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RESEARCH PAPER

Evaluation of Gasoline Samples from Several Erbil Petrol Stations

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A B S T R A C T:

Gasoline is one of the main petroleum products used in transportation sectors in the Kurdistan region. The amount of gasoline provided from official refineries present in the region, which cover only a small portion of the total gasoline demand. The second source, which is the main one, is provided from outside of the region by private companies and includes three grades of gasoline (regular, premium, and super). The third source is blended gasoline, prepared locally in the region. Accordingly, to evaluate the available gasoline in the region, more than 100 samples of the three grades of gasoline were collected from different oil stations in Erbil City. Physical and chemical specifications were carried out, including sulfur content, octane number (RON and MON), density, vapour pressure, distillation curve, aromatic content, and olefin content using ASTM methods. The obtained results were compared with regional standards, Iraqi standards and worldwide standards.

The results revealed that the majority of the gasoline samples had greater sulfur content, greater vapour pressure, low Initial Boiling Point (IBP), low distillation temperature at 10% and regular 50% and final boiling points (FBP). In addition, the majority of samples failed to meet all specifications in tests conducted following international, Kurdistan and Iraqi standards. The low quality of gasoline leads to an increase the environmental pollution, increase fire hazards of cars, and destroyed engine cars.

KEY WORDS: Gasoline, Sulfur content, Octane number, Aromatic, Olefin.
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1. INTRODUCTION:

Gasoline, the most common vehicle fuel used globally, is a petroleum product used for gasoline engines. It makes up the greatest portion of the product obtained from a barrel of crude oil (Demirbas et al., 2015) (Sugiarto et al.) (Simonato et al., 2011). Typical hydrocarbon chains range in length from C_4 to C_{l2}, with a broad hydrocarbon distribution of 25–40% isoalkanes, 20–50% aromatics, 3–7% cycloalkanes, 1-4% cycloalkenes, 2–5% alkenes, and 4–8% alkanes (Naggar et al., 2017) (Demirbas et al., 2015). Gasoline is very hazardous since it can quickly evaporate at atmospheric pressure and room temperature, and when the volatile gas is coupled with air, it becomes flammable. A limited quantity of nitrogen compounds, sulfur compounds, and oxygenates are also included in the gasoline mixture (Jeon et al., 2017).

The government has given corporations authorization to import various types of gasoline (regular and premium) from other countries because the needs of the Iraqi Kurdistan region for gasoline in the transformation section exceed the territory's official refiners' production capability. It is important to mention here that besides these two sources of providing gasoline, local companies also contributed to producing so-called low-quality gasoline or regular gasoline by blending available light and heavy naphtha with other petroleum products and commercial additives. This process is carried out without employing any quality control measures even daily government test gasoline samples from petrol stations. Accordingly, it is of great

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importance to survey and make a scientific evaluation of all these sources of gasoline and report the risks resulting from their low quality to both human and environmental considerations in the region to stabilize the quality required in improvement for this section.

The goal of this work is to collect gasoline samples in some of the oil stations in Erbil city and then evaluate them by measuring the main physical and chemical tests of gasoline. Compare the results with standards from other parts of Iraq and from around the world. The characterization of the main physical and chemical properties, such as research octane number, sulfur content, density, vapour pressure, distillation curve, olefin, and aromatic compounds was tested.

2 MATERIAL AND METHODS

2.1 Sampling

Three set gasoline samples, which contain all kinds of gasoline, including one hundred and seventy gasoline samples (in the summer season), were collected directly from different petrol stations in Erbil city. The gathered samples were stored in glass reagent bottle (500 mL), and their physical and chemical characteristics were ascertained by analysis.

2.2 ASTM Specifications and Equipment

The American Society of Testing and Materials (ASTM) guidelines for analysis were followed for all samples used for specification and evaluation. The octane number was measured by applying the Eralytics Eraspec Fuel, FTIR Fuel Analyzer, Austria, following a correlation between ASTM 2699 and ASTM D2700. Using an X-ray sulfur meter and the (RX-360SH), sulfur content was determined (ASTM-D4294). Vapour pressure was analyzed using the Eravap (Austria) based on ASTM D5191. Moreover, fractional distillation was evaluated using an automated distillation tester, AD-86 under ASTM AD-86, and density was determined at 60 ºF (15.5 ºC) using a U-tube method following the standard procedure (ASTM-D4052). Lastly, aromatic and olefin compounds are measured using the Eravap (Austria) based on ASTM D6378.

