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Assessment of Dibdibba Groundwater Quality Using the Multivariate Statistical Technique in Zuber area South of Iraq

Tariq Abed Hussain[1], Inass Abdalrazaq Almallah[2], Wasan S. Al-Qurnawi[*2]
[1]Civil Engineering Department-University of Technology-Baghdad
[2] Geology Department-College of Science-University of Basrah

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Abstract

Thirty-three samples of groundwater were taken from Dibdibba unconfined aquifer in the Zuber area southwestern parts of Basrah governorate south of Iraq to assess the groundwater quality. A statistical multivariate analysis was done using cations and anions, pH, total dissolved solids (TDS), and electrical conductivity (EC) that were measured for drinking, livestock, and construction purposes. Residual sodium bicarbonate (RSBC), Magnesium Ratio (MR), and Permeability index (PI) were used to evaluate the suitability of the present samples for irrigation activity. The quality of groundwater in the study area is unsuitable for drinking water, industrial and building uses. But it is suitable for livestock uses, According to Residual Sodium Carbonate and Magnesium Ratio the groundwater in the study area are suitable for irrigation purposes, but unsuitable for Permeability index. Multivariate analysis results indicate the high positive correlation between Ec and TDS with other constituents, two significant clusters I and II are obtained with significant Ec and TDS responsible for playing the most effective in classifying the present samples. 71.85% and l2.21% of the present of the total variance of the groundwater samples were explained by Factor analyses, Factor I indicated increasing Cl^-, Mg^{+2}, Na^+, and Ca^{+2} with the highest weight and Factor II show lower weight average of K^+ concentration only. The results confirm the dissolution of sulfate salts and evaporate minerals, in addition to high agricultural lands and farm activities, besides the wastes from chemical construction industries.

Keywords: Groundwater quality, Multivariate analyses, Dibdibba formation, Zuber, Iraq.

التقييم النوعي لخزان الدبدبة باستخدام التقانات الاحصائية المتعددة المتغيرات في منطقة الزبير جنوب العراق

طارق عبد حسين[1]، ايناس عبد الرزاق الملاح[2]، وسن صبيح حمدان*[2]
[1]قسم الهندسة المدنية، الجامعة التكنولوجية، بغداد، العراق
[2]قسم علم الارض، كلية العلوم، جامعة البصرة، البصرة، العراق

الخلاصة

تم نمذجة 33 عينة من المياه الجوفية من خزان الدبدبة غير المحصور في منطقة الزبير ضمن محافظة البصرة, جنوب العراق لغرض تقييم نوعية المياه الجوفية. تم اجراء التحليلالاحصائي المتعدد المتغيرات بأستخدام الايونات الرئيسية الموجبة والسالبة، دالة الحامضية Ph، المواد الصلبة الكلية الذائبة TDS ،

*Email: wasan.hamdan@uobasrah.edu.iq

والتوصيلية الكهربائية Ec واستخدامها في تقييم مدى صلاحيتها لاغراض الشرب والرعي والبناء، تم استخدام مؤشر بيكربونات الصوديوم المتبقية (RSBC) ونسبة المغنيسيوم (MR) ومؤشر النفاذية (PI) لتقييم مدى ملائمة العينات لمنطقة الدراسة لاغراض النشاط الزراعي. جودة المياه الجوفية في منطقة الدراسة غير صالحة لمياه الشرب والاستخدامات الصناعية والمباني. لكنها مناسبة للاستخدامات الحيوانية ،وفقًا لنسبة كربونات الصوديوم والمغنيسيوم المتبقية، فإن المياه الجوفية في منطقة الدراسة مناسبة لأغراض الري، ولكنها غير مناسبة لمؤشر النفاذية. تشير نتائج التحليلات الاحصائية المتعددة المتغيرات إلى وجود علاقة موجبة عالية بين Ec و TDS مع المكونات الأخرى ، تم الحصول على مجموعتين من العناقيد المهمةI و II مع Ec و TDS ذات تاثير معنوي كبير نسبة لبقية العناصر الاخرى . وجد اثناء التحليل المعاملي وجود71.85٪ و I2.21٪ من إجمالي التباينات من عينات المياه الجوفية ، اشار تحليل العامل الاول I الى زيادة في تراكيز كل من Na^+, Mg^{+2}, Cl^- و Ca^{+2} مع زيادة معنوية بينما اوضح تحليل العاملي الثاني II الى انخفاض في معنويةتركيز البوتاسيوم k^+ . وأكدت النتائج زيادة بذوبانية أملاح الكبريتات ومعادن المتبخرات ضمن العينات المدروسة ، ويرجع هذا الى زيادة ارتفاع ألانشطة الزراعية ، إلى جانب زيادة وجود مخلفات الصناعات الكيماوية الإنشائية في المنطقة.

1- Introduction:

In the southwest of Iraq, Zuber-Safwan is located in the province of Basra in Zuber-Safwan between longitudes (47° 30′ 0″ - 47° 50′ 0″) Easting and latitudes (30° 12′ 0″- 30° 25′ 0″) Northing, (Figure- 1). In this regian there are some of trough valleys, some of which are occupied by drainage, which are common in the southern and western parts of the study area. In the rainy season, the valleys are going to be filled with water and are regarded as a recharge system for the main aquifer [1].

