

## Groundwater quality and origin within Dibdibba aquifer, near Jabel Sanam area southern of Basrah Governorate, Iraq

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**Abstract** - The study aims at assessing the groundwater quality and identifying its origin within the Dibdibba aquifer (Jabel Snam area) south of Basrah. Twenty wells were selected from the studied area and subjected to comprehensive physical and chemical analyses involving major cations ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$  and  $\text{K}^+$ ), anions ( $\text{HCO}_3^-$ ,  $\text{Cl}^-$  and  $\text{SO}_4^{2-}$ ) and trace elements (Zn, Cd, Ni and Pb) besides general parameters (pH, EC, TDS and total hardness). The spatial distribution of parameters were drawn using geostatistic, interpolation technique, namely, ordinag Kriging in Arc GIS 10.2.2. Based on the results, the groundwater quality was classified to chloride group-sodium family-type ( $\text{Na}^+ > \text{Ca}^{2+} > \text{Mg}^{2+}$ ). On the other hand, the groundwater origin investigated by Sullin diagram which showed old meteoric origin for all the studied wells.

**Keywords:** Dibdibba, groundwater, aquifer, meteoric, Jabel Sanam.

### Introduction

Groundwater is an important resource in many areas of the world for drinking, irrigation, industrial and other usages. In recent years, concerns have been grown about the decrease in discharge and water quality degradation of the Tigris and Euphrates Rivers, thus increasing the need for detailed studies of groundwater quality. Then, a best management for the important water source in Iraq could be made, as there are several formations bearing groundwaters such as Dibdibba aquifer. Recently, many water purification stations (RO) had been built using groundwater from wells in the area to produce drinking water. Dibdibba aquifer is considered as one of the main shallow aquifer in central and southern Iraq, because of the high horizontal extension of its outcrops, as well as the present of clastic sediments make the runoff percolation to the aquifer easy (Al-Kubaisi, 1996).

The study area is considered as a part of the Dibdibba aquifer, Southern Desert of Iraq. The upper part of the Dibdibba formation (Pliocene-Upper Miocene), in which the most productive units are sands and gravels, is the main aquifer in Safwan-Zubair area. It is characterized by unconfined to semi-confined conditions. The average of its saturated thickness is nearly 14 m (Haddad and Hawa, 1979; Al-Jawad *et al.*, 1989; Al-Kubasi, 1996).

Many studies have been made on the study area and its surroundings. These studies included the southern region as a whole and particularly the area in Zubair-Safwan. These included hydrological, hydrogeological and hydrogeochemical assessment of groundwater system of the region (Al-Kubaisi, 1996; Al-Suhail, 1999; Al-Mansoury, 2000), as well as studies on the contamination of groundwater with saltwater (Al-Musawi, 2009) and the water balance in the region of Safwan by Haddad (1977). Most of these studies dealt with the region as a whole, and showed that there was significant variations in the groundwater levels and quality of the sites of selected areas, as well as neighboring wells. Therefore, the present study aims at examining the quality of groundwater of the area between Jabal Sanam and Safwancity, one of the most important areas which is within the zone of Dibdibba formation.

## Materials and Methods

Groundwater (40 samples) were collected from 20 water wells in the south west Basrah province near Jabal Sanam. Locations of these wells were shown in Figure (1). The groundwater samples were collected by clean polyethylene bottles during 2013 by sampling programme set for water quality studies (Hem, 1991). Major ions ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{HCO}_3^-$ ,  $\text{Cl}^-$  and  $\text{SO}_4^{2-}$ ) were analyzed according to the standard methods as described by APHA (1992).

