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ISOTOPIC COMPOSITION OF AL-HABBANIYA LAKE AND GROUNDWATER SURROUNDING IT, AL-ANBAR GOVERNORATE, IRAQ

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ABSTRACT : In this study, environmental isotopes composition (δ^{18}O and δD) were conducted on Al-Habbaniya lake, stream channels and wells during (August, 2020 and March, 2021). The results showed that there was a typical spatial distribution of surface isotope in August and March. Relatively high δ^{18}O values with low d-excess were found in groundwater (W1) in August and March and the lowest δ^{18}O with highest d-excess were found in surface water (Ch2) in August and March. Also, the results of isotopes values showed there is a little difference between the periods due to the seasonal change and the trend of distribution can be attributed to evaporation, drainage flow; the origin of salinity in Al-Habbaniya lake water have been resulted from evaporation processes, while in groundwater, the origin of salinity is caused by dissolution processes. This study provides a reference for the long-term monitoring and is important for the regional water resource.

Key words : Al-Habbaniya lake, hydrochemical, environmental isotopes, Central Iraq.

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INTRODUCTION

The use of the isotope technique is of great significance for understanding the hydrologic balance of lakes and regional hydrologic cycles. As a powerful investigative tool, the stable isotope technique has increasingly been utilized for estimating water balances and regional hydrologic cycles. In particular, the stable isotopes of hydrogen and oxygen have been used to study lakes and their geochemical processes. also surface water quality is determined by water chemistry, which affects environmental functions in aquatic environments (Wetzel, 2001 in Gurung *et al*, 2018).

Stable (^{16}O, ^{17}O, ^{18}O, ^{1}H, ^{2}H) and radioactive (^{3}H, ^{14}C) isotopes in water molecules are powerful tools for the tracking of the path of water molecules in the water cycle, from precipitation to surface and groundwater, and further, into the drinking water supply. They are commonly used to trace the source of water and its flow pathways, or to quantify exchanges of water, solutes, and particulates between hydrological compartments during different hydrological processes (Aggarwal *et al*, 2005). Isotopic techniques such as using stable isotopes of hydrogen and oxygen as markers of water source have been applied in water resource investigations for several decades. Natural isotopes (stable) have a role in a variety of hydrological, hydrogeological, and geochemical applications, including evidence of water source knowledge, water quality and groundwater recharge and movement (Verhagen *et al*, 1991; Izbicki *et al*, 1998 in Al-paruany, 2013). The stable isotopic method is used assuming that the isotopic signature does not change unless it is affected by fractionation processes. The isotopic composition of water is expressed in comparison with the isotopic compositions of ocean water and is expressed in per mil (‰) deviation from the standard mean ocean water (SMOW) (Craig, 1961).

Many publishers have investigated of Al-Habbaniya Lake (Al-Lami *et al*, 2002, Al-Saadi *et al*, 2002, Salah *et al*, 2014, Khazaal *et al*, 2019 and Al-Kubaisi, 2020).

Description of the study area

Al-Habbaniya Lake is located in middle of Iraq, within Al-Anbar Governorate, on the distance of 68 Km west city of Baghdad (latitudes 33° 25’ 30º -33° 12’ 0º East