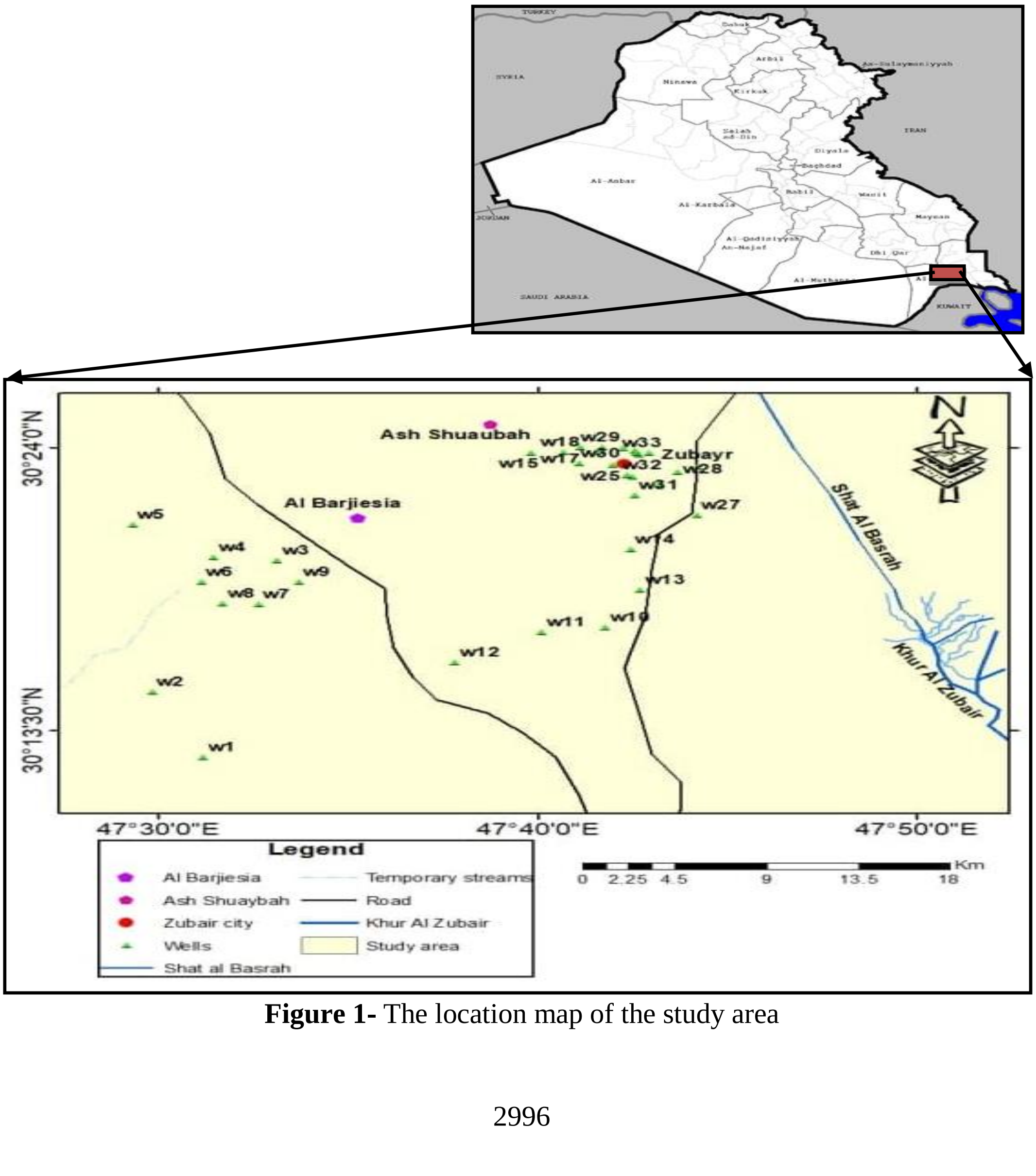

Figure 1- The location map of the study area

Geologically the area is covered by the formation of Dibdibba containing sandy gravel soil. In Dibdibba plain there are numerous geomorphological features in the area, Sand dunes, and shallow wadies including Jabal Sanam hill [2]. In the Mesopotamia area and Zuber area is located within Sagged Basin according to the tectonic divisions of Iraq of the Arabian plate [3].The Mesopotamian Valley is divided into three sub-regions [4] which are Euphrates Subzone, Tigris Subzone and Zuber Subzone. The study area is located within Zuber Subzone.

Dibdibba is considered to be the most important aquifer of the study region in which both the top of the aquifer is unconfined and semi-confined to confined, separated in the deepest layer of the aquifer by a hard clay layer of two to four meters thick. [2].The flow area pattern is distinguished by a path from the west and southwest of the area to the east and northeast towards the Khor al-Zuber drainage area, as well as the Channel of Shatt AL-Basrah, depending on corrected static water levels. (Figure-3).The structural and geological status regulates the flow movement of the groundwater. There are a large number of studies that including the study of Dibdibba aquifer like: [5], who carried out a study on the groundwater quality and hydro-geochemical processes of the shallow Dibdibba aquifer in Basra Governorate, southern Iraq, and concluded that all groundwater samples are not appropriate for human drinking use and for irrigation, as well as noticing a deterioration in the quality of groundwater due to the drilling of a large number of wells In the region, [6] In addition, a study titled Hydrochemical Assessment of Groundwater of Dibdibba Aquifer in Al-Zuber Area, Basra, South of Iraq, and its Suitability Irrigation Purposes was carried out. And concluded that groundwater belongs to Na, Mg, and Ca-Chloride types. The predominance of calcium is obtained mainly by dissolving gypsum. [7] Study type quality of groundwater in elected wells in the Zuber area and the water is classified as having a high rate of minerals. They also concluded that the studied groundwater wells are not suitable for drinking by humans. The research proposed to re-evaluate the under groundwater in the Al-Zuber area as well as to study the multivariate analyzes of the studied samples in the area in addition to studying the validity of groundwater for different uses.

