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Comparative Physiognomies of Crude Oil and Petroleum Products from Kwale in Delta State, Nembe, and Kula in the Niger Delta Region of Nigeria

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ABSTRACT: This paper investigated selected physiognomies of crude oil and petroleum products collected from Kali in Delta State, Kula in Rivers State, and Nembe in Bayelsa State in the Niger Delta Region of Nigeria using the standard procedure of the American Society for Testing and Materials (ASTM). The result shows that the crude oils were different in terms of API gravity and specific gravity. API gravity of 52.17, 46.31, and 45.38 for Kwale, Kula, and Nembe respectively. This shows that they are not heavy crude oil. The low water content and low viscosity of the crude oils lower the risk of pipe and container corrosion and flow difficulty. The result of density, specific gravity, viscosity, and kinematic viscosity shows the value of those parameters increase from light fraction to heavy fraction. The pour point and flash point recorded for light fractions were lowered than that of heavy fractions, for the three samples of crude oil. The flash point is 61.3^0 C, -34^0 C, and -31^0 C while the pour point is $9\ ^0$ C, 2^0 C, and $6\ ^0$ C respectively for Kwale, Kula, and Nembe. The level of heavy metal analyzed was generally low but metals such as nickel and vanadium and other elements such as Nitrogen, Oxygen, and Sulphur were in abundance in the samples of the crude oil. The results are discussed in terms of importance and implication.

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Crude oil, also known as petroleum, is a naturally occurring mixture made up primarily of hydrocarbons, with traces of additional elements including oxygen, nitrogen, and Sulphur as well as some metals that might appear as organic molecules or even form complexes with metals (Carey, 2003). Globally, the usage of crude oil and its refined derivatives for chemical purposes has grown over time (Udeme *et al*., 2012). It has been noted that a deeper understanding of the composition, structure, and characteristics of the fractions is required due to the ever-increasing chemical usage of crude oils and petroleum products (Olajire and Oderinde, 1992; Odebunmi *et al*., 2001). A concerted effort is being undertaken to comprehend its composition, structures, and characteristics as a result. This understanding guides in processing methods and condition to improve the yield and the quality of products Composition of crude oil determines their characteristics (Carey, 2003). These qualities, in turn, vary depending on the specific oil field from which the crude oil was extracted. Each oil field has a diverse mixture of tertiary sedimentary layers and numerous sand reservoirs, which gives the crude oil content a distinctive flavor. These variations are what make the oil fields unique. As a result, the samples of crude oil contain varying ratios of the various hydrocarbons with varied molecular kinds, sizes, and other elemental components. As a result, it

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is necessary to define the oil to determine its qualities, to develop a precautionary strategy, to refine the oil, and to determine its potential to be a source of environmental toxins (Udeme *et al*., 2012). Hence, the objective of this paper is to investigate selected physiognomies of crude oil and petroleum products collected from Kali in Delta State, Kula in Rivers State, and Nembe in Bayelsa State in the Niger Delta Region of Nigeria.

MATERIALS AND METHODS

Description of study areas: Kwale-Ogoda Oil Pipeline: This is an existing oil pipeline, running from Kwale to Ogoda in Nigeria. The pipeline runs from Kwale to Ogoda, in Delta State, Nigeria. Operator: Agip and NNPC; Parent Company: Eni and Nigerian National Petroleum Corporation; Current capacity: 10/14 inches; Length: 80 kilometers; Status: Operating

Fig 1: Location of Kwale oil pipeline

Nembe Creek Trunk Line (NCTL): This is a 97 kilometre, 150,000 barrels of oil per day pipeline constructed by Royal Dutch Shell plc and situated in the Niger Delta region of Nigeria (*Nembe Creek Trunk Line, 2016)*. The Trunk Line is one of Nigeria's major oil transportation arteries that evacuate crude from the Niger Delta to the Atlantic coast for export (*AITEO, 2016).* It is owned by Aiteo Group, which recently purchased it as part of the related facilities of the prolific oil bloc OML29 from Shell Petroleum Development Company, SPDC (*AITEO, 2016).* By March 2015, the Shell Petroleum Development Company of Nigeria Limited (SPDC), a subsidiary of Royal Dutch Shell plc (Shell), completed the assignment of its interest in OML29 and the Nembe Creek Trunk Line to Aiteo Eastern E&P Company Limited, a subsidiary of Aiteo Group. The other joint venture partners, Total E&P Nigeria Limited and Nigerian Agip Oil Company Limited also assigned their interests of 10% and 5% respectively in the lease, ultimately giving Aiteo Eastern E&P Company Limited a 45% interest in OML29 and the Nembe Creek Trunk Line (SPDC, 2016).

