STABL ISOTOPES AND HYDROCHEMICAL PARAMETER AS INDICATORS OF AL-RAZZAZA LAKE WATER INTERACTION WITH GROUNDWATER SURROUNDING / KARBALA GOVERNORATE- IRAQ.

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ABSTRACT

This research was aimed to study the exposure of Razzazah Lake to major hydrological changes in recent years as a result of natural climatic changes and drought, high evaporation in lake due to stop discharge from Habbaniyah Lake by Al- majera channel. During 2019, we collected surface water samples at three locations, and three samples from groundwater, in addition one samples from each location Imam Ali Drop and Sewage water of Karbala. The Results show that the heavy isotopes in lake and groundwater well are enriched during the warm period, and depleted during the cold period. Chemically, The dominant cations and anions in Al-Razzaza lake water are mainly of in Order Ca > Na > Mg and Cl>SO_4 and the water type Ca-Chloride in both period. according to the ratio of Ca/Cl concentration in water samples in the study area, it can be see that same ratio of Ca/Cl between Al-Razzaz lake water and W1 well, this indicator to the interaction between them.

Key word: isotopes , imam ali drop, water quality, deuterium, ion concentration.

النظائر البيئية والمتغيرات الهيدروكيميائية كدلائل لتداخل مياه بحيرة الرزازة مع المياه الجوفية المحيطة بها في محافظة كربلاء / العراق

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المستخلص

يهدف البحث الى دراسة واقع بحيرة الرزازة مع تصاعد وتيرة الجفاف والتغيرات المناخية وفقدان التغذية من بحيرة الحبانية عبر قناة المجرة ، فضلا عن تصريف مياه الصرف الصحي لمدينة كربلاء .خلال عام 2019 ، تم سحب ثلاث نماذج من البحيرة فضلا عن ثلاث مواقع لابار محيطة بها ونموذج واحد من قطارة الامام علي ومياه تصريف الفضلات. اشارت النتائج الى وجود اغناء واضح في النظائر المستقرة خلال فصل الصيف ونضوب في قيم النظائر خلال موسم الشتاء . كيميائيا بينت النتائج ان ايون الكالسيوم هو الايون الموجب السائد في مياه البحيرة في حين ان ايون الكلورايد هو الايون السالب السائد حيث تبين ان نوعية مياه بحيرة الرزازة هي من نوع كالسيوم – كلورايد خلال فترتي الدراسة . واعتمادا على نسبة Ca/Cl فان هنالك تشابة سحني واضح بين مياه البحيرة والبئر W1 وهو دليل على وجود تداخل بين مياه بحيرة الرزازة والمياه الجوفية في منطقة الدراسة .

الكلمات المفتاحية : النظائر، قطارة الامام علي، نوعية المياه، الديتيريوم، تركيز الايون .

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INTRODUCTION

Stable isotopes of hydrogen and oxygen are important in understanding hydrological processes (14,25) .In Iraq after 2003, the population growth, and increased the domestic, agricultural and industrial usage of water resulted the water scarcity. Iraq is an arid country at least in the central and southern parts, this country is heading towards a water crisis mainly due to the improper management of water resources, water policies is important source of water used for human utilization and agricultural activities. In Karbala Desert. water plays an important role for society, economy, Agriculture Activities. The water problems, poor management ,technical problem, real demand for water has rapidly increased over the past few years and this has resulted in water scarcity in many parts of Iraq. On the other hand, the prevalence of drought conditions caused by climatic changes. During the past few decades, rapid increase of population, groundwater levels in main freshest aquifer in Iraq have been falling due to the increase in extraction rates and very bad management scenarios.(2,23). The large hydrological changes that have occurred in water resources in Iraq such as Razzaza lake as a result of natural climate changes, drought and high evaporation in the lake due to decrease the recharge from Habbaniyah lake through the Al_Majara channel, in addition to connect the discharge of water Sewage from the city of Karbala to the lake directly, that led to a significant increase in the concentration of salts (TDS) and thus its effect in the main groundwater aquifer near the lake such as Dabbidba and Dammam aquifers, which feed water wells processed for agricultural land and uses of rural population in the area. Many Hydrochemical and Hydrogeological studies of groundwater and Al_Razzaz lake have been conducted on the Karbala Governorate (1,3,5,7,18,21,22) while. the isotopic studies are very limited. Stable isotopes of water (^{2}H and ^{18}O) have been used globally since 1950 (11, 13, 15). To utilize and protect water resources (Al-Razzaza lake and groundwater) it's necessary to understand the hydro chemical parameter of (pH), electrical conductivity (EC), total dissolved solids (TDS), Sodium absorption ratio (SAR), total hardness (HT), major anion (CO_3^{2-}, HCO_3^-, Cl- and SO_4^{2-}) concentrations, and major cation (Ca^{2+}, Mg^{2+}, Na^+ and K^+) concentrations, and water quality of Al_Razzaza lake, Groundwater surrounding it ,Sewage water of Karbala Governorate. In addition use stable isotopes (Deuterium ^{2}H and oxygen ^{18}O) to define the sources, origin, and the interaction between groundwater, surface water and rain water. This study aimed to evaluate the water quality of Al-razzaza lake and build new plan for water policies and support sustainable development.

MATERIALS AND METHODS

study area

The study area (Al-Razzaza lake) is located about 100km form Baghdad, south-East Karbala Governorate-Iraq. it lie between (44° 25 - 43° 45) E longitudes and(32° 40 -32° 20) N latitude with area of 50 Km^2.(Figure 1). Its located on the contact between stable and unstable shelf (Al-Salman Zone).

