Statistical Analysis of the Relations between API, Specific Gravity and Sulfur Content in the Universal Crude Oil

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Abstract: ***This study was conducted on the universal crude oil samples for the purpose of understanding the relationships between some of the characteristics that control the oil quality. Data were collected from previous works, includingspecific gravity and weight percent of 13 crude oil samples as well as the API and S% of138 crude oil samples belong to oil reservoirs located in the different parts of the world.The APIagainstboth of specific gravity and weight percent (kg/m^3)is governed byaninverse perfect linear regression (r= -0.98) with a better prediction (96%) for the outcomes data. The API relies not only sulfur content, but there are other parameters control the oil density, where the API° is exponentially correlated with S%.***

Keywords: crude oil, statistical analyses, API, specific gravity, sulfur content

1. Introduction

Crude oil is a complex mixture doesn't a uniform material consisting of up to 200 or more different hydrocarbon organic compounds, where its quality based on American Petroleum Institute (API) gravity,specific gravity (SG) and sulfur content (S%) (Dickson and Udoessien, 2012).The most important of commercial parameters is a specific gravity, which is used for measuring the quality of crude oils. Low specific gravity indicates good quality of crude oil having lighter fractions and vice versa.Crude oil is classified as light, medium or heavy, according to its measured API gravity. The API gravity of less than 10 defines bitumen and extra heavy oil;asphalt on average has an API gravity of 8°, which sink in fresh water, while oil floats; API gravity less than 10° generally considered natural bitumen (Danyluk and others, 1984).Generally, API from 10° to22.3° defines heavy oil, from 22.3° to 31.1° was considered as medium oil,higher than 31.1° defines the light oil(dnr.louisiana.gov, 1989). The specific gravity of the crude oil is inversely related to the API values and provides a preliminary estimation of the amount of type (heavy or light) of hydrocarbons present. The lower the specific gravity and higher API gravity are characterized the high quality crude oil. Therefore, higher API gravity crude oil hasa higher price and is of good quality**.**The total sulfur content in the crude oil is represented by sulfur compounds such as thiols, sulfides, disulfides and thiophenes, where sour and sweet oil classes are based on S% in the crude oil (Wang and Huang, 1992). The oil classification on the basis of physical characteristics is commercially important (Sun et al., 2009; Odebunmi et al., 2002).

This study was carried out on data that have been collected from international published studies regarding the oil reservoir throughout the world.It aimsto discuss therelations betweensome of the parameters (API, SG and S%) that are related tothe quality ofcrude oil(API, SG and S%), and attempt to predict outcomes of the API as criterion variable from the data scores on an SG and S% and vice versa for initial rough estimationthe crude oil quality.

2. Results and discussion

2.1Statistical analysis of API, SG and Wt%

Crude oil isa naturally liquid consisting mainly of hydrocarbons, as well as sulfur, nitrogen and metals(Yasin et al., 2013)witha wide range ofdensities. Basically, crude oil was commercially rankedfromvery light to very heavy oil. The light oilhas high proportion of light hydrocarbonfractions characterized by less content of wax, therefore it has low viscosity and specific gravityas well and high API gravity.API gravity determines the grade or quality of crude oils(Dickson and Udoessien, 2012). It is an inverse measure lighter the crude, higher the API gravity, and vice versa. The formula for API gravity can be expressed as:

$$API = (141.5 / SG) - 131.5 \qquad (1)$$

where API = Degrees API Gravity
SG = Specific Gravity (at 60^{o}F or 15.5^o)

