Groundwater Quality Evaluation in the Upper Part of the Mandali Basin

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Abstract
Mandali Basin is located between latitudes (33◦ 39 '00 "- 33◦ 54' 55") to the north and longitudes (45◦ 11 '00 "- 45◦ 40' 00") to the east, eastern Diyala province. The research study attributes hydrochemical properties groundwater upper part of the Mandali basin for 20 wells through the data from the analysis of the hydrological information bank of the General Directorate for drilling water wells 2007, hydrochemical study of the water tube wells for two seasons showed water surplus season (February) and season the water deficit (August) It's water colorless, odorless dominated by sulfate ion and sodium, and through hydrochemical formula and the type of water was found that most of the water area of study is the sodium sulfate type Na_2SO_4 and through the study of the origin of groundwater showed it that is atmospheric origin for two seasons. Through classification Schoeller show that the predominant chemical type for two seasons is sulphates. Either through the study of water for different purposes validity was shown that the groundwater and the seasons are not suitable for drinking and is suitable for industrial uses while it is valid for animal consumption and for the purposes of building and construction As for irrigation Most water samples are invalid accept wells (3,4,7,15 , 18,19) and for two seasons.

Keywords: Groundwater, Mandali Basin, hydrochemical properties,

تقييم نوعية المياه الجوفية للجزء الأعلى من حوض مندلي

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الخلاصة:
يـقـع حـوض مـنـدلـي بـيـن دائـرتي عـرض (″55 ′54 °33 – ″00 ′39 °33) شمـالا وخطـي طـول (″00 ′40 °45 – ″00 ′11 °45) لاشرقا, شرق محافظة ديالى. تناول البحث دراسة الصفات الهيدروكيميائية للمياه الجوفية للجزء العلوي من حوض مندلي لعدد من الآبار وبواقع 20 بئرا وذلك من خلال تحليل المعطيات المأخوذة من بنك المعلومات الهيدرولوجية التابع للمديرية العامة لحفر الآبار المائية لعام 2007 , بينت الدراسة الهيدروكيميائية لمياه الآبار الأنبوبية وللموسمين موسم الزيادة المائية (شباط) وموسم النقصان المائي (آب) إنها مياه عديمة اللون والرائحة يسود فيها ايونات الكبريتات والصوديوم, ومن خلال الصيغة الهيدروكيميائية ونوع المياه تبين إن اغلب مياه منطقة الدراسة هي من نوع كبريتات الصوديوم Na_2SO_4 ومن خلال دراسة أصل المياه الجوفية ظهر إنها ذات أصول جوية مترشحة وللموسمين. ومن خلال تصنيف شولير (Shoeller) ظهر إن النوع الكيميائي السائد وللموسمين هو الكبريتات. اما من خلال دراسة صلاحية المياه للأغراض المختلفة فقد ظهر إن المياه الجوفية وللموسمين تكون غير صالحة للشرب وغير

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مناسبة للاستخدامات الصناعية في حين تكون صالحة للاستهلاك الحيواني ولأغراض البناء والإنشاءات أما بالنسبة للري فاغلب نماذج المياه تكون غير صالحة عد الآبار (3,4,7,15,18,19) وللموسمين.

Introduction:

It is known that the need for water resources available for use in a continuous decrease as a result of increased demand for this renewable resource rates, and the deterioration of water quality as a direct result of the use, so it became necessary to expand the studies to invest the available groundwater that need a variety investigation for the purpose of identification of underground sources and storing renewable, and extraction method, water quality, and their suitability for different uses. Structural and geomorphological conditions have helped in the formation of multiple underground reservoirs including Mandali basin, hence the importance of the study of aspects of hydrochemical Basin Mandali; and to identify the water quality for the best investment for these waters. The basin is located between latitudes (33° 39′ 00″- 33° 54′ 55″) in the north and longitudes (45 11 00 - 45 40 00) to the east, and that the study area is in the eastern part of Diyala province, when the Iraqi – Iranian borders. The total area of the basin is about 491 km^2, while the upper part of the basin area of approximately 200-km^2 [1], figure 1.

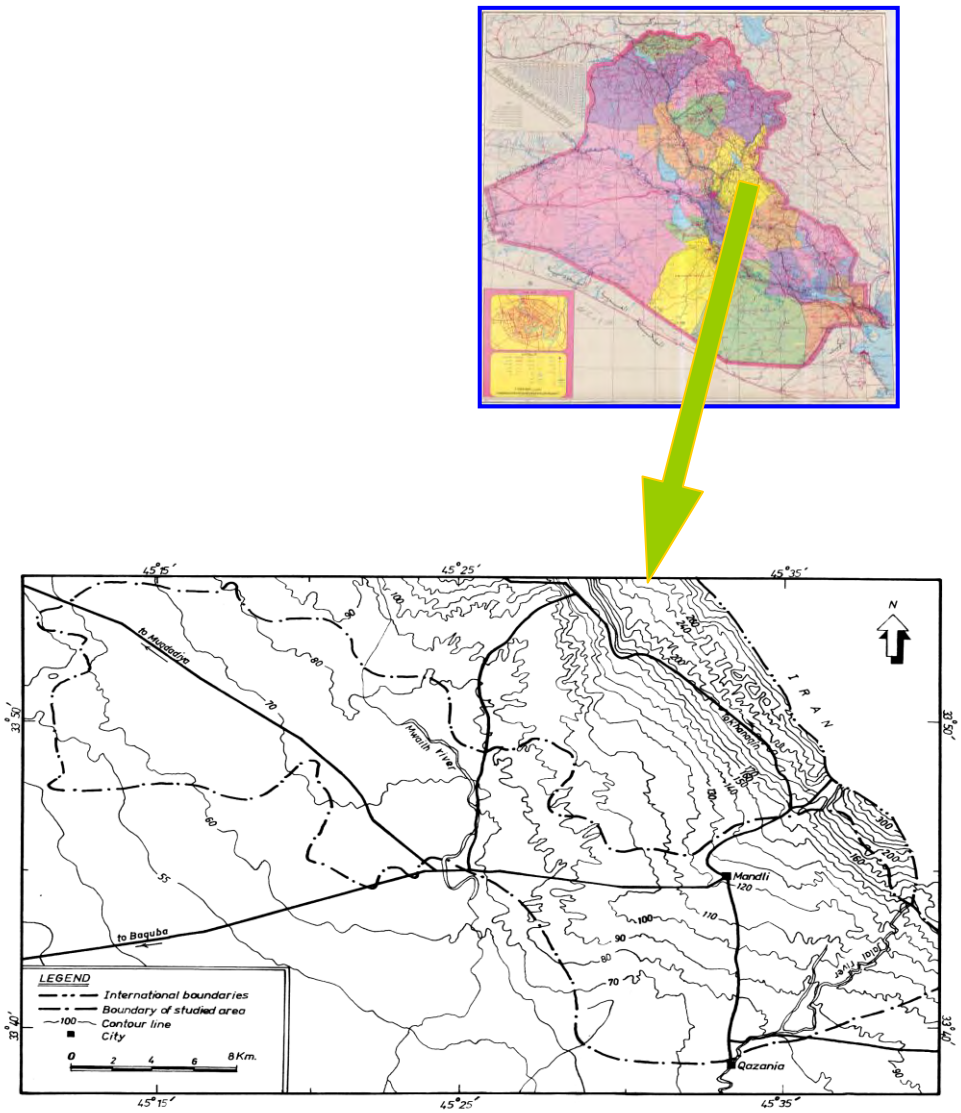

Figure 1-Map of Iraq shown the study area.

