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Comparative Analysis of Offshore and Onshore Nigeria Crude Oil

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ABSTRACT

Comparative study of offshore and onshore crude oil in terms of its physicochemical properties such as; API gravity, viscosity and Basic sediment & water has not been carried out, hence in this study samples were obtained from Atala onshore oil well and Clough Creek and Tubing offshore oil wells, both in Bayelsa state. Crude oil from both offshore and onshore locations using ASTM methods and a combination of analytical techniques to determine the API gravity, viscosity and BS&W. The crude oil investigated was found to have of API gravity of 28.40 and 35.20 API, for both offshore and onshore crude respectively. The offshore crude contains 2.5% water content while the onshore was nil. Offshore crude exhibited higher viscosity than the onshore, and the amount of oil from emulsion stability for the offshore crude was more compared to the onshore. These results provide an understanding of the major properties of these two types of crude.

Keywords: Onshore, Emulsion, Offshore, Oil, Stability.

1.INTRODUCTION

The analysis of crude oil and its product is necessary to determine the properties that can assist in resolving process problems as well as properties that indicates the function performance of the product in service (Speight, 2002). It is necessary to analyze crude oil in terms of their physical properties in order to address and mitigate process and economic problems such as high Basic Sediment and Water that can affect price, cause corrosion and deleterious product quality etc. these problems are undesirable because they reduce quality and limit fluid flow, hence laboratory analysis can assist to remediate such problems.

The compositions of crude oil vary depending on many factors, like location and age of the field. Crude oil mainly consists of hydrocarbons and additional small amount of nitrogen, oxygen, sulphur and metals (Speight, 1990).

Crude oil has both chemical and physical properties which also makes them to vary from place to place due to their origin and their migration pathway.

Some of the physical properties of crude oil.

- API gravity
- Viscosity

- Pour point
- Vapor pressure
- Salt content
- Metals pressure such as Na, Ca, Ni, V, Ag.
- Sediment and water
- Acidity
- Sulfur content.

In this work, Samples were obtained from Atala onshore oil well and Clough Creek and Tubing offshore oil well, both in Bayelsa state. Comparative analysis of following parameters; API gravity, BS&W, Viscosity and Emulsion stability were conducted.

Some of these properties are determined by techniques available and set standards governing crude oil laboratory analysis. This analysis will help refineries determine if crude oil feedstock either from offshore or onshore is compatible for particular refinery or if the crude oil could cause yield, quality, and production, environmental and other problem. (Wikipedia)

1.2 API Gravity:

The API gravity is an alternative American scale of expressing specific gravity and it is related to the specific gravity (S.G) by this relation;

That is, at 60°F or 15°C, unless otherwise stated.

$$\text{API GRAVITY} = \frac{141.5}{\text{Specific gravity @ } 60°\text{F}} - 131.5 \qquad 1$$

$$\gamma_o = \frac{\rho_o}{\rho_w} \qquad 2$$

Where

γ_o = specific gravity of the oil.

$\rho_o =$ = density of crude oil.

$\rho_w =$ = density of water (Tarek, 2006).

This scale is designed to show in a magnified way the difference in specific gravity of crude petroleum and its products.

Accurate determination of the density, S.G. or API gravity of petroleum and its product is necessary for the conversion of measured volume to volume of oil at standard temperature.

The API is used to classify crude oil as light, medium, heavy, or extra heavy. As the "weight" of oil is the largest determinant of its Market value, API gravity is exceptionally important. The API value for each weight is as follow;

- Light – API › 31.1
- Medium – API between 22.3 and 31.1
- Heavy – API ‹ 22.3

- Extra Heavy- API ‹10.0

API may be used to calculate barrels of oil per metric ton.

These are only rough valuation as the exact demarcation in API gravity between light and heavy oil, changes depending on the region from which oil came. The fluctuation as to what constitute light crude in a given region is the result of commodity trading in oil

1.3 VISCOSITY

Viscosity is a measure of the resistance of fluid to flow or shear, it is the force required to move a unit area through a unit distance. It may be reported in terms of absolute or kinematic viscosities.