The relative density is equal to the density of the substance divided by the density of water (density of water is 1000 kg/m^3). So the API gravity was designed to include a wide range from 10° to 70° API (Duissenov, 2012). APIis inversely proportional tothe specific gravity and wt (kg/m^3). At specific gravity 1, which is the density ofpure water, theAPI value equal 10, where the weight is 998kg/m^3 (Table 1).When investigate theincreasevalue ofAPIfrom 10 t0 55 for interval 5comparedwithweight; it issupposedthat theweightdecreases proportionally,but in fact,the proportionalityhas been irregular. For the purpose offollow-upthose anomaliescanshed lightonTable 1.Incase of the increasingthe value ofAPI as 10, 15, 20, 25, 30, 35, 40, 45, 50 and 55, the oil Wt% (kg/m^3)decreases as 998, 964, 932, 902, 874, 848, 823, 800, 778 and 757. The intervals of Wt%for 5 API° can be seen as 34, 32, 30, 28, 26, 25, 23, 22 and 21.The inconsistency that emerged are defined as 2,2,2,2,1,2,1 and 1. The changein the API° value forthe interval of35-40, 45-50and 50-55caused changeinweight of only 1 kg/m^3, whilethe normal changewas 2through 15-20, 20-25, 25-30 and 30-35API interval. The relationship between API and both of SG and Wt% was inverselystrong and well defined by the coefficient of determination. A model-fitting of coefficientof determination that are used to test of hypotheses, predict the other outcomes datawas statistically applied to know the amount of overlap between the regression and the real data points. Accordingly,equations that connect the API with both of SG and Wt% were determined as well as the R^2.The regression for the squares analysis R^2 that varies between 0 and 1, the larger numbers indicating better fits and 1 represents a perfect fit(Cameron et al., 1997).When X and Y are perfectly negatively correlated, the r will be equal to -1, when X and Y are perfectly positively correlated, r will be equal to +1, where X here is represented by API, whilst Y is represented by API, SG and Wt independently.It can be noted that all data observations fall on a line with perfect positive correlation (Figure 1). Thereby, R^2 for API versus both of SG and Wt is close to 1 (0.96), whist, the correlation coefficient (r) was found to be -0.98indicating an approximate fit inversely relationship between API against both of SG and Wt. Hence, a best-fitting straight line through the data points was drowning(Figure 1)and then computing the simple linear regression as:

$$y= 1.43x^{-0.15} \quad (2)$$
$$y= 1428x^{-0.15} \quad (3)$$

where y in the equations 2 and 3 are SG, and Wt%, respectively; x is API°.

A perfect positive correlation of r = 1.0. It can be noted that all data observations fall on a line; thereby the term perfect linear correlation becomes appropriate.

Table 1: Analysis of the difference intervals of the physical properties of the crude oil

API	Specific Gravity	WT (kg/m^3)	WT interval For 5 API interval	Interval difference (kg/m^3)
8	1.014	1012	---	---
9	1.007	1005	7	---
10	1.0	998	7	---
15	0.966	964	34	---
20	0.934	932	32	2
25	0.904	902	30	2
30	0.876	874	28	2
35	0.85	848	26	2
40	0.825	823	25	1
45	0.802	800	23	2
50	0.78	778	22	1
55	0.759	757	21	1
58	0.747	745	12	---

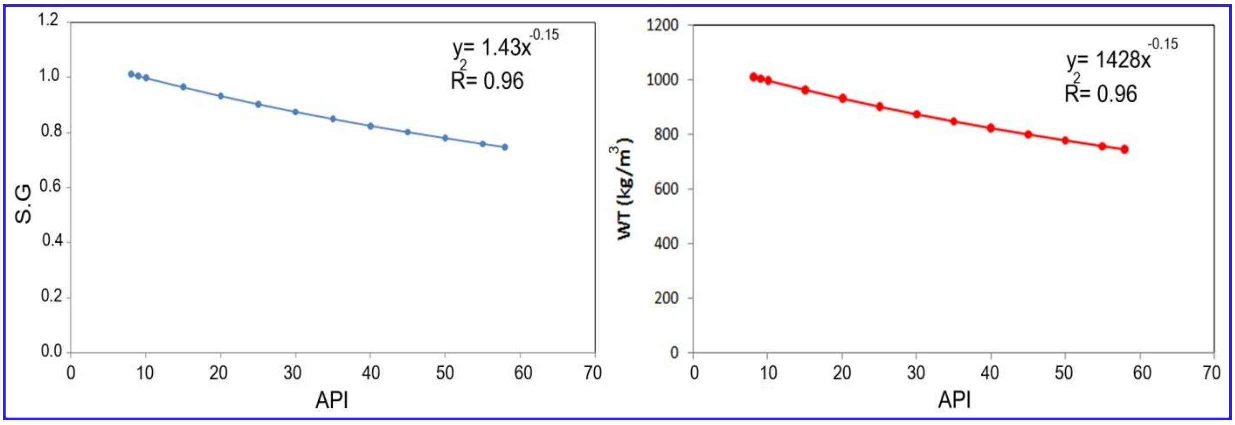

Figure 1: Statistical analysis of the API versus both of the specific gravity (SG) and Wt% of the crude oil

