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Use Isotopes to Identity the Origin of Surface Water and Groundwater in ameriyat AL-Fallujah, Center Iraq

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Abstract

Isotope tracer methods were used to determine flow paths, recharge areas, and relative age for groundwater in the Ameriyat Al- Falluja Al-Anbar governorate. The isotope of surface water and groundwater in the Ameriyat Al- Falluja area was assessed using a stable isotope technique. Data stable isotope parameters (^{2}H and ^{18}O) for three surface water and five groundwater samples were detected. The comparison of hydrogen and oxygen isotope compositions between groundwater and Euphrates River water demonstrated that the composition of the hydrogen and oxygen isotopes from Euphrates River matched that of the local meteoric water. This indicated that rainfall is the primary source of the river water. Environmental Isotopes results show that the surface water and groundwater originates from direct leakage through permeable beds. There is an interaction between Euphrates and groundwater wells in the study area except in the W1 and W5 wells sites.

Keywords: Stable Isotope, Ameriyat Al- Falluja, VSMOW, GMWL, LMWL

النظائر البيئية لتحديد أصل المياه السطحية والجوفية في عامرية الفلوجة، وسط العراق

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الخلاصة

استخدمت التقنية النظائرية لتحديد مسارات التدفق ومناطق إعادة التغذية، والعمر النسبي للمياه الجوفية في منطقة عامرية الفلوجة بمحافظة الانبار. تم تقييم النظائر المستقرة في المياه السطحية والجوفية في منطقة عامرية الفلوجة باستخدامات تقانات النظائرية المستقرة. تم الكشف عن معطيات اثنين من معلمات النظائر (^{2}H و ^{18}O) التقنات النظائرية لثلاثة عينات من المياه السطحية وخمس عينات من المياه الجوفية. أظهرت المقارنة بين تركيبة نظائر الهيدروجين والأكسجين بين المياه الجوفية ومياه نهر الفرات أن تركيب نظائر الهيدروجين والأكسجين من مياه النهر يضاهي نظائر مياه الخط المطري المحلي. هذا يشير إلى أن هطول الأمطار هو المصدر الرئيسي لمياه النهر. اظهرت النتائج أن المياه السطحية والمياه الجوفية تنبع من التسرب المباشر عبر النفاذية. هناك تداخل بين نهر الفرات والمياه الجوفية في منطقة الدراسة فيما عدا مواقع الآبار 1−5 .

Introduction

The natural isotopes (both stable and radioactive) contribute in many applications of hydrological, hydrogeological and geochemical sciences, which give evidence of knowledge of water sources, quality, and ages of water, in addition to recharge and movement of groundwater [1] and [2]. Surface water is generally abundant and resident depending mainly on surface water catchment systems and groundwater for their water supply. In the southwestern part of Ameriyat Al- Falluja area, perennial surface water is absent. The studied area covers an area of 300 km^2. Many hydrological studies use the

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stable isotopes of hydrogen and oxygen ($^1H/^2H$ and $^{16}O/^{18}O$) to determine the origin, recharge mechanisms and hydraulic inter-connection of water molecules in surface water and groundwater. These isotopes provide the information of the water molecules, derived from water level data and hydraulic conductivities. The original studies on isotopes in water were concerned with seawater and precipitation. The first was primarily a survey on variations in $^{18}O/^{16}O$ concentration ratios, soon to be followed by a study of the $^2H/^1H$ ratios in natural waters [3] and [4] observed in great detail $^{18}O/^{16}O$ variations in global precipitation, including a discussion on the meteorological patterns. Oxygen and hydrogen isotopes of water are widely used as tracers to understand hydrogeological processes such as precipitation, groundwater recharge, groundwater-surface water interactions, and basin hydrology [5], [6] and [7]. A comparison of the oxygen and hydrogen isotopic compositions of precipitation and groundwater provides an excellent tool for evaluating the recharge and a sources of groundwater recharge is important for the effective management of groundwater resources. [8], [9] and [10]. The empirical equation by Craig [11] 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 in all over of the world, known as the Global Meteoric Water Line (GMWL):

$$\delta D = 8\ \delta^{18}O + 10 \qquad (1)$$

The slope represents the ratio of the temperature relationship between δD and $\delta^{18}O$ when condensation occurs; the value of the intercept is based on the evaporative conditions in the water source region. The intercept is also called deuterium excess or d-excess ($d = \delta D - 8\delta^{18}O$) [11] and [12]. The intercepts in most places around the world are about 10‰. However, areas may have different slopes and intercepts due to different rainfall evaporation or source evaporation conditions in various air mass sources. Eight samples were collected from the wells and Euphrates River in the study area for ^{18}O, ^2H analysis, according to IAEA [13] instructions.

