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Research Project for Partial Fulfillment of EMBA

Topic: "Assessment of Regular Gasoline Adulteration at Addis Ababa Fuel Stations".

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DECLARATION

This research project is my original work and has not been presented for a degree in any University.

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ASTM	American Standard Testing Method
ATF	Aviation turbine fuel
AQIRP	Auto/Oil Quality Improvement Research Program
CNG	Compressed natural gas
CO	Carbon monoxide
EIA	Energy Information Administration
EPSE	Ethiopian Petroleum Supplies Enterprise
ESA	Ethiopian Standard Authority
ESMAP	Energy Sector Management Assistance Program
HC	Hydrocarbon
HFO	Heavy fuel oil
IEA	International Energy Agency
IJEST	International Journal of Environmental Science & Technology
LDO	Light diesel oil
LFO	Light fuel oil
LPG	Liquefied petroleum gas
MS	Motor spirit /petrol
NCAER	National Council of Applied Economic Research
NOx	Oxides of nitrogen
SKO	Super kerosene oil
PM	Particulate matter
RON	Research Octane Number
VOC	Volatile organic compound

ABSTRACT

This research project is done for the primary purpose of assessing regular gasoline (commonly called Benzene in Ethiopia) adulteration and whether the regular gasoline sold at Addis Ababa fuel stations are within the standard set by the Ethiopian Standard Authority (ESA). The study considers taking a sample of gasoline from fuel stations at Addis Ababa and conducted two types laboratory testing methods; ASTM D86 (Distillation) and ASTM D1298 (Density determination). In addition a survey is conducted to assess consumer's awareness and government authority's effectiveness in controlling the fuel adulteration at Addis petrol stations. Both the laboratory testing and the survey suggested that there is regular gasoil adulteration at Addis Ababa fuel station.

1. CHAPTER ONE: INTRODUCTION

1.1 General Background

Fuels, especially petroleum products, are currently the most widely used source of energy in the world. The same international trend is true in Ethiopia as well. Currently, Regular gasoline, Gasoil, Kerosene, Heavy fuel oil (HFO), Light fuel oil (LFO) and JTA-1 are imported by Ethiopian Petroleum Supplies Enterprise (EPSE). The Heavy fuel oil (HFO) and Light fuel oil (LFO) is imported for industrial use and JTA-1 for aviation purpose. Gasoil and gasoline are used in the transportation, construction, industries, power generation, agriculture, house hold cooking and lighting in rural areas.

It is widely believed by the public and experts in the sector that a large quantity of Kerosene is used to adulterate other fuel products namely Regular Gasoline and Diesel (Gasoil**).** Fuel adulteration is a common problem not only for Ethiopia but for several developing countries. Kenya (Elizabeth, 2010), Nigeria (O. Obodeh et al., 2010), India (Al-Ghouti et al., 2008), Nepal (Chakra, 2009), Brazil (Larissa S. et al. 2005), Greece (Kalligeros S. et al. 2003) are some of the countries that can be mentioned with regard to adulteration of fuel practiced. In an article of Society for Chemistry in Jordan, it is clearly mentioned that "the adulteration of petroleum products especially gasoline is a serious Problem in many countries. The large difference in prices of gasoline, diesel and kerosene in Jordan are the main driving factors for adulteration" (Adnan A. et al., 2013).

These days, many Governments and International unions have expressed their concern on this issue and even mandating to promote the development of a uniform system for fuel quality monitoring. Fuel adulteration problem is the case in India as explained by, Shenoy (2010) referring to National Council of Applied Economic Research (NCAER, 2005) estimated that around 38 per cent of kerosene was associated with environmental pollution, problems with engine performance, and tax losses. Furthermore, adulteration using Kerosene also diverts its intended use; while mixed with regular gasoline diverted to the black market and did not reach the intended recipients. It is also mentioned on the study to the assessment of petrol and diesel adulteration in Kathmandu India that the probable amount of kerosene present as an adulterant in

diesel dispensed at filling stations in Kathmandu city ranged between 35% and 50%. (Sh. R. Yadav, 2005)

According unpublished import data obtained from EPSE in the year 2013, Ethiopia imports over six million liters of fuels per day. Given this level of fuel import size, analyzing the level of adulteration and shading light on what is at stake will be of significant interest. Hence it is timely and appropriate to conduct this research in the Ethiopian context in order to investigate the possible degree of fuel adulteration.

1.2 Statement of the Problem

In general expensive consumer products are often adulterated deliberately adding a component or integrating with cheaper low quality materials or products having similar physical and chemical properties. Adulteration in relation to fuel quality is defined as "the introduction of foreign substances into gasoline illegally or unauthorized with the result that the product does not conform to the requirements and specifications of the product (Amit P. 2013)". As indicated on the report of independent inspection of fuel quality in India also, the fuel adulteration belongs to similar hydrocarbon families as that of automotive fuels, though varying composition, some amount of mixing is possible without changing the overall parameters of the fuel specification. Unless tests are designed to track this variation as evidence for adulteration, a wide gamut of adulterations will never be caught.

Fuel consumption in Ethiopia is showing an increasing trend and the number of fuel stations is steadily growing from time to time. From the unpublished data of EPSE, by end of year 2013, there were over six hundred eighty two fuel stations across Ethiopia and many more are under construction (see Table 3). Despite the positive impact of providing fuel to the community and help sustain the country's economic development; these same stations pose a major threat to the economy, environment and society by being a selling point of adulterated or low quality fuel. Though not supported by studies, problem of adulteration of high priced gasoline with low-priced kerosene seems evident in Ethiopia. The Ethiopian Ministry of Water and Energy, established a regulatory body to control fuel adulteration practice. However , the consumers face challenges while making decision in identifying and buy good fuel quality or fuel is within the set standard or not. Kerosene being an important domestic fuel for the society it receives the

government's attention in terms of subsidies and enjoys lesser levies of tax. As compared to Kerosene, the current subsidies and the tax structure have created a gap in the pricing of fuel products in the country and resulted in higher prices for Regular Gasoline (benzene) relative to kerosene.

Therefore, this study will try to answer some of the issues and problems by assessing regular gasoline (commonly called Benzene in Ethiopia) adulteration and whether the regular gasoline sold at Addis Ababa fuel stations are within the standard set by the Ethiopian Standard Authority.

1.3 Research Questions

Ethiopia being in the trend of one of the fast growing economy in Africa and even in the world, fuel as energy is the basic requirement to keep up this development pace. However, it is suspected that some portion of imported and subsidized low priced fuel, namely Kerosene is used to adulterate expensive regular and gasoil there by leading to government tax loss, divert benefit of the lower class society subsidies, inappropriate profit for those practicing the adulteration, impacting environmental pollution and negative engine performance. The customer who buys fuel usually suspects of fuel adulteration or at least could not be confident of the regular gasoline standard sold at Addis Ababa fuel stations.

Therefore this study will answer the following main research questions:

1. Is the regular gasoline (benzene) being sold at Addis Ababa retail stations meet the standard set by Ethiopian Standard Authority (ESA)?
2. Is government regulatory body is effective in controlling regular gasoline adulteration at Addis Ababa fuel stations?
3. What is the general mechanical effect of regular gasoline adulteration to vehicles?
4. Which type of fuel laboratory test provides effective result in identifying regular gasoil adulteration? ASTM D1298 or ASTM D86?
5. What are the main causes and contributing factors for fuel adulteration?
6. Which type of fuel and with what product is more close and vulnerable for adulteration of regular gasoline at fuel stations?

1.4 Objective of the study

The main objective of the study is to assess adulterated regular gasoline detected at fuel stations in Addis Ababa by taking a representative sample of gasoline sold at the stations and comparing it with the standard set by the regulatory body namely Ethiopian Standard Agency (ESA). In addition, the study will conduct a survey to assess customers' awareness and expectation regarding adulteration and standard of regular gasoline at Addis Ababa fuel stations and how government authorities effectively implement and protect the consumer by controlling that the fuel sold at Addis petrol stations are within country's standard or requirement. In particular the study will:

1) Determine whether the Regular Gasoline sold at the fuel stations in Addis Ababa conforms to set down fuel standard requirements of Ethiopian Standard Authority and imported by the Ethiopian Petroleum Supply Enterprise (EPSE).
2) Assess the extent /magnitude of stations involved in regular gasoline adulteration practice from the samples taken from Addis Ababa fuels stations selling regular gasoline.
3) Assess customer's awareness on regular gasoline adulteration and assessment of regulatory body effectiveness in controlling the adulteration.
4) Challenges of customers in easily identifying regular gasoline quality sold at stations are within the country's standard.
5) Find out the major motivation in regular gasoline adulteration with kerosene practice?

1.5 Scope of the Study

This paper will focus on the adulteration of automotive fuel namely regular gasoline (usually called benzene in Ethiopia) at Addis Ababa fuel stations, by low priced kerosene. It will not deal with other types of fuels adulteration that exists in the Ethiopian retail outlets market and out of Addis Ababa. Moreover, the fact that fuels can be adulterated at several points throughout the supply chain, the fuel pump at the service station is the point at which the actual specifications of the fuels should be ascertained. Therefore, this paper presents results of a survey of regular

gasoline and samples obtained at a point of service stations where the public buys its fuel and it does not deal with other segment of supply chain.

Generally, the study is limited to one product, regular gasoline in Addis Ababa and at a point of service station. The scope is limited to the topic under discussion. The financial and time resource constraints also limited the extent of study but for the topic chosen, reasonable representative sample size is considered.

1.6 Limitations of the study.

This study is dealing with one of the few areas covered by others and naturally was not without challenge and limitations. Because fuel quality and standards and compliance are relatively complex matters, as far as possible, much care and attention was given to ensure the study was relatively adequately structured to accomplish its goal. Resources limitation, time, manpower, and funds were limited and this set the primary boundary of limitations.

Secondly, the study could not see all stations in the country and limited to Addis Ababa. It could not also accommodate all aspect of fuel adulteration checking mechanism or test methods of the international standard on fuels quality; only two types of the international test method applied.

1.7 Significance of the study

It is hoped that the outcome of this study will be of benefit to others who operate in the oil industry and wants to expand the study based on the investigation of this paper including the regulatory bodies and oil companies. This work is expected to provide a preliminary base for further studies in this specific area. The study could be an initial point and could be expanded to, the whole country instead of Addis Ababa, comparisons of regions (urban and sub urban locations), adulteration with other products for example gasoil with kerosene, comparisons between international and local companies, adulteration impact on the global economy e.g. tax, maintenance etc, impact of adulteration on environment, safety and health of the society.

1.8 Organization of the paper

Chapter 1 of the paper introduces the background and discusses statement of the problem, the research questions, objectives, scope, limitations, significance of the study and organization of the paper will be laid out. In chapter 2 literature reviews to establish conceptual framework for the study will be presented and an empirical review of the fuel products and their nature and how adulteration of regular gasoline will be analyzed. In chapter 3 research methodologies and research approach that will be employed in the study and the population and sample design, sampling units, methods and tools of analysis will be discussed. Chapter 4 will deal with Presentation, analysis and interpretation of data. Summary, conclusion and recommendation will be presented in chapter 5 of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1. An overview of Petroleum products

Various literature studies reveal that petroleum is obtained from crude oil, a complex mixture containing many different hydrocarbons that vary in appearance and composition from one oil field to another (Schremp, 2005). The crude oil provides fuel to the economy by petroleum refinery operation. Petroleum refining is the process of separating the many compounds present in crude petroleum. As explained on petroleum refining process, (Freda Fung, 2011), refining adds value by converting crude oil (which in itself has little end-use value) into a range of refined products, including transportation fuels. The primary economic objective in refining is to maximize the value added in converting crude oil into finished products. The basic refinery operation includes; distillation (separation) process thermal cracking (changing size), catalytic process, treatment, formulation (changing shape) and blending. Petroleum products include: Liquefied petroleum gas (LPG) and compressed natural gas (CNG), motor spirit /petrol (MS) of all grades and naphtha, aviation spirit, solvents of all types, aviation turbine fuel (ATF), super kerosene oil (SKO), light diesel oil (LDO), high speed diesel (HSD), Furnas oil (FO) of all grades, lubricating oils and greases including base oil, wax of all grades, bitumen, (Chakra, 2009).

The study main concept is adulteration of regular gasoline at Addis Ababa fuel stations and it is worthy of discussing the general overview of few of the petroleum products. Mixing of adulterants into the fuels exists in various forms; both the type and quantity of adulterants vary from place to place. Moreover, profitability, availability and blend ability are the prominent factors governing the choice of adulterants (Dutta, 2003).

What is regular gasoline? Regular gasoline is a refined product of petroleum consisting of mixture of hydrocarbons, additives, and blending agents. The composition of gasoline varies widely, depending on the crude oils used, the refinery process available, the overall balance of product demand, and the product specifications. Additives and blending agents are added to hydrocarbon mixture to improve the performance and stability of gasoline (Freda Fung, 2011). These compounds include anti-knock agents, anti-oxidants, metal deactivators, lead scavengers,

antirust agents, anti-icing agents, upper –cylinder lubricants, detergents, and dyes (Naveen G. et al. 2015).

Though not practical in Ethiopia, consumers in other countries have a choice of several kinds of gasoline at fuel stations. The majority of pumps usually offer a product called “regular,” other pumps are labeled “premium,” “super,” or something similar, and their product sells at different prices higher than the price of “regular.” The difference in name and price is based on the gasoline’s “octane.” As per Minnesota department of commerce on consumer guide on gasoline octane facts (Minnesota Department of Commerce, 2004), regular gasoline has an octane rating of at least 87 and in EU; Gasoline is required to have minimum octane rating of 85. In Ethiopia, the minimum octane no required by the specification is 81 (ESA, 2009).

The Minnesota department of commerce also noted explained about what octane is and defined octane is a measure of a fuel’s tendency to knock or ping when it is mixed with air and burned in the cylinder of an engine. The rating is called octane because the gasoline’s ability to prevent engine knock has been rated against the performance of pure hydrocarbon octane, which has a rating of 100.Gasoline, which is made from a blend of many other hydrocarbons, may have a higher or lower rating, depending on how its anti-knock performance compares to the performance of pure hydrocarbon octane.

What is Kerosene? Kerosene is a liquid fuel, similar in composition to other fuels, obtained from distillation of crude oil. In some places it is also known as ‘paraffin’. The main use of kerosene is a base for aviation fuel but it also has application as a solvent in paints, cleaners, pesticides, and some eye medicines. In many developing countries, it is a common fuel for stoves, heaters and lamps and developed countries as a fuel for home central heating systems (Chilcott, 2006).

