Quality Assurance for Iraqi Bottled Water Specifications

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ABSTRACT

In this research the specifications of Iraqi drinking bottled water brands are investigated throughout the comparison between local brands, Saudi Arabia and the World Health Organization (WHO) for bottled water standard specifications. These specifications were also compared to that of Iraqi Tap Water standards. To reveal variations in the specifications for Iraqi bottled water, and above mentioned standards some quality control tools are conducted for more than 33% of different bottled water brands (of different origins such as spring, purified,..etc) in Iraq by investigating the selected quality parameters registered on their marketing labels. Results employing Minitab software (ver. 16) to generate X bar, and Pareto chart. It was found from X bar charts that the quality parameters of some drinking bottled water brands are not within Iraqi standards set by the "Central Agency for Standardization and Quality Control" such as pH values, Fe, Na, and Mg concentrations.

While the comparison of previously mentioned standard specifications through radar chart many important issues are detected such as the absence of lower limits the whole bottled water quality parameters such as for Na and Mg also the radar chart shows that Iraqi bottled and tap water specifications are almost equal in their quality values. Also the same chart pictured the limited range of Iraqi specifications compared to that of Saudi Arabia, and WHO and the need to introduce other water specifications such as K, Na, etc. This confirms the need to improve Iraqi bottled water specifications since it was introduced on 2000.

These results also highlighted the weakness of quality assurance activities since only 33 % of the investigated companies registered the whole water quality specifications as shown in Pareto chart. Other companies do not register any quality characteristics. Also certain companies should be stopped due to non-conforming specifications, yet these companies are still producing and selling their products in the local market. Quality assurance requires continually monitor the reliability (accuracy and precision processes) of Iraqi drinking bottled water companies to match the Iraqi Specification Standards, and those companies should continually approve "How good (accurate and precise) is their product(water quality) produced?".

Key words: quality assurance, Iraqi bottled water, labels, tap water, specifications, WHO, control chart, radar chart. Pareto chart.

ضمان نوعية مواصفات المياه العراقية المعبأة بالقناني

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الخلاصة

تم في هذا البحث التحقق من مواصفات مياه الشرب المعبأة بالقناني اعتماداً على البيانات المسجلة على الملصق التعريفي لشركات محلية والمقارنة بينها وبين المواصفات العراقية القياسية والمواصفة السعودية , و المواصفة القياسية لمنظمة الصحة العالمية للمياه المعبأه بالقناني . كما تمت مقارنة هذه المواصفات مع المواصفات العراقية القياسية لماء الشرب من الحنفية. لغرض استعراض التباين في المواصفات العراقية والمواصفات المذكوره اعلاه لاكثر من 33 % من الشركات المحلية المنتجة للمياه المعبأة بالقناني (من مصادر مختلفة مثلا ينابيع , مياه منقاة, ...الخ) استخدم بعض ادوات السيطرة النوعية ومخطط الرادار للمقارنة بين مختلف الخواص النوعية المنتخبة لمنتوجات تلك الشركات كما مثبت على ملصقاتها التجارية. تم استخدام برنامج ميني تاب (أصدار 16) لغرض توليد كل من لوحة السيطرة للمتوسط لمختلف الخواص النوعية و لمخطط باريتو. وجد من لوحة السيطرة للمتوسط ان بعض الخواص النوعية لبعض العلامات التجارية للمياه المعبأة ليست ضمن المواصفات العراقية المعدة من قبل" الجهاز المركزي للتقييس والسيطرة النوعية " كما في قيمة الدالة الحامضية وتراكيز كل من (الحديد و المغنيسيوم و الصوديوم). بينما اظهر مخطط الرادار وعبرالمقارنة بين المواصفات القياسية المذكورة انفاً عدة مؤشرات اهمها خلو المواصفة العراقية للحدود الدنيا لاي خاصية من الخواص القياسية للمياة المعبأة والذي من المهم ادراجه في المواصفة كما في الحدود الدنيا لمادتي الصوديوم و المغنيسيوم . كما اظهرت نتائج نفس المخطط التقارب الشديد بين مواصفات مياه الشرب من الحنفية والمياه المعبأة . وايضاً اظهرت النتائج محدودية المواصفات العراقية المدرجة مقارنة مع المواصفة السعودية ومواصفة منظمة الصحة العالمية من حيث خلوها من بعض المواصفات المتعلقة بتركيز البوتاسيوم و الصوديوم وغيرها مما يشير الى ضرورة تطوير المواصفة العراقية كونها اصدار عام 2000.

كما بينت نتائج البحث ضعف اجراءات ضمان النوعية حيث اظهر مخطط باريتو ان 33% فقط من الشركات قيد البحث قد سجلت كل مواصفات المياه اما بقية الشركات فلم تدرج في ملصقها التعريفي اي مواصفة. كذلك ضرورة تعليق انتاج بعض الشركات المنتجة للمياه المعبأة بسبب عدم مطابقة مواصفات منتوجها مع المواصفات القياسية العراقية علما ان هذه الشركات مستمرة بالانتاج وتزود السوق المحلية بمنتجاتها. ان ضمان النوعية يتطلب عملية مراقبة مستمرة لموثوقية (دقة وضبط العمليات) للشركات العراقية المنتجة للمياه المعبأة بالقناني للمواصفات العراقية القياسية, وعلى الشركات ان تثبت باستمرار كم هي دقيقة ومضبوطة منتجاتها (نوعية المياه) المنتجة.

الكلمات الرئيسية : ضمان النوعية, المياه العراقية المعبأة ,الملصق التجاري , مياه الحنفية , المواصفات, منظمة الصحة العالمية, لوحة السيطرة للمتوسط , مخطط الرادار , مخطط باريتو.

1- INTRODUCTION

Although Iraq has two major rivers as natural water sources, these sources are generally polluted, biologically and chemically as a result of lack in appropriate systems for safe disposal of sewage, wastewater, industrial, agricultural and medical waste. Water treatment plants, pumping stations and water networks suffered from lack of maintenance resulting breakdown ,**Stars Orbit Consultants and Management Development, 2010**. In general, the quality of water is equally important as its quantity therefore; water quality is considered as the factor to judge environment changes which are strongly associated with social and economic development ,**Toma, et al., 2013**. Bottled water can be defined as any potable water that is manufactured, distributed or offered for sale, sealed in food-grade bottles or other sanitary container and intended for human consumption Sources of water in bottled water may be springs, wells, or other approved sources, the water inside these bottles may be distilled, Carbonated, Ozonized or filtered ,**Toma, et al., 2013 and Alabdula'aly, and Khan, 1999**.

In developing countries about 1.8 million people, mostly children, die every year as a result of water related diseases. Tap water may be harmful to human health due to contamination with microbes. Tap water quality may change as a result of exposure to the surrounding environment as open tanks or in pipes throughout distances before reaching the consumers ,**1991 , والعزاوي ,المفرجي and Fadhel, 2010**. The most important characteristic of bottled water over tap water is the quality, especially in terms of taste and regularity. Therefore, bottled drinking water is one of the most important sources of drinking water not only in Iraq, but also in the entire world ,**World Health Organization (WHO), 2004**. Bottled water industry is one of the most thriving industries, in Iraq and worldwide. It is the fastest growing drink choice where water consumption worldwide is increased by average 10% annually, therefore, became the most dynamic sector of all food and beverage industries due to accessibility, relatively low cost, better taste, and lower level of impurities , **Saravanan and Nagarajan, 2013, and 2008 رزوقي والراوي** . The bottled drinking water industry in Iraq represents 54% over other food industries, more than 100 factories are registered (excluding the northern government) these factories produce about 160 Million m^3/yr. The factories authorized in Iraqi were 10 factories until the end of 2006; currently 234 factories are under construction distributed on the different Iraqi governorates. This increase is driven by decrease in tap water quality, the lack of control that offers high risk practices that contribute in environmental degradation, contamination of natural water resources, and the percentage of failure to conform health requirements to Iraqi Standard Specifications released on (2000) , **2010 , العزاوي واخرون**. Baghdad and other governorates are the most affected areas knowing that the highest production rates of bottled water factories is also in Baghdad about 11 Million m^3/yr ,**المديرية العامة للتنمية الصناعية**.