The study area

The study area is located within Anbar Governorate, approximately 40 km southeast of Baghdad Governorate, between the latitudes (33º12′ -33º 20′N) and longitudes (43º 40′- 43º56′E) with an area of about 300 km^2 (Figure-1). Euphrates River passes through the city dividing it into two parts; Ameriyat AL-Fallujah and Falluja. The area is bounded from the east of the Euphrates River and in the southwest by Karbala Governorate. The main source of water is from Euphrates River. The study area is part of the Euphrates basin, which is located within the sedimentary plain. [14]

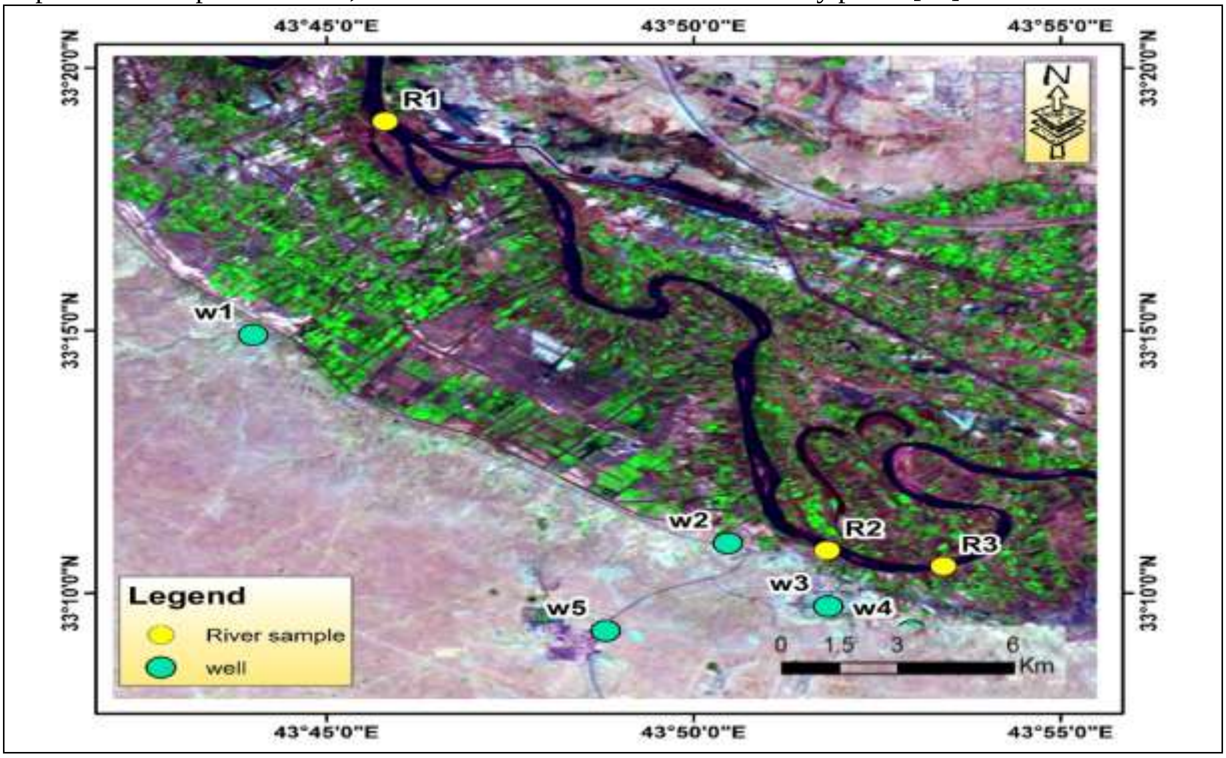

Figure 1-Location map and water sampling sites of the study area.