As detailed in the regular gasoline adulteration in India (Dutta, S. 2003), Kerosene is more difficult to burn than gasoline, so that its addition results in higher levels of HC, CO and PM emissions even from catalyst-equipped cars i.e. cars equipped with conversion of engine-out pollutants. The higher sulfur level of kerosene can deactivate the catalyst and lower conversion of engine-out pollutants. If too much kerosene is added, octane quality will fall below the octane requirement of the engines and engine knocking can occur. Besides possibly damaging the engine mechanically, knock can increase PM, HC and NOx emissions. The latter two are,

amongst others, ozone precursors. With gasoline vehicles not equipped with catalysts, the exhaust smell from kerosene is often rather acrid, creating unpleasant conditions in crowded city streets.

2.2. Importance of Fuel Quality

Fuel Quality should pass rigorous inspection of its quality control process in any country. Fuel quality control greatly helps reduce any chance of producing or distributing fuel of inferior quality. Benchmarking of fuel standardization in East Asia working group (East Asia Working Group, 2010) indicated that the main objectives of the fuel quality control are:

- ✓ observance of legal and customized requirements of the fuel properties,
- ✓ provision of a consistently high fuel quality,
- ✓ avoidance of technical problems caused by fuel ,
- ✓ creation of all user's trust in fuel they consume and also
- ✓ To promote the commercial success and public acceptance.

2.3. Development of fuel standard & harmonization

A number of overseas studies have been undertaken on fuel specification and setting standards. The Auto/Oil Quality Improvement Research Program in the US showed a clear relationship between fuel specification and emission in petrol fuelled vehicles. More recent emission control standards have been coupled with mandated quality and compositional requirements for market petrol and diesel fuel (Review of Fuel Quality Requirement for Australian Transport, 2003). The specifications further refined periodically, initially were not a legal requirement except few states contains limitations in fuel grades and elements. In 1998, following the publishing of the US and EU reports, a group of international automotive manufacturers associations produced a set of recommendations for petrol and diesel fuel specifications, which they titled a "World-Wide Fuel Charter". The purpose of the Charter is to make a major contribution to the process of achieving a harmonization of worldwide automotive petrol and diesel fuel specification. Harmonized and sufficiently advanced specifications will contribute reduced air pollution. Further, such specifications will enable the necessary quality requirements of advanced engine and emission control technologies and other performance characteristics to be met.

2.4. International practice on control of fuel adulteration

Europe: An overview of fuel quality assurance programs in US and UK is managed by environmental protection agencies and includes comprehensive fuel compliance program that combines fuel registration, extensive fuels inspections, fuel quality testing and reporting system, as well as stiff noncompliance penalties (Freda F. 2011). The failure case lead to the penalties of filling stations owner and fuel supply company. For checking fuel adulteration, a unified system of transport fuel quality monitoring system is being developed for implementation in European Union.

India: Bureau of Indian Standards has constituted a task force to look into various aspects of fuel adulteration in India. The task force identified various possible fuel adulterants for gasoline and diesel. There is Anti Adulteration Cell with a function of prevention and other malpractices in the sale of petroleum products, to conduct inquiries into complaints against dealer selection boards and to act as a coordinating agency for oil companies and Central /State Government departments in the matters related to adulteration of fuel (Gupta, 2004).

Kenya: since June 1999, the Government of Kenya has been adding a Bio code marker to fuel as a trace, to designate fuel for local consumption (taxed) or for export (untaxed). The aim is to prevent fuel adulteration and preventing fuel traders from selling fuels designed for export on domestic market as way to avoid taxes. The system is said to have reduced adulteration and illicit trade, recovering US$ 30 million in taxes for government and US$ 50 million in sales for oil companies (Masani, 2009).

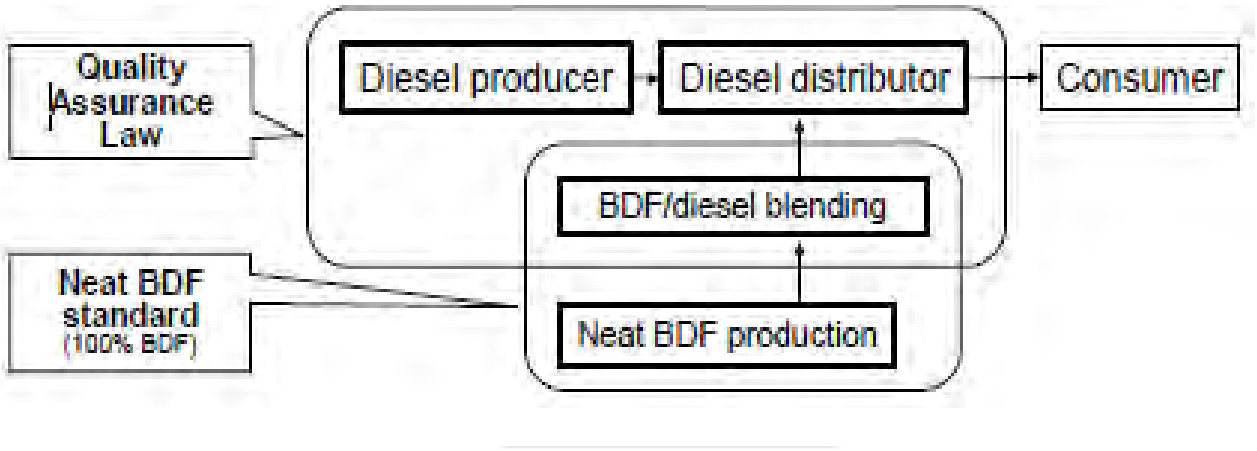
Japan: If we look the case of fuel quality process in Japan (East Asian, 2010), the Ministry of Economy Trade and Industry is responsible for fuel quality in the consumer market.

In accordance with the Japan fuel standards law, Ministry of trade is obligated to:

- ✓ Monitor registration of gas stations, where all gas stations are required to register with Ministry of trade & industry (METI).
- ✓ Petroleum based fuels are required to register with METI.
- ✓ Develop fuel quality standards (both mandatory and voluntary).
- ✓ Require gas stations to report quality sampling test of gasoline every ten days or annually if its supply chain is approved by METI.

- ✓ Monitor fuel quality at the pump, which can be outsourced to four registered testing organizations

Figure 1. The fuel quality control scheme in Japan



*BDF- Biodiesel Fuel, (From Importance of Control and Market Acceptance, Benchmarking of Biodiesel fuel Standardization in East Asia Working Group, July 2010.

2.5. What are fuel adulteration and the main reason for it?

As indicated previously, adulteration can be defined as the introduction of a foreign substance into gasoline or diesel, illegally or unauthorized with the result that the product does not conform to the requirements and specifications of the product. The foreign substances are called adulterants which when introduced alter and degrade the quality of the fuels (Kulathunga et al., 2004). Adulteration of fuel especially in this case adulteration of gasoline with kerosene makes the gasoline inferior the quality of gasoline and the performance is will be less than the expected standard. Mixing of adulterants into the fuels exists in various forms and both the type and quantity of adulterants vary from place to place. Moreover, profitability, availability and blend ability are the prominent factors governing the choice of adulterants (Dutta, 2003).

Products could be adulterated at various levels of supply chain; at distributors hand, transporters and stations dealers point before reaching to final customers.

In his review of fuel adulteration consequence in India (A.P. Gawande, 2013), explained that the types of fuel of adulteration as:

- ✓ Blending kerosene into petrol.
- ✓ Blending kerosene into diesel.
- ✓ Blending of lubricants into kerosene as a substitute for diesel.
- ✓ Blending of used lubricants into diesel.

In general, blending of variable amounts of gasoline boiling range hydrocarbons such as industrial solvents into automotive gasoline, blending small amounts of spent waste industrial solvents such as used lubricants into gasoline and diesel and blending small amounts of heavier fuel oils into diesel fuels are practiced.

In India "Fuel is consumed for a variety of purposes and relies heavily on import. This in turn gives rise to a host of concerns including, on pricing mechanism that on one hand influences technology adoption and resource allocation, while on the other hand impacts current account and fiscal balance. As a consequence, price of fuel and efforts to maintain its uninterrupted availability has engaged the attention of policy and decision makers." (Makes et al., 2012)

It is also explained in Energy Sector Management Assistance Program (ESMAP, 2005) technical Series, Senegal that evidence of ongoing malpractice in the downstream oil sector in Senegal exists, but it is difficult to quantify. It could be assumed that this malpractice takes place at a relatively small scale mainly at the secondary transportation (i.e. fuel trucks and other transport method) and retail level. This transpires mainly due to the lack of an inexpensive supply source.

"Automobile fuel adulteration is a clandestine and profit oriented operation. Adulteration of diesel by mixing kerosene is a common and widespread practice" (International Journal of Environmental Science & Technology, 2005).

However, in this paper we only see to cover adulteration of Kerosene in to regular gasoline detected at selected Addis Ababa fuel stations. Other types of adulterants like solvent, used oil and other products are not currently suspected in the country because it is not easily available to get it in the market and the volume of used oil in the hands of stations is insignificant for adulteration.

2.5.1. Regular gasoline adulteration

Gasoline may be adulterated with Kerosene, diesel fuels, industrial solvents, and gasoline with various boiling points (Masami and Robert, 2001). Addition of Kerosene in gasoline results in higher levels of HC, CO, and PM. Kerosene is more difficult to burn than gasoline, so that its addition results in higher levels of HC, CO and PM emissions even from catalyst-equipped cars. The higher sulfur level of kerosene can deactivate the catalyst and lower conversion of engine-out pollutants (Masami and Roberts, 2001). If too much kerosene is added, octane quality will fall below the octane requirement of the engines and engine knocking can occur. Besides possibly damaging the engine knock can increase in HCs and NOx emissions. The latter two are, amongst others, ozone precursors. With gasoline vehicles not equipped with catalysts, the exhaust smell from kerosene is often rather harsh, creating unpleasant conditions in crowded city streets.

High levels of adulteration could cause defect of parts of engine components in the fuel systems hence increase the maintenance cost of the vehicles. Its adverse effects on vehicle performance can calls for major engine repairs. (K.Gandhi, 2008). Adulteration also will cause increased emissions and may even cause vehicle breakdown by corroding fuel injection systems and carburetors, and by causing deposits on valves, fuel injectors, spark plugs, oxygen sensors and exhaust catalysts. Even low levels of adulterants can be very injurious and costly to the vehicle operator. The technical executive director for society of Indian automobiles manufacturers, K.K. Gandhi, 2008, addressed that for gasoline, any adulterant that changes its volatility can affect drivability. High volatility (resulting from the addition of light hydrocarbons) in hot weather can cause vapor lock and stalling. Low volatility in cold weather can cause starting problems and poor warm-up.

2.6. Major incentives for adulteration

It is well discussed on several cases in different countries that the primary cause of adulteration is the greed fueled by differential tax system. For example, in south Asia, gasoline is taxed most heavily, followed by diesel, kerosene, industrial solvents and recycled lubricants, in that order. The fact that adulteration of gasoline by diesel and that of diesel by kerosene, is difficult to

detect, combined with the differential tax structure makes such adulteration financially alluring, even though it is illegal. Mixing kerosene with diesel does not lead to an increase in tailpipe emission, but contributes to air pollution indirectly in South Asia, (Anil et al., 2010).

The main factors which generally promote the practice of adulteration are given below:

- ✓ Difference in prevailing cost of existing automobile fuels which may be due to difference in the basic price and / or difference in Government levies such as taxes, subsidy etc.
- ✓ Easy availability of adulterants in our case kerosene in the market
- ✓ Less awareness among consumers
- ✓ Uncontrolled regulations in the production, supply and marketing chain for intermediates and byproducts of refineries
- ✓ Non-popularity of easy and reliable methods for on spot checking of quality of the conventional automobile fuels.

2.7. Consequences of fuel adulteration

As noted on the Fuel Adulteration, Problem and Mitigation Strategies in India , (Naveen G. et. al. 2015), adulteration of conventional automobile fuels, which is a common practice in India , can lead to economic losses, increased emissions and worsening the performance and parts of engines. Some of the main effects of adulteration are as described below:

- ✓ Malfunctioning of the engine, failure of components like valve bend, reddish deposits in fuel line and carburetor, discoloration of various engine components like bearings, gears, cam shaft, crank shaft and cam chain etc.;
- ✓ Increased tailpipe emissions of HC, CO, NOx, and PM and can also cause increased emissions of other toxic substances. Adulteration of fuel can cause health problems directly because of increased tailpipe emissions of harmful and sometimes carcinogenic pollutants.
- ✓ Significant loss of tax revenue as various estimates have been made of that the extent of financial loss to the national exchequer as well as the oil companies as a result of diversion towards low value hydrocarbons mixed with petrol and diesel, evasion of sales tax etc.

2.8. Theoretical framework or tests for identification of fuel adulteration

The American Society for Testing and Materials International (ASTM International) has developed and documented the test methods for most of the widely used materials including petroleum products. Some of these tests involve determination of physical and chemical properties while others provide a measure of suitability of the fuel for use in automobiles from the point of engine performance and air pollution generated. As noted in fuel adulteration consequences in India (Amit.P. 2013), though there are several tests designed to measure the adulteration of petrol by mixing diesel or diesel by mixing kerosene, some tests namely Density test, Evaporation test, Distillation test, Chemical Marker test, Gas Chromatography may be used to determine the adulteration of fuel. For our purpose, selected test methods are briefly explained below.

2.8.1. ASTM D86- Determination of boiling point range characteristics of gasoline by distillation

One of the most important features of gasoline is the volatility that is measured by a distillation experiment. In this method the determination of volatility of petroleum products is done using a laboratory batch distillation unit to determine quantitatively the boiling range characteristics of products such as gasoline, light and middle distillates, aviation turbine fuels, low sulfur diesel fuels, special petroleum spirits, naphtha, white spirits and kerosene. Distillation is based on the composition, vapor pressure, expected initial boiling point, expected final end point, and combustion of the sample. Both automated and manual equipment may be used (ASTM D86, 2004).