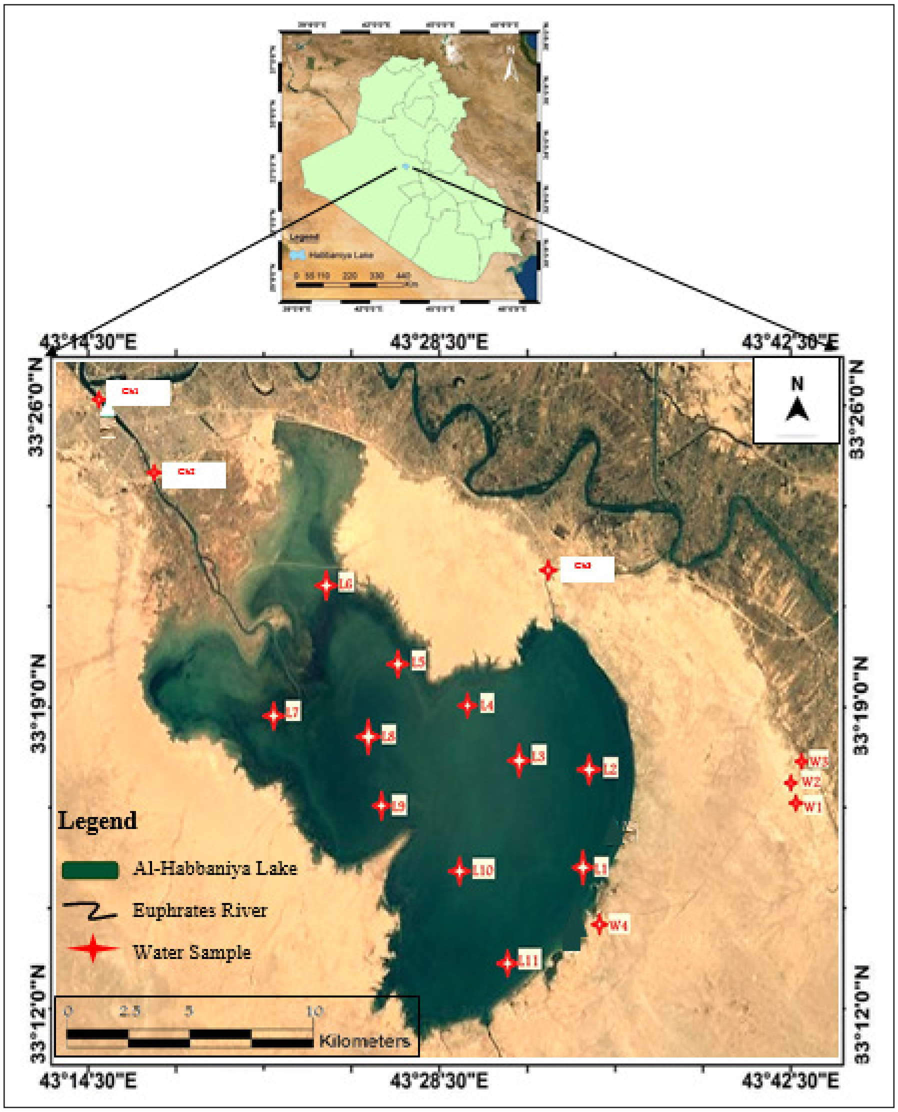

Fig. 1 : Map of study area and location of samples.

and longitudes 43° 17’ 30º -43° 35’ 30º North) (Fig. 1). It covers an area of 426 km^2 with elevation ranges from 43 to 45 m above sea level, the volume is 3.26×10^9 m^3 (Al-Saadi *et al*, 2002). The water intake to the lake by Al-Warrar Channel and There was two major channels disc arching the Habbaniya Lake: Al-Thaban channel, through which the lake’s water returns to the Euphrates river, and Al-Majara channel which drains water towards Al-Razzazah lake. Geologically, the geology of the study area characterized by four stratigraphic units, which include Euphrates Formation (Early Miocene), Nfayil (Middle Miocene), Fatha Formation (Middle Miocene) Injana formations (Late Miocene) and Quaternary deposits (Pleistocene) (Jassim and Goff, 2006).

MATERIALA AND METHODS

Sampling strategy

To determine the isotopic content of groundwater and Al-Habbanyia lake, two periods were selected, dry season (August, 2020) and wet season (March, 2021). In each period, 11 samples from Al-Habbanyia lake, (4) drilled wells, (1) San al-thaban and (2) from Al-Warrar channel were collected. Field measurements (pH, EC, W.L) using multi parameter analyzer. For stable isotopes sampling, 50 ml special bottles for ^{18}O and ^{2}H were used, then the bottles are closed up with two covers and kept in a cool box, as well as sample collection, labeling, preservation and transfer to the laboratory. The locations of samples (lake, wells and streams) are listed in the Table 1.

Analytical methods

For stable isotopes determination, Hydrogen (^{2}H) and (^{18}O) values have been performed in isotopes laboratory in Environment and water directorate, Ministry of science and technology. These analyses were conducted by using Liquid water isotopes analyzer (LWIA) techniques according to IAEA (2005). Values were reported using the standard ä notation relative to the V-SMOW (Vienna

Table 1 : Name, Code number and Geographic locations of samples in the study area.

Name	Symbol	Longitude	Latitude	Elevation	Water level	Water level m.a.s.l
Lake	L1	43° 33′ 41.99º	33° 15′ 04.65º	43	-	-
Lake	L2	43° 33′ 26.18º	33° 17′ 19.45º	45	-	-
Lake	L3	43° 31′ 04.35º	33° 17′ 26.68º	44	-	-
Lake	L4	43° 28′ 53.17º	33° 18′ 36.19º	45	-	-
Lake	L5	43° 25′ 53.22º	33° 19′ 49.82º	44	-	-
Lake	L6	43° 23′ 52.72º	33° 21′ 37.72º	45	-	-
Lake	L7	43° 20′ 55.97º	33° 18′ 40.11º	43	-	-
Lake	L8	43° 25′ 03.17º	33° 17′ 54.14º	44	-	-
Lake	L9	43° 25′ 45.19º	33° 16′ 36.66º	44	-	-
Lake	L10	43° 29′ 24.26º	33° 15′ 07.52º	43	-	-
Lake	L11	43° 31′ 09.32º	33° 13′ 22.59º	45	-	-
Well	W1	43° 40′ 53.49º	33° 16′ 41.02º	55	5	50
Well	W2	43° 40′ 47.00º	33° 17′ 10.99º	47	6	41
Well	W3	43° 41′ 26.40º	33° 17′ 36.81º	47	5.5	41.5
Well	W4	43° 34′ 11.49º	33° 13′ 58.24º	56	8	48
Al-Warrar channel	Ch1	43° 16′ 12.07º	33° 25′ 48.46º	45	-	-
Al-Warrar channel	Ch2	43° 17′ 55.73º	33° 24′ 14.88º	44	-	-
San Al-thaban	Ch3	43° 32′ 33.56º	33° 22′ 06.96º	47	-	-

Standard Mean Ocean Water). The levels of precision for $\delta^{18}O$ and δD were ±0.025% and ±0.

RESULTS AND DISCUSSION

In this study, the seasonal and temporal variations in physicochemical parameters (T, EC, pH and TDS) in the study area (Al-Habbaniya lake, Channels and Wells) as shown in Table 2.