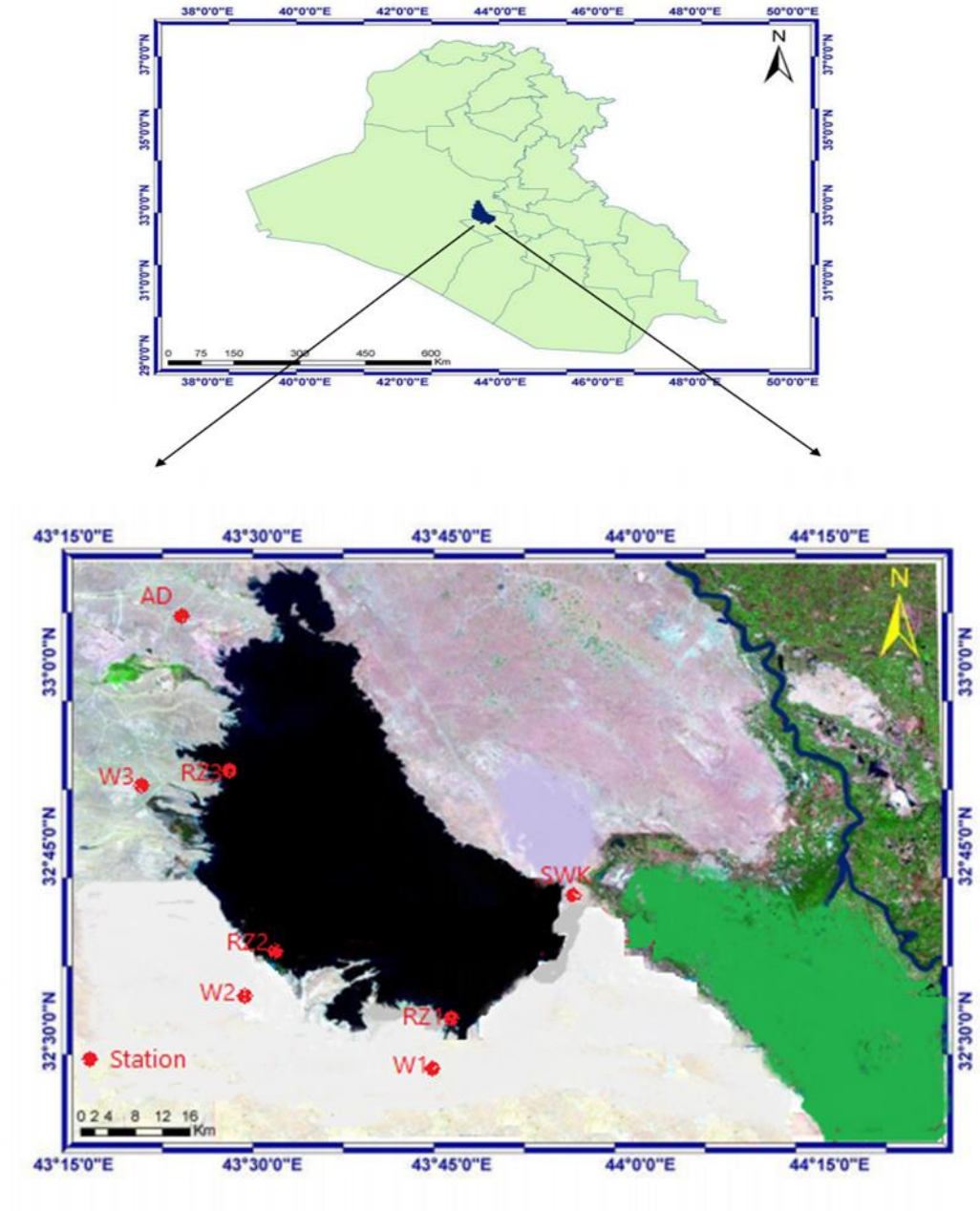

Figure 1 .Locations and sampling map of study area

Geological setting of study area is characterized by range ages from Upper Miocene to Recent (10). The stratigraphic succession is composed of Injana (U. Miocene), Dibbdiba (Pliocene - Pleistocene) formations and Quaternary deposits (Pleistocene- Holocene) (Table1). Tectonically, the platform of the Iraqi territory is divided into two basic units, the stable and unstable shelf (19). The stable shelf is characterized by reduced thickness of sedimentary cover and by lack of folding ,while unstable shelf has a thick and folded sedimentary cover. Folds are arranged in narrow long anticlines and broad flat synclines (10). the study are located in the stable shelf (Rutba-Al-Jazera zone). There are many faults in the study area, and the bigger and important one is Al-Furat fault, that extend from Hit to northwestern Smawa city. The study area is characterized by Antiforms, Syniforms, Horsts and Grabens Figures, that its under the surface and effect to bed rocks structure. According to meteorological data in Karbala station for the period 2010–2019, generally characterized as being continental, dry and relatively hot in summer, cold and with little rain in winter, (8). The monthly average of temperatures 25.16-40.09^{0}C, evaporation 230.78-400.12mm, rainfall 10.2 and 0.1mm in April and August respectively.

Table 1. Description of the lithological formations in the study area(19).

Formations	Age	descriptions
Injana	U. Miocene	Silt marl, Clay stone
Dibdiba	Pliocene-Pleistocene	Sandstone-Gravel, Sandstone Clay
Quaternary	Pleistocene-Holocene	Mixture Gravel, Sand, Silt and Clay

Field and Lab Works

A total of eight samples were collected from Al-Razzaz Lake (3 samples), Groundwater (4 samples) and Sewage water (1 samples) for two period April and August 2019 (Table. 2). For hydro chemical analysis total dissolved solids (TDS), Sodium adsorption ratio (SAR), total hardness (HT), major anion (CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-}) concentrations, and major cation (Ca^{2+}, Mg^{2+}, Na^+ and K^+), Samples were taken in duplicate and stored in one liters polyethylene bottles at 4°C. Field measurements (pH, EC, W.L) as well as sample collection, labeling, preservation and transfer to the laboratory were carried out before sampling and then prepared for regular inspection. These analyses were conducted at the Laboratory of water research in Ministry of Science and Technology. The samples were analyzed using standard procedures (9) . while the samples for isotopes were taken in 50ml and one liters in special bottles for ^{18}O,^{2}H and ^{3}H Respectively. These analyses were conducted by using LSC and /Liquid water isotopes analyzer (LWIA) techniques at the Laboratory of isotopes/ Ministry of Science and Technology according to (16).

