ASSESSMENT OF NITROGEN OXIDES (NO_2) EMISSION COMPLIANCE LEVEL OF AUTOMOBILES IN LAGOS STATE -NIGERIA

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ABSTRACT

This study focused on the assessment of NO_2 emission compliance of automobile in Lagos State, Nigeria. The automobile emission data were generated from sampling 312 different types of vehicles using Testo 350XL emission sensor. The finding on Analysis of Variance (ANOVA) on emission concentration differentials of automobiles shows that NO_2 emission concentration differs significantly by automobiles at F85.468Pvalue of 0.000. The result of emission levels based on automobiles categorization shows that Trucks, Mini buses, Tricycles and Motor cycles have higher emission concentrations of NO2 pollutant of 980ppm, 165.3ppm, 150.5ppm and 220.29ppm respectively compared to the set standards of 753.5ppm, 5.3ppm, 5.25ppm and 5.25ppm. It was also found that the emission concentration of NO_2 from petrol automobiles with 796ppm was higher than the diesel engines with 143.8ppm. The study recommended a periodic stop and checks emission analysis on Trucks, Mini buses and Tricycles which mostly violated the emission regulatory standards. The study recommended a periodic stop and checks emission analysis on Trucks, Mini buses and Tricycles which frequently violate the emission regulatory standards, as well as infuse NO2 emission check on vehicular road worthiness requirements.

Keywords: Automobile, Diesel, Emission concentration, Combustion, Engine, Nitrogen dioxide, Petrol, Pollutants and Standards.

1. INTRODUCTION

Automobile emission is the major source of air pollution in many parts of Lagos State Metropolis [1]. This cannot be disputed giving the fact that over 60% of all commuting in the State are carried out using motor vehicles supported greatly by the use of motor-cycles (Okada) and Tri cycle (Keke) used for public transport plying the nooks and crannies of the metropolis[2]. The United State Environmental Protection Agency [3]; as well as [4] unanimously identified automobile emission as a key factor in the deterioration of urban environment, constituting up to 80-90% of pollutants emitted into the atmosphere particularly in the city centres of most developing countries.

This situation is alarming and is predicated on the improvement in household living standards which resulted to a shift from non-motorised to motorised means of mobility, the poor automobile maintenance culture and importation of old vehicles which culminated in an automobile fleet dominated by a class of vehicles known as ''super emitters'' among other reasons [5].

Majority of today's automobiles use internal combustion engines that burn petrol or other fossil fuels such as diesel which are discharged into the atmosphere through an exhaust pipe, flue gas stack or propelling nozzle depending on the type of engine (internal or external combustion engines). The process of burning fuel to power motor-cycles, tricycles, cars, heavy duty vehicles, aircrafts and locomotives contributes to air pollution by releasing a variety of emissions into the atmosphere. These emissions compromise air quality and are major ingredients in the creation of smog in some large cities of the world [6]. For instance, NO_2 pollutant which is a reddish-brown gas with a sharp odour is primarily derived from motor vehicle exhausts plays a role in the formation of troposphere ozone. Others sources are petrol and metal refining, electricity generation from coal-fired power stations, other manufacturing and food processing industries. Large concentrations of nitrogen dioxide can reduce visibility and can inflames the lining of the lungs when inhaled in a higher dose, reduces immunity to lungs infections, which results to flu, bronchitis and more frequent and chronic asthma attacks and other respiratory disease [7]. Studies have shown that automobile emission contributes more to air pollution in developing countries, accounting for up to 40-80 percent of NO2 and CO concentrations [8].

Given the aforementioned, it is pertinent to carry out this study with a focus on the assessment of emission levels of NO2 pollutant from various types of automobiles as well as ascertain their compliance to standard set by the Lagos Environmental Protection Agency (LASEPA).