The temperature of surface water (Al-Habbaniya lake and channels) range from 27-33 ÚC with average of 27.9^{0}C and from 19-32^{0}C with average of 21.8^{0}C for the dry and wet periods respectively. While in groundwater the range of temperature in dry period is 22-23^{0}C with average of 22.67 and in wet period from19-22^{0}C with average of 21^{0}C. The pH values in Al-Habbaniya lake and channels range from 8.1 to 10.76 with mean of 9.41 in dry season (August, 2020) and from 8.4 to 10 with mean of 9.34 in wet season (March, 2021). While in groundwater pH ranges from 8.9 to 9 with average of 8.96 in dry season (August, 2020), and in wet season (March, 2021), it ranges from 8.3 to 8.8 with 8.5 in average. Temperature and photosynthesis of aqueous plants may be the main control factors in pH concentration due to their effect on drain the CO_2 from aqueous solution (Harned and Mayer, 1985). The pH of the surface water sample trend to Alkaline. Electrical conductivity is a very useful for detecting the amount of dissolved salts in water, by which water quality can be assessed and it is also an important evidence to determine the degree of mineralization of water (Detay, 1997). EC in surface water and during the dry season (August, 2020) range between 630 – 5651 ìs/cm, with 1476ìs/cm in average, while, it decreases and ranges from 675 -5399 ìs/cm with 1393 ìs/cm in average during the wet season (March, 2021), due to the increasing of recharge from Euphrates river and rainwater. While in groundwater and during dry season (August, 2020). EC ranges from 4321 to 8520 (ìs/cm), with average of 6725.83 (ìs/cm), and in wet season (March, 2021), it ranges from 4252.5 to 7912.5 (ìs/cm) with 6327.5 (ìs/cm) in average.

The concentration of TDS in natural water depends on the kind of soil and rocks that come into contact with it and the period of the contact process, and it is widely used in evaluating water quality, as well as a suitable method for comparing water with others water (Hem, 1985). TDS in surface water and during dry season (August, 2020) TDS range between 529 to 3770 ppm with mean values 1005.12 ppm, and in wet season (March, 2021) the range between 450 to 3599 ppm with mean values 928.59 ppm. While in ground water and during dry season (August, 2020) TDS ranges from 3050 to 5690 ppm, with average of 4546.66 ppm, and in wet season (March, 2021), it ranges from 2835 to 5275 ppm with 4218.33 ppm in average.

The relationship between electrical conductivity (EC) and total dissolved salts (TDS) in surface and groundwater in the study area during both seasons was represented in the Figs. 2-5.

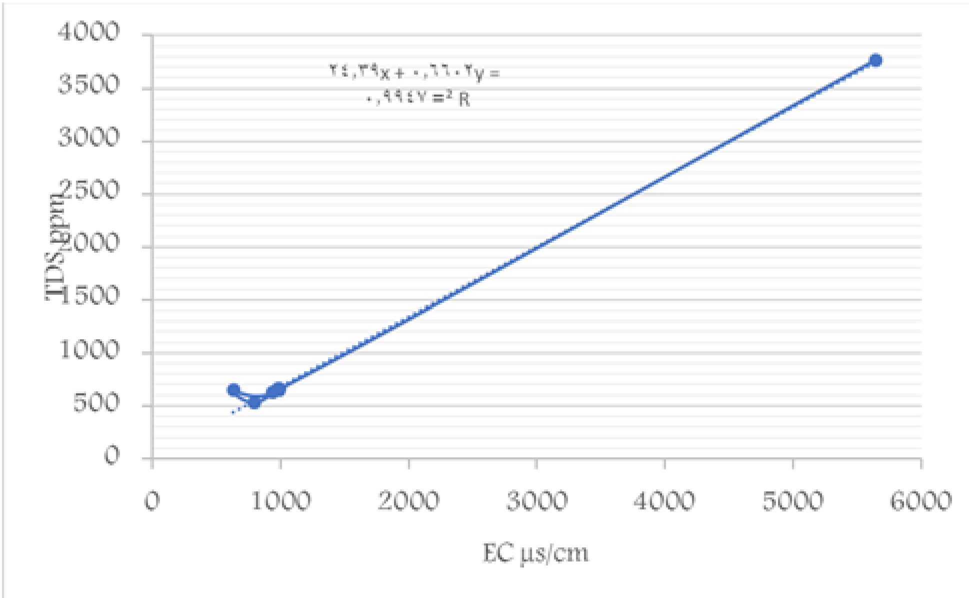

Fig. 2 : Relationship between EC & TDS for surface water during dry season (August, 2020).