Table 2. Name station, geographical positions (GPS), elevation of the study sites

Station Symbol	Station Name	Elevation	Static level	Well depth	Latitude	Longitude
RZ1	Al-Razaza (Right)	13	-	-	32°35' 27"	43° 52' 08.0"
RZ2	Al-Razaza (mid)	13	-	-	32°35' 30"	43° 52' 06.0"
RZ3	Al-Razaza (left)	13	-	-	32°35' 33.8"	43° 52' 09.0"
AD	Imam Ali drop	22	flowing	-	32°35' 34"	43° 52 ' 10.0"
W1	Farm well	57	12	120	32°30 29"	43° 32' 05"
W2	Gas station well	64	20	77.5	32°27' 49"	43° 34' 49.9"
W3	Kanana well	60	17.5	60	32°34' 46"	43° 58' 40.0"
SWK	Sewage Karbal	14	-	-	32°35' 35.8"	43° 52' 10.7"

RESULTS AND DISSCUSION

The results of water samples of Al_Razzaza lake ,groundwater and Karbala Sewage in study area for two periods April and August, 2019 were presented in Table 3. For Al-Razzaza lake, the lowest value of pH (7.2) was recorded in wet period April 2019 and the highest was 7.3 in dry August 2019. The lowest value of electrical conductivity (EC) 7855 µs/cm) was recorded in wet period April 2019 and the highest was 7919 µs/cm in dry August 2019. Total dissolved solid (TDS) ranged from 5847 mg/l in wet season April 2019 to 6281 mg/l in dry period August 2019. The minimum value of Ca, Mg, Na, K was 830,123,948,34,mg/l respectively, in wet period April, 2019 and the maximum value of Ca, Mg, Na, K was 934,155,1000,37.4mg/l respectively, in dry period August 2019. while the minimum value of Cl,SO_4,CO_3,HCO_3 was 1751 ,2035,2.0,111mg/l respectively, in wet period April 2019) and the maximum value of Cl,SO_4,CO_3,HCO_3 was 1799,2228,5,121mg/l respectively, in dry period August 2019. (Figure 2 , 3).

Table 3. Physical and chemical properties of Razzaza Lake and groundwater samples for two periods (dry and wet, 2019).

Sta.		PH	EC	TDS	Ca	Mg	Na	K	SO_4	HCO_3	Cl	CO_3
Dry	RZ1	7.3	7900	6104	883	145	1000	38.6	2133	120	1778	5
Period	RZ2	7.3	7919	6281	934	155	1000	37.3	2228	121	1799	5
2019	RZ3	7.2	7911	6175	886	143	998	37.4	2189	120	1795	5
	AD	7.6	980	518	75	19	67	2.2	112	121	114	1
	W1	7.5	7100	6245	889	148	1020	40	2231	134	1776	6
	W2	7.4	3400	2180	237	64	395	13.1	774	166	515	12
	W3	7.4	3780	2575	310	88	392	21	917	217	614	13
	SWK	7	7823	5751	780	156	890	33	1989	342	1550	10
Unit			µs/cm					ppm				
Wet	RZ1	7.2	7855	5847	830	130	950	36	2035	112	1751	2
Period	RZ2	7.2	7865	5997	880	140	955	34	2120	111	1754	2
2019	RZ3	7.2	7861	5882	856	123	948	35	2050	112	1755	2
	AD	7.52	934	455	70	15	57	2	107	100	101	1
	W1	7.4	6983	6070	873	138	998	36	2200	121	1700	3
	W2	7.3	3378	2035	365	51	222	10	744	134	499	8
	W3	7.3	3700	2547	362	68	398	16	890	200	602	9
	SWK	7	7783	5435	755	137	840	28	1943	310	1412	9
Unit			µs/cm					ppm				

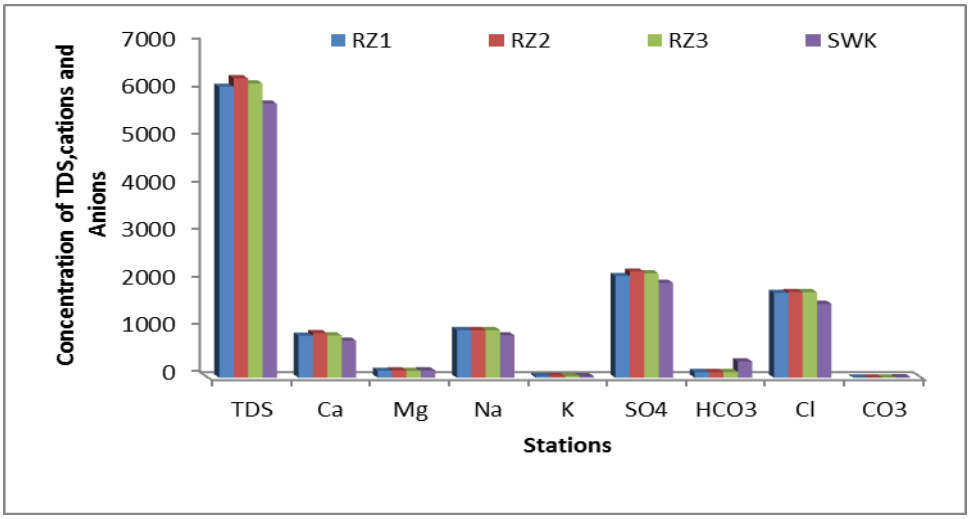

Figure 2. variation in TDS, Cations and Anions in Al-Razzaza lake and Sewage water Karbala during dry period, August,2019.

