DOI: 10.24996/ ijs.2017.58.4A.12

Iraqi Journal of Science

ISSN: 0067-2904

Assessment of water Quality Index of Groundwater in Al-Khadhimiya city

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Abstract

The present study deals with the assessment of water Quality Index to theAl-Khadhimiya Groundwater city, by collection groundwater from 13wells during four seasons, subjecting the samples to a comprehensive physicochemical analysis. The 13 parameters have been considered: pH, total hardness, calcium, magnesium, turbidity, nitrate, electrical conductivity, total dissolved solid, Sulfate, Chloride, zinc, manganic, and iron, that are used for calculating the WQI. From the result shown, the most groundwater quality lies in Unfit for human drinking purpose. The wells (1 and 11) and wells (3 and 10) were a bad water quality for drinking purpose since they lie in poor and in very poor respectively according to the WQI. The prime causes of deterioration groundwater quality are turbidity, Hardness, Cl, SO_4, Ca and Mg.

Keywords: Correlation, Ground Water, Water quality index. Pollution.

تقييم مؤشرجودة المياه في المياه الجوفية في مدينة الكاظمية

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الخلاصة

الغرض من هذه الدراسة تقييم نوعية المياه الجوفية لمدينة الكاظمية، من خلال جمع 13 عينة ماء بئر خلال اربعة فصول السنة ، لدراسة الخصائص الفيزيوكيميائية متمثلة بدراسة الدالة الحامضية . العسرة الكلية، عسرة كالسيوم، عسرة مغنيسيوم ، العكارة، نترات، التوصيلية الكهربائية، الاملاح الذائبة الكلية، كبريتات، كلورايد، زنك، مغتيسيوم، والحديد ، لدراسة دالة نوعية المياه الجوفية . من النتائج تبين ان اغلب المياه الجوفية تكون نوعيتها ضمن غير الصالحة للشرب البشري، الابار من 1-11 والابار من 3-10 ذات نوعية ماء رديئة لاغراض الشرب تكون ضمن ضعيفة والضعيفة جدا على التوالي طبقا لدالة نوعية المياه.السبب الرئيسي لتدهور نوعية المياه الجوفية هي عكورة الماء ، العسرة، وايونات الكلوريد، الكبريتات، الكالسيوم، والمغنيسيوم .

Introduction

Water quality of any specific area or specific source can be assessed using physical, chemical and biological parameters. The values of these parameters are harmful for human health if they occurred more than defined limits [1, 2, 3, 4]. The degree of severity of groundwater pollution is depends on the types and amount of waste, disposal methods, climate, and hydrologic properties of the aquifer,

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recharge capacity of the area and rate of pumping out of water [5].A quality standard sets the acceptability levels of concentration for pollutants in water to be used for various purposes, e.g., drinking, irrigation, agriculture, etc.Therefore, the suitability of water sources for human consumption has been described in terms of Water quality index (WQI), which is one of the most effective ways to describe the quality of water. WQI, a technique of rating water quality, is an effective tool to assess spatial and temporal changes in ground water quality and communicate information on the quality of water to the concerned citizens and policy makers [6-7].

The concept of WQI was firstly by Horton, [8]. Then WQIwas developed by Brown, [9], and improved by Deininger (Scottish development department, 1975), the development of WQIs for ground water is described in the literature by various authors.Khalid, [10] present the index for evaluating quality of ground water for drinking water purpose for Tikrit and Samarra cities.

Mufid [11], use WQI for Application of water quality index to assess suitability of groundwater quality for drinking purposes in Ratmao –Pathri Rao watershed, Sirajudeen, [12] used WQI for same purpose for assessment on Tamil nadu and Pondicherry, India, Sunita, [13] assessment of water quality index of ground water in Smalkhan, Haryana, Mohend, [14] study WQI to evaluation ground water quality in Green- Belt Area North of Najaf AL-Ashraf City.

The objective of the present work is to apply WQI to assess suitability of groundwater for drinking proposes in Al-Khadhimiya city,AL Khadhimiya city is one of the oldest cities located northwest of the Baghdad city within the sedimentary plain located on latitude 44 ° 12¯ and on longitude 33 ° 10 ¯ and the elevation of the surface of the earth between 30-32meters from sea level [15] Figure-1.