3 RESULTS AND DISCUSSION

Each test that was examined in this study gives an idea and indication of the quality of the gasoline, and the overall findings were utilized to assess and classify the gasoline samples in Erbil. Additionally, the gasoline was assessed in relation to international gasoline category criteria, Iraqi requirements (Ministry of oil-Iraq, 2012), and Kurdistan region standards (Ministry of Natural Resources, Kurdistan Region-Iraq, 2022) (see Table 1, Table 2, and Table 3 respectively).

Table 1: Specification of gasoline based on worldwide Standards categories (2019).

	RON	MON	Density (min.)	Density (max.)	S%	Olefins	Aromatic
Category 2							
91 RON	91	82.5	0.715	0.77	150	18	40
95 RON	95	85	0.715	0.77	150	18	40
98 RON	98	88	0.715	0.77	150	18	40
Category 3							
91 RON	91	82.5	0.715	0.77	30	10	35
95 RON	95	85	0.715	0.77	30	10	35
98 RON	98	88	0.715	0.77	30	10	35
Category 4							
91 RON	91	82.5	0.715	0.77	10	10	35
95 RON	95	85	0.715	0.77	10	10	35
98 RON	98	88	0.715	0.77	10	10	35
Category 5							
95 RON	95	85	0.72	0.775	10	10	35
98 RON	98	88	0.72	0.775	10	10	35
Category 6							
98 RON	98	88	0.72	0.775	10	10	35
102 RON	102	88	0.72	0.775	10	10	35

Table 2: Specification of gasoline based on Iraqi standards

Grade	Regular	Premium	Super
Appearance	Clear& Bright	Clear & Bright	Clear& Bright
Distilled @ 100 °C Vol.% (min)	30	30	30
Distilled @ 145°C Vol.% (min)	70	70	70
Final Boiling Point °C (max)	210	210	210
Octane No. (Research), (min)	85	90	95
Sulfur Content (ppm) (max)	100	10	10
Aromatics Content Vol.% (max)	35	35	35
Olefines Content Vol.% (max)	18	18	18
Vapour Pressure R.V.P (kPa) @ 37.8 °C	(s) 45–62 (w) 50–84	((s) 45–62 (w) 50–84	(s) 45–62 (w) 50–84
Density (g/ cm³) @ 15 °C (min)	0.710	0.710	0.710
Oxygen Content wt.% (max)	1.3	1.3	1.3

Table 3: Specification of gasoline based on Kurdistan-Iraq standards.

Grade	Regular	Premium	Super
Appearance	Clear& Bright	Clear & Bright	Clear& Bright
Final Boiling Point °C (max)	210	210	210
Octane No. (Research), (min)	89	92	95
Octane No. (Motor), (min)	80	82	85
Sulfur Content (ppm) (max)	100	100	50
Aromatics Content Vol.% (max)	35	35	35
Olefines Content Vol.% (max)	18	18	18
Vapour Pressure R.V.P (kPa) @ 37.8 °C	(s) 44-60 (w) 49–82	(s) 44-60 (w) 49–82	(s) 44-60 (w) 49–82
Density (g/ cm^3) @ 15 °C (min)	0.710-0.775	0.710-0.775	0.710-0.775
Oxygen Content wt.% (max)	3.7	3.7	3.7

3.1 Sulfur content (wt%):

Sulfur content in fuel is an environmental apprehension because sulfur is converted to SOx during combustion, which is harmful to human health. (Hassan et al., 2013). In addition, sulfur compounds are detrimental to refinery processing due to catalytic poisons, plant corrosion, and atmospheric pollution. (Bajia et al., 2017) Around the world, environmental organizations are lowering the maximum permitted sulfur content in petroleum products. Furthermore, since the last forty years, governments from numerous nations around the world have allocated sulfur removal from fuels to minimize air pollution brought on by exhaust fumes (Tom and Dennis, 1999).