In this research quality control tools is conducted for more than 33% of different bottled water brands in Iraq by investigating the quality parameters registered on their marketing labels. Since quality reported in different bottled water labels should continually be assured so that companies could answer to the question "How good" (accurate and precise) they are ,**U.S. Environmental Protection Agency Office of Research and Development, 1979**. The collected data are analyzed and compared to Iraqi, Saudi Arabia, and World Health Organization (WHO) Standards so as to investigate differences in quality characteristic. Also to inform consumers that are not involved in the operations of this product quality as it is the goal of quality assurance activities. In the next paragraph literature survey is conducted to prevail Iraqi and international interest in bottled water quality followed by analysis of results and discussion. Finally conclusions are presumed and stated.

2- LITERATURE SURVEY

The attention of many researchers is directed towards drinking bottled water quality as they studied water specifications from different aspect such as chemical, biological, etc. **Ahmed, and Bajahlan, 2009**. compared the quality of drinking bottled water with tap water; the results showed that there were no significant differences in the quality of tap water and drinking bottled water in Saudi Arabia. Their physicochemical analysis showed the persistent quality of tap water. Based on hardness analysis, bottled and tap water are categorized as soft water.

Matloob, 2011, evaluated Fluoride content of tap and drinking bottled water currently consumed in Babel governorate in Iraq to determine whether Fluoride intakes by Iraqi consumers fell within the recommended Iraqi ranges. It was found that the level of Fluoride is far below the level recommended by World Health Organization (WHO) and that of Iraqi tap water specifications.

Semerjian, 2011, collected 32 different bottled water brands, analyzed them into various physicochemical levels then compared results with Lebanese institution standards for bottled water, where many characteristics are investigated, yet the majority that met different bottled water standards for physicochemical parameters.

Abdulraheem, et al., 2012, focused on measurements and comparison of bacterial concentration of endotoxin in variety samples for tap water and bottled water in Kuwait using the Limulus Amoebocyte lysate test. Researchers proved that drinking bottled water has less endotoxin compared to that of tap water.

Queiroz, et al., 2012, presented data from two Canadian newspapers of national circulation, for tap water and bottled water. The researchers used quantitative and qualitative data for their analysis. They observed that the selected print media presented wide range of news reports that provide the reader with thoughts on the current situation of water supply quality in Canada. The media has been supportive to consumers with important advices to reduce health threats.

3 - QUALITY CONTROL TOOLS

Seven basic tools of quality is a designation of statistical techniques identified as being most helpful in troubleshooting issues related to quality. These tools can be used to solve the majority of quality-related issues. The seven tools are ;(Cause-and-effect diagram, Check sheet, Control charts, Histogram, Pareto chart, Scatter diagram and flow chart) ,**Montgomery, 2005, Kaoru, 1985, Masaaki, 1986 and Juran , 1951**.

In this research, control (X-bar) and Pareto charts were employed while Radar chart is used to show the range and differences among the Iraq Specification and other standards.

Quality control and quality assurance differs in their prime goal since, the prime purpose of quality control is to serve those who are directly responsible for conducting operations and help in regulating current operations. While quality assurance primary purpose is to serve those who are not directly responsible for conducting operations but who need to know (consumers) ,**Kazemzadeh, et al., 2013**.

In general, control chart is used to distinguish between variations in process resulted from common and that special causes. Every process has variations; this could be special cause variation. Other variations are simply the result of numerous, ever-present differences in the process ,**Miller and Freund, 1985 and Walkenbach, 2003**. Control chart (X-bar) to build need three principals lines are; the upper line (UCL_X) as the upper control limit and the lower line (LCL_X) as the lower control

the center line (CL_X) arithmetic mean ($\overline{X}$) limit, calculated according to equations below ,**Miller and Freund, 1985**.

$$CL_X = \frac{1}{n}\sum_{i=1}^{n} \bar{X}_i \quad (1)$$

$$\mathrm{UCL_X} = \mathrm{CL_X} + \frac{3\bar{R}}{d_2\sqrt{n}} \quad (2)$$

$$\mathrm{LCL_X} = \mathrm{CL_X} - \frac{3\bar{R}}{d_2\sqrt{n}} \quad (3)$$

Where; (CL_X) is the arithmetic mean of the measurements for
X 1….n denotes the number of samples.

If a point lies within UCL, LCL, then the process is deemed to be under control. Otherwise, a point plotted outside the control limits can be regarded as evidence representing that the process is out of control. The performance of a control chart, especially X-bar chart, is usually evaluated under the assumption that there are no errors in estimating the process standard deviation used to determine the control limits (this is, of course, not always the case in practice) ,**Saravanan and Nagarajan, 2013 and Miller and Freund, 1985**.

Pareto charts could be in both bars and line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line. The vertical axis is the frequency of occurrence, while the vertical axis is the cumulative percentage of the total number of defect occurrences ,**Kaoru, 1985 and Masaaki, 1986**.

Although Radar chart is not one of the seven quality control tools but it represents an effective graphical diagram of displaying multivariate data in the form of a two-dimensional chart for many quantitative variables represented on the axis starting from the same point. The application of radar charts is the control of quality improvement to display the performance metrics of any ongoing program ,**Walkenbach, 2003**.

4- EXPERIMENTAL PROCEDURE

In this study thirty five different types of Iraqi drinking bottled water labels are collected, three samples of each label is collected and the sample size is of (500ml/volume). These samples are of different Iraqi resources (springs, drinking water and purified bottled water), from different Iraqi governments. The specifications registered on the labels by the manufacturers are different, and quality parameters may vary such as for (pH, TDS, Ca, Na, Mg, K, Fe, Cl, and F) depending on the origin of the water and the manufacturing company purification processes. The previous nine parameters were chosen because they mostly exist in this study. The parameter value is compared first with Iraqi standard specifications set by the "Central Organization for Standardization and Quality Control" ,**Juran , 1951** then with other standard specifications. Results are generated employing Minitab software (Ver. 16) to generate X-bar, and Pareto chart.

5- DATA ANALYSIS, AND DISCUSSION

Each brand is given a specific number instead of the company trade name, as shown in **Table 1.** considering that No. 1 to No. 14 represent bottled from northern Iraq (are spring water), from No.15 to 35 are for other Iraqi governorate (drinking water). The specifications of the collected samples are listed in **Table1,** where some factories are not committed to set all the quality characteristics. Some factories set most of the quality characteristic such as in northern Iraq form {No.1 to No.14}.Other characteristics that are not stated since water origin is spring water from **Table 2** it could be noticed that there is no significant differences between Iraqi tap, and bottled water specifications this requires essential developments in bottled water specifications since consumers are currently paying more for almost the same water quality. Also bottled water specifications were released more than one decade ago on (2000) hence, updating these standards for such important industry is crucial as it is related to everyday use and human health.