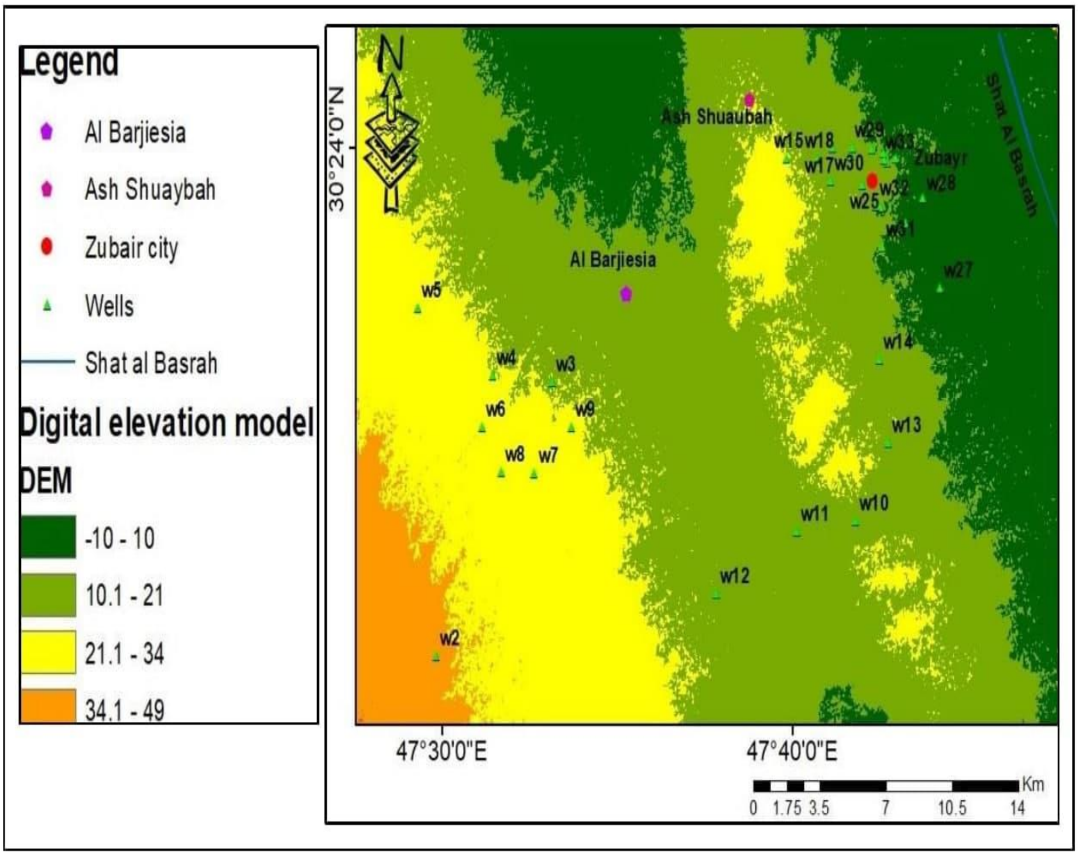

Figure 2- Surface elevation map Digital Elevation Model (DEM) of the study area.

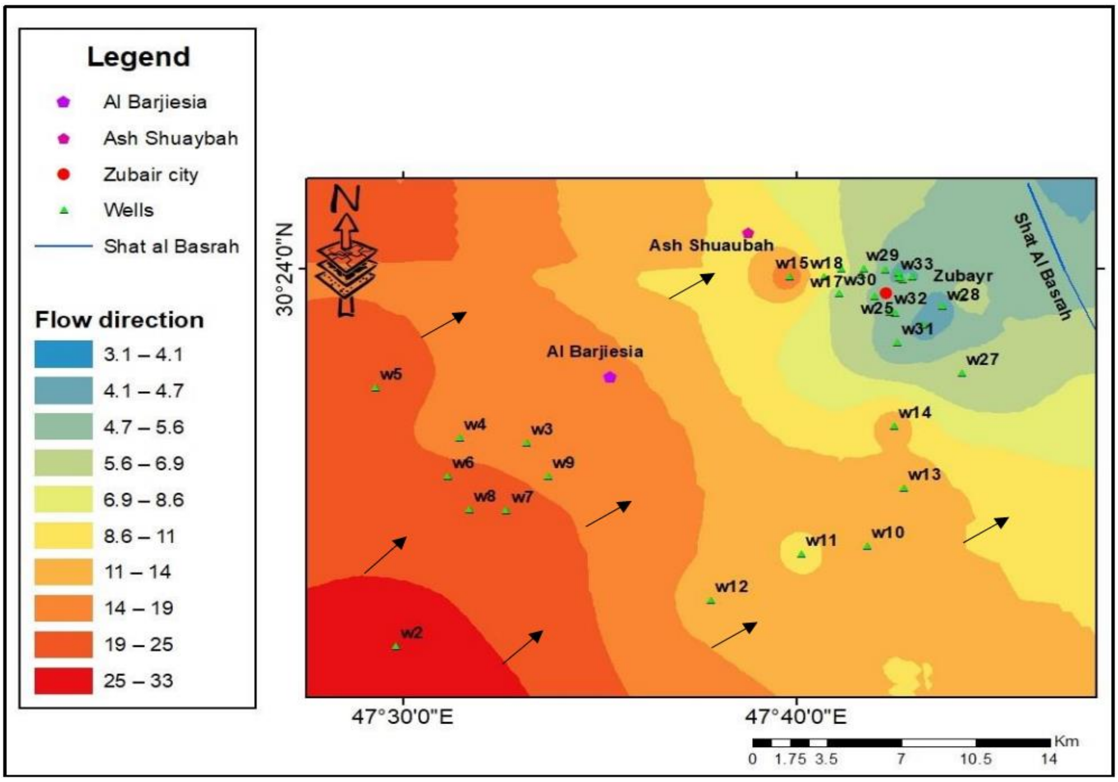

Figure 3- The groundwater flow map of the study area.

Materials and Methods

The physical and chemical parameters of Thirty-three groundwater wells in the Zuber area (Figure-1), were obtained from the General Commission for Groundwater in Baghdad, The analyzes were conducted during October 2018 to assess the quality of groundwater for the Dibdibba Shallow aquifer in Al-Zuber area in Basra Governorate through studying the hydrochemical characteristics of groundwater and evaluation its suitability for different uses. The Groundwater wells characteristics and cations (K^+ ,Na^+ ,Mg^{+2} ,Ca^{+2}), anions (Cl^-,SO_4^{-2}, HCO_3^-,CO_3^{-2} ,NO_3^-), pH, EC, and TDS as shown in Table-1. Residual sodium bicarbonate (RSBC), permeability index (PI), and magnesium (MR) were calculated according to reference research. Descriptive and multivariate analyses were evaluated using statistical SPSS program software version 22 to estimate the most hydrochemical parameters responsible for groundwater quality of the study area.

The accuracy or systematic error is an error due to a mistake in the method of work or interference during the analysis [8], when the relative difference is less than 5% the results will be acceptable and between 5-10%, the results will be used with caution, but in case of being greater than 10% hydrochemical interpretations are not reliable and Concentrations are calculated in epm units. The accuracy analysis of groundwater samples results show within the allowable limits, then it can be relied upon in hydrochemical interpretations (Tables- 1 and 2).

Table 1- Physical and chemical parameters in ppm units of groundwater wells

No.	Deep of well (m.)	pH	EC (µs/cm)	TDS	T.H.	K	Na	Mg	Ca	Cl	SO4	HCO3	NO3
w1	40	7.16	9090	6352	1817..2	13.3	725	192	412	945	1574	538	2
W2	40	7.14	8620	6029	2360.2	16	735	222	580	1086	1795	695	2
W3	24	7.12	9580	6671	1788	19	742	180	420	937	1608	525	4
W4	30	7.28	6920	4876	1700.8	70	792	188	372	845	1699	672	3

