AN EXHAUST EMISSION CHARACTERISTICS IN A SPARK IGNITION ENGINE FUELLED BY PETROL-SNOT APPLE (*Azanza garckeana*) BIOETHANOL BLENDS

[1] Christopher I., [2]Sintali I. S., [3]Abioye A. M. and [4]Habu J. T.

[1&4]*Department of Mechanical Engineering Technology, Federal Polytechnic Bauchi, Nigeria*
[2&3]*Department of Mechanical/Production Engineering, Abubakar Tafawa Balewa University, Bauchi, Nigeria*

ABSTRACT

Energy is an essential ingredient for socio economic development and hence, is a true indicator for economic growth. However, the world relies heavily on fossil fuels to meet its energy requirements of which in the near future it will be exhausted as well as environmental pollution, necessitates the need for alternative source of fuel, hence the need for bioethanol production. In this study, bio-ethanol derived from Azanza grakeana was produced by fermentation method. The physico-chemical and were determined using standard laboratory methods. The blended fuel samples were; PE2, PE4, PE6, PE8, PE10, PE12 and PE14 respectively. The engine performance and exhaust gas analysis were also conducted to investigate the effect of bio-ethanol as petrol fuel extender, with a TD110-115 single cylinder, four stroke and air-cooled, spark ignition engine test rig, under different loading conditions, and incorporated in with an SV-SQ automobile exhaust gas analyzer monitor and measure concentration of gaseous emissions such as; unburned hydrocarbon (HC), carbon monoxide (CO), and carbon dioxide (CO_2) from the engine tailpipe. The result shows that there was appreciable decrease in HC and CO, emissions were recorded for all blended fuel samples than petrol- with the least CO and HC emission levels observed for PE14 fuel samples of 97.5% and 23.2% respectively. For reasons of its satisfactory engine performance behavior, petrol fuel conservation advantages, and inherent greenhouse gas mitigation potentials, the candidacy of Azanza garckeana bio-ethanol and gasoline blends, offer a promise of a prospective fuel source for spark ignition engines.

KEYWORDS: *Emissions, Petrol, Bioethanol, Snot apple, Engine, Exhaust Gas Analyzer.*

I. INTRODUCTION

Energy is crucial for the sustainability of modern societies and its uses are inevitable for human survival. Energy is an essential ingredient for socio economic development and hence, is a true indicator for economic growth. However, the world relies heavily on fossil fuels to meet its energy requirements of which in the near future it will be exhausted. The world total consumption of energy in 2018 from fossil fuel (oil, gas and coal) sources is 84.7%; whereas from all other sources (such as nuclear, hydropower, solar, wind, others) is 15.3% [1]. At this point, energy systems employed for power generation are no doubt overburdened and will be unable to survive with the future energy requirement. The huge quantity of energy being consumed across the world is having an adverse impact on the natural environment. However, fossil fuels as the main source of energy are taking their toll on the environment. It is recorded that those technologies for fossil fuel extraction, transportation, processing and their combustion have harmful impacts; and storage of petroleum fuel, spills and gas leakages causes water pollution [2].

It is undoubtedly that fossil fuels are currently the most economically available source of power for both commercial and personal uses. Though being thought to be inexhaustible, fossil fuels have been used extensively since the

Industrial revolution. However, many believed that the world's reliance on fossil fuels for transport is unsustainable. Some experts also believed that the world has already reached its peak for oil extraction and production, and it is only a matter of time before natural gas and coal follow suit. In addition, fossil fuels are the main reason for global warming, a process that practically all climate scientists said we have to deal with not soon, not tomorrow, but now.

Hence, one of the most promising alternative sources of energy is the bioethanol. Bio-energy represents the utilization of biomass as a source for the production of sustainable fuels and chemicals [3]. Ethanol has long been considered as a suitable alternative to fossil fuels either as a sole fuel in cars with dedicated engines or as an additive in fuel blends with no engine modification requirement when mixed up to 30%. Today, bioethanol is the most leading biofuel and its global production showed an upward trend over the last 25 years with a sharp increase from year 2000 [4].

The effects of using ethanol and gasoline blends on emissions characteristics in spark ignited engine have been investigated by other researchers. Research studies of exhaust emission levels from spark ignited engine are important from different perspectives. The combustion of fuel in an engine generates by-products that we all know as emissions. The four main engine emissions are carbon monoxide (CO), carbon dioxide(CO_2), hydrocarbons (HC), and oxides of nitrogen (NOx) (though others, such as particulates and formaldehyde, are also produced). Gasoline, as a compound hydrocarbon, is not a particularly clean-burning fuel. Ethanol, in comparison, burn nearly pollution-free. Ethanol already contains oxygen integral with the fuel, which can lead to a more homogenous combustion. Ethanol burns with a faster flame speed than gasoline, and they do not contain additional elements such as sulphur and phosphorus.