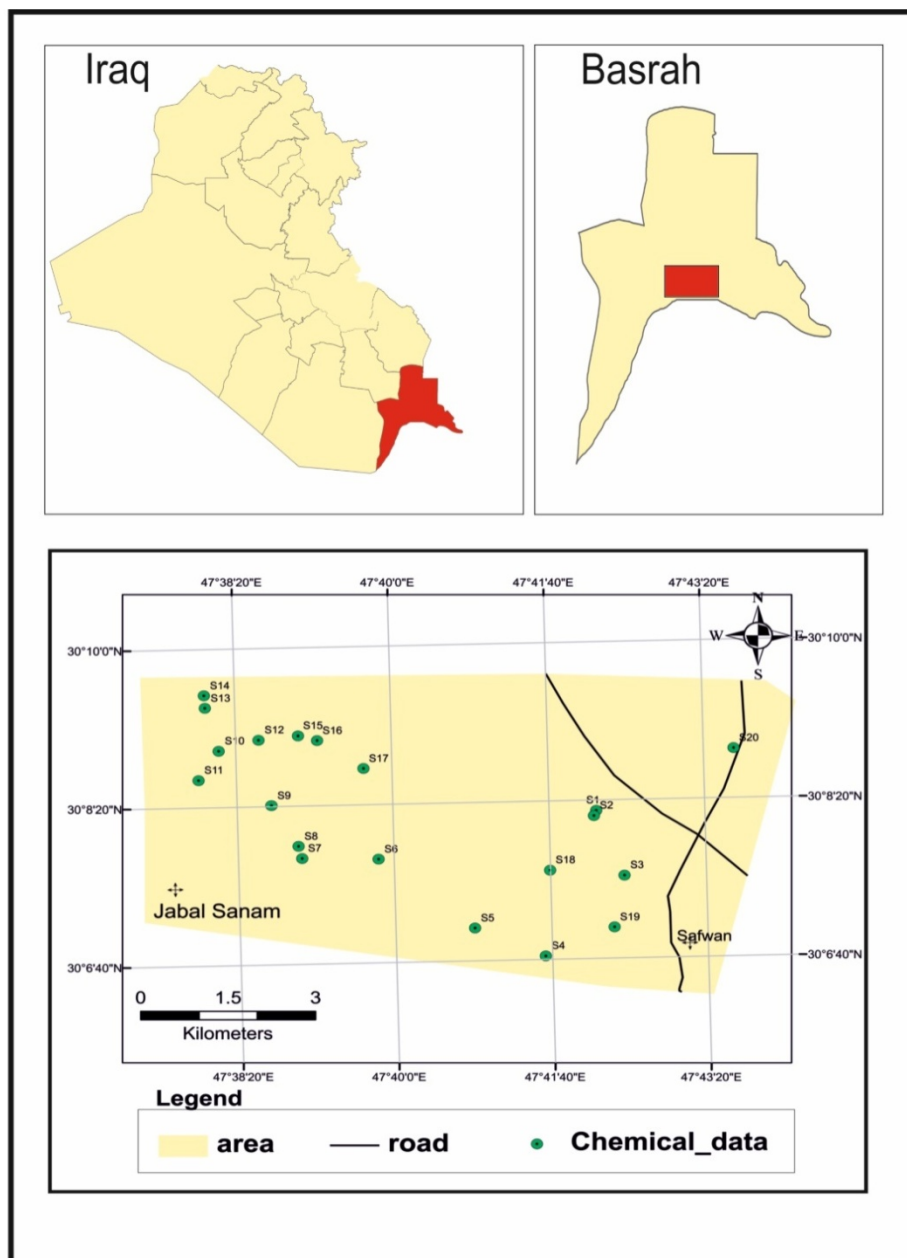


Figure 1. Location map of the study area.

After collection, samples for trace element analyses were immediately acidified to  $\text{pH} < 2$  with ultrapure nitric acid. Analyses of Pb, Zn, Ni and Cd were performed according to APHA (1992), using atomic absorption model Sens AA spectrometer.

pH and electrical conductivity (EC) were measured by using a WTW portable electronic instruments model 3210 SET 2 and 3110 SET 1, respectively.

## Results and Discussion

### Electrical Conductivity (EC):

The results showed that electrical conductivity of the groundwater ranged from  $7.37 \text{ ds.cm}^{-1}$  to  $14.36 \text{ ds.cm}^{-1}$  with an average of  $11.31 \text{ ds/cm}$  (Fig. 2). The conductivity is low at the western of Jabal senam region (about  $7.37 \text{ ds.cm}^{-1}$ ) due to recharge from the Al-Batin alluvial fan (Hadad, 1977), where the salinity decreases.