2.2 Relationship between API and S%

The crude oilis classifiedon the basis ofthe percentage of sulfur; the S% variesfrom less than 0.1% to greater than 5%. Crude oils with less than 1% Sare called low-sulfur or sweet crude, and those with more than 1% Sis called high-sulfur or sour crude(Chang et al., 2012), butthis ratiois notconstant, where other studies haveconsidered thesweet oil is thathas asulfurvalue of 0.5%, while the sour oil is that oil defined by having more than 0.5% S. API gravity has been reported to have an inverse relationship with S% of crude oil blends(Ekwere,1991) and confirmed by Madu et al. (2011), Odebunmi and Adeniyi (2007)and Awadh and Hussien (2015) whom they had mentioned that, API gravity varies inversely with both of specific gravity and the S%. Sulfur is relatively a heavier than C and H element; it has 2.07 gm/cm^3 density.Thus, it isself-evident that its presence in crude oil causes an increasethe specific gravity. This also explainswhy crude oil with low S% has a low specific gravity and vice versa.A total of 138 crude oil samples was investigated for the determination the how affect S% on the API°. Accordingly, The Data are listed in Table 2 and plotted (Figure 2). The best relationship that links S% to API value was concluded as an exponential equation as follows:

$$y = 11.903 * e^{-0.102x} \quad (4)$$

Where y is S%; x is API°.

The correlation coefficient (r) displays a medium positive relationship (0.54) and the coefficient of determination (R^2) (0.3) reflects that only 30% of the samples have correlated well. Ideally, for significant relations, the variables must be linearly correlated, but in the present study, the correlation between API and S% tend to be exponential rather than linear. Consequently, it is certainlythe existence of otherfactors rather that S% plays an important role in the API gravity. A graph of Figure 3 is useful to visualize the relationship which exists between API and S%.

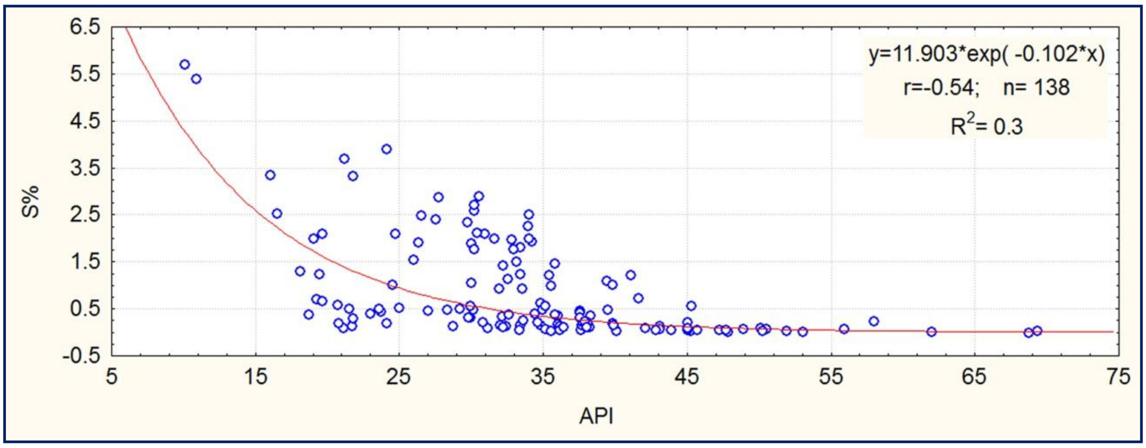

Figure 2: Statistical analysis displays the S% content effect of the API.

