ST. MARY'S UNIVERSITY COLLEGE
SCHOOL OF GRADUATE STUDIES

EVALUATING THE QUALITY CONTROL OF GASOLINE AGAINST ADULTRATION IN ADDIS ABABA CITY ADMINSTRATION.

BY

AGNCHEW TAKELE

September 2013
ADDIS ABABA, ETHIOPIA

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A THESIS SUBMITTED TO ST.MARY'S UNIVERSITY COLLEGE, SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF BUSINESS ADMINISTRATION (MBA)

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APPROVED BY BOARD OF EXAMINERS

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DECLARATION

I, the undersigned, declare that this thesis is my original work, prepared under the guidance of Nigussie Semie (Ph.D). All sources of materials used for the thesis have been duly acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for the purpose of earning any degree.

____________________________ ____________________________

Name Signature & Date

ENDORSEMENT

This thesis has been submitted to St. Mary's University College, School of Graduate Studies for examination with my approval as a university advisor.

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Advisor Signature & Date

DEDICATED TO

To my wife, Netsanet Diro

To my Mother-in-law Mulu Tiku and Father-in-law Diro Gutema

To my daughters Blen and Dagmawit.

For your love, joy, faith and eternal goodness.

May God’s grace and blessings be forever yours.

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ABBREVIATIONS AND ACRONYMS

AACA	Addis Ababa City Adminstration
ASTM	American Society for Testing and Materials
CO	Carbon monoxide
EPE	Ethiopian Petroleum Enterprise
EPSE	Ethiopian Petroleum Supply Enterprise
FBP	Final Boiling Point
HC	Hydro carbons
IBP	Initial Boiling Point
IP	Institute of Petroleum
m	million
MGR	Motor Regular Gasoline
MoWE	Ministry of water and energy
MOT	Ministry of Trade
NOC	National Oil Ethiopia Co.
Oilibya	Libya Oil Ethiopia Ltd.
PM	Particulate matter
QC	Quality Control
QA	Quality Assurance
SPC	Statistical Process Control
TQM	Total Quality Management
YBP	Yetebaberute Petroleum

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Thank You!

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ABSTRACT

Adulteration of automotive transport fuels at the point of sale and during transportation has become an acute problem in Ethiopia and Addis Ababa is not an exception. This paper evaluates the quality control practices and examines factors contributing to adulteration in Addis Ababa City Administration. It describes a quantitative study on adulteration problem in Addis Ababa and factors contributing to it. Two ways of sampling procedures were applied. 10 fuel stations' MGR samples were taken to see the current status of adulteration via ASTM scientific method and 0.01% of the city's salon vehicle drivers were sample size to study the problem of adulteration and its contributing factors. Sample taken as a surprise to see the status of the problem confirmed that 70% of the samples taken from ten petroleum stations of different companies are found to be adulterated. There are different factors contributing to adulteration of gasoline in the city. The quantities of MGR and Kerosene supplied to the city's market during the last three years, rate of supervision expressed as the frequency of supervision by regulatory body are contributing factors investigated by this research. For the last three years, the quantity of importing both products was changing significantly, the rate of supervision by regulatory body is decreasing within the same period and gasoline adulteration has increased from 15% up to 50% of product being supplied to consumers. Solving the problem of adulteration is demanding stakeholders' coordination and multilateral approaches. Consistent supervision by the regulatory body, consumers' awareness, and technical measures such as using markers are some of the measures which will have positive impact on minimizing if not eradicating the problem.

Key words*: Adulteration, Quality control, Product quality*

Chapter I

1. INTRODUCTION

1.1 Background of the study

Since the birth of automotives in the 19th century gasoline is used as the primary source of energy for the vehicles, though many alternate fuels like Liquified Petroleum Gases (LPG), Alcohol, Dimethylether, Biodiesel, Methanol, etc. are emerging in the market. The conventional fuels are basically derived from crude oil, where crude oil is fractioned by continuous distillation into several fractions: Gasoline (Petrol), kerosene (kerosene and/or paraffin oil), Gas oil (heavy oil), Vacuum gas oil, Naphtha, Lubricating oil and Residue (Parivesh, 2012).

Gasoline is one of the major transport fuels in Ethiopia. Its main application is as a fuel for internal combustion engines. Gasoline is one of the main products of petroleum refining. It is a quite volatile liquid. The suitability of gasoline for its main application (fuel for internal combustion engines) is measured through the octane number. Nowadays, gasoline is formulated using aromatic based and oxygen-containing compounds (oxygenates) to improve the octane number (Santos, 2005).

Petroleum supply chain comprises the transport of finished fuels from the door of the refinery to consumers and the sale of the products either in bulk or in small quantities in gas stations. The same is true in Ethiopia. Bulk purchase of the product is done by Ethiopian Petroleum Supply Enterprise (EPSE) at loading ports. It sales the product at Djibouti and Sudan to the retailing companies operating in Ethiopia. Unlike other parts of the world where the products are distributed by pipeline, tanker, rail or barge, distribution of finished products in Ethiopia is made by trucks throughout the country. This way of transporting the product is inefficient and very vulnerable to adulteration practice. The North-East transport route (the country's major import –export gate) is the route currently used for importing petroleum products into the country and at the same time it is the line where most of the malpractices in the downstream operation take place. Gas stations which are registered under those retailing companies supply the product to the end users. Addis Ababa has got 105 retailing gas stations (MOT, 2011).

Though there is a wide range of malpractices such as: distortions in the fuel market like tax evasion, mislabeling of products, over charging, lack of quality assurance of lubricant oils sold at the retail outlet, and manipulation of stock inventory at the retail outlet, this research focuses on investigating the factors that are responsible for the physical adulteration of gasoline with kerosene.

Adulteration of automotive transport fuels at the point of sale and during transportation has become an acute problem in Ethiopia and Addis Ababa is not an exception. Transport fuels are often adulterated with other cheaper products or byproduct or waste hydrocarbon stream for monetary gains. For example, gasoline is believed to be widely adulterated with naphtha, natural gas liquids, kerosene, waste solvents, byproduct petroleum stream, etc. With large number of adulterants available in the market, both indigenous and imported, the magnitude of the problem of fuel adulteration has grown into alarming proportions in the past few years (World Bank, 2002).

Adulteration is 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 base transport fuels (Balakrishnan et.al, 2010).

Since 1966 the present EPSE previously known as Ethiopian Petroleum Corporation was engaged importing crude oil, refining in its own refinery and supplying refined products for distributors. Based on the Council of Ministers regulation No. 265/2004 the corporation was established as a public enterprise and mandated to refine, import and sale petroleum products. In order to accomplish its objectives and at the same time to meet the ever-growing demand of petroleum products which is used for the development of the country; it import refined petroleum product via Sudan and Djibouti port and gets it distributed all over Ethiopia through petroleum distributing companies.

EPSE as a sole importer of petroleum and petroleum products has been and is supplying the mentioned products to seven local distributors namely National Oil Company (NOC), Yetebaberut Beherawi Petroleum S.C (YBP), Libya Oil Ethiopia Ltd (Oilibya), Total Ethiopia Ltd, Kobil Plc, Dalol Oil Plc, TAF Oil Plc.

1.2 Statement of the problem

The quality issues are becoming dynamic and especially constraining as the new fuels specifications demand more complex processing and expensive investment in new equipment at different parts of the world. These investments do not always provide an attractive return but are in many cases required to keep the refinery operating. Nevertheless, the quality compliance complexity offers an opportunity for differentiation, and even brand building around some of the chemical characteristics of the fuels (Manzano, 2005).

Adulteration of transport fuel, which is currently a very 'flourishing business' in our country, can lead to economic losses, increased polluting emissions and deterioration of performance on parts of engines using the adulterated fuels. The ministry of water and energy (MoWE) is preparing a draft proclamation to properly regulate the petroleum industry in Ethiopia. The ministry said that it is also committed to eliminating the current practice of adulterating petrol and diesel with kerosene which seems to be increasing at a significant rate. The adulteration of petrol and diesel with kerosene lowers the quality of fuel and results in low engine performance, higher pollution, higher maintenance costs and various health related consequences (Yigzaw, 2008).

Ethanol- MGR blending, usually called as Ethanol-Benzene blend, proportion can go up to 25% of Ethanol and 75% MGR with few automotive spare parts replacement or modification as it is currently applied in Brazil and Western Countries. This policy has its own merits. It is useful iterms of foreign currency saving, creates market for ethanol producers of suger factories, it decreases environmental pollution (Demribas 2009). But such advantages of ethanol-benzenes blends are only possible if and only if the blending is made with MGR which is not adulterated. When Ethanol-Benzene proportion was increased from E-5% (95% MGR and 5% ethanol) to E-10 (90% MGR and 10% ethanol)   by 2010, there was a frequent end users complaint which says 'the increased ethanol proportion brought technical problem on my car' (EPE, 2000). It was not the increment of ethanol-benzene proportion that brought the problem but the adulteration which had been made on pure MGR and go unnoticed could not continue as the proportion increased.