The conductivity is high at the eastern zones of the study area (about  $14.36 \text{ ds.cm}^{-1}$ ) which is due to water-rock interactions in the studied aquifer (Al-Suhail and Al-Mansory, 2003).

### Hydrogen Ion Activity (pH):

Generally, the groundwater of the study area is slightly alkaline (Fig. 3). The pH values ranged from 6.9 in well 5 at the south to 7.8 in well 1 in the north of the study area with an average of 7.41.

The variations of pH values are mostly due to the chemical composition of the aquifer rocks (Sharaky *et al.*, 2007).

### Major Ions:

#### Sodium ( $\text{Na}^+$ ):

The concentration of  $\text{Na}^+$  ion ranged from 924 mg/l in well 9 at the west to 2638 mg/l in well 18 at the east with an average of 1680.85 mg/l (Fig. 4). Sodium concentration is directly related to salinity and EC of the groundwater.

#### Potassium ( $\text{K}^+$ ):

The potassium contents of the groundwater of Jabal Senam area are the same as sodium contents but are lower in most of the wells. It ranged from 9 to 59 mg/l with an average of 24.5 mg/l (Fig. 5).

The low concentration of potassium in the study area may be due to the type of aquifer matrix, as potassium salts in most rocks are not easily dissolved in the groundwater (Stumm and Morgan, 1996).

#### Calcium ( $\text{Ca}^{2+}$ ):

The concentrations of calcium ion ranged between 371 mg/l in well 7 to 541 mg/l in well 14 with an average of 474.4 mg/l (Fig. 6).

The increase of calcium concentration is due to the type of water-caring strata, which have calcite, dolomite, gypsum and anhydrite minerals, which are responsible of enriching the groundwater with calcium ions in this aquifer (Al-Mansory, 2000).

#### Magnesium ( $\text{Mg}^{2+}$ ):

The magnesium concentrations changed from 72 mg/l in well 9 at the west to 462 mg/l in well 18 at the eastern Jabal Senam area with an average of 210 mg/l.

The minimum values were found close to Jabal Senam (Fig. 7) which is due to the recharge from the Al-Batin alluvial fan (Haddad, 1977), while the maximum value is due to dolomite rocks at the Dibdiba aquifer.

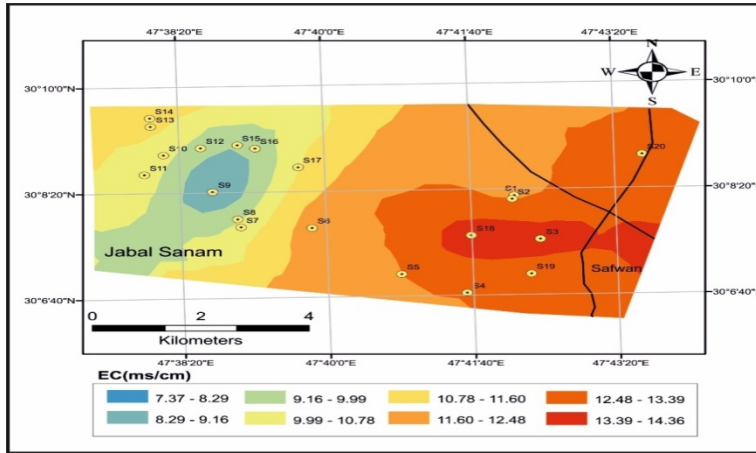


Figure 2. Spatial distribution of EC ( $ds \cdot cm^{-1}$ ) in the study area.