2.8.2. Significance of distillation

The distillation characteristics of hydrocarbons have an important effect on their safety and performance. The various ranges of a distillation profile have been correlated with specific aspect of gasoline performance. Front-end volatility is adjusted to provide: (a) easy cold starting, (b) easy hot starting, (c) freedom from vapor lock, and (d) low evaporation and running-loss emissions. Mid-range volatility is adjusted to provide: (a) rapid warm-up and smooth running, (b) good short-trip fuel economy, (c) good power and acceleration, and (d) protection against

carburetor icing and hot stalling. Tail-end volatility is adjusted to provide: (a) good fuel economy after engine warm-up, (b) freedom from engine deposits, (c) minimal fuel dilution of crankcase oil, and (d) minimal volatile organic compound (VOC) exhaust emission.

2.8.3. ASTMD 1298 - Determination of density using the hydrometer method

This method covers the laboratory determination of density petroleum products normally handled as liquids using a glass hydrometer. The values are measured on a hydrometer at either the reference temperature or at another convenient temperature, and readings corrected to the reference temperature by means of the petroleum measurement tables (ASTM D1298. 2006).

2.8.4. Significance of density

Accurate determination of the density, of petroleum products is necessary for the conversion of measured volumes to volumes or masses at the standard reference temperatures during storage. This method can also be used for viscous liquids by allowing sufficient time for the hydrometer to reach equilibrium, and for opaque liquids by employing a suitable meniscus correction. Density is an important quality indicator for automotive, aviation and marine fuels, where it affects storage, handling and combustion (ASTM D1298. 2006).

2.9. Overview of Ethiopian petroleum products supply operation

The growth of industry is highly dependent on ensuring that petroleum products at the downstream sector of the industry are distributed consistently and timely to consumers through an effective and efficient supply chain system. Distribution of fuels through effective and efficient way includes the concept of quality or keeping the fuel standard of the country. In Ethiopia, the distribution monopoly was occupied for a long time by four international oil companies namely, MOBI, SHELL , AGIP and TOTAL. Currently, the fuel distribution is expanded to ten companies though still very young and small in numbers as compared other countries. However, the growth and expansion of the fuel distribution should also consider critically the consistent maintenance of the fuel quality or standard in the country's market. The customer's requirement of getting standard or quality fuel should be carefully monitored by the concerned responsible body or stakeholder. In the fuel retail markets, which lead to an increased

number of fuel stations, a stronger competition with ensuing great quality is highly important. However, fuel quality has not being guaranteed.

In Ethiopia, though no formal complaint log existed to capture and handle customers' complaints received at service stations regarding the fuel adulteration, it has raised concerns in recent times. There are complaints from drivers, vehicles owners, technicians and others about the damage of parts and poor engine performance. Fuel adulteration is one of the main problems for underdeveloped countries and Ethiopia is part of it.

In Ethiopia the unit price of various petroleum products vary significantly as a result of highly subsidized (low Tax) Kerosene. Kerosene is mainly used for cooking and lighting of the poor citizens as an alternative to electricity and gas. The adulteration impacts Government to incur loss of revenue as a result of selling subsidized Kerosene by mixing (adulterating) with regular gasoline. At it is indicated on doing business in Ethiopia 2012 , among main import commodities to the country, food, petroleum products, chemicals, machinery, motor vehicles and textiles, petroleum product is the major import commodities , and constitutes over 19% of import (see table). Tax loss as a result of adulteration process or malpractices could be so significant. Fuel quality or adulteration also has an impact the current hot topic of gas emissions and fuel quality for cleaner and more efficient transport. All these issues focus on the quality of fuel dispensed in the fuel stations; hence there is a need to assess adulterated fuel at fuel stations. Accordingly, this adulteration of petroleum products especially regular gasoline has become a serious problem. Table 1 shows fuel is the third major item from imported items.

2.10. Regulatory bodies

2.10.1. Ethiopian Standard Authority: Ethiopia is not an oil producing country and is completely reliant on import to meet its petroleum requirements. Ethiopian Standard Agency (ESA) is a governmental non-profitable organization and the sole National Standards Body (NSB) which represents Ethiopian interest in economic, social and environmental aspects with regard to standard benefits across International and regional arena. Besides working with international and Regional standard bodies, ESA also work closely with different national standard bodies under bilateral agreements.

Table 1. Ethiopian Merchandise import in million USD

Item	2010/11 Performance	2011/12 performance	performance (%) against 2010/11 achievement
Row Material	183.7	199.7	8.7
Semi-finished goods	1,228.0	1,957.2	59.4
Fuel	1,659.3	2,124.8	28.1
Capital Goods	2,757.0	2,961.7	7.4
Transport	688.1	809.7	17.7
Agriculture	63.6	119.5	87.9
Industry	2,005.4	2,032.5	1.4
Consumption Goods	2,294.8	3,531.7	53.9
Total Merchandise Import	8,253.3	11,061.2	34.0

Source: Federal Democratic Republic of Ethiopia, Annual progress report F.Y. 2011/2012 Growth and Transformation Plan.

Ethiopian Standard Body has undergone several structural and name changes since its first birth back in 1970, and ESA was established as per the latest restructuring of Ethiopian Council of Minister Regulation No. 193/2010, which caused the splitting of former Quality and Standards Authority of Ethiopia (QSAE) into four including the new national standards body (NSB) – Ethiopian Standards Agency (ESA), Ethiopian Conformity Assessment Enterprise, Ethiopian Metrology Institute and Ethiopian Accreditation bureau .

As per the proclamation, ESA is a governmental agency which is accountable to Ministry of Science and Technology, and has a National Standardization council which works together with the agency. The primary functions of ESA are:

- ✓ To lead and coordinate national standardization.
- ✓ To confirm and publish the national Ethiopian Standards;
- ✓ To promote the implementation of standards;
- ✓ To Promote Ethiopian Standard Mark and authorize its use;
- ✓ To represent Ethiopia in the International Standards Organization and work in collaboration with other foreign national standard bodies.
- ✓ To establishes National Enquiry Point and deliver services on Standardization, Conformity Assessment Guidelines and Technical Regulation

- ✓ To enable Ethiopian industries to benefit from technology transfer by providing Technical Support, Trainings and Consultancy Services and assisting them in implementation of standards.

2.10.2. Petroleum Downstream Operations Regulatory Directorate: proclamation No 838/2014 is issued Petroleum Downstream Operations proclamation to regulate petroleum and petroleum products supply operation. It is stated in the proclamation that ensuring the petroleum products supply operation carried out in the country comply with accepted international safety and quality standards to safeguard human health, property and the environment. It is also clearly indicated to ascertain, through follow up and supervision, the required competency, in accordance with the prevailing international practice, of facilities and experts engaged in refining, storing, transporting, distributing and retailing petroleum and petroleum products and related activities.

As indicated by the Director of Petroleum Downstream Operation Regulatory Directorate at the Ministry told Fortune "The main objective of the project is to control fraud in petroleum supply and minimize petroleum quality problems by increasing the accessibility of laboratories as well as improving the regulating capacity of the directorate."

2.10.3. Ethiopian fuel supply chain: it is known that the goal of any supply chain management is to provide maximum customer service and satisfaction at the lowest cost possible. In Ethiopia the supply chain of coordination activities range from selecting and procuring quality fuel from supply source to product distribution at retail outlets. It is advisable to examine the fuel supply chain of the country because of a number of reasons. Fuels that are produced by the refineries and imported to the country at port usually comply with legislation, but alterations in the fuel properties may occur during transportation and up to the point where the fuel is dispensed into the consumer car tanks. This paper present the results on the quality of gasoline at the fuel pumps of service stations in Addis Ababa , and assess adulteration encountered in these fuels for the years 2015 by taking sample stations and regular gasoline.
The key and distinguished activities in the downstream petroleum sector supply chain of Ethiopia can be classified to importation, storage, transportation, distribution and marketing.

2.10.4. Importation & Storage: all imports of products are made via Djibouti and Sudanese port by Ethiopian Petroleum Supplies Enterprise. Ethiopian Petroleum Supplies Enterprise (EPSE) is a government body and has the authority and responsibility of supply management of petroleum or fuel products; procure based on the standard and quality set by Ethiopian Standard Agency (ESA), control quality and temporarily store at depot in Djibouti and Sudan. Fuel is imported into Ethiopia for general use and all issues in relation to quantity and quality and price are dealt by EPSE. After the fuel is procured by EPSE, then it will be sold to Oil companies and the oil companies subsequently sold to consumer and to public via the network of branded fuel stations.

Ethiopian Petroleum Supply Enterprise

Table 2. ***Petroleum Products Sales***

From 2003 to 2013(1995 to 2005 EC)

	Petroleum Products Qty in M. Tons							
Year	Regular Gasoil	Gasoil	Jet	kero	LFO	HFO	Total in M.Tons	Daily Import
2003	132,014	681,110	78,216	183,610	45,896	89,222	1,210,068	3,315
2004	141,608	701,237	87,697	208,994	45,014	90,497	1,275,047	3,493
2005	139,611	745,669	113,896	212,550	46,499	108,055	1,366,280	3,743
2006	147,514	851,381	145,775	229,898	42,318	119,623	1,536,509	4,210
2007	146,614	927,753	176,778	242,847	45,600	117,615	1,657,207	4,540
2008	143,025	1,107,193	218,850	265,664	45,861	130,066	1,910,659	5,235
2009	149,967	1,199,673	214,004	272,304	37,510	117,029	1,990,486	5,453
2010	162,070	1,250,641	248,386	257,022	10,544	106,910	2,035,574	5,577
2011	151,634	1,154,560	320,443	239,032	34,823	96,320	1,996,812	5,471
2012	154,286	1,231,815	319,870	237,399	37,126	110,740	2,091,236	5,729
2013	169,059	1,351,280	352,967	232,942	40,548	143,319	2,290,115	6,274

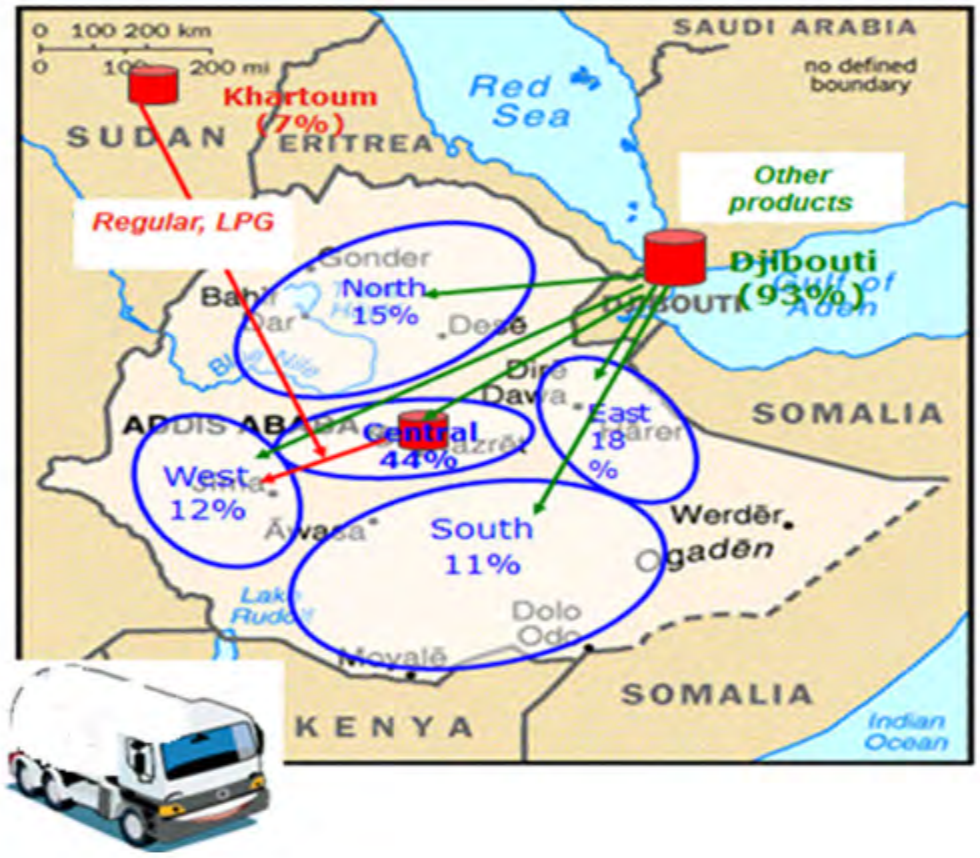
Source: Extracted by the Author from unpublished source

Limitation of entry points to the country and procuring through sole buyer EPSE, though had a negative effect on monopolizing the procurement, but limits the points of entry for such products and has great contribution on quality control at time purchase. Currently, Ethiopia has no refinery and buys refined fuel only and imports in two routes, namely Djibouti and Sudan. All products of fuel regular gasoline, gasoil, kerosene, jet A-1 (aviation fuel) and heavy and light fuel oils are imported from Djibouti, while only regular gasoline imported via Sudan.

2.10.5. Bulk Distribution & Transportation: major oil companies have been licensed as bulk distributors. In other countries these companies themselves import or procure crude or refined petroleum products, store, distribute and sell. But in Ethiopia the major oil marketing companies procure refined petroleum products from the sole supplier EPSE, transport it in bulk and retail nationwide. The players are Total Ethiopia S.C, National Oil Companies (NOC), Olilibya S.C, Yetebaberut Oil S.C (YBP), Nile Petroleum S.C., Kobil Oil, TAF oil, Dalol Oil and Allway Oil.

Figure 2. Ethiopian Fuel Supply View: 100 % Roads Based Supply

Source Compiled by the Author



Currently road transportation is the only means used to transport fuel from ports. Previously trains were used to transport fuels and government has a plan to resume transporting fuel by train again. Currently, in Ethiopia there are, there are over 2500 liquid cargo with different capacity (Chamber of Commerce, 2007) to transport fuel. Fuel is transported from Ex Djibouti and Ex-Sudan port to commercial and retail sites. The fuel price varies across the country based on the

transportation rate set by government and the fuel transporters are working with the Oil companies to supply the customers.

Even though the owners and managers of the transport companies operating this road tanker are not highly suspected and involved in any fuel malpractice, the drivers often have a very strong incentive to adulterate for various reasons, for instance, very low pay rate. Fuel adulteration or malpractice happens often in this process, but it is difficult or no study on the scale of malpractice at a time. Frequent cause of product thefts, compromised quality and lack of visibility in the operation led the transport activity chain observed (Chakra, 2009).

2.10.6. Marketing, Fuel stations and the Customers: Fuel stations in Ethiopia are owned either by the oil companies or individuals; stations can be owned by oil companies but operated by individual dealers or stations can be owned by individual dealers and operated by dealers themselves. However, in both cases fuel stations are working with a specific or branded oil companies to distribute its products. In 2013, there are about six hundred eighty two fuel stations in Ethiopia distributed throughout the country.

