Fuel Adulteration in Nigeria and its Consequencies.

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***Abstract*--- Adulteration of petrol and diesel fuel with kerosene is very common in Nigeria. It increases the tailpipe emissions of harmful pollutants from vehicles. These leads to this study, which tends to show the rate of emission of CO (carbon II oxide) and PM (Particulate matters) from engines when they are run on adulterated fuel. Also the effects of adulteration on the environment and on human health were discussed and possible solutions to combat adulteration of fuel highlighted.**

***Index term*--- Adulteration, Diesel, Kerosene, Petrol,**

I. INTODUCTION

In Nigeria, Adulteration of fuel is very rampant, this is because the products of comparable quantities have different price. The fuel dealers do this(adulteration) so as to make maximum profit from the product neglecting the damages it does to motor vehicles and other harmful effects to human life example when kerosene is adulterated with petrol it can be very dangerous because it can be highly inflammable [10].

Fuel adulteration has many effects especially on any vehicle that uses such fuel; there will be an increase in the tailpipe emission and subsequently leads to engine knock [1], [4].

According to NNPC, 2007 [7], Adulteration is defined as the introduction of foreign substance into fuel illegally or unauthorized with the result that the product does not conform to the requirements and specifications of the product.

In Nigeria the fuel that are majorly adulterated are Petrol, Kerosene, and Diesel.

II. TYPES OF FUEL ADULTERATION

Blending of lubricants into kerosene as a substitute for diesel.
Blending of kerosene into petrol.
Blending of kerosene into diesel.
Blending of used lubricants into diesel [8], [5], [11]

In Nigeria the common adulterant used for petrol and diesel is kerosene and sometimes kerosene is being adulterated with petrol, this is always done when petrol price is lower than that of kerosene.

Table I, II above shows some adulterants that can be used for petrol and diesel respectively.

TABLE I
SOME ADULTERANTS FOR PETROL (MS)

Solvent/Chemicals	Source
SBP	BPCL
Naphtha	Refineries
Hexane	Refineries
Resol	Reliance
Raffinate/slop	Refineries
Pentane	Gail
MTO	Refineries
Oxygenated	Refineries
Food grd. hexane	Refineries
Free kerosene	Marketers
Pds kerosene	Govt
C6-C9 raffination	Petrochemicals
Pyrolysis gasoline	Naphtha crack

TABLE II
SOME ADULTERANTS FOR DIESEL (HSD)

Solvent/Chemicals	Source
Aromex	Digboi
Lomex	NA
C9 raffinate	Petrochemicals
MTO	Refineries
Free kerosene	Marketers
PDS kerosene	Govt

In other to determine the effects of fuel adulteration, some experiments were conducted using the equipment listed below.

III. EQUIPMENT USED

1 Cylinder diesel engine (passenger tricycle)
1 Cylinder petrol engine (motorcycle)

IV. MIXTURE PREPARATION

Diesel, petrol and kerosene samples were bought from the filling station since it was not possible to test for their purity. The samples bought were prepared in different ratios by volume and stored in different containers.

Petrol and kerosene were mixed in: 100:00, 80:20, 70:30, 60:40 and 50:50 ratios. Likewise diesel and kerosene were prepared in: 100:00, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70 and 20:80.

Before running the engines with the adulterated fuel, a pure sample 100:0 was first used to run the engines so as to have something to compare with. The engines were run on no load condition and a uniform speed was attained, before applying loads of 25, 50, 75, and 100% of their different rated load.

The engine was run for 10mins. The experiments were repeated with the other sample mixtures.

V. RESULTS AND DISCUSSION

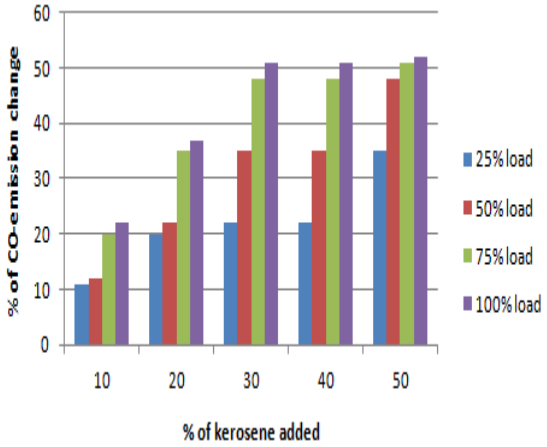

Fig. 1. Variation of CO-emission as a function of kerosene added to petrol.