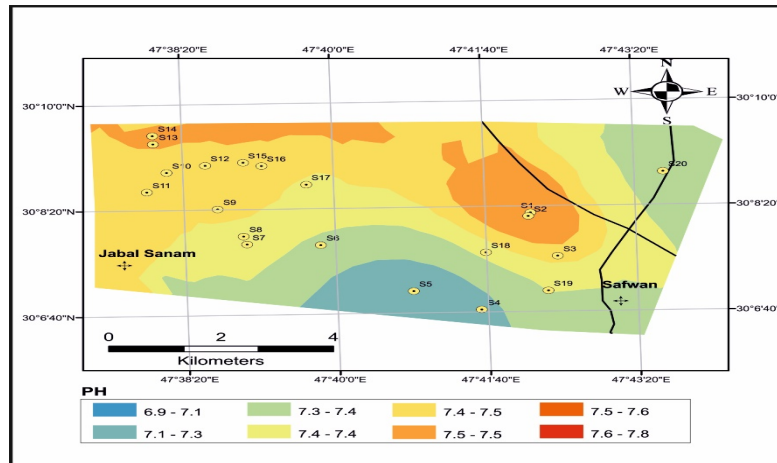


Figure 3. Spatial distribution of pH in the study area.

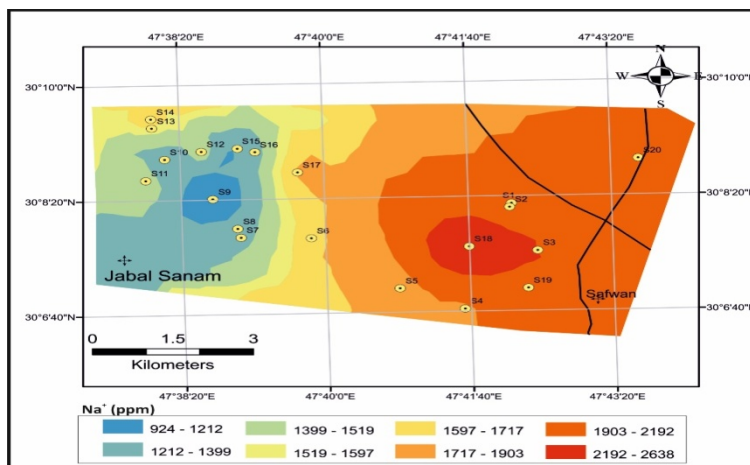


Figure 4. Spatial distribution of  $Na^+$  (ppm) in the study area.

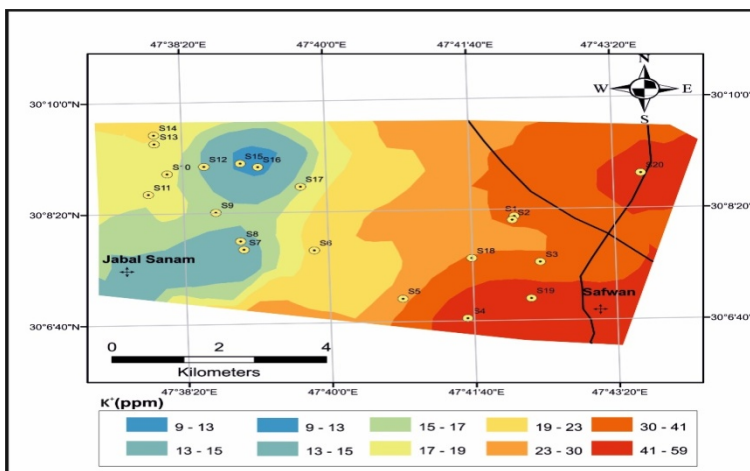


Figure 5. Spatial distribution of  $K^+$  (ppm) in the study area.

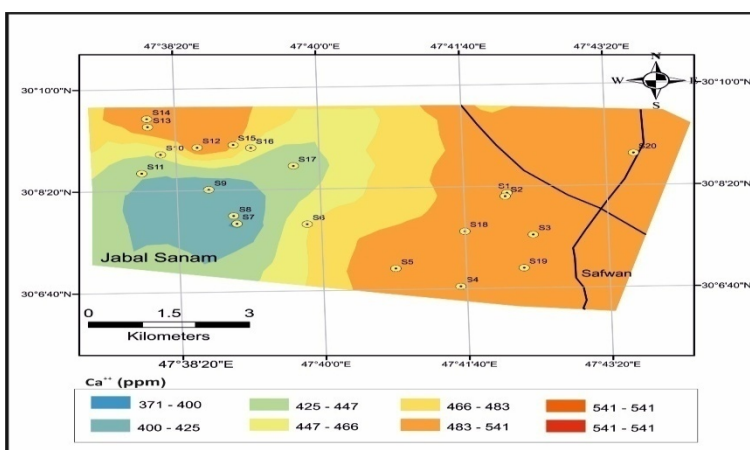


Figure 6. Spatial distribution of  $Ca^{2+}$  (ppm) in the study area.