Characterization of Crude Oil Sample: The three crude oil samples collected were characterized based on the parameters i). Appearance/colour ii). Density@15°C iii). Specific gravity@60F iv). API gravity v). Reid vapour pressure vi). Kinematic viscosity vii). Dynamic viscosity viii) Moisture ix). Gum content x). Cloud point xi). Pour point xii). Flash point

Table 1: Standard Parameters for the Characterization of Crude Oil Samples

S/N	Parameters	Standard method
1	Density	ASTM D4052
2	Pour point	ASTM D5853
3	Viscosity	ASTM D445
4	BTEX	ASTM D3328

Source: ASTM, 2012

Viscosity (ASTMD 7043): 100g of the sample was weighed and introduced into the Viscometer cup. The cup was filled with water up to the marked level on the cup and the equipment was switched on to run the experiment. The first run was done at 600rpm for 10mins while the second run was done at 300rpm for 10mins. The readings were taken and recorded and kinematics viscosity (KV) calculated. Ranges were Plastic Viscosity = (600rpm reading - 300rpm reading); Yield Point = (300rpm reading – Plastic Viscosity); Apparent viscosity = 600rpm reading/2

$$\text{KV (cSt)} = \frac{\text{Dynamic Viscosity (cP)}}{\text{Density}} \quad (1)$$

Where KV = kinematics viscosity

Pour Point Analysis (ASTMD 5853): The sample was poured into the cup up the marked point on the pour point cup. The pour point cup with the oil sample fitted with a thermometer was inserted into the pour point hole and lagged with cotton wool to minimize heat gain. The sample was open and checked for every 1^0C drop in temperature if it has solidified. The temperature at which the sample just solidified was recorded as the Pour Point of the sample.

Flash Point (ASTMD 1655): The flash point analyzer was switched on and after about 3mins the timer button was pressed and held on until a beeping sound was heard. The temperature button was pressed and when it started beeping the temperature was adjusted to a desired temperature that will be displayed on the screen. When the set temperature is attained and the ready light is on, 2ml of the sample was measured with the syringe and inserted into the cup through the hole. The gas was switched on the ignited through the nozzle. The flash point of the oil was displayed automatically after the appropriate temperature was reached.

Density (ASTMD 1298): Simply defined as the mass of a substance per unit volume. The empty pycometer glass was weighed and recorded and a known volume of the crude oil sample used to fill the pycometer glass up to the marked point on the body of the pycometer and closed with a stopper. The body of the pycometer was thoroughly cleaned and weighed to obtain the weight of the pycometer and the crude oil sample.

$$\textbf{Density} = \frac{W_{CP} - W_{EP}}{V_{crude}} \quad (2)$$

Where W_{CP} = weight of crude oil sample and pycometer; W_{EP} = weight of empty pycometer; V_{crude} = colume of crude oil

$$\textbf{Specific Gravity} = \frac{\text{Density of Oil}}{\text{Density of Water}} \quad (3)$$

$$\textbf{API Gravity} = \frac{141.5}{\text{Specific Gravity}} - 131.5 \quad (4)$$