The primary cause of adulteration is the greed fueled by differential tax system (World Bank, 2002). For example, in Ethiopia, gasoline is taxed most heavily, followed by diesel and kerosene, in that order. The fact that adulteration of gasoline by kerosene, is not simple to detect, combined with the differential tax structure makes such adulteration financially attractive, even though it is illegal. Where products of comparable quality have different prices, or consumers have trouble in distinguishing products of different quality, unscrupulous operators will always try to exploit the situation for illegal profits (Kojima *et al*., 2001).

Policy-makers often justify energy subsidies with the argument that they contribute to economic growth, poverty reduction and security of supply. However, subsidies are rarely the most efficient tool at promoting these objectives. In reality, the main motivation behind energy subsidies is often political. Subsidies are a very tangible way for governments to show that they are supporting their people. This is particularly important in countries that lack the administrative capacity to offer social and economic support through other policy mechanisms (World Bank, 2010). It is also important to bear in mind that fiscal policy has multiple objectives, and reducing fuel adulteration is only one amongst many. As such, concerns about fuel adulteration, however serious, cannot and should not be the sole driver of fiscal policy. The cost depends on the ability of the regulating authorities to detect adulteration, and to impose sufficiently punishing sanctions to deter recurrence of fuel adulteration (World Bank, 2002).

As adulteration is a global problem different researchers have made their own contribution to tackle the problem (Roychowdhury, 2002; Balakrishnan *et al.,*2010; Osueke, 2011; Ogali 2012;). The papers had given emphasis on the effects of adulteration and methods of detecting adulterated petroleum products. But, as far as my knowledge is concerned, factors contributing to adulteration and the quality control (QC) practices which help to maintain the product quality were not covered on their researches. Knowing the existence of the problem by itself does not tell us the root causes contributing to adulteration. Therefore, this paper tries to investigate the QC practice of gasoline in Addis Ababa city administration (AACA) and the effects of quantity supplied of both MGR and Kerosene as the difference on selling price of gasoline and kerosene is widening and the existence of credible monitoring and surveillance system (as defined by the rate of supervision) on quality of gasoline towards adulteration. Moreover the factors that contribute to adulteration of gasoline would be uncovered and solutions will be suggested.

1.3 Research Questions

The research on adulteration problem Evaluating the Quality Control of Gasoline against Adultration in addis ababa city administration addresses to major questions.

Q1: Is adulteration currently a problem to the Addis Ababa city Administration?

Q2: What are the factors contributing to adulteration in the city administration?

Different factors are assumed to contribute to the problem of adulteration. Differential taxation is the one which is repeatedly mentioned, but there are also other factors contributing to the problem. One important factor is the manner in which retail fuels are distributed which has an important bearing on fuel adulteration. For example, having large numbers of small, independent transport trucks operators moving fuels from terminals to the point of sale creates an environment conducive to adulteration. Lack of strong regulatory body that is backed up by sound financial and legal framework is another point which is repeatedly mentioned for aggravating the problem (Masami, 2001). Legal penalties weakness is another factor mentioned by consumers.

1.4 Objectives of the study

1.4.1 General objective

- To evaluate the quality control of gasoline and examine factors contributing to the quality control practice in Addis Ababa City Administration (AACA), Ethiopia.

1.4.2 Specific objectives

The main trust of this research is to evaluate quality control practices on transport fuels in Addis Ababa city Administration in particular, this study seeks to:

- Evaluating the effectiveness of two quality parameters of gasoline density@ $20^{o}c$ (ASTM D-1298) and distillation (ASTM D-86) which are applicable during product transaction. The tests measurements will be conducted by following the standard methods (ASTM) for use in petrol engines.

- Identify the contributing factors to quality control of transport fuels and gasoline in particular.

1.5 Significance of the study

Petroleum products are one of the single most items transact in the market. Therefore, looking at the effectiveness of QC practices of gasoline especially in terms of product transfer becomes apparently important. It is valuable to support decision makers for effective management of transport fuels and the sector at large. To ensure that Ethiopian policymakers have sufficient and updated information in order to draft appropriate legislations and guidelines for elimination or minimization of adulteration. Though it is not the research’s primary objective, the results of the study might be use as an input or baseline information for further studies regarding the effectiveness of fuel subsidies and malpractices that the petroleum industry is facing.

1.6 Scope and limitations of the study

The research is limited with the geographical boundary of AACA. The city is selected as the representative city because it is major consumer of gasoline (65%) of the country (EPSE, 2010). Nowadays different kinds of adulteration practices are undergoing; blending of lubricants into kerosene as a substitute for diesel, blending of kerosene into petrol, blending of kerosene into diesel, blending of used lubricants into diesel are some of them. Although there are different kinds of adulteration in the city, the research is limited to gasoline physical adulteration specifically by kerosene as adulterant because kerosene is available in huge quantity compared to other hydrocarbons which are also applicable for adulteration purpose. No other hydrocarbon is available in such quantity. Kerosene is colorless and easily miscible with gasoline which makes it ideal for such mal practices.

1.7 Definitions of Terms

Adulteration: is the introduction of foreign substance into fuel illegally or unauthorized with the result that the product does not conform to the requirements and specifications of the product.

'Adulterated' when used to describe any petroleum or alternative fuel product, denotes a petroleum or alternative fuel product, which fail to meet the specification' (SGS, 2000).

Ethanol: Ethanol (ethyl alcohol) is an alternative fuel fermented from corn, grains or agricultural waste or it is chemically extracted from ethylene (hydration). It is used primarily as a supplement to gasoline.

MGR: is a mixture of hydrocarbons distilled from crude oil containing specified maximum levels of impurities and some minimum levels of performance enhancing additives. The overall characteristic of MGR was traditionally defined by an allowable maximum vapor pressure and a performance index called and octane number (Wolf, 2000).

Kerosene: a light fuel oil obtained by distilling petroleum, used especially in jet engines and domestic heating boilers; paraffin oil.

Chapter II

2. LITERATURE REVIEW

2.1 Theoretical reviews of product quality control and quality management

Historically, the concept of quality has evolved from QC and using statistical methods to address practices such as employee involvement and a culture for change and innovation more recently, the concept of quality has broadened its scope to the supply chain, addressing quality issues dealing with activities and processes between the firm, its suppliers, and customers (Mellat *et al*., 2010).

The meaning of quality for businesses changed dramatically in the late 1970s. Before then quality was still viewed as something that needed to be inspected and corrected. However, in the 1970s and 1980s many U.S. industries lost market share to foreign competition. In the auto industry, manufacturers such as Toyota and Honda became major players. In the consumer goods market, companies such as Toshiba and Sony led the way. These foreign competitors were producing lower-priced products with considerably higher quality.

The evolution of quality management is thought to be divided into four stages. The four stages are inspection, QC, and quality assurance (QA) and total quality management (TQM). On the hand Dr. Joseph Juran argued that QC should be conducted as an integral part of management control. Juran coined the phrase, “There is gold in the mine”, referring to the huge cost savings which can be made by measuring and resolving quality problems. However, it is not at the surface, you have to dig for it (Bendell *et al.*, 1995). To achieve the total quality (TQ), it needs the total quality control (TQC) and the TQM. Whether the organization can realize the TQ, it depends on the success of these two aspects (Wu *et al*., 2008).

2.1.1 Historical evolution from quality to total quality

According to Oakland (quoted by Pycraft, Singh & Phihlela 2000) TQM is a philosophy, a way of thinking and working that is concerned with meeting the needs and expectations of customers. TQM applies to all parts, departments and sections of the institution and, further, it is the responsibility of all people in an institution. TQM can be viewed as a logical extension of the way in which quality-related practice has progressed.

Originally quality was achieved by inspection – screening out defects before customers noticed them. The QC concept was developed in a more systematic approach to not only detecting, but also treating quality problems. QA widened the responsibility for quality to include functions other than direct operations of an institution. It also made increasing use of more sophisticated statistical quality techniques Dale (2003) and (Pycraft, et. al 2000).

According to Schlotz (1998), the evolutionary development of the quality concept can be regarded as a continuum consisting of three different stages/phases in the development of quality each one separated by a substantial paradigm shift in the thinking approach of quality, namely (1) quality of product, (2) quality of institution and (3) quality of life.

2.1.2 Defining product quality

Research in QM has been unable to arrive at a single definition of product quality. At best several optional definitions were proposed. Gravine (1984) identified five major approaches to the definition of quality and the discipline in which they are rooted.

Table 1: presents representative examples of each approach

Approach	Definitional Variables	Underlying discipline
Transcendent	Innate excellence	Philosophy
Product-based	Quantity of desired attributes	Economics
User-based	Satisfaction of individual consumer preference	Economics, Marketing and operational mgt
Manufacturing-based	Conformance to requirements	Operational management
Value-based	Affordable excellence	Operational management

Source: Garvine (1984).

The formal study of product quality evolved in the beginning of this century with the focus being on the quality of conformance. A variety of techniques evolved for QC. The vast literature deals with (i) the use of control charts to detect process changes which lead to increased non-conforming items being produced and (ii) QC schemes to detect and weed out nonconforming items. Initially, they were done in solely in the context of manufacturing with little consideration for the impact of poor quality on sales.

