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Field and Laboratory Analysis of Petroleum Products in Four Local Government Areas of Delta Central Senatorial Districts of Delta State

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ABSTRACT

Adulteration of petroleum products is referred to as the practice of adding cheaper, lower quality substances to petroleum products to increase volume, decrease production costs or enhancing certain properties. This can include mixing additives to modify its properties. Adulteration compromises the quality and performance of petroleum products and may even lead to environmental and health hazards. It has led to loss of lives, health problems, damaged of vehicles, loss of houses/homes, loss of livelihood, pollution of the air due to tail-pipe emission, significant loss of tax revenue etc. It is often illegal as a result, there is are government regulatory agencies. The detection of adulterated petroleum fractions are experimentally determined by analysis of physiochemical properties which is done in compliance with known regulatory standard. The focus is on physio-chemical properties on two (2) petroleum products (PMS and AGO) samples were collected from filling stations (owned by both independent marketers and major marketers) and black marketers situated at the Head-quarters of the four(4) Local Government Areas Delta Central Senatorial District of Delta State. The physiochemical properties carried out were: specific gravity, API gravity, viscosity, flashpoint, cloud and fire point. All these were in accordance with the American Society's standard process for testing and materials (ASTM). In the final analysis from the result, it is evident that most of the sample obtained from the various petroleum stations /outlets from the areas under study meets the standards. More so, those from the black market and artisanal. But for Diesel and kerosene there is a slight variation from the ASTM standard. This therefore can be infrared that there is adulteration of the products.

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1. INTRODUCTION

Petroleum is processed by distillation in oil refineries to get different products which include petrol or gasoline (Premium Motor Spirit, PMS), kerosene (House Hold Kerosene, HHK), diesel (Automotive Gas Oil, AGO), asphalt and chemical reagents used to make plastics and pharmaceuticals. These products are essentially for transportation, energy generation and manufacturing across industries. The major use of petroleum products is as a fuel (gasoline, jet fuel, heating oil). Other uses of petroleum products in our everyday lives include plastic (used almost everywhere, in cars, houses, toys, computers and clothing), asphalt (used in road construction), synthetic rubber (for tires), paraffin wax, fertilizers, pesticides, herbicides, detergents, photographic film, furniture, packaging materials, surfboards, paints and artificial fibers(used in clothing, upholstery, and carpet backing).

Nigeria oil sector can be can be categorized into upstream, midstream and down stream segments. The upstream involves the exploration, drilling and production of crude oil. Companies operating in this segment search for oil reserves, drill wells, and extract crude oil from underground reservoir. Nigeria is a significant player in the upstream sector, with oil production being a crucial part of its economy. The Midstream segment involves the transportation and

storage of crude oil. It includes activities such as pipeline transportation, shipping and storage terminals. Nigeria has an extensive network of pipeline and terminal transporting crude oil from production sites to refineries and export terminals. The downstream sector involves refining crude oil into petroleum products and distributing them to consumers. This includes activities such as marketing and retailing of gasoline, diesel and others petroleum products. Nigeria has several oil refineries that process crude oil into various products for domestic consumption and export.

In Nigeria, possible causes of adulteration of petroleum products can occur due to various reasons which includes;

Economic Gain: adulterating petroleum products with cheaper substances allows fraudsters to increase profit by selling lower quality products at the price of higher quality ones.

Supply Shortages: During periods of high demand or supply shortages, unscrupulous individuals may dilute petroleum products to stretch available supplies and meet demand, albeit with lower quality

Lack of Regulation; Weak regulatory enforcement or loopholes in regulatory frameworks can encourage illegal activities such as adulteration, as perpetrators may believe the can evade detection and penalties

Cost-cutting measures: some manufacturers or distributors may adulterate petroleum products as a cost-cutting measure to reduce production expenses, compromising product quality and safety in the process.

Ignorance or Negligence in some cases: Adulteration may occur dues to ignorance or negligence regarding proper handling and storage procedures, leading to unintentional contamination of petroleum products.

