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Hydrochemical Classification of Groundwater in Safwan - Al-Zubair Area, South of Iraq

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Abstract

The groundwater quality is almost equal to its quantity. Determination of its chemical, physical, and bacterial characteristics is very important for municipal, Commercial, industrial, and domestic water supplies. Twenty five different groundwater samples were taken from twenty five wells distributed over Safwan- Zubair area in order to identify their hydrochemical properties, including its contamination by their major ions. Their TDS values range between 3810 to 9225 ppm, while their EC values lies between 4.77 and 8.95 mmhos/cm. There is a direct relationship between EC and TDS, square coefficient of correlation is 0. 9636. Plotting the values of ionic concentration on Sulin's graph appeared that the considered water source can be divided in to two types, the first one is of marine origin, and the second is meteoric water. Marine origin of groundwater indicates that the groundwater of Dibdibba Formation which was gathered through sedimentation under marine environment during Miocene age or this marine water came from a deep source, due to the existence of different pressures which caused a vertical flow of this saline water. Scholler- Sulins method is used to classify this groundwater, sulphate and chloride ions are the dominant anions. The group of sulphate contains two major families which are sulphate-sodium and sulphate-calcium, while chloride group contains also two families including both chloride- sodium and chloride- calcium.

1-Introduction

Safwan-Zubair area lies in the Southwestern part of Basrah Province in the south of Iraq. It is located between longitudinal lines ($47^{o}\ 30^{'}$ - $47^{o}\ 55^{)}$ and latitudinal lines ($30^{o}\ 03^{'}$ –$30^{o}\ 25^{'}$). The studied area is about 1400 km^2 as shown in figure (1). Rain usually begins to fall in October and continues till May, where maximum value of this rain may be attended during January. The average annual rainfall is 148 mm. Maximum average peaks monthly evaporation is 453mm during July and the minimum is 64mm during January. The maximum and minimum average of monthly relative humidity

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is (72-30.5%) during January and July, respectively. The consumed groundwater has been overweighing the amount of recharged water (Al-Aboodi, 2003). Increasing demands on water may revive development in groundwater usage; however any development adds new problems. The reduction of groundwater storage of the usable aquifer during the last three decades has led to a marked deterioration of groundwater quality. The uses of bad waters do not only affect the crops production, but also on the soil itself. That is affecting all the good properties of these soils, so it may change their salinity, alkalinity and toxicity with time. All the previously mentioned problems need prediction and further research in order to specify and quantify the most important properties related to the groundwater resources.