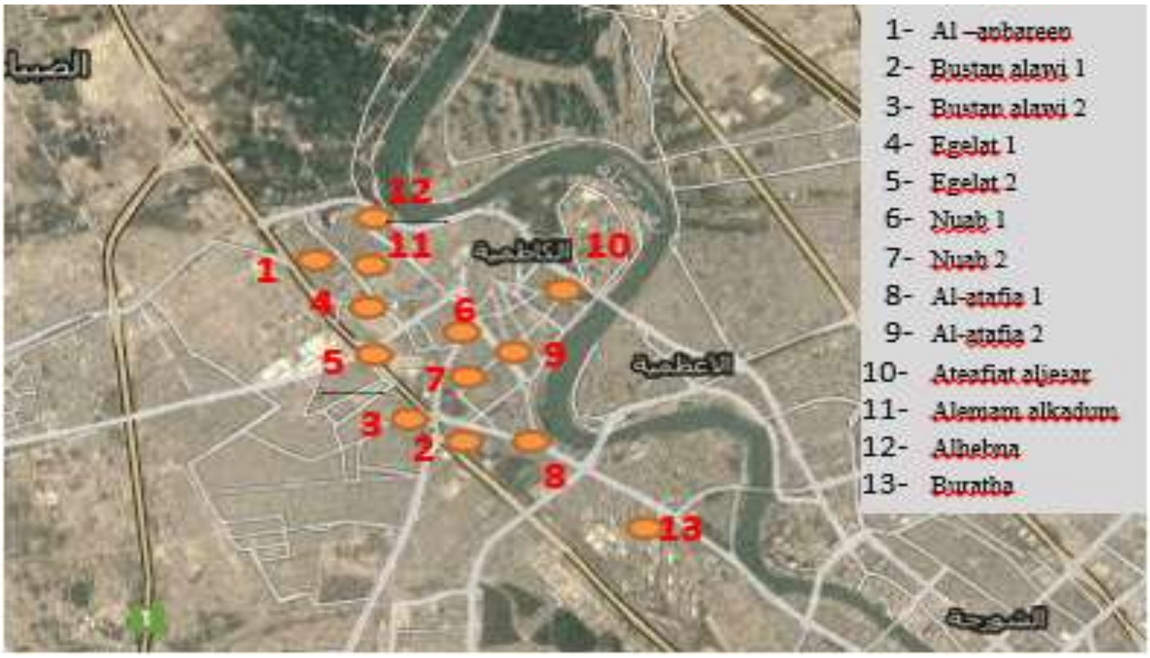

Figure 1-Location map of the study area.

Materials and methods

For the purposes of research, the city of Kadhimiya was divided into 13 districts for the possibility of covering the entire city study. Water samples were collected from 13 wells. Total depth of wells were varies from 7.5 m. to 18 m. and figure (1) shows sampling location of the water well. Groundwater samples were collected for the period from 1/1/2013 until 1/1/2014 the test are quarterly (winter, spring, summer and Autumn) and at the rate of three samples per season. The necessary test was carried out to evaluate this water, so used for this purpose the bottle is made of polyethylene of 2 liters capacity. The water samples were clear, odorless and analyzed for physiochemical testing. Samples were tested for thirteen parameters such as pH, TDS, EC, Total Hardness (TH.), Turbidity, calcium, magnesium, chloride, sulfate, nitrate, (Mn), (Fe) and (Zn). And test in the methods listed in Table-1, Chemical test were conducted in a laboratory Health Engineering/ University of Technology. The results of physio-chemical parameters are shown in Table -2.

Table 1- Ground water constituents of studied area and Methods of their analysis.

Well No.	Well Name	pH	EC (Umohs/cm)	TDS Mg/l	Turb. NTU	Cl^- Mg/l	So_4^{-2} Mg/l	TH	Ca^{+2} Mg/l	Mg^{+2} Mg/l	No_3^- Mg/l	Mn Ug/l	Fe Ug/l	Zn Ug/l
1	Al – anbareen	6.8	3746	1873	0.84	1163	959	3563.4	771	399	15	550	40	100
2	Bustan alawi 1	6.7	4300	2150	15.9	1095.5	75.3	4554.8	833	603	7.9	8100	35	150
3	Bustan alawi 2	7.3	2966	1483	9.3	1124	66.6	3859.1	845	426	9.8	75	77	20
4	Egelat 1	6.7	3904	1952	13.2	1375	69.5	2991.6	539	401	9.3	1750	103	10
5	Egelat 2	7.4	4560	2280	23.3	938	46.57	2365.2	213	447	6.7	360	17	150
6	Nuab 1	7.1	4532	2266	42	1186	62	3650.9	683	474	13.2	6630	90	200
7	Nuab 2	7.3	4356	2178	14.8	1250	61.9	9769.3	508	2073	12.5	2020	20	200
8	Al-atafia 1	6.8	3280	1640	47.8	1577	200	16217	2600	2370	7.5	300	10	150
9	Al-ateafia 2	7.4	2978	1489	21.4	1185	44.8	2596.6	422	376	14.8	60	65	300
10	Ateafiat aljesar	7.1	3446	1723	7.4	1243	85.8	3801.7	619.5	549.5	11.8	80	30	150
11	Alemam alkadum	7.3	3636	1818	1.33	1097	37.9	3737.5	552	575	12.6	35	70	220
12	Alhebna	7.2	5006	2503	45.5	555	49.1	976.3	115	168	18.16	4100	380	13
13	Buratha	7.9	3784	1892	41.3	377	33.1	625.88	120.3	79.3	44.7	2450	3970	300