TABLE III.
RESULT GENERATED WHEN THE PETROL ENGINE WAS RUN ON VARIOUS LOADS

% kerosene added	25% Load	50% Load	75% Load	100% Load	
10	11	12	20	22	% of CO emitted
20	20	22	35	37	
30	22	35	48	51	
40	22	35	48	51	
50	35	48	51	52	

For petrol and kerosene mixture (adulteration), the CO (carbon II oxide) emission increases as the content of kerosene is increases. Also the UHC emission increased significantly with high kerosene adulteration [9]. The inference from CO emission set of tests is that it is a good indicator for fuel adulteration testing in normal adulteration levels that we encounter with many vehicles and fuels.

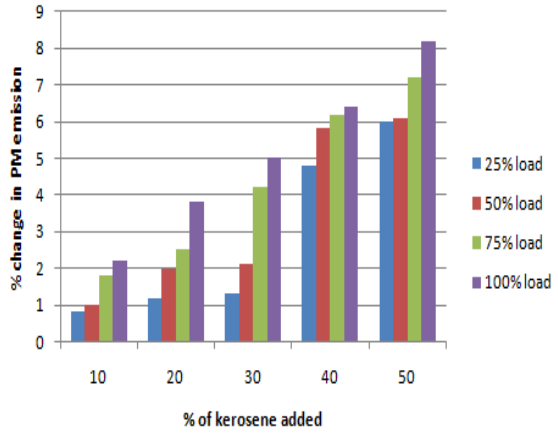

Fig. 2. Variation in PM emission as a function of kerosene added to diesel.

TABLE IV.
RESULT GENERATED WHEN THE DIESEL ENGINE WAS RUN ON VARIOUS LOADS

% kerosene added	25% Load	50% Load	75% Load	100% Load	
10	0.8	1.0	1.8	2.2	% of PM emitted
20	1.2	2.0	2.5	3.8	
30	1.3	2.1	4.2	5.0	
40	4.8	5.8	6.2	6.4	
50	6.0	6.1	7.2	8.2	

For diesel, the level of particulate matters (PM) gradually decreased with the increasing amount of kerosene in diesel. There is also an increasing trend of unburned hydrocarbon though insignificant in value with the increasing amount of kerosene in diesel. The level of CO was negligible and was not affected by the adulteration at all.

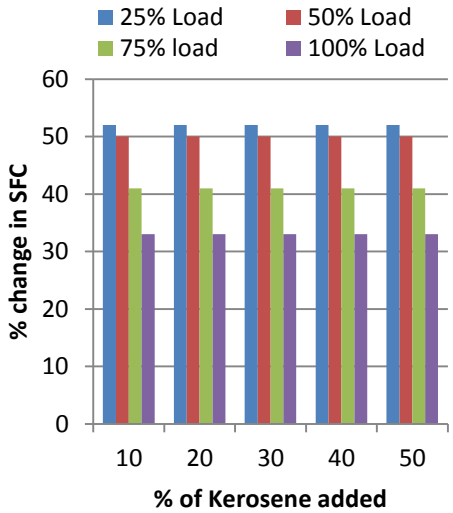

Fig. 3. Variation in SFC as a function of kerosene added to petrol.

TABLE V
RESULT SHOWING VARIATION IN SPECIFIC FUEL CONSUMPTION (SFC) AS FUNCTION OF DIFFERENT PROPORTIONS OF KEROSENE AT DIFFERENT LOAD CONDITIONS

% kerosene added	25% Load	50% Load	75% Load	100% Load	
10	11	12	20	22	% of CO emitted
20	20	22	35	37	
30	22	35	48	51	
40	22	35	48	51	
50	35	48	51	52	

Increase in SFC for all load conditions ranges from 34 - 36% compared to pure gasoline operation. Increase in fuel consumption rate is attributed to lower heating value of kerosene as compared to pure gasoline [14]. In other words, more fuel is needed in order to produce the same amount of energy. The consistent increase in the SFC with increase amount of kerosene in the fuel blends is due to more fuel supplied to the engine in order to maintain constant brake mean effective pressure [13].

