Estimating of groundwater age and quality of Al-Shanafiya Area Southwest Iraq

Ayser. M. Al-Shamma'a, Kareem. G. M. Al-Mutawki*
Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq

Abstract

The study area is located to the south of Iraq at Al-Shanafiya town, south west of Iraq. Groundwater is the main source for crops irrigation, household uses and livestock drinking. To determine the relative age of groundwater by measuring the tritium concentration in groundwater, four wells and four springs water samples were taken. Found that the mean tritium concentration in springs samples is 4.125 TU where in wells samples is 2 TU. Using Clark and Firtz (1997) classification found that the relative age is amix of sub modern and modern water. Through modern study was performed by Al-Paruany (2013) found that the tritium concentration in rainfall in Al-Diwaniyah Meteoric Station has reached the natural level (approximately 5TU). Through this , recent study can be applied by Mazor (2004) to determine the age of more accurate, found that the spring water effective age may be not more than 5 years. Eighteen representative groundwater samples were collected from wells and springs, were subjected to chemical analysis to measurement the major ions concentration. The water samples are alkaline in nature, they have high TDS and EC. Piper classification was applied and found that the groundwater samples are confined in the fields 2, 3 and 5 (Na-Cl, Ca-Mg-Cl and Ca-Cl water types). Chadha's diagram was applied for better understanding, water samples are confined in the fields 6, 4 and 7, nearly identical with Piper classification. The groundwater is unsuitable for human drinking, building and for all industries. But it is suitable for domestic uses and live stocks. The suitability of groundwater for irrigation, the samples (S1, S2, W1, W8, and W13) are fair water while the other samples were classified poor water.

Keywords: groundwater, tritium, TDS, EC.

تحديد عمر ونوعية المياه الجوفيه في منطقة الشنافيه، جنوب غرب العراق

ايسر محمد الشماع، كريم غافل مهجج المطوكي*
قسم علم الارض، كلية العلوم، جامعة بغداد، بغداد، العراق.

الخلاصه:

تقع منطقة الدراسه الى الغرب من مدينة الشنافيه ، جنوب غرب العراق . تعتبر المياه الجوفيه المصدر الرئيس لري المزروعات وشرب المواشي والاستعمالات المنزليه في المنطقه. لتحديد العمر التقريبي للمياه، تم اخذ اربع نماذج مياه ابار واربع مياه عيون وذلك لحساب تركيز التريتيوم . وجد ان معدل تركيز التريتيوم في مياه الابار هو (2 TU) بينما التركيز في مياه العيون هو (4.125 TU). ان استخدام تصنيف كلارك و فيرتز وجد ان عمر المياه الجو فيه التقريبي هو مياه حديثه ممزوجه مع مياه قديمه قبل سنة 1950. هنالك دراسه حديثه انجزت من قبل البيروني، اشارت الى ان تراكيز التريتيوم قد بلغت مستواها الطبيعي تقريبا (5 TU). توجد دراسه يمكن تطبيقها للعالم مازور في حالة بلوغ التريتيوم المستوى الطبيعي في مياه الامطار، وبما

*Email:Kghafel@yahoo.com

ان تركيز التريتيوم مقارب للمستوى الطبيعي في مياه الينابيع ، فيمكن الاستنتاج بتطبيق منحنى تحطم نظير التريتيوم ان العمر التقريبي لمياه العيون لا يزيد عن خمس سنين.
للتعرف على نوعية المياه الجوفيه واستعمالاتها تم اجراء تحاليل فيزيائيه وكيميائيه ل ثمان عشرعينة مياه ابار وينابيع. حيث وجد ان هنالك ارتفاع عال في كمية الاملاح الذائبه والتوصيليه وان المياه تميل للقاعديه . تم استخدام تصنيف (Piper, 1944) حيث وجد ان المياه تتوزع على (Na–Cl،Na–Mg–Cl و Ca–Cl) .ولتحديد اكثر وضوحا تم استخدام تصنيف (Chadha,1970)، حيث وجد ان عينات المياه تتوزع على الحقول 6 و4 و7 من التصنيف. ايضا وجد ان هذه المياه غير صالحه للشرب البشري والاغراض الصناعيه واعمال البناء ومواده بينما تكون صالحه لشرب الحيوانات والاغراض المنزليه. تم تصنيف هذه المياه لاغراض السقي حيث وجد حسب تصنيف [15] عيناتها تتوزع بين مياه ري مناسبه الى مياه فقيره.