Table 2-Average values of physic-chemical parameters concentration at different location of Al-Khadhimiya city

Parameter	Method of analysis
EC	APHA 2540-E Field electrode meter device (Consort)
TDS	APHA 2540-D Field electrode meter device (Consort) and Freeze and Cherry Formula
TH (Ca^{+2} and Mg^{+2})	APHA 2340C Titration with Na_2-EDTA using Eriochrome black-T indicator
Ca^{+2} , Mg^{+2}	APHA2110C Titration with Na_2-EDTA using Murexide indicator
SO_4^{-2}	APHA 4500—SO4E Gravimetric method
Cl^-	APHA 4500-CLD Titration with $AgNO_3$ using Potassium chromate indicator
NO_3^{-2}	APHA 4500-NO_3UV-Spectrophotometric method (λ = 220 nm)
Turbidity	APHA (2130B)
Mn, Fe and Zn	APHA 4500-P EAtomic absorption spectrometer/ GBC 933 puls

APHA: (American Public Health Association) [16]

Calculation of Water Quality Index (WQI)

Li Pei et al., [17] explained that WQI is widely used in the world due to the capability of fully expression of the water quality information and is one of the most effective tools and important parameters to the evaluation and management of groundwater quality for the concerned citizens and policy makers all over the world.

(Horton, 1965) was the first researcher who developed and proposed the concept WQI. A weighted arithmetic index method have used to calculate WQI

1- Calculating the constant of proportionality, K, by using the following equation:

$$K = \frac{1}{\sum_{j=0}^{n} \frac{1}{Si}} \quad (1)$$

Where:

Si= permissible limit for the i^{th} parameter

n= number of parameter

2- Calculating of weightage of i^{th} parameter, relative weight by using equation:

$$wi = \frac{K}{Si} \quad (2)$$

3- Calculating sub index of i^{th} parameter Qi by the expression:

$$Qi = \frac{100Vi}{Si} \quad (3)$$

In which Vi is the monitored value of the ith parameter.

While, the quality rating for pH (Q_{pH}) was calculated based on:

$$QpH = 100\left[\frac{Vi-S}{Si-S}\right] \quad if\ pH>7 \quad (4)$$

$$QpH = 100\left[\frac{S-Vi}{Si-S}\right] \quad if\ pH<7 \quad (5)$$

Where:

Vi: value of the water quality parameter obtained from the laboratory analysis.

S: the ideal value of pH considered as equal to (7.00).

Si: value of the water quality parameter equal (8.5).

4- Calculating water quality index WQI as follows:

$$WQI = \frac{\sum_{j=1}^{n} \mathrm{QiWi}}{\sum_{j=1}^{n} \mathrm{Wi}} \quad (6)$$

Based on the WQI, the quality of the water has been categorized into five statuses from excellent purpose to unfit for human drinking as shown in Table-3.

Table 3- Status of water quality based on WQI (Pei-Yue et al., 2010).

WQI Value	0-25	26-50	51-75	76-100	> 100
Water Quality Statuses	Excellent	Good	Poor	Very Poor	Unfit for human drinking purpose

Water Quality Index for drinking:

According to Iraqi standard limits for drinking water (ICOSQC, 2009) [18] calculation WQI for every well and relative weights (Wi) for each parameters were calculated according to equation (1) and (2) were submitted in Table -3.

Table 4-Relative weight (Wi) for the WQI parameters.