The total product quality concept brings together the different functional units. Typically engineering and marketing functions are responsible for the design aspects of quality, manufacturing operations is responsible for the process, and final product quality while service/distribution is accountable for after-sales service quality. Clearly, much of after-sales service support depends on product reliability which is a function of both design parameters, such as reliability, and manufacturing process capability to conform to specifications (Mellat *et al.*, 2010).

We have identified two areas where complete agreement exists among the authors on the purpose of quality. All the authors emphasize that the customer defines quality and, in turn, that quality creates customer satisfaction which leads to an improved competitive position (Reeda *et al.*, 2000).

2.2 Quality tools and techniques

2.2.1 Quality control tools

Statistical process control (SPC) aims to produce the products in the most economic and useful way by using statistical principles and techniques at every stage of the production. In this manner, SPC aims faithfulness to the standards, provides the fitness of the specifications that have been determined earlier.

It is used to reduce the defected products as much as possible. SPC is a powerful collection of problem-solving tools useful in achieving process stability and improving capability through the reduction of variability. The company had used some of the "seven basic quality control tools (QCTs)" in their problem solving technique. The seven quality tools are (Ishikawa, 1985). These tools, often called magnificent seven are;

• Check Sheet

A check Sheet is any kind of a form that is designed for recording data. In many cases the recording is done so the patterns are easily seen while the data are being taken. It helps analysts being find the fact or patterns that may aid subsequent analysis. An example might be a drawing that shows a tally of areas where defects are occurring or a check list showing the type of customer complaints Heizer J. (2011).

• Pareto Chart

Pareto charts are a method of organizing errors, problems, or defects to help focus on problem solving efforts. They are based on the work of Vilfredo Pareto, a 19th century economist. Joseph M. Juran popularized pareto's work when suggested that 80% of firms problem are the result of only 20% of the causes Heizer J. (2011).

• Histogram

Histogram shows a range of value of a measurement and the frequency with which each value occurs. They show the most frequently occurring readings as well as the variation in measurements. Descriptive statistics may be calculated to describe the distribution. However the data should always be plotted sothat the shape of the distribution can be "seen". A visual presentation of a distribution may also provide insight into the cause of the variation.

• Scatter Diagram

Scatter diagram shows the relationship between two measurements. An example is the positive relationship between the lengths of service call and the number of trip a repairperson makes back on the truck for parts. If the two items are closely related, the data points will form a tight band. If a random pattern results, the items are unrelated. Heizer J. (2011).

• Process Flow Chart

Flow charts graphically present process or system using annotated box and interconnected lines. They are simple but great tools for trying to make sense of a process or explain a process Heizer J. (2011).

• Cause and Effect Diagram or Fish Bone Diagram or Ishikawa Diagram

In Cause- and- Effect Diagram each bone indicates the possible source of error. Usually the operation managers start with four possible sources; Machine, Manpower, Material and Method. These are the 'causes'. They provide a good checklist for initial analysis. Individual causes associated with each category are tied in a separate bone along that branch, often through a brainstorming process. When a fishbone chart is systematically developed, possible quality problems and inspection points are highlighted Heizer J. (2011).

• Control Chart

The control chart is perhaps the most widely used of the "seven basic quality control tools". It is the key tools in statistical process control (SPC) because it displays process behavior graphically and it is used to monitor and control processes within the specified control limits (Bisgaard, S. 1993). There are two basic types of control chart, depending on the type of data collected; namely variable control chart and attribute control chart. Variable control chart are designed to control product characteristics and process parameters which are measured in continuous scale. Attribute control charts are designed to control the process. Measurements used are in terms of good or bad, accept or reject, go/no-go, or pass or fail criteria (e.g. conforming or nonconforming) (Freeman, et.al 1999).

To control quality characteristics on the methods, machine, products, equipments both for the company and operators, the SPC. SQC and quality improvement methods have been widely recognized as effective approaches for process monitoring and diagnosis.

The primary tool of SPC is the Shewhart control chart. The Shewhart control chart quantifies variation as either special cause or common-cause (natural) variation. The control limits on control charts quantify variation as that inherent to the process (natural variation data inside the control limits), or variation caused by an event or assignable-cause (special cause variation data located outside the control limits). Data outside the control limits are also referred to as “out of control” points. The study documented the change in sawyer operating targets when sawyers are presented with real-time thickness data in the form of control charts.

SPC is used to describe the variability that can be controlled or cannot be controlled. This variability is also called common cause or special cause. Common cause occurs with the nature of the process. It exists in all processes and it is the variability from the system. Special cause is not the part of the process. It exists almost in all processes because of some certain reasons. If there is not variability because of special causes, that means the process is statistically under control. For a process that is statistically under control, the researcher can conclude that, it has a definable identification and a definable capability. In a process that is under control, by removing all special causes that are noticed until then, the remaining variability would come from common causes.

According to the literature on TQM there are two components in a TQM system: the management system and the technical system, or the ‘soft’ and ‘hard’ part. The hard part includes production and work process control techniques, which ensure the correct functioning of such processes (amongst others, process design, the ‘‘just in time’’ philosophy, the ISO 9000 norm, and the seven basic QC tools). The two dimensions reflect all the issues which a manager must bear in mind for a successful TQM implementation (Jos’e, *et al.*, 2003).

Quality tool is an important pillar of the TQM framework (Liang, 2010). Researchers have identified a number of tools and techniques for quality improvement. A single tool is a device with a clear function, and is usually applied on its own, whereas a technique has a wider application and is understood as a set of tools and.

Due to different understandings of quality systems, there are different strategies for quality tools. For instance GM believes “quality is what the customer perceives to be acceptable to achieve his/her enthusiasm”. Quality motto, “quality creates customer enthusiasm” drives this message down to the production line by ensuring “do not accept build ship a defect.” To support this motto, GM uses Shingo’s Poke-yoke methodology with added resource inspection to improve the quality. Based on the information alone, it is evident that there are two schools of thoughts at the use of statistical tools for quality management, and Juran also said that it was risk in taking a tool-oriented approach to quality instead of a problem oriented or results-oriented approach (Liang, 2010).

2.3 Gasoline product

In May 1876, Nicolaus Otto built the first practical four-stroke-cycle internal combustion engine powered by a liquid fuel. By 1884, he concluded development of his engine with the invention of the first magneto ignition system for low-voltage ignition. The liquid fuel used by Otto became known as gasoline in the United States (US); elsewhere it may be known as gasolina, petrol, essence, or benzin (not to be confused with the chemical compound benzene) (chevron, 2002).

In spite of the U.S. petroleum industry was almost 50 years old when the first model Trolled off Henry Ford’s production line in 1908, gasoline and the automobile grew up together. The industry was born in August 1859 near Titusville, Pa., when a drilling effort financed by Edwin Drake hit crude oil at a depth of 70 feet. The major product in the early years wasn't gasoline; it was lamp oil, called coal oil or kerosene. People were reading more and wanted better light than that provided by candles and whale oil lamps. The natural gasoline in crude oil was a surplus byproduct. Being too volatile to use in lamps, it was burned at refineries, dumped, or converted to a gaseous fuel for gas lights.

The development of the electric light and the astonishing popularity of the automobile in the first decades of the 20th century turned the petroleum industry's focus from kerosene to gasoline. In 1911, gasoline sales exceeded kerosene sales for the first time. The simple engines in the first cars ran on almost any liquid that burned. As the demand for power increased and engines became more sophisticated, gasoline was recognized as the right fuel for the spark-ignition internal combustion engine.

Drivers can obtain the performance they expect only when the characteristics of the fuel they use match the fuel requirements of the engines in their cars. As a result of this correlation, the gasoline engine and its fuel matured as mutually dependent partners. An engine was not designed without considering the gasoline available in the marketplace. In turn, gasoline was not made without considering the requirements of the engines that would burn it. The partnership became a triumvirate in the last decades of the 20th century as environmental considerations began to change both engine design and gasoline characteristics (chevron, 2002).

2.3.1 Gasoline property

Gasoline is a mixture of hydrocarbons distilled from crude oil containing specified maximum levels of impurities and some minimum level of performance-enhancing additives. The overall characteristics of the blend were traditionally defined by an allowable maximum vapor pressure and a performance index called an octane number (Wolf, 2000).

The majority of some 200 gasoline components are alkanes, i.e. saturated hydrocarbons, with 4 to 12 carbon atoms. The balance of gasoline consists of unsaturated hydrocarbons, alkenes, akynes or olefins, all of which are less stable than alkanes, and some polynuclear aromatics (PNAs) which are high boiling, unstable, and the source of some residues and gums (Wolf, 2000).

Although proper vehicle design and maintenance are necessary, gasoline plays an important role in meeting these expectations. In a typical gasoline engine, a pre-mixed charge of fuel and air is admitted into a cylinder, compressed, combusted and exhausted. The exhaust constituents depend on the completeness of the combustion, which is influenced primarily by engine design, but to some degree by gasoline composition. Complete or stoichiometric combustion of a fuel, including gasoline, results in carbon dioxide and water as by products (Wolf, 2000).