As illustrated in Figure 1(A-C), the sulfur content (mg/l) of some gasoline samples taken at Erbil petrol stations was higher than Iraqi standards and worldwide categories (see Table 1 and 2). The fact that most of the gasoline offered is made by combining light or heavy naphtha, which already has a greater level of sulfur compounds, may be the cause of the high sulfur content of the gasoline in Erbil's petrol stations.

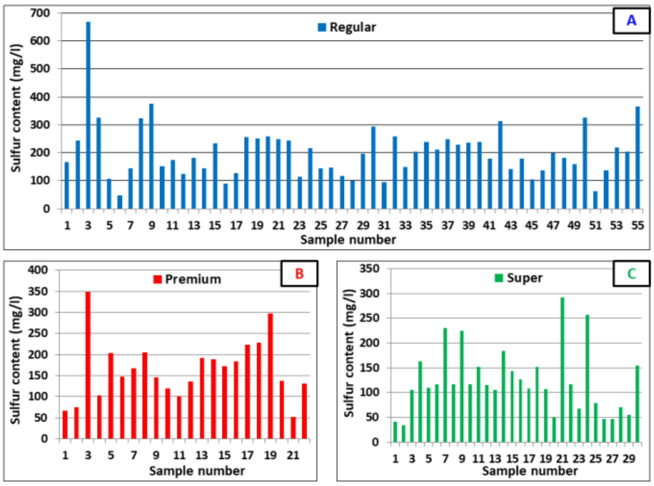

Figure 1 (A-C): sulfur content (mg/l) of gasoline samples A= Regular, B= Premium, C= Super

When the gasoline samples were compared to the Kurdistan standard, as shown in Figure 2, gasoline could be classified based on whether it passed or failed the Kurdistan standard. Only 9.1% of regular gasoline samples met the standard, whereas, 13.6% and 16.7% of the premium and super gasoline samples met the Kurdistan standard qualification, respectively. Significantly, the sulfur content of available gasoline in Erbil oil stations was higher and out of worldwide criteria even than Iraqi standards, especially for premium and super grades.

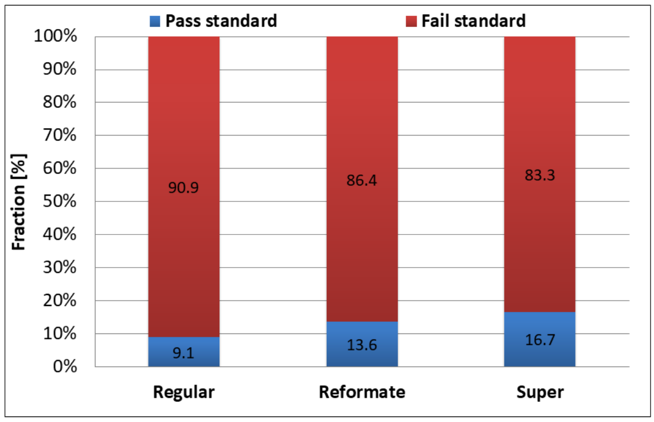

Figure 2: Classification of sulfur content (mg/l) of gasoline samples in Erbil depending on the pass or fail of the Kurdistan standard.

3.2 Octane number

The gasoline sold in Iraqi petrol stations comes in three different octane number ranges: standard, premium, and super. These three fuel types come in a range of octane ratings and cost different amounts. Research Octane Number (RON) and Motor Octane Number (MON) are two quantifiable factors used to assess octane number. The RON of typical commercially available gasoline samples varies by category and kind of gasoline, as shown in Table (1). Regular fuel is required for categories 2-4 at 91 RON, while categories 5 and 6 are related to 95 and 98 RON, respectively. In a regular Iraq standard, the minimum limit of RON is 85, whereas, RON is 89 of the Kurdistan region standard (see Table2 and Table 3). Moreover, in Figure 3 (A-C), the RON of the gasoline samples ranged from 83.6 to 93.9, and nearly most of the samples were in accordance with Iraqi standards. The values of RON of premium and super gasoline samples were in the range of 90.4 to 96.9 and 91.4 to 98.6 respectively.