Criminal Activities: organized crime groups may engage in the adulteration of petroleum products as part of larger illicit activities such as smuggling and trafficking.

Adulteration have adverse hazard on health environment and engines.

The health risks: Adulterated Petroleum products can contain harmful substances that pose health risks to consumers, these substances may lead to respiratory problems, skin irritation or other adverse health effects, especially when used in vehicles or machinery

Environmental Damage: adulterated petroleum products can release pollutants into the environment,, contributing to air and water pollution, improperly formulated fuels may produce higher emission of harmful pollutants such as sulfur dioxide, nitrogen oxides and particulate matter leading to environmental degradation and health hazards

Engine Damage: Adulterated fuels can damage vehicle engines and machinery leading to reduced performance, increased maintenance costs, and potentially catastrophic failures. Contaminants in adulterated fuels can clog fuel injectors, corrode engine components and cause premature wear and tear.

Economic Losses: Adulteration undermines the integrity of the petroleum supply chain, erodes consumer confidence and can lead to economic losses for legitimate businesses. It also results in increased healthcare costs environmental remediation expenses and decreased productivity due to equipment downtime and repairs

Legal Consequences: Adulteration of petroleum products is illegal in many jurisdictions and can result in legal consequences for individuals and business involved in the illicit activity. Penalties may include fines, imprisohment and forfeiture of assets.

Reputation Damage: companies found to be selling and adulterated pettoleunm products risk damaging their reputation and losing the trust of consumer and stakeholders. Rebuilding reputation can be lengthy and costly process

1.1. STUDY AREA UNDER REVIEW

This study is on field and laboratory investigations of physio-chemical properties on two (2) petroleum products (PMS and AGO) samples collected from filling stations (owned by both independent marketers and major marketers) and black marketers situated at the Head-quarters of the four(4) Local Government Areas Delta Central Senatorial District of Delta State, Nigeria.

Delta State was created 27 August, 1991 and is one of the thirty six states (36) in Nigeria. It is an oil and agricultural producing state that is situated in the region known as the South-South geo-political zone of Nigeria with a population of 4,112,445 (males: 2,069,309; females: 2,043,136) (National Population Commission, 2006) The capital city is Asaba, located at the northern end of the state, with an estimated area of 762 square kilometres (294 sq mi). The state covers an estimated landmass of 18,050 km^2 (6,970 sq mi). The state lies approximately between 5°00' and 6°45' E and 5°00' and 6°30' N (Ebowore, 2020). The state consists of twenty five (25) Local Government Areas and they are spread among the three (3) three Senatorial districts thus: Delta Central (8 Local Government Areas) which are Ethiope East,

Ethiope West, Okpe, Sapele, Ughelli South, Ughelli North, Udu and Uvwie, Delta North (9 Local Government Areas), and Delta South (7 Local Government Areas)

1.2. OBJECTIVE:

The objective of this work is to determine the physiochemical properties to be carried out are specific gravity, API gravity, viscosity, flashpoint, fire point, cloud point and pour point values of the Samples from major petroleum station (NNPC), individual petroleum stations, black market and local artisanal in comparison with the ASTM standard if they are adulterated and to what degree, Major causes of adulteration and recommend appropriate remedies aim at eradicating or reduce it to the barest minimum.

2. LITERATURE REVIEW

Adulteration is the introduction of a foreign undesirable substance to a substrate which affects the quality of the substrate. Premium Motor Spirit (PMS), House Hold Kerosene (HHK) and Automotive Gas Oil (AGO) can be adulterated by blending with less expensive petroleum products such as condensates or used lubricants.

Premium Motor Spirit (PMS) also known as petrol or gasoline is one of the products of fractional distillation of petroleum. This product is in high demand in the developing countries as a result of their inability to refine enough quantities of the product to meet the consumers' need. Petrol or gasoline with boiling range 40-200°C(consists 5 to 12 carbon atoms) is a complex mixture of hydrocarbons produced by mixing fractions obtained from the distillation of crude oil with brand-specific additives to improve its performance.