To verify and compare Iraqi bottled water specifications with that of drinking water and tap water standards. Also Saudi and WHO standards are listed in **Table 2.**This table shows that Iraqi specification ,**Stars Orbit Consultants and Management Development, 2010,العزاوي واخرون and المواصفة القياسية العراقية لمياه الشرب رقم(417) , 2001, 2010** . are less restricted (wide range of values as in Mg and Ca values). Sometimes these specifications are far behind these standards as in TDS values, other quality characteristics values are not even included as in Na, or K values. As a result, these characteristic should be introduced and reviewed continuously to reduce the gap between other standards and that of Iraqi standards. It's worth mentioning that Saudi Arabia specifications' , **الهيئة العربية السعودية للمواصفات والمقاييس, 1997, كامل, 2002**. is one of Iraqi specifications references, yet Iraqi specifications are still behind their reference values. On comparison with WHO specifications ,**World Health Organization (WHO), 2004, and Darapu, and et al., 2011**. the values of Iraqi standards for (Ca, Fe, Cl) are on its maximum acceptable values to WHO standards as could be noticed from **Table 2.**

All samples had expire date of one year from production date (that should be included also in the specifications). From **Table 1** and **Fig. 1** it could be noticed that most of the investigated companies (35) does not classify more than (33%) Iraqi bottled water required characteristics {No. 1937/ (2000)}.Only (28 %) of the investigated bottled water factories registered all specifications that are declared in Iraqi bottled water specifications (2000). Also (40%) of the investigated companies in this research do not register (50%) of the Iraqi specification. While for company No. (27). No specific characteristic of the nine characteristics is registered, and this company still selling in the local market.

Pareto chart shows the accumulative specifications that are not registered for the collected Iraqi samples **Fig.1** where the horizontal axis represents the not registered characteristics on the water bottle label, and the vertical axis presents the number of companies investigated in this study. The above mentioned percentages could be observed clearly in this Pareto chart **Fig. 1.**

Fig.2 presents comparison between (Iraqi, Saudi Arabia and Worldwide) Standards, Radar chart is conducted to reveal the range for each specification value, and the full view of each standards in graphical comparison between (Iraqi, Saudi Arabia and Worldwide). From **Fig. 2** and **Table 2** it could be noticed the absence of minimum limit values for Iraqi tap water standards. Since only the maximum values for each quality is stated, consequently updating this standards is essential. Also the limited range of coverage for Iraqi bottled water specifications in both aspects of values and existing characteristics, compared to the wide range covered especially by World health

organization standards. This means that Iraqi Specifications should be developed to enhance water specifications and update the standard periodically for this important industry that is related to everyday use and human health. These not including characteristics should be introduced and reviewed continuously to improve these characteristic also to reduce the gap between other standards and that of Iraqi standards.

Detailed notes and results of specifications for selected parameters are shown below as control charts for nine different water in **Figs. 3** to **11** {knowing that the red line indicates to the upper and lower control limits and the green line indicates to center line or means} generated employing Minitab software (Ver. 16).

- **pH**

pH is a measure of the activity of Hydrogen ions (H+) in a solution therefore, solution is either acidic (pH less than 7) or alkaline (pH greater than 7), pure water of pH very close to 7 ,**http://www.engineeringtoolbox.com/food-ph-d_403.html**. pH value according to Iraqi Standards for drinking bottled water ranges (6.5 – 8.5), but for WHO Specifications pH ranges (6.5 – 8.5) and their values do not exceed the allowable limits, as shown in **Fig.3** from this control chart it was found that company No. (18) does not reach the minimum limit (almost acidic). While for companies No. (26 and 30) pH values are not verified in their labels although it is basic and important characteristics.

- **Total Dissolved Solids (TDS)**

This quality characteristic is not included in Iraqi standard specification yet, although it is an important quality characteristic parameter. Yet it could be noticed from **Fig.4** that (50 %) of Iraqi companies tested in this study haven included the (TDS) values in their labels. Total dissolved solid (TDS) describe the inorganic salts and small amounts of organic matter present in water. The presence of dissolved solids in water may affect its taste. The estimated taste levels of TDS found as excellent (less than 300 mg/l), good between (300 and 600 mg/l) fair, between (600 and 900 mg/l); poor, between (900 and 1200 mg/l) and unacceptable (greater than 1200 mg/l).Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste ,**Gray, 2008, Total dissolved solids in Drinking-water, 2003**. As a benchmark for assessment and verification X-bar chart for this investigated characteristic employ Saudi Arabia standard specification of bottled water as shown in **Fig. 4** where the minimum TDS value is (100) and the maximum value is (700).

- **Calcium (Ca)**

Calcium is one of the important elements to human body essential to embryonic stages of growth, pregnancy and lactation, as well as its importance in the formation of bones and teeth, blood clotting, and the work of the nervous system ,**Gray, 2008**. From control chart **Fig. 5** it could be noticed that all the investigated companies haven't exceed Iraqi standard specification limits that is equal to (75.0 mg/l). Ca value for WHO specifications is (0.10 mg/l). It could be noticed from **Fig. 5** for companies' No. (22 and 24) hadn't inscribed Ca content in their labels. Whilst for companies No. (13 and 21) Ca value is out of control limits. Therefore, better quality control, inspection and quality assurance to such factories' specification is mandatory.

- **Sodium (Na)**

Sodium value must be kept at minimum values because death of babies may occur, drinking formula feeds made up with high-Sodium mineral waters, so exploit the water with lowest Sodium content you can get. The taste sill for sodium in water depends on the associated anion and the temperature of the solution ,**Gray, 2008**. Na values are also not set in Iraqi standards neither in Saudi Arabia standards, but the minimum value for WHO standards is (0.20 mg/l) and the maximum limit is not recorded since less is better. Certain Iraqi companies didn't exceed the minimum limit, while for companies No. (17 and 23) their values are out of control limit. Whilst (25 %) of companies haven't include Na in their specification labels. as shown in control chart **Fig. 6.**

- **Magnesium (Mg)**

Along with Calcium, Magnesium is a major constituent of water hardness and a major dietary requirement for human. Levels are generally low in bottled water, although there are except ions ,**Gray, 2008**. Mg value in Iraqi standards is (30.0 mg/l).From control chart **Fig. 7** It could be noticed that for companies No. (7, and 17) exceed Iraqi limits while for two companies No. (27, and 35) haven't mention the Mg content in their labels, while company No. (17) Mg value is out of control as shown in **Fig. 7**

- **Potassium (K):**

It is an essential element the body finds it hard to deal with excess Potassium, resulting in kidney stress and possible kidney failure. Although Potassium is not considered to be toxic, long-term exposure to high Potassium concentrations should be avoided ,**Gray, 2008**. Iraqi and Saudi standards haven't included K values, but world health organization sets only the minimum value of K as (0.10 mg/l). This value is used on employing the control chart as shown in **Fig. 8.** Some Iraqi companies haven't exceed the minimum value, for company No.(20) K value is out of control as shown in **Fig. 8**

- **Iron (Fe)**

Iron is an essential and is very unlikely to cause a threat to health at the concentrations occasion ally recorded in water supplies. It is undesirable in excessive amounts and can cause number of problems. Iron encourages the development of a microbial slime comprised of iron bacteria on piped surfaces that can affect flow and cause consumer complaints. Iron also causes staining of laundry and discoloration of vegetables such as potatoes and parsnips during cooking. More importantly, Iron has a fairly low taste threshold for such a common element, giving the water strong unpleasant bitter taste that may spoils most beverages made from tap water , **Gray, 2008**. Control chart **Fig. 9** shows the companies under this study are within control limits of Fe values except for company No. (17) exceeded the upper control limit of Iraqi specifications (0.3 mg/l) {Fe value for this company is (22 mg/l)}.While (85 %) companies haven't register or evaluate an important content (Fe) in their specifications, as shown in **Fig. 9**

- **Chloride (Cl)**

Chloride is not dangerous at the concentrations found in bottled waters. It has a taste threshold of about (200 mg/l), but levels are generally much lower than this in mineral waters. If bottled water is to be used for making up drinks such as tea, coffee and fruit juice, then the lower the Cl is the better

,**Gray, 2008**. Control chart **Fig. 10** shows that Iraqi companies of bottled water hadn't exceeded Iraqi or World standards for Cl concentration. The range of Cl in Iraqi and World standards Specification is (0.10 – 250) mg/l. Control chart showed that Cl values of companies No. (17, 19, and 23) are out of control as shown in **Fig. 10**

- **Fluoride (F)**

If consumers are going to use bottled water as a complete replacement for tap water, for both drinking and cooking, then the F level must be (1.0 mg/ l) or less to avoid dental Fluorosis and other associated problems ,**Gray, 2008**. The studies show that drinking water containing (1.0 mg/l) Fluoride concentration helps to reduce the incidence of tooth decay by 65% for the children aged between (12-15) years ,**Fadhel,2010**. Iraqi specification did not include F concentration therefore, Saudi Standards are taken as a benchmark of (0.6 – 1.0) mg/l. Control chart showed that the whole investigated companies are within control limits as shown in **Fig.11** Also all Iraqi these companies haven't exceeded the WHO specifications. According to control chart **Fig. 11** (60 %) of the investigated companies haven't included the F specification label.