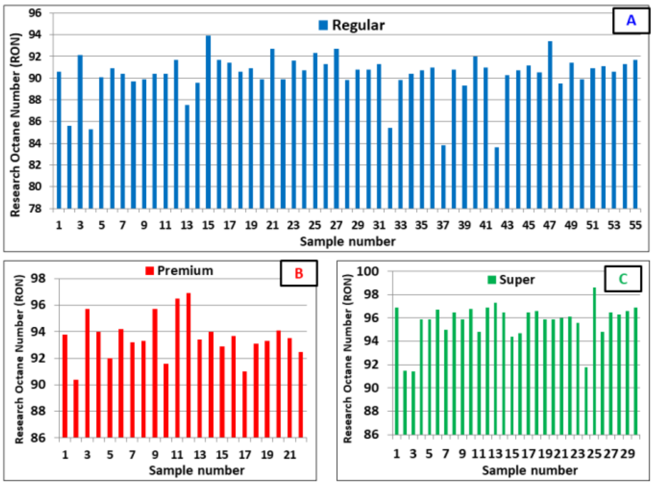

Figure 3 (A-C): Research Octane Number (RON) of gasoline samples A= Regular, B= Premium, C= Super

On the other hand, the MON values of gasoline samples are shown in Figure 4 (A-C) for regular, premium, and super grade repeatedly. The MON values of more than 90% of regular gasoline samples were around 80, for premium, it was above 82, and for super it was around 84-86. All of the MON results for the gasoline sample were within the allowable range and in accordance with international, Iraqi, and Kurdistan standards (see Tables 1-3).

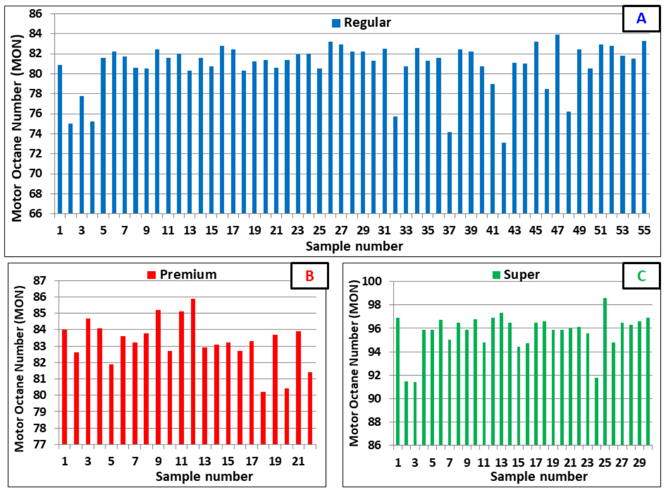

Figure 4 (A-C): Motor Octane Number (MON) of gasoline samples A= Regular, B= Premium, C= Super

Antiknock Index (AKI) or Pump Octane Number (PON) sometimes Posted Octane Number) is a measure of a fuel's ability to resist octane quality or engine knock. The Anti-Knock Index utilised in the USA and some countries is a specific case, which predates a more general relationship between vehicle octane requirement, RON and MON. It is the average of the RON and MON as determined by the formula (R+M)/2 (Demirbas et al., 2015).

As illustrated in Figure 5 (A-C), the lowest value of AKI for regular gasoline was 78.4 for sample 42, whereas, the highest value of AKI for regular gasoline was 88.6, which refers to sample 47. The highest AKI values of premium and super gasoline are 91.4 and 91.5 respectively. Also, the minimum values of premium and super types of gasoline were 91.4 and 91.5 respectively.

