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Hydrochemical characteristics and environmental evaluation of surface and groundwater quality at Al-Tarmiyah Area, Baghdad, Iraq

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Abstract

The present study aims to assess the water quality and the hydrochemical characteristics and seasonal variation of surface water on the aspect of trace elements in Al-Tarmiyah District, Baghdad, Iraq. Ten water samples were collected, four from surface water and six from groundwater on October 2017, and on April 2018. All samples were analyzed for physiochemical parameters such as water temperature, pH, EC, TDS,TH,TSS, major ions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-}, Cl^{-}, and HCO_3^{-}), and nutrients (NO_3^{-}, and PO_4^{3-}). In addition, samples were analyzed for trace elements that include Fe, Al, Pb, Zn, Mn, Cr, Cu, Co, Ni, and Cd. Suitability of water for domestic uses was evaluated depending on the criteria or standards of acceptable quality for that use.

Surface water samples of October 2017 were classified as Ca-Cl and Na-Cl water type while they were classified as Na-Cl water type in April 2018. Most groundwater of both months' samples was classified as Ca-Cl and Na-Cl water types. There is only one groundwater sample (GW2) was classified as Ca-SO_4^{-2} water type. According to water classification based on the Piper diagram, most of surface and groundwater samples for both months falling in class (e), this means that the type of water is "Earth alkaline water with increased portions of alkalis with prevailing sulfate or chloride". Suitability of water for drinking purpose is evaluated depending on the criteria or standards of acceptable quality for that use (WHO and Iraqi Standard). All surface and groundwater samples from the studied area are not suitable for drinking purposes and within "excellent type" for livestock and poultry use. Additionally, almost all surface water samples were within Good class based on the suggested limits of EC value (Ayers and Westcot, 1985) for irrigation while most of the groundwater samples are within unsuitable class. All surface water and groundwater samples lie within low hazard class of the irrigation water based on SAR values.

Keywords: Al-Tarmiyah District, Surface water, Groundwater, Hydrochemistry, Major ions, Trace elements.

الخصائص الهيدروكيميائية والتقييم البيئي لجودة المياه السطحية والجوفية في منطقة الطارمية، بغداد، العراق

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الخلاصة

تهدف الدراسة الحالية إلى تقييم نوعية المياه ومناقشة الخصائص الهيدروكيميائية والتغير الموسمي للمياه السطحية و الجوفية اضافة لتواجد العناصر النزرة في قضاء الطارمية، بغداد، العراق. حيث تم جمع 10 عينات ماء من منطقة الطارمية في شهر تشرين الاول من عام 2017 و 10 عينات في شهر نيسان من عام 2018. تم تحليل عينات المياه الملتقطة لمعرفة الخصائص الفيزوكيميائية مثل درجة حرارة الماء، الأس الهيدروجيني (pH)، التوصيلية الكهربائية (EC)، الاملاح الذائبة الكلية (TDS)، عسرة الماء (TH)، المواد الصلبة الذائبة (TSS) وكذلك الأيونات الرئيسية (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-}, Cl^{-}, and HCO_3^{-}) والمغذيات (NO_3^{-} و PO_4^{3-}) بالإضافة إلى العناصر النزرة مثل(Fe, Al, Pb, Zn, Mn, Cr, Cu, Co, Ni و Cd). تم تقييم ملاءمة المياه للشرب والاستخدامات الزراعية الأخرى على المعايير او امواصفات المقبولة لذلك الأستخدام.

صنفت عينات المياه السطحية لشهر تشرين الاول كنوع ماء Ca–Cl و Na–Cl على التوالي بينما صنفت كنوع ماء Na–Cl خلال نيسان 2018. صنفت معظم عينات المياه الجوفية خلال الشهرين كنوع ماء Ca–Cl و Na–Cl. هناك عينة واحدة من المياه الجوفية (GW2) صنفت كنوع ماء $Ca–SO_4^{-2}$. ووفقا لتصنيف المياه حسب مخطط بايبر ، فإن معظم عينات المياه السطحية والجوفية تقع في الصنف (e)، وهذا يعني أن نوع الماء في معظم عينات منطقة الدراسة لكلا الشهرين هي مياه قلوية مع وفرة الكبريتات أو الكلوريدات. تم تقييم ملاءمة المياه لأغراض الشرب ، اعتمادا على معايير أو مواصفات الجودة المقبولة لهذا الاستخدام(منظمة الصحة العالمية و المواصفات القياسية العراقية) . جميع عينات المياه السطحية والجوفية من منطقة الطارمية خلال الموسمين غير ملائمة لأغراضالشرب وضمن "النوع الممتاز" لاستخدام الماشية والدواجن، بالإضافة إلى ذلك، فإن جميع عينات المياه السطحية من كلا الشهرين تقع ضمن فئة جيدة بناءً على الحدود المقترحة لقيمة EC للري في حين أن معظم عينات المياه الجوفية تقع ضمن الفئة غير الملائمة للارواء (وفقا لتصنيفWestcot & Ayers, 1985) ، حيث تقع جميع عينات المياه السطحية و الجوفية في كلا الشهرين ضمن فئة منخفضة الخطورة حسب قيم SAR لاستخدامات لري.