From existing literature, there are lots of other alternative fuels presently in use, these includes: methanol, methane, natural gas, propane, hydrogen, etc. Nevertheless, the remarkable fuel characteristics of ethanol distinguish it as a better candidate for automobiles. It has high latent heat of vaporization, high octane number and rating, and emission of toxic compounds on its combustion is low [5]. Thus, when ethanol and gasoline are respectively burned in correct stoichiometric ratios, they have about equal volumetric efficiency. When gasoline is burned, it produces water, carbon dioxide, carbon monoxide and other impurities such as; oxides of sulphur and nitrogen, and heavy metal. On the other hand, pure ethanol is burned to produce carbon dioxide, water and a much lower amount of carbon monoxide. Hence, ethanol will be a better replacement for gasoline [6].

The use of ethanol blended with gasoline was a subject of research in the 1980s, and it has shown that ethanol-gasoline blends were technically acceptable for existing gasoline engines. The relatively high cost of ethanol production at that time meant that the fuel could only be considered in case of fuel shortages. Consequently, there has been renewed interest in the ethanol-gasoline blends with a particular emphasis on emission reductions. An additional factor that makes ethanol attractive as a fuel extender or substitute is that it is a renewable resource [7].

II. MATERIALS AND METHODS

2.1 Material/Equipment

The material and equipment used for this work are as follows:

2.1.1 Snot apple (*Azanza garckeana*)

The Snot apple fruits were obtained from Tula in Kaltungo LGA of Gombe state. The material was collected and packaged before it was transported down to the chemistry laboratory at Abubakar Tatari Polytechnic (ATAP), Bauchi State where the ethanol extraction, production and characterization process were carried out.

Plate I: Snot Apple

2.1.2 Gas analyzer

Automobile Exhaust Emission Analyzers are usually deployed for purposes of research, auto repairs, inspection safety checks and general engine tuning. It is used by inserting the probe tip in to the exhaust pipe and the keys are pressed to measure exhaust gases. Readings appear on a back-lit liquid crystal display screen in front of the analyzer.
Concentration of emissions of carbon monoxide (CO), carbon dioxide (CO_2), unburnt hydrocarbons (HC), oxides of nitrogen (NO_X) were measured using SV-5Q Automobile Exhaust Gas Analyzer (China) which was obtained at the Automobile Laboratory of the Department of Mechanical Engineering, Federal Polytechnic, Bauchi-Nigeria. The Automobile Exhaust Gas Analyzer is shown in plate II.

Plate II: SV-5Q Automobile Exhaust Gas Analyzer

2.2 Method

2.2.1 Emission Analysis

The rate of gas emissions from the blended samples and petrol were analysed using gas analyser. AVL DiGas 4000 gas analyser was used to measure the concentration of gaseous emissions for oxides of nitrogen (NO_x), unburnt hydrocarbon (UHC), carbon monoxide (CO), carbon dioxide (CO_2) and oxygen (O_2) to evaluate and compute the behaviour of the petrol engine. The results obtained from performance analyses were tabulated and necessary graphs were plotted.

III. RESULTS AND DISCUSSION

3.1 Emission Analysis

The rate of gas emissions from the blended samples and petrol were analysed using gas analyser. AVL DiGas 4000 gas analyser was used to measure the concentration of gaseous emissions for oxides of nitrogen (NO_x), unburnt hydrocarbon (UHC), carbon monoxide (CO), carbon dioxide (CO_2) and oxygen (O_2). This is to evaluate emissions arising from different loading conditions. The results obtained from performance analyses were plotted in Figures 1-3

3.1.1 Carbon dioxide emission

Figure 1 shows the emission levels of carbon dioxide (CO_2) for various blends and petrol. Test measurements revealed that the CO_2 emissions for all blends were found to be lower compared to petrol for different loads under study. However, CO_2 emission increased with increase in load for all blends. The rising trend of CO_2 emission with load is due to the higher fuel entering as the load increases. This is attributed to the fact that the bio-ethanol is a low carbon fuel and has a lower elemental carbon to hydrogen ratio than petrol fuel [8]. According to [9], the effect of biofuel on global greenhouse gas emissions through the life cycle of CO_2 emissions is such that biofuel will contribute to 50–80% reduction in CO_2 emissions compared to petroleum diesel. This result complements the experimental outcome of studies conducted on biofuel and bioethanol fuel samples respectively.