Absolute viscosity is difficult to measure but kinematic viscosity is a measure of the fluid flow resistance to gravity. The pressure of the fluid being proportional to its density. Kinematic viscosity may be determined by allowing oil/fluids to flow through a standard capillary or orifice of a viscometer under the force of gravity.

Absolute viscosity of fluid at the same temperature may be calculated by multiplying kinematic viscosity by density of the fluid.

Viscosity are important properties of crude oil as it measures the resistance to flow hence, used in calculation of power(force) required to move fluid from one part of a system to the other and for the purpose of transporting fluid through a network of pipeline (PTI, 2017)

Mathematically it is expressed as;

$V = C \times t$

$Vis = V \times e$

Where V= Kinematic viscosity (mm^2/sec)

C= Constant of the U-tube viscometer ($mm^2 sec^2$)

t= Time of flow (sec)

Vis = Dynamic/Absolute viscosity ($N.S/M^3$)

e= Density (Kg/m^3)

1.4 Basic Sediment and Water (BS&W)

The Basic Sediment and Water determination in the laboratory is one of the various tests needed to be carried out on crude oil samples in other to ascertain their international marketability.

Crude oil is produced from the reservoir with a lot of impurities especially water and certain elementary metals. These impurities are collectively referred to as basic sediment and water.

In practices, total removal of all impurities in the crude petroleum is not possible as there must still be some traces of these impurities remaining. Procedures have thus been worked out for determining the quantity of BS&W in the crude oil, and one of these procedures is the centrifuge method, which is a physical separation of denser substance from lighter ones by spinning the mixture at high speed. A centrifuge machine can be manually operated or electrically operated (PTI, 2017).

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There are centrifuge tubes graduated in percentage of various capacities. The lighter substances collect towards the center of gyration while the heavier ones settles at the bottom. The maximum allowable BS&W is 1.0% and mathematically;

BS&W PERCENT = ×

Where x is the different value of fraction that separates from the original volume.

2. METHODOLOGY

EXPERIMENTAL PROCEDURE AND ANALYSIS

The crude oil sample used in this research was obtained from two oil field locations Clough creek& tubing offshore oil well and Atala onshore oil well both in Bayelsa state, Nigeria. The following experiments were conducted to determine the BS&W, API & SG, Viscosity and emulsion stability of both samples. All analysis was done with reference to ASTM and API standards (ASTM, 2017).

2.1 DETERMINATION OF BS&W

APPARATUS:

Centrifuge machine (electric machine), centrifuge tube, Stopwatch, crude oil sample (Atala & Clough creek and tubing), organic solvent (Xylene or Toluene), Beaker.

PROCEDURE:

The apparatus were properly set up, making sure that it is well positioned on the work bench.

The crude oil was agitated vigorously to ensure a homogenous mixture using Centrifuge machine.

The centrifuge tubes were selected, washed and dried with clean soapy water.

They were rinsed with the sample and then the centrifuge tubes were filled with 10mL of sample based on the capacity of the working centrifuge tube.

4 Tubes containing measured sample were placed in the centrifuge tube holder of the machine and made sure they were properly fitted to avoid accident during spinning.

The machine was turned on and whirled for 5 minutes at 4000RPM and 10 minutes at 3000RPM at intervals of 2 tubes each. After which, the machine was turned off and allowed to stop.

The centrifuge tubes were brought out and the various levels of oil, water and sludge were read off from the graduated body of the tube, results were recorded and the percentage of each fraction to the original volume calculated.

2.2 DETERMINATION OF API GRAVITY

APPARATUS:

Density bottle, Thermometer, weighing balance, stopper, crude oil sample, water.

Figure 1 weighing balance

PROCEDURE:

The density bottle and its stopper were washed cleaned and dried. They were first weighed (Figure 1) while empty and the weight recorded, the bottle was then filled with water and weighed, and was emptied and dried.