2.3.2 Contamination and adulteration

During manufacturing and distribution, gasoline comes into contact with water and particulate matter and can become contaminated with such materials. Water is allowed to settle from fuel in storage tanks and is regularly withdrawn. Particulate matter is removed by filters installed in the distribution system recommends the installation of filters of 10 micrometers (μm) or less nominal pore size on all dispensers delivering fuel to the customer (Wolf, 2000).

Adulteration differs from contamination in that unacceptable materials are deliberately added to gasoline. It may be as simple as adding regular-grade gasoline to a premium grade gasoline storage tank, which lowers the octane number of the premium. Adding low-taxed or subsidized kerosene to gasoline lowers the octane number of the mix and adversely affects its volatility, which affects driveability. Used toluene containing soluble silicon compounds from manufacturing processes is another adulterant that has been found in gasoline. In vehicle engines, the silicon fouls oxygen sensors and plugs exhaust catalysts, causing severe performance problems and necessitating expensive repairs. In some countries, dyes and markers are used to detect adulteration. ASTM D86 distillation testing and/or ASTM D2699/ASTM D2700 octane number testing may be required to detect adulteration (Wolf, 2000).

2.3.3 Gasoline distribution

The great majority of gasoline today is blended at refineries to either regular or premium specifications and shipped to distribution terminals via pipelines or on barges. From the terminal, it is delivered via tank truck to the service station. If ethanol is used as oxygenate, it may be blended at the terminal truck rack during loading. If the station uses blending dispensers, only regular and premium products are delivered; the mid-grade product is blended at the dispenser. Older stations, with non-blending three-product dispensers will have all three products delivered, with mid-grade gasoline blended at the terminal (Wolf, 2000).

Most gasoline is fungible; a terminal may supply the same base gasoline to different branded outlets, while differentiating the performance by blending the specific brand's detergent additive package at the truck rack. Terminal rack blending operations have become quite sophisticated, in providing automated additive injection and data logging for many different additives. Prior to loading into tankers, the product may be filtered to minimize contaminants. Some major oil companies routinely filter gasoline delivered to stations (Wolf, 2000).

2.3.4 Quality parameters of gasoline

Density, viscosity, heating value, flash point, acid value, pour point, cetane number, etc. are considered as the most important properties of a fuel for its application in engine. These properties indicate the quality of the fuel. Engine performance and emission are also directly related to these. There are different types of standard like ASTM, EN, ISO, etc. to define the limit of each of the fuel properties. Among them ASTM is the most widely followed standard. To meet the standard engine performance and emission, the value of the fuel properties must be in the range. In this regard study of fuel properties are the most important part to use any liquid as fuel Arbab (2010).

The following parameters are the major criteria in the production of finished gasoline with respect to its performance. These are: octane number, thermal efficiency, volatility of the gasoline, and engine deposits. The common tests to check the quality of finished products cover the following: specific gravity, ASTM distillation, sulfur content, reid vapor pressure, copper corrosion, and gum content (ASTM, 2002).

2.3.4.1 Octane number

Among the most important parameters in the manufacture of gasoline is its resistance to 'knocking'. This resistance is expressed as an 'octane number'. Knocking limits the power that can be developed by the engine/fuel combination. Detonation is the spontaneous explosion of the residual fuel (after almost complete combustion) and the air in the combustion chamber as the normal mechanism of combustion nears its end. It's a very fast oxidation reaction which sets up its own flame front. The knocking occurs when this front and the normal combustion collides creating a pressure wave (Onojake,2010)

Another a more destructive form of engine knock is 'pre-ignition'. It is the spontaneous ignition of the fuel/air mixture before the ignition sparks. This in turn is caused when the unburned gases are compressed in the cylinder and the resulting temperature reaches the auto ignition point before the ignition spark occurs. The pre-ignition usually causes major engine damage in just a few seconds or minutes. Increasing humidity, cooler ambient air temperatures, and altitude reduce requirements for antiknock(ASTM, 2002).

2.3.4.2 Thermal efficiency

As may be expected fuel economy is a factor in determining the thermal efficiency of the auto engine. The engines efficiency increases with the increase in compression ratio. However with the increase in compression ratio there is an increasing need for fuels that do not knock. Since around 1980s engine manufacturers have been incorporating knock sensors to the engine electronic management system to continuously adjust the ignition timing. This development allows the timing of the spark to occur in advance of the piston reaching the top of its travel. The maximum engine efficiency is produced with this timing control measured and adjusted by the computer control of fuel to air ratio. Further development and testing of individual engine design sets optimum criteria for fuel octane number of the fuel and air ratio for lean mixture combustion(ASTM, 2002).

2.3.4.3 Engine deposits

Engine deposits affect fuel efficiency and emissions. Deposits are of particular concern in the carburetor, fuel injectors, inlet valves, and combustion chamber. These deposits are essentially fine carbon granules which are formed by high inlet valve temperatures, air flow inconsistencies, and minor oil contamination.

2.3.4.4 Reid Vapour Pressures (RVP)

The Reid Vapour Pressure (RVP) is an important physical property of volatile liquids. It is the pressure a vapour exerts on its surrounding. It is an indirect measure of evaporation. The volatile property of PMS is of paramount importance to spark ignition engines.

2.3.3.4 Specific gravity

Density ASTM D 1298—Density, relative density (specific gravity), or API gravity of crude petroleum and liquid petroleum products is determined by hydrometer method.

The API gravity which is always quoted in degrees API can be calculated from the hydrometer test at 60°F using the equation as follows:

°API= 141.5-131.5/specific gravity

The calculation of the weight per unit volume from the specific gravity is based on the US measure of volume (gallons). A summary table of the relationship between specific gravity at 60°F, °API, and lbs per gallon is shown as in Table 16.13.

2.3.4.4 Volatility of the gasoline

Another important property of gasoline is its volatility. It must be volatile enough to provide the engine capable of starting at the lowest temperature expected in its service.

At too low volatility the engine would have difficulty starting and would be prone to stalling in service. On the other hand too high volatility would cause excessive vapor which in turn would cause vapor lock in pipes and pumps.

2.4 Impacts due to gasoline adulteration

Adulterating gasoline with kerosene increases emissions as kerosene is more difficult to burn than gasoline and this result in higher levels of hydrocarbon (HC), carbon monoxide (CO) and particulate matter (PM). High sulfur contents of the kerosene can deactivate the catalyst and lower conversion of engine out pollutants. Kerosene addition may also cause fall in octane quality, which can lead to engine knocking. When gasoline is adulterated with diesel fuels, the same effects occur but usually at lower levels of added diesel fuel. Both diesel and kerosene added to gasoline will increase engine deposit formation. Gasoline may also be adulterated with gasoline boiling range solvent like toluene, xylene and other aromatics. With the ‘judicious” adulteration, the gasoline would not exhibit drivability problems in motor vehicles. Larger amounts of toluene and /or mixed with xylene cause some increase in HC, CO, NOx emissions, and significant increase in the level of air toxins, especially benzene in the tailpipe exhaust. The adulterated gasoline itself could have increased potential human toxicity if frequent skin contact is allowed. Adulteration of gasoline by waste industrial solvents is especially problematic as the adulterants are so varied in composition. They will cause increased emissions, may even cause vehicle breakdown. Even low levels of these adulterants can be injurious and costly to vehicle operation (Animeta, 2002).

2.4.1 International experience in dealing with adulteration

2.4.1.1 Europe

In Europe currently national standards bodies such as British Standard Institute (BSI) carries out fuel quality checks. The failure cases lead to the penalties of filling station owners and fuel supply companies. Belgium has been active on fuel quality checks for last 3 yrs. Initially, 30% fuel samples failed. Recently the situation has improved with the threat that the offending companies would be named & heavily fined. For checking fuel adulteration, a unified system of transport fuel quality monitoring system is being developed for implementation in European Union.

2.4.1.2 United Kingdoms (UK)

In U.K, the following procedures are used by companies to comply with government quality guidelines and to avoid fraud in the handling and marketing of the petroleum products: audit checks are carried out by customs authorities; samples of products are collected from retail outlets and analyzed for conformity with British standards for gasoline and diesel fuels; the results are shared with the product suppliers; and any reasons for the requirement are investigated and necessary remedial actions are taken. In parallel with government audits, responsible petroleum companies do product quality checks from the point of manufacture to the point of sale (EPE, 2010).

2.4.1.3 United States of America (USA)

In USA there are two systems. United States Environmental Protection Authority (USEPA) carries out tests on spot basis. During the complete lead phase out much vigil was kept and heavy fines were imposed for adulterated unleaded gasoline with leaded gasoline. The automobile manufacturers association conducts regular survey to assure proper fuel quality for the required performance of the vehicles (EPE, 2010).

2.4.1.4 Australia

The commonwealth government has passed legislation to ensure Australian consumers receive high quality petrol & diesel. The fuel quality standards act 2000 and fuel quality standards regulations 2001 provided the framework for enforcing national fuel quality standards. It regulates the supply of fuel to consumers, reduce toxic emissions and ensure that, by using clean fuels, modern vehicles fitted with advanced emission control technologies operate at peak performance. Commonwealth inspectors appointed under the act will monitor compliance with fuel quality, legislation and assist with enforcement supplier or producer found guilty of supplying “off-specification” fuel may face penalties of up to $550,000 (EPE, 2010).