Table 3 Year 2013, Number of Stations in Ethiopia by Oil Companies

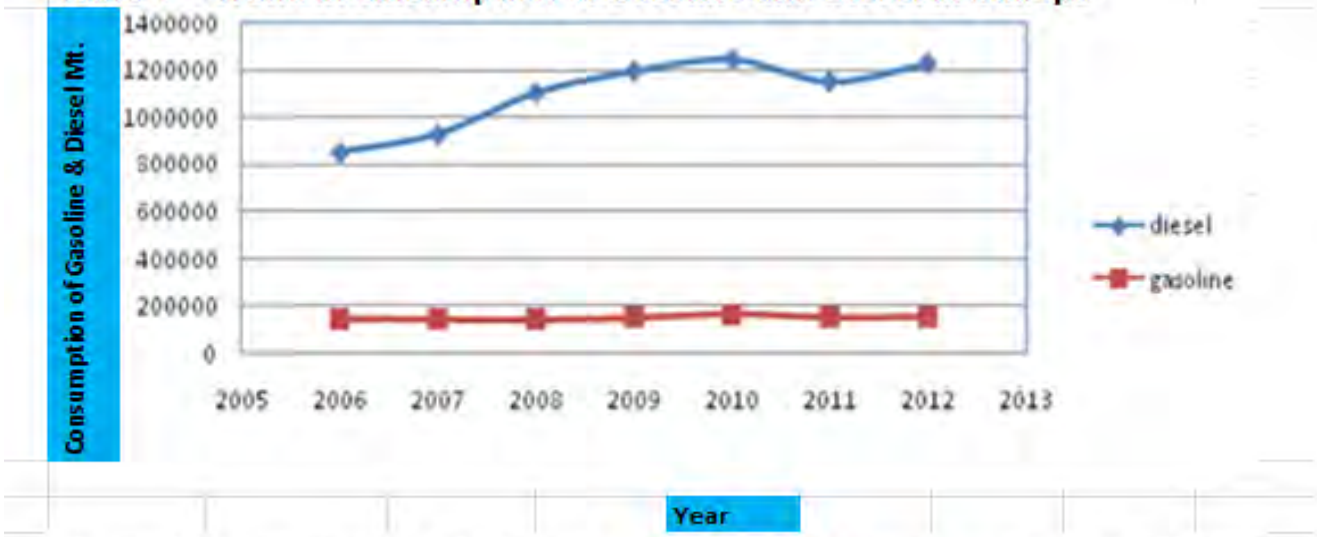
Oil Companies	Number of Stations
Total	173
OiLibya	158
NOC	140
YBP	104
Kobil	50
TAF	24
NILE	16
WAS	10
Dalol	7
TOTAL	682

Source : Compiled by Author

Like other activities in the supply chain, stations can have exceptionally made it vulnerable to a certain type of malpractice or fuel adulteration. However, this paper focused on detection at the final point of sale.

The customer knowledge about the product is very minimal as the fuel pumps or dispensers at the fuel stations are not equipped with any device that could allow the customer to actually see the product sold to him is adulterated or not . By adapting such devices to the dispensers and informing the public of the color difference, it is possible to limit the fraud on fuels quality at the gas station. Consideration of dyeing the product with a distinctive color makes it so easy for the customer to identify fuels adulteration by the color.

Table 4 Trend in Cinsumption of Gasoline and Diesel in Ethiopa



Adapted from presentation of draft report on pilot global fuel economy Initiative Study in Ethiopia by Demiss A. (Phd)

2.11. Ethiopian fuel quality and specifications

The Ethiopian Government expressed its concern in this aspect and through proclamation 838/2014 issued that the country will promote the development of a uniform system for fuel quality monitoring. Codes, standards or specifications for the fuel products have been laid down in different countries. National or other legally enforceable specifications represent the minimum quality that must be supplied and it is implicit that engine designers should ensure that their

vehicles will run satisfactorily on such quality of fuel. Below find the Ethiopian Fuel specification provided by ESA.

Table 5 Ethiopian Standard Authority : Gasoline for Motor Vehicle - Specification /Requirement

No.	Characteristics	Requirements		Test method
		Premium	Regular	
1	Octane rating Research octane number (RON), min.	95	91	ES 636:2001
	b) Motor octane number (MON), min.	85	81	ES 637:2001
2	Colour	Read	Orange/Yellow	Annex A
3	Density at 20 °C, g/ml	0.705 - 0.740		ES 641:2001
4	Distillation (At vapour pressure of 54 Kpa anda t 101.3kpa pressure (760 mm Hg) a) Temperature, °C for 10 % (by volume)evaporated, max. 50 % (by volume) evaporated 90 % (by volume) evaporated, max. b) Final boiling points, °C. Max. c) Residues, % (by volume), max.	 70 77-121 190 225 2.0		ES ISO 3405:2001
5	Reid vapour pressure (RVP), Kpa, max.	69		ES ISO 3007:2001 ES ISO 644:2001
6	Lead content, gpb/l,max.	0.013		ES 640:2001 ES 640:2001
7	Oxidation stability induction period, minutes, min	240		ES 634:2001
8	Existent gum contents,mg/100ml. Max.	4		ES 627:2001
9	Sulphur content, % (by mass),max.	0.10		ES 635:2001
10	Copper strip corrosion (3h at 50 °C), max.	1		ES ISO 2160:2001

Density Requirement

Distillation Requirement

2.12. Ethiopian fuel pricing policy

In his publication of petroleum product pricing and complementary policies and experience of sixty five developing countries explained that ‘’at the peak of high oil prices, nearly all developing countries studied intervened with price –based policies to mitigate the price increase on the world market for at least one fuel (Masami, 2009)”. The government intervenes in direct and indirect way in setting prices. Ministry of Trade examines and revises fuel prices usually every month and adjusts them, although not regularly. The ministry in its price structure was highly subsidizing the fuel price. As indicated on the However, Government stopped the policy of subsidizing petroleum fuels in 2008 and set domestic prices higher than import costs beginning in Oct 2008 to repay the debt accumulated in the Oil Stabilization Fund. The price of kerosene, which is untaxed and also cross-subsidized to some extent, is lower than other fuel prices. Prices are sometimes frozen for months at a time, for instance kerosene prices did not change between March and Oct 2011, and between October 2011 and Jul 2012; regular gasoline and diesel prices did not change between January and July 2012.

The large price differential is the main motive for mixing the cheaper with the more expensive fuel. Most gasoline adulteration cases could involve the illegal mixing of the cheaper kerosene into regular gasoline. The main impact is lost taxes and increased emissions, also lead to engine damage.

Table 6 Ex- Djibouti Fuel Price: January 2015

Fuel Type	*Price (Birr/Lit)*	*Price Variation*	*Variation Percentage of Price /Lit*
Regular gasoline	*17.96*		
Kerosene	*14.13*	*3.83*	*21%*
Diesel (automotive)	*16.10*	*1.97*	*12%*

Source Ministry of Trade Public notice

The huge price differential is the main reason and motivation as several studies in other countries indicated. Ethiopian fuel margin left to station dealers were only four cents per liter and it is in January 2015 improved to seven cents for average cost of birr seventeen. It is common sense that most stations especially up country could not survive with this margin after covering their operating costs unless adulteration contributes major portion of their earning; of course adulteration could not be the only means of major factor of the earning and further analysis needed specifically to assess the adulteration impact alone.

CHAPTER THREE: METHODOLOGY

3.1 Research methodology

The study most suited within the framework of a qualitative approach, in assessing and understanding of the fuel adulteration specially adulteration of regular gasoline at Addis Ababa fuel stations. It involves laboratory experiment to check that the fuel keeps the standard set by the country's regulatory body. It also involves data collection and analysis through questionnaires and interviews of officials to explore end users assessment of the regular gasoline adulteration and effectiveness of regulatory body control at Addis Ababa fuel stations.

3.2 Main information requirement

The main information needed to conduct the study in seeking response to the research question on fuel adulteration assessment at Addis Ababa, its impact and controlling practice of government of the adulteration are:

- Customers survey result to get information from drivers of regular gasoline vehicle.

- The oil companies officials interview regarding main motive for adulteration.

- The regular gasoline sample tested at the laboratory and compared to the country's standard to determine the adulteration to assess product is adulterated or not.

3.3 Research design

Following is list that summarizes the steps used to carry out this research:

- Questionnaires distributed to consumers in Addis Ababa designed to collect and analyze end users assessment, impact and government's efficiency in controlling of the regular gasoline adulteration at Addis Ababa fuels stations.
- Samples of regular gasoline from stations are tested in laboratory and the laboratory result of the samples is compared with the county's standard of regular gasoline set by ESA to assess adulteration.
- The major oil companies interview to identify the major reason for fuel adulteration.

- Furthermore, the laboratory result of fuel test is compared with the consumers or end users assessment of the fuel adulteration obtained from the survey result.

The research design is considered the reliability and relevance of data identification, assessing and interpretations of regular gasoline adulteration at Addis Ababa fuel stations. The data gathering, analysis and the report writing process considered research ethics and unethical action strictly not in use. This research approached by descriptive method, using questionnaire to examine and assessing the regular gasoline adulteration. The finding and conclusion of the study depends on the utilization of statistical data collected and based on qualitative and quantitative data analysis

3.4 Data source and collection tools

Data collection covered both primary and secondary sources. Primary data are collected through questionnaires, laboratory tests and observation while secondary data are gathered from relevant documents. Interviews with the three major oil companies Retail Network Managers and officials were done in two sessions taking reasonable time (over 30 minutes). The interview was guided by set of initiating questions and subsequent discussion on the points raised.

Moreover in order to improve and strengthen the study and findings, revision of articles, academic journals, and useful texts through different sources, such as library, emerald journals, academic books and relevant documents from resources is done. The source data was compiled using spreadsheet, and the data were processed for evaluation using SPSS. Various statistical tools and graphs used to analyze the data collected from several sources.

3.5 Population and sample design

The questionnaires are made up of five main sections, each focusing on a specific aspect of the study. Sections 1 details collecting profile data general information on the sampled units (experience, type of car, age of car, educational background, etc.). Section 2 focused on the main idea of this study, deals with assessment of adulteration and awareness of fuels standard by consumers. Section 3 is related with how end users or consumers get information about fuel quality which is used to enforce the recommendation and conclusion part. Section 4 also deals with one of the problem area of how end users assess efficiency of government body in

controlling the fuel adulteration. Finally, section 5 deals with knowledge of consumers on the impact or effect of fuels adulteration. The Final part of the questionnaires focus on remedial actions-related issues.

Questionnaire is developed for regular gasoline drivers (consumers) at Addis Ababa. Representative sample is determined based on random sampling method at 95% confidence level and 5% margin of error. As per this procedure, 383 samples are determined out for over 100,000 regular gasoline vehicle drivers in Addis. For fuel laboratory analysis, 12 regular gasoline samples is collected and tested from a total of 68 stations in Addis Ababa selling regular gasoline. The questionnaires are both close and open ended. The questionnaires have a 75 % response rate and using convenience method, the questionnaires are distributed in different kifle ketema (parts) of Addis Ababa to be filled.

For fuel laboratory test, the target population for this study was the regular gasoline selling stations and their clients in Addis Ababa. Currently the number of fuel stations selling regular gasoline in Addis is sixty eight. Analysis of the current status of these stations indicates, homogeneity of the supply source i.e. EPSE is the only source of supply. In addition three major oil companies holding 87 % of the regular gasoline market share and 97% of the number of stations. Therefore a non-probabilistic sampling was employed and twelve stations were selected representing 18% (12 out of the 68) of the population with parameters of interest, for analysis in this study. The sample considered proportionately i.e. 18 % of each of the three major oil company's station selling regular gasoline in Addis Ababa. Once the number of stations from each of the three companies is decided, the specific stations from which the sample is selected randomly.

With regards to deciding the sample size for this study, the following determinant factors were considered:

- ✓ Cost and time required to collect data from large sample size,
- ✓ Randomization considered because of the large size of the population mainly the individual fuel consumers.
- ✓ Exploratory nature of the study

In view of the above facts, combinations of Non-probability sampling techniques were employed to collect data.

- ✓ Convenience Sampling was used for those immediately accessible or available, to the researcher, to locate more parking, cafeteria, taxi stations etc
- ✓ Snowball or referral sampling method was then used by making use of the initially identified samples to nominate more participants to the study by utilizing their social networks, previous accountancies.

3.6 Questionnaires reliability and validity

In order to check the questionnaire's reliability of each respondent, SPSS Cronbach's alpha calculations were performed and the result is found out to be 70.9% and 73% for the questionnaires developed for consumers. Hence this result shows that the questionnaires were consistent enough to return the same results.

CHAPTER FOUR: DATA ANALYSIS, INTERPRETATION & FINDING

4.1 Methods of analysis

In this section a qualitative analysis of the data obtained from primary source (survey and experiment) and from secondary data, i.e. government issued standard and price regulations is be presented.

4.1.1. Survey result: survey conducted for assessment of consumers on fuel adulteration, its impact and monitoring practice of regulatory body at Addis Ababa fuel stations, and

4.1.2. Experimental: The purpose of this work was to see two types of laboratory test results for samples of regular gasoline collected from retail stations across Addis Ababa and compared to the country's set standard and assess the regular gasoline adulteration. This result also indicate which type of test is mostly used by regulatory body and how effective in detecting adulteration.

4.1.3. Government fuel price and fuel standard regulations & interview: from this data the fuel price set by Ethiopian Ministry of Trade is extracted and analyzed to show price variance between regular gasoline and kerosene. This variation in price is the main motive for fuel adulteration as a result of price variance and why kerosene is a prime candidate and close to adulteration with regular gasoline.

4.2 Analysis of survey

For this task a questionnaire is developed for end users (regular gasoline vehicle drivers). The sample size is determined based on a method at 95% confidence level and 5% significance interval. As per this method 383 samples is determined for regular gasoil vehicle drivers in Addis Ababa. The questionnaires are both close and open ended, and from the total distributed question 75% of them are responded and collected. The analysis is done with both quantitative and qualitative techniques through descriptive research methods.

For the open ended questionnaires, the results is summarized with the five points likert scale used and the result has been systematically given values as Strongly Agree =5, Agree=4 Neutral=3, Disagree=2 strongly Disagree=1.