Introduction:

The study area is a part of the Iraqi Southern Desert which is bounded by (31°15'-31°45') Latitude and (44°25'-44°56') Longitude, covering an area of about 1117 Km^2 ,figure-1. The main formations bearing water in the study area extends from Paleocene represented by Umm-Er Radhuma Formation to the Quaternary deposit. The lithological characteristics of the stratigraphic column are discussed briefly;

Umm-Er Radhuma Formation: The formation was deposited in the late Paleocene cycle, it is composed of anhydrite and dolomite limestone and deposited in a supratidal sabkha environment [1]. Dammam Formation: The formation is composed of variable carbonate rocks, mainly limestone, dolomitic limestone, and dolomite with marl and evaporates. It is characterized by the presence of cavities and karstified canals. The formation was deposited between Early and Late Eocene [2]. The lithology of the formation composed of shelly, chalky and recrystallized dolomitized limestone. The formation was deposited in Early Miocene [1]. Quaternary deposits: Near and in the study area, the Quaternary deposits are wadi fill, depression fill, aeolian deposits, gypcrete and karst depression [3]. The main objective of this study is to determine the relative age of the springs water and wells, also determining the quality of groundwater, its classification and suitability for different purposes.

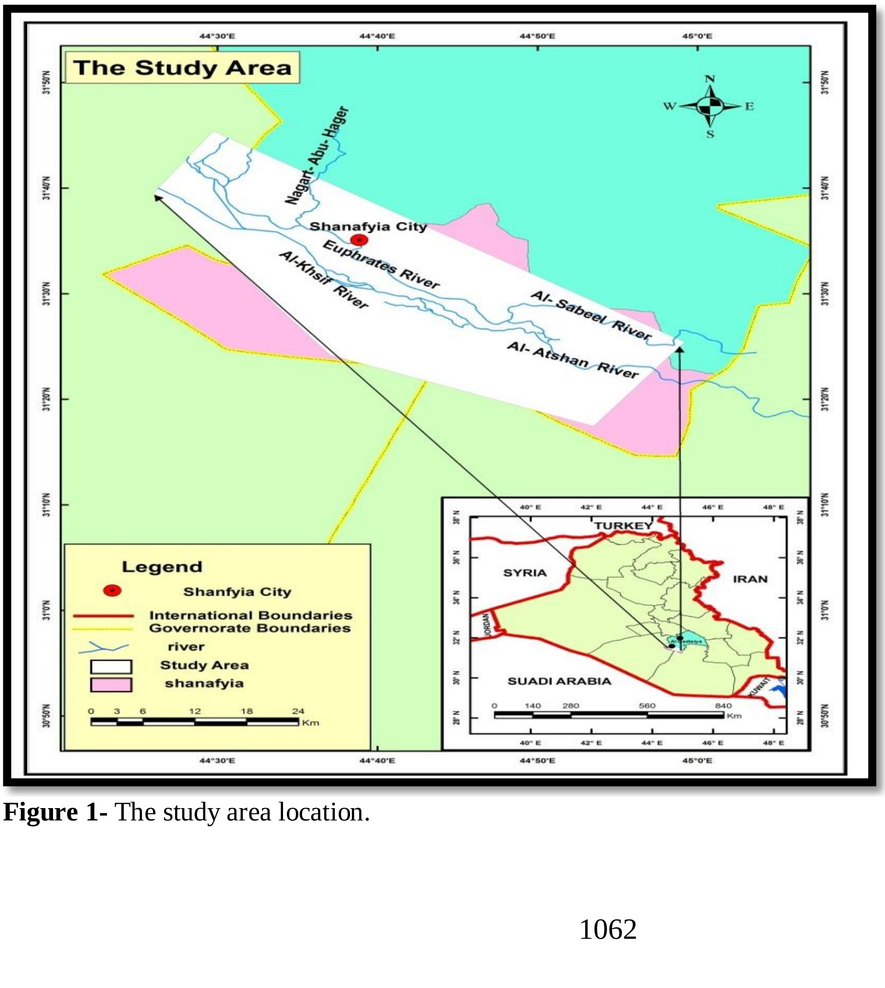

Figure 1- The study area location.

Materials and methods:

Thirteen wells samples and 5 springs water samples were collected in polyethylene bottles and transported into laboratory of Iraqi General Commission of Groundwater for hydrochemical analysis. Also four well water samples and four spring water samples were collected in duel glass bottle, and transported into laboratories of Ministry of Science and Technology (Iraq) for tritium measurement. After sampling, pH, EC and temperature were measured in the field, table-1. The samples location was chosen in such a way that it represents the whole study area, figure-2.

