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The Suitability and Determining Factors of Groundwater Origin in Safwan –Al Zubair Area, South of Iraq.

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Abstract

The study of groundwater quality involves a determination of the various constituents occurring in this groundwater and their relationships to the use of this groundwater. So in order to evaluate the groundwater quality in the study area, twenty five groundwater samples are taken from twenty five wells distributed over the Safwan-Al Zubair area. The results indicate that the groundwater in the studied region is unsuitable for human drinking and almost all the groundwater here is not suitable for poultry and horses also, but it is suitable for beef cattle and sheep. The yield of vegetable crops such as Tomato, Lettuce and Onion may be reducing to 25 % or more due to high salinity in the groundwater. After studying the other factors which have affecting the suitability of groundwater for agriculture purposes such as sodium absorption ratio, Na %, bicarbonates and carbonates. The results also show that this groundwater is suitable for agriculture purposes despite the high salinity of this water. The hydrochemical ratios (rNa/rCl),(r(Na-Cl)/rSO_4) and (rSO_4/rCl) are used to determinate the origin of this groundwater. After comparing the values of these factors obtained in the studied area with the standard values, it appears that the origin of groundwater is divided into two types, marine and meteoric origin, and also it shows that it changes gradually from deep groundwater of marine origin to shallow one of meteoric origin.

1-Introduction

Recently, the water resources study becomes a basic necessity that must be met, because it is an indispensable and economic fortune. Sources of groundwater are numerous, and its quality and quantity are affected by geological formation, hydrological conditions and human activities. All of the above mentioned factors impose on water to vary in its quantity and quality. The study area lies in the

south- west part of Basrah province in the south of Iraq. It locates between longitude line ($47^{o}30^{'}$ – $47^{o}55^{'}$) and latitude line ($30^{o}03^{'}$ – $30^{o}25'$). The considered area is about 1400 km^2 (fig. 1). The studied area is involved within the Dibdibba plain, which has the characteristics of being sand – gravel soil with rising ground surface level toward the west and southwestern. Dibdibba Formation (Pliocene-upper Miocene age) has a large extension over a wide area in southern part of Iraq (fig. 2) and also it was found in some parts of the middle of Iraq. It has simple slope in the south of Iraq toward the north-eastern making Dibdibba plain. (Macfadyen, 1983) (11) who was the first to describe the Dibdibba Formation, stated that this formation composes mainly from sand and gravel with some cementing materials such as silt and clay, as it is found in the west of Al – Zubair area. Dibdibba's deposits contain other minerals such as quartz, feldspare, gypsum, and calcite (Al-Dabbas *et al*, 1989) (3). Rainfall in this area begins in October and continues till May, and the maximum rain values may be attended during January, and vanished during the period between June and August. The average annual rainfall is 148 mm. The maximum average of highest monthly temperature is 46.10 ^{o}C in August and the minimum is 18.10 ^{o}C in January. The maximum average of highest monthly evaporation is 453 mm during July and the minimum is 64 mm during January. The maximum and minimum average of monthly relative humidity is (72, 30.5) during January and July respectively. All wells of groundwater developed in Safwan Al Zubair area penetrate quaternally sediments and then Dibdibba Formation, as mentioned by (Haddad and Hawa, 1979) (7), (Al Rawi *et al*, 1983) (5) and (Al Jawad *et al* 1989) (4). (Al-Manssori, 2000) (2) had done a research related to hydraulic and hydrogeochemical characteristics of the upper unconfined aquifer. He calculated its transmissivities by using 50% and 90% recovery test that ranged from 115 to 3255 (m^2/day) and from 18 to 135 (m^2/day) respectively. The calculated values using numerical method ranged from 235 to 5880 (m^2/day). In this study hydrogeochemical-modeling approach was adopted to study the chemical reactions thought to be responsible for the variation of the chemical composition of the studied aquifer. A groundwater management model for the upper aquifer in Safwan Al-Zubair area was presented by Al-Abadi (2002) (1). The model domain ranges to 1235 km^2.