4.2.1 Respondent general information

In general, as summarized in the table below, out of the total respondents of 287 questionnaires, 85.3 % are male and 13.9% are female. The total respondents with driving experience above 2 years are 81.9% and those with less than 2 years experience are 18.1%. Driving experience detail indicated 22.3 % between 2 to five years, 34 % between 5 to ten years and 25.5% above 10 years of experience.

The response for question related to the age of vehicles they drive, 43.8 % is over 10 years old, 24.9 % between 5 and 10 years and 31.3 % age of vehicle with less than 5 years old. Furthermore, 82.3 % of the respondents drive their own private car and the rest 17.7% drives business car.

Respondent Profile: in Percentage

	%	Total %
Gender		
Male	14.7	
Female	85.3	100
Age		
Younger than 25	10	
25-34	36.4	
35-44	34.3	
Above 45	19.3	100
Educational back ground		
High school & less	36.6	
College diploma	21.1	
First degree	38	
Second degree & above	4.3	100
Driving Experience		
Less than two years	18.2	
Between 2-5 years	22.3	
Between 5-10 years	34	
Over 10 years	25.5	
		100
Type of Vehicles		
Personal	82.3	
Company/Organization	17.7	100
Vehicles Age		
Less than 5 years	31.3	
Between 5-10 years	24.9	
Over 10 years	43.8	100

Source: Author survey 2015

4.2.2 Assessment of consumer's regular gasoline adulteration at Addis Ababa fuel stations and awareness of country's fuel standard.

a) Awareness of fuel standard of the country: regarding awareness of the existence of fuel standard in Ethiopia, the study revealed of the 281 respondents, 24.2 % are neutral. However, 7.5% strongly agree and 31.3 agree, while 19.6% disagree and 17.4 % strongly disagree of the existence of fuel standard in Ethiopia.

I am aware that there is fuel standard set by a regulatory agency in Ethiopia in general and I believe most people around me are also aware of the standard.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	49	17.1	17.4	17.4
	Disagree	55	19.2	19.6	37
	Neutral	68	23.7	24.2	61.2
	Agree	88	30.7	31.3	92.5
	Strongly Agree	21	7.3	7.5	100
	Total	281	97.9	100	
Missing	System	6	2.1		
Total		287	100		

From this study one can learn most consumers are not well aware of the existence of fuel standard in Ethiopia.

II) Consumers assessment of regular gasoline adulteration at A.A. fuel stations:

This is the area of the study main focus to analyze, the research question that "the regular gasoline sold at Addis Ababa fuel stations are within the standard and believe that it can be adulterated." The result shows, 9.7 % strongly disagree that the regular gasoline can be adulterated, 8.2% disagree that the regular gasoline can be adulterated, and 14.3% are neutral. But 41.6% agree that the regular gasoline can be adulterated and 26.2% strongly agree that the regular gasoline can be adulterated.

Q3_ I suspect the regular gasoline (benzene) sold at Addis Ababa fuel stations can be adulterated.

		Freq.	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	73	25.4	26.2	26.2
	Agree	116	40.4	41.6	67.8
	Neutral	40	13.9	14.3	82.1
	Disagree	23	8	8.2	90.3
	Strongly Disagree	27	9.4	9.7	100
	Total	279	97.2	100	
Missing	System	8	2.8		
Total		287	100		

Furthermore, in assessing how common the adulteration practice , 23.5 % of them strongly agreed and 37.5% of them agreed, cumulative of 61% responded that adulteration of the regular gasoline sold at Addis Ababa fuel station is a very common practice. 20.3% of the respondents are neutral, while 16.3% disagree and 2.4% strongly disagree on the common practice of fuel adulteration.

Q4_ If you agree to question 3 above and in your assessment of the extent to such unfair commercial practice, fuels adulteration is a very common practice by most fuel stations in Addis Ababa.

		Freq.	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	59	20.6	23.5	23.5
	Agree	94	32.8	37.5	61
	Neutral	51	17.8	20.3	81.3
	Disagree	41	14.3	16.3	97.6
	Strongly Disagree	6	2.1	2.4	100
	Total	251	87.5	100	
Missing	System	36	12.5		
Total		287	100		

The experimental test result of ASTM D86 also supported the survey result. The Final Boiling Point (FBP) is the key parameter in measuring the quality of petrol and it is determined from distillation process (Chakra, 2009). The result for FBP showed apparent discrepancy and variations in five samples out of twelve i.e. indicated that the regular gasoline is adulterated. In addition one station in Residue (R) property is out of standard.

4.2.3. Consumers assessment of the regulatory body in controlling regular gasoline adulteration at Addis Ababa fuel stations.

This part of the survey also supports the second research question.

a) Surprise checking of fuel quality by government body: Form the survey result, it is noted that 14 % strongly agreed and 34.4 % agreed, cumulative of 48.8%, responded that government body is doing surprise fuel quality checking at Addis Ababa fuel station while that 18.9% are neutral.

However, in assessing how regularly (at least every six months) this surprise checking is done, only 5 % of them strongly agreed and 11.7 % of them agreed, cumulative 16.7% responded that government body is doing it on regular basis at Addis Ababa fuel station. 13.1% strongly disagree and 38.3% disagree, with cumulative 51.4% replied that that government body is doing it on regular basis at Addis Ababa fuel station.

Q10_ Surprise fuel quality checking is done at Addis Ababa fuel stations on a regular basis (at least every six months)

		Freq.	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	11	3.8	5	5
	Agree	26	9.1	11.7	16.7
	Neutral	71	24.7	32	48.7
	Disagree	85	29.6	38.3	87
	Strongly Disagree	29	10.1	13.1	100.1
	Total	222	77.4	100	
Missing	System	65	22.6		
Total		287	100		

b) Level of consumer satisfaction in controlling fuel adulteration: It is also indicated that out of 275 respondents, 35.6 % of them strongly disagree and 38.2 % of them disagreed (in total 73.8%) that they are satisfied with the government control of regular gasoline adulteration at Addis Ababa fuel station.10.5% are neutral, 11% agree and 4.7% strongly agree that they are satisfied with the government control of regular gasoline adulteration at Addis Ababa fuel station.

Q12_ I am satisfied with the government control of benzene adulteration at Addis Ababa fuel stations

		Freq.	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	13	4.5	4.7	4.7
	Agree	30	10.5	11	15.7
	Neutral	29	10.1	10.5	26.2
	Disagree	105	36.6	38.2	64.4
	Strongly Disagree	98	34.1	35.6	100
	Total	275	95.8	100	
Missing	System	12	4.2		
Total		287	100		

From the survey result it is possible to say that though most agreed that the government body do surprise checking and agreed that doing this surprise-check help to control fuel adulteration, consumers are not satisfied with the level of control and do not believe that it is done on regular basis.

4.2.4. What is the general mechanical effect of fuel adulteration to vehicles?

This part of the questionnaire will focus on getting data to support the research question for what is the general mechanical effect of fuel adulteration to vehicles.

Effect of adulteration on vehicles performance: In the survey, 55.9 % strongly agreed and 35.2 % agreed, cumulative 91.1%, of the respondent knows that poor standard of fuel (quality) used in vehicles can negatively affect the performance of the engine and will cost maintenance. In addition, 46.6 % of them strongly agreed and 27.9 % of them agreed that poor standard fuel can negatively affect the safety, health and environment.

In assessing the level of end users experiencing or facing major problem, 26.6 % of them strongly agreed and 21.1 % of them agreed that they have faced major problem in their own vehicle and 36.5 % of them strongly agreed and 33.9 % of them agreed that they know other peoples have faced major problem in their vehicle emerging from benzene adulteration. Only 14.5% of them are neutral.

I know that poor standard of fuel (quality) that I use for my vehicle can negatively affect the performance and will cost me at the maintenance. But any ways I buy the fuel.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	4	1.4	1.4	1.4
	Disagree	16	5.6	5.7	7.1
	Neutral	5	1.7	1.8	8.9
	Agree	99	34.5	35.2	44.1
	Strongly Agree	157	54.7	55.9	100
	Total	281	97.9	100	
Missing	System	6	2.1		
Total		287	100		

Hence from the result it is indicated that though consumers know the negative impact of fuel adulteration and even faced major problem as a result of fuel adulteration, but they still buy because they do not have information about which stations could provide good quality product.

4.2.5. Other general implication form the survey

a) Getting information about fuel quality: The survey question related to how easy to get information about benzene quality in deciding to buy at specific station, 27.9 % strongly disagree and 36% disagree that it is easy to get easy information about fuel quality at specific service station. 16.6% are neutral and 16.3 % agreed that it is easy to get information about fuel quality.

But, 53.4% strongly agree and 34.4 agree, cumulative 78.8% that the wish to get information to differentiate stations selling good quality of fuel.

In deciding to fill up fuel, it is easy to get information about the benzene quality of a specific station.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	79	27.5	27.9	27.9
	Disagree	102	35.5	36	64
	Neutral	47	16.4	16.6	80.6
	Agree	46	16	16.3	96.8
	Strongly Agree	9	3.1	3.2	100
	Total	283	98.6	100	
Missing	System	4	1.4		
Total		287	100		

b) Preference of good quality fuel: the survey result shows that customers prefer fuel quality than price and location and even willing to pay more for better quality. In the request to rank their preference from most important to less important 56.38 % opt quality, 41.3 % price and then 2.4 % convenient location. With similar question to indicate their preference to pay more for good fuel quality, 34.8% strongly agreed and 30.8% agreed. 5.7% neutral and 15% disagree and 13.8% strongly disagree to pay more for better quality.

From the above response it is possible to generalize that though the end users prefer quality than price and other options. The consumers is even willing to pay more, however, it is not easy to get information about the fuel quality in deciding to fill his vehicles.

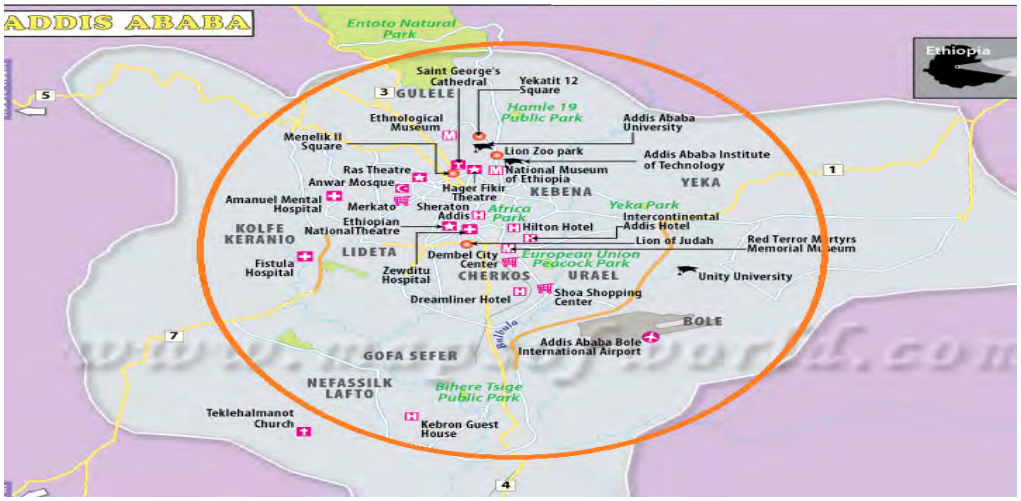
c) Who should provide information about the fuel quality: In the response, the frequency distribution shows that, 18.4 % proposes oil companies, 55.9 % public authorities, 5.7 % car dealers, mechanics and 13.9 % recommended media. This indicates that peoples tend to trust or think that it is government than anybody or institution to provide information about the fuel quality.

4.3 Analysis of Experiments: ASTM D1298 & ASTM D86 test analysis

Test of ASTM D1298 (Density determination) and ASTM D86 (test of Distillation or Boiling Points) done to see various properties in an approved laboratory of Ethiopian Petroleum Supplies Enterprise located at Addis Ababa. The test result information is extracted from the certified copies of the result submitted by ESPE laboratory (Annex II).

The target population for this experiment was the stations selling regular gasoline in Addis Ababa. Therefore a non-probabilistic sampling was employed and three oil companies representing 87% market share and 97 % of the number of stations in Addis selected. Again out of these three companies, 18% of their stations selling regular gasoline taken randomly of the population with parameters of interest, namely stations selling regular gasoline. Accordingly, eighteen percent (twelve) samples from sixty eight functional stations selling regular gasoline were taken across Addis. The sample station areas are located in various Kifle ketemas within Addis.

Figure 3 Kifle ketemas included in fuel stations sample



4.3.1. ASTM D1298 (Density determination): is a method used test density of the product using a hydrometer method. As per ESA the Ethiopian standard density of the country should be between 0.705 g/ml to 0.740g/ml @20 ℃ (ESA, 2008).

Result: The result for ASTM D1298 analysis shows that all the twelve samples except one (sample 12) are found to be acceptable i.e. eleven samples are within established tolerance range.

However, ASTM D1298 is the most widely used test method by Ethiopian regulatory body to check station's fuel quality and the same samples were tested by the other test method i.e. ASTM D86and the result showed six stations out of twelve were found adulterated. This reveals that ASTM D1298 (density determination) method is not effective in identifying level of adulteration. Hence, the regulatory body should use alternative test method, e.g. ASTM D86 as well (see fig below).