Rock exposures in the basin extends from age (Pliocene-Recent) represented by Euphrates, fatha (lower fars), Anjana (upper fars) and Muqdadiyah and Bai Hassan as well as deposits of Quaternary figure 2.

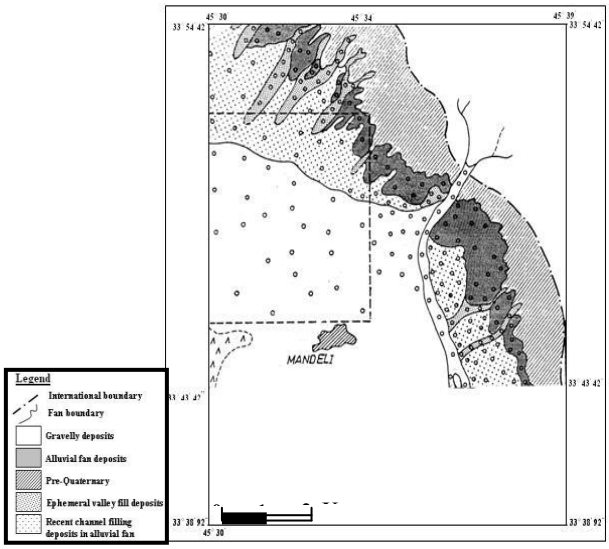

Figure 2-Geological map of studied area (Zainel, 1992)

Methodology and research aim:

The research aims to study the hydrochemical qualities of groundwater and then determine the origin of groundwater and the optimal use of this water in the upper part of Mandali fan by identifying tube wells studied which are (20) wells have been relying on the hydrochemical information, from a hydrogeological information bank of the state Directorate of water wells [1], as well as relying on available reports for the study area from different sources. These wells take water from the confined bed belonging to the formation Bai Hassan and Muqdadiyah [2].

Wells selected sites to search has been proj on topographic map of the scale (1: 100,000) figure 3 and the use of system (GPS) to find the latitude and longitude and altitude above sea level table 1. by this information was drawn map of the distribution of groundwater levels for the purpose of identifying the groundwater movement and flow net figure 4 can be seen from the above figure that the direction of movement of water to be from the northeast to the southwest i.e have the same direction of topography and inclined of bed.

Hydrochemical study of groundwater included measuring the concentrations of the major cations (Ca^{+2} , Mg^{+2}, Na^{+}, K^{+}) and negative ions main (HCO_3^{-}, Cl^{-}, SO_4^{-2}), as well as measuring the pH (pH) and the values of electrical conductivity (EC) and total dissolved soled (TDS), and the temperature of the water taken from the wells that have been studied for two seasons: the first season (is water surplus season in February) and the second season (is water deficit season in August).

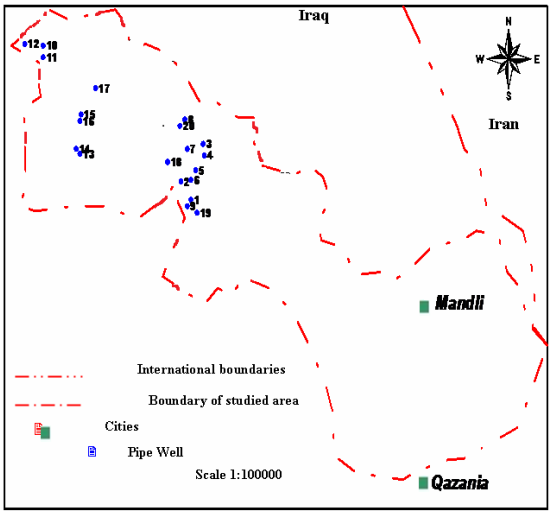

Figure 3-The map for study area shown the tube wells sites

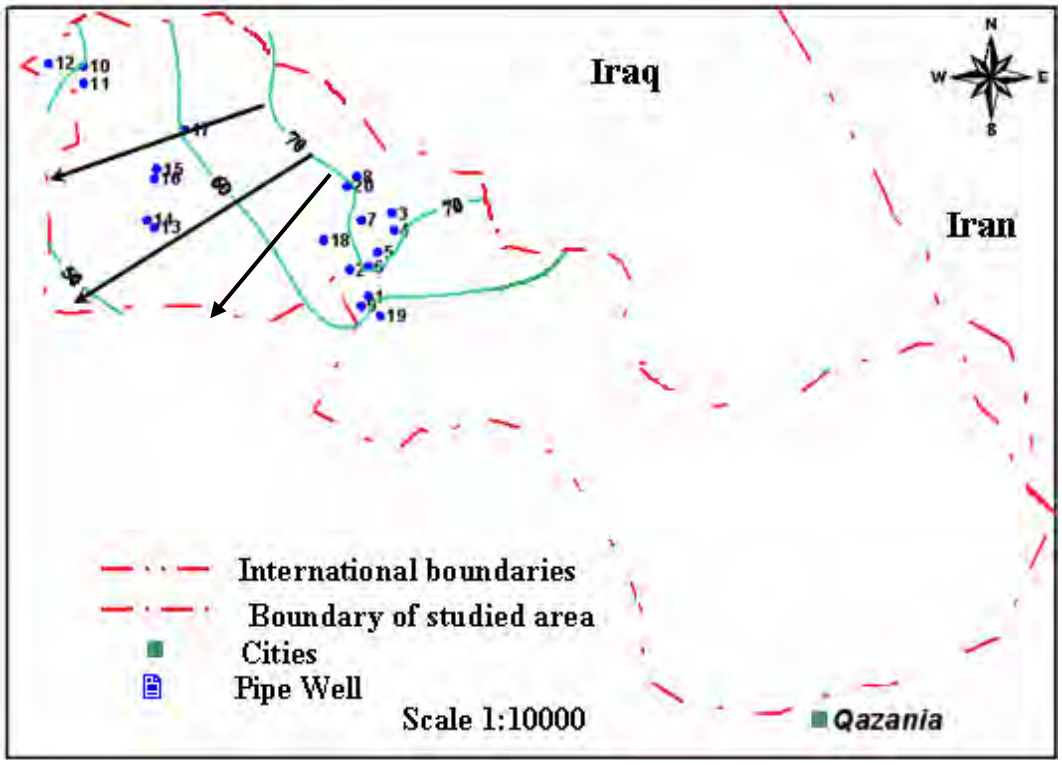

Figure 4-Distribution of water levels in the tube wells in the upper part of the Mandali basin map during the first season (February).