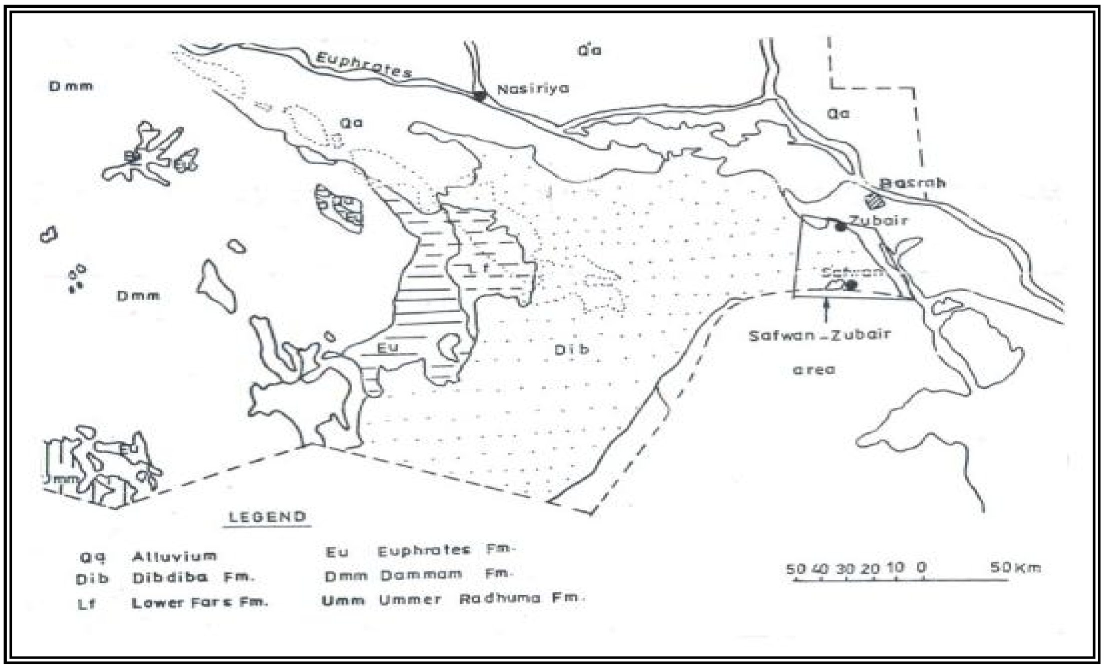

Fig.(1) A regional distribution of Dibdibba Surface [2]

Physical and Geological Features of the Studied Area

The studied area is located within the Dibdibba Plain, which is considered as apart of Iraqi western desert. Dibdibba Formation is characterized by its sandy –gravel soil and increasing groundwater surface toward the west and southwest of Iraq. This area is also, characterized by sand dunes, especially in the southwest part of the region. These sand dunes are either stable or movable. The height of the stable sand dunes may reach about 8m, while the movable ones may reach 4m (Al-Kubaisi, 1996). A singular significant feature of isolated salt dome is known as Jabal Sanam pierces this area, and it has an altitude of more than 150m

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above sea level, and similar to this salt dome there are several salt domes spreading over the Arabian Gulf area and also in the south western part of Iran. Geologists believe that this dome came into being as a result of rising salty strata during the Tertiary period (Al-Naqib, 1970). This area also contains some shallow valleys, which extend parallel to each other, and they are considered to be the only drainage systems. These valleys are locally called "Shaib" that might fill with water during rainy seasons after heavy showers of rains.

Dibdibba Formation (Upper Miocene-Pliocene age) extends over a large area in the south of Iraq (figure 2), and also it is found in some parts in the middle of Iraq. Dibdibba Formation has a simple slope in the south of Iraq toward the north-eastern side of Dibdibba plain. The sediments of Dibdibba Formation gradually changes from marine sediments into river sediments which are generally increased in the quantity and sizes of granules from oldest into recent , which do not have any index fossils (Buday, 1980). This formation consists mainly from sand and gravel with some cementing materials such as silt and clay (Macfdyen, 1938). Dibdibba Formation has maximum thickness in most northern wells of Zubair oil fields up to 350m and decreases gradually toward the south and west of Iraq. Dibdibba Formation is underlain by the Ingana Formation (Middle Miocene age), which consists of anhydrite, gypsum, marls and shallow water limestone as shown in figure (2). This formation in turn is underlain by the Ghar Formation (Middle –Lower Miocene) and it lies unconformable on the Dammam Formation, which consists of limestone ((Miocene Eocene in age) (Haddad and Hawa, 1979). Mineralogical Dibdibba deposits are mainly composed of some quartz, feldspars, gypsum and calcite, while clay minerals consist of montmrillonite,chlorite,illite, kaolinite in addition to polygorsikite (Al-Dabbas *et al.*, 1989). Al-Kubaisi, 1996 ; Hassan *et al.* (1989) stated that the sea origin of this groundwater of sandy Dibdibba Formation was gathered through sedimentation under marine conditions at the late of Miocene age, so that the continental water is considered as a conveying factor of marine origin. Therefore, salinity decreases but stays as marine origin. Al-Rawi *et al*,1983 and Al-Jawad *et al*, 1970 mentioned that this marine water may come from a deep source through the existence of different pressures causing a vertical flow of this groundwater.