The Dibdibba Formation consists of two levels, the first one has a changeable thickness up to 30 m in Safwan area, while the second level can be penetrated by wells as its depth increases more than the pervious one. These two levels are separated by a hard layer, which is locally called Jaojab. So in order to evaluate the suitability and determining factors of

groundwater origin in the study area, twenty five groundwater samples are taken from twenty five wells distributed over this area. The samples are used for various chemical analyses for determining the groundwater quality and its contamination by major ions contained in the groundwater as shown in table (1).

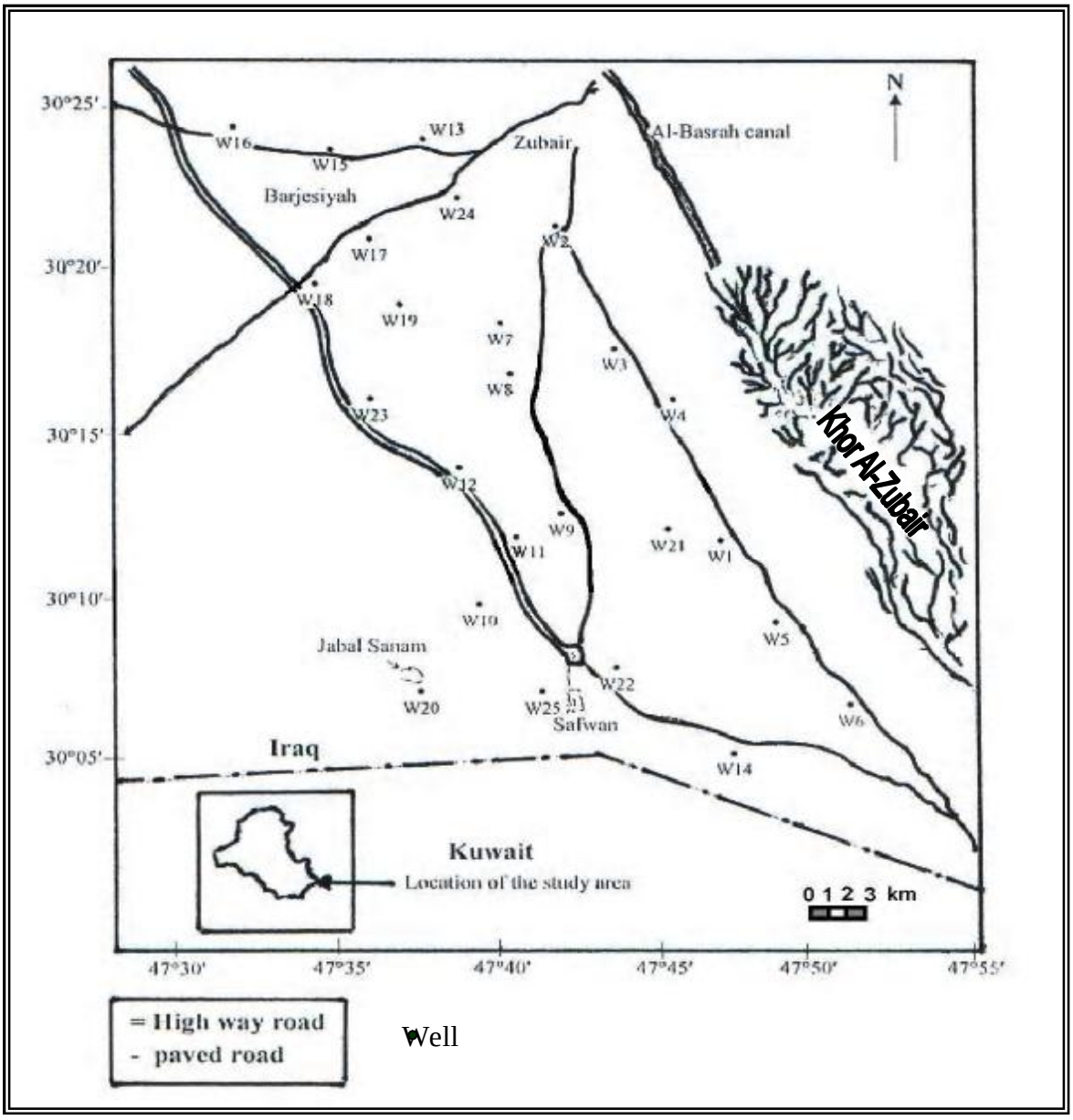

Fig.(1) Study area and locations of the wells

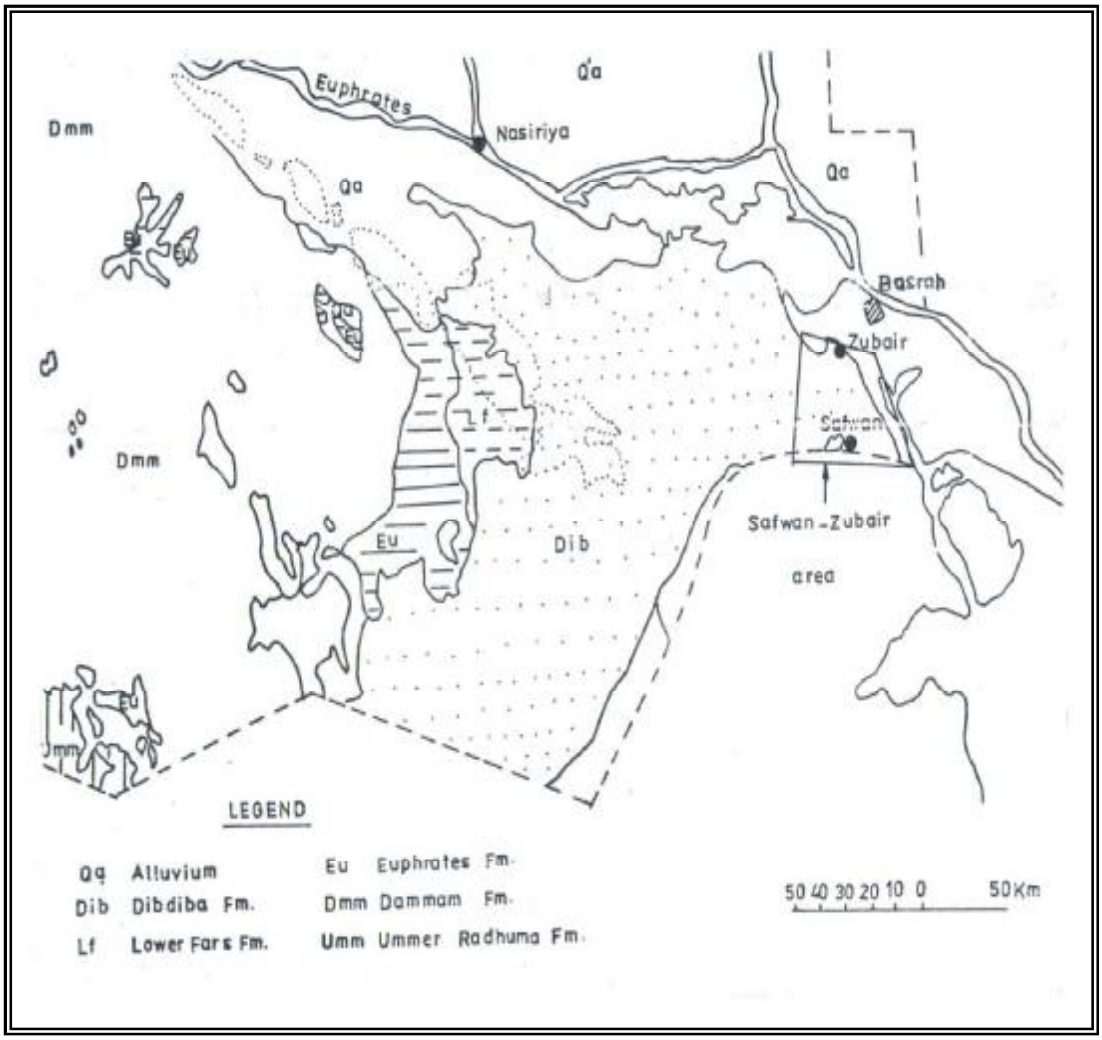

Fig.(2) The Dibdibba hydrogeological basin in the southern eastern part of Iraq including the Safwan Al Zubair area (Hassan *et al*, 1989) (8)

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

Well	$(Na^{+}+K^{+})$	Mg^{++}	$Ca^{+}+$	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	TDS	EC
	meq / l	meq/l	meq/l	meq/l	meq/l	meq/l	ppm	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

Suitability of Groundwater for Drinking

There are many standards that determine the suitability of drinking water for human purposes. Such as (WHO, 1983) (17) , Iraqi standards (IRS, 1989) (9) and American standards (U.S.P.H.S, 1962) (15), as shown in table (2).