W5	30	7.31	6330	4460	1046	40	580	140	340	680	1483	403	3
W6	30	7.23	8160	5751	1977.8	11.7	694.7	204.1	456.6	962	1584	555	0.2
W7	30	7.62	9730	6768	1914.3	23.4	762	198	441	994	1684.8	610	4
W8	30	7.11	10840	7539	1691	39	900	240	542	1242.5	1920	793	5.5
W9	24	7.25	7950	5608	1828.8	11.9	719	193	415	938	1556	535	3.1
W10	15	7.39	8120	5725	1326.1	12	723	199	419	945	1560	541	2.9
W11	12	7.09	14190	9960	2526.22	74	1384.8	372.3	802	2201	2256	1342	9.1
W12	16	7.7	10430	7269	1839.58	74.1	1084.7	312.2	561	1526	2068.8	915	6.2
W13	16	7.19	7510	5319	1177	11	628	180	370	740	1512	514	2.1
W14	17	7.23	7900	5575	1291	13	720	190	410	941	1560	537	2
W15	27	7.2	13300	9860	2031.9	77	1150	346	619	1595	2254	1090	11
W16	25	7.67	3580	2640	1223.2	81	411	127	281	546	997	454	7
W17	16	7.51	4890	3580	1477.8	116	534	158	332	715	1300	508	4
W18	30	7.17	6240	4445	1604.8	99	608	178	350	700	1830	509	2
W19	17	7.62	5003	3890	1379.3	97	545	148	309	668	1297	488	2
W20	24	7.31	6300	4482	1481	99	568	160	330	681	1413	492	2.5
W21	17	7.18	10310	7800	2345.6	39	906	241	543	1242	1912	791	5
W22	18	7.11	13930	10415	2548.3	72	1380	372	811	2209	3260	1340	10
W23	22	7.14	5220	3800	1083.8	18	615	167	340	645	1445	487	2
W24	24	7.51	8730	6437	1547.4	120	586	164	350	791	1367	310	2.3
W25	24	7.12	6230	4338	1572	50	600	170	350	681	1520	512	2
W26	25	7.14	7005	4933	1551.3	91	570	168	345	680	1519	479	2.5
W27	18	7.11	5810	3960	973	93	543	145	308	665	1292	488	3
W28	16	7.43	5720	3890	1526.5	18	614	165	340	675	1445	481	2.5
W29	24	7.31	5310	3748	1532.2	17	615	167	339	673	1445	479	2.5
W30	24	7.23	4160	3018	1427.5	114	530	150	325	710	1213	806	3
W31	18	7.21	7900	5506	1292.1	13	721	189	411	939	1549	540	3
W32	24	7.11	4430	3285	1358.1	95	509	141	312	681	1182	481	2
W33	24	7.14	3970	2890	1175.7	80	416	127	262	540	990	450	9

Table 2- concentrations of major cations and anions for the study area in epm units

Well NO.	K	Na	Mg	Ca	Cl	SO4	HCO3	Accuracy
w1	0.34	31.537	15.793	20.558	26.658	32.77	8.817	0.045
W2	0.409	31.972	18.261	28.942	30.636	37.371	11.391	0.0868
W3	0.485	32.277	14.806	20.958	26.432	33.478	8.604	0.575
W4	1.789	34.452	15.464	18.562	23.837	35.373	11.014	0.032
W5	1.022	25.23	11.516	16.966	19.182	30.876	6.605	1.784
W6	0.299	30.219	16.789	22.784	27.138	32.978	9.096	0.631
W7	0.598	33.147	16.287	22.005	28.04	35.077	9.997	-0.741
W8	0.99	39.15	19.742	27.045	35.05	39.974	12.997	0.627
W9	0.304	31.276	15.876	20.708	26.46	32.395	8.768	0.397
W10	0.306	31.4505	16.369	20.908	26.658	32.479	8.866	0.582
W11	1.892	60.2388	30.625	40.019	62.09	46.969	21.995	0.585
W12	1.894	47.18445	25.681	27.993	43.048	43.072	14.996	7.9
W13	0.281	27.318	14.806	18.463	20.875	31.479	8.424	0.038
W14	0.332	31.32	15.629	20.459	26.545	32.479	8.801	0.079
W15	1.968	50.025	28.461	30.888	44.994	46.928	17.865	0.611
W16	2.071	17.878	10.447	14.021	15.402	20.757	7.441	0.929
W17	2.966	23.229	12.997	16.566	20.17	27.066	8.326	0.203
W18	2.531	26.448	14.642	17.465	19.747	38.1	8.342	-4.009
W19	2.480	23.707	12.174	15.419	18.844	27.003	7.998	-0.055
W20	2.531	24.708	13.161	16.467	19.211	29.418	8.063	0.154
W21	0.997	39.411	19.824	27.095	35.036	39.807	12.964	-0.274
W22	1.841	60.03	30.6	40.468	62.315	67.873	21.962	6.799
W23	0.46	26.752	13.737	16.966	18.195	30.084	7.981	1.406
W24	3.068	25.491	13.49	17.465	22.314	28.46	5.081	3.172
W25	1.278	26.1	13.984	17.465	19.211	31.646	8.391	-0.356
W26	2.326	24.795	13.819	17.215	19.182	31.625	7.85	-0.429
W27	2.378	23.620	11.927	15.369	18.759	26.899	7.998	0.407
W28	0.460	26.709	13.572	16.966	19.041	30.084	7.883	0.609
W29	0.434	26.752	13.737	16.916	18.985	30.084	7.85	0.8008
W30	2.914	23.055	12.339	16.217	20.029	25.254	13.21	-3.51
W31	0.332	31.363	15.547	20.508	26.489	32.25	8.85	0.059
W32	2.429	22.141	11.598	15.568	19.211	24.609	7.883	0.063
W33	2.045	18.096	10.447	13.073	15.233	20.611	7.375	0.508

2- Results and Discussion

Table-3 show the descriptive statistics results of the present groundwater samples

2-1 Physical Properties

In natural waters, the color comes from many reasons such as organic matter, dissolved components, and hemic compounds, which will be enhanced at high water temperature [9]. And from iron, decay organism, planktons, manganese oxides, and industrial wastes [8].The present study results show that all groundwater samples are colorless and odorless, while it has salty taste in some of the groundwater samples due to the increase in TDS values, which causes the salty taste.

Table 3-The descriptive statistics of the physical and chemical properties of groundwater of the study area

Parameter	Minimum	Maximum	Mean	Std. Deviation
pH	7	8	7.27	0.181
EC (ms/cm)	3580	14190	7679.03	2774.448
TDS(ppm)	2640	10415	5479.36	2009.351
K^{+}(ppm)	11	120	55.07	37.903

Na^{+}(ppm)	411	1385	715.49	236.316
Mg^{+2}(ppm)	127	372	196.78	64.792
Ca^{+2}(ppm)	262	811	418.11	133.745
Cl^{-}(ppm)	540	2209	939.95	412.408
SO_4^{-2}(ppm)	990	3260	1608.81	421.302
HCO_3^{-2}(ppm)	310	1342	616.97	243.090
NO_3^{-2}(ppm)	.20	11.00	3.8303	2.62863
RSBC	-18.506	-3.007	-10.75151	3.475819
MR	38.687	47.956	43.65667	1.767339
PI	0.004	0.006	0.00503	0.000166

The temperature has an impact on the acceptability of chemical contaminants and inorganic constituents that may affect groundwater characteristics, where the high water temperature tends to odor, taste, color and corrosion problems [9]. In the study area, groundwater temperature is ranged (21.8-23) with an average 22C^{o}

Hydrogen Number (pH) measurement is among the most important and widely used water chemistry tests, and it plays an important role in the chemical and biological properties of water. [10]The pH values in the groundwater samples rang between (7.09-7.7) with an average (7.27). This indicates that most well water is weakly alkaline.