2.4.1.5 Kenya

Since June 1999, the government of Kenya has been adding a biocode 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 the domestic market as a way to avoid taxes. The system is said to have reduced adulteration and illicit trade, recovering US $30m in taxes for government and US $50m in sales for oil companies (EPE, 2010).

2.4.1.6 Russian Federation

To give retail outlets an incentive to maintain high standards, the Moscow fuel association has started awarding blue quality sign to those meeting its quality standards. The retailer applying to the association signs a code of honor binding them to sell fuel meeting the standards. Any caught violating the standards are denied the quality sign (EPE, 2010).

2.4.1.7 Pakistan

Shell, an oil company in Pakistan has upgraded about 200 new retail outlets. In addition to widespread fuel adulteration and short weighing, its marketing strategy is to compete on the basis of superior quality and service quality. To demonstrate its commitment to product quality, Shell has been dispatching chemists to its retail outlets where they test samples publicly (EPE, 2010).

2.4.1.8 Ethiopia

'The Ministry of Water and Energy is preparing a draft proclamation to properly regulate the petroleum industry in Ethiopia according to Wendimu Tekle, State Minister for Water and Energy'. The ministry is also committed to eliminating the current practice of adulterating petrol and diesel with kerosene which seems to be increasing at a significant rate he noted. The adulteration of petrol and diesel with kerosene lowers the quality of fuel and results in low engine performance, higher emissions, higher maintenance costs and various health related consequences noted Yigzaw, researcher and former CEO of Ethiopian Petroleum Enterprise. The government is losing revenue in the millions due to this process claimed representatives of the MoWE at a workshop organized for petroleum downstream operators (Meron, 2012).

Chapter III

3. RESEARCH METHODOLOGY

3.1 Description of the study area

This study is a case study of quality control practice against adulteration in Addis Ababa City Administration. The city is selected as the representative city because the city is major consumer of gasoline (65%) of the country (EPSE, 2010). Addis Ababa is located at the central part of the country. The main entry to the supply of conventional fuels is through the North-East route i.e from Djibouti-Addis Ababa and through the North-West route of Ethio-Sudan. As the city is the main economic and political center of the country, there is significant consumption of conventional transport fuels up to 65% of motor regular gasoline (MGR) and 45% of automotive gas oil (AGO).

3.2 Sampling design and sample size

For a credible testing system, it is important to pay attention to the integrity of the sample itself. For samples of the product gasoline taken from fuel stations located in different parts of Addis Ababa, proper procedure was taken as per the standard of American Society Testing Materials (ASTM) 4057. A list of fuel stations and the population size of trucks in the country was solicited through contact with the Ministry of Trade (MOT) and Transport and Communication Bureau of Addis Ababa. A total number of 105 fuel stations are identified. Out of these 10% of the stations were sampled and the samples were given to Ethiopian Petroleum Supply Enterprise for scientific adulteration test. The samples of surprise inspection were taken as per the company's market share as of 2010-2012 (Table 2). From the 10 MGR samples three sample each was taken from Total, NOC, and Oilibya. The remaining two samples were taken from YBP and Kobil companies. Accordingly, the same criterion was applied to distribute questionnaire among petroleum stations. Out of the sixteen stations, Total, NOC, and Oilibya has got four each and the remaing four stations were selected from YBP and Kobile two each. The name of petroleum stations and their parent company is attached on Annex 3. But results of the research are displayed by giving each station unique code. Because adulteration practices can be done on any one of the station without the knowledge of brand holders (parent companies) by doing so the paper can differentiate practitioners from the neutral ones.

Table 2: Quantity of Petroleum Products (Ltr) Sold from 2010-2012

company	Quantity purchas from EPSE	Market share	Number of samples taken
Total Ethiopia Ltd.	2,316,902,081	31.33%	4
National Oil Company	2,006,179,214	27.13%	4
LibyaOil Ethiopia Ltd	1,986,469,424	26.86%	4
Yetebaberut Petroleum	754,816,274	10.21%	2
Kobil PLC	264,972,193	3.58%	2
TAF Oil	45,921,895	0.62%	none
DALOLE	11,038,784	0.15%	none
Nile Petroleum	7,037,106	0.1%	none
WAS	1,404,605	0.02%	none
Total	**7,394,741,576**	**100%**	

Source; Petroleum Sales Directorate, EPSE

It is estimated that the vehicle population in Ethiopia has exceeded 3,500,000 and growing with about 8% annually. Among this 196,982 are vehicles in Addis Ababa. Total number of gasoline vehicles in Addis Ababa is the research's interest and it is 123,645 which is a significant amount of vehicles stock (62.7%) in the city (Danial, 2012 and Demiss, 2012). Gasoline vehicles can be further classified based on Engine capacity, year of manufacturing, type of fuel air mixture formation and even by body type. From the above criteria the researcher has chosen a classification based on 'body type' which is simple technique even for those individuals who are far from the technical aspects of automotive industry. Based on this classification Addis Ababa has 85.3% salon vehicles, 10.4% minibuses, 4.2% small utility vehicles and 0.2% pickups.

Because salon vehicles account for 85.3% of gasoline vehicles in Addis Ababa, the researcher selected salon vehicles as a population size and 0.01% salon vehicles drivers as sample size of for this research.

3.3 Data type and data collection

Data was obtained from two major sources; primary data and secondary data. Primary data was obtained through samples collected from fields and questionnaire given to respondents from the employees of the selected retailing companies and salon vehicles driver in Addis Ababa (Annex-2). Secondary data was taken from published materials, such as related journals and books.

3.3.1 Survey instrument

A survey instrument is used to gather information on quality control practices of gasoline product. The selected quality control practices are those which are applicable for gasoline product transfer during transaction. Because it has been applied and tested for the last four decades as a means of quality control. The survey solicits information from the participants about their perceptions of quality control practices.

In-depth cite interview was conducted at each stations and EPSE expertise to obtain detail information about adulteration problem. The structure portion of the questionnaire was developed based on a comprehensive review of literature and previous survey instruments. The questionnaire was refined using a two stage pre-test process. The questionnaire was tested for clarity and relevance by quality expertise in EPSE. In order to gain an understanding about factors contributing to adulteration stations were asked to identify the factors and rank them from highest contributor to lowest once. The questionnaire allowed firms to rank up to five main contributors.

The assessment of impact of adulteration on product quality was based on the specification limit deviations from originally supplied MGR. the requirements on the specification are listed on Annex-3.

3.4 Data analysis

3.4.1 Descriptive analysis

Descriptive statistics are used to describe the basic features of the sample in the study area. Tools like mean, standard deviation and statistical tests are used. They provide simple summaries about the sample and measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data.

3.4.2 Econometric analysis

Multiple Linear Regression – MLR, A statistical technique that uses several explanatory variables to predict the outcome of a response variable, is applied for data analysis.

Generally, it is used to predict the value of the dependent variable for individuals for whom some information concerning the explanatory variables is available, or in order to estimate the effect of some explanatory variable on the dependent variable. The dependent variable is 'adulteration' and explanatory variables are: 'the number of times that the price of gasoline and kerosene changed' and 'the number of times that supervision has takes place on the station'.

Model equation: The model expresses the value of a predictand variable as a linear function of one or more predictor variables and an error term:

$$\mu_{x1\text{-}n}=\beta_0+\beta_1 X_{1i}+\beta_2 X_{2i}+\varepsilon$$

where:

$\mu_{x1\text{-}n=}$ the level of adulteration

β_0 = y-intercept {a constant value}

β_1 = slope of Y with variable x_1 holding the variables x_2, x_3, ..., x_P effects constant

β_2 = slope of Y with variable x holding all other variables' effects constant

X1i= Quantity of MGR purchased for the last three years

X2i= Quantity of Kerosene purchased for the last three years.

Chapter IV

4. RESULTS AND DISCUSSIONS

4.1 Descriptive analysis Results

Results of sample taken by surprise inspection

4.1.1. Specific Gravity

Results from Table 1 show, the specific gravity, ranged from 0.72 to 0.77. The value of the reference sample is 0.73, which is relatively at the lower end of result distribution. 70% of the samples have higher specific gravity than the reference sample taken from Ethiopian Petroleum Supply Enterprise.

Table 3. Results of SG for Gasoline samples.

Samples	SG @60/60°C
1	0.77
2	0.75
3	0.74
4	0.76
5	0.72
6	0.73
7	0.76
8	0.75
9	0.73
10	0.76
Reference sample 0.73	

4.1.2 Reid Vapour Pressure/RVP

The RVP is a measure of the volatility of the gasoline when in use in the automotive engines. According to the Ethiopian Standard Agency, the maximum Reid Vapour Pressure value should not be above 0.69 KPA, if this value is exceeded, it depicts that the samples have light ends and high volatility. Results from Table 2 show that the reference samples fall below this maximum specification and can vapourize readily in pumps, fuel lines and carburettors and will cause a decrease in fuel flow to engines. Conversely, samples 3, 4 and 7 have RVP less than 0.45 KPA. This connotes that the samples are heavy which means that either the samples were partially refined or have been adulterated. The implication is that they may contain heavy fractions of petroleum products.