TDS values in the groundwater of study area are higher than the permitted limits. Furthermore, we noticed that the sodium, magnesium and calcium exceed the allowable limits. In addition, the concentration of (Sulphate, Chloride) ions also exceed the permitted limit. The non-existence of the suggested limits for potassium, sodium and bicarbonate ions for standards of drinking water attributed to a little presence of these ions in the natural water (Brown *et al.,* 1970) (6). In the mean time it doesn't have a harmful effect on human beings except in rare situations, but high concentration of these elements gives unnatural taste.

U. S. Public Health Service puts some limits for using water to serve type of animals drinking purposes (table 3). TDS values obtained for groundwater in the study area as compared with permitted limits, we deduced that the groundwater in the research region is not suitable for poultry and horses. But this groundwater is suitable for beef cattle and sheep.

Suitability of Groundwater for Agriculture

Factors that determine the suitability of water for agriculture with various ions concentration and their effects on plants have been the subjects of many researches and publications. Only a few of the more important factors were cited concerning the quality of water acceptable to growing of crops. These cited factors are based on limitation of current species of plants and presuppose the maintenance of situation in which the choice of crops to be planted by the farmer is governed by factors other than water quality.

The following limiting factor concerned the suitability of water for agricultural purposes are:

1- Salinity

It is well known that there is a close relationship between irrigation water salinity and plant growth. The U. S. Department of Agriculture reports emphasized that both growth and yield of plants are progressively decreases as salinity increases.

Salts may harm plants growth physically by limiting the up take of water through modification of osmotic processes, or chemically by metabolic reactions such as those caused by toxic materials (Todd, 1980) (14) .

Salt tolerances of vegetable crops have been graphically summarized by the U.S. Department of Agriculture, Fig. (3) Which indicates also the salinity of which 10, 25 and 50 percent reduction in yield might be anticipated. From the electrical conductivity

data for the groundwater in the study area as compared with values in Fig (3) , we can deduce a reduction in yield of vegetable crops such as (tomato, lettuce and onion), which are the dominant vegetable crops in this Safwan – Al Zubair area to 25% or more.