The apparent qualitative age of groundwater is considered to be the amount of time determined from an age dating tracer that has elapsed from the time water lost contact with atmosphere. Tritium is a short-lived radioactive isotope of hydrogen with a half-life of 12.32 years. Tritium is formed naturally as cosmic radiation interacts with the upper atmosphere and all precipitation that falls to earth has small amount of tritium. During the $1950_{S,}$ and early 1960_S, global atmospheric testing of nuclear weapons raised the atmospheric concentrations of tritium hundreds of times above the normal background concentration [4]. After the early 1960_S, when the Nuclear Test Ban Treaty (NTBT) was signed, tritium concentration in the atmosphere decreased and is approaching natural levels as is shown in figure-3 [5].

Table1– Method used for chemical analysis of groundwater samples.

Parameter	Method of Analysis
EC,PH,and Temperature	Field electrode meter
Total Dissolved Solid (TDS)	Evaporation and drying method
Sodium(Na^+)and Potassium(K^+)	Flame photometer
Calcium(Ca^{2+})and Magnesium(Mg^{2+})	Titration with EDTA (Ethylene Diamine Tetracitic Acid)
Chloride(Cl^-)	Titration with 0.02N $AgNO_3$ using potassium dio-chromate indicator
Sulphate(SO_4^{2-})	Gravimetric method by using wave length (430nm)
Nitrate(NO_3^{2-})	UV-Spectrophotometer by using wave length(270nm)
Bicarbonate(HCO_3^-)	Titrationwith (0.02N)H_2SO_4 and phenoephtaline indicator
Tritium isotope	Tritium Isotope was measured by Liquid Scintillation Counter (Ministry of Science and Technology (Iraq)

Result and discussion:

1. Groundwater age:

Relative dating of groundwater has been carried out via the analysis of tritium content (^3H). The wells water from the study area had a mean tritium value of 2.0 TU. It is ranging between 1.9 and 2.1 TU, whereas springs water exhibited a mean tritium 4.125 TU. It is ranging between 4 and 4.3 TU, table-2.

Table 2- Tritium concentration in wells and springs water samples in (TU).

Well No.	Concentration in (TU)	Spring No.	Concentration in (TU)
W1	1.9	S1	4.3
W3	2	S3	4.2
W10	2	S4	4
W13	2.1	S5	4

Tritium concentration alone generally cannot be used to quantitatively date groundwater, but can be used to qualitatively determine whether groundwater is modern (less than about 5-10 years in age) or sub-modern (older than 1950_S in age), depending on the following classification, that has been developed by Clark and Firtz, 1997 [8].

- <0.8 TU indicates submodern water (prior to 1950s).
- 0.8 to 4 TU indicates a mix of submodern and modern water.
- 5 to 15 TU indicates modern water (5 to 10 years).
- 15 to 30 TU indicates some bomb tritium.
- >30 TU: recharge occurred in the 1960s to 1970s.

