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A PRELIMINARY STUDY OF THE PETROLEUM GEOCHEMISTRY OF EASTERN AND WESTERN ONSHORE NIGER BASINS: OIL-OIL COMPARISM AND CORRELATION USING BULK PROPERTIES.

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Abstract

A comparative study of the Eastern onshore(EO) and Western onshore(WO) oil fields in Niger Delta Basin was undertaken using classical analytical techniques in order to correlate their thermal maturities, organic matter type, extent of biodegradation, ecofriendly and economic viability. Low mean API gravity value was found for the EO (39.35±3.64^{0}API) and WO (41.98±3.12^{0}API). This indicated that the EO oils were slightly more thermally mature than the WO oils and that the studied oils contained more terrestrial/algal organic matter type with slightly greater terrestrial input in EO (mean=71.94±1.66%) than WO(mean =74.95±5.56%) oils. Higher mean percentage saturate fraction recorded for the EO than the WO oils reflected higher fuel and economic values of the former than the later. Lower mean percentage aromatic fraction found for the EO (mean of 9.49±2.61%) relative to WO (mean =14.65±3.61%) oils implied that oils from the former field were more ecofriendly. Lower mean percentage resin fraction recorded for the EO (7.27±3.13%) oils than their WO (mean =9.08±1.52%)which indicated lesser tendency of the EO oils to resist biodegradation than the WO oils. Pearson correlation model showed weak to moderate positive relationships between API gravity and such properties as saturate, aromatic, resin and asphaltene contents, reflective of complexity of the geochemical processes involved in the generation of petroleum hydrocarbons. The strong positive correlation that existed between asphaltene and resin, aromatic and resin and asphaltene and saturate, somewhat indicated that the studied oils originated from similar organic matter type and that these oils might have somewhat experienced similar thermal maturity history. Characterization of Aliphatic and aromatic biomarkers in the studied oils will further provide supportive evidence

and more insight into the petroleum geochemistry of the Eastern and Western onshore Niger Delta Basin.

Keywords: Oil Quality, Organic Matter Type.

1.0 Introduction

An estimated recovery of about forty trillion cubic feet of natural gas and more than forty billion barrels of crude oil makes the Niger Delta to be ranked among the most prolific hydrocarbon producing provinces in the world (Adegoke *et al.,* 2017). The Niger Delta is situated in the Gulf of Guinea tropical West Africa and covers an approximate area of about 75,000 km^2 with 9000-12,000m thickness of siliciclastic deposits (Adegoke *et al.,* 2017). Stratigraphical data revealed that the Niger Delta is composed of delta front paralic facies of mostly sands and pro-delta marine shales as well as upper delta top lithofacies of continental sands and gravels. (Avbovbo 1978; Evamy *et al.,* 1978). Its area is subdivided into a series of independent depositional centers known as depobelts, which represent successive stages of the delta development (Stacher, 1995; Knox and Omatsola, 1989;). Detailed geology of the Niger Delta Basin is decribed in Ekpo *et al.,* (2018). Earlier investigation indicated that the hydrocarbons from the Niger Delta are derived from terrestrial higher plants, mostly Type II/III (Onyia *et al.,* 2005) and mixed Type III Kerogen (Akinlua *et al.,* 2005: Anyanwu et.,al 2021). However, there is need to investigate the genetic relationship among crude oils from Eastern and Western onshore of the Niger Delta in order to ascertain if there are subtle similarities or differences among oils from different parts of the delta using bulk properties. Akinlua and Ajayi (2009) reported that crude oils from Central offshore Niger Delta derived from organic materials of both terrestrial and algal sources, deposited in an oxic environment. Similarly, Ekpo *et al.,* (2018) showed that the crude oils from some parts of the Offshore Niger Delta are genetically related. This preliminary study utilizes bulk properties to investigate the possible variations in the commercial/economic values, Organic matter type and environmental implications of the selected crude oil samples from the Eastern and western onshore depobelts of the Niger Delta.

The main objectives of the present study were to apply bulk properties to compare and correlate the thermal maturities, organic matter type, extent of biodegradation and environmental friendliness between Eastern and western onshore oils of the Niger delta Basin.