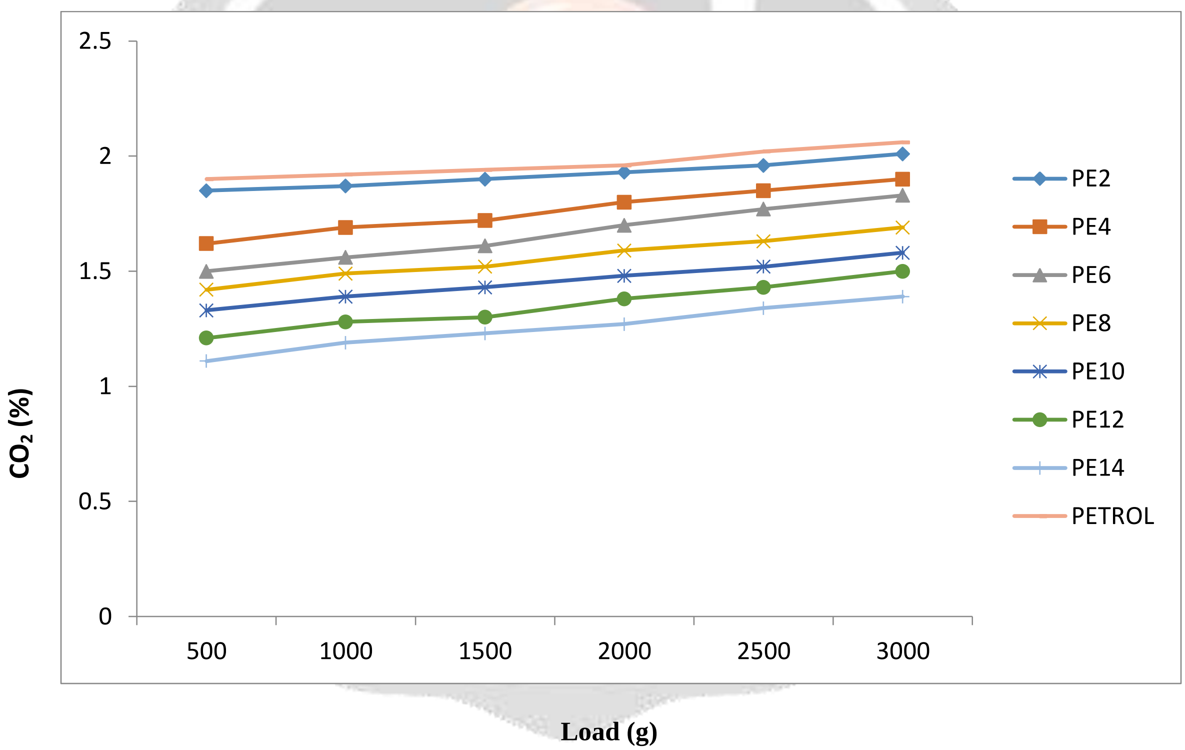

Figure 1: Emission of Carbon Dioxide for all Samples with Increase in Load

3.1.2 Carbon monoxide emission

Carbon monoxide (CO) is an intermediate combustion product and is formed mainly due to incomplete combustion of fuel. If combustion is complete, CO is inverted CO_2. However, if the combustion is incomplete due to shortage of air or low petrol temperature, CO will be formed. The variation of CO emission with load is shown in figure 11. It was observed that the engine emits more CO for petrol under all load conditions when compared to other blends studied. However, as the proportion of ethanol in the blends increases, the percentage emission of CO levels decreases due to high oxygen content and lower carbon to hydrogen ratio in bio-ethanol compared to petrol [5].

The percentage variation of carbon monoxide for all the blends when compared with petrol is very much less. These lower CO emissions of bio-ethanol blends may be due to their higher tendency for complete oxidation than petrol due to combustion. Initially, at low load condition, cylinder temperature might be too low, which increases with engine loading due to the fact that is injected into the cylinders. From figure 2, as engine load increases the overall CO_2 emission decreased, this points to improved combustion behaviour of the fuel samples. However, the trend drops further with the bioethanol blend due to the improved oxygenation of the fuel samples occasioned by the presence of hydroxyl molecules from the bioethanol. The reduction of CO emission is apparently caused by the wide flammability and oxygenated characteristic of ethanol [10].