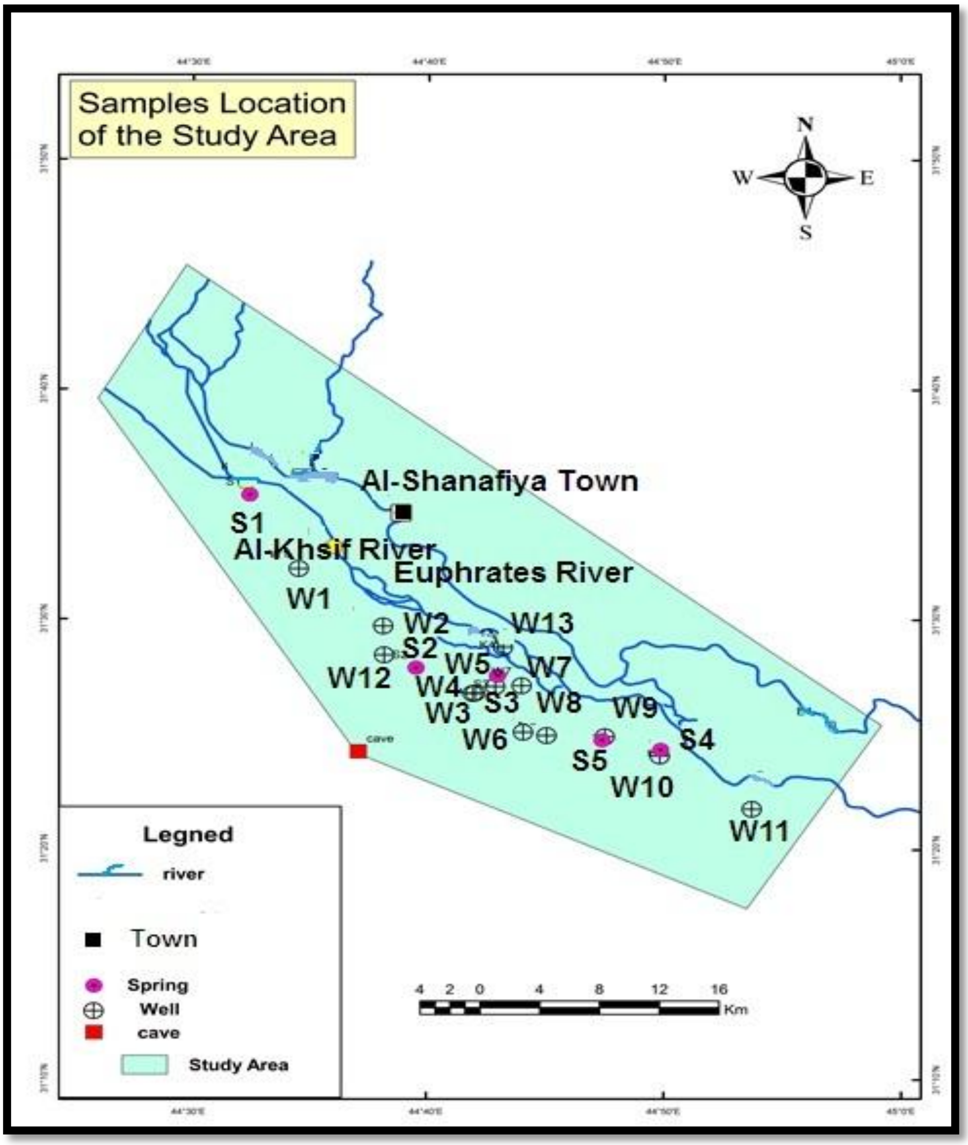

Figure 2- Wells (W) and springs (S) sites.

According to the above classification, a mix of submodern and modern water is classified depending on tritium values ranging from (1.9 and 4.3 TU) in the wells and springs of the studied area.

There is a modern study can be applied by Mazor (2004), in the case of tritium concentration in rainfall in normal level (approximately 5TU). According to Al-Paruany (2013), the tritium concentration has reached the normal level in the study area (Fig. 3) [9]. When we calculate the tritium concentration percentage in accordance with following formula (sample tritium concentration / natural concentration × 100). Can enter the percentages values in the radioactive decay curve of tritium, figure-4 [10], where it can calculate the relative age of spring water. This is because the tritium concentration in springs water samples is approaching the tritium normal level in rainfall.

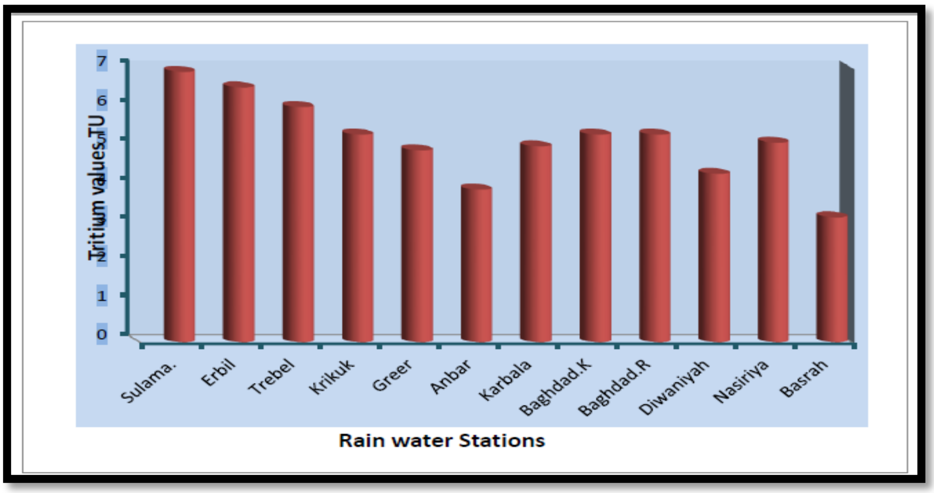

Figure 3- Tritium Values Variations in Iraqi rainfall Station, 2011. (After Al-Paruany, 2013).