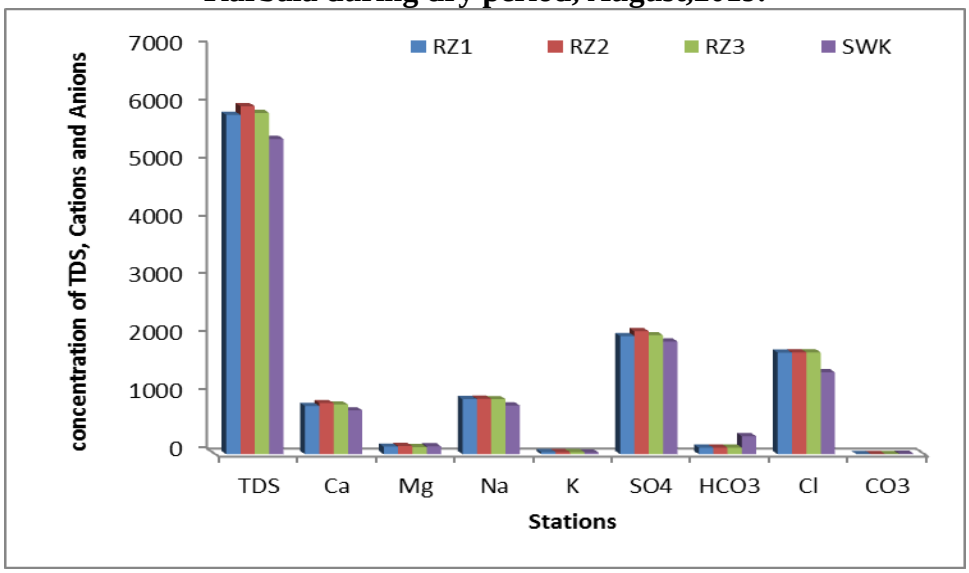

Figure 3. Variation in TDS, Cations and Anions in the Al-Razzaza lake and Sewage water Karbala during wet period April,2019

There was a clear variation between two periods. Figure (4 , 5), shows a clear variation for EC and TDS in Al-Razzaza lake , The lowest values were noticed in April 2019 (wet Period), while the highest values were noticed in August 2019 for both EC and TDS. Also same trend where was observed to other parameters Ca^{2+},Mg^{2+},Na^{+},K^{+} and SO_4,Cl,HCO_3,CO_3) that maximum values noticed in dry period, 2019 due to Evaporation processes during the studied periods.

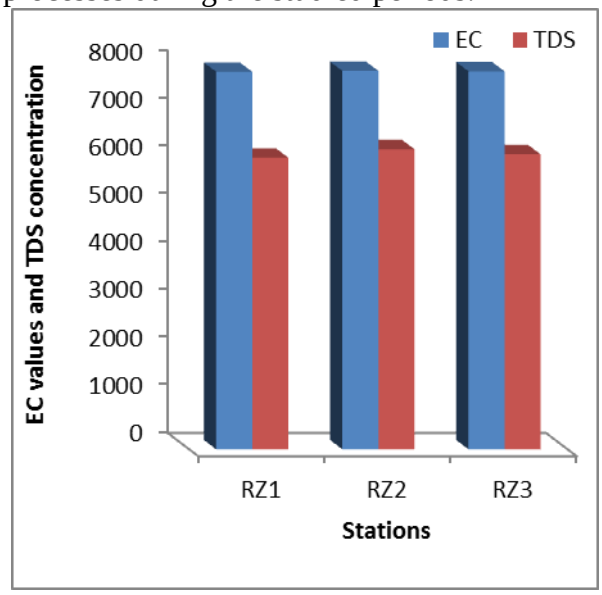

Figure 4.Variation of ECand TDS/ dry

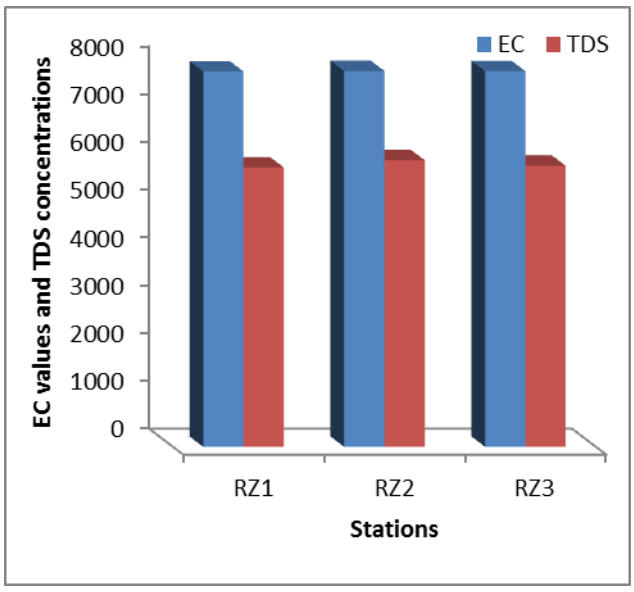

Figure 5.Variation of EC and TDS/ wet

The Razzaza lake water is characterized by their wide variation in TDS (ranging from 14000 to 16640 ppm during 1995 while during 2013 ranging from 21400 to 24960 ppm (5). Figure 6. Comparison of TDS values for both periods 1995 and 2013 with current study (5848-6281ppm). indicate that increasing the deteriorated of water quality in the Al-Razzaza lake due to stopped the Discharge from Al-Habbanyia lake in addition effect of climate change (low rainfall, High temperature) and continues discharging the Sewage from the city of Karbala. but the decrease in TDS concentration in Al-Razzaza lake water in 2019 (dilution in TDS) is related with increase of rainfall in 2019 and their effect for more discharge to the lake water.

