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ON VEHICULAR EMISSIONS OF PETROL AND DIESEL ENGINES

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ABSTRACT: The rise in the number of vehicles in Nigeria has significantly increased the vehicular emissions in the country especially in towns and cities. Some studies in the area of vehicular emissions of petrol and diesel engine vehicles concentrating on CO and CO_2 existed. This study in addition to CO and CO_2 emissions characteristics attempt to study the O_2 emission of both types of engines. The analysis of data conducted on the emissions of petrol and diesel engine vehicles using a two-sample equal variance one-tail t-test showed that there were significant differences between the data of CO for the two types of engines ($p=4.86x10^{-6}$), for CO_2 ($p=1.77x10^{-14}$) and O_2 ($p=1.65x10^{-19}$). The CO and CO_2 emissions were consistently higher for petrol engines as compared to diesel engine vehicles while O_2 was consistently lower. Pearson Correlation Coefficient for age and CO of petrol engine vehicles showed that there was very low negative correlation (r= -0.27). Same test showed that there was no correlation between age and CO_2 (r=0.00) as well as age and O_2 (r= -0.02). Similarly, for diesel engine vehicles there was very low positive correlation between age and CO (r= 0.29), no correlation between age and CO_2 (r= -0.03) as well as a very low positive correlation between age and O_2 (r= 0.25).These results suggest that the rise in manufacture and distribution of diesel engine vehicles can be further strengthened if its higher emission of O_2 is considered in addition to lower emissions of poisonous CO and green house gas CO_2. It may also be stated that emissions from vehicles irrespective of type of type of engine is independent of age.
KEYWORDS: Vehicle Emissions, Petrol Engines, Diesel Engines

INTRODUCTION

The number of vehicles in Nigeria has increased substantially in the last 10 years and as such significantly increases vehicle emissions that pollute the air. According to Karlsson (2004) vehicular emissions pollute the air and must be controlled to alleviate the problems that may be associated with such pollution. Okoko (2005) observed that journeys of short duration lead to incomplete combustion of fuel and thus vehicles run less efficiently. This may be applicable to Nigerian cities and towns where traffic hold ups hold sway. Bull (1991) had observed that due to congestion and traffic hold ups, vehicle emissions increase much faster than the actual growth in the number of vehicles. Transportation Research Board (2008) buttressed the observation of Bull (1991) and found that for the same amount of time in operation, vehicles in idling condition produce higher average concentrations of Carbon Monoxide (CO), Nitric Oxide (NO), Nitrogen dioxide (NO_2) and Sulphur dioxide (SO_2).

Vehicle emissions include volatile organic compounds, Nitrogen Oxides, lead and Carbon Monoxide that have adverse effects on natural environment, human health, agricultural productivity and natural ecosystems as noted by Bolaji and Adejuyigbe (2006). Also, Dewaram (2002) stated that hydrocarbons present in the exhaust particularly in vehicles with poor combustion cause respiratory problems. Once these fumes are emitted into the atmosphere, Zannetti (1992) opined that the pollutants undergo mixing or diffusion, the degree of which depends on topographic, climatic and meteorological conditions.

The effects of vehicle emissions on humans and other natural ecosystems led to the study on vehicle emissions and how they can be controlled.

Frey and Zheng (2002) noted that vehicle emissions are dependent on vehicle design, operation, maintenance and fuel composition. Emissions from cars are greatest when an engine is cold. On a cold day a petrol car may take up to ten kilometres to warm up and operate at maximum efficiency, whereas a diesel car may only take five kilometres. Therefore diesel cars will produce less unburnt fuel during a cold start, which will result in fewer emissions of carbon monoxide and hydrocarbons. This would mean that diesel cars would make a significant impact on air quality in urban areas where *most cold starts occur, especially when it is considered that a catalyst on a petrol car would take several minutes to get to its operating temperature. For example, QUARG (1993) stated that a journey of one kilometre could lead to emissions of CO being as much as 14 times higher from a catalyst equipped petrol car, compared with a diesel car.*