6. ANALYSIS OF QUALITY ASSURANCE ACTIVITIES

Quality assurance necessitates continuous monitoring processes to presents product (bottled water) with accurate and precise recorded results which are the quality characteristics claimed on the bottles (products) of these companies where:

- Some of the investigated companies have the same symbol (same specifications in the logo) such as companies (No.1, No.2, No.11, No.12), (No.3, No.9), (No.5, No.6) (No.22, No.24) and (No.29, No.33) or three different products (labels) such as company No.32. Others claim that the product is according to standards other than Iraqi standards as in company No.27 that did not register specific characteristic its register the minimum and maximum values as discussed earlier. On the other hand company No. 32 is promoting for their product depending on certain characteristics (low Sodium) that is not even included in Iraqi bottled water standards. Therefore, the quality should be assured so as the legal consequences could be enforced and activated.
- Although the water expire date is essential and it is one of the required characteristics to be registered on labels according to Iraqi standards, but none of the investigated companies(for 35 different Iraqi factories) fix the expired date on their labels rather fix the duration of use as one year.

7- CONCLUSIONS

Water issues are important for life and human health, this study highlighted the following conclusions are deduced:-

i. Plants in northern Iraq committed to recording water specifications on their labels more than other governorates in Iraq; this is due strict monitoring and demanding for control there.
ii. The expired date for all samples is one year as recorded by the manufacturer's note. It is within Iraqi specifications requirements and must be recorded on the labels too.
iii. It was found that some companies produces the same bottled water specifications under to different brands(trademarks){(No.1,No.2,No.11,No.12)},{(No.3,No.9)},{(No.5,No.6)},{(No.22,No.2

4)}and{(No.29,No.33) }, and one company produce its product brand with four different colors (No. 32).

iv. It was found that some companies misleading the consumers by labeling wrong data, use inappropriate or the same logo for different water sources when promoting their product.

v. Iraqi bottled water specifications need to introduce new and important quality parameters that are introduced Saudi standards such as (TDS, F) and WHO standards such as (Na, K) and to continual updating is needed towards reducing the gaps between them and those international standards.

8. RECOMMENDATIONS

i. Most of companies under study did not conform Iraqi specifications therefore; governmental quality control, quality assurance on this industry factory is required.

ii. Need of better control on manufacturing plants since most of the used bottled water lack in writing complete required information of Iraqi standards.

iii. Some manufacturing companies should be stopped since their water

iv. Characteristics are not registered either because they are not quantifying them or there is no quality control department in these companies.

v. Other sources of water: natural mineral, spring, etc. must be tested periodically to license them.

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Table 1. Iraqi bottled water specifications of brands according to their labels.

Quality Parameters									
Company No.	**pH**	**TDS**	**Ca**	**Na**	**Mg**	**K**	**Fe**	**Cl**	**F**
1	7.2	**N.A**	24.2	**N.A**	4.4	**N.A**	**N.A**	11.5	0.03
2	7.2	**N.A**	24.2	**N.A**	4.4	**N.A**	**N.A**	11.5	0.03
3	7.2	120	22	2.2	5	0.2	**N.A**	4.1	0.7
4	7.8	**N.A**	26	**N.A**	7.5	**N.A**	**N.A**	**N.A**	**N.A**
5	7.38	**N.A**	28	2.91	3.4	**N.A**	0.003	1.4	**N.A**
6	7.38	**N.A**	28	2.91	3.4	**N.A**	0.003	1.4	**N.A**
7	7.48	**N.A**	16.74	2.76	42.44	1.17	**N.A**	5.27	0.19
8	7.48	257	25.65	0.4	7.05	0.2	**N.A**	4.9	**N.A**
9	7.2	120	22	2.2	5	0.2	**N.A**	4.1	0.7
10	7.3	125	34.2	7	11	1	**N.A**	11	**N.A**
11	7.2	**N.A**	24.2	**N.A**	4.4	**N.A**	**N.A**	11.5	0.03
12	7.2	**N.A**	24.2	**N.A**	4.4	**N.A**	**N.A**	11.5	0.03
13	7.9	**N.A**	52	**N.A**	9	**N.A**	**N.A**	**N.A**	0.32
14	7.2	124	27	1.1	8	0.5	**N.A**	**N.A**	**N.A**
15	7	110	0.5	16	13	1	**N.A**	**N.A**	**N.A**
16	7.2	**N.A**	10	9	12	6.2	**N.A**	20	0.7
17	8.2	150	3.5	50	125	**N.A**	22	40	**N.A**
18	6.08	**N.A**	8.64	**N.A**	5.40	2.36	**N.A**	**N.A**	**N.A**
19	7.2	150	3.6	21	10	1	**N.A**	50.2	0.02
20	7.5	180	19	13	11	15	**N.A**	**N.A**	**N.A**
21	7.3	**N.A**	64	11	22.08	2	**N.A**	4	**N.A**
22	7	110	**N.A**	16	1.3	1	**N.A**	**N.A**	**N.A**
23	7	170	16	44	11.7	1.5	**N.A**	59	**N.A**
24	7	110	**N.A**	16	13	1	**N.A**	**N.A**	**N.A**
25	7.4	180	33	2.3	16	0.3	0.01	7	0.1
26	**N.A**	110	5	16	13	1	0.01	27.5	1
27	7.5	30	15	10	**N.A**	5	**N.A**	10	**N.A**
28	7.5	120	24	21.9	7	1.06	**N.A**	14	**N.A**
29	7.4	**N.A**	22	**N.A**	10	0.3	**N.A**	7	**N.A**
30	**N.A**	80	15	13	4	0.9	0.02	14	0.9
31	7.9	130	31.3	3.5	5.2	0.5	**N.A**	5.1	0.01
32	7.2	101	12	11	3	0.6	**N.A**	25	1
33	7.4	**N.A**	22	**N.A**	10	0.3	**N.A**	7	**N.A**
34	7.3	190	20	5	2.4	0.4	**N.A**	**N.A**	**N.A**
35	7.6	30	15	10	**N.A**	5	**N.A**	10	**N.A**

N.A: Not Available Values

Table 2 . Comparison between Iraqi bottled water and other standards.