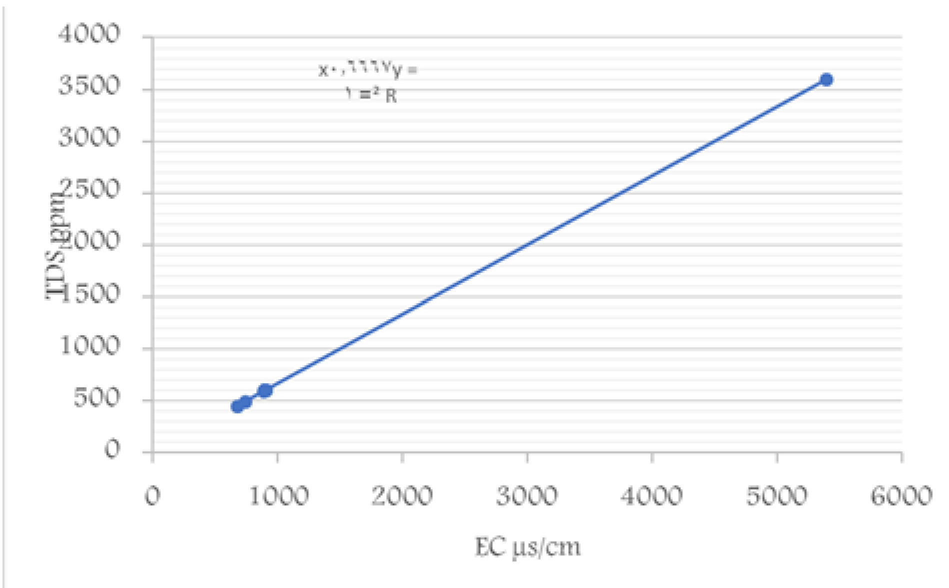

Fig. 3 : Relationship between EC & TDS for surface water during wet season (March, 2021).

The stable isotopes composition in the study area

The result of isotopic values of Al-Habbaniya Lake, stream channels and wells are presented in Table 3.

Seasonal variability of stable isotopes in the study area

The isotopic composition of Al-Habbaniya Lake and channels samples ranged from (-3.83 to -3.73%) and (-4.75 to -4.43%) for ä^{18}O and from (-25.78 to -24.82%) and (-33.98 to -29.84%) for äD in dry period (August, 2020), respectively. While in wet period (March, 2021) the isotopic composition of Al-Habbaniya Lake and channels samples ranged from (-4.11 to -4.01%) and (-5.1 to -4.76%) for ä^{18}O and from (-27.99 to -26.95%) and (-36.9 to -32.4%) for äD, respectively. There is a clear variation in isotopic content of Al-Habbaniya lake in each period, this indicates the existence of homogeneity due to low differences in depth of water, as well as, the variation in the isotopic composition is related to the same recharge conditions and the amount of rain water that reaching to the lake, while the low variation of isotopic values of Al-Habbaniya lake in both studied periods due to the differences in water level and discharge from Euphrates river as well as effect of climate parameters. The isotopic composition of groundwater sample ranged from (-3.97 to -1.09%) for ä^{18}O and from (-25.5 to -20.09%) for äD in wet period (March, 2021), while the isotopic composition of ground water sample ranged from

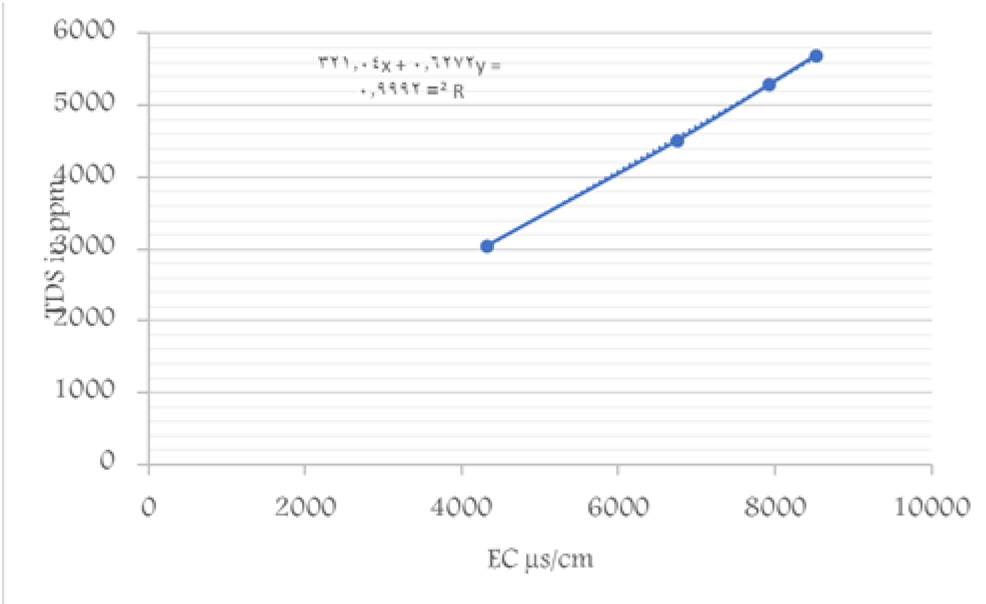

Fig. 4 : Relationship between EC & TDS for groundwater during dry season (August, 2020).