Parameters	**Limits (Si) ICOSQ,2009**	**1/Si**	**K**	**Relative Weight (Wi)**
pH	8.5	o.117647		0.424984
Ec	1500	0.0006		0.002408
TDS	1000	0.001		0.003612
TURB.	10	0.1		0.361236
Cl	350	0.00285		0.010321
So_4	400	0.0025		0.009030
TH.	500	0.002	3.6123644	0.007224
Ca	150	0.0066		0.024082
Mg	100	0.01		0.036123
No_3	50	0.02		0.072247
Mn	100	0.01		0.036123
Fe	300	0.0033		0.012041
Zn	3000	0.00033		0.001204
		∑= 0.276827		∑ = 1.00063

The WQI for all wells were calculated according to equation (3), (4) and (5) as example for that W1 and W2 as shown in table (5) and (6) and WQI for all wells as shown in table (7):

Table 5- value of WQI for w1

parameters	Data (Vi)	Qi	WiQi
pH	6.8	13.3	5.69
EC (µmohs/cm)	3746	249.73	0.6
TDS (mg/l)	1873	187.3	0.67
TURB. (NTU)	0.84	8.4	3.05
Cl (mg/l)	1163	332.2	3.45
SO_4 (mg/l)	959	239.7	2.18
TH (mg/l)	3563.4	712.68	5.14
Ca (mg/l)	771	514	12.46
Mg (mg/l)	399	399	14.51
NO_3 (mg/l)	15	30	2.18
Mn (µg/l)	550	550	20.01
Fe (µg/l)	40	13.33	0.16
Zn (µg/l)	100	3.33	0.004
GWQI			∑= 66.99

Table 6-value of WQI for w2

parameters	Data (Vi)	Qi	WiQi
pH	6.7	20	8.5
EC (μmohs/cm)	4300	286.66	0.69
TDS (mg/l)	2150	215	0.77
TURB. (NTU)	15.9	159	57.43
Cl (mg/l)	1095.5	313	3.23
SO_4 (mg/l)	753	188.25	1.7
TH (mg/l)	4554.8	910.96	6.58
Ca (mg/l)	833	555.3	13.37
Mg (mg/l)	603	603	21.78
NO_3 (mg/l)	7.9	15.8	1.14
Mn (μg/l)	8100	8100	292.59
Fe (μg/l)	35	11.66	0.14
Zn (μg/l)	150	5	0.006
GWQI			∑= 405.01

Table 7-values of WQI for all wells

	QiWi W1	QiWi W2	QiWi W3	QiWi W4	QiWi W5	QiWi W6	QiWi W7	QiWi W8	QiWi W9	QiWi W10	QiWi W11	QiWi W12	QiWi W13
pH	5.69	8.5	8.5	8.5	11.33	2.83	8.5	5.69	11.33	2.83	8.5	5.66	25.5
EC	0.6	0.69	0.47	0.62	0.73	0.72	0.7	0.52	0.47	0.55	0.58	0.8	0.6
TDS	0.67	0.77	0.53	0.7	0.82	0.81	0.78	0.59	0.53	0.62	0.65	0.9	0,68
TURB	3.05	57.43	33.59	47.68	84.16	151.72	53.46	172.6	77.3	26.73	4.8	164.3	149.2
Cl	3.45	3.23	3.314	4.054	2.766	3.5	3.686	0.465	3.49	3.61	3.23	1.636	1.11
SO_4	2.18	1.7	1.503	1.568	1.05	1.4	1.4	4.515	1.011	1.93	0.855	1.108	0.747
TH	5.14	6.58	5.57	4.32	3.41	5.27	14.11	23.43	3.75	5.49	5.4	1.41	0.9
Ca	12.46	13.37	13.56	8.653	3.42	10.96	8.155	41.74	6.77	9.94	8.86	1.902	1.931
Mg	14.51	21.78	15.38	14.48	16.14	17.122	74.88	85.61	13.58	19.84	20.77	6.068	2.86
NO_3	2.18	1.14	1.416	1.343	0.968	1.9	1.806	1.083	2.138	1.705	1.82	2.62	6.458
Mn	20.01	292.6	2.709	63.21	13.0	239.5	72.96	10.83	2.167	2.89	1.26	148.1	88.5
Fe	0.16	0.14	0.308	0.413	0.068	0.361	0.08	0.04	0.26	0.12	0.28	1.525	15.93
Zn	0.004	0.006	0.0008	0.0004	0.006	0.008	0.008	0.006	0.012	0.006	0.008	0.0005	0.012
WQI	70.09	407.92	86.85	155.53	137.83	436.1	240.52	347.11	202.8	76.26	57.013	336.02	294.42

Class	poor	unfit	Very poor	unfit	unfit	unfit	unfit	unfit	unfit	Very poor	poor	unfit	unfit

Results and Discussion

1- Electrical conductivity and Total dissolved solid

In the absence of potable water source the permissible limit is up to 1000 mg/L**.** From the result of EC & TDS show value of EC exceed the allowable Limits, because to increase the dissolved salt duo to contact this water to soil, especially for wells that leaved using them for a long time to solve the different elements in them. While the value of the total soluble solid with the limitation except Bustan alawi 1, Egelat 1, Nuab 2, and Alhebna, these wells are used daily, this is to be expected that gets from dissolved processes in the soil as well as impact of leaching wastewater in soil of the city, these result show in Figure-2.