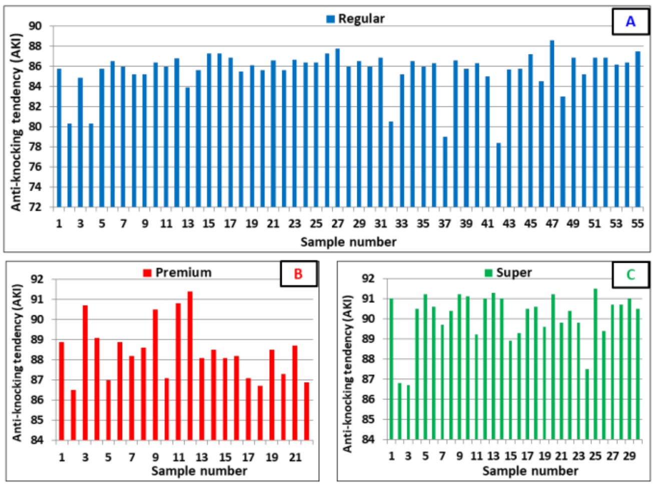

Figure 5 (A-C): Anti-Knocking Tendency (AKI) of gasoline samples A= Regular, B= Premium, C= Super

3.3 Density

The density of gasoline ranges from 0.715 to 0.770 g/cm^3 in categories 2-4, and from 0.720 to 0.775 g/cm^3 in categories 5-6 as indicated in the worldwide standards (Table 1). It is a minimum value of 0.710 g/cm^3 by Iraqi standards, and it ranges from 0.715 to 0.770 g/cm^3 by Iraqi Kurdistan standards (Table 2 and Tabe 3).

According to the results shown in Figure 6-A, which are specific for regular gasoline, almost all the gasoline samples are in the acceptable range. Also, the density of premium and super gasoline is shown in Figures Figure 6-B and Figure 6-C laid in the ranges dependable on worldwide, Iraqi and Kurdistan standards. Most types of gasoline have a density of around 0.720 to 0.770 g/cm^3. The density of most gasoline ranges from 0.720 to 0.770 g/cm^3.

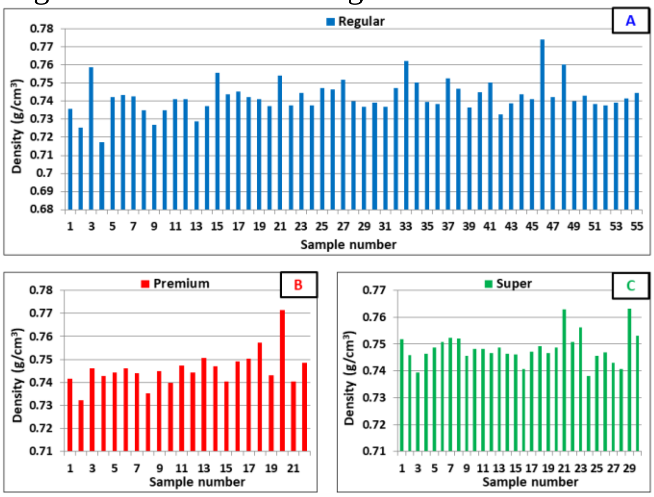

Figure 6 (A-C): Density (g/cm^3) of gasoline samples A= Regular, B= Premium, C= Super

The types of components used to combine the gasoline affect the density. If comparing compounds with the same amount of carbon atoms, aromatic compounds have the highest density, paraffin and naphthene have the lowest density, and olefins are in the middle (Mello et al., 2014).

3.4 Vapour Pressure

In the combustion process and the gasoline supply system, particularly in continuous operation on hot days and while starting the engine on cold days, the vapour pressure of gasoline is a fundamental physicochemical feature for the quantity of emission of volatile compounds (Brandão and Suarez, 2018; DASILVA et al., 2005). In order to reduce evaporative emissions from gasoline, which contribute to ground-level ozone and lessen the effects of ozone-related health conditions, the EPA restricts the vapour pressure of gasoline sold at retail stations during the summer ozone season (June 1 to September 15) (United States Environmental Protection Agency, 2022).

As illustrated in Figure 7 (A-C), the vapour pressure of gasoline ranges from 40 kPa to 87 kPa in regular gasoline, from 41-68 kPa, and 38-67 kPa in premium and supper respectively.