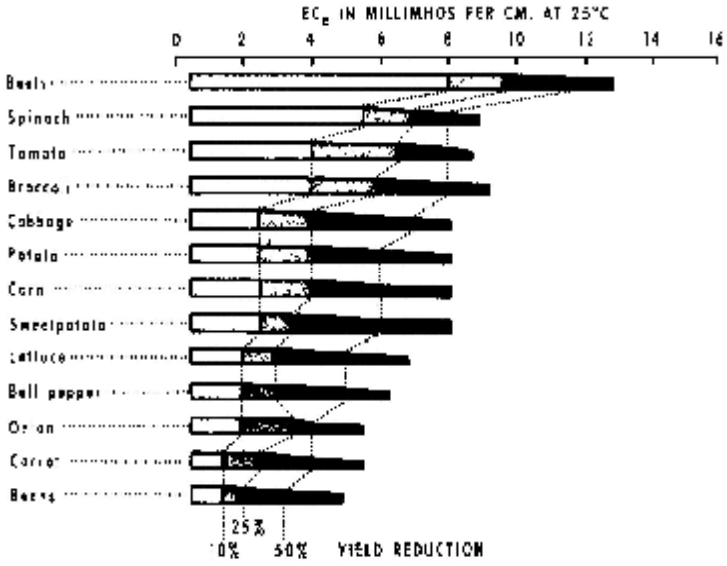

Fig. (3) Salt tolerance of vegetable crops

Table (2), International standard (WHO, 1983), Iraqi standard (IRS, 1989) and American standard (U.S.P.H.S, 1962) for human drinking water.

Elements	WHO,1983		IRS (1989)	American standard(U.S.P.H.S,1962)
	Standard lower limits (ppm)	Standard upper limits(ppm)	Standard upper limits (ppm)	Standard upper limits (ppm)
K	-	-	-	20
Na	-	-	200	200
Mg	30	150	50	125
Ca	75	200	200	200
Cl	200	600	250	250
SO_4	200	400	400	250
HCO_3	-	-	-	500
TDS	500	1500	1000	1000

Table (3) U.S. Public Health Service classification of water for animal drinking water purposes.

TDS (mg/L)	Classification	Animals
0		
	Excellent	
1000		
	Good	
		2860
3000		
	Bad	
5000		
	Very Bad	6435
7000		
	Unsuitable	10000
		12900
13000		

2- Sodium –Absorption Ratio and Na%

The U. S. Salinity laboratory staff (1954) have proposed the use of the sodium absorption ratio for studying the suitability of groundwater for irrigation purposes (Walton, 1970) (16).

Sodium renders soils impermeable to air and water, and when wet, these soils become plastic and sticky (McGauhey, 1968) (13).

The classification of water according to its sodium content is based on the ratio of Na^{+} to $(Ca+Mg)^{++}$, the formula used is.

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

(Cations expressed as meq/l). (Walton, 1970) (16)

After comparison table (4) which represents the suitability water to serve

agricultural purposes depending on SAR values with table (5) which represents SAR values in the study area, the wells (5,6,11,12,13,14,15,16 and 19) lie in the first class, while the remaining wells lie in the second class.

Na% represents the ratio of sodium ion to the total cations, the formula used is

$$Na\% = \frac{Na}{Na+Ca+Mg+K} \times 100$$ (Todd, 1980) (14)

or

$$Na\% = \frac{(Na+K)\times 100}{Na+Ca+Mg+K}$$ (Matthess, 1982) (12)

Where concentrations are measured in meq/l.

The values of Na% in this study area lie between 14.8% and 59% and after its comparison with sodium ratio listed in table (6) one may suggest that groundwater in the studied area can be used for agricultural purposes.

3- Bicarbonates and Carbonates

The presence of sodium in the groundwater becomes more harmful as carbonate and bicarbonate ions concentration increases.

When calcium bicarbonate enters the soil any increase in temperature or evaporation rate may lead to calcium deposition as $CaCO_3$ in the soil. This process is considered to be an important one since it keeps the calcium content of the soil high; this reduction of calcium in the percolated water results in an increase in the sodium-absorption ratio.

