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Determination of the Total Sulphur Content in Khurmala and Guwayar Oil Fields of Kurdistan Region, Iraq

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Abstract

Five different samples of crude oil were evaluated. Three samples are from Khurmala crude oil field, and two samples are from the Guwayer crude oil field. All samples were evaluated to distinguish between qualities of both fields which are important sources of crude oil in the Kurdish Region. The specific gravity, API gravity, and the sulphur content were measured for all samples. Energy Dispersive X-Ray Fluorescence (EDXRF) was used to determine total sulfur content, a hydrometer was used to measure specific gravity and by using a mathematical equation we can find API gravity. By estimating these three parameters, crude oil of both fields were evaluated. In the samples of Guwayar oil field that measured the total sulfur in one of the well is 0.607 %(mean) wt and in second well was 0.6905 % wt(mean), while the total sulphur content in samples of three wells in Khurmala oil field were 2.3324% wt(mean), 2.1016% wt(mean), and 0.7362% wt(mean). We are 95% confident that there is no significant difference and we rejected the null hypothesis. There is strong relationship between sulphur content wt. % and specific gravity of the samples.

Keywords: (crude oil; total sulphur; Guwayar oil field; Khurmala oil field).

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1. Introduction

Today, the conditions that control the transportation of oil have become increasingly important due to the presence of sulphur. As a result, the separation of sulphur from crude oil is one of the central requirements in most refineries and the price of oil is identified by the amount of sulphur [1]. Sulphur is an element that results in inefficient burning, pollution, and damage to the engine life [2].

Sulphur in crude oil is problematic because it results in various problems such as the corrosion of metals. Air pollution is another negative outcome that is a result of burning crude oil which contains a high amount of sulphur. Sulphur compounds poison and expensive refining catalysts pollute the atmosphere in the form of sulfur oxides when burned, making environment problems [3].

When the percentage of sulphur in crude oil is less than 0.5, it is sweet crude oil but if the percentage is more than 0.5, this crude oil is sour. Sour crude oil is difficult to refine, unsafe to extract and hard to transport compared to sweet crude oil. As the percentage of sulphur is high in sour crude oil it needs more refining, which includes both financial and environmental costs [4]. Each crude oil has unique molecular characteristics which are understood by the use of crude oil assay analysis in petroleum laboratories (Duissenov, 2012)[3]. Organic sulphur molecules such as thiols, sulfides, and thiophenic compounds represent the main source of sulphur found in crude oil [5].

The removal of sulphur from compounds that contain aliphatic sulphur, i.e. thiols and sulfides, is simpler than separating sulphur from compounds that contain aromatic sulphur, i.e. thiophenics [6]. Refining of petroleum is done because of two reasons; first, to distinguish hydrocarbons of different sizes from each other to create different fuels and oils. Second, refining is used to remove contaminants [7].

Sulphur is the most common and well known contaminant of petroleum because it affects the quality of petroleum. Some of this sour crude oil would be in the form of carbon sulfide. High quantities of carbon sulfide can cause several health problems and can become fatal. In addition, hydrogen sulfide can be used to produce pure sulphur, a highly valued industrial element used in the production of fertilizers; Hydrogen sulphide can also be used to prepare sulphuric acid [8]. Therefore, it is important to determine the total concentration of sulphur to check the quality of crude oil.

Many methods are used to determine the concentration of the total amount of sulphur either in crude oil or refined oil. Each method depends on the objective. The objective in this research is to determine the total concentration of sulphur in crude oil in those oil fields in the Kurdistan region; in particularly in Erbil and then check the concentration of sulphur in the refined oil. The device that we use for this experiment is Energy Dispersive X-Ray Fluorescence (EDXRF).

2. Materials and methods

2.1. Sample collection

Five crude oil samples were collected for this work in sterilized bottles. Nine of the samples were from Khurmala, and six of them were from the Guwayer oil fields.

2.2. Materials

The materials used for analyzing a crude oil samples, XRF (RX-360SH), AC adapter, Sample cell assembling jig, Sample cell disassembling jig, Sample cell stand, Mayler Film (200mm×1,000m), Printer roll paper, Spare Printer ink ribbon, and 2-piece Teflon cup. Hydrometer.