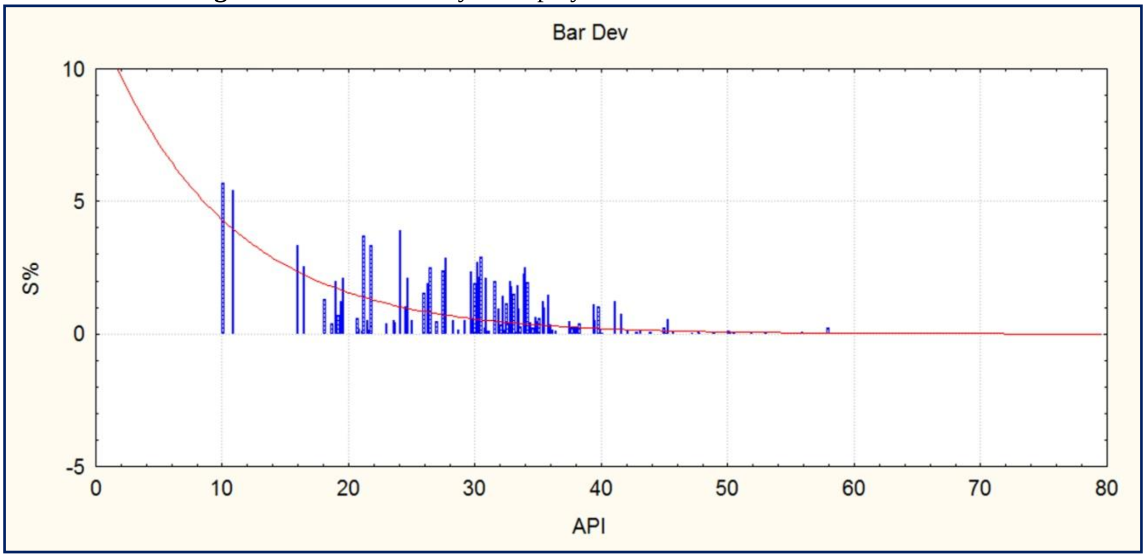

Figure 3: Bar deviation of S% against API has roughly fitting with the exponential trend

Cumulative frequency analysisshowsthatnearly70% ofthe API° valuesare located within theinterval 30 t0 70 indicating light oil, and the remnant API (30%) is heterogeneously distributed within the interval varies from 10 to 30 (Figure 4)indicating medium to heavy oil.But about 57% ofcrude oil samples contained S% less than 0.5 defining sweet oils, while the other samples (43%) represent sour oil (Figure 5). It is clear that the API° is inversely affected by S%, and this conclusion confirms the notice reported byKomine and Tomoike (1997)assulfides are fairly evenly distributed over medium and heavy factions of crude oils.

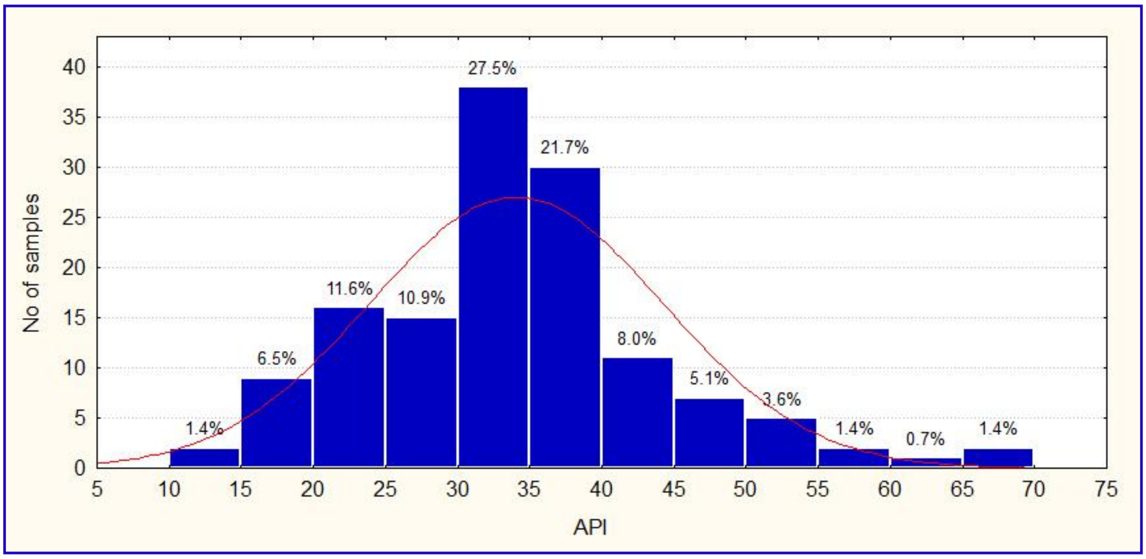

Figure 4: Cumulative frequencycurve ofAPI in of 138 crude oil samples.