Additionally, the specific composition of gasoline results in a high energy density. This high energy density is what makes gasoline such a valuable fuel, as a relatively small volume of fuel can provide a large amount of useful energy.

Petrol is a transparent, petroleum-derived liquid that is used primarily as a fuel in internal combustion engines.

Petrol adulteration involves blending it with less expensive petroleum products such as condensates, AGO or used lubricants (Sukdev, 2002). The primary cause of adulteration is the intention of maximizing profit orchestrated by differential tax system. The fact that adulteration of PMS with AGO is difficult to detect, combined with the differential tax structure makes such adulteration financially rewarding, even though it is illegal (Osueke and Ofondu, 2011).

House Hold Kerosene (HHK) also known as Kerosene is a combustible hydrocarbon liquid (Anon, 2009). The early production of kerosene was distilled from oil extracted from shale and bitumen (Zayn, 1995). Today, kerosene is distilled in modern refineries as one of the numerous products of crude petroleum oil. It is called kerosene in Nigeria and paraffin in some countries. Kerosene is of two grades; the domestic kerosene which is called the House Hold Kerosene (HHK) and the jet kerosene which is called the Aviation Technical Kerosene (ATK). This study is on HHK and it was simply called kerosene except where clarification became imperative. Kerosene is a colourless thin mineral oil which density varies between 0.75 and 0.85 g/cm3. It has been described as a mixture of carbon that contains between 6 and 16 carbon atoms molecule. While kerosene is miscible in petroleum solvents, it is not miscible in water. The flash point of kerosene is between 37°C and 65°C and its auto ignition temperature is 220^0C (Anon, 2009). The volatility of kerosene is very low. it produces unpleasant smell and emits fumes which becomes poisonous in insufficient concentration.

Kerosene has many uses. In Nigeria, it is the main fuel used for cooking and lighting especially by the poor, who are in the majority, as an alternative to electricity and gas. Other uses include fire breathing, fire juggling and fire dancing in the entertainment industry for fire performances because of its low flame temperature when burnt in free air, powerful antidote for snakebites, poured on the surface of stagnant pond of water as local insecticide, local disinfectant to treat cuts, burns, athlete foot, ring worm, hemorrhoids and stop bleeding, as a solvent in engineering for the removal of hard mucilage, candle wax on glass, degreaser and lubricant for cutting glass, machining aluminum and it alloys. Kerosene only expands and contracts very slightly with ambient temperatures. Since it is less volatile, expands and contracts very slightly at ambient temperature, it is safe to store it in plastic containers and any steel tank which is provided with a vent or some head space left in the tank (Miles, 2011). Kerosene may be adulterated by adding other liquids which may be miscible or immiscible.

Automotive Gas oil (AGO), also known as diesel, is generated from crude distillation process. Diesel is obtained in the mid-boiling range of the distillation process of crude oil. The average chemical formula for common diesel fuel is $C_{12}H_{23}$, ranging approximately from $C_{10}H_{20}$ to $C_{15}H_{28}$ (*Date, 2011)*. Diesel is used to efficiently power internal combustion diesel engines like road vehicles (trucks, buses, vans and cars). It can also be used to power generators.

AGO when used by road vehicles, its ignition takes place, without any spark, as a result of compression of the inlet air mixture and then injection of fuel. Therefore, diesel fuel needs good compression ignition characteristics.

Diesel fuel is mostly used in high-speed diesel engines, especially motor-vehicle (e.g. car, lorry) diesel engines, but not all diesel engines run on diesel. For example, large two-stroke watercraft engines typically use heavy fuel oils instead of diesel and certain types of diesel engines, such as MAN M-System engines, are designed to run on petrol with knock resistances of up to 86 RON. On the other hand, gas turbine and some other types of internal combustion engines, and external combustion engines, can also be designed to take diesel fuel.