2.2.1. Sample preparation

A sample cell stand was used as a table on which to prepare the sample .Then, a 2 piece Teflon cup was utilized with the sample cell stand. The first piece was placed on the sample cell stand and the Mylor film was used to cover the bottom to prevent the oil from leaking out. Using a dropper, 5ml of oil was dropped onto the Teflon cup. After that, another piece of Mylor film was put on the top of the Teflon cup to prevent the oil from leaking. After that, the second piece of Teflon cup was used to close the film tightly and prepare it for putting into the XRF device. To improve the validity of the test, one should not touch the underneath of the prepared sample as it may bring about an error in the results [9].

2.2.2. Determination of Total Sulfur Content by XRF technique

The sample is put in a place called a X-ray source. On the top of the X-ray source there is a film that should always be kept clean to prevent any dirt from scratching the film. If the film becomes unclean or scratched, it must be replaced with another film. Then, close the X-ray source gate and press the START button. The device counts for 100 seconds and then gives the result on the screen and the result is in a percentage (Technologies, 2014) [9].

3. Results

Crude oils are not uniform materials. They are categorized on the basis of physical characteristic which are commonly called “commercial parameters” and it has been used with the oil industry for quality evaluation and the costing purposes of the crude oil[10][11].

Table 1: Shows the mean of API gravity, sulphur content and specific gravity at $60F^0$**.**

Sample No	Location	API Gravity (Mean)	Sulphur content wt % (Mean)	Specific Gravity at 60 ◦ F (Mean)
1	Khurmala 1 crude oil	34.14	2.33	0.85
2	Khurmala 2 crude oil	2.40	0.61	1.06
3	Khurmala 3 crude oil	32.55	0.69	0.87
4	Guwayer well 2 crude oil	25.80	2.10	0.90
5	Guwayer well 3 crude oil	53.63	0.76	0.76

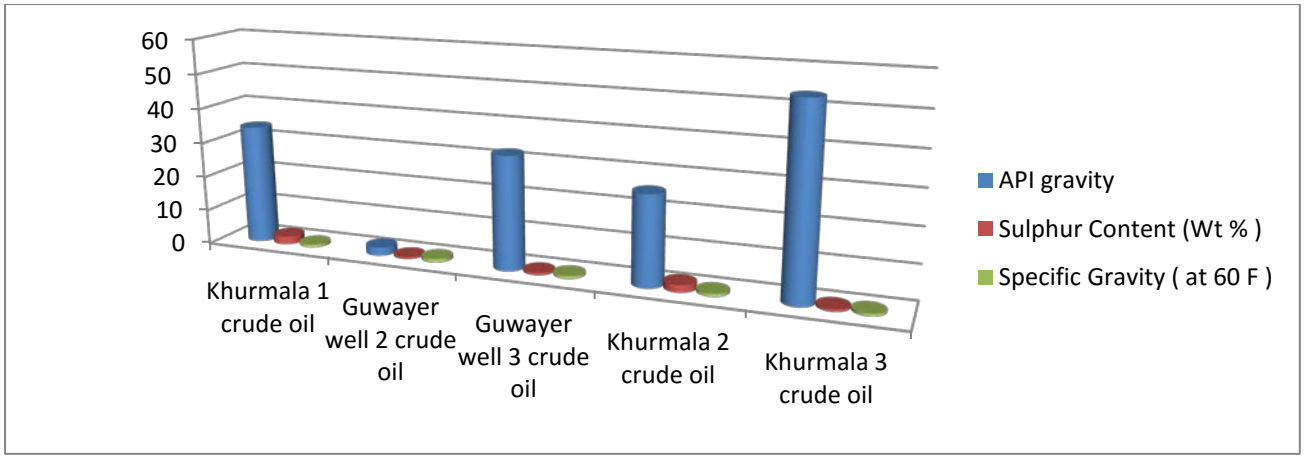

Figure 1: Shows the mean of API gravity, sulphur content and specific gravity at $60F^0$.

4. Discussion

Table 2: Shows the mean, variance and standard deviation of API gravity, sulphur content and specific gravity at $60F^0$.

Sample No	Location	API Gravity (Mean)	Sulphur content wt % (Mean)	Specific Gravity at 60 ◦ F (Mean)
1	Khurmala 1 crude oil	34.14	2.33	0.85
2	Khurmala 2 crude oil	2.40	0.61	1.06
3	Khurmala 3 crude oil	32.55	0.69	0.87
4	Guwayer well 2 crude oil	25.80	2.10	0.90
5	Guwayer well 3 crude oil	53.63	0.76	0.76
	Mean	29.70	1.30	0.89
	Var	340.25	0.71	0.01
	SD	18.45	0.84	0.11

Table 2 the standard deviation is smaller than the mean. It means the data points are near to each other.

