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COMPARATIVE CHEMICAL ANALYSIS OF CRUDE AND INDUSTRIAL PROCESSES DUAL PURPOSE KEROSENE AND PREMIUM MOTOR SPIRIT PRODUCTS IN NIGER DELTA

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Abstract
For over thirty decades, refineries in Nigeria have been producing below installed capacities hence, the inability to refine enough petrol and kerosene to meet local consumption. Consequently, there has been an increase in the activities of crude refining in the Niger Delta, which culminated in adulteration of the products. This study (362±1.41ppm), Moisture content of CP (165±5ppm) and IP (168±3.54ppm), Gum content compared the chemical properties of crude and industrial processes of Petrol (CP and IP) and Kerosene (CK and IK) with ASTM standards to ascertain their compliance. The Petrol and Kerosene samples of crude and industrial processes were purchased then prepared and analyzed using ASTM. The results obtained for Petrol were: Research Octane Number (RON) of CP (81.73±1.11%) and IP (78.50±0.57%), Sulphur content of CP (236±2ppm and IP CP (5±0.001mg/100ml) and IP (<5 mg/100ml). Those of Kerosene were: RON of CK (65.33±2.52%) and IK (71.80±0.14%), Sulphur content of CK (306.33±1.53ppm) and IK (120±1.41ppm Moisture content of CK (130±5ppm) and IK (120ppm), Gum content of CK (<5mg/100ml) and IK (<5mg/100ml). The findings revealed that RON for crude process kerosene was below ASTM specification as well as RON for crude and Industrial petrol whereas it was within specification for industrial kerosene. Sulphur and moisture content for both crude and industrial process petrol and kerosene were within ASTM specifications. By these findings, the crude petrol and kerosene may not have been refined properly, however, the local refining technology should be upgraded to modular refineries for optimal efficiency.

Keywords: Crude Process, Industrial Process, Crude Kerosene, Industrial Kerosene, American Standard of Testing

Introduction

Crude oil, a brown to black viscous liquid found under the sedimentary rock on the earth's crust is sometimes found alongside gases in free or dissolved form (Achuba, 2006). Crude oil is composed mainly of hydrocarbons but is also found with some impurities like sulphur, hydrogen sulphide (H_2S), ferrous (Fe), nickel (Ni), sand and water (H_2O). The geological techniques only determine the existence of rock formations that are favourable for oil deposits, but drilling is the sure way to ascertain the presence of oil (Al-Qahtani, 2011). Distillation separates the crude oil into fractions of different volatility. The fractions obtained from the refinery include liquefied natural gas (LNG), petrol (PMS), kerosene (DPK), diesel (AGO), bitumen, and asphalt (Asimiea & Omokhua, 2013).

Kerosene also known as Dual Purpose Kerosene (DPK) ignites slower than gasoline which vaporizes easily and ignites very fast when close to the source of the ignition while diesel ignites slower than kerosene. The refining of the fractions in the refinery is by standard and specification. The standard colour of kerosene is white and kerosene is often referred to as the white product (Asimiea & Omokhua, 2013).The fractions if not properly refined pose a danger to the users, engines, and environment. Kerosene is less volatile than petrol hence a lighted match thrown into a kerosene pool will quench and if not properly refined it produces unpleasant odour and emits fumes which are poisonous in sufficient concentration (Boym et al., 2007). Petrol also known as Premium Motor Spirit (PMS) is one of the products of fractional distillation of petroleum. This product is in high demand as a result of an increase in population with a resultant increase in vehicular and industrial activities. However, refineries are producing at below-installed capacities or are non-functional resulting in the inability to refine enough petrol to meet local

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consumption. The unfortunate development has led to the emergence and increase of crude process refining activity in the Niger Delta (Yabrade&Tanee, 2016).