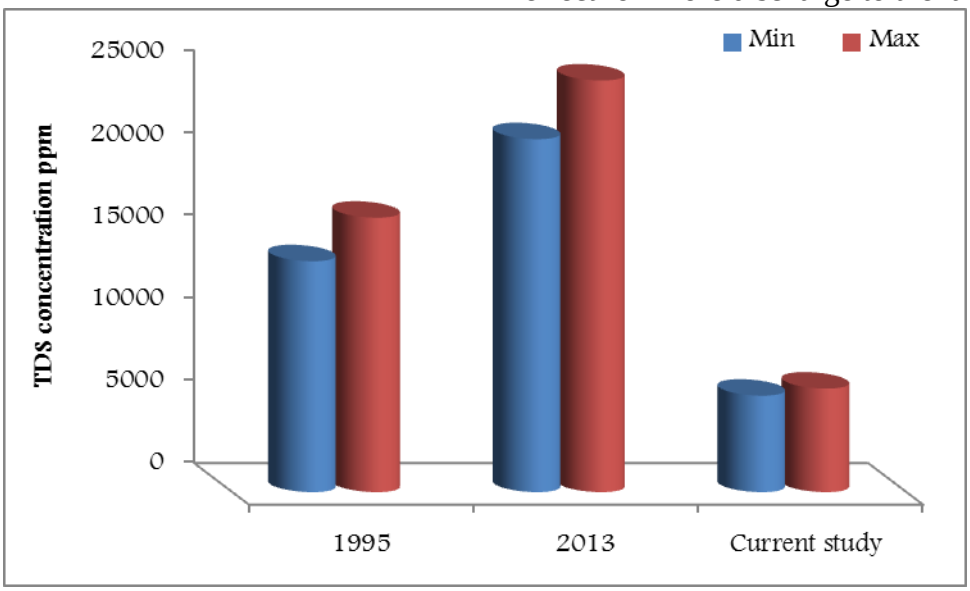

Figure 6. Trend of TDS during 1995.2013 and 2019 in Razzaza lake

The minimum value of EC and TDS of Ad station was 934 µs/cm, 455 mg/l respectively, in wet period April, 2019 and the maximum value of EC and TDS of AD station

980 µs/cm 518 mg/l respectively, while The minimum value of EC and TDS of SWK station was 7783 µs/cm, 5435 mg/l respectively, in wet period (April, 2019) and the maximum value of EC and TDS of SWK station 7823 µs/cm 5751 mg/l respectively. its seem there is low change in the concentration of TDS in the AD station this indicate that same condition of aquifer. While the change of TDS in SWK station is related with Human activates of Karbala city, technical processes and effect of climate. For groundwater, The lowest value of pH (7.3) was recorded in wet period April 2019 and the highest was 7.5 in dry August 2019. The minimum values of EC was 3378 µs/cm in wet periods April 2019) and the maximum values was 7100 µs/cm in dry period August 2019. The minimum concentration of TDS was 2035 mg/l in wet periods April 2019 and the maximum concentration was 6245 mg/l in dry period August 2019. The minimum concentration of Ca^{2+},Mg^{2+},Na^{+},K^{+} was 830,130,950,36 mg/l in wet periods April 2019), respectively, and the maximum concentration of Ca^{2+},Mg^{2+},Na^{+},K^{+} was 883,145,1000.38.6 mg/l in dry period August2019,respectively. while The minimum concentration of SO_4,Cl,HCO_3,$CO_3$was 2035,1751, 112, 2 mg/l in wet periods April 2019, respectively, and the maximum concentration of SO_4,Cl,HCO_3,CO_3 was 2133,1778,120,5 mg/l in dry period August 2019,respectively**.** from the results above, there is a variation in cations and Anions concentration between the wells in study area during the studied periods, this variation can be attributed to the temporal variation by climate effect, rainfall and differ in recharge or to the spatial variation in controlling factors that are responsible for lithology content in the geological formations and dissolution processes. (Figures 7,8).

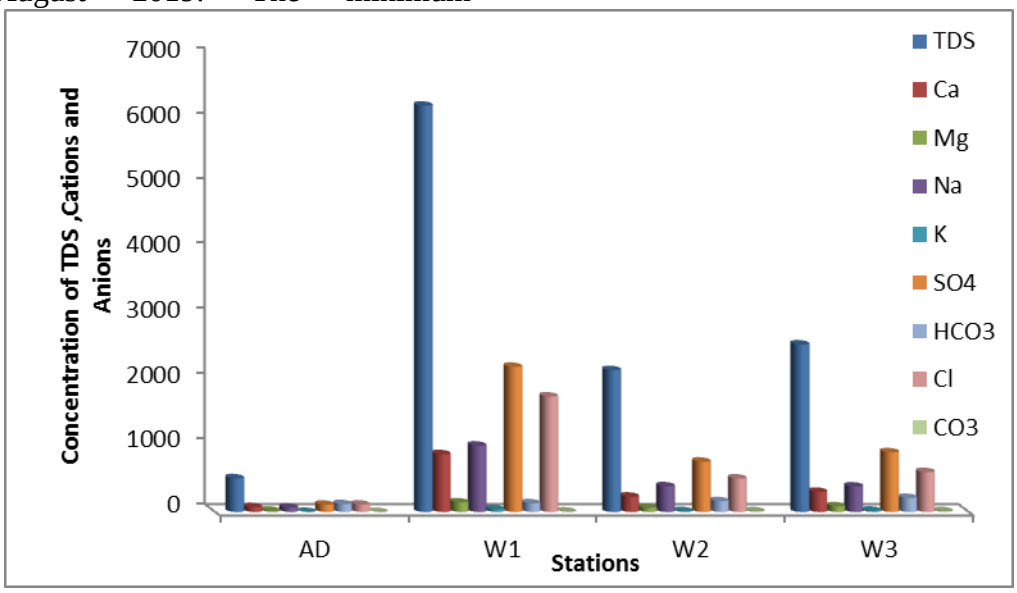

Figure 7. Variation in TDS, Cations and Anions in Groundwater and Ali Drop in the study area during wet period August,2019.