Standards				
Specifications/units	**Iraqi Standards**		**Saudi Arabia Bottled Water Standards**	**WHO Bottled Water Standards**
	Tap Water	**Bottled Water**		
pH	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
TDS (mg/l)	1000	N.A	100-700	1-500
Ca (mg/l)	50	75	75	0.1-75
Na (mg/l)	200	N.A	N.A	0.20
Mg (mg/l)	50	30	30	0.10
K (mg/l)	N.A	N.A	N.A	0.10
Fe (mg/l)	0.3	0.3	0.3	0.01-0.3
Cl (mg/l)	250	250	250	0.1-250
F (mg/l)	1	N.A	0.6-1	0.1-2

N.A: Not Available Values

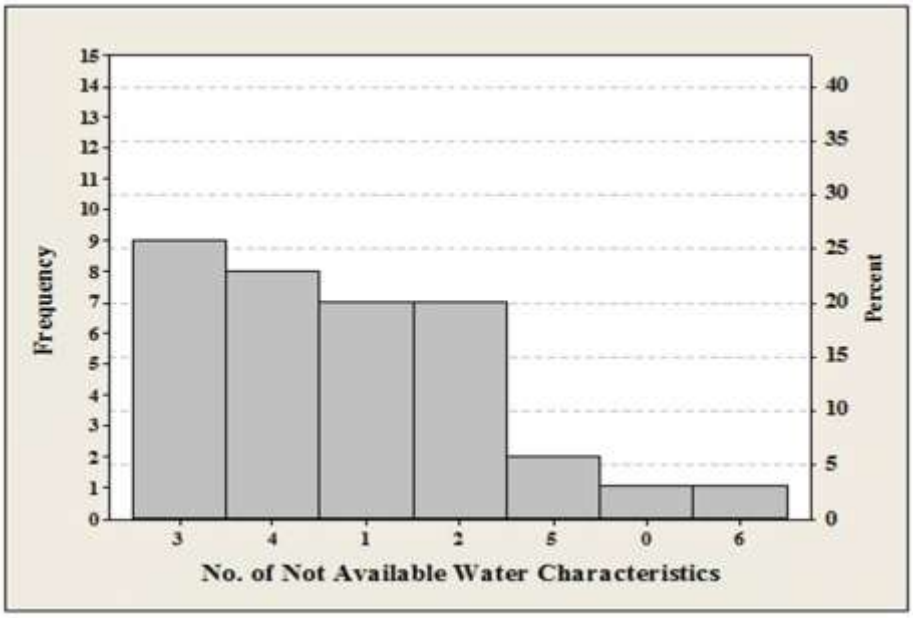

Figure 1. Pareto chart of Iraqi bottled water specifications.

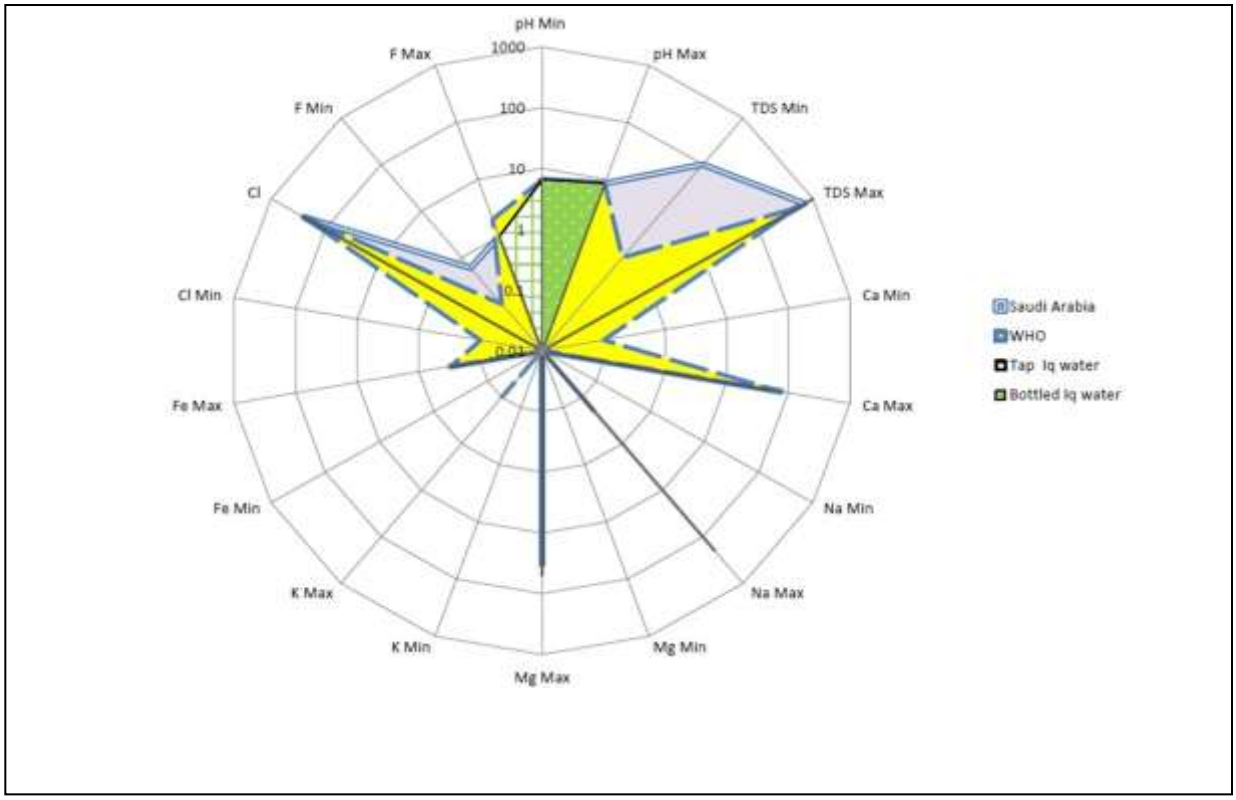

Figure 2. Radar chart of {Iraqi, Saudi Arabia, and WHO} bottled water specifications.

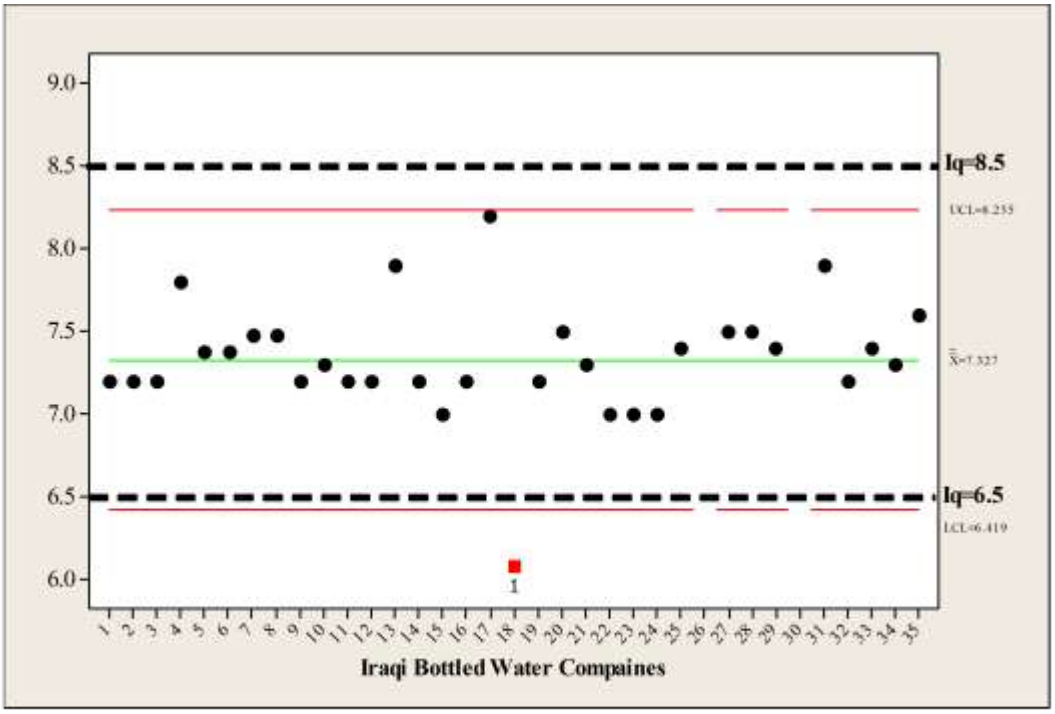

Figure 3. X-bar of pH values in bottled water companies.