The bottle was filled with sample under test and the stopper inserted when it was filled, allowing it to spill from the stopper vent to avoid air being trapped in the sample. Spill was cleaned from the bottle body and the weight of the bottle containing crude oil weighed and readings recorded. The temperature of the crude oil was taken and measured with the aid of a thermometer.

A simple arithmetic was performed to obtain the weight of the oil alone and result recorded.

2.3 DETERMINATION OF VISCOSITY

APPARATUS:

U-tube glass viscometer, Retort stand, Thermometer, Stop watch, Measuring cylinder, Water baths, Crude oil sample.

Figure 2 U-tube glass viscometer

PROCEDURE:

A clean, dried calibrated U-tube glass viscometer (Figure 2) was selected and carefully clamped on the retort stand. The crude oil sample was poured into the U-tube viscometer through the reservoir section while the working section was closed with a finger and monitored till it reaches point A while maintaining the constant volume at reservoir section as the crude oil sample flows to point B, the stopwatch was started, and stopped when it flows to C. Time taken between point B to point C was recorded.

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2.4 DETERMINATION OF VOLUME OF OIL IN EMULSION

APPARATUS/MATERIALS:

Measuring cylinder, rotating mixer, separating funnel, emulsifying agent, demulsifying agents (HCL), Crude oil sample.

Figure 3 Rotating mixer

PROCEDURE:

100ml of crude oil sample was measured and poured into the rotating mixer (Figure 3); 1ml of emulsifier was added into the sample. The mains was turned on and allowed to agitate for 3 minutes, 150ml of distilled water was added into the gradually and allowed to continue rotating for 3 minutes. When the mixing period was completed, the emulsion were collected from the mixer and poured into the separating funnel in which 2ml of HCL (demulsifying agent) was added and readings recorded.

3. RESULTS AND DISCUSSION

The results of this research work are presented and discussed as follows;

The total amount of BS&W precipitated from the crude oil sample using centrifuge method was determined and the results are reported in Table 1 below. Both values obtained were compared with API standard.

Table 1: Experimental data of BS&W (Appendix A)

Sample Identity	Fraction of Water (mL)	% of Water	Fraction of Oil (mL)	% of Oil
Clough creek & Tubing	0.25	2.5%	9.5	95%
Atala	Nil	Nil	10	100%

From the results obtained it is notable that Atala (Onshore) had no value for water content as such it is the best amongst both samples, since set standard stipulated an allowable 1% water content.

Clough creek & tubing (Offshore) had 2.5% of water, which is above 1% and not accepted. This indicates that the crude sample withdrawn from the well head have not undergone field treatment. However the values obtained are subject to error that may have occurred during the experiments since there was no repetition of runs done.

With the foregoing, Atala can be said to have been treated and it is on the storage tank awaiting exportation.

The crude oil samples used in this study has an estimated API gravity estimated to be 28.4° and 35.2° respectively and enables one to determine the type of crude oil using API set standard.

Table 2 Experimental data on API gravity

S/NO.	Sample Identity	Test Temperature (°F)	Standard Temperature (°F)	Specific Gravity at Test Temperature	Specific Gravity at Standard Temperature	API Gravity
1.	Clough creek & Tubing	87.8	60	0.875	0.885	28.4
2.	Atala	87.8	60	0.838	0.849	35.2

The results of API gravity is summarized and reported in Table 2. The values reported are obtained using correction factors to calculate for specific gravity (STD) according to the ranges which the specific gravity at test temperature falls. Higher API gravity "lighter" oils tend to flow better for production a transportation, have lower molecular weight etc.

Clough creek & tubing (offshore) has an API of 28.4 indicating a medium crude and Atala (onshore) 35.2 which indicates light crude.