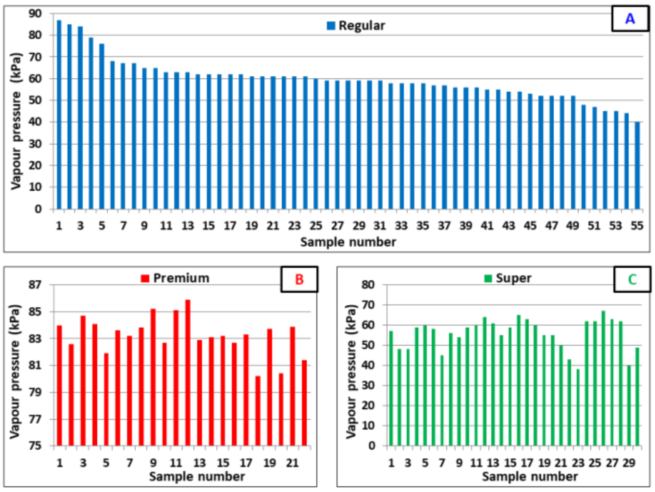

Figure 7 (A-C): Vapor pressure (kPa) of gasoline samples A= Regular, B= Premium, C= Super

When the gasoline samples were compared to the Kurdistan standard, as shown in Figure 8, gasoline could be classified based on whether it passed or failed the Kurdistan standard. Besides, 54.5% of regular gasoline samples passed the standard, whereas, 59% and 60% of the premium and super gasoline samples, respectively, passed the Kurdistan standard qualification.

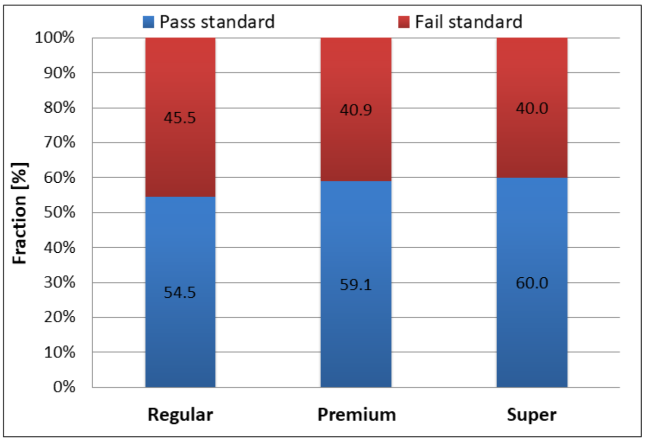

Figure 8: Classification of vapour pressure (kPa) of gasoline samples in Erbil depending on the pass or fail of the Kurdistan standard

Moreover, some gasoline samples have larger quantities of light petroleum fractions or oxygenated chemicals, which is why their vapour pressure has increased. Besides, the ethanol or methanol/hydrocarbon azeotrope formation increases the vapour pressure and decreases the boiling point temperature. (DASILVA et al., 2005)

3.5 Distillation Curve:

The distillation curve is a graph that contrasts the volume fraction distilled with the boiling temperature of a fluid mixture. It is useful for determining the fuel's boiling range and the ratio of heavy to light components, and it gives information that makes it possible to link quality to engine performance (Brandão and Suarez, 2018). Three points, T10, T50, and T90 represent the temperatures at which 10%, 50%, and 90% of the original volume of the gasoline vaporisers, respectively, can be used to represent the distillation curve. The volatile properties of the heavy, medium and light fractions of the fuel are characterized by these temperatures. The temperature of 10% of the volatilized gas portion recovered illustrates the vaporization situation, whereas the temperature of 90% of this fraction indicates the presence of high molecular weight molecules for which complete vaporization will be challenging (Bruno, 2006). It should be kept in mind that controlling one or more gasoline properties results in proper combustion in automobile engines and may result in a reduction in the emissions of unburned hydrocarbons (HCs), carbon monoxide (CO), and nitrogen oxides (NOx) (Mello et al., 2014).

A set of seven gasoline samples (5 in regular samples and 2 in premium samples) were chosen to evaluate their distillation curves, and the results are shown in Figure 9 and Figure 10. In this set, all samples are in the final boiling point range, which is 210 º C of the Kurdistan standard distillation curves (see Table 3). However, the IBP of gasoline samples was low, and this was because gasoline samples were prepared by blending lower boiling point materials such as light naphtha and other low boiling points oxygenated additives, which are used to increase the octane number of gasoline (DASILVA et al., 2005).