Table 7

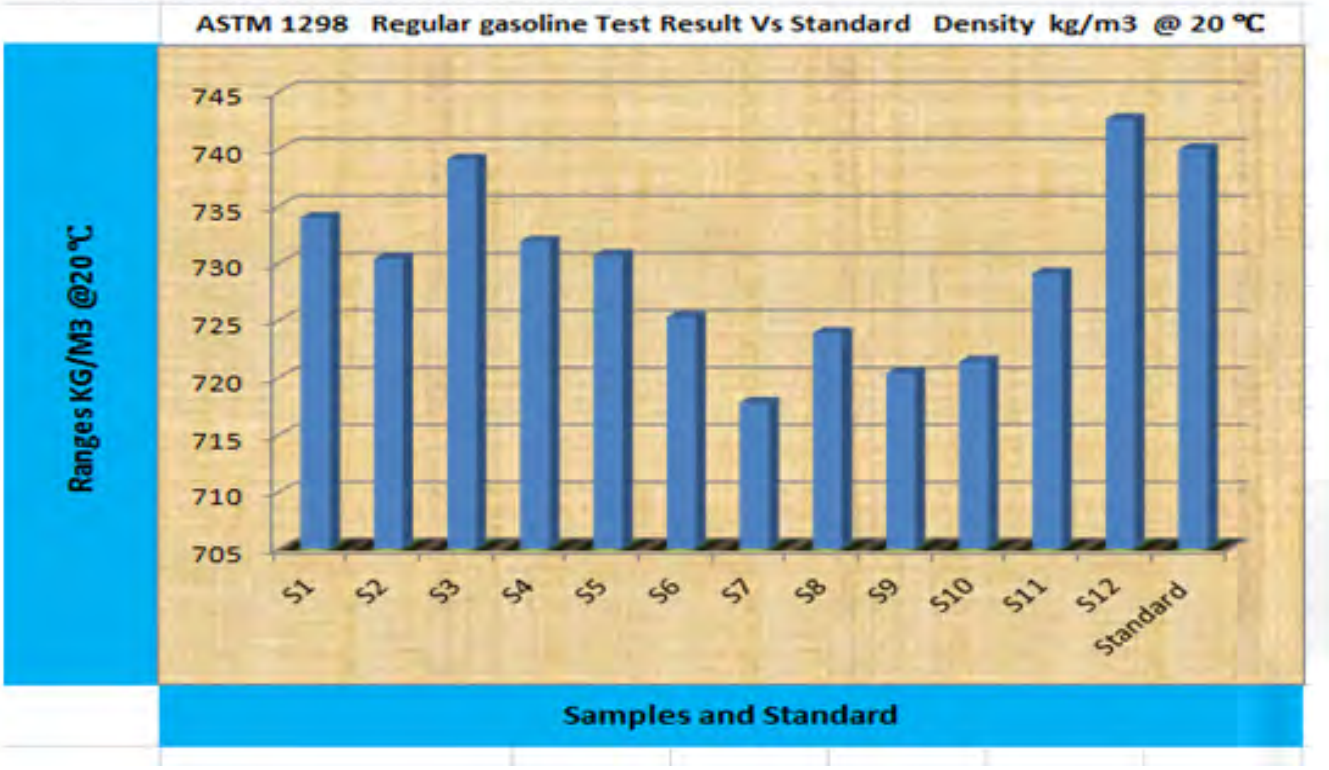
ASTM 1298 Regular gasoline Test Result Vs Standard (Density kg/m3 @ 20) ℃

S1	734	
S2	730.4	
S3	739.1	
S4	731.9	
S5	730.7	
S6	725.3	
S7	717.8	
S8	723.9	
S9	720.4	
S10	721.4	
S11	729.1	
S12	742.6	Variance from Standard
Standard	740	

ASTM 1298 Source = Experiment result from EPE

Standard ranges from 705 to 740 kg/m3 @20℃

Figure 4



4.3.2. ASTM D86 (Distillation): determination or an indication of the boiling ranges of fuel, and also a property of volatility of fuel. This parameter provides information, more pointedly to drivability issues particularly at cold-start, /warm –up or hot start and other issues such as vapor lock and variability engine performance when temperature varies.

Results: figure 5 shows the results of distillation temperatures of the regular gasoline standard and those of regular gasoline samples. The result of analysis indicate that in this parameter six stations are out of the range for the samples and the rest six within the range specified by ESA. As per the standard, maximum Final Boiling Point (FBP) 225 and Residue (R) are 2, but comparison of samples revealed there is a variation in five of the samples for FBP and two sample in R, indicating adulteration. The final boiling point (FBP) is the key parameter in measuring the quality of petrol and it is determined from distillation process (Chakra, 2009). The result showed apparent discrepancy and variations in six samples; five stations in relation to FBP test and one station at Residue (R) test. Sample 3 fails to meet at both point of FBP and at R parameter.

In general the quality characteristics of the regular gasoline were tested with twelve samples and the experimental results showed that only in 50% of the samples the quality of all fuel was within the limit by Ethiopian specification as shown in the table.

The one sample t test for 12 samples with degree of freedom of 11 at 95% confidence level gave a p-value of 0.88. This value was found to be greater than the α-value 0.05; hence this suggests that the values of ASTM D86 are not statistically different from the standard.

However, the mean for the twelve samples at FBP point is 226 with a standard deviation of 22.357 and Standard error of 6.4541.

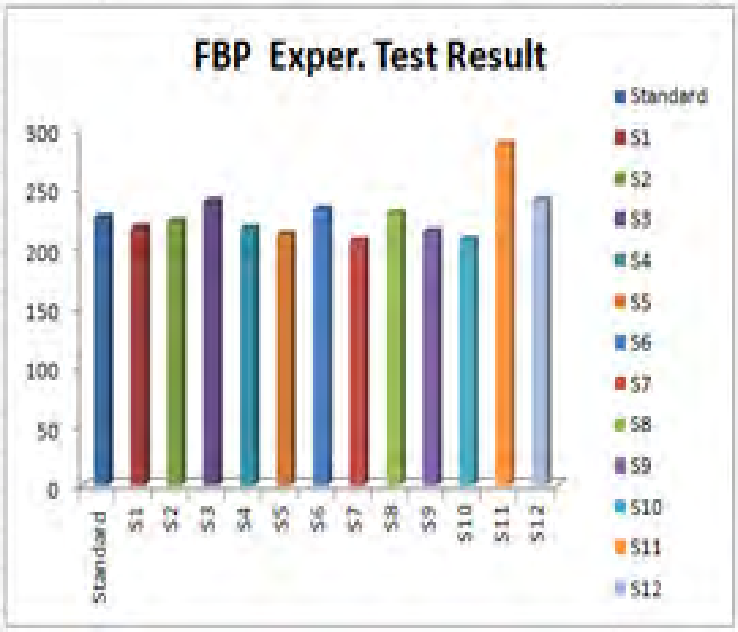
From the below table it can be observed that sample No 3, 6, 8, 11 and 12 had the highest FBP as compared to all the samples and the standard and sample No. 1& 3 had higher residue (R) at measured temperatures indicating that they had heavy adulterants which raised the boiling point at each volume collected.

Figure 5

% Regular gasoline Volume Vapor at FBP (Final Boiling Point)

Samples	FBP Exper. Test Result	Remark
Standard	225	
S1	216	
S2	221.5	
S3	238.5	Out of range
S4	215.5	
S5	211	
S6	231.5	Out of range
S7	205	
S8	228	Out of range
S9	213	
S10	206	
S11	286.5	Out of range
S12	239.5	Out of range

ASTM 86 Source = Experiment result from EPE



4.3.3. Which type of fuel laboratory test provides effective result in identifying regular gasoil adulteration? ASTM D 1298 or ASTM D 86?

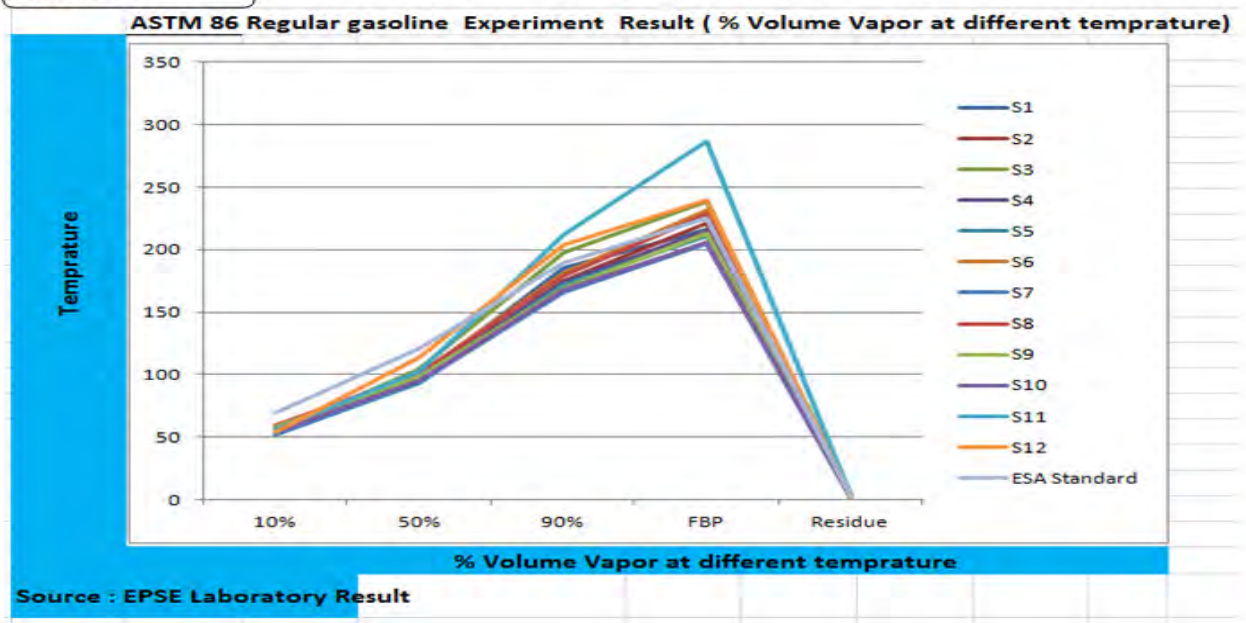
Table 8

Comparison of Density (ASTM 1298) and Distillation (ASTM 86)

Samples	Density Std. Max 740 kg/m3 @20°C	Distillation Std. Max Volume percentage at FBP is 225	Comparison Remark of two test
S1	734	216	As per ESA standard in both test
S2	730.4	221.5	As per ESA standard in both test
S3	739.1	238.5	As per ESA standard in Density test only
S4	731.9	215.5	As per ESA standard in both test
S5	730.7	211	As per ESA standard in both test
S6	725.3	231.5	As per ESA standard in Density test only
S7	717.8	205	As per ESA standard in both test
S8	723.9	228	As per ESA standard in Density test only
S9	720.4	213	As per ESA standard in both test
S10	721.4	206	As per ESA standard in both test
S11	729.1	286.5	As per ESA standard in Density test only
S12	742.6	239.5	Not as per ESA standard in both test

Source: EPSE experiment result

Figure 6



In comparing the two laboratory test methods (ASTM D86vs. ASTM D1298) in identifying regular gasoline adulteration with kerosene, it is possible to observe that the density (ASTM D1298) method is less capable of identifying the adulteration as compared to fractional distillation. "The system of measuring quality with density and FBP of the product is incapable of detecting adulteration within its given range. A considerable adulteration, so the uninterrupted business of money making is going scot-free" (Chakra, 2009).

4.4 Main causes and contributing factors for fuel adulteration & fuel type vulnerable for adulteration of regular gasoline at fuel stations in Ethiopia?

4.4.1 Analysis of interview with Oil companies managers and officials

Interviews with the three major oil companies Retail network managers and officials were done in two sessions taking reasonable time (over 30 minutes). The interview was guided by set of initiating questions and subsequent discussion on the points raised.

In identifying the main reason for adulteration of regular gasoline with kerosene, an interview was conducted with retail managers and officials of the three major oil companies in the country. The finding of the interviews indicated that the major reason for adulteration of regular gasoline with kerosene is the significant price variation existed between the two products. Generally, all agreed that the adulteration practice is common and they received repeated complaints from customers. Some companies expressed that that they regularly conducted fuel quality test at stations using ASTM D1298 (Density method), and found discrepancies between the standard.

The officials were asked to identify if there are any action to be taken to control the adulteration and, they have proposed that both the government and the oil companies should work closely to prevent fuel adulteration in the country. Minimizing the price variation and Fuel marking is among the mentioned actions recommended.

The interview with the officials also revealed that among the challenges faced by the Oil Companies in controlling the adulteration is the lack of strict subsequent legal ground and punishment as a result of the adulteration.

4.4.2 Analysis of fuel price buildup

Price Variation between regular gasoline and Kerosene is the main causes and motives of fuel adulteration and indicates fuel type more close to adulteration. In Ethiopia currently, there is birr 3.83 per liter or 21% variation between regular gasoline and Kerosene. This variation motivates station dealers and all involved in the supply chain to adulterate and involve in lucrative illegal business. Therefore as can be evidenced from the below table of price build-up (Table 9), the price of kerosene at port and before tax is less or cheaper than regular gasoline.

The price of regular Gasoline at port before tax/subsidy …… birr /lit 8.5993
The price of kerosene at port before tax /subsidy…… birr/lit 9.4030,
NB: Kerosene is expensive until the point of port than regular gasoline.

Therefore, the total tax imposed in regular gasoline is birr 8.3548/lit, while in kerosene it is 3.7286 /lit (stabilization fund only). The price variation between regular gasoline and kerosene is the main contributing factor for fuel adulteration and Kerosene being low in price due to low tax is close or prime candidate to adulteration with regular gasoline.

Any stations mixing a liter of kerosene with regular gasoline get illegal profit margin of birr 3.83/ lit because kerosene is sold at a price of regular gasoline birr 17.96/ lit not a regulated price of birr 14.13/lit.

The study in India and other studies also support the study findings, the primary cause of adulteration is the greed fuelled by differential tax system (World Bank reports July 2002, September 2001, December 2001, CSE India report March 2002). For example, in south Asia, gasoline is taxed most heavily, followed by diesel, kerosene, industrial solvents and recycled lubricants, in that order. The fact that adulteration of gasoline by diesel and that of diesel by kerosene, is difficult to detect, combined with the differential tax structure makes such adulteration financially alluring, even though it is illegal (Anil, 2010).

Table 9 Ex- Djibouti Fuel Price: January 2015

Fuel Type	*Price (Birr/Lit)*	*Price Variation*	*Variation Percentage of Price /Lit*
Regular gasoline	*17.96*		
Kerosene	*14.13*	*3.83*	*21%*

Table 10

Regular gasoline & kerosene price buildup effective January 31, 2015

		Price birr/ lit			
S/N	Description	Regular Gasoline	Kerosene	Variance in price	Variance %ge
1	Ex-Djibouti/Metema Price	8.5016	9.3230	(0.8214)	-10%
2	Dj.-Dewele/Galafi Transport			-	
3	Total Border Price (1+2)			-	
4	EPSE's Margin	0.0977	0.0800	0.0177	18%
5	**Product Cost (1+4)**	8.5993	9.4030	(0.8037)	-9%
6	Excise Tax [30% on (1+2)]	2.3975		2.3975	100%
7	VAT [15% on (1+2+6)]	1.5584		1.5584	100%
8	Road Fund	0.0950		0.0950	100%
9	Municipality Tax	0.0200		0.0200	100%
10	Stablization Fund	4.2839	3.7286	0.5553	13%
11	**Total Duty (6 to 10)**	8.3548	3.7286	4.6262	55%
12	**EPE Invoice Price (5+11)**	16.9541	13.1316	3.8225	23%
13	Distribution Margin	1.0059	0.9984	0.0075	1%
14	**A.A. Retail Price (12+13)**	17.96	14.13	3.8300	21%

Source from Min of Trade & Oil Compnaies adopted by author

4.5 The Research Findings

The research findings bases the analysis of primary data collected through questionnaire from the end users, laboratory test result and from the review secondary data of government petroleum products standard and fuel price regulations.