Table 3 Experimental data on viscosity

SAMPLE IDENTITY	VISCOMETER CONSTANT	TIME TAKEN FOR THE EXPERIMENT (Sec)	MASS OF EMPTY BOTTLE (g)	MASS OF SAMPLE + BOTTLE (g)	MASS OF SAMPLE ALONE
Clough creek & tubing	C= 0.002428	847	22.17	65.15	42.98
Atala	C= 0.002428	724	22.17	63.33	41.16

From the result obtained above in Table 3 above, it can be observed that Clough Creek & tubing crude oil sample took a longer time while Atala took a shorter time indicating that the offshore crude can be said to be more viscous than the onshore.

Table 4: Volume of oil recovered from an oil emulsion.

Time (mins)	Volume of oil recovered (mL)	
	Clough Creek & Tubing	Atala
0	-	-
5	4	-
10	5.5	-
15	6	-
20	6	-
25	6	-
30	6.5	-
60	10	-

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90	12	-
120	12.5	-
180	14	-
240	16	1
300	18	2
360	20	2
420	20	2
480	22	2
1080	26	3
1440	28	6
1800	29	6
2160	30	6
2520	30	6
2880	32	7
3240	32	7
3600	32	7
5040	36	10
6480	37	10
7920	38	10
9360	42	10

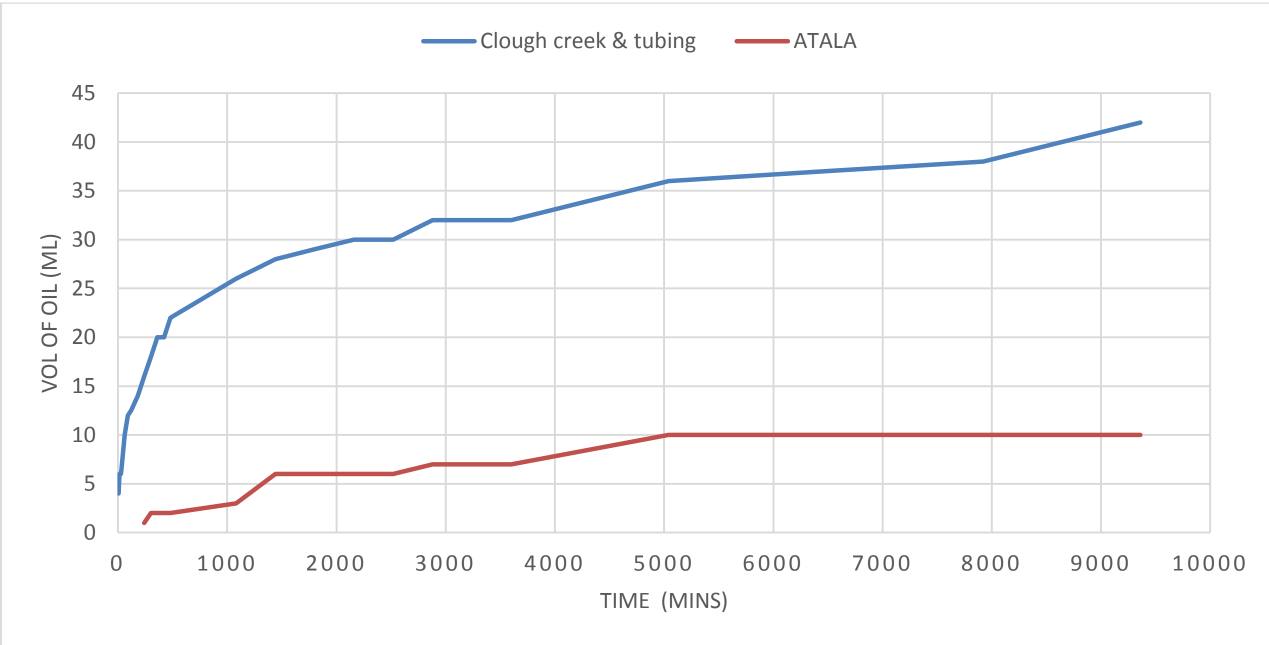

Figure 4: Chart showing Clough Creek &Tubing and Atala crude plot of Time against Volume of oil.