TDS (Total Dissolved Solids) in a water sample denotes all dissolved, ionized or non-ionized solids in solution. When calculating TDS suspended materials, colloids, or dissolved gases are not taken into account [11] .TDS values in the groundwater samples range between (3800-10415) ppm with an average (5479.36) ppm. According to [12]and [13]the water samples are considered to be Slightly-brackish water.

The Electrical Conductivity (EC) value of groundwater samples ranged between (3580-14190) (μs/cm) with an average of 7679.03 (μs/cm). According to [14], the groundwater samples in the study are classified as excessively mineralized water. Figures- (4 and 5) show the distribution of TDS and Ec within the study area, with the greatest concentrations concentrated in the northern part of the study area due to increased irrigation purposes in addition to municipal activity in these areas

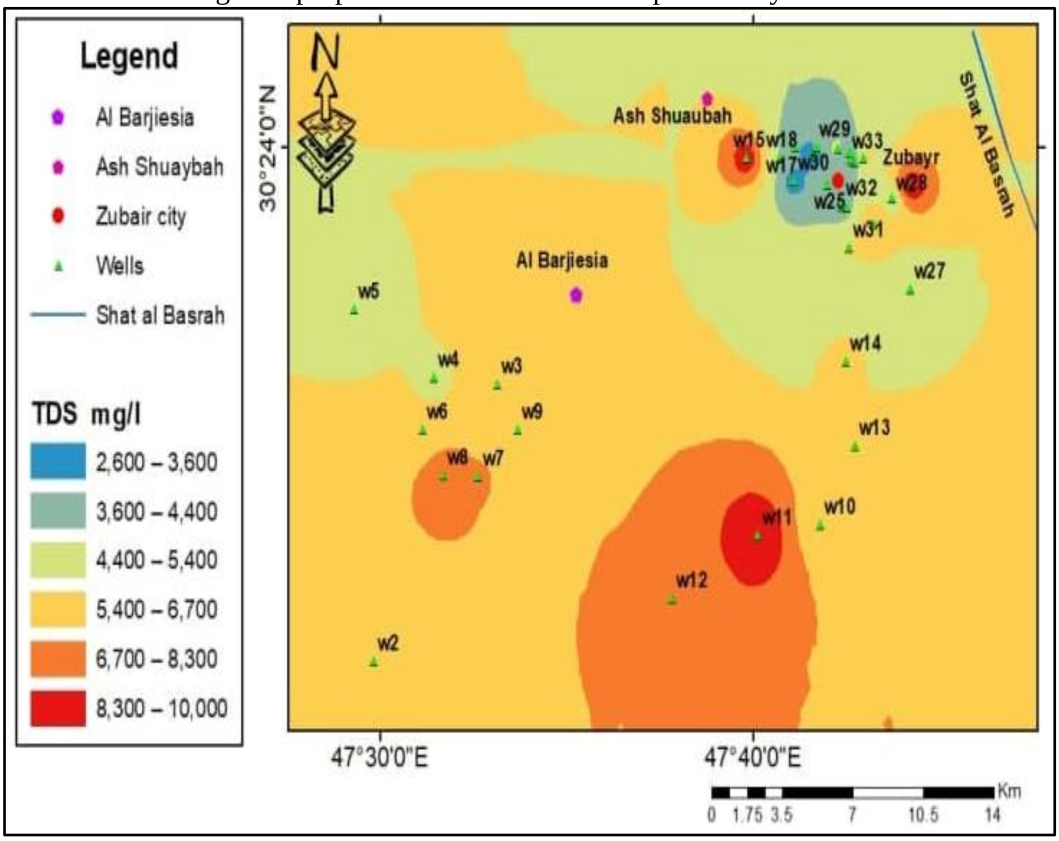

Figure 4- Total dissolved solids (ppm) distribution in the study area.

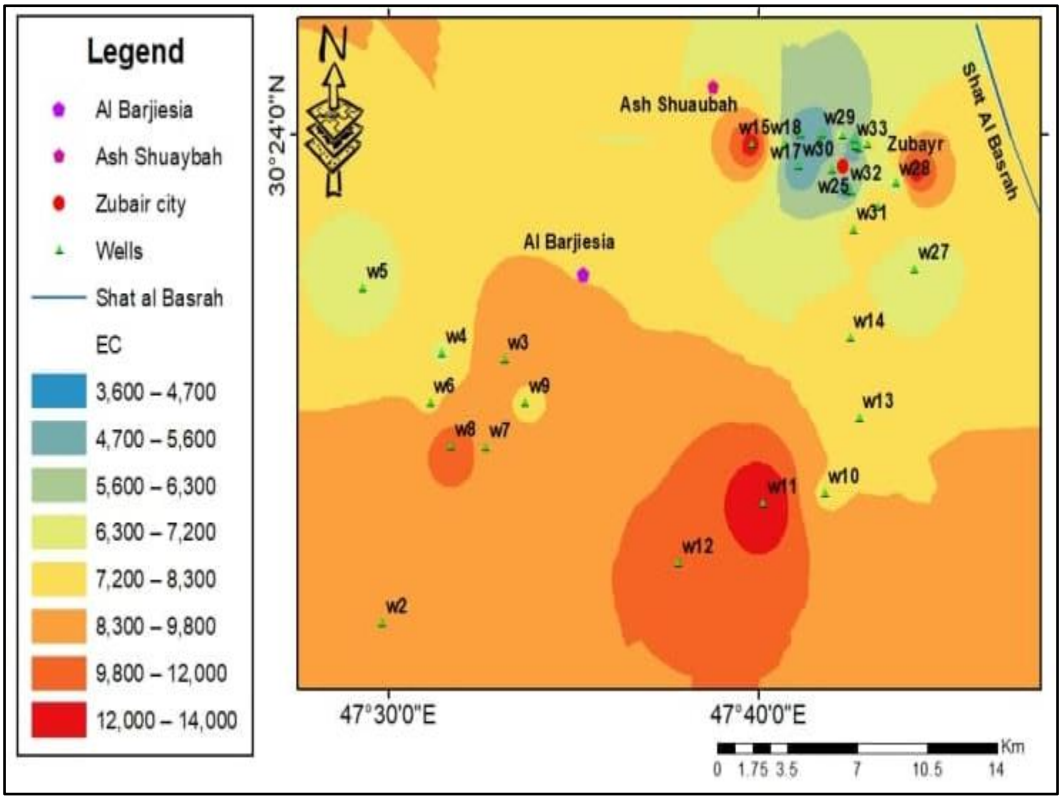

Figure 5- Electricity concentration (µs/cm) distribution in the study area.