Geological setting

The local formations in the study area are shown in Figure-2. The geology in the studied area plays a role and considered as one of an important factor in determining the quality of Euphrates River. The litho stratigraphic section in the study area is known by Injana Formation (Upper Miocene) and Quaternary deposits. Quaternary Deposits are divided into [14]:

(A) Pleistocene deposits

Its heterogeneous deposits are formed from fine pebbles consisting of silica types, carbonate and clay. [14].

(B) Holocene deposits

The Holocene deposits in the study area comprise valley sediments, flood plain deposits and aeolian deposits. All these types of deposits form flood plains like Euphrates flood plain near Hit) [14].

In terms of geomorphology, the topographic map is shown in Figure-3. The vast majority of the study area is a flat plain covered by Quaternary deposits [14].

Some of this land is used as an agricultural field, except the west border, where the highest parts of the study area are outside of the agricultural land use.

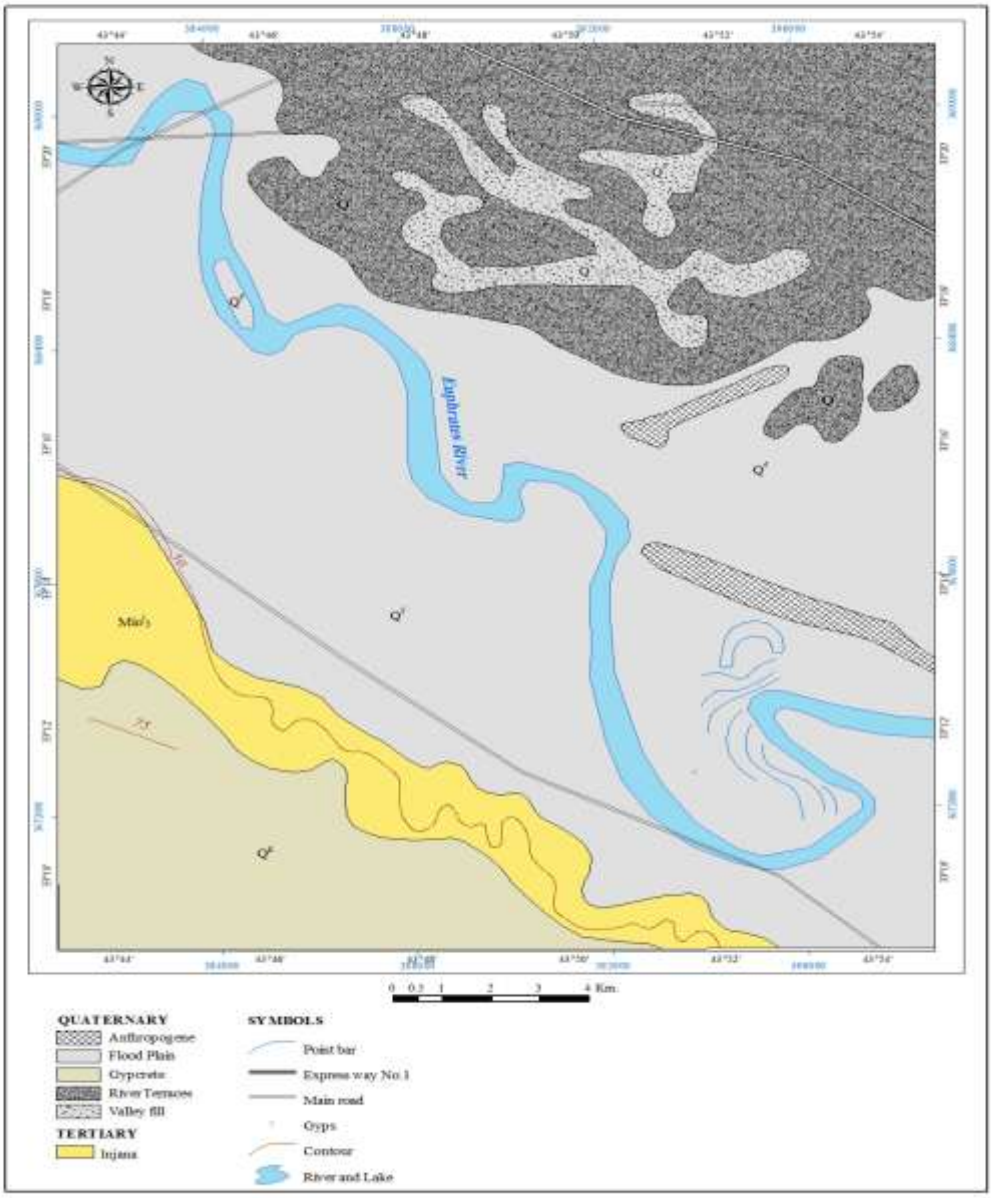

Figure 2- Geological map to the study area (modified after GEOSURV. 1994).