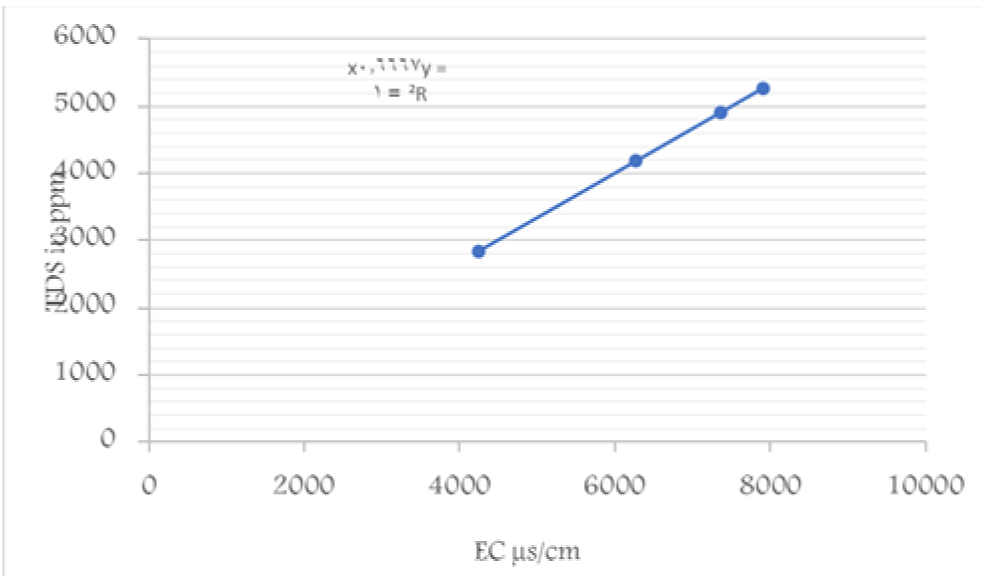

Fig. 5 : Relationship between EC & TDS for groundwater during wet season (March, 2021).

(-3.70 to -1.01%) for ä^{18}O and from (-23.49 to -18.50%) for äD in dry period (August, 2020). There is a variation in isotopic values of groundwater (ä^{18}O and äD) due to the depth of water level and climate effect. And it can see that Well (4) become more depleted, that may be effects by Al-Habbaniya lake water.

Spatial Variability of stable isotopes in the study area

In Al-Habbaniya lake water and channels, highest ä^{18}O values are found in (L3, L8 and L10) and (Ch1), and lowest values are found in (L11 and Ch2) respectively. While highest ä^{2}H values are found in (L11 and Ch1) and lowest values are found in (L6 and Ch2) respectively. There is a low variation in isotopic content of Al-Habbaniya lake in all locations, this indicates the existence of homogeneity due to low differences in depth of water and climate effects (evaporation).

The results of isotopic values of wells in the study, show that, highest ä^{18}O and ä^{2}H values are found in (W1), and lowest values are found in (W4). Generally, a differences range of isotopes content is noticed within groundwater (W4 with other wells) in the studied area. The distinct differences of ^{2}H and ^{18}O between W4 and the other wells, this changes in Oxygen isotope composition of the groundwater between the wells may be caused by the dilution with near surface water (Al-Habbanyia lake) which has different isotope compositions.

From Fig. 6, the difference in the isotopic content had already been observed in the study area. Based on

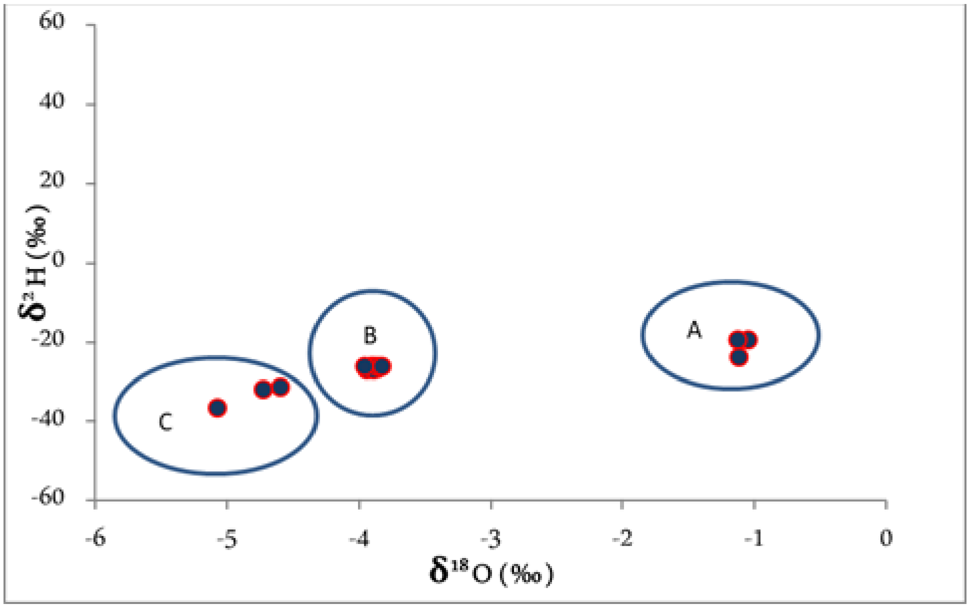

Fig. 6 : Three groups distinguished in the study area.

Table 2 : Physicochemical parameters in the study area during dry (August, 2020) and wet (March, 2021) periods.