2-2: **Chemical analysis:**

Calcium is one of the alkaline elements that have a major presence in the earth's crust. It is formed as a natural byproduct of the dissolution of sedimentary rocks such as limestone, dolomite, and gypsum [15]. General, groundwater chemistry reflects the aquifer lithology. The high concentration of calcium in the study area comes from dissolved carbonate rocks that are found in Dibdibba Formation. The concentration of calcium (Ca^{+2}) in the groundwater samples ranges between (262-811) ppm.

Magnesium (Mg^{+2}) is a water-soluble alkaline earth metal with a single oxidation state. The sources of magnesium in natural water are the weathering of rocks and minerals containing magnesium like: dolomite, magnesite in sedimentary rocks [15]. It occurs as an adsorbed ion on clays in clay minerals. [16]. The main source of magnesium (Mg^{+2}) in the studied area is the dissolution of dolomite limestone of Dibdibba Formation. Magnesium (Mg^{+2}) concentrations in groundwater samples range from (127-372.3) ppm.

The main source of sodium in groundwater is the effect of evaporate rocks, alkalinity feldspar, and ionic exchange of clay minerals during the erosion process. [8], where the salts and sodium compounds have high solubility in water. Sodium has many salts such as, sodium carbonate, which forms generate in salty lands, sodium bicarbonate, which is the least soluble salts, and sodium sulfate, which is soluble and able to be deposited under affected temperature in cold climates [15]. The main source of sodium (Na^{+}) in the studied area is evaporates deposits. The concentration of sodium (Na^{+}) in the groundwater samples ranges between (411-1384.8) ppm.

Potassium (K^{+}) is slightly more common in sedimentary rocks than sodium, but it is less abundant in all igneous rocks. The scarcity of potassium in groundwater is attributable to two factors: one is the resistance to weathering of minerals of potassium and another to weathering of potassium in clay minerals [17]. The potassium (K^{+}) concentration in the groundwater samples ranges between (11-116) ppm.

Total Hardness (T.H.) is a measurement of water's ability to precipitate soap. It is similar to alkalinity, which would be typically described as an equivalent concentration of $CaCO_3^-$ Hardness, on the other hand, is a property of cations (Ca^{+2} and Mg^{+2}), whereas alkalinity is a property of anions (HCO_3^- and CO_3^{-2}).The total hardness is the sum of concentrations of calcium and magnesium ions in mg/L. and is usually expressed as the equivalent of $CaCO_3$ [18].

Total hardness (as $CaCO_3$) = 2.497 [Ca^{+2}] + 4.118 [Mg^{+2}]. -------- (1)
Where: TH, Ca^{+2}, Mg^{+2} are all measured in ppm (mg/L). Calcium Ca^{+2}, magnesium Mg^{+2}, and HCO_3^- often account for the majority of total dissolved solids (TDS), so hardness can be used as an indicator proportionate to the total dissolved solids present. Hardness is a significant criterion to determining water drinking usability, domestic and many industrial uses [17]. The (T.H.) in the groundwater samples ranges between (973- 2548.3) ppm.

The chlorine (Cl^-) is the most abundant of the halogens and is a minor component of earth crusts, but in most natural water it is considered as a major dissolved component. The presence of high chloride ion concentrations in water is caused by the difficulty of adsorption on clay mineral surfaces and the ease of solubility [19]. The main source of chloride in groundwater samples due to clay and gypsum units within the Dibdibba Formation. The chlorine (Cl^-) concentration in the groundwater samples ranges between (540-2209) ppm.

The main source of sulfate in groundwater is sulfate mineral solutions found in sedimentary rocks, as well as oxidation of barite minerals, [16]. The main source of sulfate (SO_4^{-2}) in the study area is solutions of sulfate minerals that exist in evaporate rocks such as gypsum. The concentration of sulfate SO_4^{-2} in the groundwater samples ranges between (990-3260) ppm.
Bicarbonate (HCO_3^-) and carbonate (CO_3^{-2}) are the source of water alkalinity. Bicarbonate ions in groundwater derived from the carbon dioxide (CO_2) in the atmosphere, carbon dioxide in the soil and the dissolution of carbonate rocks such as limestone and dolomite. The concentration of bicarbonate (HCO_3^-) in the groundwater samples ranges between (310-1342) ppm.
Nitrate is highly soluble in water and weak retention by soil. Nitrite (NO_2^-) can be transformed into nitrate (NO_3^-) when brought the groundwater to the surface or exposed to air in wells. Nitrate originates mainly from agricultural activities due to the use of fertilizers. The sources of organic nitrates related to human sewage and livestock manure, especially from feedlots [15]. The concentration of nitrate (NO_3^-) in the groundwater samples ranges between (0.2-11) ppm.

Statistical analyses

The studied groundwater samples were evaluated statistically by using multivariate analyses (Correlation coefficient, Cluster analyses, and Factor analyses). TDS, EC, pH, Cations, and Anions for 33 groundwater samples were used after eliminated the scale difference among these parameters by the standardization of each variable firstly according to [20].

The correlation coefficient analyses show significant correlations between the groundwater variables Table-4. High positive correlation value between TDS, EC with Na^+, Ca^{+2}, Mg^{+2}, and Cl^- in addition to the significant correlation between SO_4^{-2} and HCO_3^-, whereas there is medium positive correlation between EC, TDS and HCO_3^-. NO_3^{-2}concentration has a weak correlation with HCO_3^-, Cl^-, Mg^{+2} and Na^+ parameters.