Table 1- Water levels above sea level for the wells of the study area

Well No.	X	Y	Depth of well	Elevation (m)	SWL (m)	W.T. (m)
1	15.3	18.9	80	69.18	8	62.01
2	14.5	20	70	70.72	6	65.55
3	16.3	22.3	60	76.2	6	71.1
4	16.4	21.6	60	77.12	6	72.03
5	15.7	20.7	76	79.25	7	73.18
6	15.3	20.1	70	79.55	7.25	73.24
7	15	22	68	80.16	7	74.1
8	14.8	23.8	65	84.43	7	78.43
9	15	18.5	72	71.63	6	66.47
10	3.2	28.3	75	55.77	6	50.44
11	3.2	27.6	70	59.52	5	54.52
12	1.7	28.4	80	49.96	4	45.96
13	6.2	21.7	70	57.67	6	51.67
14	5.9	22	82	64.76	6	58.76
15	6.3	24.1	30	65.38	7.5	57.88
16	6.2	23.7	75	65.38	9.5	55.88
17	7.5	25.7	66	63.22	3	60.22
18	13.4	21.2	90	70.62	6	64.62
19	15.8	18.1	60	60.75	6	54.75
20	14.4	23.4	60	72.78	7	65.78

The following table shows the physical properties and concentrations of major positive and negative ions (ppm), for water sampiling of well water for the two season, first period of the water surplus (in February) and the second period of the water deficit (August).

Table 2- Physical properties and concentrations of major ions by units (ppm) for the well water sample in the study area for two season.

No. of Sample	TC°	pH	Ca	Mg	Na	K	Cl	HCO_3	SO_4	EC	TDS	TH	Accuracy
1	23	7.11	179	100	437	3.5	451	287	800	3430	2350	858.46	3.1662
2	22.7	7.5	181	85	368	3	330	245	780	3110	2150	801.73	4.1960
3	22.5	7.8	150	60	276	2.9	320	200	548	2750	1720	621.45	1.7072
4	22	7.46	138	43	322	1.5	320	200	543	2670	1700	521.53	1.8440
5	23	7.99	250	120	828	7.5	975	610	1000	6090	4020	1118.05	0.2665
6	23.5	7.1	161	86	437	4	383	305	890	3880	2500	755.91	-0.1026
7	25	7.34	181	61	299	3.5	355	244	649	2840	1900	702.97	-0.6211
8	22	7.8	250	100	506	3.5	447	427	1000	3410	2850	1035.75	2.9171
9	22	7.9	370	145	529	4.1	808	488	1000	4760	3500	1520.57	1.8964
10	22.5	7.14	201	90	529	3.11	430	400	900	4160	2800	872.25	4.0361
11	23	7.9	281	110	506	1.64	568	367	961	4340	2900	1154.31	3.6067
12	22.7	7.81	200	100	437	1.72	451	306	900	3880	2580	910.90	1.1357
13	22.3	7.5	281	100	506	1.64	585	427	1000	4410	3000	1113.16	0.0499
14	22	7.11	200	95	391	2.42	440	324	800	3550	2400	890.33	0.7805
15	23	7.22	181	80	322	1.92	344	287	644	3060	2000	781.16	3.3014
16	23.5	7.11	220	85	437	1.64	390	318	880	3840	2450	899.12	3.5398
17	25	7.5	181	85	414	1.64	419	317	750	3400	2275	801.73	2.2359
18	22.7	7.55	161	80	345	1.2	354.6	306	673	3080	2020	731.22	1.1349
19	23	7.65	151	37	276	1.5	240	260	457	2180	1500	529.30	4.8683
20	22.5	7.76	300	130	805	1.95	958	600	1010	5350	4000	1284.05	2.4694
	Second season												
1	23.5	7.08	193	108	471	3.2	487	264	860	3700	2505	926.34	4.2252
2	23.4	7.42	195	91	397	2.7	356	225	843	3350	2300	861.38	5.0418
3	23	7.6	162	64	298	2.6	345	184	590	2970	1850	667.87	2.6946
4	22.6	7.3	149	46	347	1.4	346	186	585	2860	1825	561.34	2.7091
5	24	7.8	270	129	894	6.9	1053	561	1075	6570	4340	1205.03	1.5692
6	24	7.09	173	93	471	3.7	413	281	960	4190	2650	814.68	0.9142
7	25.6	7.2	195	66	322	3.2	383	225	700	3067	2050	758.51	4.380
8	23	7.65	270	107	546	3.4	482	393	1080	4650	3070	1114.50	4.1146
9	22.5	7.7	399	156	571	3.7	872	449	1070	5100	3750	1638.24	3.1683
10	22.8	7.1	217	96	574	2.8	464	368	970	4490	3000	936.89	5.4144
11	23.5	7.78	303	118	544	1.5	613	337	1035	4680	3120	1242.16	4.5596
12	23.4	7.62	216	107	468	1.6	487	282	975	4190	2750	979.66	1.7513
13	22.7	7.4	305	108	546	1.57	631	393	1079	4750	3240	1206.01	1.330
14	22.5	7.07	217	110	422	2.23	475	298	865	3800	2570	994.50	2.760
15	24	7.13	193	100	344	1.76	371	264	695	3300	2150	893.42	5.8841
16	24	7.09	237	86	470	1.55	421	292	950	4145	2625	945.68	3.9466
17	25.6	7.39	196	91	447	1.53	452	291	800	3670	2450	863.88	3.6992
18	23	7.46	175	90	372	1.1	382	281	725	3325	2110	807.33	3.0525
19	23.5	7.57	164	40	296	1.45	259	239	490	2350	1600	767.51	6.523
20	23	7.65	324	140	869	1.8	1034	552	1090	5775	4300	969.51	3.730

Accuracy:

Accuracy or systematic error is an error due to a mistake in the method of work or interfere during the analysis [3]. Analytical accuracy was calculated from charges balance (Electroneutrality "En") by epm units, summation of major cations must equal summation of major anions and difference is (Relative difference) [3]

The analytical results are acceptable when the relative difference is less than 5%, according to [3] between 5-10% will be using the results with caution, but in case of being greater than 15% hydrochemical interpretations not reliable.

When applying the above method found accuracy analysis of water samples is within the allowable limits, then it can be relied upon in hydrochemical interpretations, table 2.

