)	34,470	-0.1	-13.0	1.0	-6.9	-59.9	-0.4

5. Proposed Vehicular Emission Standards and Regulations

Presently in Nigeria, the regulator has adopted EURO II (1996 emission standards) as National Emission Standards for mobile sources (NESREA, 2010). As mentioned earlier, all vehicles in Nigeria operate close to EURO II Standards, while countries like Egypt and India are on EURO VI Standards.

The analyses of the various scenarios for GHG Emission Reduction as modelled by the SIMS-AIR showed that the most attractive options are:

- Change in the Emission Standards will yield the maximum benefits, because a shift from EURO II to EURO IV, will lead to at least, 50% improvement in the emission.
- A fuel switch from diesel/gasoline to CNG will yield substantial environment benefits from cars and buses.

Since most of the imported new vehicles meet EURO II, this can serve for now as standard for used vehicles. EURO IV can be proposed as standard for brand new vehicles entering the Nigeria market.

These vehicles are not manufactured locally. Dialogue between Government and importers on Policy and Standards should precede publication of the Standards or Emission Limits. It should not be difficult for the major importers like Toyota, Honda etc. as EURO IV standards we are recommending for brand new vehicle have been in use for about two decades in other world countries like Brazil, India, Egypt, Mexico and Argentina.

For these standards to have impact, some timetable for compliance must be enforced. Prior to enforcement, government must dialogue with the major importers and assembly plant owners. Penalties should be stipulated for non - compliance.

Emission Testing and certification should be made a prerequisite for annual licensing renewal.

- Relevant government ministries and parastatals should draft review and circulate to other stakeholders.
- Implementing regulation must be very specific in the Legislative Act regarding:
  - Emission Certification
  - Enforcement audit
  - Customs screening procedures

6. Conclusion

The Emission Factors for most vehicles plying Lagos Roads are close to EURO II. Also, the EF for CO, in particular, is 3 to 4 times of the European values, while EFs for NO_x and HC are comparable to European values. Idling emission concentrations of the gases from cars and SUVs are generally in compliance with United States Health and Safety standards. However, the emission concentrations of HC, O_2 and NO_x are too high and CO_2 levels too low for the buses, trucks and motorcycles/tricycles. Emission Factors (EF) have been measured for both used and new spark plug-type vehicles. From these, emission inventories of GHGs were calculated using the SIM Air Model. Various scenarios of emission reduction were modelled by the SIM-Air model. Emission standards and regulations have been proposed for motor vehicles in Nigeria based on the results of this study.

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