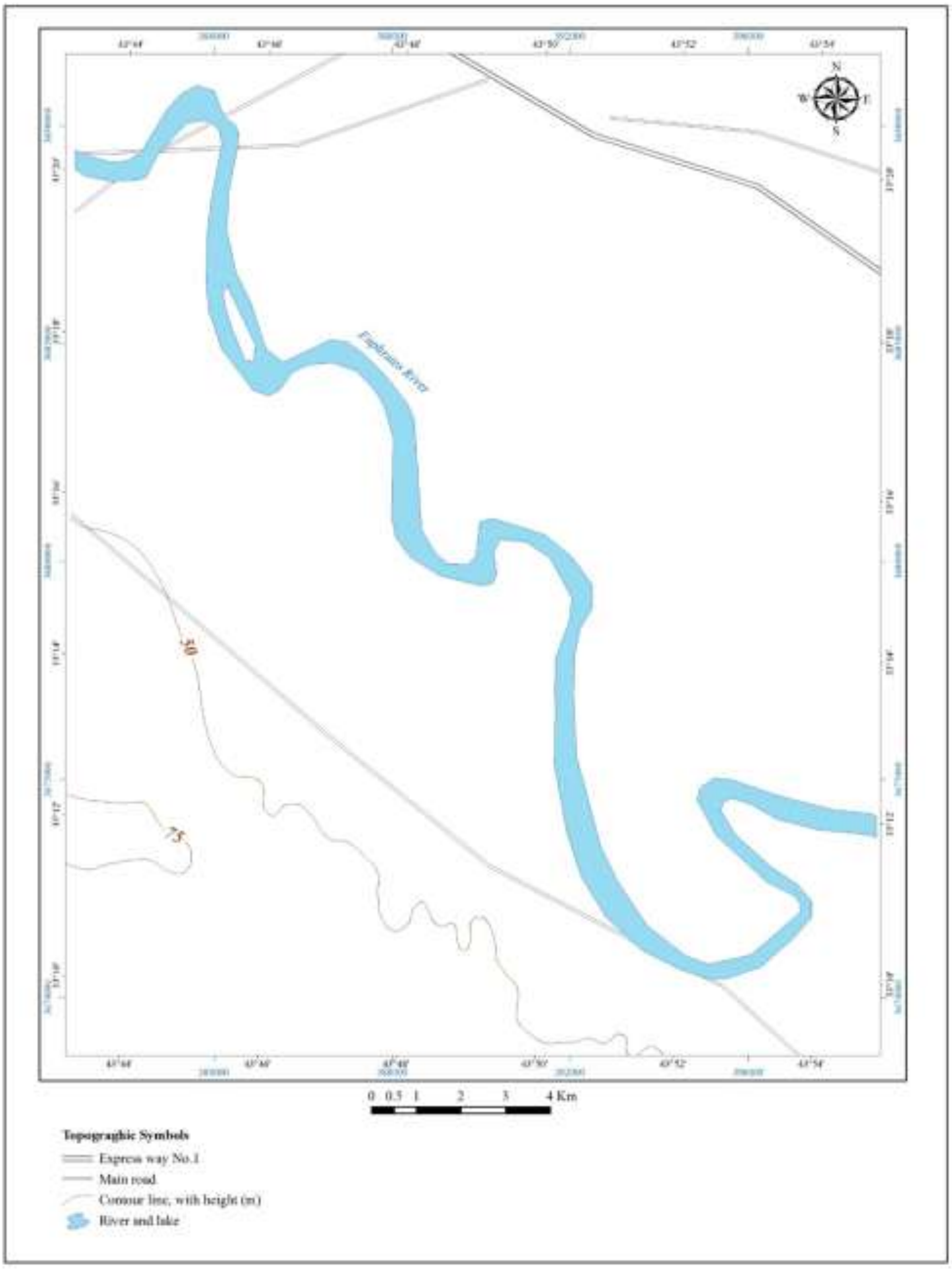

Figure 3- Topography map the study area.