1 THE STUDY AREA

Lagos State is located in the south-western part of Nigeria. It lies within latitudes 6°20' N and 6°40'N and longitude 2°40'E and 4°20'E. The state shares boundaries with Benin Republic to the West, Ogun State to the north and east and Bright of Benin of the Atlantic Ocean to the south. It has a land area of about 3,577.28sq.km out of which 22% is occupied by water (See Figure 1) [9]. The state occupies a pre-eminent position based on all urban indicators, most especially demography with a total population of 17,552,942 [10].

The state has a population density of about 2,400 persons/ km² with annual population growth rate of between 5.0 to 5.5%[2]. It is known to occupy an enviable position as the most commercial, and industrial state as compared to other states in Nigeria and it is adjudged to be accountable to about 25% of Nigeria's gross domestic products [11]. The state has well developed inter-modal transport infrastructure; with the road transport dominating more than 90 percent of all intra -urban movement [12]; as well as having the highest national vehicular density of over 222 vehicles/km against country average of 11/km with a resultant impact on high incidence of air and noise pollution.

2 MATERIALS AND METHODS

Prior to data collection a reconnaissance survey was carried out during which consultations were made with relevant personnel and agencies responsible for environmental regulations and traffic management such as Lagos State Environmental Protection Agency (LASEPA) and Lagos State Traffic Management Authority (LASTMA) for updates on environmental and traffic related issues, as well as a visit to the State command of the Federal Road Safety Corp (FRSC) and Vehicle Inspection Office (VIO) for assistance in the data collection processes.

2.1 Experimental Design

Exhaust emission study required extensive planning, preparations and coordination with traffic officials and security agencies. The first step was to understand the fleet of automobile types, models, maker/manufacturer, fuel types used, vehicular size and weight as well as an understanding of the operational modes of the various types of automobiles that is of interest. The data collection procedures employed include:

i. *Instrumentation:* Exhaust emission of NO_2 levels was measured using a standard Testo350XL gas sensor. The instrument was setup to provide emission analysis output on a 1-second interval. In order to facilitate efficient data logging, the instrument was connected to the computer and data download was performed on a real-time basis. Plate

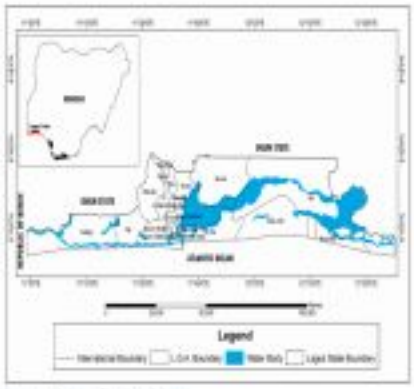

Figure 1Map of Lagos State

Extracted from Administrative Map of Lagos State

ii. 1 and 2 shows the Testo 350XL connected to the computer system displaying the measured pollutant concentrations. The shortfall of Testo 350XL is that
iii. the reading can only be taken on vehicles on idling mode, unlike on road vehicles or cruising cycle mode.
iv. *Automobile Selection and Sampling Process:* The emission data collection for the sampled automobiles was conducted between February 4th - 23th, 2017. In order to collect maximum data within a short span of time, avoid the obstruction of traffic flow and ensure reasonable compliance of drivers, the Lagos State vehicle Inspection Officers were involved in the process of data collection.
v. *Exhaust pipe attachment:* Testo 350 XL sensor pipe was inserted into the vehicle exhaust; this was wide enough to allow the probes to pass through while the vehicle was on idle mode. Thereafter the reading was recorded and downloaded into the computer system.

Plate 1: Shows the Emission Testing on Toyota Camry and Range Rover Car

iv. Exhaust pipe Testing Procedures: The emission data were collected on Idling testing procedure: Idle testing refers to the emission testing cycle in which the vehicle in the idling mode is connected to an emission analyser pipe which is attached to a computer from where the reading is displayed. Thereafter, the analysed pollutant is then generated and prepared for data-logging. Emission monitoring instrumentation was connected to the sampling probes that were setup at the tailpipe/exhaust. Both sets of instruments were started simultaneously for easy comparison of the data. The automobile was then started in the desired idling mode (fast or normal idle) and the emission characteristics were monitored for at least 3-5 minutes period.

