Analysis of Exhaust Gas Emissions from Gasoline engine-powered passenger vehicles in Nigeria

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Abstract: Emissions from vehicles in developing country constitute a large percentage of global emissions. The study involved the analysis of exhaust emissions using a gas analyser. The vehicles studied are mini buses and private vehicles of different model of carswhich constitute about 80% of the vehicles on Nigeria roads. It was established that the main types of exhaust gases from the automobiles were CO_2, NO_2, CO, and O_2. The highest emission of CO_2 was found to be 413.13 mg/m^3 in the 2007 Peugeot car model. The highest exhaust gas emission of NO_x, O_2 and CO was discovered in the 1998 Honda passenger car model and recorded as 40.23 mg/m^3, 45.41mg/m^3 and 192.43 mg/m^{3}respectively. The study of emissions will spur further studies on more efficient combustor design aimed at minimizing emissions.

Keywords—*Emissions, Exhaust gas, BMW, Peugeot, Mercedez, Toyota, Honda*

I. INTRODUCTION

It is a well-established fact that vehicular emissions constitute major air pollutions and consequently requires management [1]. The increase concern for global warming which is as result of emission of greenhouse gases has necessitated rise in the research on emissions with a view to minimizing air toxics in the atmosphere. Emissions from vehicles which constitute a great percentage are usually made of oxides of nitrogen, sulphur, carbon, and unburnt hydrocarbon. According to the i*nternational energy agency (*IEA), within the previous one hundred years, the extent of carbon (IV) oxide in the surrounding air has elevated by greater above thirty percent on account of societal endeavours by human activities [2]. The Intergovernmental Panel on Climate Change (IPCC) revealed that world environmental temperature has risen by nearly 8°C since the previous century. It is anticipated that temperature would rise by an additional value of 1.8 – 4 °C by 2100. It is expected that this increase would lead to in ocean stage rise of 15 to 95 centimetres [3]. Ken *et al.* [4] reported that the input of the mobility segment to CO_2 given off in advanced countries is predicted to rise to 30% in 2020. According to Ming *et al.* [5], the mobility segment of the economy is responsible for virtually all of the processed crude petroleum demand progress all over the world. Underdeveloped nations amount for close to ten percent of the worldwide motor vehicle total number and just a bit more percentage of the worldwide mobility power usage [6].

Automobiles used on the roads are one of the predominant users of global power and so they overshadow world processed crude usage, taking close to eighty percent of mobility power [7]. The mobility segment's portion of processed crude usage has been rising gradually at close to 0.6 percent in each 12 months [8]. There exist rising proof that connects automobile contaminants biological life in poor biological state. World health organisation (WHO) revealed that automobiles are vital pollutants avenues for a large number of atmospheric contaminations, together with oxygenated compounds of nitrogen, carbon, particulate matter (PM), and hydrocarbons (HCs) [9]. The contaminants have relevant influences on biological life and the ecological surroundings. Automobile pollution extent is based on the attributes of vehicular congestions and movement rate, automobiles and kind of motor able route junctions and by pass [10]. Perry and Gee [11] revealed that the life span of an automobile and repair status also influences the pollutions of all categories of automobile. Several other investigations have been carried out by researchers to analyse the exhaust gas emissions of automobile [12-16].

A yearly recorded automobile documentation shows increase of over 30% in 2012 and the amount of used vehicles regularly increase geometrically in the city of Abuja, Nigeria [17]. The number of automobile in use in the Abuja is regularly increasing leading to symptoms of ecological burden described by bad atmospheric nature, high noise pollution, vehicular uneasy flow, and damage to structural landmark as well as historical sculptures. A good understanding of the pending disasters of the increase in automobile numbers on the atmospheric is necessary. Very few works has been carried out concerning the function of vehicular pollutions on the atmospheric value in major cities. This paper presents the emission performance of passenger vehicles via tail pipe emissions in Nigeria.

II. MATERIALS AND METHOD

A. Materials

The tools employed for this study include a gas analyser model IMR 1000-4 with the probe, fleet of passenger vehicles of different car manufacturers and gasoline. The IMR1000 is a portable palm top-sized size stack gas analyzer for burning examinations on boilers, burners, among others. The IMR1000-3/-4 has a 4-line LCD and incorporates 3 sensors. Measured parameters of combustion gas analyzer are Oxygen, oxides of carbon (CO_x) and oxides of Nitrogen. Fig. 1 shows the IMR1000-3/4 Gas Analyser used for the study. Passenger vehicles used for the study were those manufactured from 1998 to 2014 by different car manufacturers (BMW, Peugeot, Mercedez, Toyota and Honda). The gasoline was utilized as an energy source to power the vehicle. Common gasoline contains hydrogenated carbon compounds within four and twelve carbon atoms in each compound. The relative density of gasoline spans from 0.71 to 0.77 with heavy relative density having a larger capacity of ring shaped-hydrocarbon compounds. Gasoline consisted of almost 132 MJ/US gal, while its mixtures vary by up to 4% much or lower than the mean. The given off of carbon dioxide from petrol is about 73.38 g/MJ. Table 1 shows the constituent of a gasoline.