Physical and hydrochemical properties of the groundwater of the study area:

Groundwater characterized in the study area as a colorless, odorless, As for the temperature ranged between (22-23.5) and an average of 22.9°C for the first season and between (22.5-25.5) and an average of 23.48°C for the second season.

Hardness values are calculated based on the concentrations of dominant calcium and magnesium in the water ranged values for the first season between (521.53-1520.57) at a rate of 895.2 while values ranged second season between (561.34-1638.24) and an average of 975.72, as for electrical conductivity It depends on the degree of water temperature increase because the water temperature one degree Celsius caused an increase in the electrical conductivity of 2% [4] also increased with increasing concentration of dissolved salts [5]. The importance of measuring electrical conductivity to identify the amount of dissolved material in the water as well as they represent a good guide to determine the degree of mineralization of water, according to [5].

Electrical conductivity values of groundwater in the study area ranged between the first season (2180-6090) and at the rate of 3709.5 second season ranged between (2350-6570) and at the rate of 4046.6 and so this water is very high degree of mineralization (Excessively mineralized water).

Concentrations of the total soluble salts vary in the water depending on the recharge of water to groundwater and speed of groundwater, rock and mineral composition of reservoir [10], total dissolved sold values ranged in the study area for the first season between (1500-4000) and an average of 2530.75 for the second season ranged between (1600-4340) and the rate of 2712.75 and can be seen from the above that the total dissolved sold behave the same as the EC values. Are lower in the first season because of recharge operations that lead to dilution operations and this was also noted in amount of positive and negative ions.

The hydrochemical formula and water type:

The importance of identifying the quality of water in the knowledge of geochemical processes through the path of groundwater as increasing the length of the flow path of the water type changes from bicarbonates to sulfate & chloride, and this is reflected in addition to the length of the path and the flow path on ionic exchange process between calcium and sodium forming $NaHCO_3$, as can be ion exchange occurs as $CaSO_4$ turns into Na_2SO_4 the reduction of sulfate to the types of $CaSO_4$ and Na_2SO_4 leads to the formation of Ca $(HCO3)_2$ and $NaHCO_3$ [6]. The details of these variables to the quality of water are shown in figure 5.

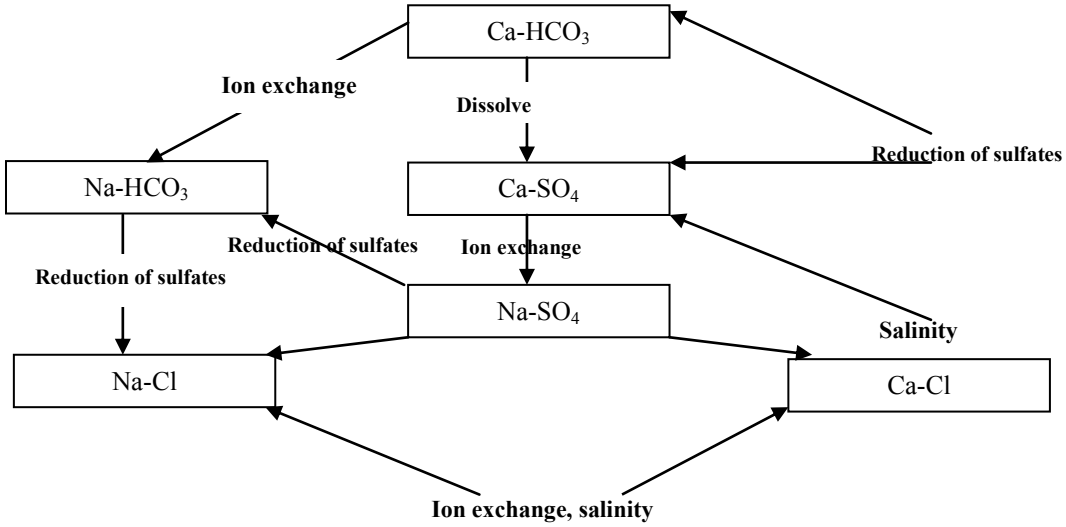

Figure 5-the chemical operations responsible of different ground water (after Adams, et al., 2001)

The following table shows the hydrochemical formula and chemical type of ground water of the upper part of Mandali basin, shows through those tables that chemical predominant type of water is sulphate followed by chloride.

Table 3- Hydrochemical formula and ground water type for the study area wells (first season)