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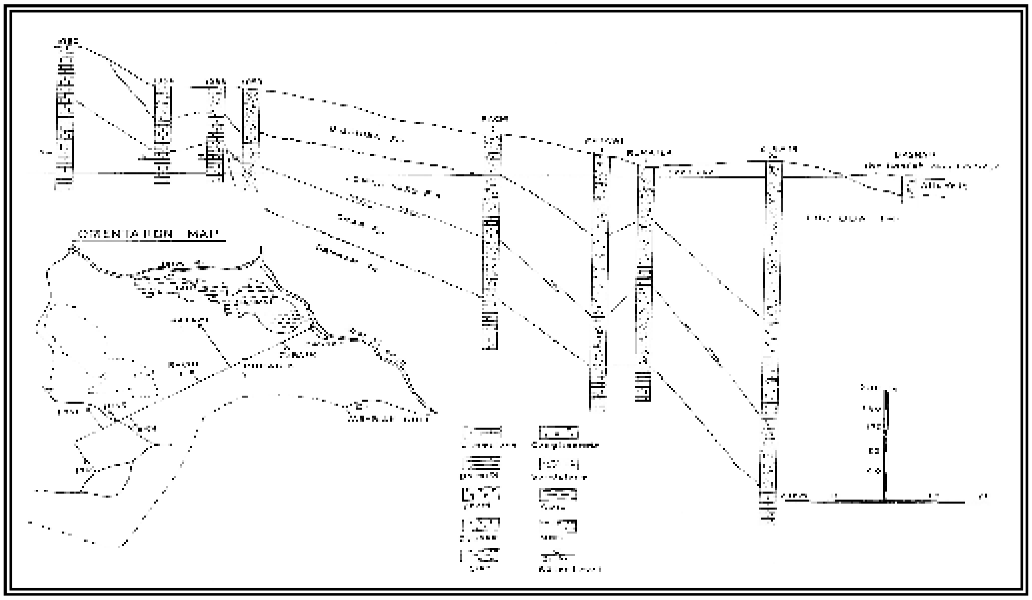

Fig. (2), Geological cross-section showing the vertical- lateral extension of Dibdibba Formation (Sadik, 1977)

Chemical Analyses of the Groundwater in the Study Area

Twenty five different groundwater samples were taken from twenty five wells distributed over Safwan- Zubair area in order to identify their hydrochemical properties, including its contamination by their major ions. Chemical analyses were conducted in the laboratories of Marine Science Center,Basrah University. Results of their chemical analyses, their electrical conductivity, and their total dissolved solids of these groundwater samples are shown in table (1). The correction for the accuracy of the groundwater analyses were achieved using the criterion for acceptance is that (sum of cations - sum of anions / sum of cations+sum of anions) x 100% should be within ± 5% (Matthess, 1982) as shown in table(2). TDS values range from 3810 to 9225 ppm, while EC values lies between 4.77 and 8.95 mmhos/cm. There is a direct relationship between EC and TDS, square coefficient of correlation is 0. 9636 as shown in figure (3).

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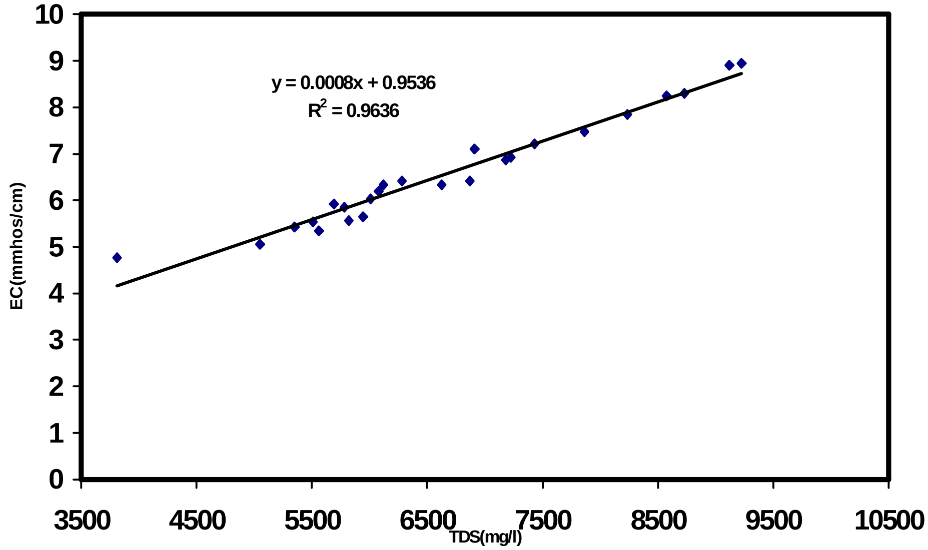