VI. CONSEQUENCES OF ADULTERATED FUEL

Adulteration of transport fuel, which is currently a very flourishing business in our country, can lead to economic losses, increased emissions and deterioration of performance and parts of engines using the adulterated fuels. Some of the effects of adulteration are outlined below:

1 Mal-functioning of the engine, failure of components, safety problems etc. The problem gets further magnified for high performance modern engines [3].

2 Increased tailpipe emissions of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx), particulate matter (PM) and can also cause increased emissions of air toxin substances [2], [6].

3 Adulteration of fuel can cause health problems directly in the form of increased tailpipe emissions of harmful & sometimes carcinogenic pollutants [5]. While indirectly in the form of diversion of kerosene to the diesel sector for adulteration, thus prompting the use of biomass as domestic fuel which in turn leads to health problems of various types due to indoor air pollution. It may be noted that all forms of adulteration are not harmful to public health. Some adulterants increase emission of harmful pollutants significantly, whereas others have little or no effect on air quality.

4 Significant loss of tax revenue: - Various estimates have been made of the extent of financial loss to the national GDP (Gross Domestic Product), as well as the oil companies as a result of diversion of kerosene which is mixed with petrol and diesel.

VII. WAYS OF CONTROLLING FUEL ADULTERATION

1. An important step in tackling fuel adulteration is reducing incentives and opportunities for adulteration. Though it is generally recognized that eliminating pricing differential is the most effective method of controlling adulteration, it will be difficult to eliminate differences among such a wide variety of fuels and solvents meant for different usages [2].

2. Checking adulteration requires a credible monitoring and surveillance system. To ensure that the engine can give the desired performance including low emissions, it is necessary to ensure the fuel quality at the consumer end, which can be achieved by appropriate surveillance programs.

3. Any anti-adulteration programme should be backed up by sound financial and legal framework. The fiscal framework should take into account-associated costs like monitoring & testing infrastructure. Policy for imposing severe penalty & exemplary punishment to the adulterators needs to be imbibed into legal framework to discourage adulteration.

4. The manner in which retail fuels are distributed has an important bearing on fuel adulteration. For example, having large numbers of small, independent transport trucks operators moving fuels from terminals to the point of sale creates an environment conducive to adulteration. One effective "market based" approach is the practice in many industrialized countries whereby oil companies market at retail and assume responsibility throughout the supply chain to guarantee fuel quality in order to protect their public image and market share [2].

5. One of the acceptable internationally accepted methods for detecting and thereby preventing adulteration of fuels is the use of markers. A number of chemical and biochemical markers are available in the international market. Some of them are dyes.

6. The Standard fuel test method being used today when properly executed should be able to give acceptable results. Precision and repeatability could be improved by setting up programmes for cross checking inter-laboratory variability.

7. Use of alternative fuels which are less prone to adulteration, can play a positive role in minimizing adulteration. Thus, promoting use of cleaner fuels like CNG (compressed natural gas), LPG (liquefied petroleum gas) etc can prove effective in dealing with adulteration.

8. Taking & maintaining samples for checking fuel quality is not easy. Finding proper sample containers and not being personally harassed at retail outlets while sampling are just two of the very real operational problems to be resolved.

VIII. CONCLUSION

Adulteration of petrol with kerosene has many effects on both the engine and the human health. HC is slightly increased when kerosene is added in petrol. Similarly, there is an increasing trend of CO emission with the increasing amount of kerosene in petrol [11], these has negative health effects. PM is decreased and HC is increased with the increasing quantity of kerosene in diesel respectively in diesel engine [11]. The experiment also showed that blending kerosene with petrol increased knocking tendency drastically. This is due to the accumulation of the heavier fractions in the cylinders of the engines [12].

To curb fuel adulteration, oil companies should carryout filter paper test, density checks, blue dyeing of kerosene. Oil companies and government agencies should carryout surprise and regular inspections of retail outlets with mobile laboratories. Heavy penalty on sale of adulterated fuels should be enforced in order to discourage fuel adulteration [13].

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