Water discharged from springs with (4.3, 4.2, 4.0 and 4.0 TU) tritium, from, table-2 had preserved 4.3×100/5$\frac{100}{5}$, 4.2×100/5, 4×100/5 and 4×100/5 which equals to (86%, 84%.80% and 80%). These percentages represent the tritium concentration in the springs water samples (S1, S3, S4, and S5) respectively, table-2, which were equivalent to an age of 5 years approximately by application of radioactive decay curve figure-4. This figure is used when the tritium concentration in rainfall is in natural concentration around only 5TU [9].

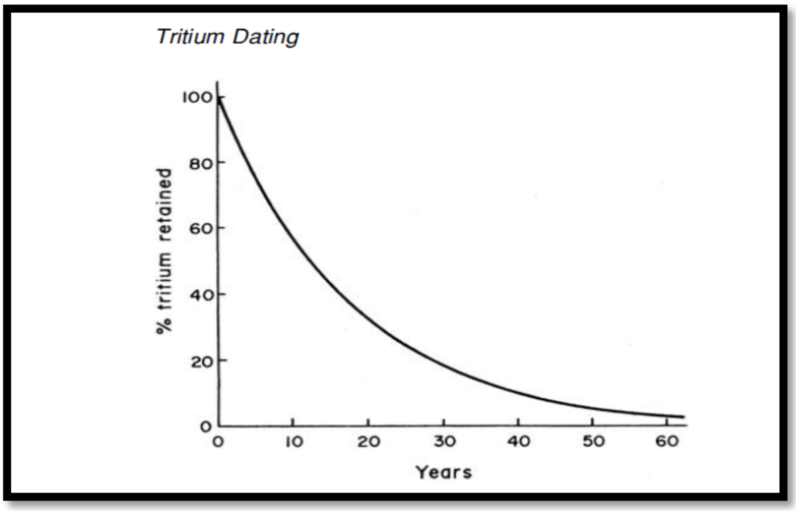

Figure 4- Radioactive decay curve of tritium (after Mazor, 2004)

2. Groundwater quality:

Water quality parameters of the study area are presented in tables-(3, 4). All the samples were alkaline, with a range of (7.45-8.01). The permissible limit of TDS in the drinking water is 1000 mg/L [10]. However in this study, the TDS values were varied between (1752-3674) mg/L while the temperature range is between 23.1º to 24.5º. All the 18 samples exceeded the permissible limit. Calcium and magnesium in the study area ranged between (73-324 ppm) and (50-168 ppm) respectively. The calcium concentrations were increased as a result of calcium carbonate dissolution and weathering of carbonate and silicate minerals and ionic exchange processes are also contributing towards the enrichment of these ions. Na^+ and K^+ concentrations were varied between (212-687 ppm) and (2.5-110 ppm) respectively. Sodium in the groundwater is largely controlled by the saline intrusions and evaporates. Bicarbonate was varied between (180-800 ppm). The dissolution of carbonate rocks is the major origin of bicarbonates. The concentration of Cl^- ion was (290-708ppm). Sulphate in the study area varied between (498-1268). The major origin of sulphate is the dissolution of gypsum.

Table 3- pH, TDS, EC and temperature measurement.

Sample No.	Temp C°	pH	TDS mg/l	EC µmho/cm
W1	24	8	2592	3640
W2	23.7	8.2	2800	3670
W3	23.5	7.80	3509	5130
W4	24.3	8	2860	4120
W5	24.5	8.2	2540	3510
W6	23.5	8	3182	3800
W7	23.6	7.90	2900	3800
W8	23.1	8.2	1752	2500
W9	24	8.5	3674	5320
W10	23.7	7.95	2940	4070
W11	23.2	8	3256	4600
W12	23.9	8.3	2769	3770
W13	23.6	8.1	1872	2530

3- Groundwater types:

A Piper diagram was created for the study area using the analytical data obtained from the hydrochemical analysis, figure-5. In general, we can classify the sample points in the Piper diagram into 6 fields. They are 1. Ca-HCO_3 type 2. Na-Cl type 3. Ca-Mg-Cl type 4. Ca-Na-HCO_3 5. Ca-Cl type and 6. Na-HCO_3 [11]. However, in the present study water types were confined to the 2, 3 and 5types. Majority of the samples (100%) of spring water are plotted in the field 2. 61 % of wells samples are plotted in field 3, 23 % of well samples are plotted in field 5 while 15 % are plotted in field 2. The dominant cation in spring water is Na while the dominant anion is Cl. The dominant cation in well water is Ca, while the dominant anion is Cl.