Fig. (3), Relationship between TDS (ppm) and EC (mmhos/cm) in the study area

2-Groundwater Classification Methods

There are several hydrochemical classification methods which can be used to classify the groundwater. The well known methods are (Sulin, 1946), (Schoeller, 1962) and (Schoeller- Sulin,1981). These methods are used to classify the groundwater of the study area.

Sulin's Method:

This method uses the percentage of the concentration (meq %) instead of the values of concentration itself, as well as the condition of terminating the concentration of each participant in the classification in ratio 15% (Sulin, 1964). Sulin could terminate 15x15 type of water as shown in table (3). He divides the graph into two squares upon the concentration rate of both Na and K in meq% to the concentration of chloride (Cl) (meq%) as shown in figure (4). The upper square represents the marine water. Using the ratioA= r Cl^- –r $(Na^+ + k^+)$ / r Mg^{++}, where r means ratio, this square is divided into two triangles, the first when A>1 that represents water from marine origin in a confined basin from the family (Ca-Cl). The second triangle when A<1 which represents marine water in semi confined basin. But in the case of the ratio B = r $(Na^+ + K^+)$ – r Cl^- / r $SO_4^{=}$, the square also is divided into two triangles, the first one when B>1 represents meteoric water (continental) and its type from the family of Na + K –bicarbonate. The second triangle (B<1) represents a meteoric origin and its type from the family of Na+K – sulphate. After plotting the values of the concentration upon Sulin's graph, it appeared that the water samples in the study area are divided into two types, the first represents marine water and the second represents meteoric water.

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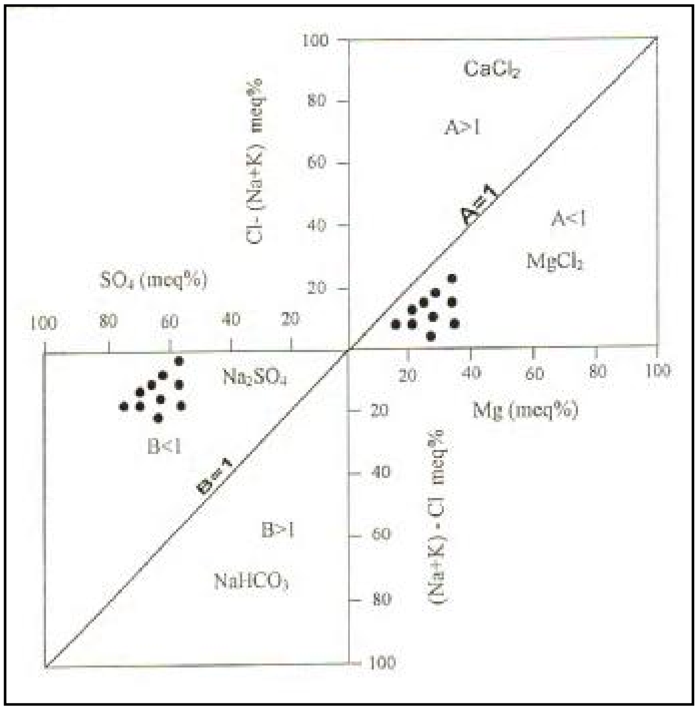

Fig.(4), Groundwater type on Sulin's graph

Schoeller's Method:

In 1962 schoeller developed a new method using the concentration of the major ions identified in this groundwater. He used the deductive arrangement of the concentration of cations and anions and he was able to obtain 36 types of water as shown in table (4) (Schoeller, 1962). By this method, water samples can be recognized in two numbers; the first on the left represents the deductive arrangement of the concentration of cations, the second on the right represents the deductive arrangement of the concentration of anions.