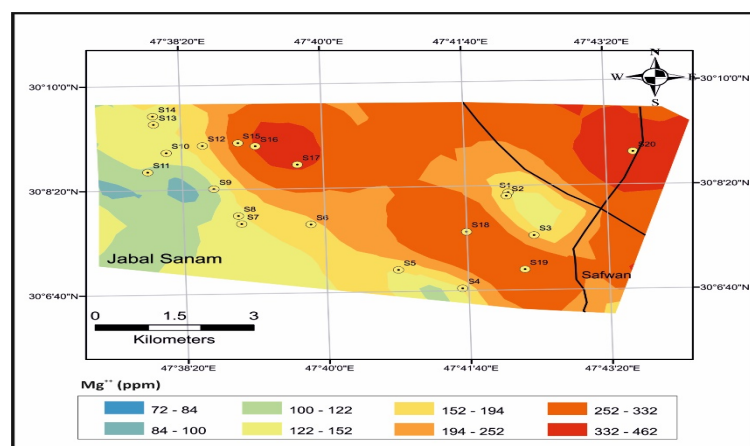


Figure 7. Spatial distribution of  $Mg^{2+}$  (ppm) in the study area.

### Major Anions:

#### Chloride (Cl<sup>-</sup>):

Chloride concentration changes from 1479 mg/l in well 16 west to 2726 mg/l in well 18 east of Jabal Sanam area with an average of 2070.6 mg/l (Fig. 8). Chloride ion is the common major anion in the Dibdiba aquifer groundwater. Chloride and sodium contents increased rapidly with the increase of TDS (Fig. 9) (Sharaky *et al.*, 2007).

#### Sulfate (SO<sub>4</sub><sup>2-</sup>):

The sulfate concentration changes from 1884 mg/l in well 12 north west to 2731 mg/l in well 3 eastern with an average of 2276 mg/l (Fig. 10). The high sulfate contents in the study area are due to the extending of Miocene sediments containing gypsum and limestone to the present area which means that there is a local sources of sulfates (Qusay and Al-Mansory, 2003).

#### Bicarbonate (HCO<sub>3</sub><sup>-</sup>):

The bicarbonate concentration changed from 86 mg/l in well 7 close to Jabal Senam to 161 mg/l in well 11 western to the Jabal, with an average of 128 mg/l (Fig. 11). The maximum value is due to the dissolution of carbonate rocks (Hem, 1991).

### Water Type:

Sulin's graph (Sulin, 1948) for genetic classification has been used to indicate the groundwater genesis using the chemical composition.

According to Sulin's classification, all the 20 wells samples are located in the lower quadrant of Sulin's diagram and characterized by sodium-sulfate (Fig. 12) indicating an old meteoric water in origin.

Also the groundwater origin could be detected using the NC value from the following equation (Ivanov *et al.*, 1968):

$$NC = [r \text{ epm Na}^+ + r \text{ epm K}^+] / r \text{ epm Cl}^-$$

If the calculated NC value is higher than 1.0 it indicates that the water is meteoric in origin while NC value less than 1.0 it indicates a marine water origin (Ivanov *et al.*, 1968). Calculated NC values in Table (1) showed that all the 20 wells in the area have meteoric ground water origin.