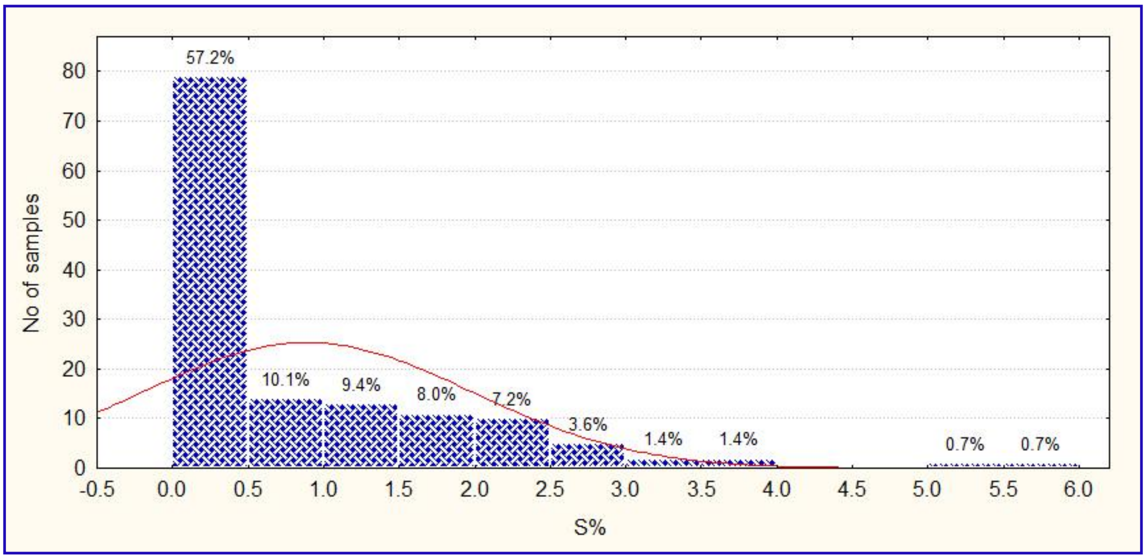

Figure 5: Cumulative frequencycurve of S% in 138 crude oil samples

3. Conclusions

The findings of this study are drawn as follows:

1) The linear regression betweenAPI versus both of SG and Wt% is strongerthan it isfor S%, where all are inversely proportional.
2) The perfect linear correlation between API and both of SG ($y=1.43x^{-0.15}$) and Wt% ($y=1428x^{-0.15}$) with a large set of data (r=98) represented the degree of linear regression association which was inversely correlated with high probable prediction (R^2= 0.96) for the parameter outcomes.
3) The API°versus S% hasan exponential correlation($y = 11.903 * e^{-0.102x}$) that reflectsthe existenceof other parameters that affect the crude oil density,such asheavy metals (Ni and V), NSO compounds asphaltene, wheresome studies, for example:Akpan (2005) emphasizedthat the light crude oil usually contain relatively low trace metal contents compared to the heavy crudes.Thereby, a rough estimation can be predictedfor API from data of S% and vice versa.

Table 2: Data of API gravity and sulfur content in the universal crude oil (Data Referenced by Teugels and Tillbert, 2012; Lillis and Peter et al.,2003; Kenny, 2009; API, 2011).