Table 4- Correlation coefficient matrix of the studied groundwater quality in the study area

Correlation Matrix[a]												
		pH	**Ec**	**TDS**	**K^-**	**Na^+**	**Mg^{+2}**	**Ca^{+2}**	**Cl^-**	**SO_4^{-2}**	**HCO_3^-**	**NO_3^{-2}**
Pearson Correlation	Ph	1.000										
	Ec	-.203-	1.000									
	TDS	-.196-	**.996**	1.000								
	K^-	.188	-.202-	-.163-	1.000							
	Na^+	-.181-	**.930**	**.932**	-.120-	1.000						
	Mg^{+2}	-.159-	**.914**	**.920**	-.064-	**.981**	1.000					
	Ca^{+2}	-.236-	**.921**	**.924**	-.148-	**.961**	**.962**	1.000				
	Cl^-	-.176-	**.915**	**.921**	-.049-	**.980**	**.975**	**.979**	1.000			
	SO_4^{-2}	-.238-	**.866**	**.878**	-.102-	**.923**	**.911**	**.909**	**.901**	1.000		
	HCO_3^-	-.218-	**.777**	**.789**	.087	**.917**	**.927**	**.909**	**.935**	**.840**	1.000	
	NO_3^{-2}	-.027-	.526	.553	.250	**.616**	**.652**	.586	**.658**	.520	**.713**	1.000
****. Correlation is significant at the 0.01 level (1-tailed).**												

The cluster analysis technique is used to assume the assemblages of groundwater samples according to their characteristics into many groups [21]. Figure-6 shows the Dendrogram of the hierarchical cluster analyses of 33 groundwater samples for the same chemical and physical parameters. Two significant clusters I and II are obtained, the groundwater samples 11 and 12 have different in their properties from the other samples. The most important factors that responsible for playing the most important role in classifying the present water samples are TDS and Ec that reflect the high salinity pollution in the present study area.

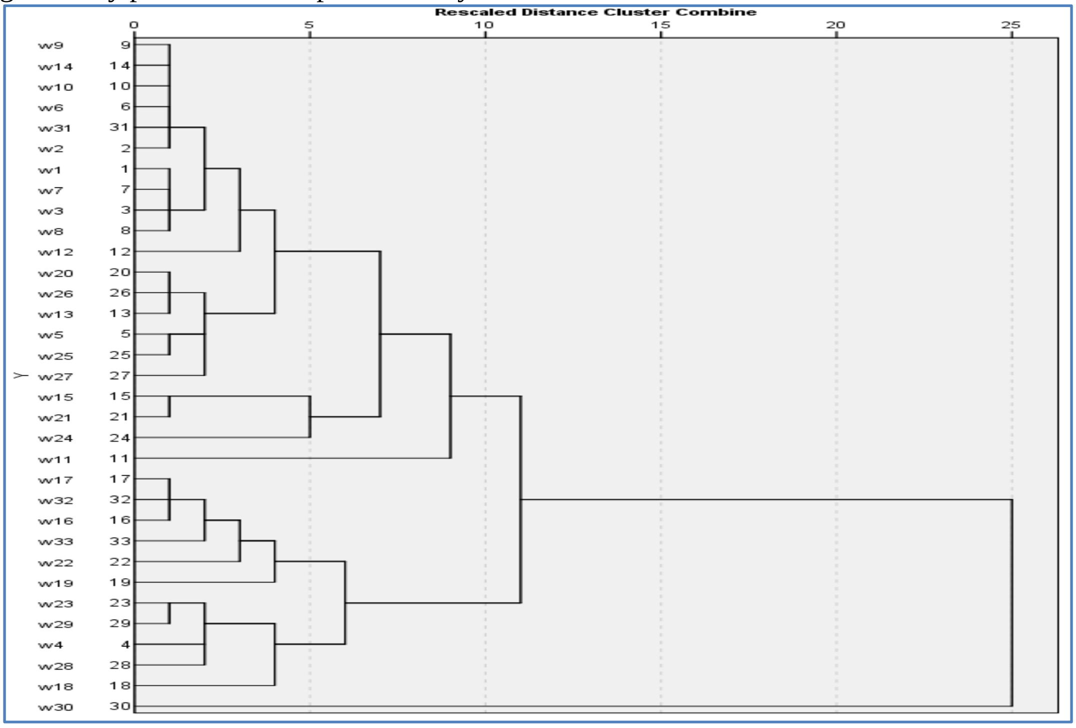

Figure 6- Dendrogram of the studied groundwater samples.

Factor analysis technique is applied to many observed variables to find the reducing factors (subsets of variables) depend on the correlation matrix of observed variables contain the weighted average of the original variables. The principle component analysis method was used to evaluate principle component, factors, eigenvectors, or loading that represents the score of the forecasting component [22]. The subsets of variables (sub-clusters) in one cluster that depend on the similarity of the observed chemical and physical parameters refer to the strong correlation between them.

Based on the eigenvalues >1, two Factors explained about 71.855% and 12.214% of the percent of the total variances of the groundwater samples (Table -5). The factor I show that Cl^-, Mg^{+2}, Na^+ and Ca^{+2} with highest weighted variables average as well as HCO_3^-, TDS, Ec, and SO_4^{-2}. Nitrate NO_3^{-2} has the lowest weight variable among the other variables, whereas, Factor II shows a high weight average of K^+ concentration only (Table-6).

The correlations and Factors analyses suggest a common source of Mg^{+2}, Ca^{+2}, Cl^-, and K^+ that related to the dissolution of sulfate salts and evaporates minerals, in addition to high drainage from agricultural lands, farms, besides the chemical construction industries [23]. The excessive used of softeners, the powder of detergents caused increasing in Mg^{+2} and Na^+ because these form insoluble salts with soap [24].

Table 5- The extracted total variance percent of the studied groundwater quality.

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.904	71.855	71.855	7.904	**71.855**	71.855	7.823	71.121	71.121
2	1.344	12.214	84.069	1.344	**12.214**	84.069	1.424	12.948	84.069
3	.866	7.875	91.944						
4	.428	3.889	95.832						

5	.236	2.147	97.979						
6	.124	1.125	99.104						
7	.043	.387	99.490						
8	.028	.258	99.748						
9	.020	.185	99.933						
10	.005	.043	99.976						
11	.003	.024	100.000						
Extraction Method: Principal Component Analysis.									

Table 6- The Factor loading of the studied groundwater quality.

variable	Component	
	Factor I	Factor II
pH	-.228-	.528
Ec	**.943**	-.143-
TDS	**.950**	-.104-
K^-	-.088-	**.866**
Na^+	**.987**	-.019-
Mg^{+2}	**.984**	.044
Ca^{+2}	**.979**	-.071-
Cl^-	**.987**	.049
SO_4^{-2}	**.931**	-.070-
HCO_3^-	**.929**	.178
NO_3^{-2}	**.670**	.488
Extraction Method: Principal Component Analysis.		

Ground Water Uses:

Groundwater is used for several purposes in the area region depending on the type of water and the anions and cations content, which varies from one type to the other. As a result, water must be evaluated by local and international standards to determine its suitability for various uses.