Sa. No.	Hydrochemical Formula	Water Type	Sa. No.	Hydrochemical Formula	Water Type
1	$\underset{2.35}{TDS}\ \frac{\underset{48.9}{SO_4^{-2}}\ \underset{37.3}{Cl^{-1}}\ \underset{13.8}{HCO_3^{-1}}}{\underset{52.3}{Na^{+1}}\ \underset{24.6}{Ca^{+2}}\ \underset{22.7}{Mg^{+2}}\ \underset{0.3}{K^{+1}}}\ pH=7.11$	Na_2SO_4	14	$\underset{2.4}{TDS}\ \frac{\underset{48.48}{SO_4^{-2}}\ \underset{36.06}{Cl^{-1}}\ \underset{15.45}{HCO_3^{-1}}}{\underset{48.69}{Na^{+1}}\ \underset{28.64}{Ca^{+2}}\ \underset{22.48}{Mg^{+2}}\ \underset{0.17}{K^{+1}}}\ pH=7.11$	Na_2SO_4
2	$\underset{2.15}{TDS}\ \frac{\underset{54.9}{SO_4^{-2}}\ \underset{31.4}{Cl^{-1}}\ \underset{13.5}{HCO_3^{-1}}}{\underset{49.7}{Na^{+1}}\ \underset{22.2}{Ca^{+2}}\ \underset{21.8}{Mg^{+2}}\ \underset{0.2}{K^{+1}}}\ pH=7.5$	Na_2SO_4	15	$\underset{2.00}{TDS}\ \frac{\underset{48.24}{SO_4^{-2}}\ \underset{34.84}{Cl^{-1}}\ \underset{16.92}{HCO_3^{-1}}}{\underset{47.12}{Na^{+1}}\ \underset{30.46}{Ca^{+2}}\ \underset{22.25}{Mg^{+2}}\ \underset{0.16}{K^{+1}}}\ pH=7.22$	Na_2SO_4
3	$\underset{1.72}{TDS}\ \frac{\underset{48.2}{SO_4^{-2}}\ \underset{38.09}{Cl^{-1}}\ \underset{13.83}{HCO_3^{-1}}}{\underset{48.72}{Na^{+1}}\ \underset{30.57}{Ca^{+2}}\ \underset{20.21}{Mg^{+2}}\ \underset{0.31}{K^{+1}}}\ pH=7.8$	Na_2SO_4	16	$\underset{2.45}{TDS}\ \frac{\underset{53.09}{SO_4^{-2}}\ \underset{31.22}{Cl^{-1}}\ \underset{15.02}{HCO_3^{-1}}}{\underset{51.26}{Na^{+1}}\ \underset{29.67}{Ca^{+2}}\ \underset{18.95}{Mg^{+2}}\ \underset{0.12}{K^{+1}}}\ pH=7.11$	Na_2SO_4
4	$\underset{1.70}{TDS}\ \frac{\underset{47.42}{SO_4^{-2}}\ \underset{38.18}{Cl^{-1}}\ \underset{13.88}{HCO_3^{-1}}}{\underset{57.16}{Na^{+1}}\ \underset{28.17}{Ca^{+2}}\ \underset{14.51}{Mg^{+2}}\ \underset{0.16}{K^{+1}}}\ pH=7.46$	Na_2SO_4	17	$\underset{2.27}{TDS}\ \frac{\underset{47.89}{SO_4^{-2}}\ \underset{36.18}{Cl^{-1}}\ \underset{15.93}{HCO_3^{-1}}}{\underset{52.76}{Na^{+1}}\ \underset{26.83}{Ca^{+2}}\ \underset{20.59}{Mg^{+2}}\ \underset{0.12}{K^{+1}}}\ pH=7.50$	Na_2SO_4
5	$\underset{4.02}{TDS}\ \frac{\underset{47.11}{SO_4^{-2}}\ \underset{33.74}{Cl^{-1}}\ \underset{17.15}{HCO_3^{-1}}}{\underset{61.12}{Na^{+1}}\ \underset{21.33}{Ca^{+2}}\ \underset{16.92}{Mg^{+2}}\ \underset{0.33}{K^{+1}}}\ pH=7.99$	NaCl	18	$\underset{2.02}{TDS}\ \frac{\underset{48.31}{SO_4^{-2}}\ \underset{34.42}{Cl^{-1}}\ \underset{17.28}{HCO_3^{-1}}}{\underset{50.52}{Na^{+1}}\ \underset{27.11}{Ca^{+2}}\ \underset{22.26}{Mg^{+2}}\ \underset{0.11}{K^{+1}}}\ pH=7.55$	Na_2SO_4
6	$\underset{2.50}{TDS}\ \frac{\underset{54.01}{SO_4^{-2}}\ \underset{31.43}{Cl^{-1}}\ \underset{14.56}{HCO_3^{-1}}}{\underset{55.46}{Na^{+1}}\ \underset{23.49}{Ca^{+2}}\ \underset{20.47}{Mg^{+2}}\ \underset{0.30}{K^{+1}}}\ pH=7.10$	Na_2SO_4	19	$\underset{1.50}{TDS}\ \frac{\underset{46.34}{SO_4^{-2}}\ \underset{32.91}{Cl^{-1}}\ \underset{20.57}{HCO_3^{-1}}}{\underset{52.98}{Na^{+1}}\ \underset{23.34}{Ca^{+2}}\ \underset{13.51}{Mg^{+2}}\ \underset{0.17}{K^{+1}}}\ pH=7.65$	NaCl
7	$\underset{1.90}{TDS}\ \frac{\underset{49.13}{SO_4^{-2}}\ \underset{36.34}{Cl^{-1}}\ \underset{14.53}{HCO_3^{-1}}}{\underset{47.83}{Na^{+1}}\ \underset{33.29}{Ca^{+2}}\ \underset{18.55}{Mg^{+2}}\ \underset{0.33}{K^{+1}}}\ pH=7.34$	Na_2SO_4	20	$\underset{4.00}{TDS}\ \frac{\underset{46.64}{SO_4^{-2}}\ \underset{36.36}{Cl^{-1}}\ \underset{16.99}{HCO_3^{-1}}}{\underset{57.57}{Na^{+1}}\ \underset{24.67}{Ca^{+2}}\ \underset{17.67}{Mg^{+2}}\ \underset{0.08}{K^{+1}}}\ pH=7.76$	Na_2SO_4
8	$\underset{2.85}{TDS}\ \frac{\underset{51.54}{SO_4^{-2}}\ \underset{31.15}{Cl^{-1}}\ \underset{17.32}{HCO_3^{-1}}}{\underset{51.34}{Na^{+1}}\ \underset{29.17}{Ca^{+2}}\ \underset{19.25}{Mg^{+2}}\ \underset{0.21}{K^{+1}}}\ pH=7.8$	Na_2SO_4			
9	$\underset{3.5}{TDS}\ \frac{\underset{44.12}{SO_4^{-2}}\ \underset{40.38}{Cl^{-1}}\ \underset{15.52}{HCO_3^{-1}}}{\underset{42.92}{Na^{+1}}\ \underset{34.52}{Ca^{+2}}\ \underset{22.36}{Mg^{+2}}\ \underset{0.20}{K^{+1}}}\ pH=7.9$	NaCl			
10	$\underset{2.80}{TDS}\ \frac{\underset{50.11}{SO_4^{-2}}\ \underset{32.37}{Cl^{-1}}\ \underset{17.52}{HCO_3^{-1}}}{\underset{56.69}{Na^{+1}}\ \underset{24.77}{Ca^{+2}}\ \underset{18.34}{Mg^{+2}}\ \underset{0.20}{K^{+1}}}\ pH=7.14$	Na_2SO_4			
11	$\underset{2.9}{TDS}\ \frac{\underset{47.63}{SO_4^{-2}}\ \underset{38.06}{Cl^{-1}}\ \underset{14.31}{HCO_3^{-1}}}{\underset{48.69}{Na^{+1}}\ \underset{31.09}{Ca^{+2}}\ \underset{20.13}{Mg^{+2}}\ \underset{0.09}{K^{+1}}}\ pH=7.9$	Na_2SO4			
12	$\underset{2.58}{TDS}\ \frac{\underset{51.41}{SO_4^{-2}}\ \underset{34.84}{Cl^{-1}}\ \underset{13.75}{HCO_3^{-1}}}{\underset{50.92}{Na^{+1}}\ \underset{26.81}{Ca^{+2}}\ \underset{22.15}{Mg^{+2}}\ \underset{0.12}{K^{+1}}}\ pH=7.81$	Na_2SO_4			
13	$\underset{3.00}{TDS}\ \frac{\underset{47.02}{SO_4^{-2}}\ \underset{37.18}{Cl^{-1}}\ \underset{15.79}{HCO_3^{-1}}}{\underset{49.59}{Na^{+1}}\ \underset{31.67}{Ca^{+2}}\ \underset{18.63}{Mg^{+2}}\ \underset{0.09}{K^{+1}}}\ pH=7.5$	Na_2SO_4			

Table 4- Hydrochemical formula and ground water type for the study area wells (second season)