2.0 Materials and methods

A suit of eight crude oils obtained in June 2022 via vertical drilling through the three hydrocarbon depobelts from two oilfields located in the Eastern onshore (EO-1 to EO-4; longitude 5.3881^{o}E and latitude 5.8732^{o}N) and western onshore (WO-1 to WO-4: longitude 7.0302^{o}E and latitude 4.8693^{o}N) depobelts of the Niger Delta (Fig.1) were analyzed for this study. API gravity was determined based on the expression API=(141.5/SG)-131.5 Where SG= Specific gravity of the oil. The specific gravity of the oils were determined using hydrometer and measuring cylinder as described in www.ubookly.com. Fractionation of the crude oils into saturate, aromatic

hydrocarbons, and NSO compounds were called out after deasphaltination process. (Schoell et al 1981; Wehner and Teschner, 1981; Ekpo *et al.,* 2013). Deasphaltination of the studies oils were performed in a centrifuge with about 3500rpm using a mixture of dichloromethane and petroleum ether (Bp 40-60 ℃). the fractionation was carried out in an open glass column chromatography using n-hexane to elute the saturated fraction, dichloromethane (50 ml) was used to elute the aromatic fractions, and the mixture, (1:2) methanoldichloromethane (50 ml) was used to remove the heterocyclic fractions (NSO). Data evaluations including descriptive statistics of mean and standard deviations as well as Pearsons correlation were carried out using Microsoft excel model.

3.0 Results and discussion

3.1 Bulk properties of the studied oils

American Petroleum Institute gravity (^{0}API) is a bulk physical property of oils used as a crude oil quality indicator. Oil samples having API gravities in the range 20° - 45° are regarded as normal crude oils, those less than 20° are often times biodegraded, whereas those above 50° are rated as condensate oils (Makeen *et al.,* 2015; Collins, 2018). However, API gravities can also be classified in the range of heavy to light oils thus: Extra heavy oils: < 10° API, heavy oils: 10° - 22.3° API, medium oils: 22.3° - 31.1° API, light oil**s**: > 31.1° API. (Ali *et al.,* 2018).

API gravity values for the Eastern onshore oils were in the range 35^0-43^0 with a mean of 39.35±3.64^0(Table 1), while those for the Western onshore oils were in the range 39^0-45.90^0 with the mean of 41.98±3.12^0(Table 2). The results indicated that oils from the Eastern onshore Niger Delta had higher degree of lightness than those of the Western onshore oils. The implication here was that Eastern onshore oils were derived more from terrestrial over Algae organic matter (OM) than their Western Onshore oils counterpart. It also implied that the Eastern onshore oils were more thermally matured than the Western onshore oils.

The API gravity for the studied oils fell within a class of oils known to be mature and light, and are of good commercial and economic values, mainly of terrestrial over algal organic matter sources.

Saturate fractions

Saturate fractions of the Eastern onshore oils range from 70.27% to 73.93% with a mean of 71.94±1.66%, while those for the Western onshore oils were in the range 70.53-82.67% (mean =74.95±5.56%)Table1 and 2. Comparing data in the present study with other fields within the Niger Delta Basin, lower mean saturate fraction was recorded for the Eastern coastal and shallow offshore oils (Anyanwu et., 2021), whereas similar values we found for the Western offshore oils (Ekpo et.al 2018). The implication here was that the studied oils were of higher fuel value than those of the Eastern coastal and shallow offshore Niger Delta.

Aromatic fractions of the Eastern onshore oils range from 6.20% to 12.27% with a mean of 9.49±2.61%, while those for the Western onshore oils were in the range 9.47-17.60% (mean =14.65±3.61%) Table 1 and 2. Much lower mean percentage aromatic was recorded for the studied oils than those for the Western offshore oils (Ekpo et.,al 2018) and the Eastern coastal/shallow offshore Niger Delta oils (Anyanwu et.,

2021). The implication here was that the studied oils were more ecofriendly than oils from other fields within the Niger Delta Basin.