4.5.1 Findings from primary Survey Data analysis

Through analysis of survey questionnaire response the following major findings are identified:-

- An indication that respondents or consumers are not well aware of the existence of fuel standard in Ethiopia. Taking out the 24.2 % neutral response, 38.8% knows (sum of strongly agree and agree) while 37% do not know (strongly disagree and disagree summed) the existence of the fuel standard in the country.
- The finding of the interviews indicated that the major reason for adulteration of regular gasoline with kerosene is the significant price variation existed between the two products.
- Research question that the fuel sold at Addis Ababa fuel stations are within the standard is not supported by the survey result that and the respondents believe that it can be adulterated. The result shows, 26.2 strongly agree and 41.6% agree that the regular gasoline can be adulterated, while summed up it is 67.8%.
- Furthermore, in assessing how common the adulteration practice, 23.5 % of them strongly agreed and 37.5% of them agreed, (cumulative of 61%) responded that adulteration of the regular gasoline sold at Addis Ababa fuel station is a very common practice.
- The experimental test result of ASTM D86also supported the survey result. Six stations out of twelve samples indicate that it is adulterated.
- Most consumers agreed i.e. 48.8% that the government body does surprise checking and that doing the surprise check helps to control fuel adulteration, however, 73.8% of respondents are not satisfied with the level of control by regulatory body.
- From the result it is learnt that though consumers indicated that

- there is adulteration at Addis Ababa fuel stations

- they are aware of the negative impact of fuel adulteration & even faced major problem in their vehicle as a result of fuel adulteration.

- though the 64.4% of end users prefer quality than price and even is willing to pay more to get quality fuel, it is not easy to get information about the fuel quality at stations in deciding to fill his vehicles.

- Not satisfied by the regulatory body in controlling the adulteration. However, as it is not easy to get information about the quality of fuel at specific stations, they are forced to buy without being confident about the fuel quality; as there is no option to differentiate.
- The study indicated that respondents expect, trust or think that it is government than other institution to provide information about the fuel quality.

4.5.2 Findings from experimental test results data analysis

- ASTM D86test result (Distillation) showed apparent discrepancy and variations from the country's standard in six samples out of twelve.
- The result for ASTM D1298 (Density determination**)** analysis shows all samples test except one found to be acceptable i.e. within established tolerance range. However, ASTM D1298is the most widely used test method by Ethiopian regulatory body at stations. The same samples were tested by the other test method i.e. ASTM D86and the result showed five stations out of twelve were found adulterated, indicating that ASTM D1298(density determination) method is not effective in identifying level of adulteration.

4.5.3 Findings from interviews and secondary data analysis (Fuel price buildup)

- 21% price variation between regular gasoline and Kerosene motivates station dealers and all involved in the supply chain to adulterate and get illegal money making business.
- Kerosene being low in price due to low tax is very close to adulteration with high price regular gasoline.

5. CHAPTER FIVE: CONCLUSION & RECOMMENDATION

5.1 Conclusion

Hereunder, the conclusion reached will be presented in relation to the previously raised research questions.

i) Is adulterated regular gasoline (benzene) sold at Addis Ababa fuel stations? Does the regular gasoline (benzene) being sold at the retail stations in Addis Ababa meet the standard set by the Ethiopian Standard Authority (ESA)? The result of the study both survey and the experiment was indicative that the quality of fuel/regular gasoline on the market is questionable. The sample result revealed that the regular gasoline (benzene) sold at Addis Ababa retail stations does not meet the standard set by Ethiopian Standard Authority (ESA) and indicated that there is adulteration practice.

ii) Which type of fuel is more close and vulnerable for adulteration? What are the main causes and contributing factors for fuel adulteration? Are addressed by the study.

The big variation in the price of regular gasoline and kerosene caused by tax imposed by government is the main contributing factor for adulteration. The total tax imposed in regular is birr 8.3548/lit, while in kerosene it is only 3.7286 /li. The price variation between regular gasoline and kerosene is the main contributing factor for fuel adulteration and Kerosene being low in price due to low tax is close or prime candidate to adulteration with regular gasoline.

iii) What is consumer's awareness and expectation of regular gasoline adulteration at Addis Ababa fuel station? What is the general effect of fuel adulteration to the engine of the vehicle? As the study result shows the consumer is well aware of that there is regular gasoline adulteration at Addis Ababa fuel station, the impact of poor fuel quality in the performance of the vehicle and the society, however it is not easy to get information about fuel quality at time of deciding to fill their vehicle.

iv) Consumer's assessment of how the regulatory body is effective in controlling regular gasoline adulteration at Addis Ababa fuel stations? The result clearly indicated that end users are not satisfied with the regulatory body regular surprise check though believes that the checking process could help to minimize fuel adulteration practice.

v) In addition, the laboratory fuel test result shows, the main test method i.e. density determination (ASTM D1298) conducted by the regulatory body is less capable of identifying the adulteration as compared to fractional distillation (ASTM D86).

Generally, absence of consistent implementation of regulations in sustainable manner leaves an open door on the issue and because of the complex nature of fuel quality issues. Though major share of responsibility should lie on the government to monitor fuel adulteration a single body or oil companies simply cannot force into complying with fuel standards unless a comprehensive approach is taken to address such an issue, backed by legislation.

The public should request information from the oil companies in regards to their fuel quality and should also demand specific information in regards to issues which require mechanical intervention (professional bodies) on their vehicles.

5.2 Recommendation

From the result it is learnt that though experiment and survey indicated that there is practice of adulteration at Addis Ababa fuel stations and consumers are aware of the negative impact on the vehicle performance. It is also indicated that consumers are not satisfied by the regulatory body in controlling adulteration. Getting information about the quality of fuel at specific stations is difficult and consumers have no confidence in getting good fuel quality.

The results of this limited study on fuel indicate a clear need to significantly strengthen fuel quality monitoring. The steps involved in setting up an effective system are to examine the regulatory framework, including handling of noncompliance and requirement of cooperation among stakeholders. The current regulatory system of fuel quality system is very weak, largely resulting from the weak enforcement leading to unfair adulteration practice and lack of accountability in the petroleum industry.

I) In order to deter fuel adulteration and improve government controlling of this practice, the following action are recommended: 1) Upstream testing and downstream quality check. 2) Stiff noncompliance penalties; both financial and criminal. This includes fines and shut down of business for the retailers and oil companies. 3) Fuel marking: marker is used as a quick check on adulteration; it is added to lower value fuel and an invisible chemical marker that is detectable by a few drops of fuel into a test tube with the product sample (Chemik, 2011).4) Secure industry

cooperation (mandatory /voluntary self -testing and mandatory reporting). Make oil companies accountable for quality of fuel at the fuel station end. It is a reputational damage; "Name and shame program could potentially be a persuasive tool to induce companies to monitor the quality of fuel sold by their own suppliers and their competitors" (ICCT, 2010). 5) Develop alternative testing procedure for more accurate detection

II) Regarding availability of information about fuel quality at stations and improve consumer's confidence, the following actions could be taken: 1) Media coverage, Periodic Public rating of retail outlets based on independent inspection, testing and audit of the outlet. For instance in Kenya and Tanzania (annex). 2) Consumers front: forming anti-adulteration groups. Consumers are sufferers of this malpractice and any consumer conscious of quality has the right to be assured of the product quality and if the consumer demands, should be able for samples checked for adulteration. 3) Create awareness session via various media to public. 4) Awarding for quality, awarding those stations consistently maintaining fuel quality.

III) Generally, the following action can be also being considered (Gupta, 2004); in India the ministry of petroleum & natural gas took the following initiatives to control adulteration of fuel in the country. The ministry caused oil companies take various steps listed blow to detect /prevent adulteration of regular gasoline at retail outlets: filter paper test, density checks, dyeing/marking subsidized kerosene, regular /surprise inspection of retail outlets by the oil companies, and joint inspection of retail outlets by industry teams, regular /surprise inspection by mobile laboratories.

IV) In relation to price variation, in addition to fuel marking explained above: 1) revision of fuel prices to minimize or eliminate significant variation between price of kerosene and regular gasoline as a result of tax and subsidies. This may need detail study, but practiced by several developing countries (Annex price subsidy). 2) Develop controlling means that kerosene reached to the targeted poor. There is a possibility that kerosene is diverted to fuel adulteration Purpose and further study needed to investigate the location of where the kerosene is sold, consumed, and in general the where about of kerosene sales.

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ETHIOPIAN PETROLEUM SUPPLY ENTERPRISE

02 OCT 2015

Ref. No. 1581/6.1.3.4.4/015

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TEGEGN MEKURIA
AAU College of Business and Economics
Addis Ababa

With reference to letter dated February 20, 2015; please find the test results for the gasoline samples as follows.

TEST REPORT

SN.	Property	Test Method	Limits	Test results			
				YBas.	Y.L	O/L#3	N.K-15
1.	Density@15°C, g/ml	ASTM D1298	Report	0.7382	0.7345	0.7432	0.7360
2.	Density@20°C, g/ml	ASTM D1298	Report	0.7341	0.7304	0.7391	0.7319
3.	Distillation	ASTM D86					
	IBP, °C			40.5	38.5	37.5	39.5
	10% volume, recovered, °C		Max 70	57.0	53.0	54.0	58.0
	50% volume, recovered, °C		77-121	97.5	96.5	105.0	98.5
	90% volume, recovered, °C		Max 190	185.5	175.5	198.0	174.5
	FBP, °C		Max 225	216.0	221.0	238.5	215.5
	Residue, % vol		Max 2	3.0	0.9	2.4	1.2
				S1	S2		

- The results in this report relate only to the sample tested.

Remarks. - The 90% volume, recovered, °C FBP, °C and Residue, % vol distillation characters tics of sample **O/L#3** are off spec which is due to higher level of contamination/adulteration by kerosene.

Liability

Ethiopian Petroleum Supply Enterprise, its Laboratory, its Servants or agents Shall not be held liable for any damages, loss, claims or expenses direct or indirect howsoever caused, arising in connection with the laboratory test carried out on MGR samples submitted to it for analysis whether in tort or in contract, due to any act, omission or error of whatever nature, whether or not negligence and howsoever caused. Furthermore all expenses and implied warranties are specifically disclaimed.

Best regards,

Manaye Balcha
Head, Petroleum Quality
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ETHIOPIAN PETROLEUM SUPPLY ENTERPRISE

Ref. No. 1553/6-1-3-4-9/015

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02 OCT 2015

TEGEGN MEKURIA
AAU College of Business and Economics
Addis Ababa

With reference to letter dated February 20, 2015; please find the test results for the gasoline samples as follows.

TEST REPORT

SN.	Property	Test Method	Limits	Test results			
				T-HAR 70 A/1	C/S N	O/LJ.R 13	R/D/T
1.	Density@15°C, g/ml	ASTM D1298	Report	0.7348	0.7295	0.7220	0.7281
2.	Density@20°C, g/ml	ASTM D1298	Report	0.7307	0.7253	0.7178	0.7239
3.	Distillation	ASTM D86					
	IBP, °C			37.5	38.5	36.5	39.5
	10% volume, recovered, °C		Max 70	52.0	59.0	52.0	60.0
	50% volume, recovered, °C		77-121	93.5	100.0	94.5	100.5
	90% volume, recovered, °C		Max 190	172.5	181.5	166.0	179.5
	FBP, °C		Max 225	211.0	231.5	205.0	228.0
	Residue, % vol		Max 2	1.2	1.4	0.9	1.2

- The results in this report relate only to the sample tested.

Remarks: - The FBP, °C distillation characters tics of samples **C/S N** and R.D.T are off spec due to small level of contamination/adulteration by kerosene..

Liability

Ethiopian Petroleum Supply Enterprise, its Laboratory, its Servants or agents Shall not be held liable for any damages, loss, claims or expenses direct or indirect howsoever caused, arising in connection with the laboratory test carried out on MGR samples submitted to it for analysis whether in tort or in contract, due to any act, omission or error of whatever nature, whether or not negligence and howsoever caused. Furthermore all expenses and implied warranties are specifically disclaimed.

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ETHIOPIAN PETROLEUM SUPPLY ENTERPRISE

02 OCT 2015
Ref. No. 1531/61-3-44/015
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TEGEGN MEKURIA
AAU College of Business and Economics
Addis Ababa

With reference to letter dated February 20, 2015; please find the test results for the gasoline samples as follows.

TEST REPORT

SN.	Property	Test Method	Limits	Test results			
				T/Y TO	Lebu	N.E	O/L2
1.	Density@15°C, g/ml	ASTM D1298	Report	0.7246	0.7256	0.7333	0.7467
2.	Density@20°C, g/ml	ASTM D1298	Report	0.7204	0.7214	0.7291	0.7426
3.	Distillation	ASTM D86					
	IBP, °C			40.5	38.5	39.5	40.5
	10% volume, recovered, °C		Max 70	58.0	54.0	56.0	54.0
	50% volume, recovered, °C		77-121	98.5	95.5	102.0	113.5
	90% volume, recovered, °C		Max 190	169.0	168.0	212.0	203.5
	FBP, °C		Max 225	213.0	206.0	286.5	239.5
	Residue, % vol		Max 2	0.9	1.1	1.8	1.5

- The results in this report relate only to the sample tested.
- The 90% volume, recovered, °C and FBP, °C distillation characters tics of samples **N.E and O/L2** are off spec which is due to higher level of contamination/adulteration by diesel for **N.E** kerosene **O/L2** .

Liability

Ethiopian Petroleum Supply Enterprise, its Laboratory, its Servants or agents Shall not be held liable for any damages, loss, claims or expenses direct or indirect howsoever caused, arising in connection with the laboratory test carried out on MGR samples submitted to it for analysis whether in tort or in contract, due to any act, omission or error of whatever nature, whether or not negligence and howsoever caused. Furthermore all expenses and implied warranties are specifically disclaimed.