In crude process refining, crude oil is boiled at atmospheric temperature; the resultant fumes are condensed and collected in tanks and used locally as automotive fuel. This local refining skill is believed to have been drawn from indigenous technology (Goodnews &Wordu, 2019). The crude process refineries operating in the creeks of the Niger Delta, though illegal, employ the locals as well as bridge the gaps in the availability and supply of refined petroleum products in the oil-bearing communities of the region (Brandes & Möller, 2008; Goodnews &Wordu, 2019; Addeh, 2020). The (Nigeria National Petroleum Corporation) in its report stated that Nigeria is not currently refining crude oil and therefore the corporation distributes only imported petroleum products in the country.

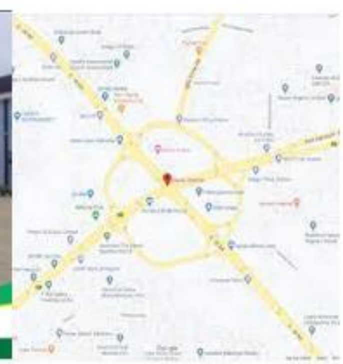
Though petrol produced by crude process refiners is not tested well enough to certify its compliance to any local or international set parameters, it still cushions the effect of petrol scarcity. Makeshift techniques are used by crude process refiners in processing raw crude oil via thermal cracking into useful products. These procedures could be unsophisticated and not very safe but could be effective all the same. The petroleum fractions obtained by local refiners are skeptically referred to as 'KPO FIRE' or "bunkering oil" adulterated products or "Asari fuel". Indigenous innovation and ingenuity in harnessing natural resources should be appreciated, and regulated and the products assessed if they meet local and international specifications. Also, there is a need to assess the level of quality compliance of the petrol samples distributed in the area to guard against environmental pollution and engine malfunctioning. According to (Vempatapu &Kanaujia, 2017) physicochemical properties like distillation profile, research octane number (RON), motor octane number (MON) and Reid vapour pressure are frequently used to detect the adulteration and quality of petrol. The study therefore was conducted to determine the chemical parameters of crude process petrol and kerosene comparing same with those of industrial products to ascertain the minimum acceptable limits with regulatory bodies.

Materials and Methods

Study Area

Gokana LGA map

NNPC filling station, Eleme junction, Obio/Akpor LGA



Eleme junction map

Three samples of crude process refined petrol (CP) and kerosene (CK),, as well as samples of industrial process petrol (IP) and kerosene (IK),, were randomly purchased in labelled sample bottles (2.5L) with glass stoppers from

Gokana local government area and NNPC station at Eleme junction along Aba/PH expressway, ObioAkpor Local government area in Rivers state respectively. The analyses were done using modified ASTM/IP Methods to determine the chemical properties.

Results

Results of the comparative analyses of some chemical properties of crude petrol and kerosene with industrial petrol and kerosene are presented in Tables 1 and 2 below.

Table 1: Comparison of chemical properties of crude and industrial petrol and their ASTM specifications.

Parameter	Unit	CRUDE PETROL	INDUSTRIAL PETROL	ASTM STANDARD
Gum content	mg/100ml	5.00 ± 0.00	<5± 0.00	5 Max ASTM (2005)
Moisture	ppm	165.00 ±5.00	168.00±5.00	100 – 200 ASTM (2005)
Research Octane Number (RON)	%v/v	81.73 ±1.11	78.5± 0.57	91 - 98
Motor Octane Number (MON)	%v/v	74.77 ±1.15	72.6± 0.42	82 – 88 ASTM D2700-19 (2019)
Sulphur content	ppm	236.00 ± 2.00	362.00± 1.41	100 – 500 ASTM (2008)

Table 1 showed the chemical properties of crude and industrial petrol as compared with American standard method of testing materials. The gum, moisture and Sulphur content of the two processes revealed that they fall within the ASTM Specifications while the RON and MON of both processes falls below the specification.

Table 2: Comparison of chemical properties of crude and industrial kerosene and their ASTM specifications.