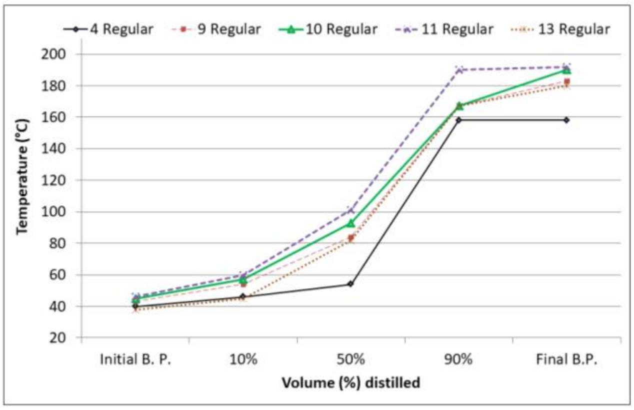

Figure 9: Distillation curve of regular gasoline samples.

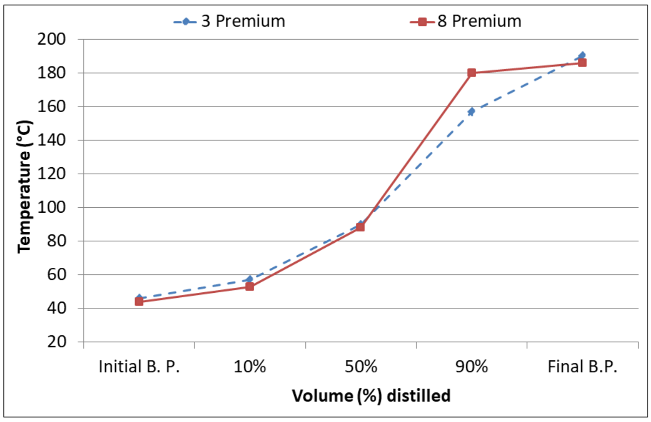

Figure 10: Distillation curve of premium gasoline samples.

3.6 Aromatic compounds

Polycyclic aromatic hydrocarbons (PAHs), which are precursors of soot particles, are known to be formed from aromatic hydrocarbons, which are unsaturated molecules with a structure resembling a benzene ring. Alkylbenzenes may have a greater impact on MON than RON, however, aromatic hydrocarbons raise both MON and RON. But increased particulate matter (PM) will result from more aromatics in the gasoline (Demirbas et al., 2015). These aromatics are extremely dangerous and carcinogenic substances, and because of their high volatility, it is easy for people to contact them by smell. Additionally, they are highly carcinogenic and readily absorbed via the skin (A. Y. El-naggar and m. M. Al majthoub, 2013).

As shown in Table 1-

Table 3, the aromatic content according to all worldwide categories (except category 2, which is 40 vol %) Iraqi standard, and the Kurdistan guideline is 35 vol %. The results in Figure 11 (A-C) show a wide range of fluctuations ranging between 9.7 vol.% and 40.1 vol%. Moreover, the aromatic content of regular gasoline samples (3 and 46) and premium samples (20) are 37.4 vol.%, 40.1 vol.%, and 37.9 vol.%, respectively, and was an acceptable aromatic content according to all guidelines and standards.

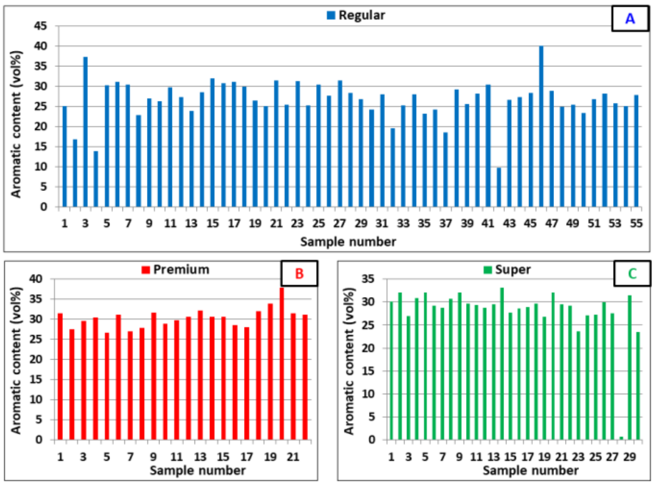

Figure 11 (A-C): aromatic content (vol%) of gasoline samples A= Regular, B= Premium, C= Super