Best regards,

Manaye Baldira
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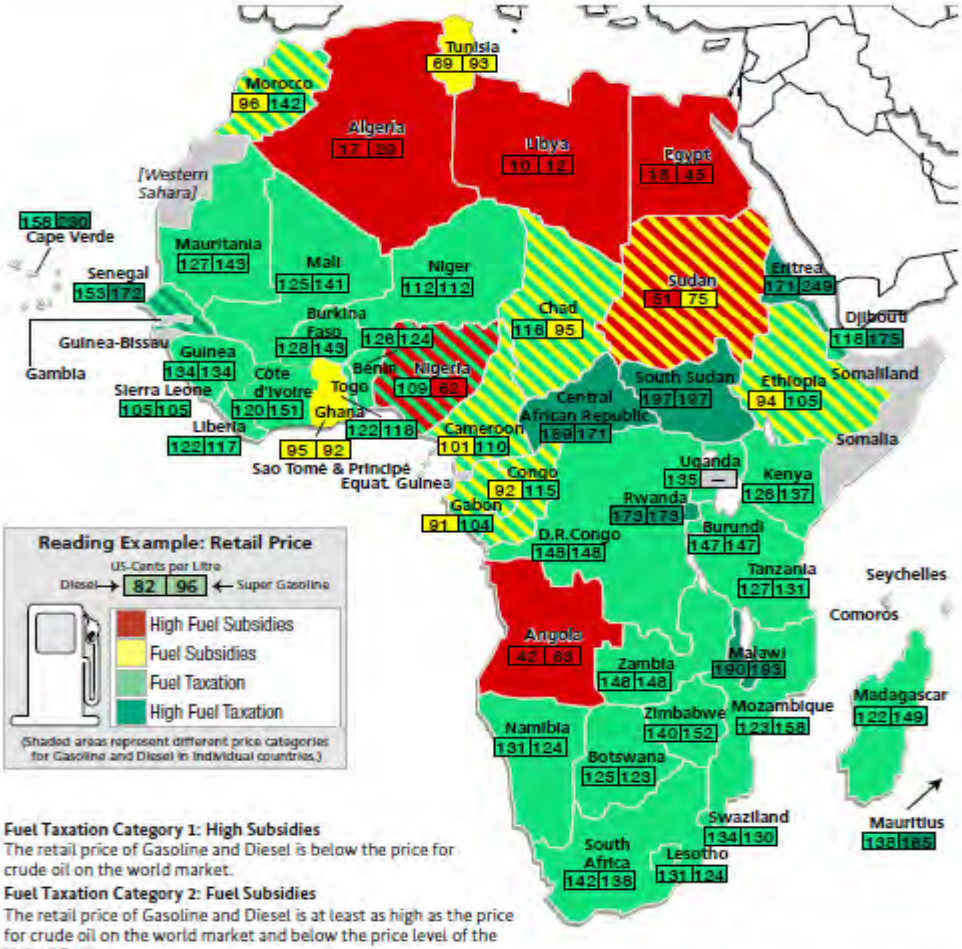
3.1.1 Retail fuel prices in Africa – as of November 2012 (in US-cents/litre)



Fuel Taxation Category 1: High Subsidies
The retail price of Gasoline and Diesel is below the price for crude oil on the world market.

Fuel Taxation Category 2: Fuel Subsidies
The retail price of Gasoline and Diesel is at least as high as the price for crude oil on the world market and below the price level of the United States.

***Note**: The fuel prices of the United States are average cost-covering retail prices incl. industry margin, VAT/sales tax and incl. approx. 10 US-cents for the 2 road funds (federal and state). This fuel price may be considered as the international minimum benchmark for a non-subsidised road transport policy; though not yet covering external costs for health and environmental damages.*

Fuel Taxation Category 3: Fuel Taxation
Retail price of Gasoline and Diesel is at least as high as the price of the United States and below the price level of Luxembourg.

***Note**: In November 2012, Gasoline prices and Diesel prices in Luxembourg were the lowest in EU-27. Prices in EU countries are subject to VAT, specific fuel taxes as well as other country specific duties and taxes. The EU sets minimum taxation rates for fossil fuels.*

Fuel Taxation Category 4: High Taxation
The retail price of Gasoline and Diesel is at least as high as the price level of Luxembourg.

***Note**: At these levels, countries are effectively using taxes to generate revenues and to encourage energy efficiency in the transport sector.*

Energy Regulatory Commission

PETROLEUM OUTLETS FOUND OFFERING FOR SALE ADULTERATED OR EXPORT (TRANSIT) MOTOR FUELS IN THE MONTHS OF MAY, JUNE AND JULY 2014.

The Energy Regulatory Commission (ERC) is established under the Energy Act, No 12 of 2006 (the Act) as the energy sector regulatory agency, with responsibility for economic and technical regulation of electric power, renewable energy and downstream petroleum sub-sectors.

Section 95 of the Act prohibits the storage, transportation and/or sale within Kenya of petroleum products that do not conform to the Kenya Standard or of adulterated petroleum products. The section also prohibits the sale within Kenya of petroleum products intended for export.

ERC runs a program of continuous monitoring of the quality of petroleum motor fuels being sold throughout the country. During the months of May, June and July 2014, ERC together with the Kenya Revenue Authority (KRA), the Kenya Bureau of Standards (KEBS) and other government agencies conducted a countrywide monitoring exercise to enforce compliance with the provisions of the Act. In the exercise, a total of **2,251** tests were carried out in **401** petroleum outlets and over **97%** of the stations tested were found to be compliant.

However, **seventeen (17)** tests from **fourteen (14)** sites were non-compliant. The following is a list of the petroleum outlets which were found offering for sale adulterated and/or motor fuels intended for export.

	Test Date	Name of Station	County	Physical Location	Nature of Default	Status as at 13th August 2014
1	13.05.14	Metro Filling Station	Kakamega	Ikonyero	Offering for sale motor gasoline contaminated with Kerosene	Station closed
2	13.05.14	Bukhayo Filling Station	Kakamega	Shisiru	Offering for sale transit/ export diesel	Station closed
3	15.05.14	Sango Filling Station	Bungoma	Ndalu	1. Offering for sale transit/ export motor gasoline 2. Offering for sale transit/ export diesel	Station closed
4	19.05.14	Thumbs Filling Station	Nyandarua	Haraka	Offering for sale diesel contaminated with Kerosene	Station closed for 8 days and re-opened after paying of fines, penalties and taxes/ duties of KShs. 600,000 to KRA
5	19.05.14	Eltex Service Station	Nyandarua	Oljororok West, Kasuku	Offering for sale diesel contaminated with Kerosene	Station closed for 7 days and re-opened after paying of fines, penalties and taxes/ duties of KShs. 380,000 to KRA
6	10.06.14	Atam Service Station	Nairobi	Embakasi, Outer Ring Road	1. Offering for sale motor gasoline contaminated with Kerosene 2. Offering for sale diesel contaminated with Kerosene	Station closed for 7 days and re-opened after paying of fines, penalties and taxes/ duties of KShs. 1,500,000 to KRA
7	10.06.14	Atam Service Station	Nairobi	Ex-KBT 263D	Transporting diesel contaminated with Kerosene	
8	11.06.14	Glorious Filling Station	Nairobi	Kasarani, Mwiki	Offering for sale diesel contaminated with Kerosene	Station closed for 36 days and re-opened after paying of fines, penalties and taxes/ duties of KShs. 100,000 to KRA
9	12.06.14	Shell Service Station, Kiambu	Kiambu	Kiambu town	Offering for sale diesel contaminated with Kerosene	Station closed for 22 days and re-opened after paying of fines, penalties and taxes/ duties of KShs. 700,000 to KRA
10	12.06.14	National Oil Service Station	Kiambu	Kiambu town	Offering for sale motor gasoline contaminated with Kerosene	Station closed for 37 days and re-opened after paying of fines, penalties and taxes/ duties of KShs. 500,000 to KRA
11	01.07.2014	Shell Service Station Sonning	Nairobi	Adams Arcade	Offering for sale motor gasoline contaminated with Kerosene	Station closed for 10 days and re-opened after paying of fines, penalties and taxes/ duties of KShs. 500,000 to KRA
12	03.07.14	Fast Energy Service Station Gacharara	Kiambu	Kiambu town	Offering for sale motor gasoline contaminated with Kerosene	Station closed
13	08.07.14	Nile Filling Station	Kajiado	Kajiado Central, Namanga	Offering for sale diesel contaminated with Kerosene	Station closed for 9 days and re-opened after paying of fines, penalties and taxes/ duties of KShs. 550,000 to KRA
14	18.07.14	Ujamaa Filling Station	Mombasa	Likoni	Offering for sale diesel contaminated with Kerosene	Station closed

The County Commissioners were requested to withdraw the licenses of operators of the defaulting outlets and defaulters were further required to pay penalties and taxes prescribed under the applicable tax laws before consideration for resumption of business.

A list of all stations found with adulterated product is available in our website **www.erc.go.ke**.

It is notified for public information that ERC together with KRA, KEBS and other government agencies shall continue to carry out the monitoring of petroleum outlets and any that are found to be in contravention of the Act shall be dealt with in accordance with the law.

The Commission maintains a hotline number (**0708 444 000**) operational during normal working hours with a view of increasing its engagement with stakeholders to enhance enforcement and compliance activities.

Corporate Communication
ENERGY REGULATORY COMMISSION

ISO 9001: 2008 Certified

ADDIS ABABA UNIVERSITY
COLLEGE OF BUSINESS AND ECONOMICS
DEPARTMENT OF MANAGEMENT

Dear respondent,

My name is Tegegne Mekuria. I am a postgraduate student in the Department of Management: Executive Masters Program in Business Administration at Addis Ababa University. I am conducting a research with the aim of assessing the Fuel adulteration, specifically benzene (regular gasoline) at Addis Ababa fuel stations assessment of customer's awareness and effectiveness of regulatory body in controlling the fuel adulteration. This research is required to fulfill the partial requirements for the Masters of Business Administration (EMBA) degree. Hence this questionnaire is designed to solicit your individual feedback on your awareness, perception on the subject

I would like to assure you that this research is only for academic purpose. No other person will have access to the data collected. In any sort of report I might publish, I will not include any information that will make it possible to identify any respondent.

General Instructions

- There is no need of writing your name
- In all cases where answer options are available please put "✓" in the appropriate space.
- For questions that demand your opinion, please try to honestly describe as per the questions on the space provided
- If you need further explanation, you can contact me through my

  Mobile phone 911-244975 or at the email: tegegnemekuria@yahoo.com

Thank you very much in advance for your generous time, honest, and prompt responses!!!

Tegegne Mekuria

Part I: Respondent Profile

A. Gender : Female **[ ]** Male **[ ]**

B. Age : **[ ]** Younger than 25 **[ ]** 25-34 **[ ]** 35- 44 **[ ]** >45

C. What is your current educational status**?**

High School complete and below **[ ]** College diploma **[ ]** First degree **[ ]** ,

Second degree & above **[ ]** other (please specify) ----------

D. How long have you been driving a car in Addis?

[ ] Less than 2 years **[ ]** between 2 to 5 years

[ ] Between 5 to 10 years. **[ ]** Over 10 years

E. What kind of vehicle are you driving?

[ ] Personal Car **[ ]** Private company car **[ ]** Government institution car

F. How old is your vehicle?

[ ] less than 5 years old **[ ]** between 5 to 10 years old [**]** Over 10 years old

For the next parts please indicate the degree with which you agree, disagree with each statement by ticking (√) on the space provided.

Note that: SA- Strongly Agree, A- Agree, D- Disagree, N- Neutral, SD- Strongly Disagree

Part II Fuel standard at station	SA	A	N	D	SD
1. I am aware that there is fuel standard set by a regulatory agency in Ethiopia in general and I believe most people around me are also aware of the standard.					
2. The regular gasoline (benzene) sold at Addis Ababa fuel stations are as per the standard set by the Ethiopian standard authority (ESA).					

3. I suspect the regular gasoline (benzene) sold at Addis Ababa fuel stations can be adulterated (mixed with Kerosene, gasoil, water etc.)					
4. If you agree to question 3 above and in your assessment of the extent to such unfair commercial practice, fuels adulteration is **a very common** practice by most fuel stations in Addis Ababa.					
Part III Differentiating station in deciding to buy good quality fuel	SA	A	N	D	SD
5. In deciding to fill up fuel, it is easy to get information about the benzen quality of a specific station.					
6. If I need any information regarding fuel adulteration (quality), I **can easily get** it from the concerned body (stations, government offices, Oil companies etc).					
7. How do you feel about the statement, "I wish this community had some means of information to differentiate stations selling good quality of fuel?"					
8. In deciding to buy benzene, I prefer to pay more for better quality.					
Part IV. Fuel adulteration control	SA	A	N	D	SD
9. The government authorities **do surprise fuel standard (quality) checking** at Addis Ababa fuel stations.					
10. If you agree to question 9 above, surprise fuel quality checking is done at Addis Ababa fuel stations **on a regular basis** (at least every six months).					
11. I believe surprise checks by the regulatory body are helping to control fuel adulteration.					
12. I am satisfied with the government control of benzene adulteration at Addis Ababa fuel stations.					
Part V. Effects (Problems) of fuel adulteration	SA	A	N	D	SD
13. I know that poor standard of fuel (quality) that I use for my vehicle can negatively affect the performance and will cost me at the maintenance. But any ways I buy the fuel.					
14. I know that poor standard of fuel (quality) that I use for my vehicle can negatively affect the safety, health and environment pollution. But any ways I buy the fuel.					

15. I have experienced or faced major problem in my vehicle emerging from benzene adulteration at Addis Ababa.					
16. I know other people experienced or faced major problem in their vehicle emerging from benzene adulteration.					

17. Assuming there is no shortage of fuel supply in the city, in deciding to fill up your vehicle, what are your main considerations for choosing a particular fuel stations. Please rank the following reasons in order of importance, form the most important to the least important (Most preferred 1= Least preferred = 4)

Perception	**Forced Ranking**
1. Good fuel quality	
2. Lower fuel price offer	
3. Convenient location	
4. Other …. please indicate	

18. Which body do you think should provide information about the fuel quality?

a) Oil companies b) Public authorities c) Car dealers, mechanics d) Media

e) Other please mention……

19. As a stakeholder, I am interested in any other comments you might have concerning fuel quality sold at stations. Please write in the space below any thoughts you'd like to share with us----------
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