Parameter	Unit	CRUDE KEROSENE	INDUSTRIAL KEROSENE	ASTM STANDARD
Gum content	mg/100ml	<5.00±0.00	<5.00±0.00	<5 ASTM (2005)
Moisture	ppm	130.00 ±5.00	120.00±0.00	100-200 ASTM (2005)
Research Octane Number (RON)	%v/v	65.33±2.52	71.80±0.14	71- 98
Motor Octane Number (MON)	%v/v	60.33±1.53	65.70±0.71	61-70 ASTM D2700-19 (2019)
Sulphur content	ppm	306.33 ±1.53	120.00±1.41	100 -500 ASTM (2008)

Table 2 showed the chemical parameters of Crude and industrial kerosene processes as compared to ASTM standards. The gum, moisture and sulphur contents are within the ASTM specifications whereas the RON and MON of crude kerosene process were below the specification, the RON and MON of industrial kerosene process were within the ASTM specifications

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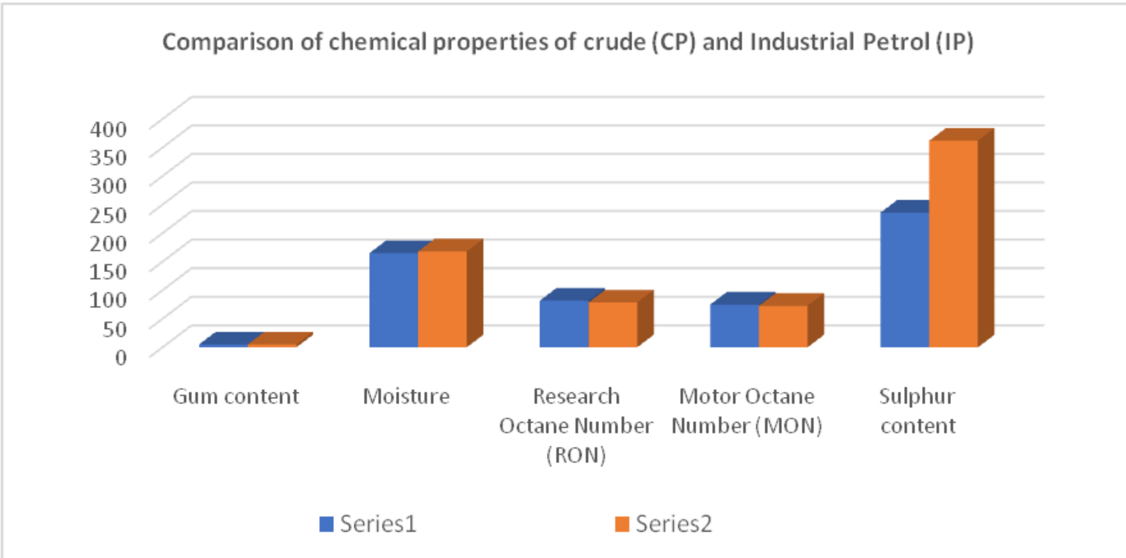

Figure 1: Bar chart showing the chemical properties of crude and industrial petrol.

The bar chart in Figure 1 showed that, the gum content, moisture content, RON and MON of the crude and industrial petrol processes are almost at equal except for Sulphur content that showed significant difference of Industrial petrol higher than crude petrol.

Table 3: Correlation matrix comparing the chemical properties of crude and industrial petrol

	Gum content IP	Moisture IP	Research Octane Number (RON) IP	Motor Octane Number (MON) IP	Sulphur content IP
Gum content CP	0				
Moisture CP	1	0			
Research Octane Number (RON) CP	1	-1	0		
Motor Octane Number (MON) CP	1	1	1	0	
Sulphur content CP	-1	1	-1	-1	0

Table 3 showed RON and MON of crude and industrial processes matrix correlated significantly while RON and MON with Sulphur content correlated insignificantly.