Resin fractions of the EO oils ranged from 3.73% to 11.33%with a mean of 7.27±3.13% (Table 1). while those for the WO oils were in the range 7.53-10.67% (mean =9.08±1.52%)(Table 2).Environmental samples contaminated with more sulphur compounds such as dibenzothiophene were reported to be more resistant to biodegradation than those infested with lesser hetero-compounds due to the fact that sulphur poisons OM degrading microorganisms (Oyo-ita et al., 2017a)the implication here is that the WO oils were more resistance to oils degradation than their EO oils counterpart. Comparable percentage resins values were found between the studied oils and that of the Western offshore Niger Delta oils (Ekpo *et,al.,* 2018), while Eastern coastal and shallow offshore Niger Delta oils exhibited higher percentage resins content (Anyanwu *et al*., 2021).

Asphaltenes fractions of the EO oils range from 4.16% to 16.45% with a mean of 10.71±5.09, while those for the WO oils were in the range 0.62-2.89% (mean =1.60±1) Table 1 and 2. Heavy oils are reported to contain 14% and above asphaltene content with API gravity values and are formed when certain algae species degrades hydrocarbon deposits which lead to the loss of its lighter hydrocarbon fractions, leaving behind the heavier hydrocarbon fractions. The relatively low percentage Asphaltene in the studied oils supported the light nature of this oils and their economic viability.

Correlation of bulk properties of the studied oils

Pearson correlation model was applied to understand the relationships among bulk properties. Weak positive correlations existed between API gravity and properties such as saturate (r=0.0699). asphaltene (r=0.1842) and aromatic (0.2433) fractions, implying that saturate, asphaltene and aromatic contents of the studied oils did not play a major role in the determination of the quality and/or lightness of the studied oils. Fairly good positive correlations existed between API gravity and such parameters as depth (r=0.3847) and resin (r=0.4018) (Table 3). Although other complex geochemical factors may be involved, it appears therefore that the resin content and depth to some extent determined the quality of the studied oils.

The strong positive correlation that existed between asphaltene and resin (r=0.6126; Fig. 2), aromatic and resin (r=0.6381; Fig. 3), and asphaltene and saturate (r=0.636; Fig. 4), somewhat indicated that the studied oils originated from similar organic matter type and that the studied oils might have somewhat experienced similar thermal maturity history.

Conclusions

In the study, bulk properties of the Eastern and Western onshore Niger Delta oils were utilized to compare and correlate their thermal maturities, organic matter type, extent of biodegradation, eco-friendliness and economic viability. The results revealed that the Eastern onshore oils were slightly less thermally mature and contained higher proportion of terrestrial/algal organic matter type than their Western onshore counterpart.

The strong positive correlation that existed between asphaltene and resin, aromatic and resin and asphaltene and saturate, somewhat indicated that the studied oils originated from similar organic matter type and that these oils might have somewhat experienced similar thermal maturity history. Characterization of Aliphatic and aromatic biomarkers in the studied oils will further provide supportive evidence and insight to the petroleum geochemistry of the Eastern and Western onshore Niger Delta Basin.

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Table 1: Bulk properties of Eastern onshore oils

Sample ID	Depth (ft)	API gravity	SARA COMPOSITION (wt %)				Sat \Aromatic
			Saturates	Aromatic	Resin	Asphaltenes	
EO-1	9913	43	70.93	10.67	6.67	12	6.68
EO-2	9444	41.6	70.27	12.27	11.33	4.16	5.89
EO-3	9303	35	73.93	6.20	3.73	16.45	11.92
EO-4	9806	37.8	72.61	8.82	7.37	10.23	8.23
Mean±SD		39.35± 3.638223	71.935± 1.655083	9.49± 2.607285	7.275± 3.129702	10.71± 5.090665	8.18± 2.676079

Table 2: Bulk properties of Western onshore oils

Sample ID	Depth (ft)	API gravity	SARA COMPOSITION (wt %)				Sat \Aromatic
			Saturates	Aromatic	Resin	Asphaltenes	
WO1	9407.5	40	71.30	17.60	10.67	0.62	4.05

WO2	9669.5	43.0	70.53	16.53	10.06	2.89	4.27
WO3	9,770	39.0	75.33	15.00	8.07	1.88	5.02
WO4	9557	45.90	82.67	9.47	7.53	1.03	8.73
Mean±SD		41.975± 3.12023	74.9575± 5.555822	14.65± 3.614406	9.0825± 1.517792	1.605± 1.004606	5.5175± 2.18155

Table3: Correlation Co-efficient of the studied oil bulk properties.