Materials and Methods

Surface water and groundwater samples were selected in September 2017, where the sampling sites are shown in Figure-1. Groundwater samples were collected after 10 minutes of pumping starting process to ensure of collecting representative samples. The coordinates of each sampling site (longitude, latitude) are accurately determined using a global positioning system (GPS) instrument (Table-1). Fifteen ml for each sample per well is collected in glass bottles. All bottles were labeled with code number, identification name, date of sampling, coordinates, and the in situ measured the physical properties (EC, pH, T). Then the bottles are closed up with two covers and kept in a cool box to be sent to the laboratory. The isotopic analyses were carried out at the Water Research Center / Ministry of Science and Technology. The stable isotopic composition of the water samples was determined by LWSIA with an analytical precision of ±0.8‰. The results of the hydrogen and oxygen isotope measurements are expressed as delta notations ($\delta^{18}O$, $\delta^{2}H$), relative to the Vienna Standard Mean of Ocean Water (VSMOW).

Table 1-Coordinates of surface water and groundwater sampling sites

Symbol	Latitude	Longitude	Well depth(m)	Static water level (m)	Name location
W1	33 14` 55.1``	43 44` 0.72``	40	12	Ameriyat AL-Falluja
W2	33 10` 57.3``	43 50` 28.7``	30	15	Ameriyat AL-Falluja
W3	33 09` 45.8``	43 51` 50.8``	30	16	Ameriyat AL-Falluja
W4	33 09` 17.9``	43 52` 58.5``	30	20	Ameriyat AL-Falluja
W5	33 09` 17.4``	43 48` 48.5``	21	8	Ameriyat AL-Falluja
R1	33 18` 59.1``	43 45` 48.4``	-	-	Ameriyat AL-Falluja
R2	33 10` 49.1``	43 51` 49.6``	-	-	Ameriyat AL-Falluja
R3	33 10` 31.5``	43 53` 24.3``	-	-	Ameriyat AL-Falluja

Results and Discussion

Stable Isotopes in Euphrates river and groundwater in the studied area. The isotopic compositions ($\delta\ ^{18}O$ and $\delta\ ^{2}H$) of water samples, collected from the water resources (groundwater and Euphrates River) at 8 stations during the period 2017, are listed in Table-2, together with the values of deuterium excess (d), and EC concentration.

Table 2-Isotopes values, Duterium excess (d) and EC concentration in the studied area.

Sta.	$\delta^{2}H$	$\delta^{18}O$	EC	pH	T	d
W1	-37.8	-5.81	11345	7.8	25.3	8.68
W2	-37	-5.8	10111	7.8	22.7	9.4
W3	-37.1	-5.81	6780	7.9	22.7	9.38
W4	-37	-5.83	6800	7.2	28.1	9.64
W5	-37.81	-5.81	8360	7.9	29.3	8.69
R1	-39.3	-6.22	1088	7.9	22.1	10.46
R2	-39	-6.3	1055	7.9	24.3	11.4
R3	-39.1	-6.29	1059	7.8	25.5	11.22

The δD of the Euphrates river was between −39.3‰ and −39‰, with a mean of −39.133‰ The $\delta^{18}O$ ranged between −6.3‰ and −6.22‰, with a mean of −6.27‰. While, the δD of the groundwater in the study area was between −37.81‰ and −37‰, with a mean of −37.4‰. The $\delta^{18}O$ ranged between −5.81‰ and −5.83‰, with a mean of −5.88‰. The composition of the hydrogen and oxygen isotopes from Euphrates river water matched that of the local meteoric water. This indicated that rainfall is the primary source of the Euphrates River water. Environmental Isotopes results show that the surface water (Euphrates river) and ground water originates from direct leakage through permeable bed, in addition to the presence of an interaction between Euphrates river and some wells (W2,W3 andW4).