Stations	Dry Season				Wet Season			
	T°C	pH	EC (ìs/cm)	TDS ppm	T°C	pH	EC(ìs/cm)	TDS ppm
L1	27	10.8	992	662	19	8.7	908	605
L2	27	10.5	982	655	19	8.7	900	600
L3	27	10.7	984	660	19	10	902	601
L4	27	10.2	981	655	19	10	902	601
L5	27	9.8	981	655	19	10	903	602
L6	27	9.53	979	654	19	10	897	598
L7	27	8.62	982	655	19	10	899	599
L8	27	8.31	979	653	19	10	897	598
L9	27	8.3	985	657	19	9.1	900	600
L10	27	8.1	979	653	19	8.4	900	600
L11	27	9.8	981	654	19	8.9	899	599
Ch1	28	9.5	792	529	26	8.7	743	495
Ch2	28	9.1	630	650	26	8.7	675	450
Ch3	29	8.4	938	626	26	9.3	885	590
W1	23	8.9	7922	5290	22	8.3	7358	4905
W2	23	9	8520	5690	22	8.4	7913	5275
W3	23	9	6752	4510	22	8.4	6278	4185
W4	22	9	4321	3050	19	8.8	4253	2835

the distribution of the data points on ä^{2}H and ä^{18}O diagram for water resources in the study area. three groups could be recognized. Group A, represented Wells (W1, W2 and W3). Group B, represents the well (W4) and Al-Habbaniya Lake samples (L1, L2, L3, L4, L5, L6, L7, L8, L9, L10 and L11). Group C, represent the channels (Ch1, Ch2 and Ch3). This may be attributed to the different sources of recharge (interaction/ mixing) with Al-Habbaniya lake water.

The relationship between δ^{18} o and δd in surface water (LMWL)

Harmon Craig (1961) published a schematic based on ä^{18} O and äD. roughly 400 river, lake, and precipitation water samples from diverse locations countries. The data is neatly lined up along the best-fit line. According to the global precipitation data (**äD =8 ä^{18} O +10**), there is a certain linear relationship between the contents of äD and ä ^{18}O in the precipitation. Where the slope (8) represents the balance between evaporation and

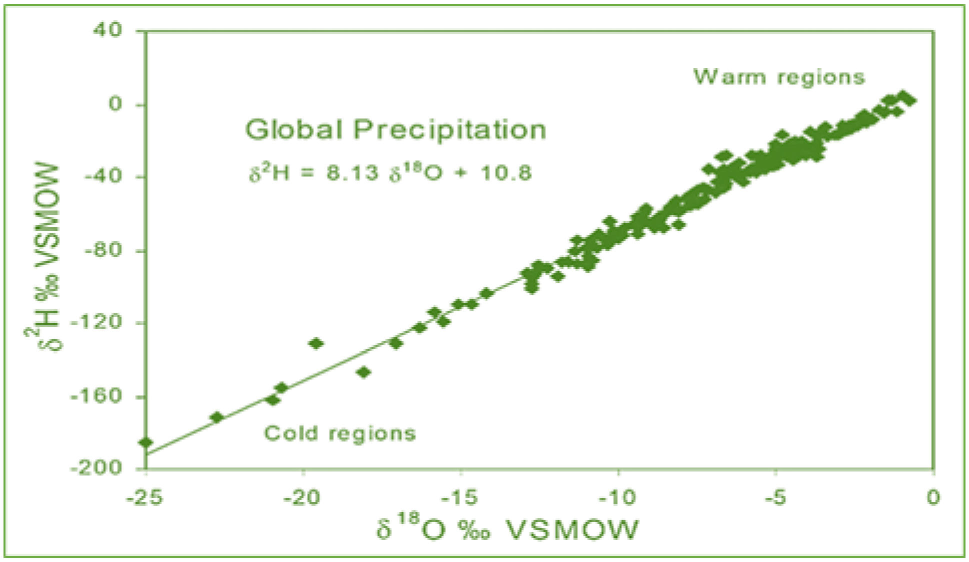

Fig. 7 : The relationship between ä^{18}O and äD (GMWL) as estimated by IAEA (2005).

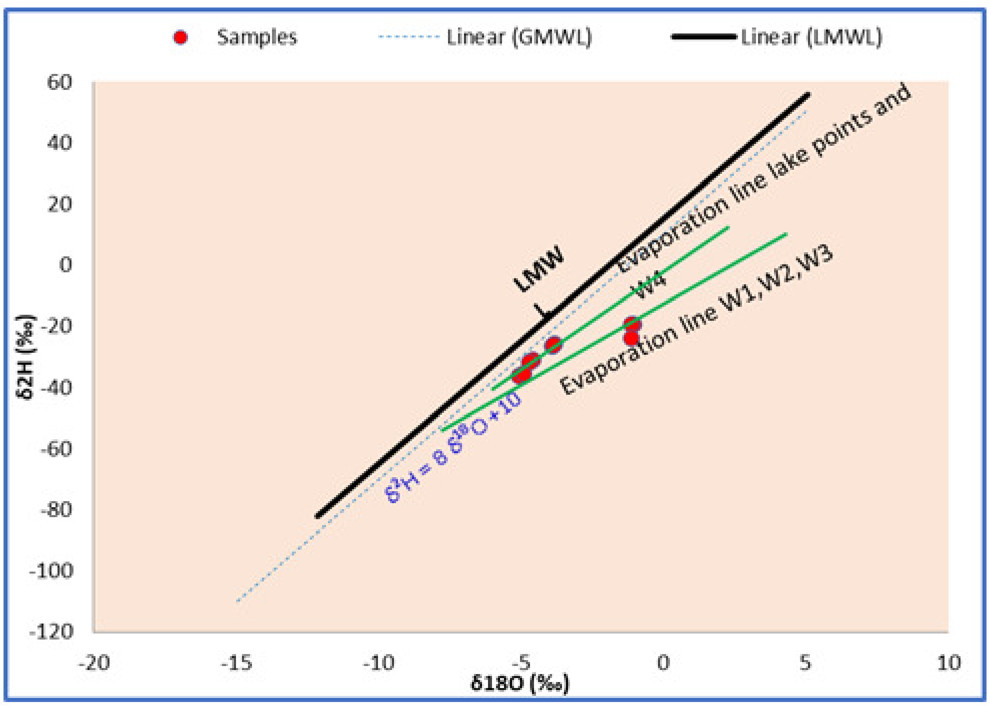

Fig. 8 : The relationship of δ^{18}O and δD in the water samples in selected station with LMWL and GMWL during August, 2020 and March, 2021.