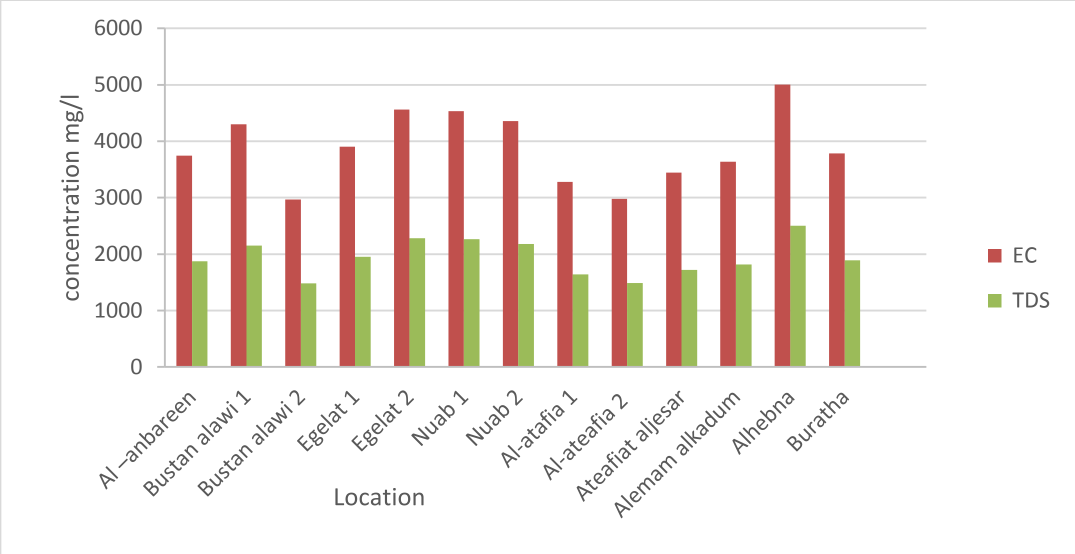

Figure 2- Result of EC and TDS concentration

2- Chloride and Sulfate

Chloride is a widely distributed element in all types of rocks in one or the other form. Its affinity towards sodium is high. Therefore, its concentration high in ground waters, when the temperature is high and rainfall is less. Present of Chloride in natural water refer to pollution by sewage water [19], the greater effect of chloride on process of erosion pipes and has a negative effect on patients with hypertension, from this study showed chloride concentration increase on the limit except Alhebna and Al-atafia 1.

From the result show higher sulfate concentration on the limitation values for water wells, due to the sewage seepage into groundwater, also due to ion exchange between the sulfate ions with soil, the result of chloride and sulfate show in Figure -3