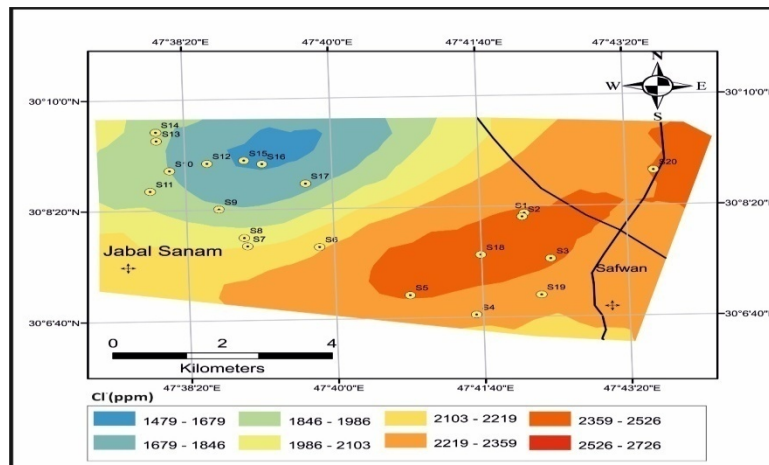


Figure 8. Spatial distribution of Cl<sup>-</sup> (ppm) in the study area.

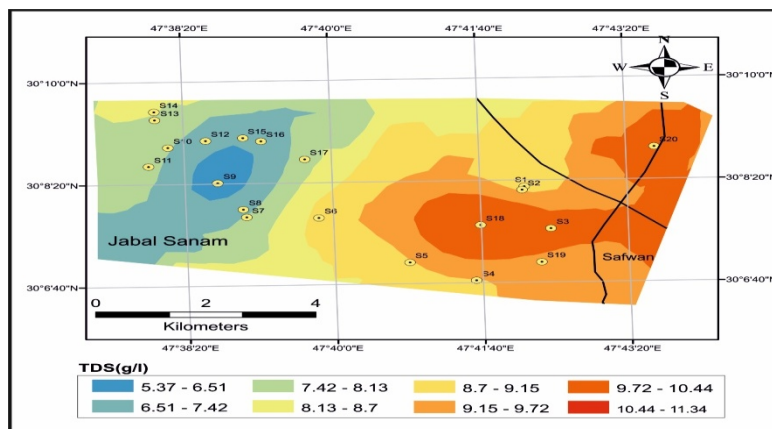


Figure 9. Spatial distribution of TDS (g/l) in the study area.

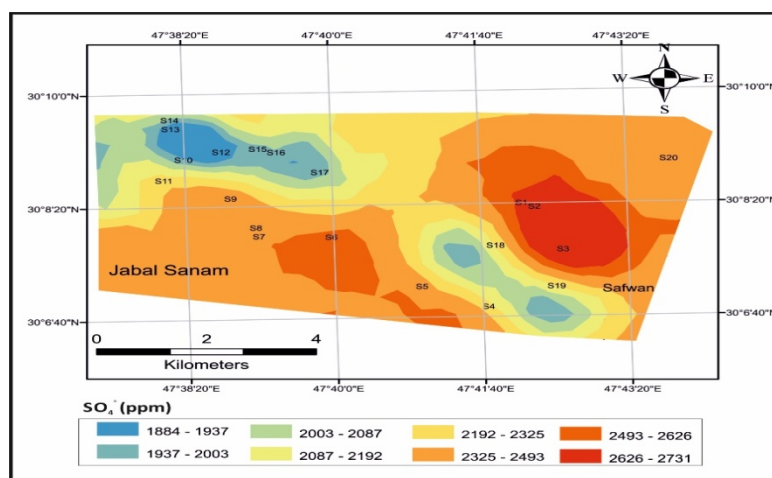


Figure 10. Spatial distribution of SO<sub>4</sub><sup>2-</sup> (ppm) in the study area.

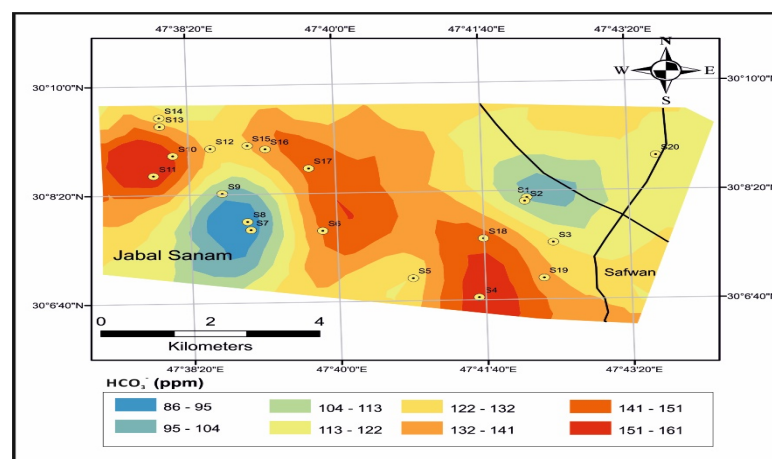


Figure 11. Spatial distribution of HCO<sub>3</sub><sup>-</sup> (ppm) in the study area.