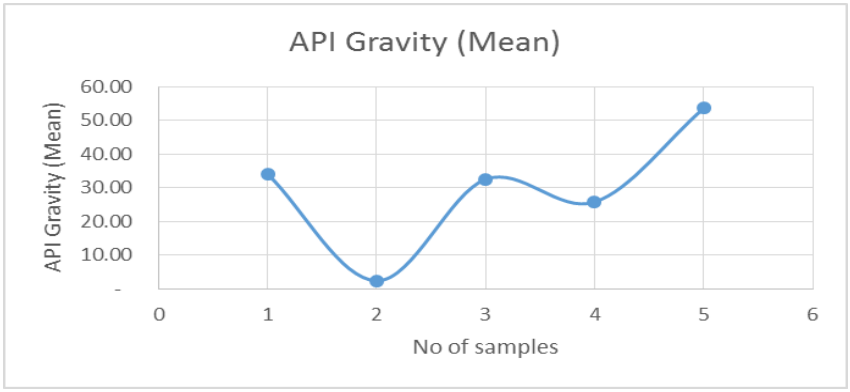

Figure 2: Shows the changes in API with location.

API gravity of crude oil, in which higher API (American Petroleum Institute) gravity of crude oil has a higher price and is of good quality and vice versa. Petroleum with API gravity between 40 and 45 orders the highest costs; over 45 the molecular chains become shorter and less valuable to refineries [12]. In general, density is weight per volume; and the specific gravity is the density of a substance relative to density of water [13]. By API (American petroleum institute); the specific gravity is fixed at 1 g/cm^3. The following formula is used to calculate the API gravity:

API=141.5/specific gravity -131.5

If API gravity is greater than 10 degree it indicates that hydrocarbon is lighter than water, and if the number is lower than 10 degree it indicates that hydrocarbon is heavier than water. Most oil has a higher API gravity which means they are lighter than water and that is why oil usually flows on top of water [13].

Therefore, API gravity is used to catalogue oil as light; medium; heavy; or extra heavy (Table 3).

Table 3: Show API gravity and crude oil types.

Type of crude oil	**API gravity**
Light	API>31.1
Medium	API between 22.3 and 31.1
Heavy	API<22.3
Extra Heavy	API<10.0

Reference [8] During the refining process, crude oils with high API gravity yield light fractions, while the process would be vice versa when the crude has a low API gravity.

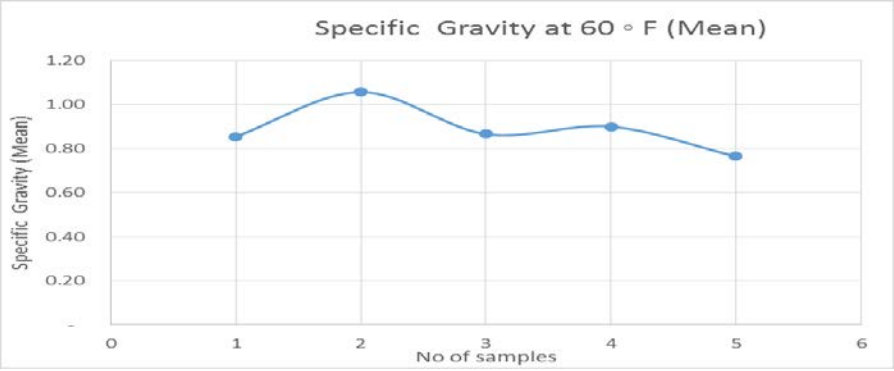

Figure 3: Shows the changes in specific gravity with location.

One of the important parameters used to measure the quality of crude oil is specific gravity. Low specific gravity means good quality of crude oils which have lighter fractions, while a high specific gravity indicates a worse quality of crude oil which has tough fractions. The specific gravity of Khurmala fields is low in

comparison to Guwayer oil fields, so this indicates that the quality of Khurmal crude oil fields are better than the Guwayer oil fields. In other words, Khurmala crude oil is better quality than Guwayer according to the specific gravity parameter for sample for both fields. The specific gravity of the crude oil gives an irregular measure of the amount of lighter hydrocarbons content.