Neff, *McKelvie and Ayers, 2011, concluded that one major* disadvantages of diesel in cold climates is that its viscosity increases as the temperature decreases, changing it into gel that cannot flow in fuel systems. This makes it possible for special low-temperature diesel to contain additives to keep its liquid at lower temperatures. Poor quality diesel has been used as an extraction agent for liquid– extraction of palladium from nitric acid mixtures. Diesel is also often used as the main ingredient in oil-base mud drilling fluid.

3. Experimental Materials and Method

Sample collection

Samples of petroleum products were gathered from various sources, including a major marketer filling station, independent oil marketing filling stations, black marker sales outlets, and locally processed petroleum product sources from the Head Quarters of the eight local governments areas of Delta Central (Ughelli, Oghara Effurun and Oto-Udu and also from the Nigeria National Petroleum Corperation (NNPC) situated at Warri, Delta State and Port Harcourt, River State. These samples were then stored in clean airtight plastic containers of 5 liters each before being transported to the laboratory for analysis

3.1. Evaluation of the Sample

The physiochemical parameters analyzed, includes Specific gravity values, viscosity values, density values, flashpoint, boiling point values volatility, fire point and cloud point were determined by using the American Society's Standard processing for testing and materials(ASTM)

Questionnaires were also distributed to five (5) Independent Marketers, five (5) Major Marketers, five (5) private filling station situated at the Head Quarters of the four (4) Local Government Areas of Delta Central, Nigerian National Petroleum Corporation (NNPC) Warri and Port Harcourt, five (5) black marketers and fifty (50) consumers residing at each Local Government Area Head Quarters. The benefits led to critical review of the results gotten from the laboratory after samples have been subjected to laboratory investigations to confirm if the samples are adulterated from the determination of the physio-chemical properties which include but not limited to octane values, specific gravity values, density values, Reid vapour pressure values etc. of the samples. Comparative analysis was finally done.

3.2. Results And Discussion

Specific gravity and API gravity: The specific gravity and API gravity of gasoline, diesel and kerosene collected

Table 3.1 Result of the specific gravity and API gravity of gasoline, kerosene and diesel from different collection points.

Specific Gravity

Sample source	Gasoline	Kerosene	Diesel
Major Petroleum station	0.75	0.82	0.85
Individual Petroleum station	0.82	0.77	0.85
Black Market	0.77	0.79	0.83
Local artisanal	0.76	0.79	0.89
ASTM Standard	0.750 – 0.77	0.80 – 0.875	0.825 -0.925

API Gravity

Sample source	Gasoline	Kerosene	Diesel
Major Petroleum station	57.17	41.06	34.97
Individual Petroleum station	41.06	52.27	34.97
Black Market	52.27	47.61	38.98
Local artisanal	54.68	47.61	27.49
ASTM Standard	52.26 – 57.16	30.21- 45.38	21.47 -40.01