From Table 4 and figure 4, it can be observed that Clough Creek and tubing crude oil sample first separation of oil appeared at the first 5 minutes after the demulsifer was added to the emulsion indicating that it is a medium emulsion while Atala crude oil sample is a tight emulsion very stable and hard to break .Primarily because the dispersed droplet are very small, it took several hours before the first separation occurred. Clough Creek and Tubing crude oil sample separated faster.

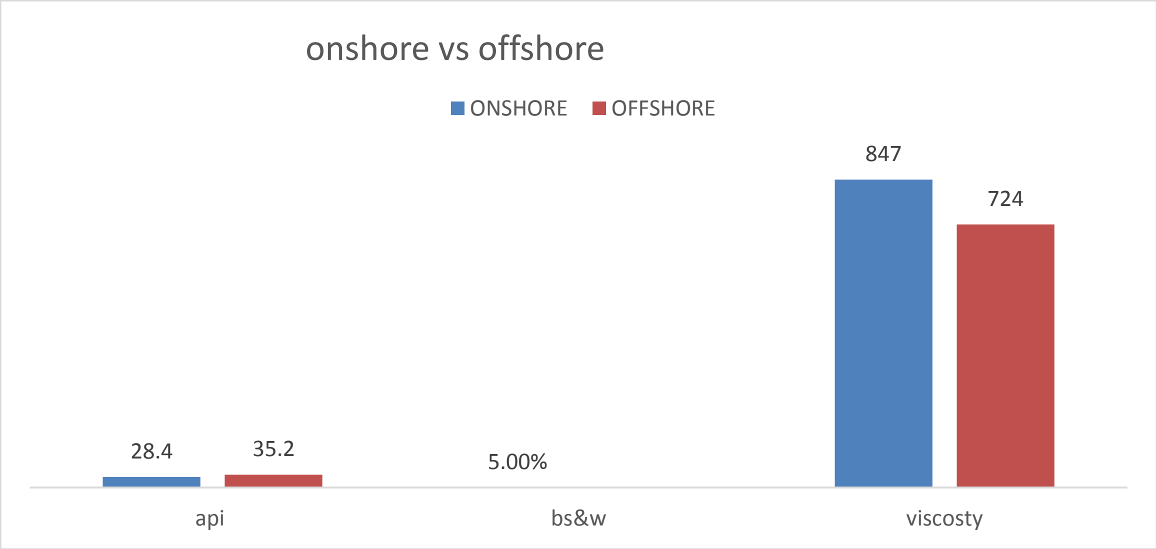

Figure5: Comparison between experimental data for both offshore and onshore crude.

From figure 5, one can say that the onshore crude exhibited a better option than the offshore crude oil; economically it is more valuable than the offshore crude oil.

3. CONCLUSION

The main idea of this study was to evaluate and measured various physical parameters of the crude oil samples taken from different fields in Nigeria. Parameters were studied according to ASTM standard and compared with API specification of crude oil. The result obtained were able to identify and qualify the major physical properties of crude oil in the studied sample, all measurement and results obtained are summarized in the Table 1, 2, 3 and 4 above.

In comparison with the offshore crude oil sample as shown from the results, the onshore crude oil sample had no BS&W, fell within the light crude range, and is less viscous.

It can therefore be inferred strictly from the results obtained that the onshore sample has better economic value and it's more desirable.

It is important to note that this result is not applicable to all comparison of offshore and onshore crude oil because these properties vary from well to well.

Finally, the scope of this work was limited to analysis of only four crude oil properties. This implies that the offshore crude oil sample could have been better than the onshore crude oil sample on other quantities, so the result is not conclusive.