Table 1: Emissions for road vehicles (per vehicle kilometre)

Vehicles	Carbon monoxide	Hydrocarbons	Oxides of Nitrogen	Particulate matter	Carbon dioxide
Petrol car without a catalyst	100	100	100	--	100
Petrol car with a catalyst	42	19	23	--	100
Diesel car without a catalyst	2	3	31	100	85

*Source: DOT (1993) (NB*petrol cars without catalysts have been given a relative value of 100 for comparison)*

As a way of reducing vehicle emissions that may affect the natural environment, vehicle manufacturers are promoting diesel engine cars as cleaner than petrol engine cars. In fact, Yin (2005) observed that in Europe fifty percent of vehicles currently sold use diesel fuel. He added that the figure is higher for France and Belgium with sixty seven percent and Austria with over seventy percent.

However, there is scant of literature of oxygen emissions comparison of diesel and petrol engine cars. This study in addition to CO and CO_2 emissions attempts to study this comparison.

METHODOLOGY

The exhaust emissions from different vehicles were collected from Pescasen Nigeria Limited, a company granted the authority to implement vehicle and generator emissions testing in Ogun State by Ogun State Environmental Protection Agency on behalf of Ogun State Government. To the author's knowledge, Ogun State Government is the first to set up such an emissions control scheme in Nigeria. The emissions test involves concentration measurements of raw exhaust at idle speed (600-1200rpm). Data on 80 vehicles were provided for analysis. T-test and Pearson Correlation Coefficients were used for the analysis.

RESULTS AND DISCUSSION

The data on emissions obtained for petrol and diesel engines are presented in Tables 2 and 3 respectively in terms of 5^{th}, 50^{th} and 95^{th} percentiles and Standard Deviations. The analysis of data conducted on the emissions of petrol and diesel engine vehicles using a two-sample equal variance one-tail t-test showed that there were significant differences between the data of CO for the two types of engines ($p=4.86 \times 10^{-6}$), for CO_2 ($p=1.77 \times 10^{-14}$) and O_2 ($p=1.65 \times 10^{-19}$). The CO and CO_2 emissions were consistently higher for petrol engines as compared to diesel engine vehicles (Figures 1 and 2 respectively) while O_2 was consistently lower (Figure 3). The emission characteristics of petrol and diesel engines are shown in Figures 4 and 5 respectively.