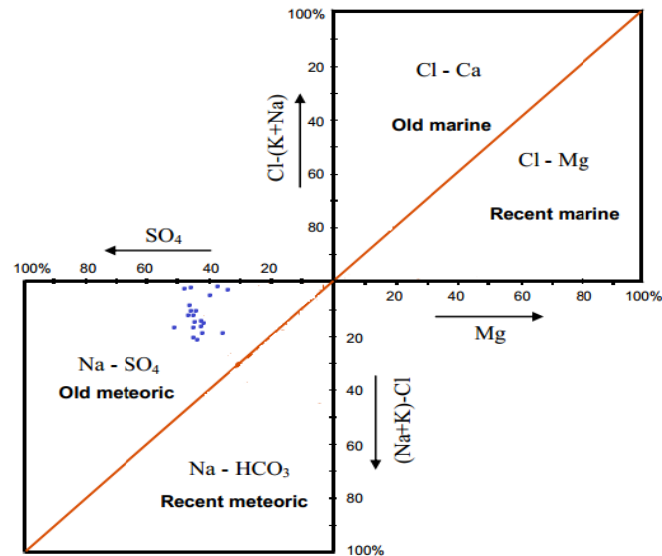


Figure 12. Sulin diagram of the genetic classification of the groundwater.

Table 1. NC values at the study area.

| Well no. | NC   | Well no | NC   | Well no | NC   | Well no | NC   |
|----------|------|---------|------|---------|------|---------|------|
| 1        | 1.03 | 6       | 1.28 | 11      | 1.24 | 16      | 1.28 |
| 2        | 1.15 | 7       | 1.16 | 12      | 1.27 | 17      | 1.38 |
| 3        | 1.02 | 8       | 1.24 | 13      | 1.16 | 18      | 1.37 |
| 4        | 1.01 | 9       | 1.12 | 14      | 1.37 | 19      | 1.32 |
| 5        | 1.07 | 10      | 1.02 | 15      | 1.17 | 20      | 1.23 |

The chloride group is dominant in the studied wells. In spite of the concentrations of sulfates which are relatively high, it is still less than the concentrations of chlorides. The previous studies of water type are referred to the chloride group as contain two families (sodium and calcium). However, all the studied groundwater wells are chloride group-sodium family-type ( $\text{Na}^+ > \text{Ca}^{2+} > \text{Mg}^{2+}$ ) only.

#### Trace Elements:

Figures (13 and 14) showed that Zn and Pb concentrations in the groundwater of the studied area changed from 0.1 mg/l and 0.02 mg/l in wells 9 and 16 to 2.2 mg/l and 0.18 mg/l in wells 20 and 10 with an average of 0.98 mg/l and 0.07 mg/l, respectively. The minimum values was found north of Jabal Senam. Concentrations of Zn and Pb may belong to natural causes such as contact between the groundwater and the parent rocks in sandstone Dibdibba formation that contain (Zn and Pb) medium (39 and 7), respectively (Al-Bassam and Yousif, 2014).

The high values of Pb and Zn may attributed to the anthropogenic activities such as using the hydrocarbon fuel and soil fertilizers which contained Pb and Zn as a result of the agriculture activities in the studied area.