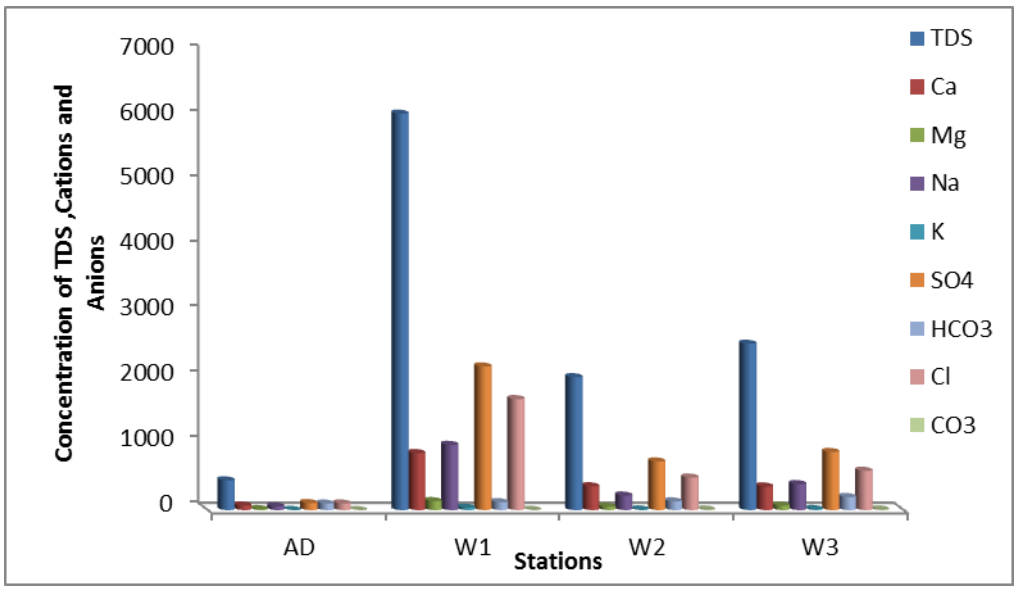

Figure 8. Variation in TDS, Cations and Anions in the Groundwater and Imam Ali Drop in the study area during wet period April,2019.

The dominant cations and anions in Al-Razzaza lake water are mainly of in Order Ca > Na > Mg and Cl>SO_4 and the water type Ca-Chloride in both period. while in some wells in order Ca>Na >Mg >SO_4 >Cl and the water type Ca- Chloride, The other well it Ca >Na >Mg > SO_4 >Cl) and their type Ca – Sulfate. The Ad (Imam Ali Drop) have formula (Ca >Na>Cl->SO_4) and the type Ca-Chloride. From the chemical composition of the all samples of groundwater characterizes as Ca-SO_4 in W1 well , and characterizes as Ca-Sulfate in W2,W3 wells and the other type as Ca-Cl in Razzaza Lake, good evidence for strong interaction between W1 and Al-Razzaza water , specifically in the south-west Razaza area. this match with (4), concluded that the main groundwater recharge sources at the west and south west of Razzaza lake are from the subsurface water flow from the west and south west catchment of the studied area which flow through fractures and subsurface channels that affected by the fault systems of the area represented by Abu Jeir and emam Ahmad faults. On the other hand depend on the ratio of Ca/Cl concentration in the water samples in the study area, it can be see that same ratio of Ca/Cl between Al-Razzaz lake water and W1 well camper with other samples in the study area, this other indicator to the interaction between them. For uses, depend on SAR (12) classification. all samples from Razzaza lake and groundwater for two periods are doubtful to unsuitable for irrigation.

Isotopes of study area

Isotopes analysis in this study included O,H. The Results of current study shows that O an H of Al_Razzaza lake ranged from 2.66 to2.68‰ and 4.79 to 4.82 ‰ in dry period August,2019 respectively, while ranged from -1.15 to-1.25‰ and from-15.25 to-15.43 ‰ for O and H in wet period April,2019. respectively. For the groundwater. The isotopic composition ranges between (-2.89‰ to 1.29 ‰) for ^{18}O and between (-20.06 to -5.40) for ^{2}H in wet period April,2019. while, ranges between (-2.14‰ to 3.22 ‰) for ^{18}O and between (-22.36‰ to 4.1 ‰) for ^{2}H in dry period April,2019. On the other hand, the isotopic composition of the water selected from AD and SWK recorded (-5.40 ‰ and -2.9 ‰) for ^{18}O , (-34.5‰ and -21.2‰) for ^{2}H in the wet period respectively. while it recorded (-3.23 ‰ and -3.84 ‰) for ^{18}O , (-20‰ and -23.36‰) for ^{2}H in dry period respectively. In general, the isotopes values of groundwater enriched during dry period (defined in this study as the period in August) and depleted during the wet period , Table 4.These values of groundwater are more depleted when compare with the isotopic composition of the Razzaza Lake. It is a logical result since Razzaza usually has been affected by evaporation which caused it to be more enriched and to be close to the groundwater W1.

Table 4. Isotopic values of Al- Razzaza Lake and groundwater samples for two periods dry and wet, 2019

Sta.		^{2}H Reportable Value (permil)	^{18}O Reportable Value (permil)	Ec µs/cm
wet	RZ1	-15.43	-1.15	7900
Period	RZ2	-15.25	-1.20	7919
2019	RZ3	-15.34	-1.25	7911
	AD	-34.51	-5.40	980
	W1	-16.01	-1.77	7100
	W2	-5.40	1.29	3400
	W3	-20.06	-2.89	3780
	SWK	-21.2	-2.9	
	RZ1	4.82	2.68	
dry	RZ2	4.80	2.67	7855
Period	RZ3	4.79	2.66	7865
2019	AD	-20	-3.23	7861
	W1	4.1	1.52	934
	W2	2.57	3.22	6983
	W3	-22.65	-2.14	3378
	SWK	-23.36	-3.84	3700
				7783

The empirical equation was found by Craig (1961) (15) when he used a linear regression method to analyze the composition of the isotopes of oxygen and hydrogen in samples of precipitation, snow water, and river water from all over the world. His finding is known as the Global Meteoric Water Line (GMWL):

δD = 8 δ18O + 10

The δ18O and δD diagram Figure.9 shows that Al-Razzaz lake water and wellW1 of the isotopic values in study area lie close to the Global Meteoric Water Line (δ2H = 8 δ18O + 10), and LMWL suggested by Al-paruany (2013)(6),which indicate that Al-Razzaza Lake water and some groundwater (W1) which indicates the same source of rainwater (source of recharge) with different degrees of evaporation processes, due to their difference in depth and their influence by evaporation to the resident time effects. Figure 10.shows the groundwater in the study area are divided as three groups, the first represented W2,W3 wells that lie to the East south Al-Razzaza Lake water. which underwent less evaporation and it recharged by rainwater. the second one represented W1 well which underwent more evaporation , that enriched with isotopes values .third group represented Razzaza lake, underwent more enrichment with high evaporation process. (δ18O and δD). third group represented Razzaza lake , underwent more enrichment with high evaporation.