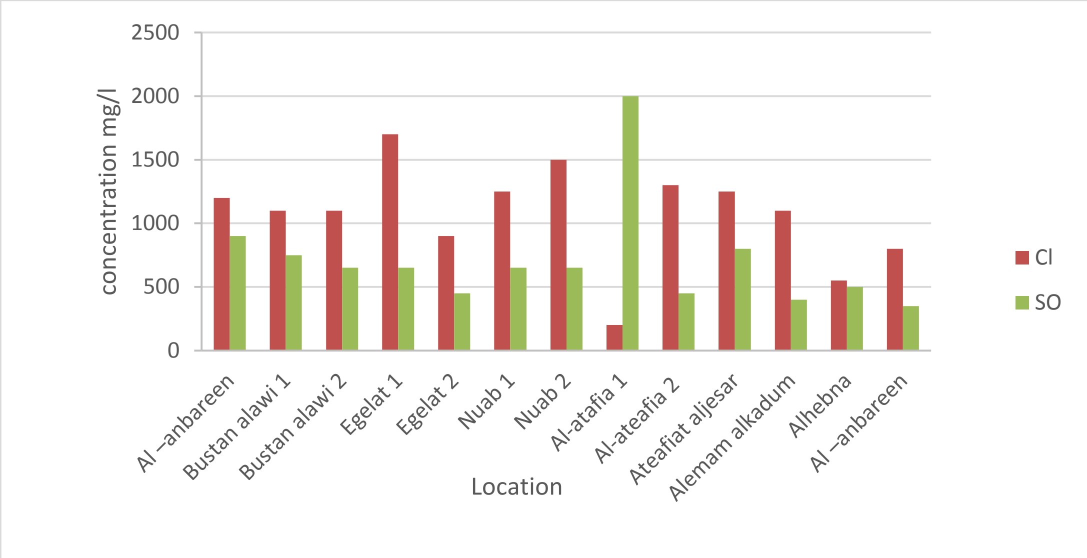

Figure 3- Chloride and Sulphate ions concentration

3- Total Hardness, Calcium, and Magnesium

The result show water of the wells very hardness due to high concentration of sulfate in groundwater, Calcium depends on the quality of the areas that water Pass out.The effects of increasing Magnesium concentration on the limited concentration (150 mg/l),these concentration caused diarrhea, the Calciumand magnesiuminvolved in the formation of sediment crust in Heaters and pipes [20][21], Figure-4 show.

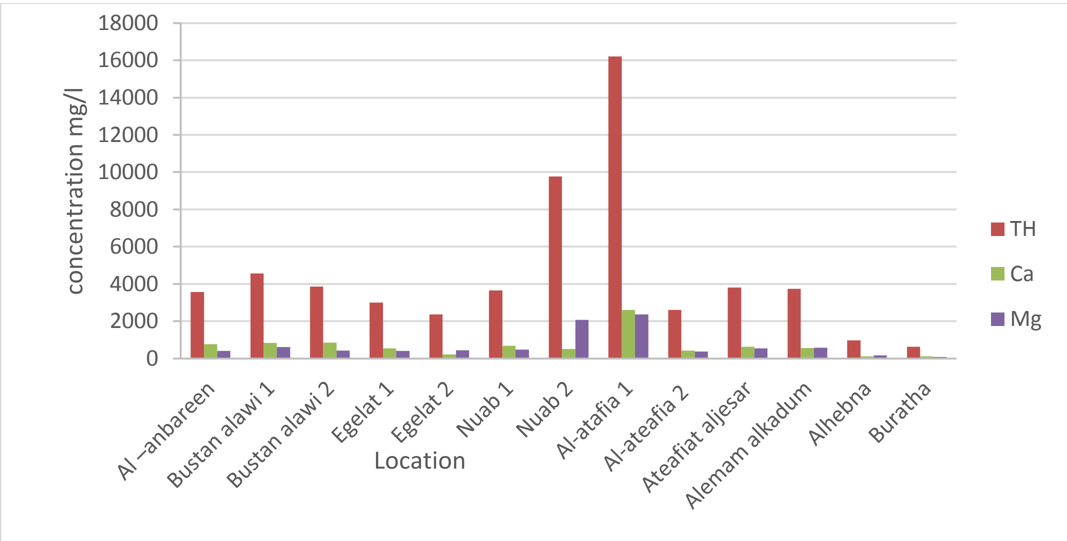

Figure 4- the total hardness and the concentration of Calcium and Magnesium concentration

4- Turbidity

Increased turbidity of water wells samples because the lining not well,Some are newly dug holes in the soil layer has been incoherent easy breakdown, the turbidity of water well higher than the allowed values, Figure-5 turbidity in water wells