About 80% of regular gasoline samples have an aromatic content that lies between 25 vol% and 30 vol%. The aromatic content of regular gasoline samples is seen to be lower than those limited in worldwide, Iraqi and Kurdistan standards. While approximately 72% of premium gasoline samples have an aromatic content ranging from 30 vol% to 35 vol%, this is close to global, Iraqi, and Kurdish standards. The aromatic content of super gasoline samples was between 28 vol% and 32 vol% for about 90% of the total samples under study.

3.7 Olefin compounds

According to worldwide standards (Category 2), Iraqi and Kurdistan standards must be 18 vol%, whereas, the accepted value for worldwide categories 3-6 was 10 vol%. The olefin content for a regular gasoline sample was very low. Figure 12 (A–C) illustrates the results, showing that the olefin content of all samples was lower than the values indicated in international, Iraqi, and Kurdistan standards. However, some gasoline samples fall into categories 3-6 (Table 1), Only 7% of the samples, the olefin content was 12% and about 50% of the samples were less than 3% and the remaining contented 4-8%. The same result was observed for premium gasoline samples. About 50% of the premium samples contented less than 2% olefin, and the others contend between 4-10%. For super gasoline samples, the olefin content was relatively better; about 60% of the samples had contented between 8% and 12% and about 25% content between 4% and 8%, and the remaining content with 2% to 4% olefins. These gasoline fuels have some drawbacks due to their high olefin content, including higher olefin content exhaust emissions with a higher ozone formation potential (OFP) and a greater tendency to form deposits in intake valves and engine injectors (Hajbabaei et al., 2013).

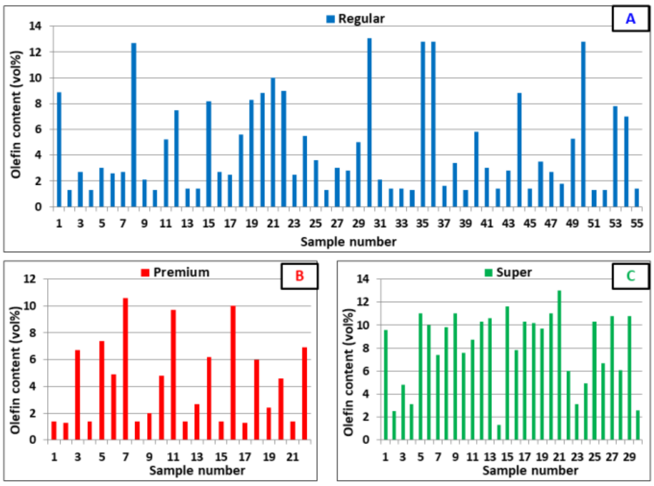

Figure 12 (A-C): Olefin content (vol%) of gasoline samples A= Regular, B= Premium, C= Super

4 CONCLUSIONS

The results showed that most of the gasoline samples have higher vapour pressure, higher sulfur content, a low initial boiling point and 10% distillation temperature, a regular 50% distillation temperature, and a regular final boiling point. Based on your results, in most of gasoline samples collected, the olefin content is quite low if compared with Iraqi specifications, this mean that the fuels originated from local small refineries that do not have chemical processes responsible for olefin production. The overall conclusion observed from the evaluation of gasoline samples used in Erbil petrol stations most gasoline samples have low quality according to worldwide, Iraqi, and Kurdistan region guidelines. Most gasoline fuels are prepared by blending different petroleum products in addition to some chemical materials. The low quality of gasoline leads to an increase the environmental pollution, increase fire hazards of cars, and problems in engine cars.

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