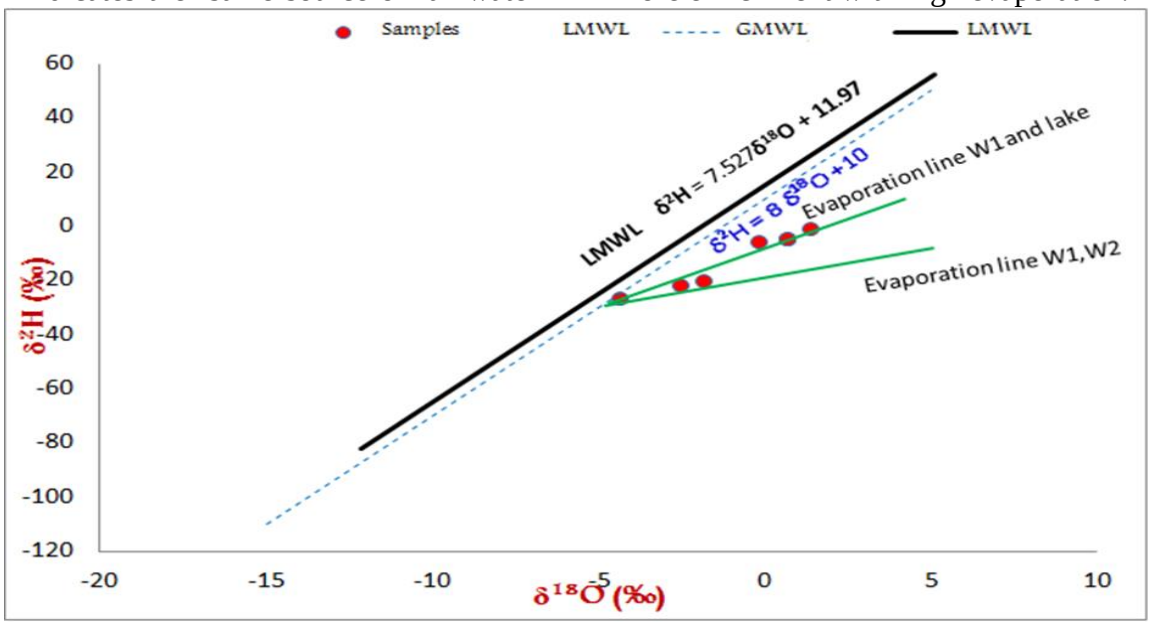

Figure 9. The LMWL with the GMWL and water samples in the study area

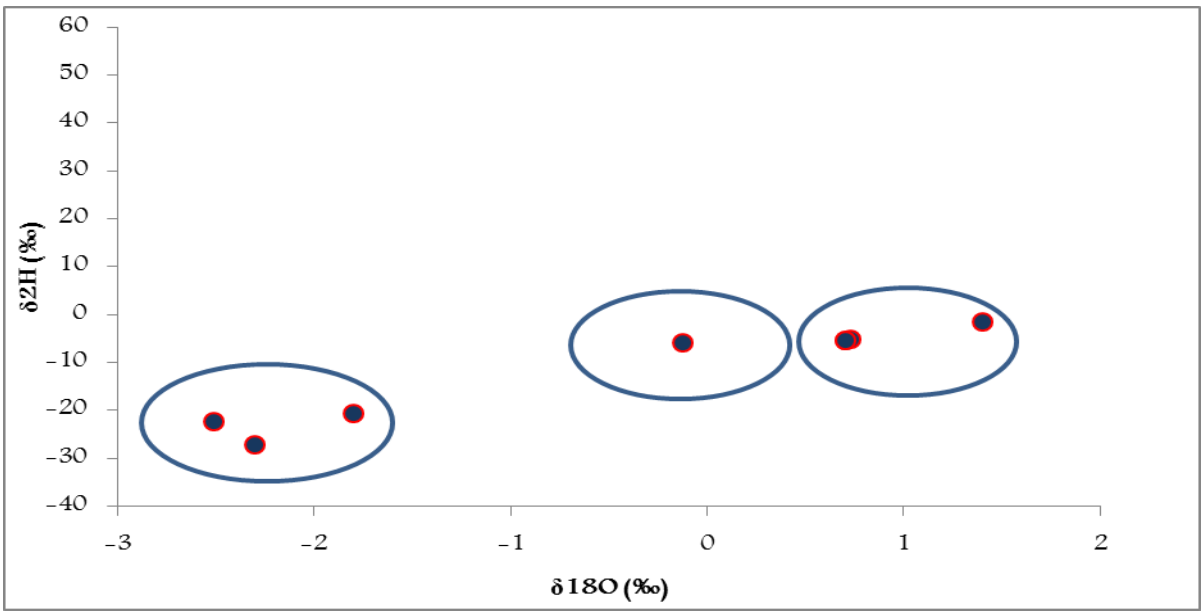

Figure 10 .Three groups distinguished in the study area .

Deuterium-excess

The d-excess value can be used to identify the evaporation effect and vapor source (20,24). The value of d is estimated by (15) for large number of stations around the world. Deuterium excess, defined for slope of 8, is calculated for any precipitation sample as: (in per mil) = δ^2H - 8 $\delta^{18}O$. Table 5. shows the average variations of d-excess of Al_Razzaza lake water and groundwater in studied area. Figure11 shows during the study periods d - values of the Al-Razaza lake water and groundwater varied from -12.61%0 to -2.2 %0. The d values of the Razzaza lake water were lower in August 2019 and were higher in April 2019. Figure11. shows that two groups of water could be distinguished in water resources in Al-Razzaza region : group A, which is influenced by lower evaporation and group B which is influenced by more evaporation rain water within. This result of d-excesses supports the above conclusion that difference source and condition between two groups of water in study area.