Table 4- Result of hydrochemical parameters in ppm

Sites	Ca^{2+}	Mg^{2+}	Na^+	K^+	$HCO3^-$	$SO4^{2-}$	Cl^-
W1	254	141	212	10	201	791	540
W2	211	111	337	10.5	409	611	521
W3	193	116	687	17	412	1201	630
W4	73	45	425	15	268	513	362
W5	155	90	230	6	200	528	373
W6	324	149	520	110	800	1268	708
W7	260	131	440	83	448	1001	551
W8	160	50	228	2.5	180	498	290
W9	211	111	337	11	401	612	520
W10	208	99	423	8	451	772	478
W11	180	80	322	3	445	663	305
W12	250	142	513	95	480	1181	681
W13	160	91	236	7	210	572	389
S1	173	60	270	2.4	210	585	338
S2	73	45	425	15	268	513	362
S3	140	98	365	5.1	351	679	468
S4	207	91	433	3.2	449	780	489
S5	302	122	508	6	354	1074	664

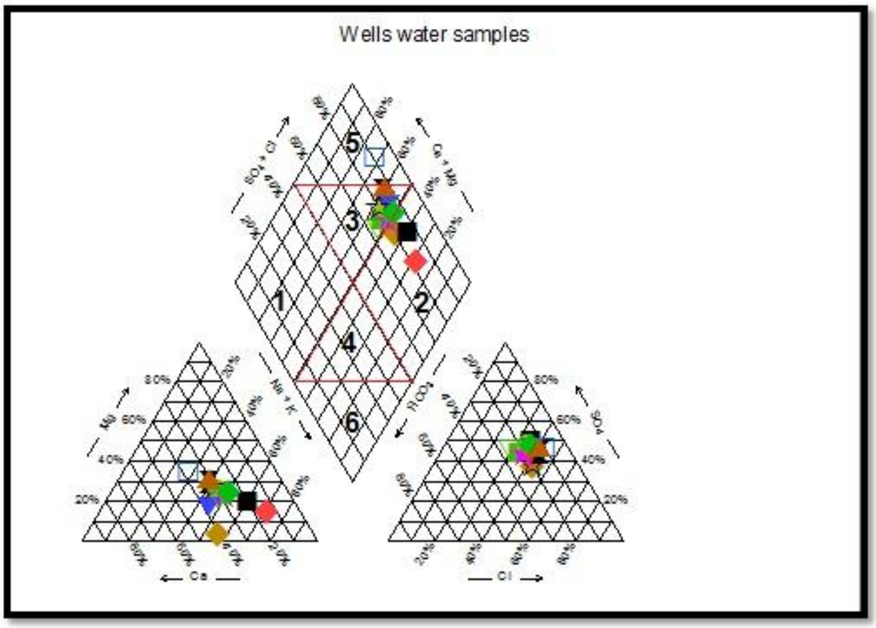

Figure 5- Piper diagram of wells and springs of the study samples.

For better understanding the hydrochemistry and comparing the water types Chadha's diagram was plotted figure-6. The six fields are mentioned by Chadha (1999) is given below. 1. Alkaline earth exceeds alkali metals. 2. Alkali metals exceed alkaline earth. 3. Weak acidic anions exceed strong acidic anions. 4. Strong acidic anions exceed weak acidic anions. 5. Alkaline earths and weak acidic anions exceed both alkali metals and strong acidic anions, respectively. 6. Alkaline earths exceed alkali metals and strong acidic anions exceed weak acidic anions. 7. Alkali metals exceed alkaline earths and strong acidic anions exceed weak acidic anions. 8. Alkalic metals exceed alkaline earths and weak acidic anions exceed strong acidic anions [12].
In the present study all the samples are confined to 6, 4 and field 7 respectively. A majority of the samples (61 %) are plotted in the 6th field. Representing Ca-Mg-Cl type, Ca-Mg dominant Cl type, or Cl- dominant Ca-Mg type waters. This is nearly similar to the results obtained from the Piper plot. Field 7 represents the Na-Cl type of water, the percentage of samples in the category is (22 %). Field 4 represents the strong acidic anions exceed weak acidic anions, the percentage of samples in this category is (16.6 %).