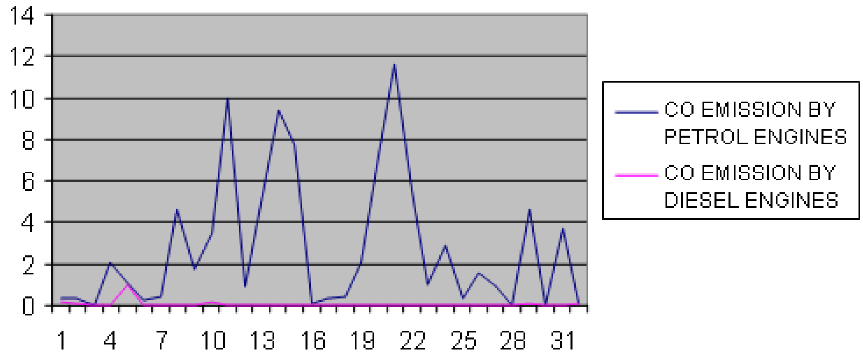

Figure 1: CO Emissions Comparison between Petrol and Diesel Engines

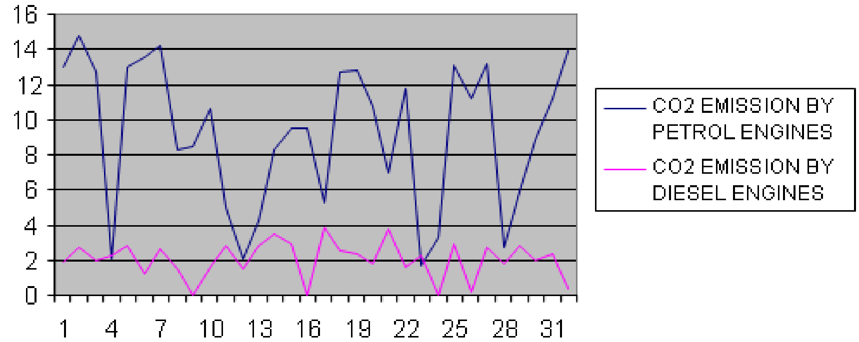

Figure 2: Co_2 Emissions Comparison between Petrol and Diesel Engines

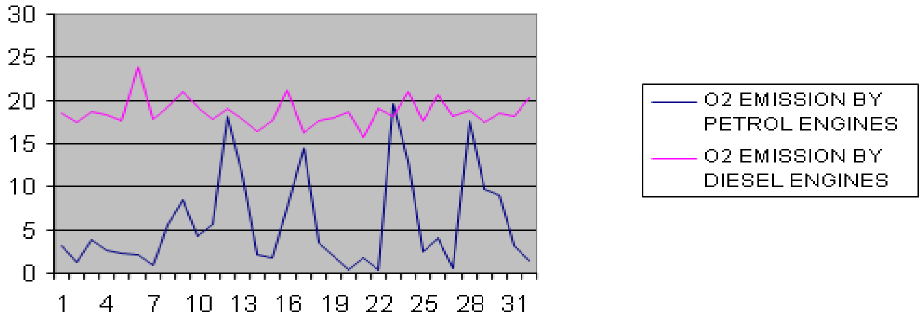

Figure 3: Comparison of O_2 Emissions for Petrol and Diesel Engines

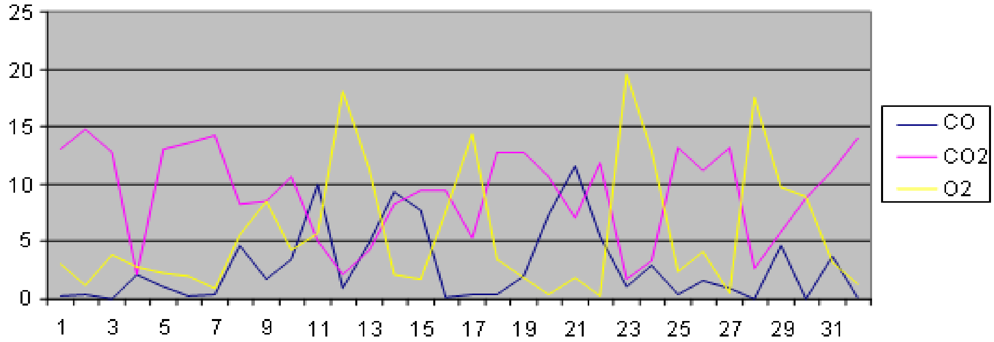

Figure 4: Emissions Characteristics for Petrol Engines

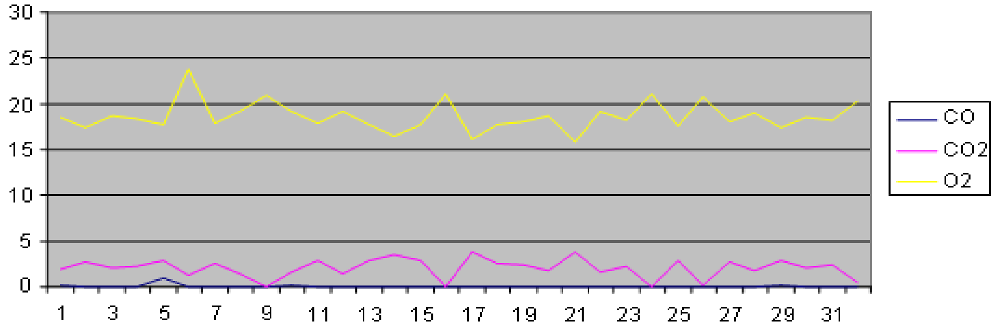

Figure 5: Emissions Characteristics of Diesel Engines

Pearson Correlation Coefficient for age and CO of petrol engine vehicles showed that there was very low negative correlation (r= -0.27). Same test showed that there was no correlation between age and CO_2 (r=0.00) as well as age and O_2 (r= -0.02). Similarly, for diesel engine vehicles there was very low positive correlation between age and CO (r= 0.29), no correlation between age and CO_2 (r= -0.03) as well as a very low positive correlation between age and O_2 (r= 0.25). This probably showed that factors other than age may be responsible for vehicular emissions as they were independent of age. This seems to be in agreement with the study of Transportation Research Board (2008) which observed that engine technology was a deciding factor affecting the emission behaviour of vehicles. Also, Malkin et al (2006) found that gasoline powered forklifts usually produce the highest amount of CO but propane powered forklifts may also emit substantial amount of CO particularly if the forklift is not properly maintained thus buttressing the fact that higher emissions of CO may not be due to age but inadequate maintenance. This is however in contrary to the observation of Wenzel et al (2000) that as the age of vehicle increases and thus accumulates mileage, their emissions tend to increase.

Moreover, Campbell (2006) noted that by applying the repair results obtained from his study to various fleet scenarios suggested that repairing the 10% worst emitters as identified by idle simple testing would be expected to reduce on-road petrol fleet CO and HC emissions somewhere in the order of 10% and reduce NOx emissions much less than this. A reduction in fuel consumption of less than 0.5% would be expected.