Sa. No.	Hydrochemical Formula	Water Type	Sa. No.	Hydrochemical Formula	Water Type
1	$\underset{49.82}{SO_4^{-2}}\ \underset{38.14}{Cl^{-1}}\ \underset{12.03}{HCO_3^{-1}}$ $\underset{2.505}{TDS}$ $\frac{\underset{52.32}{Na^{+1}}\ \underset{24.66}{Ca^{+2}}\ \underset{22.81}{Mg^{+2}}\ \underset{0.21}{K^{+1}}}{}$ $pH = 7.08$	Na_2SO_4	14	$\underset{49.66}{SO_4^{-2}}\ \underset{36.87}{Cl^{-1}}\ \underset{13.46}{HCO_3^{-1}}$ $\underset{2.57}{TDS}$ $\frac{\underset{47.85}{Na^{+1}}\ \underset{28.29}{Ca^{+2}}\ \underset{23.17}{Mg^{+2}}\ \underset{0.20}{K^{+1}}}{}$ $pH = 7.07$	Na_2SO_4
2	$\underset{56.15}{SO_4^{-2}}\ \underset{32.06}{Cl^{-1}}\ \underset{11.79}{HCO_3^{-1}}$ $\underset{2.30}{TDS}$ $\frac{\underset{49.88}{Na^{+1}}\ \underset{28.17}{Ca^{+2}}\ \underset{22.81}{Mg^{+2}}\ \underset{0.20}{K^{+1}}}{}$ $pH = 7.42$	Na_2SO_4	15	$\underset{49.48}{SO_4^{-2}}\ \underset{35.72}{Cl^{-1}}\ \underset{14.79}{HCO_3^{-1}}$ $\underset{2.15}{TDS}$ $\frac{\underset{45.44}{Na^{+1}}\ \underset{29.32}{Ca^{+2}}\ \underset{25.12}{Mg^{+2}}\ \underset{0.12}{K^{+1}}}{}$ $pH = 7.13$	Na_2SO_4
3	$\underset{47.62}{SO_4^{-2}}\ \underset{38.83}{Cl^{-1}}\ \underset{12.05}{HCO_3^{-1}}$ $\underset{1.85}{TDS}$ $\frac{\underset{48.05}{Na^{+1}}\ \underset{30.66}{Ca^{+2}}\ \underset{20.03}{Mg^{+2}}\ \underset{0.25}{K^{+1}}}{}$ $pH = 7.60$	Na_2SO_4	16	$\underset{54.32}{SO_4^{-2}}\ \underset{32.55}{Cl^{-1}}\ \underset{13.14}{HCO_3^{-1}}$ $\underset{2.625}{TDS}$ $\frac{\underset{51.82}{Na^{+1}}\ \underset{30.05}{Ca^{+2}}\ \underset{18.03}{Mg^{+2}}\ \underset{0.10}{K^{+1}}}{}$ $pH = 7.09$	Na2SO4
4	$\underset{48.78}{SO_4^{-2}}\ \underset{39.01}{Cl^{-1}}\ \underset{12.21}{HCO_3^{-1}}$ $\underset{1.825}{TDS}$ $\frac{\underset{57.21}{Na^{+1}}\ \underset{28.25}{Ca^{+2}}\ \underset{14.42}{Mg^{+2}}\ \underset{0.14}{K^{+1}}}{}$ $pH = 7.30$	Na_2SO_4	17	$\underset{48.77}{SO_4^{-2}}\ \underset{37.26}{Cl^{-1}}\ \underset{13.96}{HCO_3^{-1}}$ $\underset{2.45}{TDS}$ $\frac{\underset{51.82}{Na^{+1}}\ \underset{26.63}{Ca^{+2}}\ \underset{20.44}{Mg^{+2}}\ \underset{0.11}{K^{+1}}}{}$ $pH = 7.39$	Na_2SO_4
5	$\underset{48.43}{SO_4^{-2}}\ \underset{36.56}{Cl^{-1}}\ \underset{15.02}{HCO_3^{-1}}$ $\underset{4.34}{TDS}$ $\frac{\underset{61.49}{Na^{+1}}\ \underset{21.36}{Ca^{+2}}\ \underset{16.86}{Mg^{+2}}\ \underset{0.28}{K^{+1}}}{}$ $pH = 7.80$	NaCl	18	$\underset{49.57}{SO_4^{-2}}\ \underset{35.32}{Cl^{-1}}\ \underset{15.12}{HCO_3^{-1}}$ $\underset{2.11}{TDS}$ $\frac{\underset{49.93}{Na^{+1}}\ \underset{27.02}{Ca^{+2}}\ \underset{22.96}{Mg^{+2}}\ \underset{0.08}{K^{+1}}}{}$ $pH = 7.46$	Na_2SO_4
6	$\underset{55.12}{SO_4^{-2}}\ \underset{32.10}{Cl^{-1}}\ \underset{12.72}{HCO_3^{-1}}$ $\underset{2.65}{TDS}$ $\frac{\underset{55.48}{Na^{+1}}\ \underset{23.44}{Ca^{+2}}\ \underset{20.83}{Mg^{+2}}\ \underset{0.26}{K^{+1}}}{}$ $pH = 7.09$	Na_2SO_4	19	$\underset{47.65}{SO_4^{-2}}\ \underset{34.06}{Cl^{-1}}\ \underset{18.28}{HCO_3^{-1}}$ $\underset{1.60}{TDS}$ $\frac{\underset{52.72}{Na^{+1}}\ \underset{37.59}{Ca^{+2}}\ \underset{13.45}{Mg^{+2}}\ \underset{0.15}{K^{+1}}}{}$ $pH = 7.50$	Na_2SO_4
7	$\underset{50.18}{SO_4^{-2}}\ \underset{37.13}{Cl^{-1}}\ \underset{12.70}{HCO_3^{-1}}$ $\underset{2.05}{TDS}$ $\frac{\underset{57.61}{Na^{+1}}\ \underset{21.60}{Ca^{+2}}\ \underset{20.50}{Mg^{+2}}\ \underset{0.28}{K^{+1}}\ 31}{}$ $pH = 7.20$	Na_2SO_4	20	$\underset{47.84}{SO_4^{-2}}\ \underset{37.29}{Cl^{-1}}\ \underset{14.86}{HCO_3^{-1}}$ $\underset{4.30}{TDS}$ $\frac{\underset{57.59}{Na^{+1}}\ \underset{24.69}{Ca^{+2}}\ \underset{17.64}{Mg^{+2}}\ \underset{0.07}{K^{+1}}}{}$ $pH = 7.65$	NaCl
8	$\underset{52.92}{SO_4^{-2}}\ \underset{31.93}{Cl^{-1}}\ \underset{15.15}{HCO_3^{-1}}$ $\underset{3.07}{TDS}$ $\frac{\underset{51.42}{Na^{+1}}\ \underset{29.24}{Ca^{+2}}\ \underset{19.15}{Mg^{+2}}\ \underset{0.19}{K^{+1}}}{}$ $pH = 7.65$	Na_2SO_4			
9	$\underset{45.31}{SO_4^{-2}}\ \underset{41.12}{Cl^{-1}}\ \underset{13.57}{HCO_3^{-1}}$ $\underset{3.75}{TDS}$ $\frac{\underset{42.97}{Na^{+1}}\ \underset{34.54}{Ca^{+2}}\ \underset{22.32}{Mg^{+2}}\ \underset{0.16}{K^{+1}}}{}$ $pH = 7.70$	NaCl			
10	$\underset{51.41}{SO_4^{-2}}\ \underset{33.25}{Cl^{-1}}\ \underset{15.35}{HCO_3^{-1}}$ $\underset{3.00}{TDS}$ $\frac{\underset{56.96}{Na^{+1}}\ \underset{24.76}{Ca^{+2}}\ \underset{18.12}{Mg^{+2}}\ \underset{0.16}{K^{+1}}}{}$ $pH = 7.10$	Na_2SO_4			
11	$\underset{48.62}{SO_4^{-2}}\ \underset{38.93}{Cl^{-1}}\ \underset{12.45}{HCO_3^{-1}}$ $\underset{3.12}{TDS}$ $\frac{\underset{48.67}{Na^{+1}}\ \underset{31.17}{Ca^{+2}}\ \underset{20.07}{Mg^{+2}}\ \underset{0.08}{K^{+1}}}{}$ $pH = 7.78$	Na_2SO4			
12	$\underset{52.55}{SO_4^{-2}}\ \underset{35.49}{Cl^{-1}}\ \underset{11.96}{HCO_3^{-1}}$ $\underset{2.75}{TDS}$ $\frac{\underset{50.83}{Na^{+1}}\ \underset{26.97}{Ca^{+2}}\ \underset{22.08}{Mg^{+2}}\ \underset{0.11}{K^{+1}}}{}$ $pH = 7.62$	Na_2SO_4			
13	$\underset{48.14}{SO_4^{-2}}\ \underset{38.06}{Cl^{-1}}\ \underset{13.77}{HCO_3^{-1}}$ $\underset{3.24}{TDS}$ $\frac{\underset{40.51}{Na^{+1}}\ \underset{31.80}{Ca^{+2}}\ \underset{18.61}{Mg^{+2}}\ \underset{0.08}{K^{+1}}}{}$ $pH = 7.40$	Na_2SO_4			