Table 1: Compositional Analysis of a Sample of gasoline using GC/MS [18]

Constituents	Composition by Mass (%)
Ethylbenzene	11.97
Isopropylbenzene	5.12
2-4 Dimethyistyrene	7.21
Oxylene	17.85
1-ethyl-3-methylbenzene	15.5
Octane	5.98
Undecane	7.69
4-Methyloctane	7.42
2-Methylheptane	8.14
Toluene	19.75

Fig.1. IMR1000-3/4 Combustion Gas Analyzer

B. Methods

At the commencement of each field work, the gas analyser was initially purged and then a leak examination conducted to ensure that that there was no presence of air in the equipment. The filter was regularly inspected to ensure that it was neat and not choked with dirt. The start-up period prior to examination was 3 minutes. The gas analyser probe was inserted into the tail pipe or silencer outlet and fastened to keep it rigidly in position. The automobile driver was asked to start the automobile power unit in inactive speed for 5 minutes and measurements were taken. The throttle was then raised and held for five minutes and measurements were again taken. The throttle was then raised to a higher position for 5 minutes and reading taken. The procedures were repeated for different cars (BMW, Peugeot, Mercedez, Toyota and Honda) and in each of case 5 cars from same manufacturer were used and the average value recorded.

The emissions obtained from the above measurements using gas analyser were expressed in percentages or part per million (ppm). The data were converted to mg/m^3 using equation (1).

$$1\text{ppm} = \frac{M(^{mg}/_{m^3})}{22.4} \qquad (1)$$

III.RESULTS AND DISCUSSION

A. Honda Cars

Fig. 2 shows the results of emission of CO_2, CO, NO_x and O_2 for passenger vehicle of Honda car in different years of manufacture. The emission of CO_2 is higher than that of CO. This is to indicates that higher percentage of the fuel went through complete combustion and the percentage with incomplete combustion produced the CO while emission of NO_x in newer cars are lower and within the range of euro 5 standard in EU countries because some of the cars were purchased new with a low millage.

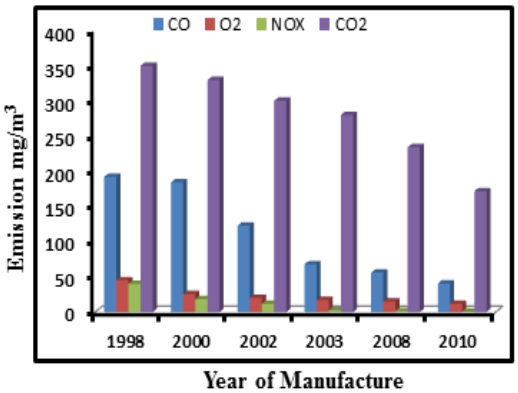

Fig.2. Variation of Emissions from Honda Cars with the Year of Manufacture

B. Peugeot Cars

The result of emission of CO_2, CO, NO_x and O_2 from Peugeot model passenger cars is presented in Fig. 3. It is obvious that emission increased with age of vehicles. The emission of CO_2 in 2007 models of Peugeot cars was highest with a value of 153.5 mg/m^3 higher than for 2010 model of the same car. This is about 37% reduction in emission of CO_2 between 2007 and 2010. From the emission which shows O_2 in the exhaust and also CO, this implies incomplete combustion in the presence of excess air. This can be attributed to inefficient combustor or fuel mix.

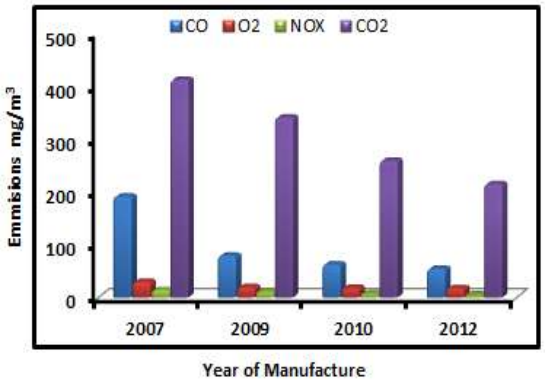

Fig.3. Variation of Emissions from Peugeot Cars with the year of Manufacture

C. Toyota cars

Fig. 4 shows the result of emission from Toyota cars. For 2006 models of Toyota cars, the emission of CO_2, CO, NO_x and O_2 are 250.12, 90.51, 10.36 and 20.06 mg/m^3. For all the models considered for experimentation, the results shows that similarity in the emission of CO and O_2 for cars of 2012 to 2014 models of the brand of cars.