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APPENDIX

1. FOR BS&W CALCULATIONS

Sample identity	Basic sediment content (ml)	Water content (ml)	Basic sediment + water content (ml)
Clough Creek & Tubing	0.25	0.25	0.5
Atala	Nil	nil	nil

Clough Creek and Tubing

Total Volume of sample = 10ml

Fraction of water = 0.25ml

% of water $= \frac{0.25}{10} \times 100 = 2.5\%$

Faction of oil = Total volume – Fraction of BS&W

= 10 – 0.5 = 9.5 ml

Percentage of oil $= \frac{Fraction\ of\ oil}{Total\ volume} \times 100$

$= \frac{9.5}{10} \times 100 = 95\%$

1. **READINGS FOR API GRAVITY**

Weight of empty bottle = 22.17g

Weight of bottle + water = 71.28g

Weight of water alone = 49.11g

Clough Creek & Tubing

Weight of bottle + oil = 65.15g

Weight of oil only = 42.98g

Test temperature of crude oil = $31^{O}C$ / $87.8^{O}F$

S.G Clough creek & tubing $= \frac{weight\ of\ oil\ alone}{Weight\ of\ water\ alone}$

$S.G_{TT}$ Clough Creek & tubing $= \frac{42.98}{49.11} = 0.875$

$S.G_{STD} = S.G_{TT} \pm 3.5 \times 10^{-4} \Delta T$

$= 0.875 \pm 3.5 \times 10^{-4} (-27.8)$

$= 0.885$

API gravity $= \frac{141.5}{S.G\ @\ STD} - 131.5$

$= \frac{141.5}{0.885} - 131.5$

$= 28.387^{O}$ API

ATALA

Weight of bottle + oil = 63.33g

Weight of oil only = 41.16g

Test temperature of crude oil = $31^{O}C$ / $87.8^{O}F$

S.G Atala= $\frac{weight\ of\ oil\ alone}{Weight\ of\ water\ alone}$

$S.G_{TT}$ Atala = $\frac{41.16}{49.11} = 0.838$

$S.G_{STD} = S.G_{TT} \pm 4.0 \times 10^{-4} \Delta T$

$= 0.838 \pm 4.0 \times 10^{-4}$ (-27.8)

= 0.849

API gravity = $\frac{141.5}{S.G\ @\ STD} - 131.5$

$= \frac{141.5}{0.849} - 131.5$

= 35.167^{o} API

2. VISCOSITY

CLOUGH CREEK AND TUBING

Observed flow time = 874 secs.

Viscosity constant = 0.002428 mm^2/s^2

Converting to m^2/s^2 since we are using M.K.S

$\frac{0.002428}{10^6}$

$=2.428 \times 10^{-9}\ m^2/s^2$

Kinematic viscosity = Viscosity constant × observed flow time taken in seconds.

K.V = $2.428 \times 10^{-9} \times 874$

$=2.122 \times 10^{-6}\ m^2/s^2$

Mass of sample alone = 42.98 = 0.04298kg

Volume of density bottle alone = 50ml = $50cm^3 = 5 \times 10^{-5} m^3$

$Density = \frac{Mass}{Volume}$

Density of sample = $\frac{0.04298}{5 \times 10^{-5}}$

$= 859.6 kg/m^3$

Dynamic viscosity = Kinematic viscosity × Density of fluid

D.V = $2.122 \times 10^{-6} \times 859.6$

$= 1.824 \times 10^{-3} NS/m^2$

ATALA (ONSHORE)

Observed flow time = 724 sec.

Viscosity constant = 0.002428 mm^2/s^2

Converting to m^2/s^2 since we are using M.K.S

$\frac{0.002428}{10^6}$

$=2.428 \times 10^{-9}\ m^2/s^2$

Kinematic viscosity = Viscosity constant × observed flow time taken in seconds.

K.V = $2.428 \times 10^{-9} \times 724$

$=1.757 \times 10^{-6}\ m^2/s^2$

Mass of sample alone = 41.16 = 0.04116kg

Volume of density bottle alone = 50ml = $50cm^3 = 5 \times 10^{-5} m^3$

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$Density = \frac{Mass}{Volume}$

Density of sample = $\frac{0.04116}{5\times10^{-5}}$

= $823.2 kg/m^3$

Dynamic viscosity = Kinematic viscosity × Density of fluid

D.V = $1.757 \times 10^{-6} \times 823.2$

$= 1.446\times10^{-3} NS/m^2$