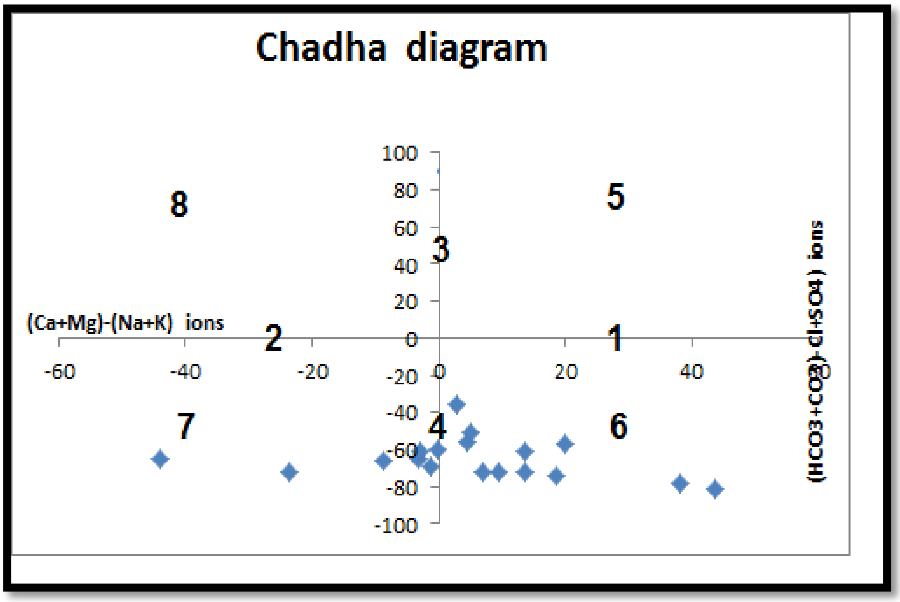

Figure 6- Chadha's diagram of wells and springs of the present study samples.

Groundwater suitability

Groundwater suitability for any purpose is related to its physical, chemical and biological properties. Water is mainly used for drinking, irrigation or for industrial purposes if it fulfills the criteria or standards of certain limits. Groundwater is the main sources of water supply in the study area because of the arid desert climate and little rainfall.

Groundwater suitability for human drinking

There are several standards defining the suitability of water for drinking such as World Health Organization (WHO, 2007) and Iraqi standards 2009 (IQS, 2009). According to these two standards, groundwater in the study area were unsuitable for drinking purpose, because of TDS, Ca^{2+}. Na^{+}, and $SO^{-}4$ is out of permissible limits, table-5.

Table 5- Standards of drinking water (WHO, 2007 and IQS. 2009)

Parameters	IQS Standard	WHO, 2007	Wells	Springs
TDS	1000	1000	3147	2715
pH	6.5-8.5	6.5-8.5	7.7	7.4
Ca^{2+}	150	75	202	229
Mg	100	125	102	107.8
Na	200	200	376	363
Cl	350	250	488	490
SO_4	400	250	785	768

Groundwater uses for livestock purpose

The groundwater of the studied area had been evaluated for livestock uses depending on the classification proposed by Altoviski (1962). This classification is based on some of the major cations and anions as shown in table-6. According to Altoviski classification. All groundwater samples are good for domestic uses, animals and livestock.

Table 6- Specifications of waters for livestock consumption purposes (Altoviski, 1962).

Element	Very good water (ppm)	Good water(ppm) (ppm)	Permi (ppm)	Can be use (ppm)	Threshold (ppm)
Na	800	1500	2000	2500	4000
Ca	350	700	800	900	1000
Mg	150	350	500	600	700
Cl	900	2000	3000	4000	6000
SO_4	1000	2500	3000	4000	6000
TDS	3000	5000	7000	10000	15000

Waters uses for building purposes

The suitability of water samples for building purposes is based on Altoviski, (1962) classification, according to this classification all water samples of the groundwater are unsuitable for building purposes, because of high values of carbonate ions in groundwater of the studied area and an increase in the TDS value of the drain water samples, table-7.

Table 7- Water quality Guide for Building Uses (Altoviski, 1962).

Parameters mg/l	Na^{+}	Ca^{+2}	Mg^{+2}	Cl-	SO^{-2}_4	HCO^{-}_3
Permissible limit	1160	437	271	2187	1460	150

Quality criteria for industrial purposes

The quality requirements of water used in different industrial processes vary widely, salinity, hardness and silica are three parameters that usually are important for industrial water (Todd and Mays, 2005). According to Hem (1991) classification, all groundwater samples are not suitable for all industries, due to high ions concentration, table-7.