Table 4. Results for Reid Vapour Pressure (RVP) @ 100 °F.

Samples	RVP (KPA)
1	0.57
2	0.46
3	0.28
4	0.41
5	0.65
6	0.64
7	0.40
8	0.50
9	0.58
10	0.56
Referece sample: 0.58	

4.1.3 Atmospheric distillation profile

The results of the Atmospheric distillation profile are shown in Table 3and Table 4. According to the Ethiopian Standard Agency, gasoline at 10 ml recovery should not exceed 70 °C. This is the range at which the auto ignition spark plug will be first ignited. Also the specified limit for 50 ml recovery and Final Boiling Point should not exceed a maximum of 125 °C and 225 °C respectively. A close look at Table 3 shows samples 1, 5, 6 and 9 are unadulterated when compared to the distillation profile of reference sample in Table 5. This is because they have 10 ml recovery temperature of less than 70 °C and Final Boiling Point (FBP) less than 205 °C. By comparison with the result of the distillation profile from the reference sample which have a 10 ml recovery temperature of 56 °C and Final Boiling Point (FBP) less than 70 °C samples 2, 7, 8 and 10 have 10 ml recovery temperature greater than 70 °C and FBP well above the maximum limit of 205 °C. These samples are said to be adulterated or may have been blended with other products that are not properly refined and are therefore low quality grade products. This may affect the chemical characteristics of the petroleum products when put to intended use.

Table 5. Results of the distillation profile of the Gasoline research samples.

	Samp 1	**Samp 2**	**Samp 3**	**Samp 4**	**Samp 5**	**Samp 6**	**Samp 7**	**Samp 8**	**Samp 9**	**Samp 10**
Volume	Temp	Temp	Temp	Temp	Temp	Temp	Temp	Temp	Temp	Temp
IBP	39	47	49	40	42	43	64	47	41	57
10	58	73	77	62	65	62	88	82	61	75
20	67	78	92	72	75	70	101	94	76	82
30	78	91	103	84	86	79	113	104	86	94
40	89	101	111	95	96	88	121	114	97	101
50	101	113	127	110	107	100	134	124	109	118
60	113	125	138	121	117	112	147	137	120	131
70	127	159	154	131	133	127	167	154	133	149
80	144	199	161	145	152	144	193	179	145	174
90	169	251	198	165	175	169	233	215	168	225
FBP	189	251	225	202	198	190	245	251	185	232
TR	99%	95%	97%	99%	96%	98%	97%	96%	99%	96%

Table 6. Results of distillation profile of the reference Gasoline samples.

Vol distilled (ml)	**Recovery temp. (°C)**
IBP	39
10%	56
20	64
30	74
40	85
50	98
60	115
70	128
80	142
90	162
FBP	193
TR	99%

Note: IBP, Initial Boiling Point; FBP, Final Boiling Point; TR, Total Recovery.

The density measurements in most cases are higher than the reference samples. This indicates the presence of components of higher densities being mixed and the fact that the degree of adulteration probably differs from pump station to pump station in the city. The presence of heavier hydrocarbon in the fuel shifted the distillation charactesitics, esspecialy the tail-end volatility of the fuel towards higher temperature. It worth mention here that there could be fluid or fluids other than kerosene might be used for adulteration of petrol. The physical property of the mixture indicated that very high possibility of gasoline being adulterated in order of 20-25% by volume.

The research has shown that most of the Gasoline samples from the area under study are adulterated with low grade or partially refined petroleum products. There are several petroleum products available in the city, which are close substitute of gasoline, but are available at considerable lower prices (Annex 4).This act is capable of altering the chemical and behavioural characteristics of the Gasoline under investigation as some of the investigated samples varied widely in chemical characteristics from the reference sample obtained from the laboratory of Ethiopian Petroleum Supply Enterprise. Adulterated gasoline reduces the viscosity of lubricating oil as it has dilution effect on the oil which may lead to high rate of engine wear and poor performance**.**

4.2 Results of petroleum stations

4.2.1 Demographic Data

Table 7: Summar of Demographic Data

Variat	**Mean**	**Max**	**Min**
Gendeı			
Age	**32**	**53**	**24**
Experi	**9**	**21**	**3**

All of the respondents were male. The researcher had tried female respondents on the research and few were given the questionnaire but they did not give it back. As the data indicates, most of the respondents are youngsters who are working at different positions in different stations. Respondent have wider range of experience from three years upto twenty one.

4.2.2 Petroleum stations awareness on adulteration problem

Petroleum stations awareness result on the existence of adulteration problem demonstrated that 81% of the respondents replied as ‘yes’ confirming their knowledge to the problem existence. 21% of the respondents’ perception is against the problem existence. Regarding respondent’s position on supervision as a means to solve the problem, 56.25% of them are against it. But the remaining 43.75% agree on supervision as a means to solve the problem of adulteration.

4.2.3 Factors contributing to adulteration problem

From the different factors that contribute to adulteration of petroleum products; 68.75% of the respondents put consumers’ awareness as the primary or secondary contributor to adulteration. 9 out of 16 (56.25%) respondents believe that the current selling price gap between gasoline and kerosene is the primary or secondary factor for gasoline adulteration contribution. Regulations and legal penalties weakness was chosen by 18.75% of the respondents as the primary contributor to adulteration. Stations took poor supervisory capability and Product distribution systems are only taken as secondary or tertiary and beyond contributor to adulteration problem.

4.2.4 Quality control parameters

25% of the respondents believe measuring Density@20^{0}C is enough quality control parameter during product transaction. However 75% of the respondents replied that Density@20^{0}C is not enough as quality control parameter. Even though most of the respondents do not accept Density@20^{0}C as a single comprehensive parameter, Only 2 out of 16 respondents use color (visual inspection) as additional quality parameter. But all of the respondents did not mention additional quality parameter beyond color and visual inspection.

4.2.4 Regulatory Body Supervision

The maximum number of supervision that had been made by supervisory body is 3 times per year. It was a single station that was visited at such frequency. 75% of the stations were supervised one or two times per year. Three of them (18.75%) were not visited at all . The entire respondent gave a ‘none’ answer to the question ‘does regulatory body gives feedback to the result of its supervision?’

4.3 Results of salon vehicle drivers

4.3.1 Demographic Data

Table 12: Summar of Demographic Data

Variables	Mean	Max	Min
Gender			
Age	28	49	20
Experience	11	19	2

Out of the sixteen respondents two of them are females. As the data indicates, most of the respondents are youngsters. Respondent experience ranges from two to nineteen years.

4.3.2 Salon Vehicles drivers awareness on adulteration problem

The result of salon vehicle drivers perception about the existence of adulteration problem revels that significant portion (37.5%) of the respondents do not know the existence of the problem. Regarding supervision as a means to solve the problem of adulteration, 87.5% of the respondents are positive to supervision activity. This shows that even some of the respondents who believe adulteration is not the city’s problem do accept supervision as a means to solve the problem. 1 out of the sixteen respondents is against supervision and the remaining 1 respondent decline to give response to the question.

4.3.3 Quality control parameters

Two salon vehicle drivers had encountered engine problem three times that is directly related to quality of MGR they used. 25% of the respondents could not confirm whether they had encountered the problem or not by saying ‘ I do not know’ or ‘-’. As it is shown on the data only 12.5% of the respondents had identified the problem themselves. 44.75% of them were able to know the engine problem was from the MGR by the help of their mechanic or expert. One respondent out of the sixteen was taken a practical measure not to encounter the problem again by saying that ‘he had gone to court’ and the case is still ongoing.

4.3.4 Salon vehicle drivers result on factors contributing to adulteration problem

Most of the salon vehicle drivers (81.25%) have chosen selling price gap between gasoline and kerosene as the primary or secondary contributor to adulteration of MGR in Addis Ababa. One third of drivers have put Regulations and legal penalties weakness, as a primary contributor to adulteration problem. 68.75% of them put Consumers awareness as the least contributor factor to the problem by giving the fourth and fifth place.

4.4 Factors contributing to adulteration

4.4.1 Selling price difference between gasoline and kerosene

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

Financial incentives arising from differential taxes are generally the primary cause of fuel adulteration. In Ethiopia, gasoline carries a much higher tax than diesel, which in turn is taxed more than kerosene. 81.25% of salon vehicle drivers believe that, adulteration of gasoline is indulged primarily due to the significant price difference between these products and the adulterant. Currently the price of gasoline is 18.78 birr/liter and the price of kerosene is 13.85 birr/liter. The selling price difference between gasoline and kerosene is 4.93 and the profit margin that retailing companies are allowed to make is 0.04cents/liter (Annex 6). This is the margin which had been set for the last three decades without change (EPE, 2010). According to some respondents of petroleum stations, gasoline retailing by this margin is not profitable as the product is volatile.