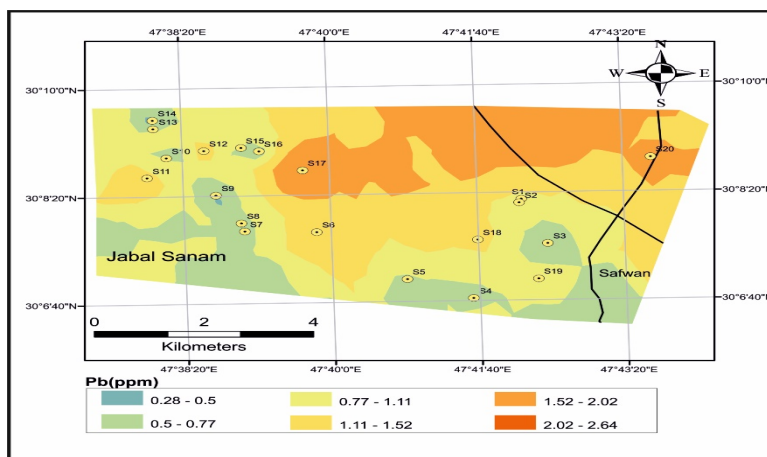


Figure 13. Spatial distribution of Pb (ppm) in the study area.

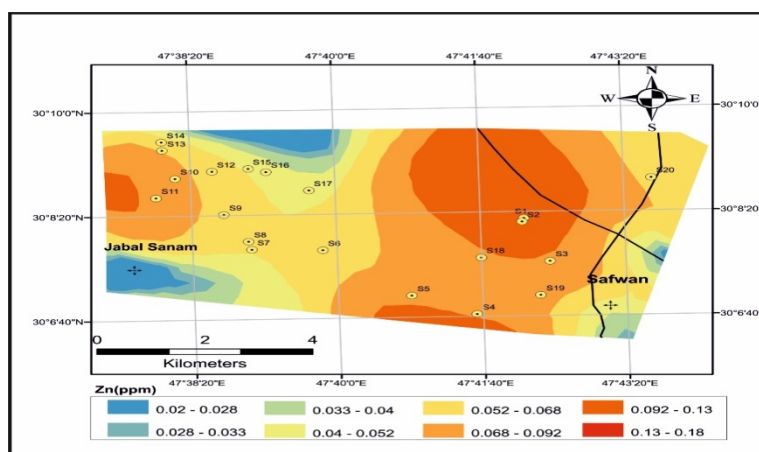


Figure 14. Spatial distribution of Zn (ppm) in the study area.

## Conclusion

Generally the concentrations of salts and major ions in the groundwater of the study area are high. The maximum values are recorded at the eastern part of the study area, whereas the minimum values were occurred in the northwestern Jabal Sanam. All the studied wells contain chloride group sodium family type. The groundwater of the studied area is of an old meteoric origin according to Sulin's classification. The concentrations of trace elements in the groundwater are very low, with the exception of lead and zinc, which may be attributed to natural and anthropogenic factors.

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## أصل ونوعية المياه الجوفية في خزان الدبديبة في منطقة جبل سنام جنوب البصرة، العراق

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**المستخلص** - تهدف هذه الدراسة إلى تقييم نوعية المياه الجوفية وتحديد أصل تكوينها في خزان الدبديبة (منطقة جبل سنام) جنوب البصرة. اختير عشرون بئراً في منطقة الدراسة لجمع عينات المياه وأجريت عليها التحليل الفيزيائية والكيميائية والتي شملت الأيونات الموجبة الرئيسة (الصوديوم، البوتاسيوم، الكالسيوم، المغنيسيوم)، والأيونات السالبة الرئيسة (الكلور، الكبريات، والبيكربونات) والعناصر النزرة (الزنك، الكاديوم، النيكل، الرصاص) إلى جانب القياسات العامة (درجة الحموضة، التوصيلية، الاملاح الذائبة الكلية، العسرة الكلية). رسمت خرائط للناتج باستخدام نظم المعلومات الجغرافية (GIS 10.2.2-based a Co-kriging) لتحديد نوعية المياه الجوفية في المنطقة وصلاحتها للري. أظهرت النتائج ان النوع السائد للمياه الجوفية في منطقة الدراسة هو (صوديوم < كالسيوم < مغنيسيوم) من عائلة الصوديوم ضمن مجموعة الكلوريد. كذلك جرى التحري عن أصل المياه الجوفية باستخدام مخطط سولن والرسم البياني أظهر ان مياه الآبار المدروسة ذات أصل قاري قديم.