The reason for lower emissions of CO and CO_2 for diesel engines may be due to the use of compression ignition technology as opposed to spark ignition technology of petrol engines which provided for complete combustion of fuel. The same reason may be adduced for the higher emission of O_2. Wilson et al (2008) observed that Diesel engines are generally more efficient than petrol engines (they have a higher compression ratio, and diesel fuel also contains more energy per unit volume), and they produce lower levels of CO and CO_2 emissions per kilometre travelled. However, diesel engines generally produce higher levels of particulates (eg, $PM_{2.5}$ and PM_{10}), which is a concern from a public health perspective. Furthermore, diesel cars usually have higher NO_x/CO_2 ratios than for *petrol cars with three-way catalytic converters. Then again the particulate problem can be mitigated with some modern diesel cars that have diesel particulate filters. Also some diesel cars also have catalytic converters in the exhaust which reduce CO and unburnt hydrocarbon emissions*

Table 2: Emissions Characteristics of Petrol Engines

Percentile	CO %	CO_2 %	O_2 %	AGE Years
5th	0.04	2.1	0.42	4
50th	1.32	10.05	3.31	10
95th	9.63	14.04	17.83	20.45
Standard Deviation	3.28	4.11	5.56	5.36

Table 3: Emissions Characteristics of Diesel Engines

Percentile	CO %	CO_2 %	O_2 %	AGE Y ears
5th	0.00	0.00	16.28	1.55
50th	0.01	2.3	18.29	8
95th	0.13	3.64	21.08	20.8
Standard Deviation	0.18	1.05	1.62	6.75

The rise in manufacture and distribution of diesel engine vehicles can be further strengthened if its higher emission of O_2 is considered in addition to lower emissions of poisonous CO and green house gas CO_2. It may therefore be stated that the use of diesel engine vehicles may increase the O_2 in the atmosphere which is being depleted by deforestation.

CONCLUSIONS

The increase in the manufacture and distribution of diesel engine vehicles in the recent times may be linked to its lower emissions of CO and CO_2 as well as higher emission of O_2 as compared to petrol engine vehicles. Increase in this type of vehicles on our road may thus lead to increase in the availability of O_2 in the atmosphere especially in towns and cities where deforestation holds sway. The study thus supports the increase in the number of diesel engine vehicles on our roads.

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