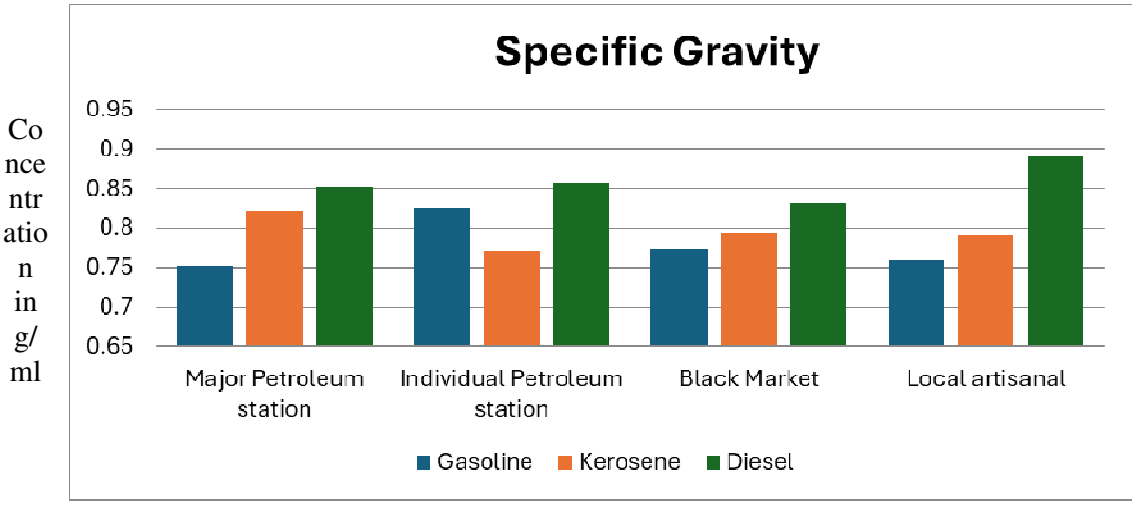

Figure 3.0 The Specific gravity of gasoline, kerosene and diesel obtained

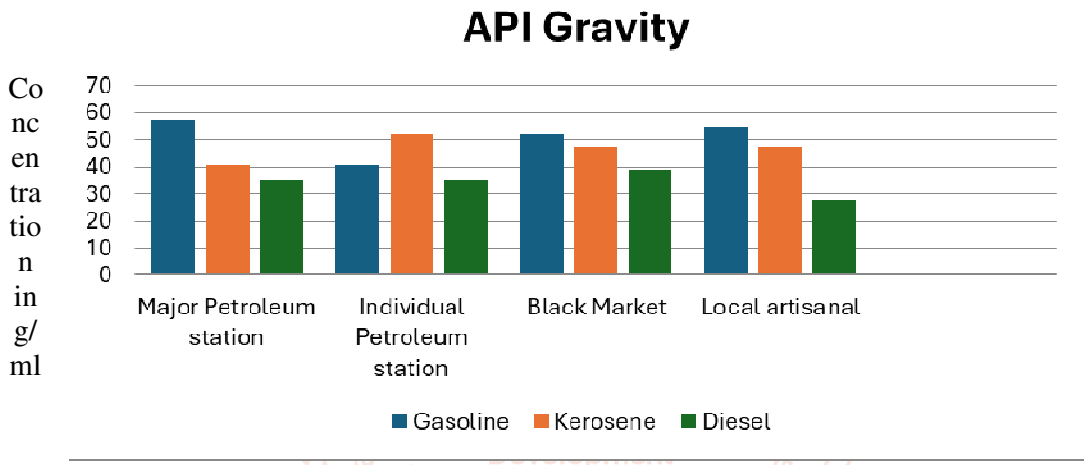

Figure 3.1 API gravity of gasoline, kerosene and diesel obtained

The four samples outlets except for gasoline sample obtained from individual petroleum station (which are slightly higher) are all within the product specification ASTM standard, while kerosene sample obtained from individual petroleum station, black market and local artisanal having specific gravity that are slightly lower than the ASTM standard.

For the API gravity for gasoline kerosene and diesel, the API gravity for gasoline sample obtained from individual petroleum stations was below the ASTM standard same as kerosene from all locations excluding major petroleum station. That of the major petroleum station have API gravity slightly higher that the ASTM standard. In comparison, with ASTM standard, they were either to lower or higher.

VISCOSITY

The viscosity of gasoline, diesel and kerosene is as shown in table 3.3 below.

The result shows that the viscosity from all petroleum stations/sales outlets(except the local artisanal are product that is within standard range) above the ASTM standard. For diesel, the viscosity recorded are above the ASTM standard.

Table 3.3: VISCOSITY OF GASOLINE, KEROSINE AND DIESEL

Sample source	Gasoline	Kerosene	Diesel
Major Petroleum station	0.67	1.99	2.79
Individual Petroleum station	1.56	1.16	4.45
Black Market	0.67	1.01	4.37
Local artisanal	0.67	5.41	10.97
ASTM Standard	0.5 - 0.84	1.0 – 1.9	1.6 -5.5