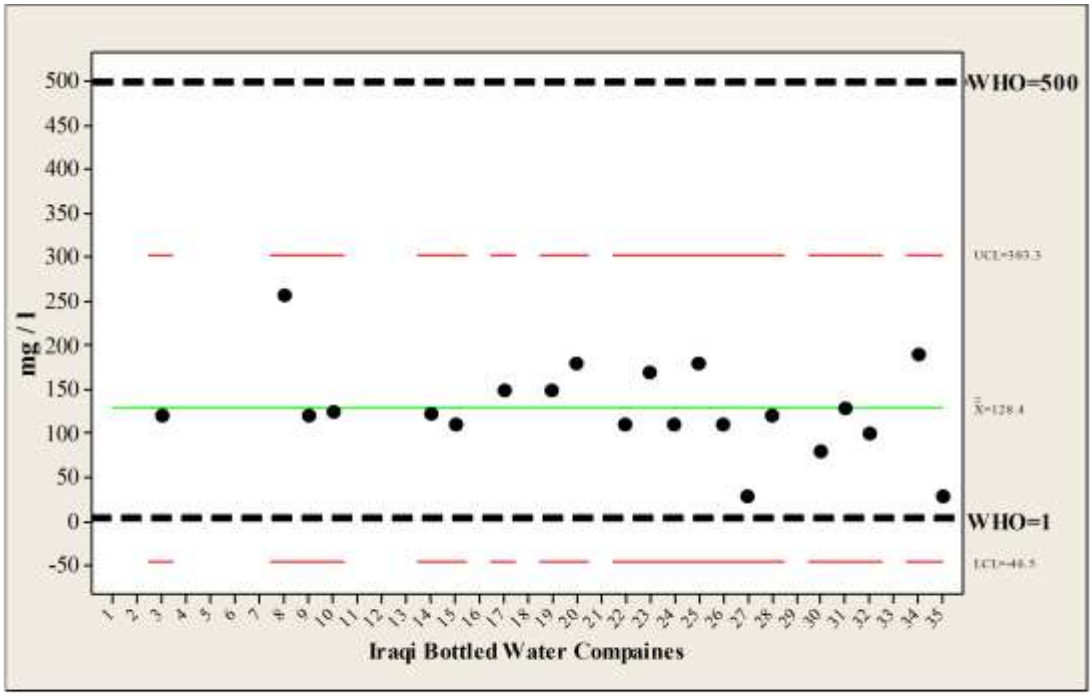

Figure 4. X-bar of TDS concentration in bottled water companies.

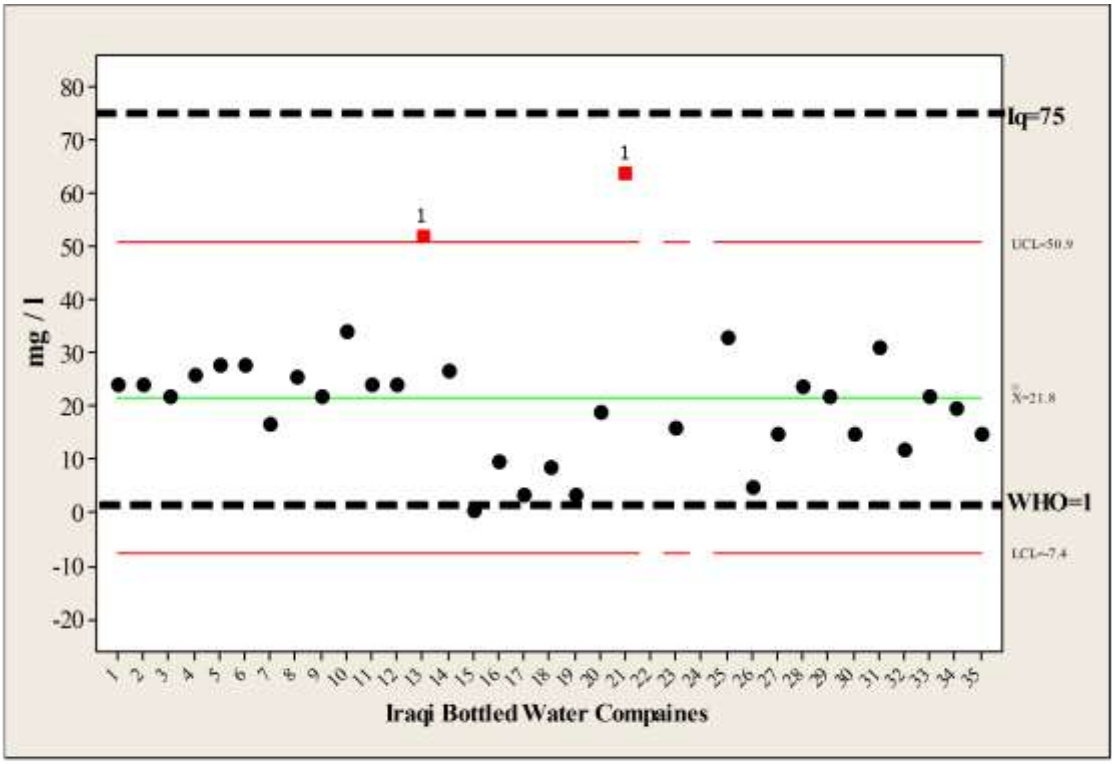

Figure 5. X-bar of Ca concentration in bottled water companies.

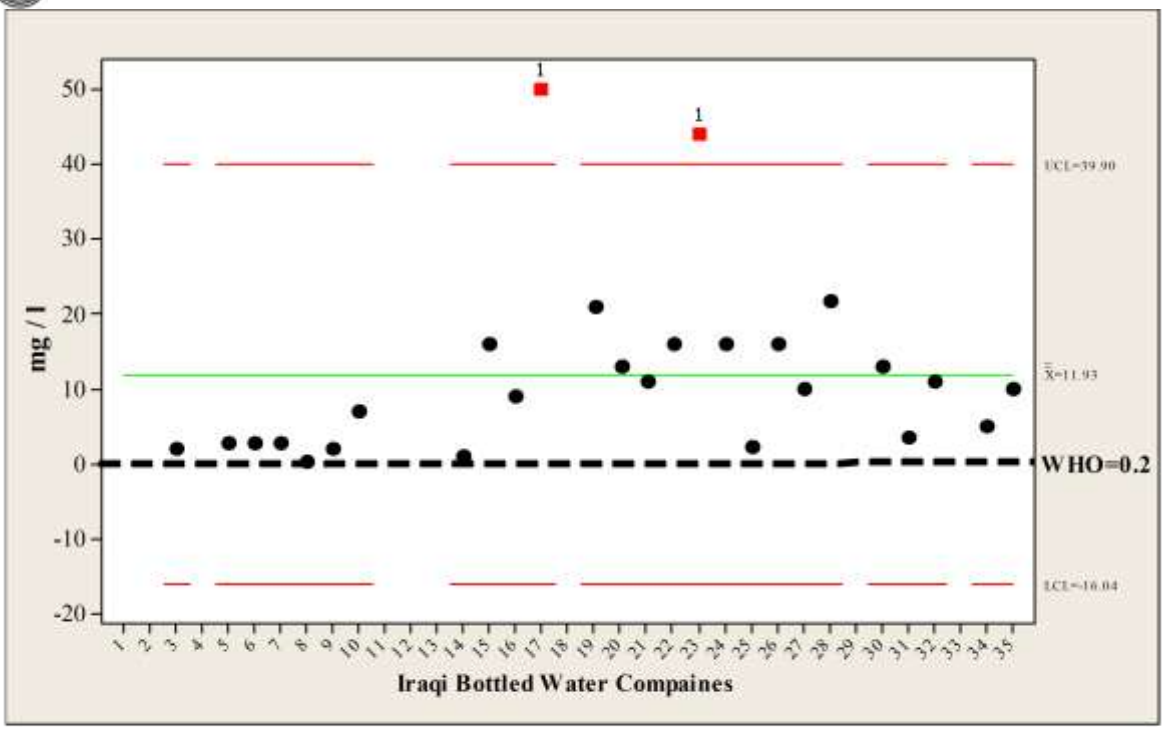

Figure 6. X-bar of Na concentration in bottled water companies.