Genetic of ground water:

To distinguish the origin of the water used ratio or index rNa + rK / rCl hydrochemical property and it value to be larger than the one in the water with cosmic origin and less than one in the same marine origin water [7] The following table shows the hydrochemical index of groundwater in the study area for two seasons, it appears through the table for two seasons as infiltrated atmospheric origin.

Table 5- functions hydrochemical index of ground water in the study area for two season

No. of Samples	rSO4/rCl	rMg/rCl	rCa/rCl	rK+rNa/rCl	rK/rCl	Na/K
First season						
1	1.312	0.651	0.704	19.007	0.007	124.857
2	1.748	0.756	0.974	16.008	0.008	122.667
3	1.267	0.550	0.832	12.008	0.008	95.172
4	1.255	0.394	0.765	14.004	0.004	214.667
5	0.759	0.361	0.455	36.007	0.007	110.400
6	1.719	0.659	0.746	19.010	0.010	109.250
7	1.352	0.504	0.905	13.009	0.009	85.429
8	1.655	0.656	0.993	22.007	0.007	144.571
9	0.915	0.527	0.813	23.005	0.005	129.024
10	1.548	0.614	0.830	23.007	0.007	170.096
11	1.251	0.568	0.878	22.003	0.003	308.537
12	1.476	0.651	0.787	19.003	0.003	254.070
13	1.264	0.502	0.853	22.003	0.003	308.537
14	1.345	0.633	0.807	17.005	0.005	161.570
15	1.385	0.682	0.934	14.005	0.005	167.708
16	1.669	0.639	1.001	19.004	0.004	266.463
17	1.324	0.595	0.767	18.004	0.004	252.439
18	1.404	0.662	0.806	15.003	0.003	287.500
19	1.408	0.452	1.117	12.006	0.006	184.000
20	0.780	0.398	0.556	35.002	0.002	412.821
Second season						
1	1.30604	0.650636	0.703439	1.49875	0.005981	249.5788
2	1.751317	0.749954	0.972261	1.728142	0.006904	249.3237
3	1.264795	0.544257	0.833478	1.340067	0.00686	194.3478
4	1.250452	0.390054	0.764379	1.551622	0.003683	420.2795
5	0.755035	0.359422	0.455128	1.316382	0.005965	219.6975
6	1.719128	0.660657	0.743523	1.768393	0.008155	215.8519
7	1.259631	0.471135	0.842153	1.216333	0.007087	170.625
8	1.657158	0.651298	0.994295	1.754842	0.006421	272.3018
9	0.907516	0.524869	0.812185	1.014557	0.003862	261.6804
10	1.546112	0.607011	0.830119	1.914882	0.005493	347.6087
11	1.248726	0.564761	0.877365	1.37197	0.002227	614.9565
12	1.480685	0.644611	0.787269	1.486251	0.002991	495.9783
13	1.264676	0.502155	0.857964	1.095664	0.002265	482.7749
14	1.467293	0.7402	0.883429	1.498573	0.004656	320.8813
15	1.385473	0.790804	0.923383	1.435468	0.004318	331.4229
16	1.668894	0.599321	0.999228	1.726474	0.003351	514.1655
17	1.308997	0.590671	0.76969	1.529486	0.003081	495.3964
18	1.403659	0.691229	0.813154	1.505694	0.002621	573.4387
19	1.399212	0.985513	1.123938	1.769071	0.005096	346.1469
20	0.779638	0.110659	0.55619	1.298763	0.001585	818.6232

The value of rCa / rCl and rSO4 / rCl and rMg / rCl higher than the in sea water in both seasons, which refers to contain this water sulfate salts due to weathering of minerals carbonate and calcium

sulfate, magnesium, configurate by gypsum and calcite and dolomite in the form of a cement between the rock components of the formation Bai Hassan and Muqdadiyah, as well as gypsum, and anhydrite in Quaternary sediments, which adds to the water ions Na, Ca, Mg, which refers to the open-oxidizing environment. Indicate that the groundwater of Mandali basin has a long flow path and go a great distance from recharge areas to discharge areas

The high value of the geochemical index Na / K, as well as low value of the geochemical index rK / rCl of Mandali basin and is evidence that this water with infiltrated atmospheric origin had dissolve layers poor of minerals potass feldspar. And is known as the formation Bai Hassan and Muqdadiyah of continental origin since the formation of Muqdadiyah is the formation of a depositional river environment and the formation of Bai Hassan is the result of erosion processes in the mountains [8]; therefore, there are no unusual or marine waters confined in precipitation basin between these two formations components rocks.