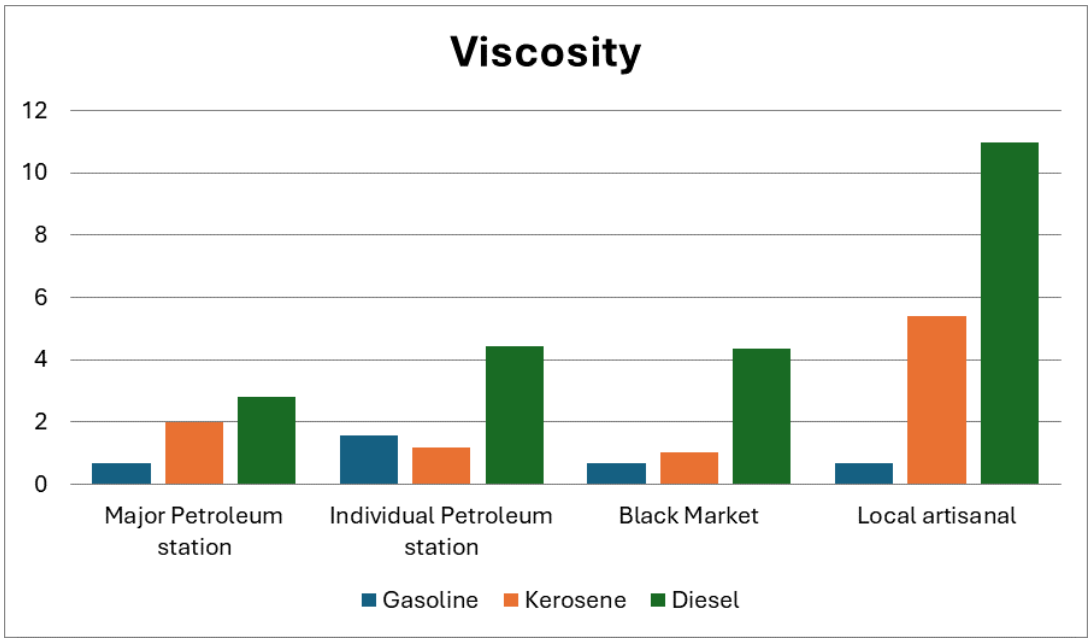

Figure 3.2 The Viscosity of gasoline, kerosene and diesel obtained

FLASH POINT AND FIRE POINT

Flash point refers to the temperature at which the fapourof a substance will ignite in the presence of an ignition source. For kerosene, the flash point typically ranges from around 38 to 74 degree Celcius (100 to 165 degrees Fahrenheit) while for diesel is between 52 to 96 degree Celcius (126 to 205 degree Fahrenheit). These values can vary depending on the specific composition and additives present in the fuel. Flash points are important for safety consideration, particularly in handling and storage, as they indicate the potential fire hazard associated with the substance

The result for flash point and fire point of the products are as shown on the table 4.0 below

Table 4. result for flash point and diesel for different petroleum stations/sales outlets.

Table 3.3: FLASH POINT FOR KEROSINE AND DIESEL

Sample source	Kerosene	Diesel
Major Petroleum station	22^0C	57^0C
Individual Petroleum station	18^0C	50^0C
Black Market	14^0C	62^0C
Local artisanal	21^0C	65^0C
ASTM Standard	38 – 72^0C	> 52-96^0C