The residual sodium carbonate (RSC) method also can be used as an index for tendency of calcium carbonate, and to some extent magnesium carbonate to precipitate in the soil,

Where

$$\mathbf{RSC=(CO_3^{=}+HCO_3^{-})-(Ca^{++}+Mg^{++})}$$

RSC value in groundwater of study area is vanishes due to the increase in the concentration of calcium and magnesium and decrease the concentration of bicarbonate and carbonate. According to previous studied indices, we can use the groundwater in the study area for agricultural purposes despite the high salinity in this water because the soil in this region has a high permeability and suitable drainage.

Determining Factors of Groundwater Origin

The indices (rNa/rCl), (r(Na-Cl)/rSO_4) and (rSO_4/rCl), are used to determinate the origin of groundwater in the study area.

1- rNa/rCl

The rNa/rCl ratio is considered as one of the most important guides in determining the origin of groundwater.

Generally speaking chloride is used in calculating the hydrochemical ratio, because

this ion is considered to be the least effected by physical and chemical changes.

The value of this index becomes less than (1) in marine water and more than (1) in meteoric water (Ivanov *et al*, 1968) (10), we can notice from Fig. (4). that the groundwater in this study area is divided into two types of water, one of marine origin and the other of meteoric origin.

2- r(Na - Cl)/rSO$_4$

The value of this index of groundwater in this study area ranged between -0.65 and 0.43 (Fig. 5). In the case of groundwater of meteoric origin, the value of this ratio becomes more than 0 and less than 1, while in ordinary seawater the value is -1.33.

After comparison the values of this ratio obtained in the studied area with those reference values, it appears that the origin of groundwater is divided into two type marine and meteoric origin.

3- rSO$_4$/rCl

The importance of the rSO$_4$/rCl ratio comes from the identification of the sulphate and chloride ions contained in the groundwater of the study area. The values of this ratio ranged between 0.6 and 4.0 and after comparing the obtained values with those values of the ratio for water of meteoric and marine origin, Fig.(6), clarifies the various origins of groundwater of the study area whether it is of marine or meteoric origin. And also shows the gradual changes from deep groundwater of marine origin to shallow groundwater of meteoric origin.

Table (4), Suggests limits of SAR for agricultural purposes.

Grade	SAR
Satisfactory	< 8
Marginal	12-15
Serious	> 20

Table (5), SAR values in study area.

Well No	SAR	Well No	SAR	Well No	SAR
1	8.49	9	12.3	17	8.9
2	12.8	10	9.0	18	10.2
3	11.77	11	7.6	19	6.8
4	10.2	12	7.68	20	8.4
5	4.5	13	7.46	21	8.2
6	4.52	14	2.46	22	11.9
7	9.86	15	7.00	23	11.0
8	11.9	16	5.2	24	8.7
				25	11.3

Table (6) Suggests limits for sodium ratio (Todd, 1980).

Grade	Sodium Ratio Na^+%
Excellent	<20
Good	20-40
Permissible	40-60
Doubtful	60-80
Unsuitable	>80