3 RESULTS DISCUSSIONS

4.1 Emission Concentration of NO_2 of Automobiles Categories and LASEPA Standards

Figure 2 shows the emission concentration of automobile categories in comparism with regulatory standards of LASEPA. The result in Figure 2 shows that Trucks, Mini buses, Tricycles (Keke) and Motor cycles (Bikes) all have higher emission concentrations of NO_2 pollutant compared to the set standards. This is indicated where trucks emits 980ppm compared to the set standard of 753.5ppm. Mini bus, motor cycles and tricycles with 165.3ppm, 150.5ppm and 220.29ppm, compared to the set standards of 5.3ppm, 5.25ppm and 5.25ppm in that order.

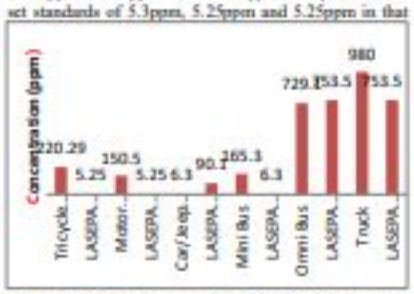

Figure 2 Emission Concentration of NO2 Pollutants across Automobile Categories

On the other hand, categories of automobiles such as car/jeeps/vans and Omni buses have lower emission concentration of NO_2 at 6.3ppm and 729.1ppm compared to the set standards of 90.1ppm and 753.5ppm respectively. The high concentration of NO_2 emission from mini buses above the set limits in the study can be likened to poorly maintained engine and physical conditions of most commercial buses (Danfo) commonly used in the study area which makes it possible to produce more harmful pollutants. Also, higher concentration of NO_2 pollutants from trucks is as expected as diesel engines are generally known to have higher emission of NO_2 due to the higher concentration of sulphur additives during the refining process. Conversely, the lower concentration of NO_2 pollutants from Car/jeeps/vans and Omni buses can be attributed to the introduction of oxidation catalysts in newer cars as specified in Euro 4 and Euro 5 automobiles.

3.2 Concentration of NO_2 by Automobile Models

Figure 3 shows the distribution of automobile models and their average emission concentrations of NO_2 pollutants from the least to the highest. From the

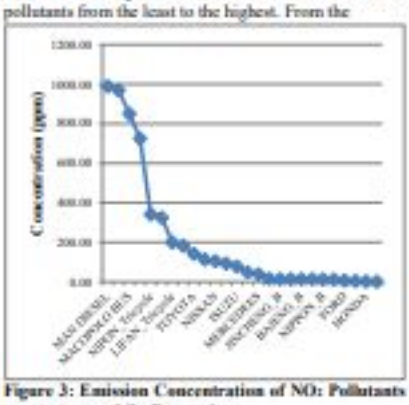

Figure 3: Emission Concentration of NO2 Pollutants across Automobile Categories
Source: Field Survey (2017)

presentations, it shows that Man diesel truck, has the highest emission concentration of NO_2 with an average concentration of 990.01ppm, followed by Mark trucks, Macopolo and Ashok Leyland/omni-buses with concentration values of 970.01ppm, 850.07ppm, 724.91ppm in that order.

Also, tricycles shows high emission concentration of NO_2 with variations across different models such as Nippon, Jincheng and Lifan models with concentration of 341.79ppm, 325.02ppm and 200.0ppm in that order. This high level of emission concentration of NO_2 despite small engine make ups especially compared to the other types of automobiles with larger engines can be attributed to mixture of engine oil and petrol to power the engine as mostly practiced by the operators/users.
On the other hand, the least emission concentration of NO_2 pollutants is recorded on Chevrolet and Mitsubishi cars models with 1.54ppm and 4.79ppm concentrations respectively. This is finding is expected because diesel and large engine automobiles are known to emit mostly NO_2 pollutants than petrol engines due to the engine and fuel characteristics of such automobiles.