Oil field/Country	API°	S %	*CS %	**DF %	Oil field/Country	API°	S %	*CS %	**DF %
Oman oil	32.5	1.14	0.89	0.25	Dukhan/(Qatar)	41.1	1.22	0.41	-0.54
Dubai oil	30.4	2.13	1.03	1.10	Dulang/(Malysia)	37.6	0.05	0.59	-1.61
Print oil	37.5	0.46	0.60	-0.14	Duri/(Indonesia)	20.8	0.2	1.81	-0.65
ESPO oil	34.8	0.62	0.75	-0.13	EA/(Crude)Nigeria	35.1	0.08	0.73	1.10
Abu/Bukhosh/Abu Dhabi	31.6	2	0.95	1.05	East MS Mix/(US)	30.9	2.1	1.00	-0.28
Agbami/Nigeria	47.2	0.044	0.13	-0.08	Ekofisk Blend/(Uk)	37.5	0.32	0.60	-0.24
Aktobe/Khazakhstan	41.6	0.73	0.39	0.34	ElSharal(Libya)	43.1	0.07	0.31	-1.59
Alshahen/Qatar	26.5	2.49	1.31	1.18	Enfield/(Australia)	21.7	0.13	1.72	-1.32
Aljurf/Libya	30	1.9	1.06	0.84	Escalante(Argentina)	24.1	0.19	1.51	-0.13
Alaska/North slope	31.9	0.93	0.93	0.00	Espo-Blend/(Russia)	34.8	0.62	0.75	1.10
Alba/Guinea	53	0.02	-0.11	0.13	Fateh(Dubai)	30.4	2.13	1.03	0.50
Alba/UK	19.4	1.24	1.95	-0.71	Flotta(UK)	35.4	1.22	0.72	1.26
Albian/Heavy/Canada	19.6	2.1	1.93	0.17	Foroozan-Blend(Iran)	29.7	2.34	1.08	0.00
Algerian/Condensate	68.7	0.001	-0.64	0.64	Furrial/(Venezuela)	30	1.06	1.06	-0.74
Amenam-Blend/Nigeria	38.2	0.12	0.56	-0.44	Girassol(Angola)	29.9	0.32	1.06	-1.65
Amenam-Mars/Nigeria	33.5	0.94	0.83	0.11	Grane(Norway)	18.7	0.38	2.03	-0.23
Ameriven-HamacaVenezuela	26	1.55	1.35	0.20	Handil mix/(Indonesia)	43.9	0.05	0.28	-1.23
Amna-Libya	36	0.17	0.68	-0.51	Harding(UK)	20.7	0.59	1.82	-0.91
Arab extra light/Saudi Arabia	39.4	1.09	0.50	0.59	Hedrun(Norway)	25	0.52	1.43	-0.37
Arab/Heavy/Saudi Arabia	27.7	2.87	1.22	1.65	Hiberina/(Canada)	34.4	0.41	0.78	0.73
Arab Light/Saudi Arabia	32.8	1.97	0.87	1.10	Iran/(Heavy)	30.2	1.77	1.04	-0.54
Arab medieum/Saudi Arabia	30.2	2.59	1.04	1.55	Iran/(Light)	33.1	1.5	0.85	0.65
Arab super light/Saudi Arabia	50.1	0.09	0.00	0.09	Isthmus/(Mexico)	33.4	1.25	0.84	0.41
Asgard-Blend/Norway	50.5	0.07	-0.01	0.08	Kirkuk/(Iraq)	33.9	2.26	0.81	1.45
Azeri BTC/Azerbijan	36.1	0.14	0.68	-0.54	Kitina/(Congo)	36.4	0.11	0.66	-0.55
Azeri light/Azerbijan	34.8	0.15	0.75	-0.60	kole/(Cameron)	32.1	0.33	0.92	-0.59
BCF-17/Venezuela	16.5	2.53	2.28	0.25	Kuwait-Blend(Kuwait)	30.2	2.72	1.04	1.68
Balder/Norway	30.1	0.48	1.05	-0.57	Laguna(Malysia)	10.9	5.4	3.13	2.27