The consumption of kerosene is increasing alarmingly for the last 3 years. Before three years ago, the MGR consumption was greater than kerosene consumption but starting from 2012, the reverse is true (Annex 5). On the other hand the use of kerosene especially in urban is becoming substituted by electric stove, though no research is found on the rate and level of substitution.

4.4.2 Absence of strong regulatory body

The surprise inspection which was done by MoWE and EPE before three years ago has a frequency of three inspections per year. The result of inspection that particular year shows that 15% of the samples were adulterated. The same activity which was done on the following year by the same organization has a frequency of 2 inspections per year. The percentage of samples that were found to adulterate was increased to 25%. Such inspection has not being done for the last twenty months. However, the results of samples taken for this particular research shows more than 70% of the sample were adulterated. This shows that as the number of inspection increases the level of adulteration decreases assuming other parameter being constant.

Any anti-adulteration programme should be backed up by sound financial and legal framework. The fiscal framework should take into account-associated costs like monitoring & testing infrastructure. Policy for imposing severe penalty & exemplary punishment to the adulterators needs to be imbibed into legal framework to discourage adulteration (c.o.o, 2011).

4.4.3 Consumers awareness

Firms have a strong incentive to engage in adulteration because of consumers' difficulty in detecting the abuses and because of the potential for substantial profit. Besides imposing direct costs on the buyers, many of these practices have external costs. Controlling the abuses requires an enforcement regime (Anumita, 2002). Moreover, petroleum products being complex hydrocarbon mixtures with batch-to-batch variations, certain inevitable mixing between different batches in transit and in storage, availability of wide variety of adulterants, and the detection methods may not be easy. Therefore to ensure that the engine can give the desired performance including low emissions, it is necessary to ensure the fuel quality at the consumer end, which can be achieved by appropriate surveillance programs.

The result of salon vehicle drivers perception about the existence of adulteration problem revels that significant portion (37.5%) of the respondents do not know the existence of the problem.

4.4.3 Econometric analysis

$$\mu_{x1-n}=\beta_0+ \beta_1 X_{1i}+ \beta_2 X_{2i}+ \varepsilon$$

where:

$\mu_{x1-n=}$ the level of adulteration

β_0 = y-intercept {a constant value}

β_1 = slope of Y with variable x_1 holding the variables x_2, x_3, ..., x_P effects constant

β_2 = slope of Y with variable x holding all other variables' effects constant

X1i= Quantity of MGR purchased for the last three years

X2i= Quantity of Kerosene purchased for the last three years.

A multiple linear regression was conducted with the following predictor variables: Quantity of MRG supplied to the Addis Ababa market, Quantity of Kerosene supplied to the Addis Ababa market and rate of supervision made by the regulatory body on fuel stations. The model produced an R^2 of 0.969 which was statistically significant ($F_{7,107}$=3.158, p<0.05). The quantiy of kerosene purchased positively related to adulteration (B=1.96, t=11.98, p<0.05) and the rate of supervision and the quantity of MGR purchased is negatively related to adulteration. The results of the regression analysis are shown in Table 11.

Table 11: The values for independent variables and dependent variable

	Independent variables			Dependent variable
S/n	Mgr con	Kerosen q	Rate of supervision	Adulteration (y)
1	2,316,902,081.00	2,249,419,496.12	3	337,412,924.42
2	2,006,179,214.00	1,947,746,809.71	3	292,162,021.46
3	1,986,469,424.00	1,928,611,091.26	3	289,291,663.69
4	754,816,274.00	732,831,333.98	3	109,924,700.10
5	264,972,193.00	257,254,556.31	3	38,588,183.45
6	45,921,895.00	44,584,364.08	3	6,687,654.61
7	11,038,784.00	10,717,266.02	3	1,607,589.90
8	7,037,106.00	6,832,141.75	3	1,024,821.26
9	1,404,605.00	1,363,694.17	3	204,554.13
10	7,394,741,576.00	7,179,360,753.40	3	1,076,904,113.01
11	2,432,747,185.05	2676809200	2	669,202,300.09
12	2,106,488,174.70	2317818704	2	579,454,675.89
13	2,085,792,895.20	2295047199	2	573,761,799.65
14	792,557,087.70	872069287.4	2	218,017,321.86
15	278,220,802.65	306132922	2	76,533,230.50
16	48,217,989.75	53055393.25	2	13,263,848.31
17	11,590,723.20	12753546.56	2	3,188,386.64
18	7,388,961.30	8130248.68	2	2,032,562.17
19	1,474,835.25	1622796.068	2	405,699.02
20	7,764,478,654.80	8543439297	2	2,135,859,824.14
21	2,676,021,903.56	3185402948	0	1,592,701,474.23
22	2,317,136,992.17	2758204257	0	1,379,102,128.61
23	2,294,372,184.72	2731106166	0	1,365,553,083.17
24	871,812,796.47	1037762452	0	518,881,226.02
25	306,042,882.92	364298177.2	0	182,149,088.60
26	53,039,788.73	63135917.97	0	31,567,958.99
27	12,749,795.52	15176720.41	0	7,588,360.21
28	8,127,857.43	9674995.929	0	4,837,497.96
29	1,622,318.78	1931127.321	0	965,563.66
30	8,540,926,520.28	10166692763	0	5,083,346,381.44

	Coefficients Standard Error	t Stat P-value
Intercept	45,303,480.13	0.657991329
	68851181.08	0.5163
MGR CON	-1.785060583	-9.925215372
	0.179851068	0.0000
KEROSEN Q	1.955854446	11.97697509
	0.163301203	0.0000
RATE OF SUPERVISION	-28532949.8	-0.867883708
	32876466.67	0.3934
R Square	0.969805625	
Adjusted R Square	0.966321659	
Standard Error	188064152.9	
Observations	30	
F	278.3625132	
Significance F	0.00000	

Regression coefficients: The positive regression coefficient indicated (β_2 =1.96) that there was a positive relationship between the explanatory variable i.e the quantity of kerosene supplied and the ordinal outcome which is adulteration. For the opposite direction, the negative regression coefficient indicated that there was a negative relationship between the quantity of MGR supplied and adulteration.

$$\text{Y-hat} = 45,303,480.13 - 1.785060583X_1 + 1.955854446X_2$$

Where: X_1= Quantity of MGR supplied to Addis Ababa market

X_2= Quantity of Kerosene supplied to Addis Ababa market

For each incremental increase in quantity supplied of kerosene, for a given frequency of supervision, the quantity supplied of MGR drops by 1.1 ltr

Chapter V

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and conclusions

Adulteration of automotive transport fuels at the point of sale and during transportation has become an acute problem in Addis Ababa. Sample taken as a surprise to see the status of the problem confirmed that 70% of the samples taken from ten petroleum stations of different companies are found to be adulterated. There are different factors contributing to adulteration of gasoline in the city. The quantities of MGR and Kerosene supplied to the Addis Ababa market as the selling price difference between gasoline and kerosene is widening, and the supervision made by regulatory body expressed as the frequency of supervision per station per year are contributing factors investigated by this research. As the selling price gap between gasoline and kerosene is increasing for the last three years and the rate of supervision by regulatory body is decreasing within the same period, gasoline adulteration has increased from 15% up to 50% of product being adulterated supplied to consumers. Regarding consumers awareness, petroleum stations have better awareness than consumers. 81% of the stations replied ‘yes’ to the problem existence. But almost 44 % of consumer is not aware of the problem existence. 56.25% of Petroleum stations position is against on supervision as a means to solve the problem. The stations are looking for different means of tackling adulteration than the usual inconsistent supervision. Unlike petroleum stations almost one third of drivers have put Regulations and legal penalties weakness, as a primary contributor to adulteration problem. A multiple linear regression which was conducted with predictor variables, quantity of MRG and Quantity of Kerosene supplied to the Addis Ababa market and rate of supervision made by the regulatory body on fuel stations, showed that For each incremental increase in quantity supplied of kerosene, for a given frequency of supervision, the quantity supplied of MGR drops by 1.1 ltr.

5.2 Recommendations/Policy Implications

Conscious and systematic efforts can reduce adulteration to a great extent. Some of the possible measures are enlisted as follows.

The research finding indicates that as the rate of supervision increases, adulteration decreases. Therefore consistent supervision by regulatory body is recommended. As the surprise sample checking results from 10 stations shows, 70% of the samples were found to be adulterated.

Rigorous surprise checking of samples from pumps should be carried out independently. This approach makes stakeholder participate in minimizing the problem of adulteration. Regulatory body usually being a single one and with limitations of infrastructure and skilled manpower would become challenging to solve the problem alone.

75% of the respondents replied that Density@20^{0}C is not enough quality control parameter during product transfer. Therefore Additional quality parameters which are easy to apply needs to be implemented to differentiate adulterated products from the normal onces.

Awareness: Significant percent of consumers (44%) are not even aware of the existence of the problem. Consumer organizations at city or nationwide with necessary support of concerned authorities can serve to protect consumers interest or even as watchdog to check adulteration.

For each incremental increase in quantity supplied of kerosene, for a given frequency of supervision, the quantity supplied of MGR drops by 1.1 ltr. Therefore EPSE needs to consider adulteration as one input besides companies demand request in the supply of both products to the Addis Ababa market.