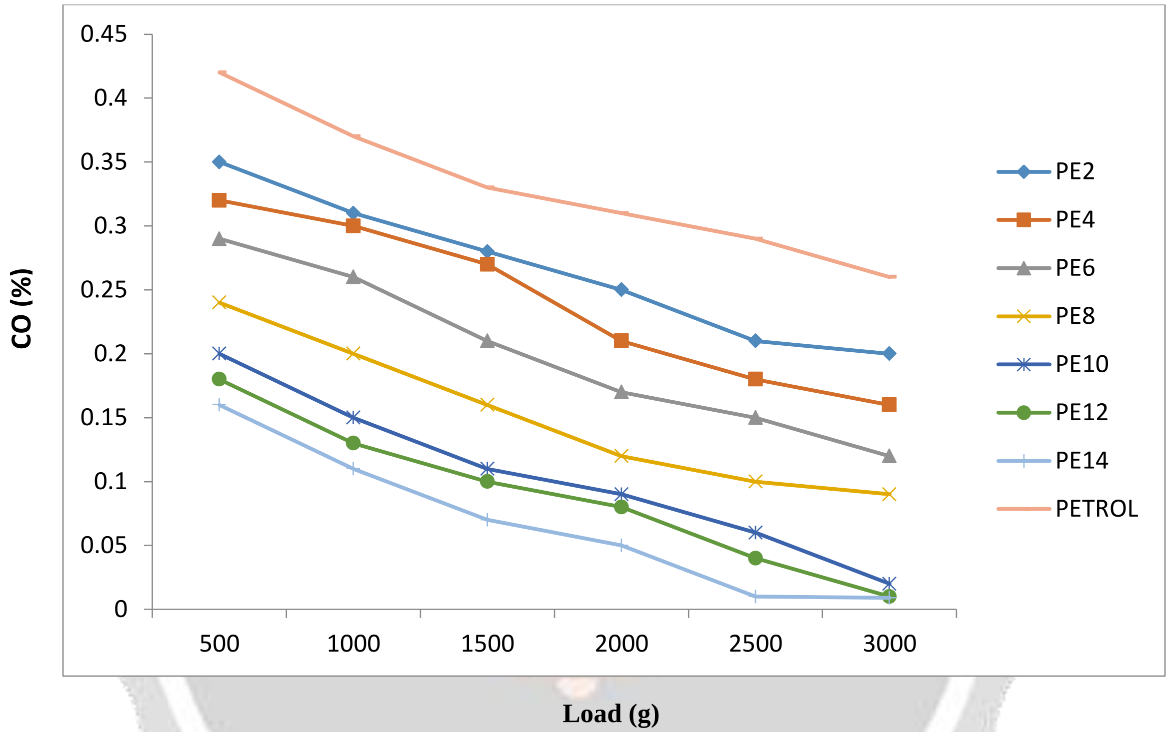

Figure 2: Emission of Carbon Monoxide for all Samples with Increase in Load

3.1.3 Hydrocarbon emission

Hydrocarbon (HC) in exhaust is as a result of incomplete burning of the carbon compounds in the fuel. The HC emission variation for different blends is indicated in figure 12. All blends have lower values than petrol owing to higher combustion chamber temperature, which helps in cracking and faster burning [10]. It was observed that the HC emission decreased with increase in engine load (i.e. 500 g-and 30000 g) for all the samples. The HC emission for the blends also followed a similar trend but comparatively the values were lower than the level for petrol emission. The presence of oxygen in the ethanol blends aids the combustion of the fuel samples and thus reduces the hydrocarbon emission considerably. However, at higher loads the effects of viscosity have increased this emission levels for the blends. As the octane number of ester-based fuel is increased higher than petrol, it tends to exhibits a shorter delay period and result in better combustion, leading to low HC emission [10].