BaoBab/Ivory Coast	23	0.46	1.60	-1.14	Lavan-Blend/(Iran)	34.2	1.93	0.79	1.14
Barrow(Australia)	36.1	0.05	0.68	-0.63	Liverpool Bay/(UK)	45	0.21	0.22	-0.01
Basrah Light/Iraq	30.5	2.9	1.02	1.88	Lower Zakum/(Abu-Dhabi)	39.8	1.02	0.48	0.54
Bayou Chactow(sour)/US	32.2	1.43	0.91	0.52	Loreto/(Pero)	18.1	1.3	2.09	-0.79
Bayou Chactow(sweet)/US	36	0.36	0.68	-0.32	Lufeng/(China)	33.3	0.06	0.84	-0.78
Bayuundan(Australia)	55.9	0.07	-0.22	0.29	Marib light/(Yemen)	48.9	0.07	0.05	0.02
Belanak(Indonesia)	47.8	0.02	0.10	-0.08	Marlim/(Brazil)	19.6	0.67	1.93	-1.26
Belayim Blend (Egypt)	27.5	2.4	1.24	1.16	Maya(Maxico)	21.8	3.33	1.71	1.62
Beryl/UK	37.5	0.42	0.60	-0.18	Mayna/(Peru)	21.5	0.5	1.74	-1.24
Bintulu condensate(Malysia)	69.3	0.03	-0.66	0.69	Medanito/(Argentina)	34.9	0.48	0.75	-0.27
Bonga(Nigeria)	35.5	0.99	0.71	0.28	NFC II /(Qatar)	57.95	0.23	-0.29	0.52
Bonny light/(Nigeria)	33.4	0.16	0.84	-0.68	Napo/(Ecuador)	19	2	1.99	0.01
Boscan/(Venezuela)	10.1	5.7	3.29	2.41	Nome/(Norway)	30.8	0.22	1.00	-0.78
Bouri/(Libya)	26.3	1.91	1.33	0.58	Oman-Blend	34	2	0.80	1.20
Bow river/(canada)	24.7	2.1	1.46	0.64	Oso-Nigeria	45.7	0.06	0.19	-0.13
Brega/(Libya)	39.8	0.2	0.48	-0.28	Pang Lai/(China)	21.8	0.29	1.71	-1.42
Brent Blend/(UK)	38.3	0.37	0.56	-0.19	Plutonio/Angola	32.6	0.39	0.89	-0.50
CPC Blend/(Kazakhstan)	45.3	0.56	0.21	0.35	Port Hudson/(US)	45	0.05	0.22	-0.17
Cabinda/(Angola)	32.4	0.13	0.90	-0.77	Premium-Albian(Canada)	35.5	0.04	0.71	-0.67
Cano Limon/(Colombia)	29.2	0.5	1.11	-0.61	Qatar marine	35.8	1.47	0.69	0.78
Captain(UK)	19.2	0.7	1.97	-1.27	Rabi light/Gabon	37.7	0.15	0.59	-0.44
Cebia(Guinea)	29.9	0.57	1.06	-0.49	Rincon/Argentina	35.8	0.39	0.69	-0.30
Cepu /Indonesia	32	0.15	0.92	-0.77	Sahran blend/Algeria	45	0.09	0.22	-0.13
Cerro Negroo/(Venezuela)	16	3.34	2.35	0.99	Santa/Barbara/Venezuela	39.5	0.49	0.49	0.00
Champion/(Brunei)	28.7	0.13	1.15	-1.02	Senipah/Indonesia	51.9	0.03	-0.07	0.10
Chim Sao/(Vitnam)	40.1	0.03	0.46	-0.43	Siberian light/Russian	35.1	0.57	0.73	-0.16
Chinguetti(Mauritania)	28.3	0.49	1.18	-0.69	Siri/Denmark	38.1	0.22	0.57	-0.35
Cinta(Indonesia)	31.1	0.09	0.98	-0.89	Sirri/Iran	33.4	1.81	0.84	0.97
Clair/(UK)	23.7	0.44	1.54	-1.10	Sleipner/Norway	62	0.02	-0.43	0.45
Cold lake/(Canada)	21.2	3.7	1.77	1.93	Souedieh/Syria	24.1	3.9	1.51	2.39
Cooper/(Ausralia)	45.2	0.03	0.22	-0.19	South arne/Denmark	37.71	0.21	0.59	-0.38
Cossak/(Australia)	47.7	0.05	0.11	-0.06	Tabs blend/Malaysia	50.2	0.03	0.00	0.03
Cusiana/(Colombia)	43.1	0.14	0.31	-0.17	Triton/UK	37.5	0.32	0.60	-0.28
DUC/(Denemark)	33.6	0.26	0.82	-0.56	Upper Zakum/Abu Dhabi	32.9	1.78	0.87	0.91
Dalia/(Angola)	23.6	0.51	1.55	-1.04	Urucu/Brazil	42.1	0.09	0.36	-0.27
Daqing/(China)	32.2	0.11	0.91	-0.80	Varg/Norway	37.9	0.23	0.58	-0.35
Dar-Blend/(Sudan)	36.42	0.12	0.66	-0.54	Vasconia/Colombia	24.5	1.01	1.47	-0.46
Djeno(Congo)	27	0.47	1.27	-0.80	Vityaz/Russia	34.6	0.22	0.76	-0.54
Doba/(Chad)	21.1	0.1	1.78	-1.68	West seno/Indonesia	38	0.12	0.57	-0.45
Doroud/(Iran)	34	2.5	0.80	1.70	White rose/Canada	29.8	0.32	1.07	-0.75
Draugam(Norway)	39.9	0.15	0.47	-0.32	Zarzaitine/Algeria	42.8	0.06	0.33	-0.27

*CS% is a computed sulfur content%
**DF= S% - CS%

References

[1] Akpan IO, (2005) Effect of sample treatment on trace metal determination of Nigerian crude oils by Atomic Absorption Spectroscopy (AAS) Technique. African Journal of environmental pollution and health, 4(2):1-5.

[2] API (The American petroleum Institute), (2011) HPV Testing Group, Washington, 101p.

[3] Awadh SM and Hussien SA, (2015) Organic geochemistry and stable carbon isotopes of oil seepages in the Abu-Jir Fault Zone at the Al-Anbar governorate, Iraq. Arabian Journal of Geosciences (submitted).