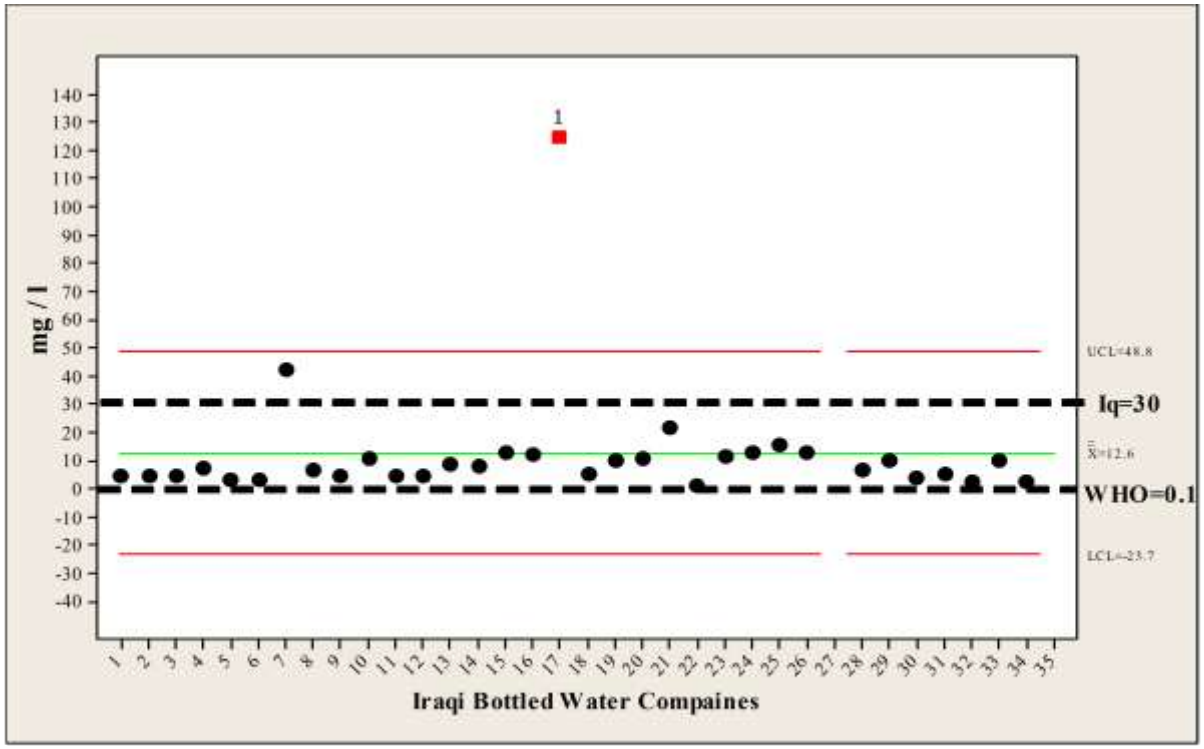

Figure 7. X-bar of Mg concentration in bottled water companies.

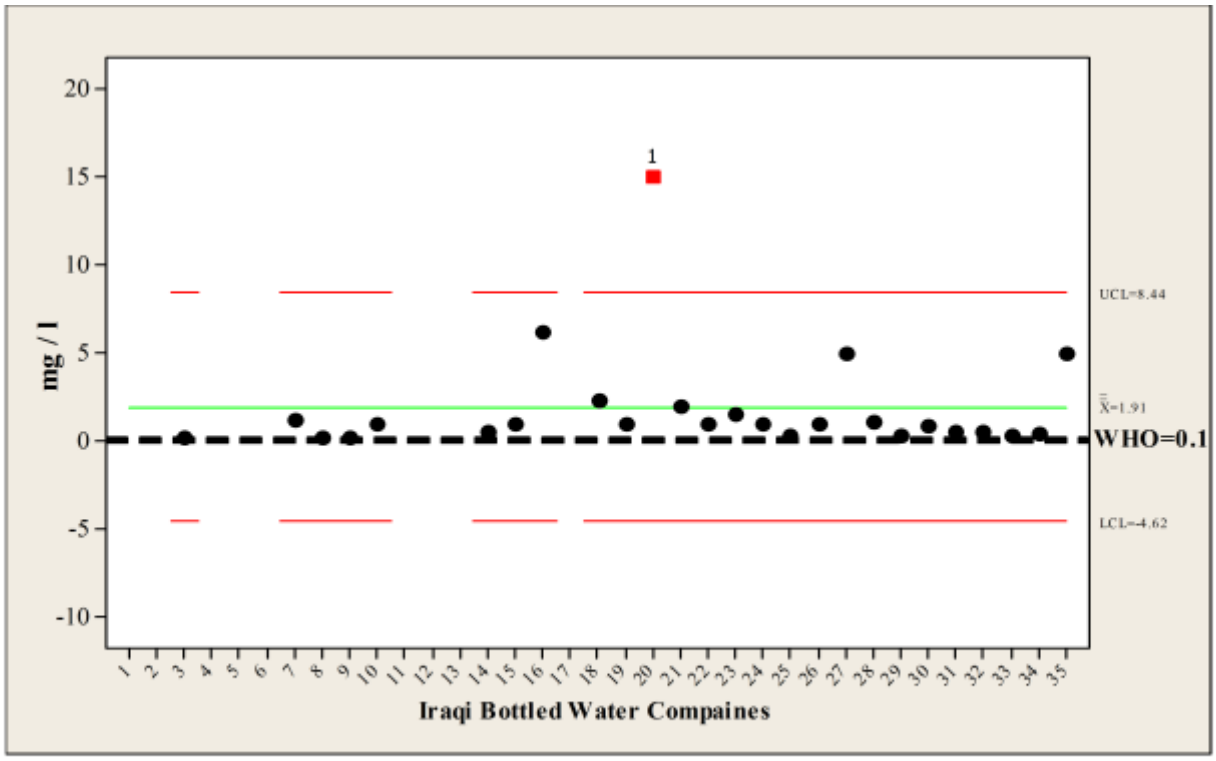

Figure 8. X-bar of K concentration in bottled water companies.