Discussion

A look at the results shows some deviations from the American Society for Testing and Materials (ASTM) standard specifications of the petroleum products of crude and industrial Petrol and Kerosene as shown in Tables 1 and 2 respectively. The chemical parameters such as research octane number (RON) and motor octane number (MON) were below ASTM specifications for crude and industrial petrol. The sulphur and moisture contents of crude and industrial petrol were within ASTM specifications. Gum, sulphur and moisture contents for crude and industrial kerosene were within ASTM standard specifications. RON and MON for industrial kerosene were within the ASTM specifications and were below for crude kerosene.

The gum content of crude petrol samples was 5mg/100ml across the three sampling locations with a mean gum content value of 5mg/100ml, these were higher than that of the industrial petrol whose value was <5 mg/100ml as shown in Table 1, which was found to be same with those reported for the quality assessment of petroleum fractions from the roadside vendors and illegal refineries in Delta State at a value <5mg/100m (Monago et al., 2013) l. The gum content for crude and industrial petrol samples was within ASTM specification of 5mg/100ml maximum. The RON value of the crude petrol samples ranged from (80.7 to 82.9 %v/v) across the three sampling locations with a mean RON value of 81.73 ±1.11%v/v, these were higher than that of the industrial petrol whose value was 78.5±0.57%v/v as shown in Table 1, which was found to be higher than those reported for the behavioural characteristics of adulterated premium motor spirit (PMS) at 57.0- 92.3%v/v (Onojake et al., 2012). The RON value of the crude and industrial petrol samples was lower than the ASTM rating of 91 to 98%v/v. The MON value of the crude petrol samples ranged from (73.6 to 75.9%v/v) across the three sampling locations with a mean MON value of 74.77 ±1.15%v/v, these were higher than that of the industrial petrol whose value was 72.6±0.42%v/v as shown in Table 1, it was tested under a more stressful condition of higher air temperature and engine speed. The ASTM requires an antiknock index (AKI) of 82 AKI or higher for premium gas and 87 AKI for industrial petrol cylinders (David et al., 2018). The higher AKI gas results in higher vehicle fuel economic climate and more enhanced performance. The volatility and octane quality of Petrol is of the utmost importance in identifying the standard of Petrol (Chikwe et al., 2016). Directly, chain alkanes convey more knocking tendencies in comparison to branched chain alkanes.

Table 3 shows the correlation matrixes of the chemical parameters of crude and industrial petrol. Assuming 1 to be significantly correlated and -1 to be insignificantly correlated, it can be deduced that, the moisture content of CP and gum content of IP, RON of CP and gum content of IP, MON of CP and gum content of IP, MON of CP and moisture of IP, Sulphur content of CP and moisture of IP, MON of CP and RON of IP were significantly correlated. On the other hand, the RON of CP and moisture of IP, Sulphur content of CP and gum content of IP, sulphur content of CP and RON of IP and sulphur content of CP and MON of IP were insignificantly correlated.

Conclusion

From the analyses conducted, it was observed that some of the chemical parameters such as moisture, sulphur and gum contents were within ASTM specification while some such as MON and RON for crude kerosene, RON and MON for crude petrol and industrial petrol were below ASTM specification with RON and MON for industrial kerosene within ASTM specification. Conclusively, about 70% of the chemical parameters of the crude petrol and kerosene were within ASTM specifications and so can be said to be ASTM complaints. While the remaining 30% were below ASTM specifications. Note that the parameters of this 30% (RON and MON) are critical or key parameters. Based on these researches, the crude petrol and kerosene may not have been properly refined or may have been adulterated and this can cause problems in automotive engines, human health and the environment if used continuously without monitoring. However, this local technology of refining can be upgraded to bring about improved quality of petrol and kerosene. Also, the Federal Government should legislate a legal framework to regulate the activities of crude refining. This will ensure environmental protection, create confidence among the refiners, promote local technology, and generate employment and economic sustainability.

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