Reid Vapour Pressure (ASTM D323): Samples were put in ice as soon as taken and transferred to the laboratory for immediate storage in the refrigerator and stored there until the tests had been completed. The sample container was removed from the refrigerator to be sure that the liquid level was approximately 90% of the container capacity. The container was shaken vigorously and placed in the refrigerator. The open gasoline chamber and the sample transfer connection were also placed in the refrigerator until the chamber and connection attained temperature (32ºF to 40ºF). The air chamber was rinsed and purged and a gauge was connected to it, the air chamber was immersed to at least 1 inch above its top in the water bath maintained at 100 ± 0.2ºF for not less than 10 minutes just before coupling it to the gasoline chamber. The gasoline chamber was filled after ensuring that the air chamber from the bath was not removed throughout the filling of the gasoline chamber. The chilled sample was removed from the refrigerator and the chilled transfer connection and air tube were inserted appropriately. The empty chilled gasoline chamber was placed over the sample delivery tube of the transfer connection. The entire system was quickly inverted so that the gasoline chambers were finally in an upright position with the delivery tube extending to within 1/4" of the bottom of the gasoline chamber. The gasoline chamber was later filled to overflowing. The gasoline chamber was tapped lightly against the workbench to ensure that the sample is free of air bubbles. After which the air chamber was connected to the gasoline chamber quickly. The assembled vapour pressure apparatus was first turned upside down to allow the sample in the gasoline chamber to run into the air chamber and shake vigorously in a direction parallel to the length of the apparatus and was later Immersed in the bath, maintained at 100 ± 0.2oF, in an inclined position so that the connection of the gasoline and air chamber is below the water level and may be observed closely for leaks. The apparatus was immersed to at least 1" above the top of the air chamber on ensuring that there were no leaks. After the assembled vapor pressure apparatus had been immersed in the bath for 5 minutes, the pressure gauge was lightly tapped, and the reading was recorded. The apparatus was withdrawn and inverted and was shaken vigorously and immediately placed back in the bath. At intervals of about 10 minutes, the agitation was repeated while observing the gauge and recording the values until the last two gauge readings were constant. The constant value is recorded as the Reid Vapor Pressure of the crude oil sample.

Moisture Content (Karl Fisher): 30mL of the extracting medium in the titration cell was prepared and the measuring cell was dehydrated by performing pre-titration in advance. 0.1 - 2.5g of sample was collected in a 5mL syringe and the weight was recorded to the nearest 0.1mg. The sample was discharged into the titration cell to dissolve in the solvent. The system was started, and the weight of the syringe was weighed as Wt1, and the empty syringe weighed was recorded as wt2. The endpoint was automatically detected, from which water content can be obtained.

$$Moisture(\%) = \left[\!\!\left[\frac{[\![Data \times F - Blank]\!]}{[Wt1 - Wt2]}\right]\!\!\right] \times 0.1 \quad (5)$$

Where: Data: Titration volume (mL); F: Reagent factor; Blank: Blank level (mg); Wt_1 : Sample + Syringe weight (g): Wt_2 : Empty syringe (g)

Cloud Point (ASTM Standard D-2500): The ASTM standard cloud-point determination method was used for the determination of the cloud point by visual observation of cloudiness in the bottom of a 1 1/2-in.-diameter glass jar. The glass jar was placed in a large metal cylinder that is immersed in a cooling bath. The temperature of the sample oil was read by a glass thermometer resting against the bottom of the jar. The temperature at which paraffin or wax are formed from observation was recorded as the Cloud Point.

RESULTS AND DISCUSSION

Characterization of Crude Oil Samples Physiochemical Analysis: The crude oil analysis results of the three crude oil samples are shown in Table 2 and 3.

Table 2 Physiochemical Properties of Kwale, Nembe, and Kula Crude Oil

Parameter	Kwale	Kula	Nembe
Appearance/Color	Light Green	Grey	Dark Grey
Density 25^{0}C	0.770	0.796	0.80
Specific gravity 25^{0}C	0.770	0.796	0.80
API gravity @25^{0}C	52.17	46.31	45.38
Reid vapour (KPa)	12.80	4.52	5.23
Kinematic viscosity	2.86	2.90	2.90
Dynamic viscosity	6.14	7.64	8.15
Moisture (v/v) content	0.03	0.47	0.50
Gram content (mg/l)	1.29	8.53	11.40
Cloud point (^{0}C)	11.0	15.0	19.0
Pour point (^{0}C)	9.0	2.0	6.0
Flash point (^{0}C)	61.3	-34	-31

Table 3: Heavy metals present in the crude samples

Heavy metals and other elements present	Kwale	Kula	Nembe
Ni (mg/l)	4.16318	2.52683	3.35113
V (mg/l)	0.19472	0.01748	0.036674
N (%)	4.15	0.95	0.90
O (%)		0.78	0.51
S (wt %)	0.064	0.154	0.16

API gravity determines the grade or quality of crude oils. Generally crude oil samples with API gravity greater than 31 are classified as light crude oils, those with API gravity between 22-31 are classified as medium crude while those with API gravity of 20 or less are referred to as heavy crude oil (Oyekunle and Famakin, 2004; SSFL, 2012).