Groundwater classification:

There are several methods for hydrochemical classification including the [9], which Schoeller suggested the semi-logarithmic to represent the kinds of water through proj the concentrations of ions of the main components of the water on the vertical axis table 6 and the use of these schemes Schoeller could divides the water to (36) species, and concluded that the increase in salinity in certain direction refers to the direction of water flow. The advantage of this scheme easily read the absolute focus of the elements and to identify the origin of groundwater through Note slop of straight line connecting the two (rCl, rNa + K). When applying classification Schoeller on water samples of the upper Mandali basin conclude predominant of sulfate group, except wells (5,9,20) for two seasons fall within the range of chlorides, figure 6

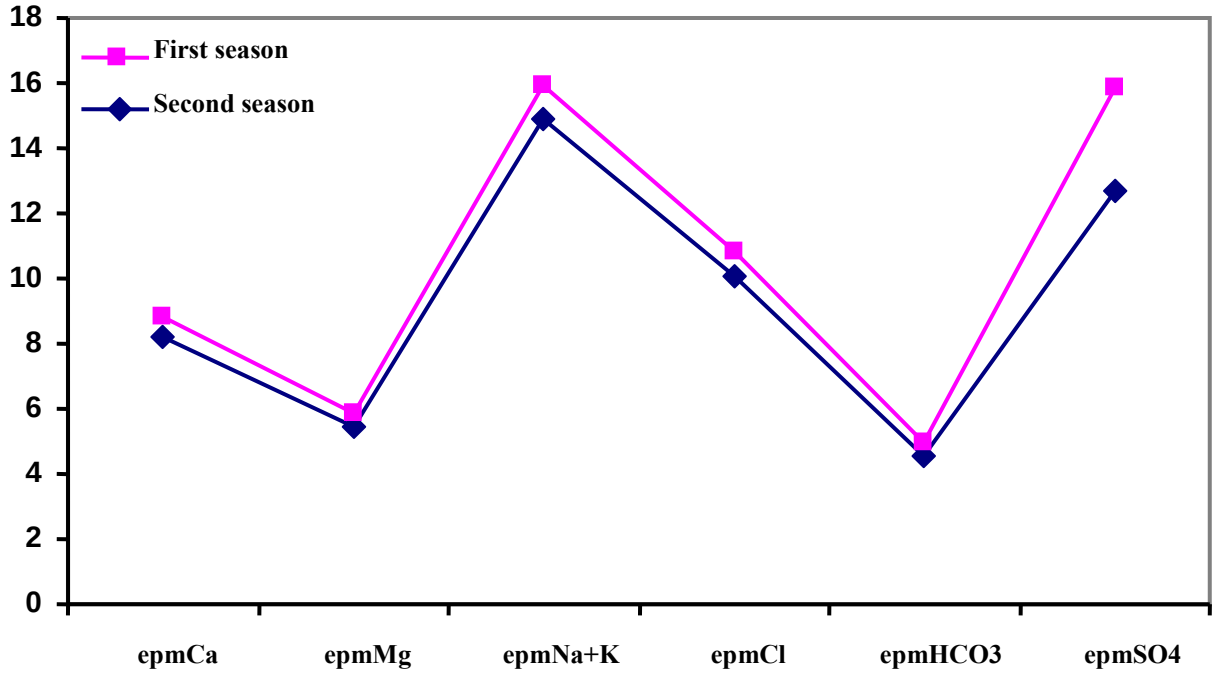

Figure 6- Schoeller classification for ground water samples for the two seasons in the study area

Table 6- Water quality for the wells of the study area for the first and second seasons by Schoeller method

Well No.	type		Family	Group
	Anions	Cations		
First season				
1	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
2	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
3	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
4	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
5	Cl>SO_4>HCO_3	Na>Ca>Mg	Na-Cl	Cl
6	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
7	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
8	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
9	Cl>SO_4>HCO_3	Na>Ca>Mg	Na-Cl	Cl
10	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
11	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
12	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
13	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
14	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
15	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
16	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
17	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
18	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
19	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
20	Cl>SO_4>HCO_3	Na>Ca>Mg	Na-Cl	Cl
Second season				
1	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
2	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
3	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
4	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
5	Cl>SO_4>HCO_3	Na>Ca>Mg	Na-Cl	Cl
6	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
7	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
8	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
9	Cl>SO_4>HCO_3	Na>Ca>Mg	Na-Cl	Cl
10	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
11	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
12	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
13	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
14	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
15	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
16	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
17	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
18	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
19	SO_4>Cl>HCO_3	Na>Ca>Mg	Na-SO_4	SO_4
20	Cl>SO_4>HCO_3	Na>Ca>Mg	Na-Cl	Cl

Groundwater uses:

Water uses for drinking purposes:

Developed a multi-standard specifications for potable water and compared the concentrations of ions and total soluble salinity samples of groundwater in the study area and for two seasons show that groundwater in the study area is unsafe to drink, according to the [10,11].

Water uses for Livestock:

Used the proposed specifications [12] that rely on some of the positive and negative ions and dissolved salts and total hardness, and when the waters of the study area compared with these specifications are found to be fit for animal consumption.

Water uses for industrial purposes:

[4] notify some of the standard specifications of the water used in various industries and water when compared to the study area and for two seasons shows that this water is not suitable to all industries

Water uses for building and construction purpose:

[12] use Classification to examine the validity of the water in the upper part of Mandali basin for the purposes of building and construction, and show that the water in the study area is valid for the purposes of building and construction.

Water quality for irrigation purposes:

According to the standard specifications of irrigation water [13], the groundwater of the study area showed that the following wells with water suitable for irrigation purposes and for two seasons (3.4, 7, 15, 18, and 19)

Conclusions:

1. There is alittle seasonal variation of the quality of ground water due to the heavy rains and excess dilution processes in the humid period
2. Groundwater of the study areas are colorless, odorless, dominated by sulfate ions, sodium, and that most of the study area of water type sodium sulfate Na_2SO_4
3. Through the study of the origin of groundwater she appeared with atmospheric assets and for two seasons, and classification of (Shoeller) show that the predominant type of chemical for both seasons is sulphates
4. Finding through the study of ground water for different uses validity that water unfit to drink and is suitable for industrial uses and for two seasons. While his valid for animal consumption for the purposes of building and construction. For irrigation water. Most samples are invalid except the wells (3,4,7,15,18,19) and for two seasons.

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