The δ^2H-$\delta^{18}O$ diagram (Figure-4) shows that most of the isotopic values lie close to the Global Meteoric Water Line ($\delta^2H = 8 \times \delta^{18}O + 10$), which suggests that Euphrates river and groundwater had indicated a same mechanism of evaporation.

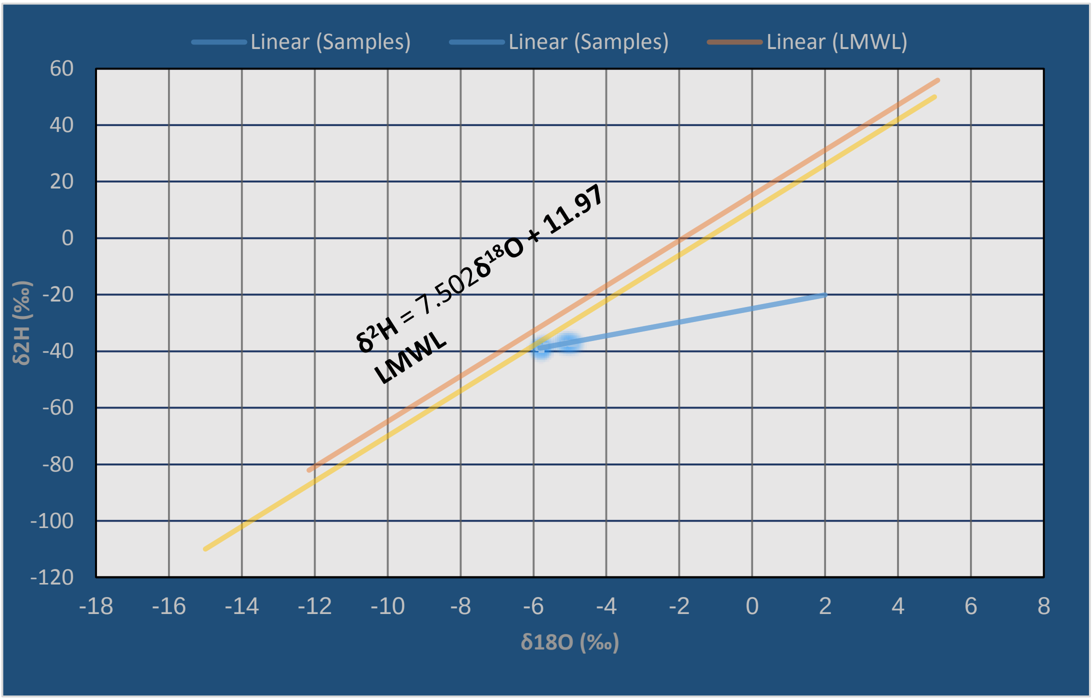

Figure 4-The ^{18}O and ^{2}H, GMWL, LMWL in the study area.

Values of dEXCESS ('d') below 10 indicate an evaporation process. The smallest 'd' values were seen in the W1and W5 (8.68), while the highest δ^2H value was observed in R2 (11.4). In addition, the d value of the groundwater less than 10, indicating that groundwater is affected by evaporation (Figure- 5).