Paremeter	Depth	Saturates	Aromatic	Asphaltene	Resin
API gravity	0.3847	0.0699	0.2433	0.1842	0.4018

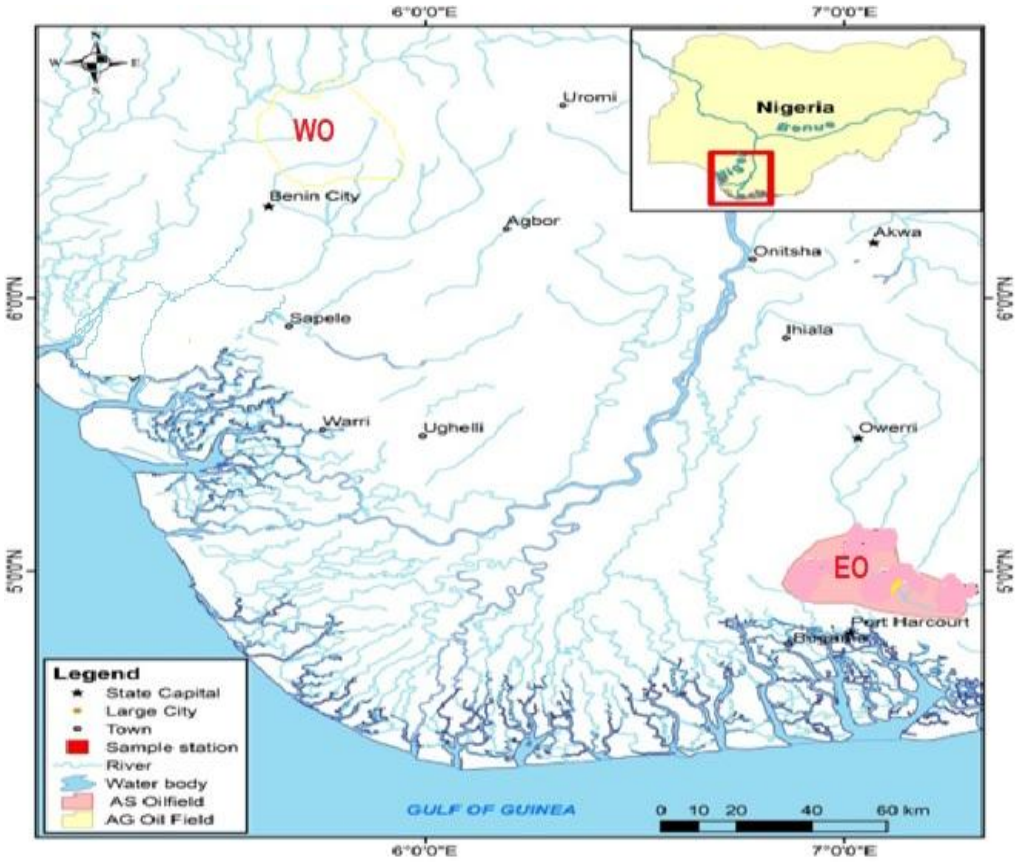

Fig 1: Map of Eastern and Western Niger Delta indicating the oil fields locations.