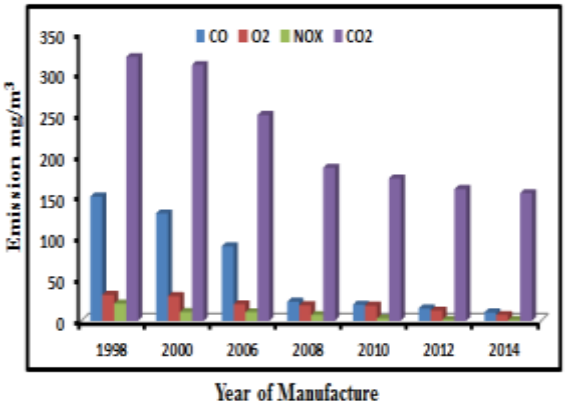

Fig.4. Variation of Emissions from Toyota cars with the year of Manufacture

D. BMW Cars

Fig. 5 shows the emission of CO_2, CO, NO_x and O_2 for BMV passenger cars. The emission of CO_2 for 2006 model of BMV cars was 286.11 mg/m^3 as compared to 159.62 mg/m^3 for 2012 model of the same car. Contrary to what was obtained in Toyota passenger cars, the emission of CO is very similar to that of O_2 for 2012 and 2014. CO emissions for BMW car models of 2006, 2017 and 2008 are quite similar with values of 89.45 mg/m^3, 87.62 mg/m^3 and 83.02 mg/m^3 respectively. The average of which is about 61% greater than the CO emissions for 2012 models of cars. The variation of emissions levels within the ranged of year of manufacture (1998-2014) for O_2 and NO_x are about 10-25% for BMW model. This indicated the manufacturer of BMW is improving on their newer cars and conscious of the influence of gases given off on biological life wellbeing plus ecological terrain.

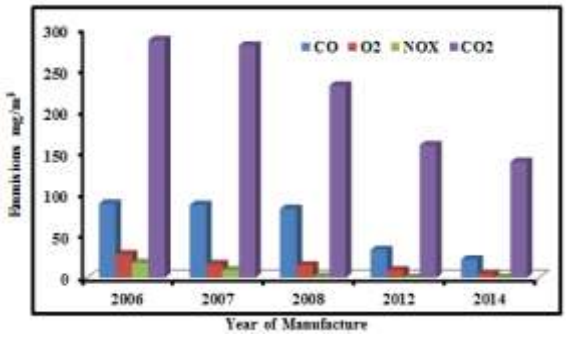

Fig.5. Variation of Emissions from BMW Cars with the Year of Manufacture

E. Mercedes Benz cars

Fig. 6 presents the emission of CO_2, CO, NO_x and O_2 from Mercedes. Emission of CO_2 from Mercedes Benz cars of 1998 is 17.08 mg/m^3 higher than that emitted by 1998 model of Toyota cars. The reduction in emission from newer model of Mercedes Benz is not only because the cars are relatively new but the fact that most owners of these cars have other cars and therefore the level of usage of the Mercedes car in greatly reduced and the mileage cover is comparative shorter than others brand of the same year of manufacture. The manufacturer has improved on catalytic converter which burned fuel perfectly during combustion thereby making the emission very low almost equivalent of EU Standard for current models.

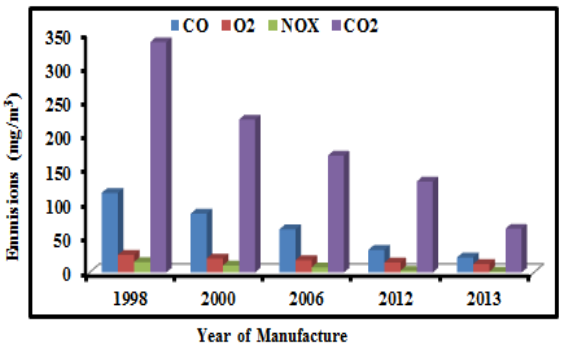

Fig.6. Variation of Emissions from Mercedes cars with the Year of Manufacture

IV. CONCLUSIONS

The analysis of emissions from passenger cars in Nigerian roads was presented. The study found out that the major types of tail pipe emission from the vehicles used in Nigeria are CO_2, NO_x, CO and O_2. The highest emission of CO_2 was found to be 413.13 mg/m^3 in the 2007 Peugeot car model. The highest exhaust gas emission of NO_x, O_2 and CO was discovered in the 1998 Honda passenger car model and recorded as 40.23 mg/m^3, 45.41mg/m^3 and 192.43 mg/m^3respectively. This research has given an insight to the emissions from passenger cars in Nigeria.

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