condensation (Mazor, 2004). Local Meteoric Water Line (LMWL) Calculated from the weighed annual mean of precipitation at throughout 18 station in Iraq, follow a linear regression: **äD= 7.53 ä^{18}O+ 11.97** (Al-Paruany, 2013). The isotope composition for any area from Local Meteoric Water Line (LMWL) has a different slop and deuterium excess values than the Global Meteoric Water Line (GMWL), as a result, the composition at the local scale can be described (Clark and Fritz, 1997). Fig. 7 represented the relationship between ä^{18}O and äD (GMWL) as estimated by IAEA (2005).

From Fig. 8, the samples of the water resources (Lake, Channels and groundwater) are situated (many locations) under the global meteoric water line (GMWL) and (LMWL), the contents of äD and ä^{18}O in different water resources are affected by many factors, such as Temperature, continental changes, rainfall, Altitude and multiple evaporation process, suggesting that there are different linear relationships between äD and ä^{18}O contents.

Deuterium (D-Excess)

Deuterium excess (d) values of water can be used to identify vapor source regions and below cold

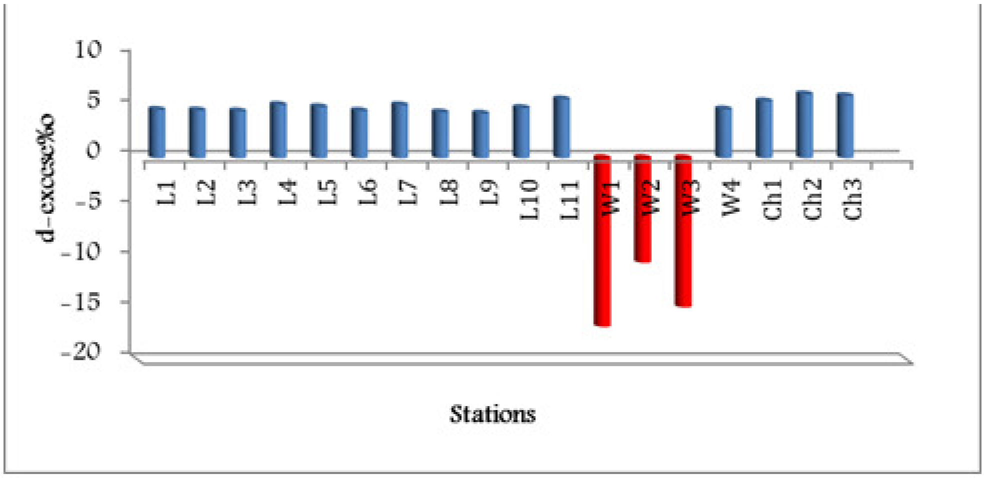

Fig. 9 : d-excess values (%) in the study area.

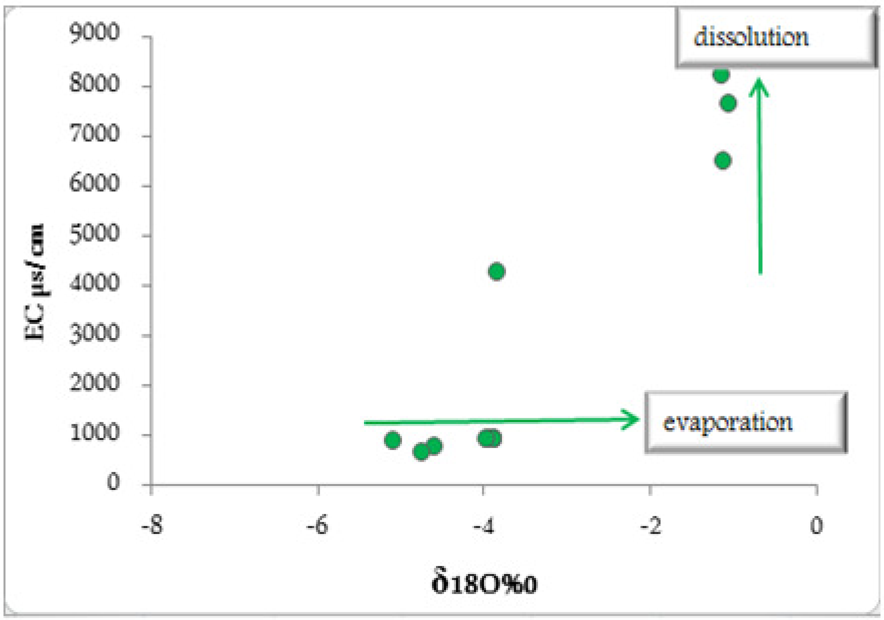

Fig. 10 : The relationship between ä[18]O and EC in the study area.