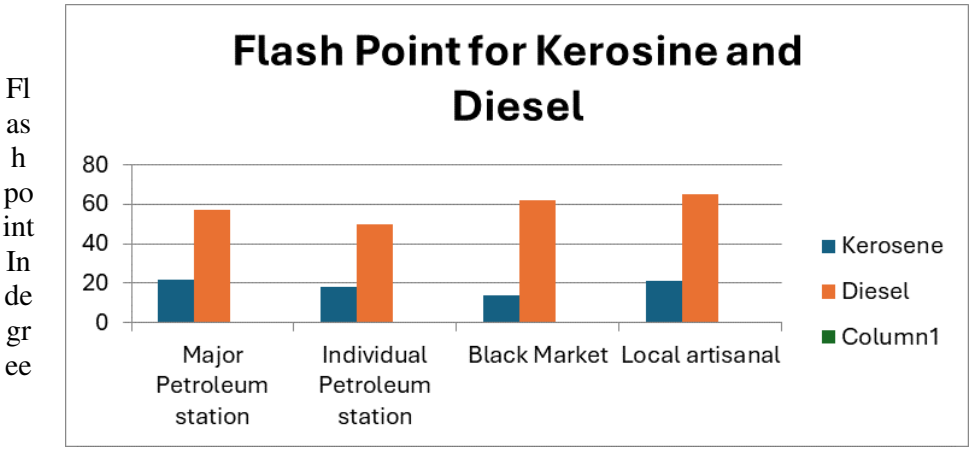

Figure 3.3 Flash Point for kerosene and diesel obtained

FIRE POINT FOR KEROSINE AND DIESEL

Fire point of substances such as kerosene and diesel is the temperature at which the vapour of the substances will continue to burn for at least 5 seconds after ignition by an open flame. It's a bit higher than the flash point, for kerosene, the fire point typically ranges from around 38 to 74 degree Celsius (100 to 65 degree Fahrenheit).while for diesel, its typically between 52 to 96 degree Celcius (126 to 205). Like flash points, these values can vary depending on the specific composition and additives present in the fuel. Fire points are also crucial for safety considerations especially in situation where prolonged exposure to high temperatures might occur.

Table 3.3: FIRE POINT FOR KEROSINE AND DIESEL

Sample source	Kerosene	Diesel
Major Petroleum station	26^0C	61^0C
Individual Petroleum station	20^0C	55^0C
Black Market	20^0C	65^0C
Local artisanal	24^0C	68^0C
ASTM Standard	$> 42^0$C	$> 60^0$C

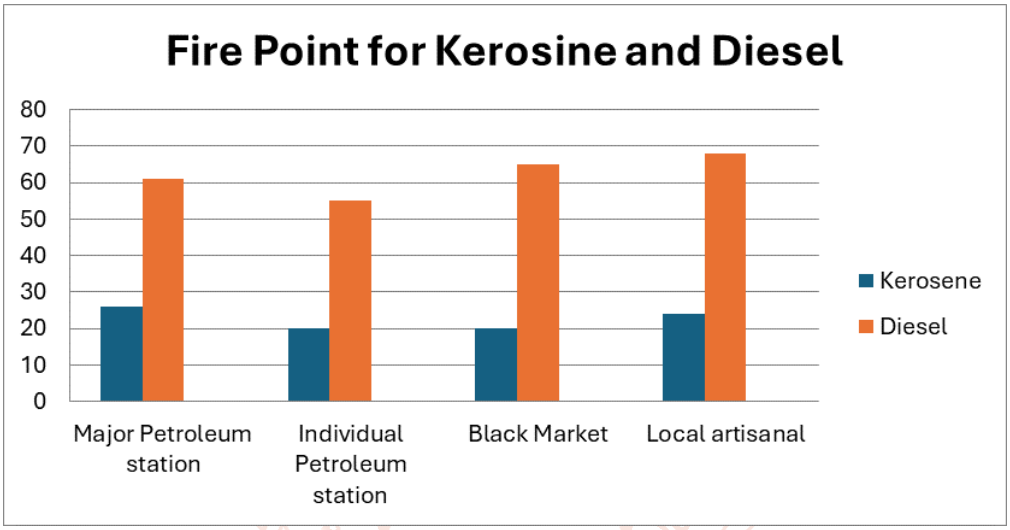

Figure 3.4 Fire Point for kerosene and diesel obtained

3.3. CLOUD POINT AND POUR POINT

Cloud point is the temperature at which solid crystals begin to form in the fuel. Causing it to become cloudy or hazy. It indicates the onset of was crystalize, which can potentially clog fuel filters and fuel lines, leading to engine performance issues. While pour point is the lowest temperature at which the fuel remains fluid enough to pour or flow. It signifies the temperature at which the fuel loses its ability to flow freely becoming more viscous and potentially causing problems with fuel delivery and engine startup in cold weather conditions. For both kerosene and diesel, lower cloud and pour points are desirable, especially in regions with cold-weather performance and prevent fuel system blockage