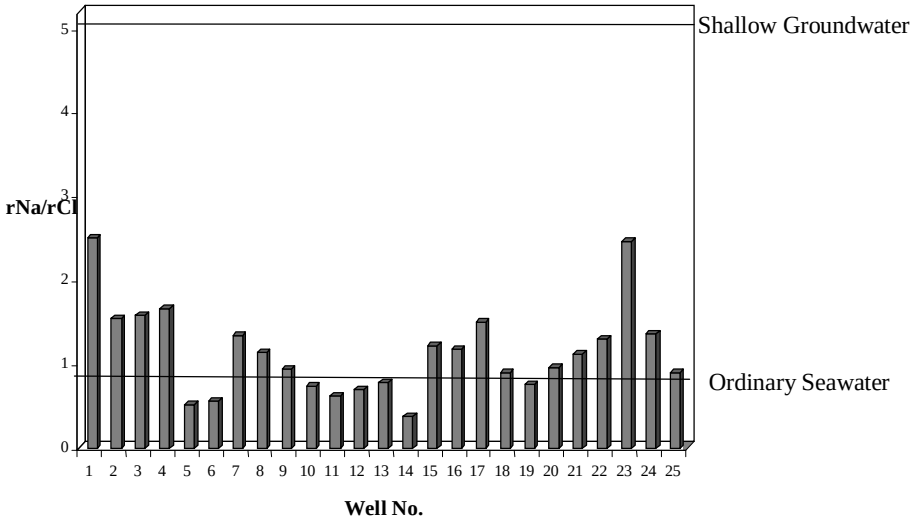

Fig. (4) rNa/rCl histogram of groundwater in the study area

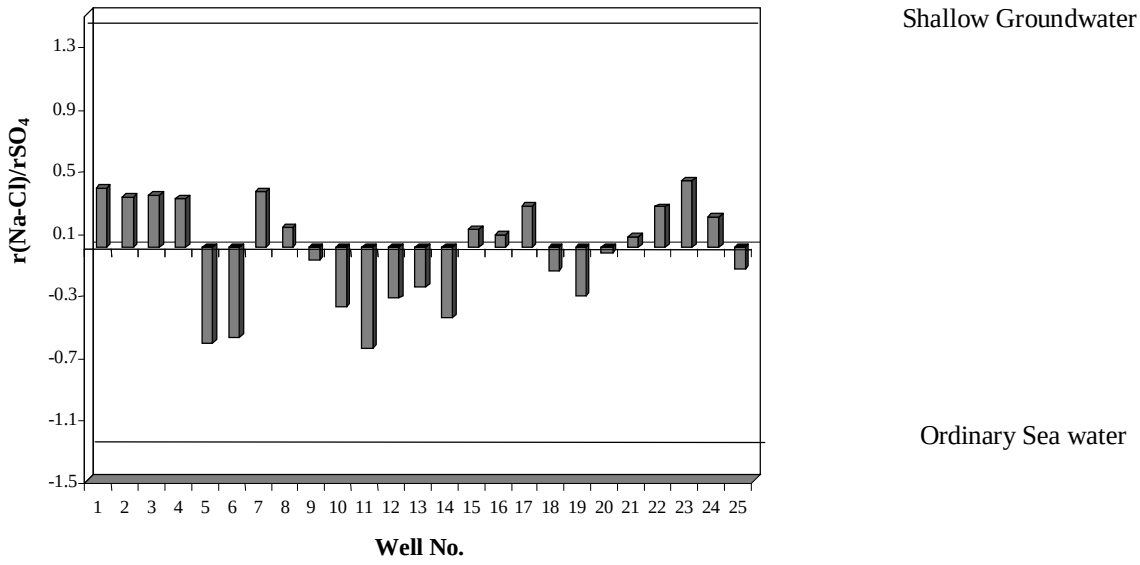

Fig. (5). r(Na-Cl)/rSO_4 histogram of groundwater in study area

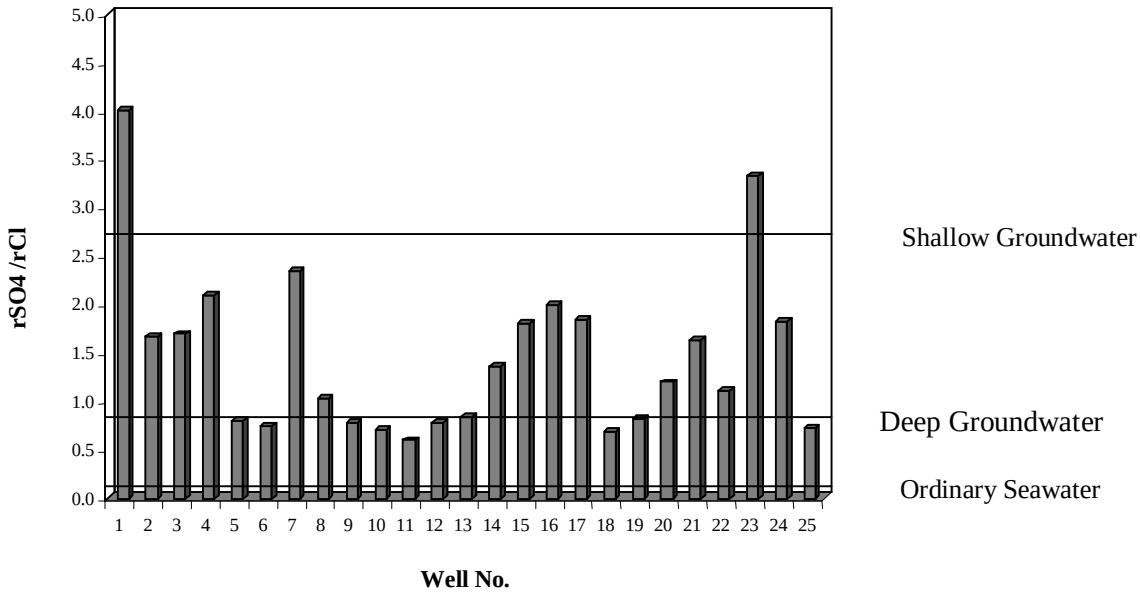

Fig.(6) rSO_4/rCl histogram of groundwater in study area

Conclusions

The groundwater in Safwan Al Zubair area is not suitable for drinking by human, poultry, and horses, but is suitable for beef cattle and sheep. Despite the high salinity of this groundwater, it may be used for irrigation purposes because the soils in this region have a good drainage. The factors (rNa/rCl),(r(Na-Cl)/rSO_4) and (rSO_4/rCl) are used to determinate the origin of this groundwater. After comparing the values of these factors obtained in the studied area with standard reference values, it appears that the origin of the groundwater is divided into two types, marine and meteoric origin, and also shows a gradual change from deep groundwater of marine origin to shallow one of meteoric origin.

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الصلاحية والعوامل المحددة لأصل المياه الجوفية في منطقة سفوان الزبير، جنوب العراق