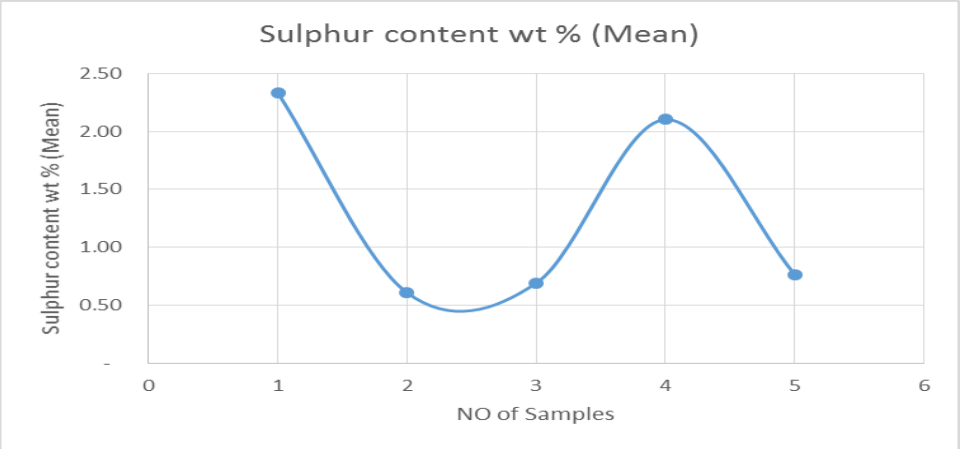

Figure 4: Shows the changes in specific gravity with location.

The amount of sulphur in crude oil is less than 0.5% which means sweet crude oil has a low percentage of sulphur making it to taste sweet, while sulphur percentage in crude oil greater than 0.5% is called sour crude oil(Petroleum.co.uk, 2015)[8].

The crude oil of Guwayer oil fields have a low amount of sulphur compared to crude oils which are present in the Khurmala oil field.

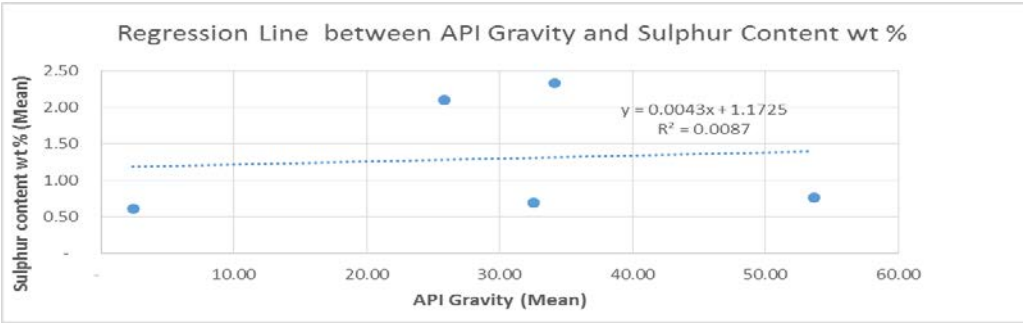

Figure5: Shows the relationship between API and Sulpur content wt%.

The straight line equation shows there is a very weak (essentially none at all since the R^2 value is so low) relationship between API and sulphur content.

The straight line equation shows data and there is a very strong relationship between API and sulphur content. Specific gravity is inversely proportional with the API gravity. So when API gravity is increasing specific gravity is decreasing and vice versa. Regarding the data the crude oil in Kurdish oil fields are all good quality

and their API gravity is usually between medium and light.