Schoeller- Sulin's Method:

This method includes the use of both cations and anions appreciated in percentage (meq%). This method contains Schoeller's graph with addition to the line 15% which was taken by Sulin in his classification method, where cations and ions participate in this classification if the concentration rate is more than 15%. Schoeller- Sulin used two numbers to indicate the concentration of cations and anions. The first number represents Shoeller's number, (table 5). The second number on the right depends on Sulin's classification, where number (1) means to eliminate the last two concentrations of cations and anions (both concentration less than 15%) , while number (2) means to eliminate the last concentration cations and anions, number (3) means that there is no elimination in the concentration of the ions.

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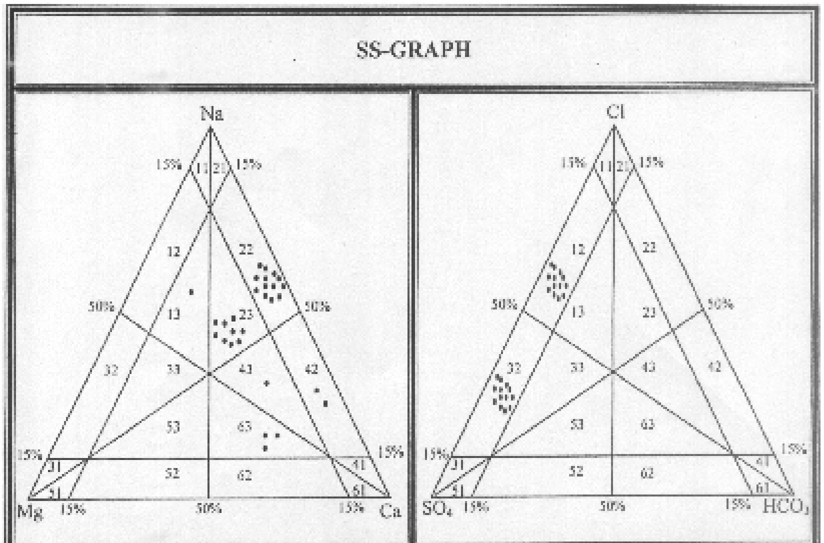
The result of using Schoeller- Sulin's method to classify the groundwater of Safwan-Al-Zubair region, and identifying their water types are shown in figure(5), and table(5). They have clearly indicated that sulphate and chloride ions are the dominant ions in the researched area. So, the sulphate group in this studied area contains two major families, these are: 1- Sulphate – sodium and 2- Sulphate –calcium, where as the Chloride group also contains two families, which includes: 1- Chloride-sodium and 2- Chloride –calcium.



11	rNa	11	rCl
12	rNa > rMg	12	rCl > rSO_4
13	rNa > rMg > rCa	13	rCl > rSO_4 > $rHCO_3$
21	rNa	21	rCl
22	rNa > rCa	22	rCl > $rHCO_3$
23	rNa > rCa > rMg	23	rCl > $rHCO_3$ > rSO_4
31	rMg	31	rSO_4
32	rMg > rNa	32	rSO_4 > rCl
33	rMg > rNa > rCa	33	rSO_4 > rCl > $rHCO_3$
41	rCa	41	$rHCO_3$
42	rCa > rNa	42	$rHCO_3$ > rCl
43	rCa > rNa > rMg	43	$rHCO_3$ > rCl > rSO_4
51	rMg	51	rSO_4
52	rMg > rCa	52	rSO_4 > $rHCO_3$
53	rMg > rCa > rNa	53	rSO_4 > $rHCO_3$ > rCl
61	rCa	61	$rHCO_3$
62	rCa > rMg	62	$rHCO_3$ > rSO_4
63	rCa > rMg > rNa	63	$rHCO_3$ > rSO_4 > rCl

Fig.(5),Groundwater type of study area on SS-Graph

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Table (1): Results of the percentage ratios of the ions concentration, TDS, and EC analyses for groundwater in the studied area