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7. APPENDICES

Annex-1

1. Technical specifications of MGR marketed in Ethiopia 2010.

PROPERTY	ASTM/IP TEST METHOD	LIMITS
N -octane	D-2699	Min. 91
Reid Vapor Pressure at 37.8°c, KPa	D-323	Max. 69
Initial Boiling Point,°c	D-86	-
10 % Vol. recovered,°c	D-86	Max. 70
50 % Vol. recovered,°c	D-86	77-121
90 % Vol. recovered,°c	D-86	Max.190
Final Boiling Point,°c	D-86	Max. 225
Residue,%vol	D-86	Max 2
Density at 15°c,g/mL	D-1298	0.705-0.74
Lead Content,g/l	CALC	Max. 0.013
Color (Dyed)	Visual	Yellow/ Orange
Total Sulfur ,%wt	D-1266	Max 0.10
Doctor Test (1)	IP-30	Negative
Oxidation Stability Induction Period at100 °c, minutes	D-525	240
Copper corrosion, 3Hr@50°c	D-130	Max No.1 strip
Gum Existent ,mg/100mL	D-381	Max 4

Source: - Ethiopian Standard Agency (ESA, 2010)

Annex-2

St. Mary University College

School of Graduate Study

MBA thesis fulfillment

Questionnaire: - to evaluating the quality control of gasoline product against adulteration and factors contributing to quality control of gasoline; the case of Addis Ababa city administration.

Dear respondents, this questionnaire is prepared to collect information or to obtain your feedback about gasoline quality control and the contributing factors to adulteration of the product. You are therefore, kindly requested to provide your answer with the degree of seriousness which the purpose deserves for. Please, be free to provide your genuine responses and all your responses are secured from any consequence. The questionnaire should take you approximately 20 Minutes to complete.

Thank you for your cooperation.

I. Demographic Data

Name ______________________________

Gender male _____ female______

Age a. 20-30 b. 30-40 c. 40-50 d. >50

For how long you have been driving the car?

a. <5 b. 5-10 c.11-15 d.16-20 e.>20

II. Specific questions to Petroleum Stations.

1. Do you think gasoline adulteration is a problem in Addis Ababa?

   a. Yes b. No

2. Do you think supervision on gasoline product quality has impact on the product quality?

   a. Yes b. No

3. For how long have you been retailing gasoline product?

4. From the following factors which one contributes to adulteration of gasoline most? Please put them in their order of priority from highest to least contributor.

a. Selling price gap between gasoline and kerosene.

b. Poor supervisory capability (Regulatory body capability)

c. Product distribution system (only truck is available)

d. Consumers awareness on adulteration problem

e. Regulations and legal penalties weakness.

f. If any other…. Please specify

5. What quality parameters do you measure while you receive the gasoline delivered to your station?

6. Do you think measuring Density@20^{0}C is enough to maintain quality of gasoline?

7. How many times per year do supervisor from the regulatory body visit your station?

8. How many times per year does supervisor from the regulatory body give feedback to the result of supervision?

Thank you!

III. Specific questions to Salon Vehicles Drivers

1. Do you think gasoline adulteration is a problem in Addis Ababa?

a. Yes b. No

2. Do you think supervision on gasoline product quality has impact on the product quality?

a. Yes b. No

3. How many times did you encounter engine problem that is directly related to gasoline quality problem.

4. Who had identified the 'engine problem is directly related to gasoline quality'?

a. yourself b. experts (mechanic) c. others

5. What measures did you take not to encounter the problem again?

6. From the following factors which one contributes to adulteration of gasoline most?

Please put them in their order of priority from highest to least contributor.

a. Selling price gap between gasoline and kerosene.

b. Poor supervisory capability (Regulatory body capability)

c. Product distribution system (only truck is available)

d. Consumers awareness on adulteration problem

e. Regulations and legal penalties weakness.

f. If any other…. Please specify.

Thank you!

Annex 3

Petroleum stations and parent companies surveyed on the research

S/N	Station	Company
1	Kera	NOC
2	Kolfe Edile Business Center	NOC
3	Mebrat Haile	NOC
4	Sunshine	NOC
5	Lideta Dilbelay	Oilibya
6	Ras Tesemma	Oilibya
7	Old Airport	Oilibya
8	EthioNippon	Oilibya
9	Kera	TOTAL
10	Amanuel Ergoye Abdulkadire	TOTAL
11	Kolfe Road Bizunesh Endalemahu	TOTAL
12	Hiwot Yehualashet	TOTAL
13	CMC	YBP
14	Kolfe Fincha Transport	YBP
15	Kampo Etu	Kobile
16	Gotera	Kobile

Annex 4

1. Chemicals/Solvents which used as adulterants of gasoline.

SL.	Solvent/Chemical
1	Naphtha
2	SBP
3	GAIL Solvents
4	GAIL Solvents
5	Pentane
6	Cixon
7	Solvent-90
8	Hexane
9	Resol
10	Raffinate/Slop
11	C6-C9 Raffinate
12	Naphtha/NGL
13	PDS Kerosene
14	Free Kerosene
15	MTO
16	Pyrolysis Gasoline
17	Oxygenates
18	Food grd. Hexane
19	Benzene
20	Toluene

Source: Ethiopian Petroleum Supply Enterprise

Annex 5

Quantity of Petroleum Products (Ltr) and % share from total volume sold (2010-2012)

Product Type	Sales Volume	% share from the total volume
Motor Regular Gasoline/ MGR	632,320,455	8.55%
Automotive Gas Oil/AGO	4,281,074,952	57.89%
Kerosene	932,722,283	12.61%
Jet A-1	1,134,426,131	15.34%
Light Fuel Oil	86,187,003	1.17%
Heavy Fuel Oil	328,010,752	4.44%
Total	7,394,741,576	100%

Source: Ethiopian Petroleum Supply Enterprise Annual Budget Report.

Annex 6
Petroleum Price Buildup

የኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ
የንግድ ሚኒስቴር

The Federal Democratic Republic of Ethiopia
Ministry of Trade

ቀን 30 ሰኔ 2004
Date

ቁጥር 01-1-22-9/383
Ref. No.

ለሊቢያ ኦይል ኢትዮጵያ ሊሚትድ
ለቶታል ኢትዮጵያ አክሲዮን ማኅበር
ለናሽናል ኦይል ኢትዮጵያ ኃላፊነቱ የተወሰነ የግል ኩባንያ
ለተባበሩት ብሔራዊ ፔትሮሊየም አክሲዮን ማኅበር
ለኮቢል ኢትዮጵያ ሊሚትድ
ለናይል ፔትሮሊየም ካምፓኒ ሊሚትድ
ለዋዲ አልሱንዱስ ፔትሮሊየም ካምፓኒ
ለታፍኦይል ኃላፊነቱ የተወሰነ የግል ኩባንያ
ለዳሎል ኦይል አክሲዮን ማኅበር
አዲስ አበባ

ጉዳዩ፡- የነዳጅ ዋጋ ግንባታ መረጃን ስለማሳወቅ

በርዕሱ እንደተገለፀው ከሐምሌ 1 ቀን 2004 እስከ ሐምሌ 30/2004 ዓ.ም ድረስ ተግባራዊ የሚደረገውን የነዳጅ ዋጋ ግንባታ አስመልክቶ በዋጋ ግንባታው መረጃዎችን ከዚህ በታች ባለው ሠንጠረዥ ቀርቧል፡፡

የአዲስ አበባ የነዳጅ ምርቶች የዋጋ ግንባታ ላይ የተያዙ የተለያዩ ወጪዎች

ሣንቲም/ሊትር

ተ.ቁ	የተለያዩ ወጪዎች	ኢታኖል ቤንዚን ድብልቅ ነዳጅ	ኬሮሲን	ነጭ ናፍታ	ቀላል ጥቁር ናፍታ	ከባድ ጥቁር ናፍታ	ጄት ፊውል
1	የኩባንያዎች መግዣ ዋጋ	1825.80	1290.55	1596.29	1386.23	1336.24	1915.89
2	አዲስ አበባ - ሱሉልታ	2.30	-	-	-	-	-
3	ጅቡቲ - አዲስ አበባ ማጓጓዣ	85.10	85.10	85.10	92.76	92.76	85.10
4	የኩባንያ የትርፍ ሕዳግ	7.24	5.35	5.60	5.00	5.00	14.00
5	የነዳጅ ማደያዎች የትርፍ ሕዳግ	4.00	4.00	4.00	-	-	-
6	የችርቻሮ መሸጫ ዋጋ	1878.00	1385.00	1691.00	1484.00	1434.00	2015.00

ኢታኖል ያልተደባለቀ ቤንዚን የትርፍ ሕዳግ 6.10 ሣንቲም/ሊትር መሆኑን እንገልጻለን፡፡ :

ከሠላምታ ጋር

አሊ ሲራጅ
ሚኒስትር ዴኤታ

እንዲያውቁት፡-

- ለኢንስፔክሽንና ሬጉላቶሪ ዳይሬክቶሬት
  ንግድ ሚኒስቴር