Water Uses for Drinking Purposes:

Developed multi-standard specifications for potable water and compared the concentrations of ions and total soluble salinity samples of groundwater in the study area and show that groundwater in the study area is unsafe to drink, according to the [25]**,** [26](Table7).

Table 7-Comparing the parameters for water samples with the standards of drinking water (IQS, 2009) [25] and (WHO, 2011) [26].

Parameters	IQS 2009	WHO 2011	studied wells (Mean)	Suitability
pH	6.5-8.5	6.5-8.5	7.27	Suitable
EC (µS/cm)	1500	1530	7679.03	All samples is not suitable
TDS(ppm)	1000	1000	5479.36	All samples is not suitable
Ca^{+2} (ppm)	150	75	418.11	All samples is not suitable
Mg^{+2}(ppm)	100	125	196.78	All samples is not suitable
Na^+(ppm)	200	200	715.49	All samples is not suitable
K^+(ppm)	-	12	55.07	Samples(10,13) is suitable and other is not suitable
CL^- (ppm)	350	250	939.95	All samples is not suitable
SO_4^{-2} (ppm)	400	250	1608.81	All samples is not suitable
NO_3^- (ppm)	50	50	3.83	All samples is suitable

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:
[15] Notify some of the standard specifications of the water used in various industries and water when compared to the study area shows that most of this water is not suitable to all industries.
Suitability of Groundwater for Construction Purpose:
The reasonableness of groundwater in the study area is assessed for structural purposes using the arrangement proposed by [27], the results show that most groundwater wells in the study region were unsuitable due to increased concentration of sulfate and bicarbonates.
Groundwater Uses for Agricultural Purposes:
The appropriateness of water for farming relies upon the sum and sort of salts present in the water and their impacts on yield development and improvement. Furthermore, crop growth and development are dependent on plant response to various environmental conditions, plant quality, soil structure characteristics, irrigation pattern, plant susceptibility to absolute disintegrated solids, and electrical conductivity in water, all of which are dependent on nature of plants [16].Comparing with [16] the samples of the study area depending on Ec value, water isnot suitable for some sorts of yields.

Groundwater Suitability for Irrigation Purposes
Water's suitability for irrigation is determined by ion concentrations in the water, with the saline content expressed by electrical conductivity salinity [27]. The irrigation water is classified by [28] into four categories based on the EC values, as shown in table (8). According to groundwater samples classification for the study area, the C4 water type represents all wells, which are generally unacceptable for irrigation, except for very salt-tolerant plants, excellent drainage, frequent leaching, and intensive management Table (8).

Table 8- Classification of irrigation water based on (EC) values [28].

level	EC (µS/cm)	Hazard and Limitations
C1	<250	Low hazard; no detrimental effects on plants, and no soil buildup expected.
C2	250-750	Sensitive plants may show stress; moderate leaching prevents salt accumulation in soil
C3	750-2250	Salinity will adversely affect most plants; requires selection of salt-tolerant plants, careful irrigation, good drainage, and leaching
C4	>2250	Generally unacceptable for irrigation, except for very salt tolerant plants, excellent drainage, frequent leaching, and intensive management

Residual sodium bicarbonate (RSBC)
The bicarbonate concentration increasing will be caused by increased concentrations of calcium and magnesium in addition, to an increase in sodium concentration [29], having a negative impact on the soil. According to [30] the RSBC was divided into three categories: acceptable when RSBC<5 meq/L, marginal if RSBC ranged between 5-10 meq/L, and unsatisfactory with RSBC<10 meq, the RSBC is calculated by using the equation in epm units for all the ion concentrations:

$$\mathbf{RSBC= (HCO_3^- - Ca^{+2})} \qquad \text{------ (2)}$$

The RSBC result of the present samples was ranged between -18.5 to -3.0 meq/L with an average of-10.7meq/L, The majority of sample RSBC values are considered satisfactory (<5 meq/L) (Table 2 and 3). The majority of the samples in the study area are suitable for irrigation.
Magnesium Ratio (MR)
The Magnesium ratio (MR) is the excess of magnesium concentration over Ca^{+2} and Mg^{2+}, and it was calculated using the equation below for [31], with the ionic concentrations in epm units

$$\mathbf{MR = [Mg^{+2}/(Mg^{+2} + Ca^{+2})\ ]*100} \qquad \text{------ (3)}$$

The soil becomes very alkaline when the values of MR is more than 50% and if MR less than 50% was suitable for irrigation purpose [29], the present groundwater samples contain magnesium ratio ranged between (38.6 – 47.9) meq/L with an average of 43.6 meq/L confirms suitable water for irrigation purposes, (Table 2 and 3)

Permeability index (PI)

Soil permeability is affected by long-term irrigation purposes which caused sodium, calcium, a magnesium and bicarbonate presence in soil. The permeability index is developed by [32] calculated by the following equation when the ion concentrations used in meq/L units:

$$\mathbf{PI = [Na + (HCO_3^-)^{0.5})]*100/(Na^+ + Ca^{+2} + Mg^{+2})} \qquad \text{------(4)}$$

According to the permeability index (PI), groundwater was divided into three classes. Class I is as excellent for irrigation with PI is greater than 75%; class II is good for irrigation when the PI is between 25, and 75%; and class III is inappropriate for irrigation when the PI is less than 25%. [33]. The present groundwater samples results are ranges between (0.004-0.005) meq/L with an average (0.0001) meq/L, were considered as unsuitable for irrigation (Table 2 and 3)

Conclusion:

The hydrochemical characteristics of thirty-three groundwater samples were studied and the following conclusions were reached:

- The water of the study area is colorless, odorless, while it has a salty taste in some of the groundwater samples due to the increase in TDS values, and has close temperatures dominated by sulfate ions, sodium. Hydrochemical analysis of groundwater proved that it has a very hard type according to Todd 2007 classification as the total hardness values ranged between (973-2548.3) ppm. As for the total dissolved solids, their value ranged between (2640-10415) ppm and that the large proportion of groundwater samples in the field area are sodium sulfate Na_2SO_4type.

-The multivariate analyses of the present studied samples indicated high drainage from agricultural lands, farms, besides the chemical construction industries, in addition to the excessive use of softeners and the powder of detergents that caused increasing in Cl^-, Mg^{+2}, Na^+ and Ca^{+2} with the highest weighted variables average as well as HCO_3^-, TDS, Ec, and SO_4^{-2}.

-Through studying the groundwater suitability for different uses validity that water unfits to drink and for industrial uses and the purposes of building and construction, as well as for agricultural purposes, while is valid for animal consumption.

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