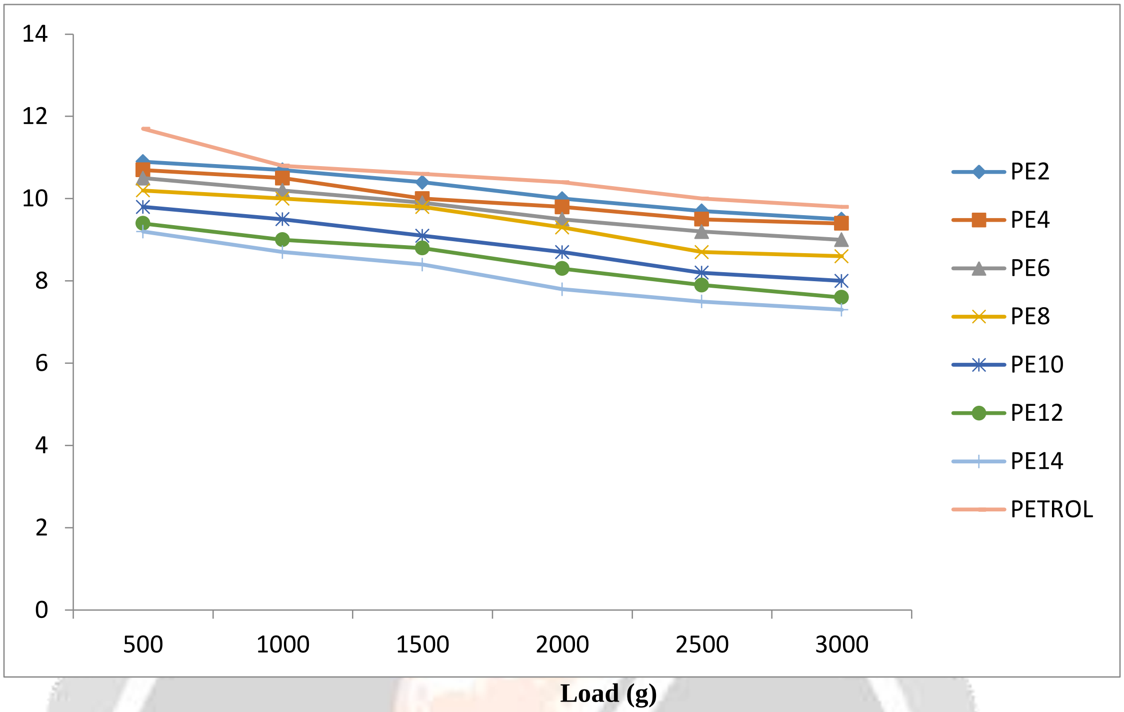

Figure 12: Emission of Hydrocarbon for all Samples with Increase in Load

.IV CONCLUSION

An impressive reduction in CO and HC emissions were recorded for all tested blended fuel samples with the least observed for PE14 fuel samples of 97.5% and 23.2% respectively more than petrol. There was an improvement for CO_2 tested blended fuel samples up to 1.32% more than petrol.. This shows that the candidacy of bio-ethanol derived from snot apple as fuel for spark ignition engines gives credence, and can also contribute to reduction in environmental pollution resulting from engine exhaust emissions run on conventional fuel (petrol)

REFERENCES

[1] Swapan, G. and Bablu, K. G. (2020). Fossil Fuel Consumption Trend and Global Warning Scenario: Energy Overview. *Global Journal of Engineering Sciences.* Vol. 5(2). ISSN: 2641-209

[2] Munear, T. and Asift, M. (2005). Energy supply, its demand and security issues for developed and emerging economies. *Renewable and Sustainable Energy Review*. **1**:26-27

[3] Fukuda, H., A. Kondo and S. Tamalampudi, (2009). Bioenergy: Sustainable fuels from biomass by yeast and fungal whole-cell biocatalysts. *Biochemistry Engineering Journal*. 44: 2-12.

[4] Talebnia, F., Karakashev D. and Angelidaki, I. (2010). Production of bioethanol from wheat straw: An overview on pretreatment, hydrolysis and fermentation. Bioresour. Technol., 101: 4744-4753.

[5] Grabys, J., Pikūnas, A., and Pukalskas, S. (2012). Influence of Composition of Gasoline - Ethanol Blend on Parameters of Internal Combustion Engines, *Journal of KONES, Internal Combustion Engines.* 10, pp 3-4

[6] Fikret Y. k. and Bedri Y. (2004). The use of ethanol–gasoline blend as a fuel in an SI engine, Renewable Energy 29

[7] Walker, J. (2006). Ethanol Production from biomass. *Journal on the World watch Institute and Center for American progress* 7, pp. 30

[8] Hubballi, P. A. and Babu, T, P. A. (2004). Effect of aqueous denatured spirit on engine performance and exhaust emissions. SAE paper 00028, pp45-46

[9] Carraretto, C., Macor, A., Mirandola, A., Stoppato, A. and Tonon, S. (2004). Biodiesel as Alternative Fuel, Experimental Analysis and energetic Evaluations. Energy potentials. 29, pp 2135-2211.

[10] Bata, R. M., Elord, A. C., and Rice, R. W. (2011). Emissions from IC engines fuelled with Alcohol-gasoline blends: a literature review, Transactions of the ASME 111, 4224-431.