evaporation. The average global d-excess in precipitation is 10% (Craig, 1961). This is due to evaporation from an average ocean surface at a temperature of 25 degrees Fahrenheit and a relative humidity of 80% (Merlivat and Jouzel, 1979). D-excess refer to the climate conditions (evaporation and moisture source) (Clark and Fritiz, 1997).

d-excess (%0) = ä ^{2}H – 8 ä^{18}O

Fig. 9 shows all the sample values of d-excess in the study area. The highest d –excess values in Al-Habbaniya lake, Channels and Wells are found in (L11, Ch2 and W4) and lowest values are found in (L9, Ch1 and W1), respectively. From the results above, the low d-excess of the lake water is resulted from strong evaporation. The values of d-excess in the Lake is more than channels, this due to the recharged from different sources. Also, the d values of the lake water were lower in March compare to the August. Generally, the warm month (August), with high solar radiation, air temperature and low flow. This indicates that the evaporation condition is not the only factor influencing d-excess, and other factors such as river recharge sources.

The two main types of wells (W1, W2, W3) and (W4) water differ in their chemical composition and d-excess as a result of the different water-rock interaction, it can also indicate different water origin.

Use isotopic techniques to determine the origin of salinity

Salinity in water can come from a variety of sources, some of which are natural and others which are industrial (Al-Charideh, 2010). Stable isotopes can be utilized to determine the source of salinity and the mechanisms that cause surface water salinization, by discus the relation

Table 3 : Isotopic values, d-excess in the study area for both periods (August, 2020 and March, 2021).

St. No	Wet Season				Dry Season			
	EC	$\delta^{18}O$	δD	d-excess	EC	$\delta^{18}O$	δD	d-excess
L1	992	-4.03	-27.41	4.83	908	-3.75	-25.24	4.77
L2	982	-4.02	-27.39	4.77	900	-3.74	-25.23	4.71
L3	984	-4.01	-27.4	4.68	902	-3.73	-25.24	4.63
L4	981	-4.05	-27.07	5.33	902	-3.77	-24.93	5.23
L5	981	-4.05	-27.3	5.1	903	-3.77	-25.14	5.02
L6	979	-4.09	-27.99	4.73	897	-3.81	-25.78	4.68
L7	982	-4.04	-27.02	5.3	899	-3.76	-24.89	5.2
L8	979	-4.01	-27.51	4.57	897	-3.73	-25.34	4.53
L9	985	-4.03	-27.8	4.44	900	-3.75	-25.6	4.41
L10	979	-4.01	-27.06	5.02	900	-3.73	-24.92	4.94
L11	981	-4.11	-26.95	5.93	899	-3.83	-24.82	5.79
Ch1	792	-4.76	-32.4	5.68	743	-4.43	-29.84	5.61
Ch2	630	-5.1	-36.9	6.33	675	-4.75	-33.98	6.24
Ch3	938	-4.9	-33	6.2	885	-4.56	-30.39	6.1
W1	7922	-1.09	-20.09	-16.65	7358	-1.01	-18.5	-15.38
W2	8520	-1.18	-20.19	-10.75	7913	-1.1	-18.6	-9.81
W3	6752	-1.17	-24.7	-15.34	6278	-1.09	-22.75	-14.03
W4	4321	-3.97	-25.5	6.26	4253	-3.7	-23.49	6.08

between ä^{18}O with EC. The origin of salinity is not accompanied by any major changes in the stable isotopic composition, while the isotopic composition of water under mixing and or evaporation processes is accompanied by sensitive changes in its stable isotopic composition. (IAEA, 2001 and Al-Charideh, 2010). The relationship between ^{18}O and EC is used to identify the process of salinity. The origin of salinization from dissolution process is not followed by any major changes in stable isotopic composition, although mixing and/or evaporation processes are always accompanied by sensitive changes in stable isotopic composition (Blackburn and Mcleod, 1983; IAEA, 2001).

Fig. 10 shows that there are no significant changes between ä^{18}O related with EC, therefore the origin of salinity in Al-Habbaniya lake water have been resulted from evaporation processes. While in groundwater (W1, W2 and W3), the origin of salinity is caused by dissolution processes.

CONCLUSION

In this study, stable isotope compositions of Al-Habbaniya lake water and other water resources surrounding it (Channels and Groundwater) were studied in August 2020 and March 2021. The surface lake water and channels of δ^{18}O and d-excess had a typical spatial pattern. Relative higher δ^{18}O and lower d-excess were distributed on the ground water (W1), where it was (-1.01 and -15.38%) respectively in August and (-1.09 and -16.65%) respectively in March, compare with surface water, where the lowest δ^{18}O with highest d-excess values were found in surface water (Ch2), where it was (-4.75 and 6.24%) respectively in August and (-5.1 and 6.33%) respectively in March. Depending on the isotopic composition of surface water (Al-Habbaniya lake) and groundwater (W4) near the lake, which show nearly the same values of δ^{18}O and δD, it could be concluded that the wells (W4) near Al-Habbaniya lake have been recharged or mixing from them. the relationship between ^{18}O and EC, show there are no significant changes between δ^{18}O related with EC, therefore the origin of salinity in Al-Habbaniya lake water have been resulted from evaporation processes.

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