Table 3.3: CLOUD POINT AND POUR POINT DIESEL

Sample source	Pour point	Cloud point
Major Petroleum station	-7.4^0C	2.6^0C
Individual Petroleum station	-7.4^0C	2.7^0C
Black Market	-6.1^0C	4.9^0C
Local artisanal	-6.6^0C	4.8^0C
ASTM Standard	$> -7^0$C	$> 4.4^0$C

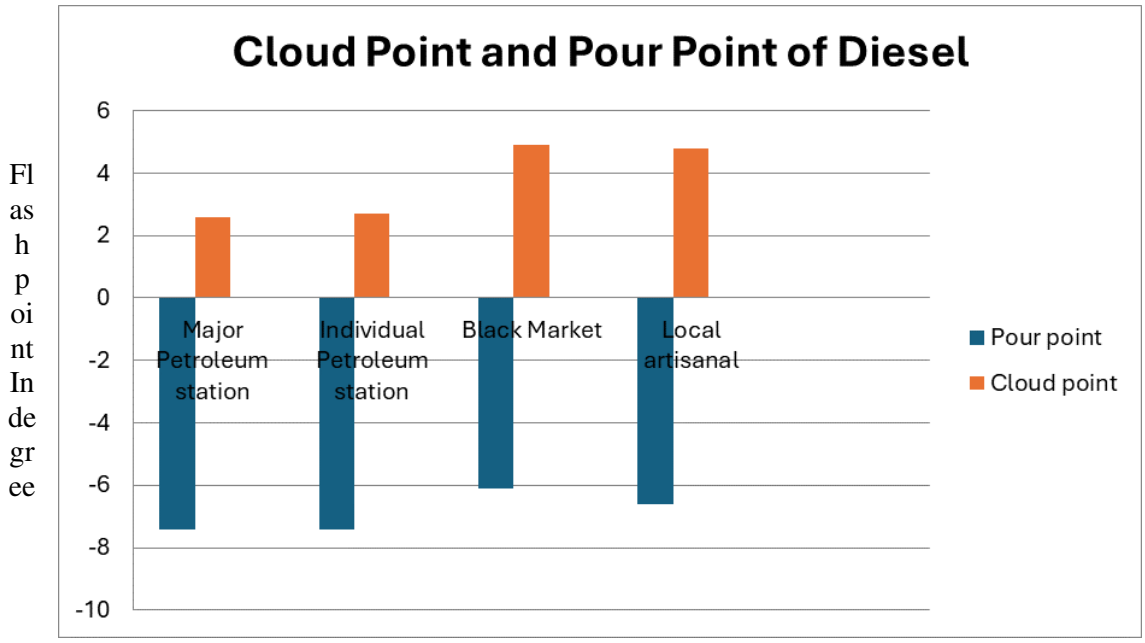

Figure 3.5 Cloud point and fire point for diesel obtained

CONCLUSION

The research paper reveals that petroleum products obtained from major petroleum stations, individual stations, black markets, and local artisanal sources in the studied area have been found to be adulterated with only a few exceptions. Its noteworthy that the paper did not delve into origin of this adulteration. This omission is because many petroleum products are imported into the country, leaving open the possibility that adulteration may have occurred overseas.

To effectively combat fuel adulteration, a proactive approach is recommended. These includes, collaborating with regulatory agencies, industries stakeholders and international partners which will provide valuable insights into the extent of adulteration in the petroleum industry and help develop strategies to combat it.

Oil companies and governmental bodies could utilize mobile laboratories for routine inspections at retail locations. These inspections would serve as a deterrent to fuel adulteration practices. Additionally, implementing punitive measures for the sales of adulterated fuel would further discourage such activities, promoting integrity within the fuel supply chain thereby ensuring the quality and safety of these products for consumers and the environment.

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