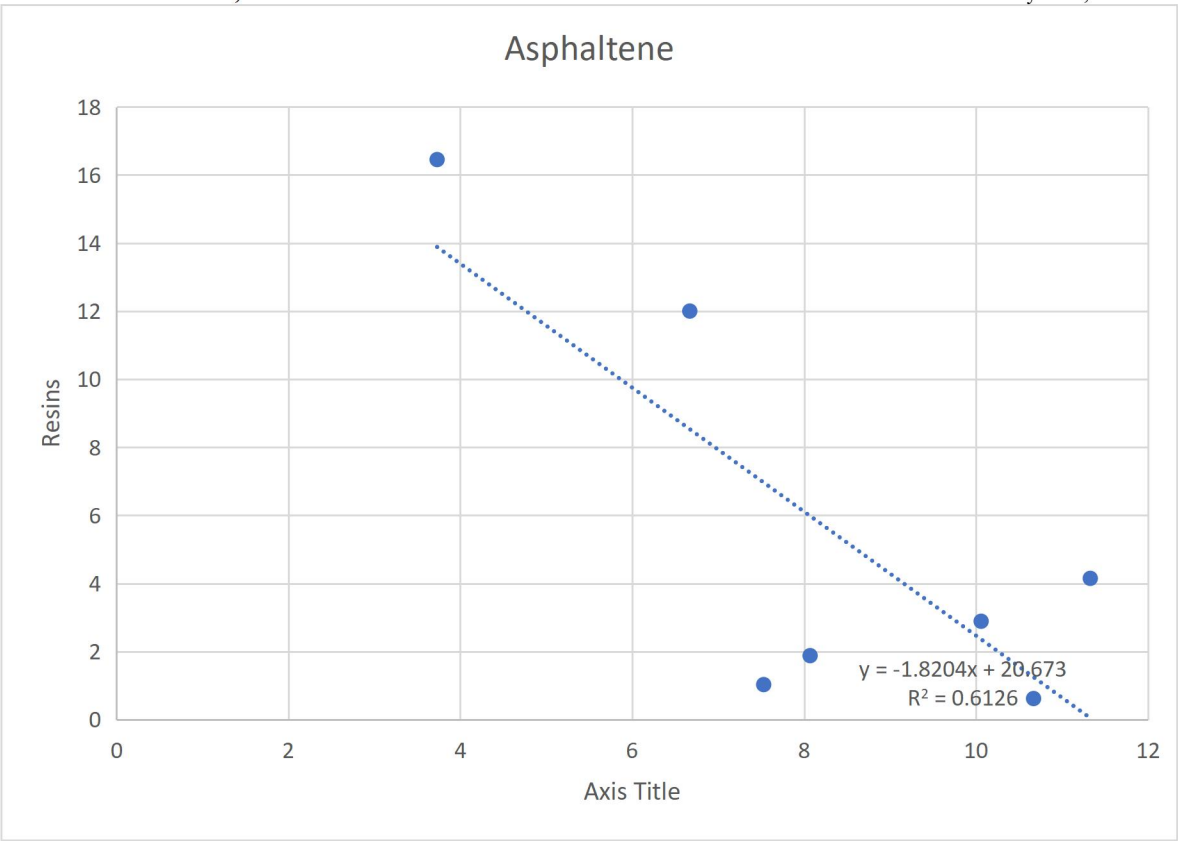

Fig 2: Correlation plot of asphaltene Vs resins for the studied oils.