Well	$(Na^{+}+K^{+})$ meq%	Mg^{++} meq%	Ca^{++} meq%	Cl^{-} meq%	$SO4^{=}$ meq%	$HCO3^{-}$ meq%	TDS ppm	EC mmohs/cm
1	49.26	7.60	43.12	19.48	77.90	2.600	5350	5.42
2	57.00	9.85	33.14	36.88	61.78	1.330	7430	7.21
3	57.54	22.86	19.60	36.36	62.17	1.466	5780	5.85
4	52.70	12.90	34.40	31.75	65.75	2.500	6010	6.03
5	26.50	27.98	45.40	51.74	41.63	6.630	6625	6.33
6	29.53	32.34	38.12	52.74	39.50	7.700	5690	5.92
7	53.69	12.18	34.14	29.19	68.50	2.280	5510	5.53
8	54.89	11.96	33.14	48.38	50.28	1.320	6870	6.42
9	51.18	23.00	25.76	55.00	43.76	1.180	9120	8.90
10	41.67	21.54	36.78	57.28	40.87	1.840	9225	8.95
11	36.64	25.00	38.25	60.46	36.43	3.100	8730	8.30
12	38.43	29.28	32.28	54.82	43.19	1.980	8235	7.85
13	42.18	17.00	40.80	53.76	45.63	0.610	6910	7.1
14	15.20	27.00	57.60	40.56	55.46	3.970	7865	7.48
15	41.95	17.00	40.90	34.38	62.34	3.270	5945	5.65
16	38.50	13.66	47.34	32.80	65.60	1.550	3810	4.77
17	51.70	13.40	34.86	34.65	63.96	1.380	5050	5.05
18	52.10	11.45	36.44	58.00	39.80	2.180	6080	6.19
19	40.29	14.40	45.30	54.00	44.22	1.720	6120	6.33
20	43.25	27.90	28.83	44.90	53.64	1.450	7225	6.93
21	41.85	22.54	35.60	37.45	61.30	1.200	7180	6.87
22	60.00	12.18	27.70	46.25	51.88	1.870	5560	5.35
23	56.23	11.78	31.98	22.84	76.18	0.970	6280	6.42
24	47.60	15.85	36.56	34.36	63.64	1.480	5820	5.56
25	51.20	13.60	35.15	57.14	41.37	1.490	8575	8.25
Min.	15.2	7.60	19.60	19.48	36.43	0.61	3810	4.77
Max.	60.0	32.34	57.60	60.46	77.90	7.70	9225	8.95

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Table (2), The results of summation of cations and anions and their percentage error

Well	ΣCations	ΣAnions	Error %	Well	ΣCations	ΣAnions	Error %
1	78.84	77.00	1.18	13	95.30	104.95	-4.80
2	111.65	108.45	1.45	14	117.65	125.91	-3.40
3	91.85	85.25	3.37	15	86.53	90.15	-2.00
4	92.93	88.20	2.61	16	58.53	54.85	3.20
5	110.69	102.44	3.87	17	74.58	75.04	-0.30
6	86.56	91.00	-2.50	18	96.04	93.03	1.60
7	82.63	78.80	2.37	19	91.38	96.53	-2.74
8	108.63	105.80	1.32	20	108.91	113.09	-1.88
9	147.50	141.63	2.00	21	114.91	106.93	3.60
10	143.72	135.47	2.95	22	81.04	77.98	1.92
11	143.24	129.00	5.23	23	87.23	92.64	-3.00
12	129.68	120.39	3.70	24	92.10	86.04	3.40
				25	126.31	139.71	-5.04

Table (3), (15x15) water type (Sulin's method, 1946)

Cations	**Anions**
Ca-Mg-Sodium	HCO3-SO4-Chloride
Mg-Sodium	SO4-Chloride
Mg-Ca-Sodium	SO4- HCO3
Ca-Sodium	HCO3-Chloride
Sodium-	-Chloride
Ca-Na-Magneisum	HCO3-Cl-Sulphate
Na-Magnisum	Cl-Sulphate
Na-Ca-Magneisum	Cl-HCO3-Sulphate
Ca-Magneisum	HCO3-Sulphate
Magneisum	-Sulphate
Mg-Na-Calcium	SO4-Cl-Bicarbonate
Na-Calcium	Cl-Bicarbonate
Na-Mg-Calcium	Cl-SO4-Bicarbonate
Mg-Calcium	SO4 -Bicarbonate
-calcium	- Bicarbonate