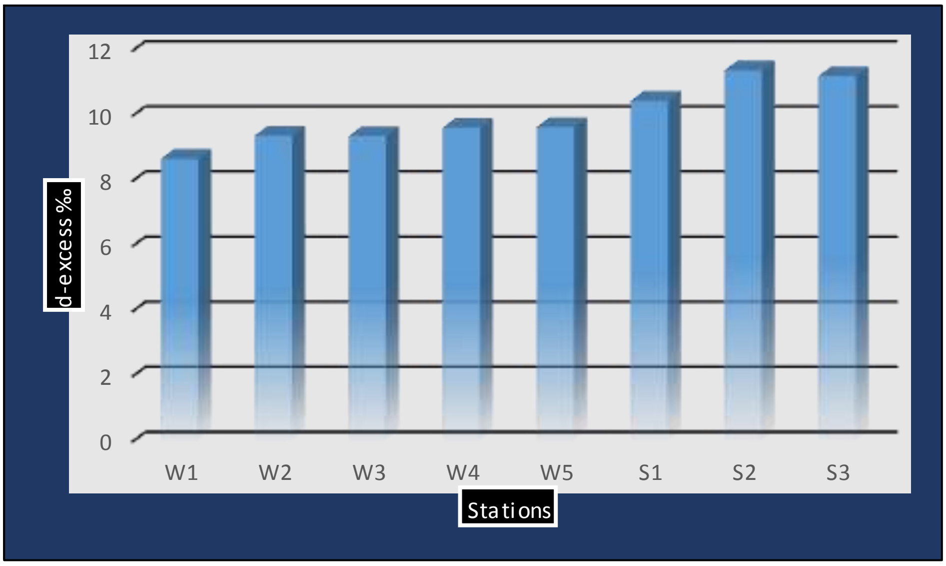

Figure 5- The d-excess vs. $\delta^{18}O$ in the study area, 2017.

Isotopes were also used to study the origin of salinity and Ec concentration of water, where δ18O versus electrical conductivity (Ec) concentration shows a spatial variation in Ec concentration at eight stations distributed in the study area during the study period (Figure-6). Evaporation process and anthropogenic activities are considered to be a reason to control the Ec concentration in the study area, same trend can use to investigate the source of salinity.

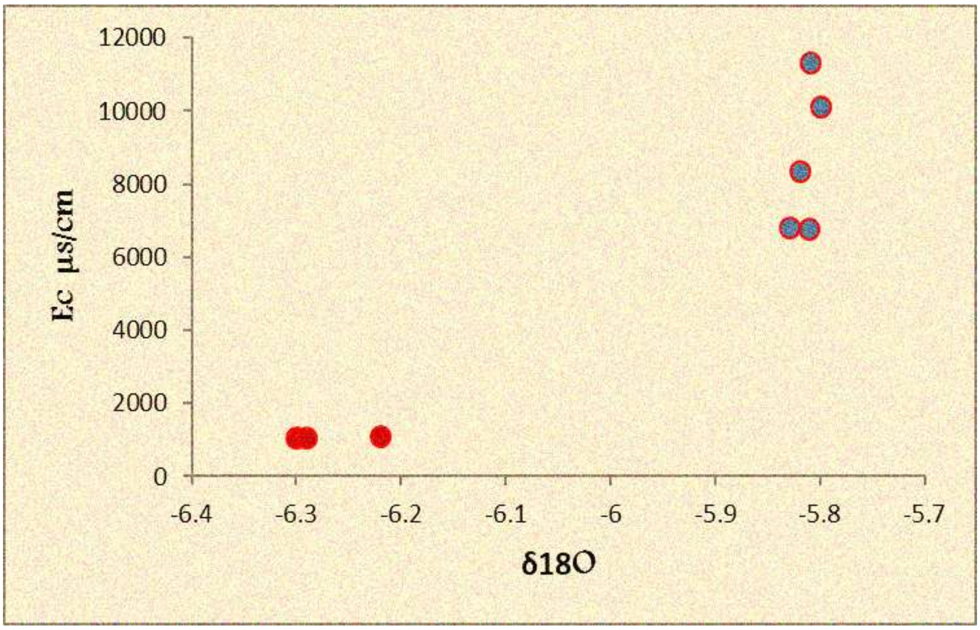

Figure 6-The EC concentration vs. δ18O in the study area, 2017.

There are two processes that controlled the increase in salinity (Ec), first the enrichment by evaporation process in samples of the Euphrates river, and second is the enrichment due to salt dissolution in groundwater samples (stable isotopes does not change with the increase in Ec values.

The different isotopic behavior of different parts of the study area reflects differences in geographical and hydro-meteorological parameters, such as the altitude, precipitation distribution and air moisture.

Conclusions

The natural isotopes contribute in many applications of hydrological, hydrogeological and geochemical sciences, which give evidence of knowledge of water sources, quality, and ages of water, in addition to recharge and movement of groundwater. Five groundwater and three surface water samples were distributed in an area of 300 Km^2 are characterized by heterogeneity of water chemical due to the run off influences. Running water on the surface is directly recharged the underneath aquifer. The composition of the hydrogen and oxygen isotopes from Euphrates river water matched that of the local meteoric water. This indicated that rainfall is the primary source of the river water. Environmental Isotopes results show that the surface water and ground water originates from direct leakage through permeable beds. An interaction between Euphrates river and groundwater (except in the W1 and W5) were existed.

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