3.3 Concentration Differentials of NO2 Pollutants in Diesel and Petrol Automobiles

Figure 4 shows the emission concentration of NO2 from diesel and petrol engine automobiles. The presentation shows that there is higher emission concentration of NO_2 from petrol automobiles with 796ppm than the diesel engines with 143.8ppm.

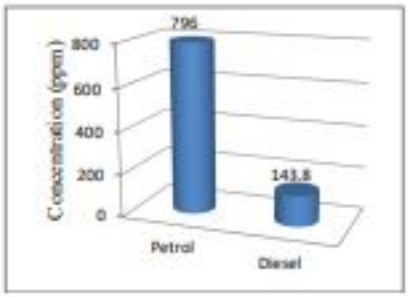

Figure 4: Emission Concentration of NO2 Pollutants in Diesel and Petrol Automobiles
Source: Field Survey, (2017)

This finding can be likened to the report by [13] that diesel fuel contains no lead; hence the emissions of regulated pollutants (Hydrocarbons and Nitrogen oxides) are lower than those from petrol cars. In addition, the lower emission concentration of Nitrogen dioxides from diesel engines compared to petrol engines can also be as a result of the introduction of a range of engine and fuel system design options by manufacturers along with exhaust emission controls, in order to meet these standards. Such technology deployed on diesel vehicles to meet the set standard or reduce emission is diesel particulate filters (DPFs)to reduce particulate matter (PM), and selective catalytic reduction (SCR) to reduce NO_2emissions [14].

3.4 Emission Differentials from Automobiles

Table 1 is a presentation of test for emission differentials of pollutants from various sampled automobiles using single time factor analysis of variance (ANOVA) statistical technique at 0.05 statistically significant levels. The result shows that emission concentration of NO_2 pollutant from the sampled automobiles differs significantly by automobiles. This is indicated where the mean differences in Nitrogen dioxide concentration between different types of automobiles (F85.468 at 0.000) is statistically significant.

Table 1: ANOVA Result of Differentials in Emission of NO_2 from Automobiles

NO2	Sum of Squares	Degree of Freedom (df)	Mean Square	Co-efficient (F)	Sig.
Between Groups	6445399.68 8	5	1289079 .938	85.468	.000
Within Groups	4630373.15 1	307	15082.6 49		
Total	1.108E7	312			

Source: Field Survey (2017).

This finding is however not surprising as it is generally known that emission levels differs by automobile types and engine sizes (large, medium or small), fuel composition, and frequency of maintenance amongst others.

Comparison of Mean Concentration of NO_2 Emission from Automobiles Multiple comparisons on the mean concentrations of NO_2 from different automobiles were made between each other, to shed more light on the differential in emission concentrations between them. As presented in Table 2, it shows that emission concentration of nitrogen oxide from cars differs statistically with trucks, mini-buses and Omni-buses at 0.05 significant levels, except for motorcycles and tricycles with p-values of .450 and .501. This can be likened to the use of petrol which is common in cars, motorcycles and tricycles, unlike trucks, Omni-buses which uses diesel to power their engines, hence the indifference in the concentration of nitrogen dioxide emissions. Nitrogen dioxide emission concentration from trucks on the other hand, differs significantly between the other types of sampled automobiles at 0.05 significant levels, except only with Omni-bus. This finding is expected because, both types of automobiles use diesel to power their engines as well as operate on higher combustion chamber pressures and temperature compared to the other types of automobiles.

Surprisingly, Table 2 also reveals that nitrogen dioxide emission concentration from mini-bus has strong statistical difference with other types of sampled automobiles at 0.05 significance levels, except with tricycles with p-value of .978.

The result on the existence of strong statistical difference on nitrogen dioxide emission concentration from mini-bus with other types of sampled automobiles except with tricycles is related to the bad conditions of most commercially used automobiles in the study area, which are often times referred to as super emitters. This assertion is further supported by the submission of [15] which described commercially used automobiles in Lagos State especially the buses as old and rickety.