[4] Cameron CA, Frank WA, Gramajo H, Cane DE, Khosla C (1997) An R-squared measure of goodness of fit for some common nonlinear regression models. Journal of Econometrics **77** (2): 1790–2.doi:10.1016/S0304-4076(96)01818-0. PMID 11230695

[5] Chang AF, Pashikanti K, Liu YA (2012) Refinery Engineering: Integrated Process Modeling and Optimization, First Edition. Wiley-VCH Verlag GmbH and Co. KGaA. 56p.

[6] Danyluk, M., Galbraith, B., and Omana, R., 1984, Towards definitions for heavy crude oil and tar sands, in Meyer, R.F., Wynn, J.C., and Olson, J.C., eds., The future of heavy crude and tar sands: United Nations Institute for Training and Research (UNITAR) Second International Conference, Caracas, Venezuela, February 7–17, 1982, p. 7–11.

[7] Dickson UJ, and Udoessien EI, 2012: Physicochemical studies of Nigeria's oil blends. Petroleum and Coal, 54 (3):243-251

[8] Dnr.louisiana.gov(1989)http://dnr.louisiana.gov(1989)./sec/execdiv/techasmt/oil_gas/crude_oil_ gravity/coments_Louisiana Department of Natural Resources.

[9] Duissenov D, (2012) Production and Processing of High Sulfur Crude and Associated Gas. TPG4510 Petroleum Production specialization project (NTNU), 45p.

[10] Kenny, N., (2009) The International Crude Oil Market Handbook, 8th edi.,EIR (Energy Intelligence Research), New York, 77p.
[11] Ekwere, D (1991). Oil and Gas Operations: its Theory and Experimentation. Paper SPE 5119. Presented at the 50th Annual Fall Meeting, Houston.
[12] Emil R and James K, (2007) Kent and Riegel's handbook of industrial chemistry and biotechnology, Volume 1. New York: Springer: 1171.
[13] Komine K, Tomoike K, (1997) Simultaneous Determination of Vanadium, Nickel and Sulfur by Energy-Dispersed Fluorescence X-ray Analyzer. J. IdemitsuGiho 40(6):616-620.
[14] Peters, K.E.,Magoon, L.B., Valin, Z.C. and Lillis, P.G.(2003) Petroleum Systems and Geologic Assessment of Oil and Gas in the San Joaquin Basin Province, California.Source-Rock Geochemistry of the San Joaquin Basin Province, California (Chapter, 11).35p.
[15] Madu AN, Njoku PC, and Iwuoha GA (2011) Extent Of Heavy Metals In Oil Samples In Escravous, Abiteye And Malu Platforms In Delta State Nigeria. Learning Publics Journal Of Agriculture And Environmental Studies.2 (2):41- 44.
[16] Odebunmi EO, Ogunsakin EA, Ilkhor PEP, (2002) Characterization of Crude oils and Petroleum Products: (I) Elution Liquid Chromatographic Separation and Gas Chromatographic analysis of Crude Oils and Petroleum Products. J. Bull. Chem. Soc. Ethiop. 16(2):115-132.
[17] Odebunmi O, And Adeniyi SA (2007) Infrared And Ultra Violet Spectrophotometric Analysis Of Chroma Tographic Fractions Of Crude Oils And Petroleum Products. Bull. Chern. Soc. Ethiop. 21(1):135-140.
[18] Sun X, Hwang JY, Huang X, Li B, (2009) Petroleum Coke ParticleSize Effect on the Treatment of EAF Dust Through Microwave heating. J. Mater. Characterisation Eng. 8(4):249-259.
[19] Teugels, W. and Tillbert, T. (2012) An overview of thehandling of extra-heavy crude oil. World Heavy oil Congress (WHOC),Alberdeen, Scotlandpp: 112-435.
[20] Wang X, Huang Y, (1992) Determination of Total Sulphur in Soil by X-ray Fluorescence Analysis. J. Guandpuxue Yu GuangpuFenxi, 12(2):119-121.
[21] Yasin G, Bhanger MI, Ansari TM, Naqvi SM, Ashraf M, Ahmad K, Talpur FN, (2013) Quality and chemistry of crude oils. Journal of Petroleum Technology and Alternative Fuels, 4(3): 53-63, DOI:10.5897/JPTAF12.025.