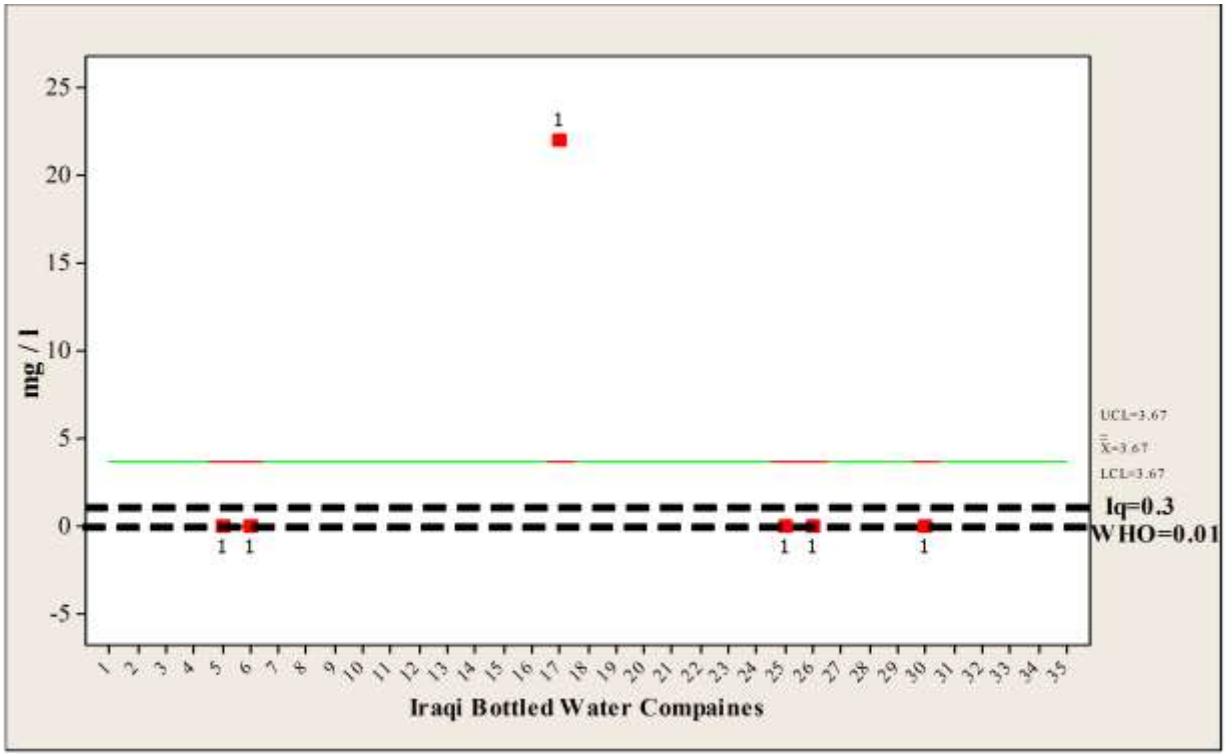

Figure 9. X-bar of Fe concentration in bottled water companies.

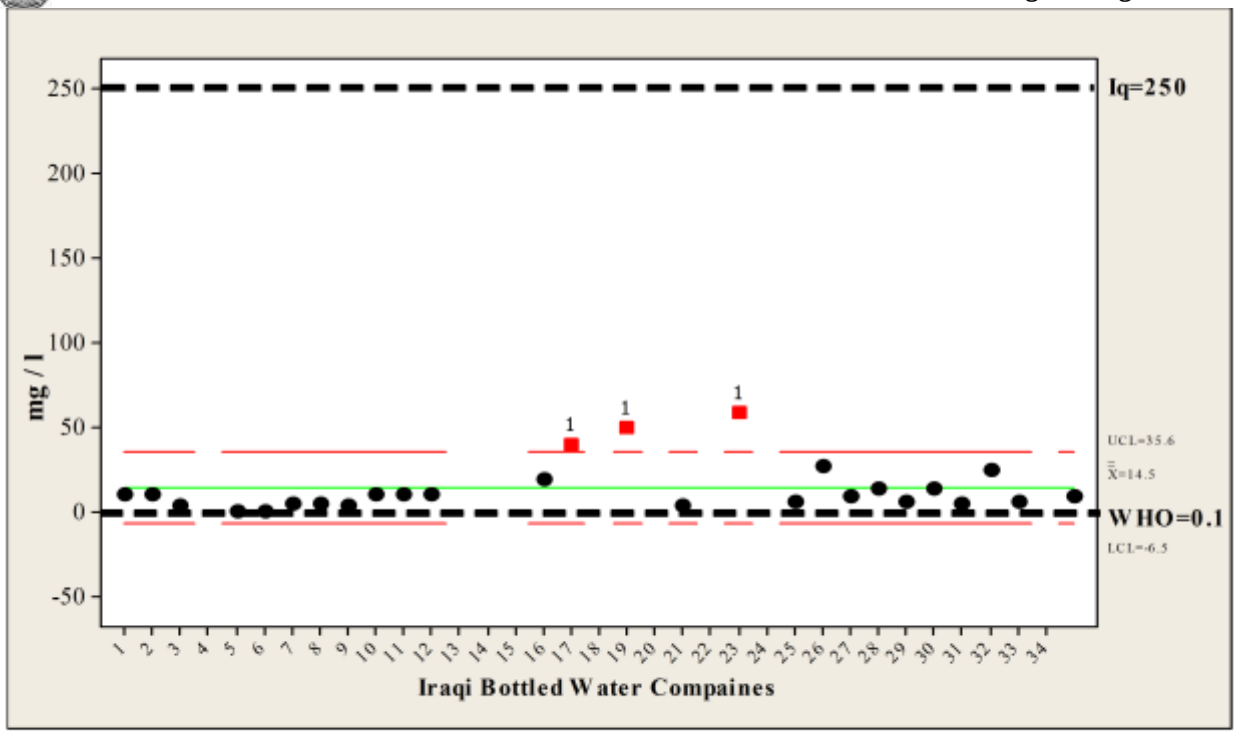

Figure 10. X-bar of Cl concentration in bottled water companies.

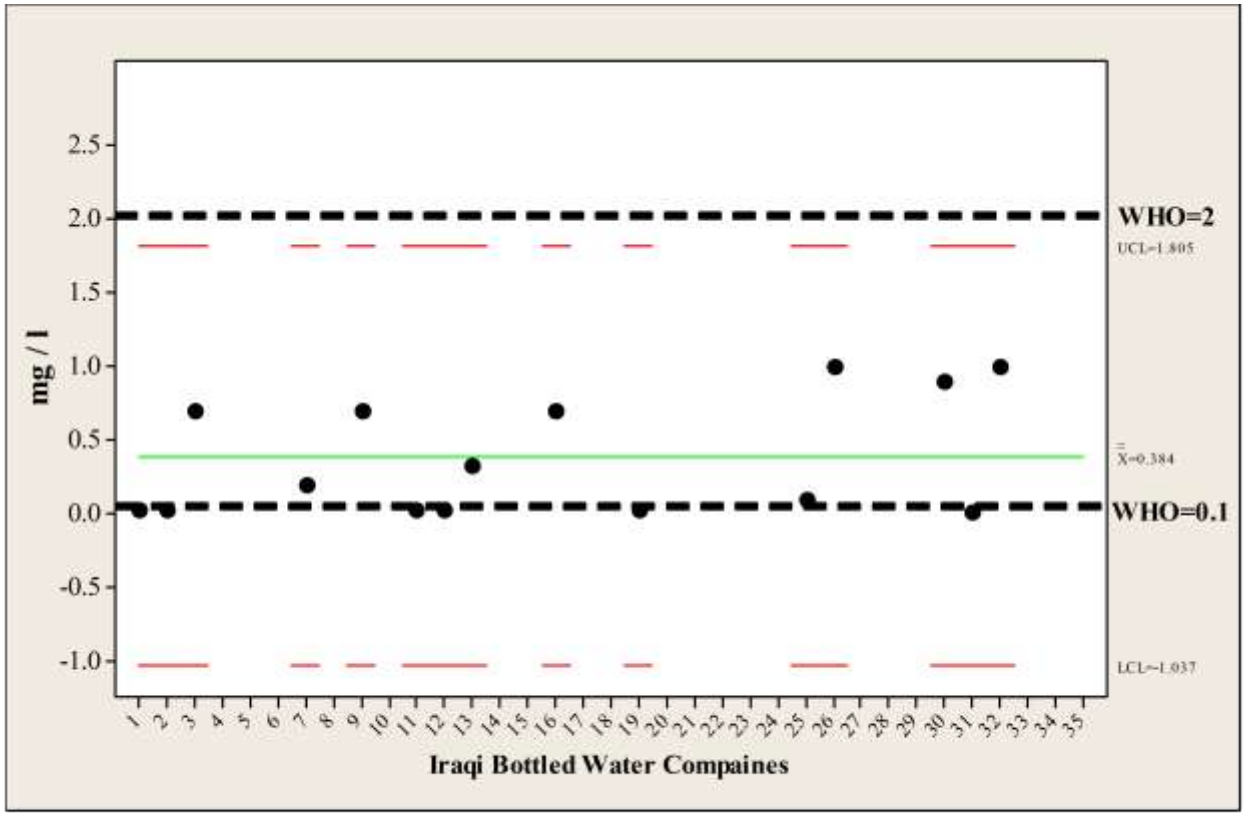

Figure 11. X-bar of F concentration in bottled water companies.