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الملخص

تتضمن دراسة نوعية المياه الجوفية وصفاً لمختلف المكونات الموجودة في هذه المياه وعلاقتها باستخدام تلك المياه. من اجل تقييم نوعية المياه الجوفية في منطقة الدراسة. لقد تم جمع خمسة وعشرين عينة من المياه من خمسة وعشرين بئر موزعة على مساحة كبيرة من المنطقة. وبعد مقارنة نتائج تحاليل المياه مع المواصفات العالمية, المياه الجوفية في منطقة الدراسة غير صالحة للشرب من قبل الإنسان والدواجن والخيول ولكنها صالحة لشرب الأغنام ومواشي اللحوم. هناك انخفاض في كمية المحاصيل مثل (الطماطة ,الخس, والبصل) يصل إلى أكثر من 25% بسبب الملوحة العالية في تلك المياه. وبعد دراسة العوامل الأخرى التي لها تأثير على صلاحية المياه للإغراض الزراعية مثل نسبة امتصاص الصوديوم, Na% , والكاربونات والبيكاربونات وجد امكانية استخدام هذه المياه على الرغم من ارتفاع ملوحتها. استخدمت الدوال((rNa/rCl) , $r(Na-Cl)/rSO_4$, (rSO_4/rCl)) لتحديد أصل المياه الجوفية في منطقة الدراسة وبعد مقارنة قيم هذه الدوال المحسوبة من المياه الجوفية في منطقة الدراسة مع القيم المرجعية لتلك الدوال اتضح أن المياه تنقسم إلى نوعين بحري وقاري, كذلك تبين أن هناك تغير تدريجي من المياه العميقة ذات الأصل البحري إلى المياه الضحلة ذات الأصل القاري.