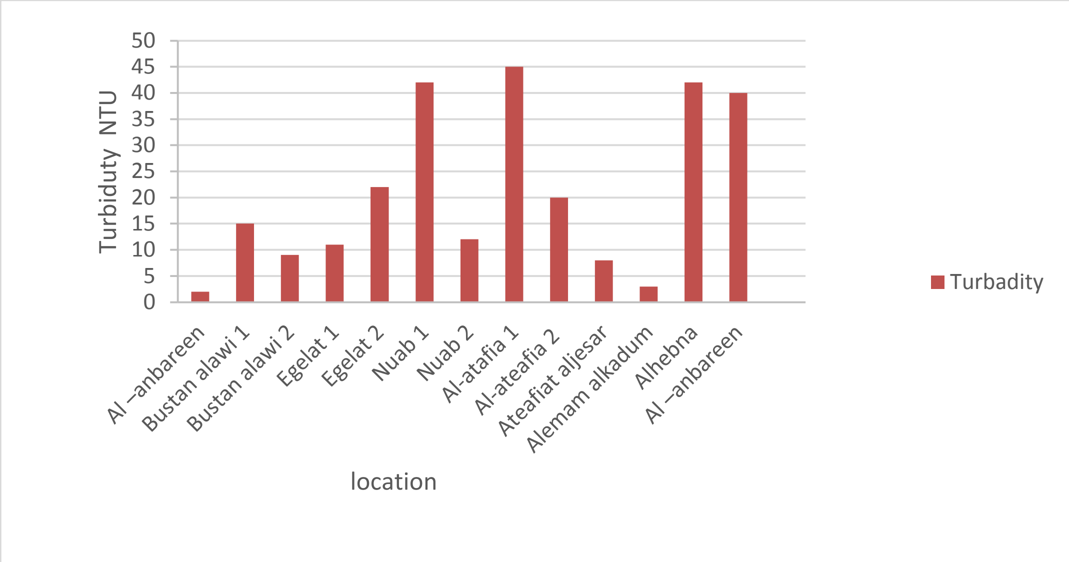

Figure 5- turbidity of water of wells

5- Nitrate

The result of Nitrate concentration within the limitation standard. Figure-6 show nitrate concentration.

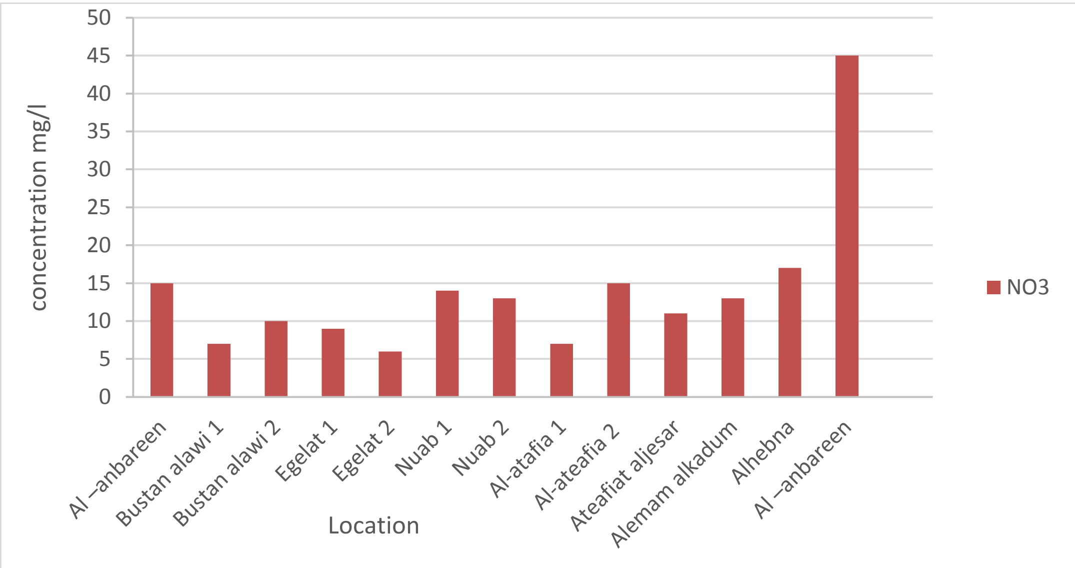

Figure 6-nitrate concentration.

6- Heavy material

The concentration of zinc and Manganese for all water wells samples within limitation, alsothe lead concentration with the limitation except Buratha, Alhebna, Egelat 2 samples, due to ion exchange between water ions and lead ionspresent in the soil origin. Figure-7 show the zinc Manganese and lead concentration.