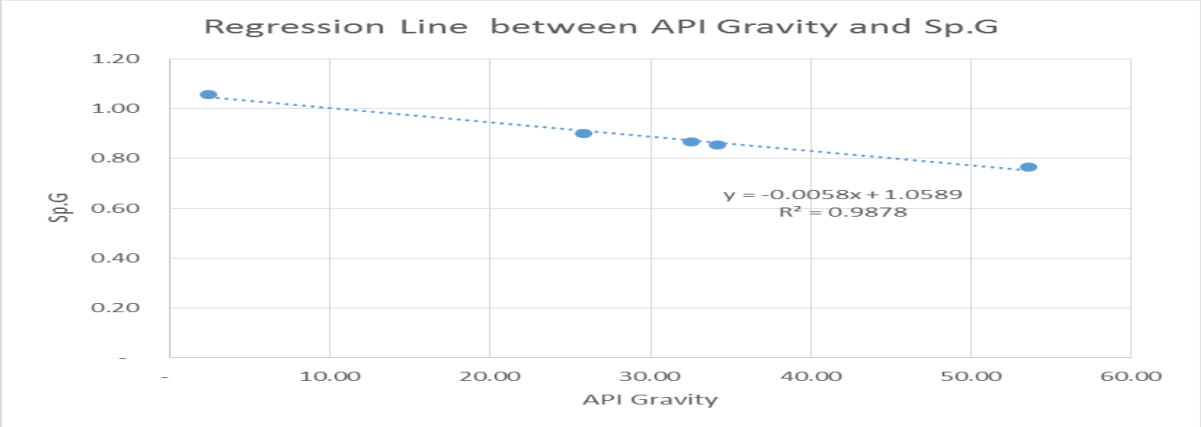

Figure 6: Shows the regression line between API gravity and specific gravity.

Table 4: Shows the correlation between API gravity, sulphur content and specific gravity at 60^0 F.

	API Gravity (Mean)	***Sulphur content wt % (Mean)***	***Specific Gravity at 60 ◦ F (Mean)***
API Gravity (Mean)	1		
Sulphur content wt % (Mean)	0.09305666	1	
Specific Gravity at 60 ◦ F (Mean)	-0.9938608	-0.17254215	1

In the above table the relationship between specific gravity and sulphur contents is directly proportional which means when specific gravity in crude oil is increasing, the sulphur content will increase too, and vice versa. On the other hand, the relationships between sulfur content and API gravity is inversely proportional, meaning when API gravity is light, there is a conduct high sulphur content.

Table 5: Shows t-test for API Gravity and specific gravity at 60 ^{0}F.

	API Gravity (Mean)	*Specific Gravity at 60 ◦ F (Mean)*
Mean	29.704	0.88804
Variance	340.24523	0.0113963
Observations	5	5
Hypothesized Mean Difference	0	
df	4	
t Stat	3.4931304	
P(T<=t) one-tail	0.0125258	
t Critical one-tail	2.1318468	
P(T<=t) two-tail	0.0250516	
t Critical two-tail	2.7764451	

In the above table, since $t_{stat} > t_{critical}$, we are 95% confident that there is a strong evidence, and therefore we accept the null hypothesis. That is strong relationship between API gravity and specific gravity of the samples.

Table 6: Shows t-test for API Gravity and sulphur content wt %.

	API Gravity (Mean)	*Sulphur content wt % (Mean)*
Mean	29.704	1.29894
Variance	340.24523	0.712075048
Observations	5	5
Hypothesized Mean Difference	0	
df	4	
t Stat	3.439780366	
P(T<=t) one-tail	0.013149515	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.026299029	
t Critical two-tail	2.776445105	

In the above table since $t_{stat} < t_{crtical}$. We are 95% confident that there is strong evidence so we are rejecting the null hypothesis that there is no relationship between API gravity and sulphur content %.

Table 7: Shows t-test for sulphur content wt. % and specific gravity.

	Sulphur content wt % (Mean)	*Specific Gravity at 60 ◦ F (Mean)*
Mean	1.29894	0.88804
Variance	0.712075	0.0113963
Observations	5	5
Hypothesized Mean Difference	0	
df	4	
t Stat	1.0802157	
P(T<=t) one-tail	0.1704138	
t Critical one-tail	2.1318468	
P(T<=t) two-tail	0.3408277	
t Critical two-tail	2.7764451	

In the above table $t_{crtical} > t_{stat}$. We are 95% confident that there is no significance difference and we rejected the null hypothesis. There is a strong relationship between sulphur content wt. % and specific gravity of samples.

5. Conclusion

From this work, we concluded that crude oil present in Khurmala and Guwayar oil fields are of good quality after measuring the samples from both oil fields. The research was done by evaluating three main parameters that decide the quality of crude oil. Amount of sulphur in crude oil is important to know in order to properly price the crude oil. API gravity and Specific gravity both have inversely proportional relationship with each other. It means when API gravity is increasing the Specific gravity will decrease directly and vice versa. As a consequence both parameters while directly effecting on the sulphur percentage of crude oil samples. Since Kurdish crude oil is of medium-high API gravity and low ratios of specific gravity, that makes the amount of sulphur low.

6. Recommendation

After analysis the samples of both Khurmala and Guwayar fields demonstrated that the sample content in both field is about more than 2% and this percentage is consider as high percentage and will affects the properties of crude oil and engine life. The recommendation from the results would be search for suitable method to reduce/remove the concentration of total sulphur to improve the efficiency of crude oil.

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