According to this classification, the three samples of crude oil can be classified as light crude since their API values are higher than 30. This also indicates tendency for a low deposit of sulfur. The samples of crude oil can be referred to as sweet crude (Odebunmi *et al*., 2001). The percentage Sulphur content of crude oil is known to increase as specific gravity increases because sulphur is a heavy element, its presence is said to add to the specific gravity of oil. (Udeme *et al*., 2012; Ghulam, 1990).

Of the three samples of crude oil, Nembe crude oil is the heaviest of all followed by Kula then Kwale. The kinematic viscosity values obtained for the three different crude oil samples were about 2.9cSt. This compared very well with the work of (Ofodili *et al* 2018) where they obtained 2.9cSt as the Kinematic viscosity for light crude oil. The density and specific gravity for the three samples are almost the same values with Nembe oil having the highest value for both properties. These values tally with the obtained by Okeola *et al* in 2016. Reid vapor pressure (RVP) is a measure of volatility and is defined as the pressure at which a hydrocarbon liquid will begin to flash to vapor under specific conditions. Reid vapor pressures (RVPs) are sometimes specified by crude oil purchasers, particularly if the crude is to be transported by tanker or truck before reaching a processing plant. Purchasers specify low RVPs so that they will not be paying for light components in the liquid, which will be lost due to weathering. RVP is used to characterize the volatility of gasoline and crude oils. The RVP of a mixture is determined experimentally according to a procedure standardized by the American Society for Testing Materials at 100 °F (37.8 °C). For the tested samples, the RVP values are 12.80, 4.52, and 5.23 for Kwale, Kula, and Nembe respectively. This shows that Kwale has the highest value and can evaporate easily compared. Viscosity is the measure of internal friction of a liquid which is the resistance of the liquid to its flow; it therefore indicates the flowing ability of crude oil from one point to another (Olajire, 2013). When compared to the related result of Ghulam *et al*. (2013), the result of the viscosity shows that the three samples of crude oil from Kwale, Kula, and Nembe have a relatively low viscosity of 2.86, 2.90, and 2.90 respectively. This implies that they can flow rapidly during spillage. The knowledge of viscosity is required to enhance transportation, in reservoir stimulation as well as determining the structure of liquid. Viscosity measurement helps in the pump design. It also gives a rough idea about the different fractions of crude oils (Ghulam *et al*., 1990). Knowledge of water contents is important in refining, purchasing, and sale of crude oil because of the corrosion associated with this parameter (Ghulam 1990; Udeme *et al*., 2014). The data show that the three samples of crude oil Kwale, Kula, and Nembe has 0.03, 0.47, and 0.50% respectively. The values of water content were appreciably low in all the samples in line with Appending *et al*. (2013) and as compiled by Brown, (2013). The water content in the distillate increases from a lighter fraction to a heavier fraction. Crude oil with low water content implies low or minimal microbial growth and reduces the tendency to retain water-soluble salts (Appenting *et al.*, 2013). Water in crude oil leads to corrosion of the plant, water in crude oil is either in the form of an emulsion or in large droplets (Verkoczy and Kamal, 1989). The pour point and flash point recorded for light fraction is lowered than heavy fraction, for the three samples of crude oil (Kwale, Kula and, Nembe) the flash point is 61.3^0 C, -34^0 C and -31^0 C while pour point is $9\ ^0$ C, 2^0 C and $6\ ^0$ C respectively. The data shows the value of those parameters increase from light fraction to heavy fraction. (SSFL, 2012; Brown, 2013). Generally, for the physicochemical parameters, there is no trend followed for the three crude oil samples as Kwale had the highest value for some and Nembe had the highest value for others.

The results of the heavy metal content of crude oil and petroleum products are recorded in Table 3. The levels of the analyzed heavy metal obtained in the exercise were generally low. The low metal content in the three samples of crude oil agrees with the reports that light crude oil sample as against heavy crude oil usually contains relatively low metal (SSFL, 2012; Udeme *et al*., 2012). The presence of heavy metals was also recorded in some petroleum products (Table 3). Heavy metal in petroleum products is not expected and should be reduced to a tolerable amount, hence the need to reduce the concentration of metals in feedstock for catalytic cracking and reforming and other processes for petroleum products (Komine,1997; Odebunmi *et al*., 2001). These metal indices vary from one petroleum product to another and provide a means of differentiating petroleum product samples (Tomoike, 1997; Nafi'u *et al*., 2012).