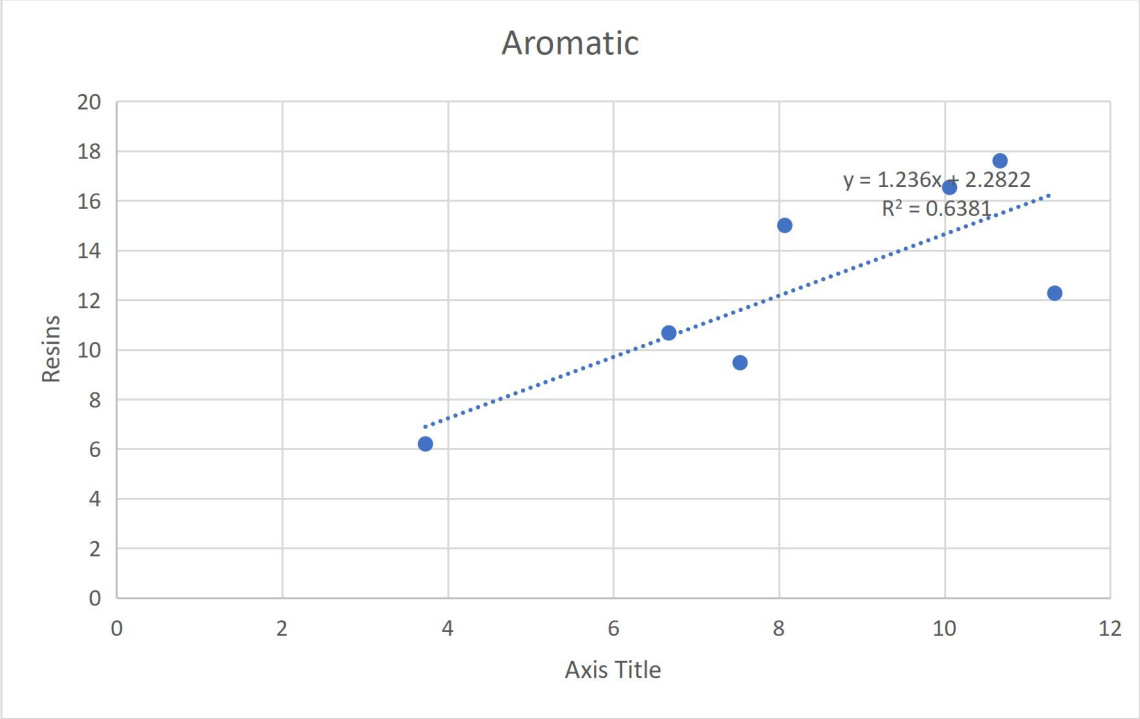

Fig 3: Correlation plot of aromatic Vs resins for the studied oils.

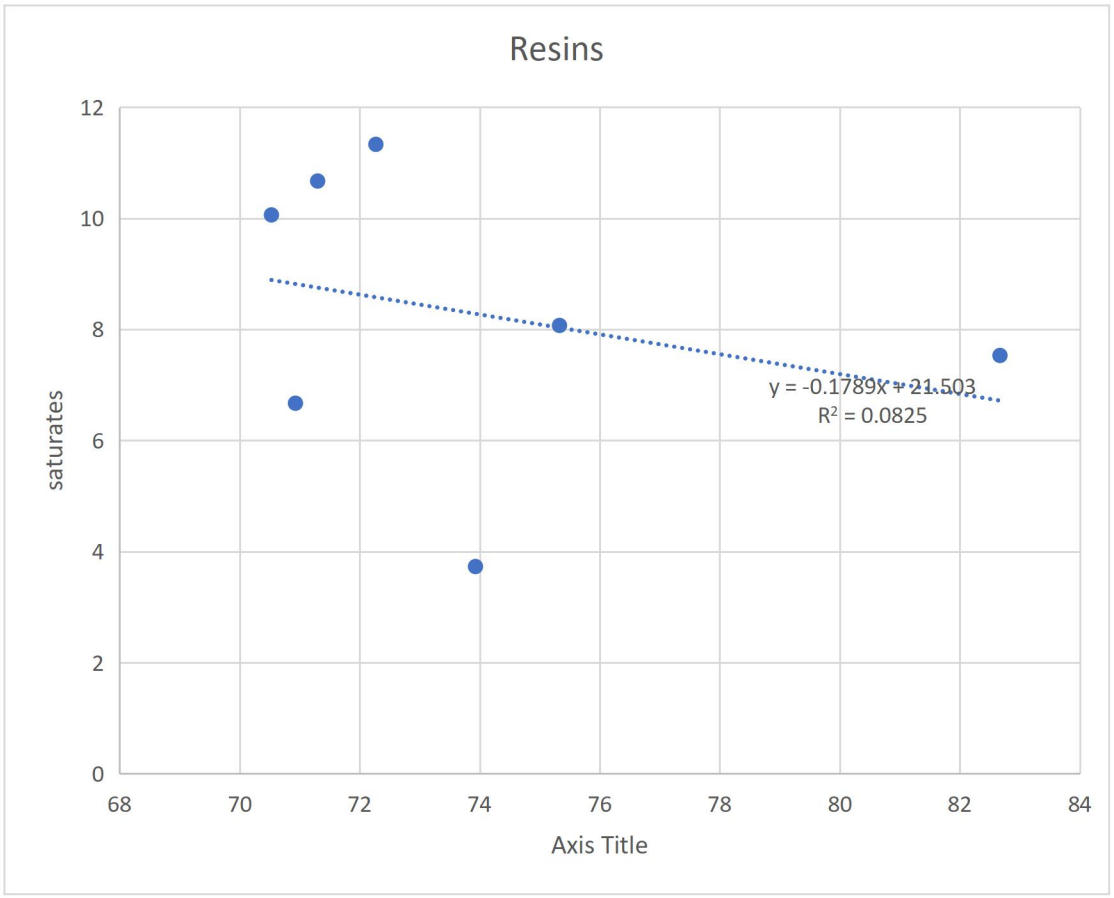

Fig 4: Correlation plot of resins Vs saturates for the studied oils.