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Table (4), Coding number of Schoeller' method with 36 water type, r = meq%

Cations	Code Index	Anions	Code index
r (Na+K)>r Mg>rCa	1	$rCl>rSO_4>rHCO_3$	1
r(Na+K)>rCa>r Mg	2	$rCl>rHCO_3>rSO_4$	2
rMg>r(Na+K)> rCa	3	$rSO_4>rCl>rHCO_3$	3
r(Ca>r(Na+K)>r Mg	4	$r HCO_3>rCl>rSO_4$	4
rMg>rCa>r(Na+K)	5	$rSO_4>r HCO_3>r Cl$	5
rCa>r Mg> r(Na+K)	6	$rHCO_3>r SO_4> rCl$	6

Table (5), Quality and family of groundwater in the study area

Family	Group	Well No.	Water type	Index
Sulphate- Sodium		1,2,4,7,8,17,22,23	rNa>rCa; rSO_4>rCl	22; 32
Sulphate- Sodium		15,20,21,24	rNa>.rCa>rMg ; rSO_4 >rCl	23; 32
Sulphate- Sodium		3	rNa>rMg>rCa; rSO_4>Cl	13; 32
Sulphate-Calcium		14	rCa>rMg>rNa; rSO_4>Cl	63; 32
Sulphate-Calcium		16	rCa>rNa; SO_4>Cl	42; 32
Chloride-Sodium		9,10,12,13	rNa>rCa>rMg; rCl>SO_4	23; 12
Chloride-Sodium		18,25	rNa>rCa; rCl>rSO_4	22; 12
Chloride-Calsium		11	rCa>rNa>rMg; rCl>SO_4	43; 12
Chloride-Calsium		5,6	rCa>rMg>rNa; rCl>SO_4	63; 12
Chloride-Calsium		19	rCa>rNa; rCl > rSO_4	42; 12

3-Results and Discussion

The groundwater of Safwan Al-Zubair area is characterized by their wide variation in TDS and EC over its area. This variation can be attributed to the lithological and mineralogical contents of Dibdibba Formation or to the spatial variation in controlling factors that are responsible for sedimentation and dissolution of different minerals. The groundwater samples in the study area are divided into two types, the first is marine water and the second is meteoric water. Marine origin of this groundwater was gathered through sedimentation under marine conditions at the late of Miocene age, or this water came from a deep origin, because of existence of a different pressure caused to make a vertical flow of groundwater. So that continental water is considered as a conveying factor to the water of marine origin. According to Schoeller Sulin's method, it clearly appeared that sulphate and chloride ions are the dominant ions in the study area.

4-Conclusions

The groundwater of Safwan Al-Zubair area is characterized by a wide variation in total dissolved solids (TDS) and electric conductivity (EC). TDS values vary over the range (3810-9225) ppm. While the EC values

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vary over the range (4.77-8.95) mmhos/cm. Direct relationship between EC and TDS, square coefficient of correlation is 0.9636. Sulin's Graph revealed that the water samples are divided into two types, the first one is of marine water and the second one is of meteoric water. According to Schoeller – Sulin classification method, sulphate and chloride ions are the dominant anions in this area, the group of sulphate contains two major families which are sulphate-sodium and sulphate –calcium, while the group of chloride also contains two families which are chloride-sodium and chloride –calcium.

5-References

Al-Aboodi A. H.,2003 ''A study on groundwater characteristics in Safwan-Al-Zubair Area, South of Iraq, Unpub, M.Sc, thesis, College of Eng.,Univ. of Basrah, 104p.

Hassan, H.A.,Ismail,S.K.,and Al-Dabbas , M.,1989,Regional hydrogeological condition of Dibdibba basin, southern Iraq,Jour. Agr. Water Resour. Res., vol.8, No.1, pp 167-180

Al-Kubaisi, Q.Y.,1996, Hydrogeology of Dibdibba aquifer in Safwan-Zubair area, south of Iraq, Unpub, Ph.D thesis, College of Science, Univ.of Baghdad, 173p.