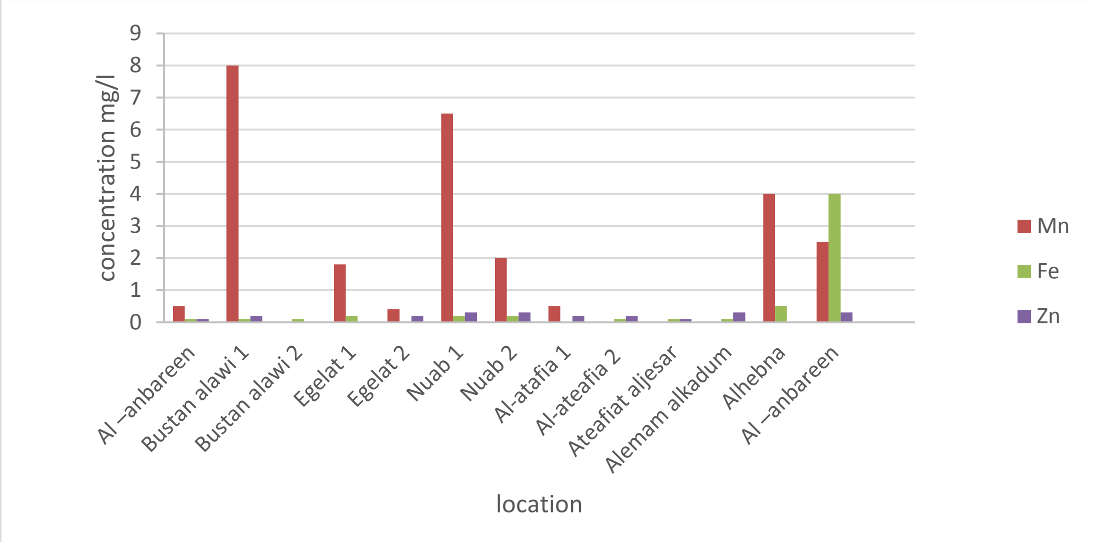

Figure 7- zinc Manganeseand lead concentration in well samples.

7- Result of GWQI

The values of GWQI for drinking purpose in wells ranged between (55.78- 435.36) and categorized as poor to unfit. The values of GWQI for W1 and W11 ranged in class poor and may be used as drinking water after treatment. But the wells W3 and W10 were categorized as very poor while the values of GWQI for wells (2, 4, 5, 6, 7, 8, 9, 12 and 13) ranged in class unfit for human drinking purpose due to the increased concentration of chlorine, sulfate, total hardness, calcium and magnesium from the permissible limits for drinking human according to the Iraqi standard 2009. This result as shown in Figure-8

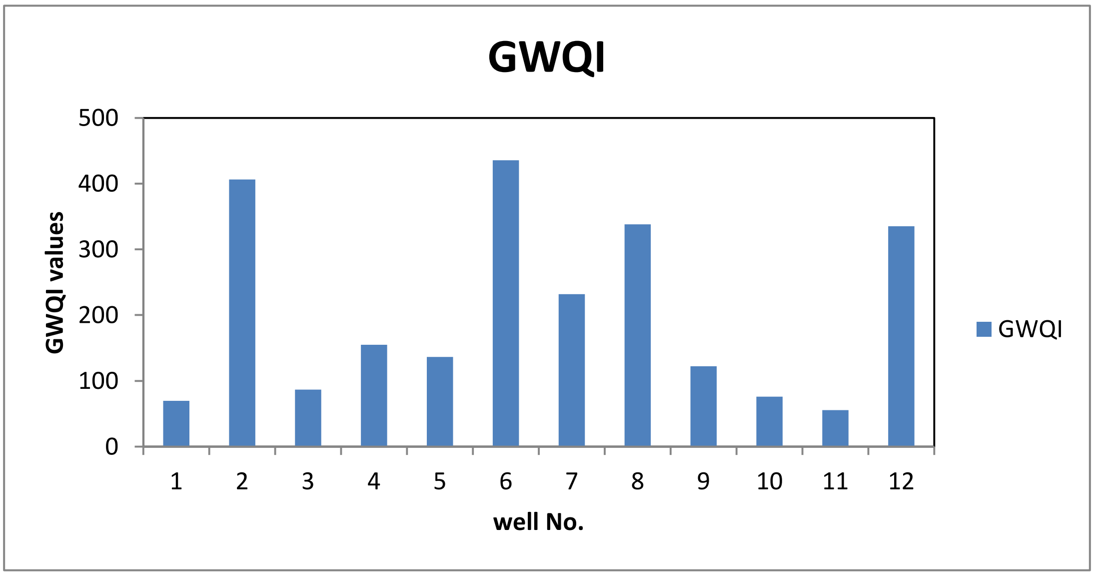

Figure 8-GWQI values at various groundwater sampling wells

Conclusions

1- The most groundwater quality lies in class 5 of WQI for drinking purpose. Therefore classify (unfit for human drinking purpose)

2- The wells (1 and 11) and wells (3 and 10) were a bad water quality for drinking purpose through lies in class 3 (poor) and class 4 of WQI (poor to very poor) respectively.

3- The prime causes of deterioration ground water quality are turbidity, Hardness, Cl, SO_4, Ca and Mg

4- There is a significant increase in the values of water quality index in wells (2, 4, 6, 8) due to increased concentrations of zinc and chloride elements, In addition to increasing the values of total Hardness and Turbidity.

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