Conclusion: The petroleum products decrease in specific gravity from kwale to Nembe, the low viscosity obtained shows that it can be easily transported through pipelines without the addition of diluents. The crude oil showed the presence of heavy metals such as nickel and vanadium and some non-metals such as nitrogen, oxygen, etc. Their abundance in petroleum products provides information on the origin, migration, and maturation of raw materials of these petroleum products. It also indicates the regional geochemical prospecting base as well as the processing and storage channels in the refinery.

REFERENCES

AITEO (2016). AITEO acquires Shell's OPL 29, Nembe Creek pipeline for $2.7 billion. Premium Times. Premium Times Services Limited. Retrieved 23 February 2016.

American Petroleum Institute. (2011). API specification for Materials and Testing for Petroleum products. API Production Dept. API 14A, 11TH edition, Dallas: 20-21.

Appenting, MK., Goloo, AA. Carboo, D. Nartey, VK, Kaka, EA, Salifu, M; Aidoo, F. (2013). Physicochemical characterization of Jubilee crude oil. J. Petroleum chemistry, 1:1-5.

Brown, GB (2013). Reigels Handbook of Industrial Chemical Products, 8th ed, Wiley, New York. p 45 – 67.

Carey FA (2003). Organic chemistry 5th edition McGraw-Hill Press, New York. pp 89-99

Crude Oil Pipelines in OPEC Member Countries - At the End of Year-2005, OPEC, accessed July 2018.

Ghulam, Y, Muhammad, IB, Tariq, MA, Syed M, Muhammad A, Khizar, I; Farah, NT (2013). Quality and chemistry of crude oils. *J. Petrol. Technol. Altern. Fuels*. 4(3):53-63.

Ghulam, Y, Muhammed, I; Long, MA, Muhammed. AA; Khizar, A (1990). Quality and chemistry of crude oils. *J. Biofuel. Allied. Sci*. 4:53-63.

Komine, K; Tomoike, K (1997). Simultaneous Determination of Vanadium, Nickel and Sulphur by Energy-Dispersed Fluorescence X- ray Analyzer. *J. Idemitsu Giho*. 40(6):616-620.

Nafi'u, T, Ike PO; Usman, BB, Malami, DI; Alacre, M. (2012). Trace elemental analysis of Nigerian petroleum products using AAS method. International Journal of Scientific research, 3:1-4.

Nembe Creek Trunk Line (2016). Oil Map NG. HexGEAR. Retrieved 23 February 2016.

Odebunmi, EO, Ogunsakin, EA; Ilukhor, PEP (2001). Characterization of crude Oil and petroleum products: Elution liquid chromatographic separation and gas chromatographic analysis of crude Oils and petroleum products. *Bull. Chem. Soc. Ethiop*. 16(2):115-132.

Olajire, AA; Oderinde, RA (1992).Characterization of Nigeria crude, middle and distilate and heavy residual oils by infrared spectrophotometry. *J. Chem* 1(6):324 – 333.

Okeola, FO; Amoloye, MA; Adebayo, GB; TO. Abu, TO; Ameen, OM; Obiechina, B (2016). Comparative Study of Physicochemical Parameters of Some Crude Oil and Petroleum Products, Nig. *J. Pure & Appl. Sci.* 29 (2) 2987-2993

Oyekunle, LO; Famakin, OA (2004). Studies of Nigerian crudes oil Characterization of crude oil mixtures. *Petrol. Sci. Technol*. 22 (5 and 6):665-675.

SSFL, (2012). Standard Specification for Fuel and Lubricant. *Book of standards*. 2 serial 56 – 90.

The Shell Petroleum Development Company completes sale of oil mining lease 29 and Nembe Creek Trunk Line in Nigeria". Euro Pétrole. Europétrole. Retrieved 23 February 2016.

Tomoike, K. (1997). Simultaneous determination of some heavy metals by Energy-Dispersed Fluorescence X-ray Analyzer. *J. Idemitsu Giho*, 41(7): 90-179.

Udeme, M; John, D; Etim, IU (2012).Petroleum and Coal. Physicochemicalstudies of Nigeria's crude Oil blends. *Pet. Coal*. 54(3):243-251.

Verkoczy. B; Kamal, NJ (1989). Characterization of heavy and medium oils from Saskatchewan reservoirs. *J. Fuel Sci. Technol. Int*. 7:535- 560.