Al-Naqib, K. M.,1970, Geology of Jabal Sanam, south of Iraq, Geol. Soci.Iraq, vol.3, No.1,pp 9-36.

Buday, T.,1980, The regional geology of Iraq,Stratigraphy and paleogeography of Iraq, Dar Al-Kutib Pub.House,Univ. of Mousal, 445p..

Macfdyen, W. A., 1938, Water supplies in Iraq, Pub. No. 1, Ministry of Economics and Communications, Iraq, Geological Dept., Government of Iraq, Baghdad printing press, 232p.

Haddad,R.H.,and Hawa, aA.J.,1979, Hydroge-ology of the Safwan area, south of Iraq, Tech. Bull. No.132, Scientific Research Foundations,Baghdad, 232p.

Al-Dabbas,M.A.,Tobia,F.and Suliuman, M., 1989, Water quality and litholgical framework for upper Dibdibba sediments interaction at Safwan-Zubair area,Proc. 5th conf.,Iraq,vol.1, part3, pp10-33.

Al-Rawi, N., Al-Sam, S., and Skavaraka, I., 1983, Hydrogeology, Hydrogeochemistry and water resources of southern desert, Fin.Rep.,vol.9, DGGSMI,Iraq,204p .

Al-Jwad, S.B., Haddad, W.I.,Hassan,H.A.,and Vander Sluijs, A.,1970,The possible commun-ication between groundwater in the Dibdibba sandstone aquifer of the Safwan-Zubair area and adjoining aquif er ,Tech. Rep.,No.0, AIRNR,Iraq,14p.

Sadik, J.M., 1977, Sedimentological investiga-tion of the Dibdibba formation, southern, central Iraq, Unpub, M.Sc, thesis, Dept. of Geo., Univ. of Baghdad, 148p.

Matthess, G., 1982, The properties of groundwater, John Wiley comp., New York , 406p.

Sulin, V.A., 1964, Oil water in the system of natural groundwater, Gostopichezdat, Moscow USSR, 21p.

Schoeller, H., 1962, Lex eaux souterraines, hydrologic dynamique et evaluation des resources, Masson and c-Paris, 642p.

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التصنيف الهايدروكيميائي للمياه الجوفية في منطقة سفوان - الزبير، جنوب العراق

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الملخص

إن نوعية المياه الجوفية لا تقل أهمية عن كميتها، لذلك تتطلب تحديد خصائصها الكيميائية والفيزيائية والبكتيرية بهدف استخدامها في المجالات الزراعية والصناعية والبلدية والمنزلية. فحصت 25 عينة جلبت من 25 بئرا موزعة على مساحة واسعة من منطقة سفوان – الزبير لغرض تحديد الخصائص الهايدروكيميائية لهذه المياه. ولقد ظهر بان كمية الأملاح المذابة تراوحت بين (9225 – 3810) جزء بالمليون،بينما كانت التوصيلية الكهربائية (8.95 - 4.77) مليموز/سم. هناك علاقة مباشرة بين EC و TDSحيث آن مربع معامل الارتباط (R^2) بلغ 0.9636 . وبعد توقيع قيم تراكيز الأيونات على مخطط سولن تبين آن مصدر هذه المياه الجوفية ينقسم إلى نوعين أحدهم بحري والثاني مياه جوية قارية.فالمياه الجوفية ذات الأصل البحري تشير إلى مياه تكوين الدبدبة المتكون أثناء عملية الترسيب تحت ظروف بحرية خلال العصر المايوسيني ، أو تكون قد جاءت من مصادر عميقة ناتجة عن اختلافات في الضغوط نشأ عنها جريان رأسي لهذه المياه الجوفية. أن طريقة شولير - سولن لتشخيص طبيعة هذه المياه الجوفية بينت تواجد مجموعتين رئيسيتين في منطقة الدراسة تمثلت بمجموعة الكبريتات والتي تضم عائلة كبريتات الصوديوم وعائلة كبريتات الكالسيوم ومجموعة الكلوريدات وتشمل عائلة كلوريدات الصوديوم وعائلة كلوريدات الكالسيوم.

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