Table7- Water quality standards for industrial Uses (after Hem, 1991).

parameter	Textile	Chemical pulp and paper		Wood Chemical	Synthetic rubber	Petroleum Products	Canned, dried frozen fruits and vevetablees	Soft- drinks bottling	Leather tanning	Hudraulic cement manufacture
		Unbleached	Bleached							
Ca		20	20	100	80	75	--	100	--	--
Mg	0	12	12	50	36	30	--	--	---	--
Cl	0	200	200	500	---	300	250	500	250	250
HCO3	0	--	---	250	---	---	---	---	---	---
SO4	0	--	--	100	--	---	250	500	250	250
NO3	0	--	--	100	--	---	---	500	---	---
Cu	0.01	--	---	---	---	---	---	500	--	--
Zn	---	--	---	---	---	---	---	---		
TH	25	100	100	900	350	350	250	---	Soft	----
TDS	100	--	---	1000	-----	1000	500	---	---	600
PH	2.5-10.5	6-10	6-10	6.5-8	6.5-8.3	6-9	6.5-8.5	----	6-8	6.5-8.5

Irrigation water criteria

The suitability of groundwater for irrigation is contingent on the effects of the mineral constituents of the water on both the plant and the soil. Salts may harm plant growth physically by limiting the uptake of water through modification of osmotic processes, or chemically by metabolic reactions, such as those caused by toxic constituents. Depending on the electrical conductivity and sodium ion percent (Na^+ %) in epm which is equal to the ratio of Na ion in epm to the total cations in epm multiplied by 100. Oklahoma Universities and USDA researches developed and divided the irrigation water in to six classes, [15] figures- (8, 9)

Springs water samples S3, S4 and S5 as shown were classified in class 4 (poor) while S1 and S2 samples were grouped in class 3 (fair) figure-8. Nearly all well water samples were grouped in class 4 (poor) figure-9, an exception was appeared with W3 which was grouped in class 5 (very poor). Another exception that the well water samples W1, W8, and W13 were grouped in class 3 (Fair).

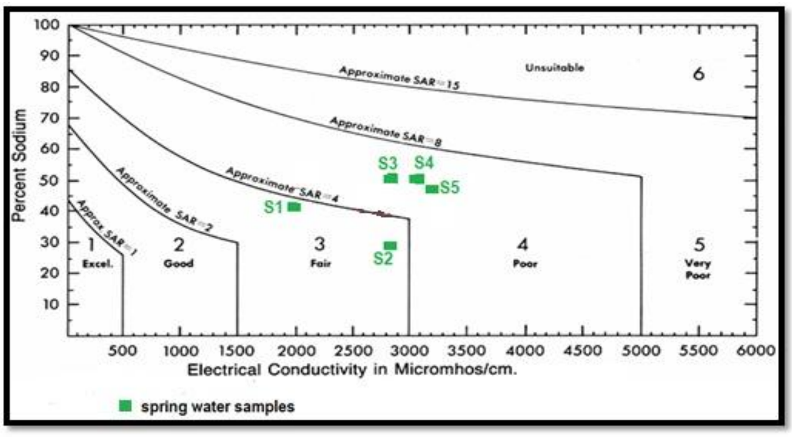

Figure 8- Oklahoma classification diagram for groundwater (Spring water samples).

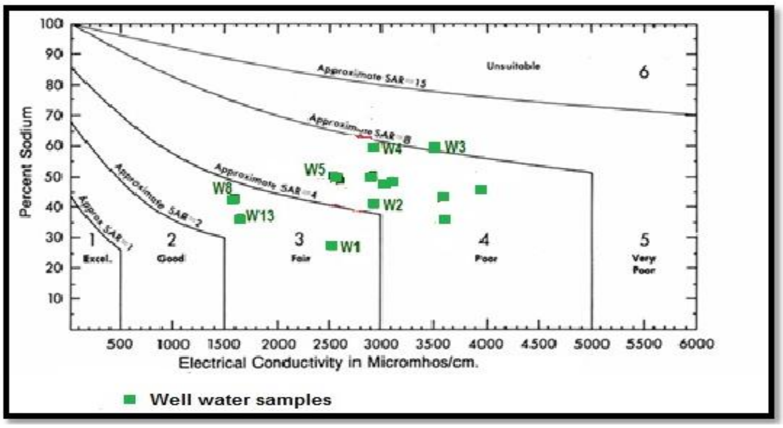

Figure 9- Oklahoma University classification diagram for groundwater (Well water samples).

Conclusions:

Groundwater age is a mix of sub modern (prior to 1950_S) and modern water (5 to 10 years). The result of the hydrochemistry suggests that all the water samples are alkaline in nature where total dissolved solid and electric conductivity were high. Dominants groundwater type were assessed and compared with Piper and Chadha's diagrams, nearly 60 % of the water samples was Ca-Mg-Cl type in the two diagrams.

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