Table 5. Average of d-excess of Al_Razzaza lake water and groundwater in studied area

Station	RZ1	RZ2	RZ3	AD	W1	W2	W3	SWK
d-excess	-10.94	-11.06	-10.90	-8.85	-4.95	-12.61	-6.61	-2.2

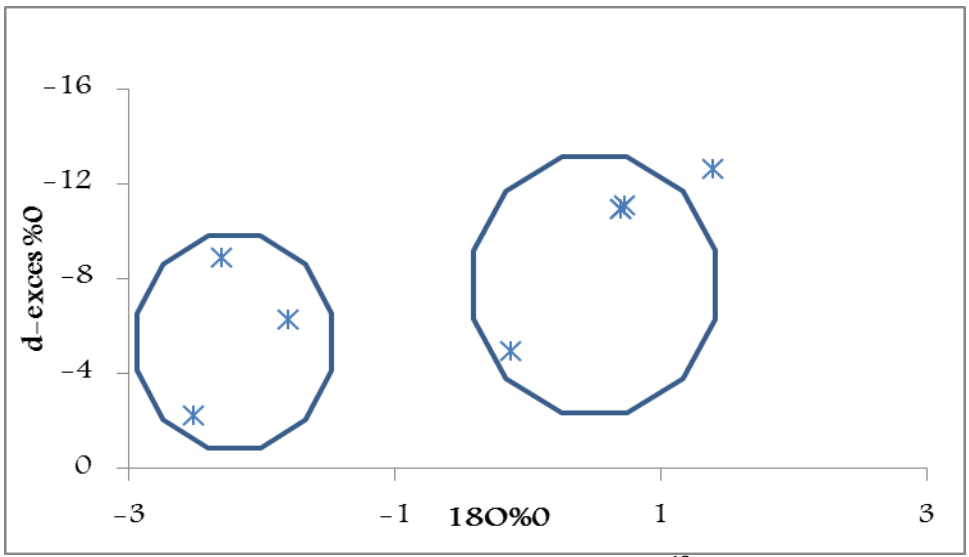

Figure11. Relationship between d-excess and δ ^{18}O in the study area

Stable isotope can be used to identify the mechanism of groundwater salinization (17). Isotopes was also used to study the origin of salinity and EC concentration of water ,Figure 12.in which $\delta^{18}O$ versus electrical conductivity (EC) concentration.. The figure shows that

there is no clear relationship between the two parameters which indicates that the essential salinity in groundwater (W2,W3 wells) caused due to dissolution and rock-water interaction. The salinity of Razazza Lake water and groundwater (W1) is due to the dissolution and highly suffering of evaporation with no enough recharge of new fresh water. Again from the diagram 12 , There are two process that controlled to increase the salinity (EC).as flow: -The first (A), Enrichment by Evaporation process in samples of Groundwater.-The second one (B) the enrichment due to salt dissolution in Al_Razzaza lake and groundwater (W1well) (stable isotopes does not change with increase the EC values. The different isotopic behavior of water resources within Al-Razzaza lake water.it came from different parts of the study area reflects differences in geographical and hydro-meteorological parameters, such as the altitude of drainage areas, spatial and temporal precipitation distribution, sources of air moisture.

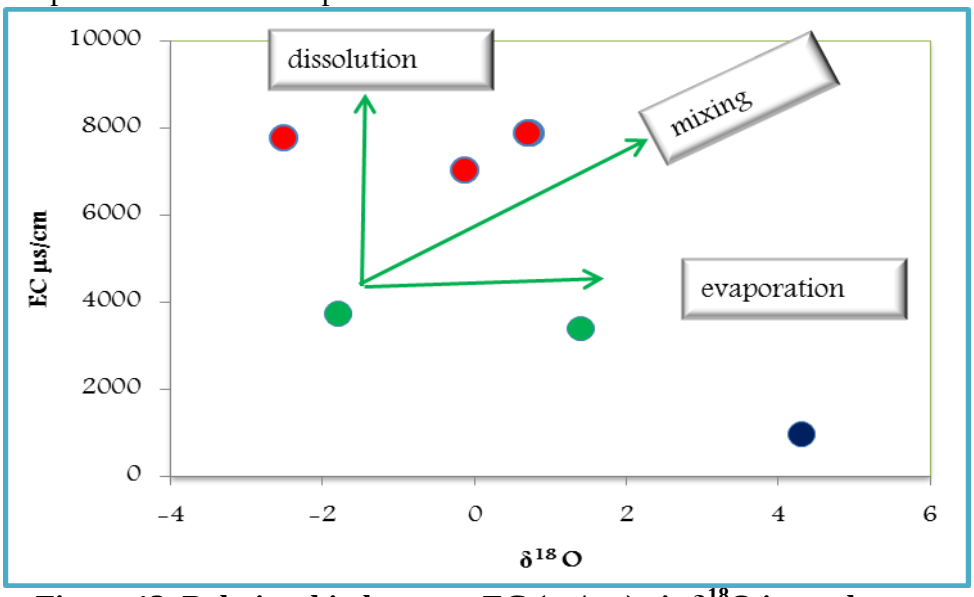

Figure 12. Relationship between EC (µs/cm) vis $\delta^{18}O$ in study area

CONCLUTION

In this work, we provide recent data of hydro chemical and isotopic measurement of Al-Razzaza lake water and groundwater surrounding it. Chemically, The dominant cations and anions in Al-Razzaza lake water and groundwater (W1) are mainly of in Order (Ca > Na > Mg and Cl>SO_4) and the water type Ca-Chloride in both period April and August2019. according to the ratio of Ca/Cl concentration and isotopic data in water samples in the study area, it can be see that same ratio of Ca/Cl and isotopic values between Al-Razzaza lake water and W1 well camper with other samples in study area, this indicator to the interaction between them. In this work the chemical Techniques and isotopic study support that there is an interaction between Al-Razzaza lake water with groundwater (define in W1well) in the East-south of Al-Razzaza Basin. We recommended to future studies to determine age of groundwater by using ^{14}C,re-conection between Al-Razzaza lake and Al-Habbanyia Lake to save the quality and quantity water and prevent any sewage,waste discharge to the any water resources (Razzaza lake) without treatment.

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