Introduction

The surface and groundwater quality are an important issue and considered one of the main factors affecting human health as well as ecological systems [1, 2]. Anthropogenic activity and changes in natural environments are two major factors for the variations of regional hydrology and water resources [3]. Water pollution represents a changing in the chemical, physical, and biological health of a waterway due to human activity [4]. Recently, the pressure on water resources is growing rapidly both in terms of expanding water extractions and quality degradation from pollution loads. Water quality degradation is pervasive in most watercourses around the world, driven by the escalating pollution loads from anthropogenic point and non-point sources [5]. Any physical, biological or chemical change in water that adversely affects living organisms or makes water unsuitable for desired uses can be considered pollution [6].

The water quality evaluation depends mainly on hydrochemical analysis. The water samples were collected and analyzed in this study to determine the hydrochemical characteristics of the surface and ground water, and assessing the water quality according to the Iraqi and WHO standards [7, 8] for surface water, groundwater, drinking water, irrigation water, and other sources. Al-Tarmiyah Area can be considered as the rural area where its characterized by flat terrain with the presence of many fruit and palm orchards, croplands, poultry field as well as fish lakes particularly along both sides of Tigris River main stream. Like many major river systems in the world, the Tigris River seems to be extensively used as both a prime water resource and disposal of waste discharged by industrial, agricultural, and domestic activities. The majority of croplands are wheat, and barely. Hence, the increased use of agrochemicals such as pesticides including insecticides, herbicides, fungicides and nematicides, and chemical fertilizers to accelerate the crop productions is intensifying the water pollution of the present study area. The water quality for drinking and irrigation are the most concern issues under the rapidly urbanization and agricultural development in Al-Tarmiyah Area. The surface water and groundwater resources are not only used as irrigation water to irrigate the orchards and grain production but also as drinking water for livestock and local people. This work investigates the natural and anthropogenic processes that influence the chemistry of surface and groundwater within Al-Tarmiyah Area.

Study area

Al-Tarmiyah District is located (22) km north of Baghdad City within Baghdad Governorate. Al-Tarmiyah lies in the middle of Iraq within the Mesopotamian Plain and covered by Quaternary Sediments. The area is a sparsely populated farming community. The area of interest comprises about 458.89 km^2 whereas the total area of Baghdad Governorate reaches 5174.09 Km^2. The study area is restricted to latitudes (33° 34' -33° 46') N and longitudes (44° 06' - 44° 26') E as shown in Figure-1. There have been no previous studies of this area, especially over the past 15 years, for security reasons.

3. Water sampling and analysis

Water samples were collected from ten different sites (Figure-1 and Table-1) on October 2017 (dry season), and in April 2018 (wet season). Six groundwater samples and three surface water samples were collected from Tigris River and only one sample from drainage channel during each month. The samples were collected on a scientific basis, using clean polyethylene bottles with a capacity of (1) liter. The water samples were labeled with an identification number. Then, the number of the bottle was recorded on the sampling data sheet in line with the sampling location. The location of the sampling area was registered using GPS. All water samplings were sent to science and technology laboratory for the analysis of important major cations and anions, nutrients and trace elements following standard test methods.

Surface and ground water samples were analyzed for physiochemical parameters such as water temperature, pH, EC,TDS, TH, TSS, major ions (Ca^{2+}, Mg^{2+}, Na^+, K^+, SO_4^{2-}, Cl^-, and HCO_3^-), and nutrients (NO_3^-, and PO_4^{3-}) for both seasons. Additionally, trace elements include Fe, Al, Pb, Zn, Mn, Cr, Cu, Co, Ni, and Cd also analyzed. Electrical Conductivity (EC) and pH values were measured in situ using portable conductivity and pH meter, respectively. Other chemical indices were derived from the measured water quality parameters by using UV Visible Spectrometer and Flame photo meter.

Table 1-Coordinates of water samples Sites in UTM coordinate system

S.ID.	Site Name	Northing	Easting	Well Depth (in m)	Static water level (in m)	Description
W1	Shaykh Jamil	3736622	442707	------	------	River Water
W2	Al-IislahAl'uwlaa	3732793	434729	------	------	Irrigation channel
W3	Al-Hialiiyn Al-Qadima	3726355	444248	------	------	River Water
W4	Al-Abaaychy	3731693	445887	------	------	River Water
GW1	Al-IislahAl'uwlaa	3733044	436469	12	8	Ground Water
GW2	Al-Ruwwad	3731655	431959	14	4	Ground Water
GW3	Al-Muhayrijat	3732615	443341	8	4	Ground Water
GW4	Al-Abaaychy	3734932	439668	20	6	Ground Water
GW5	Al-IislahAl'uwlaa	3733950	437956	9	4	Ground Water
GW6	Al-Mashahida	3723633	428418	16	5	Ground Water

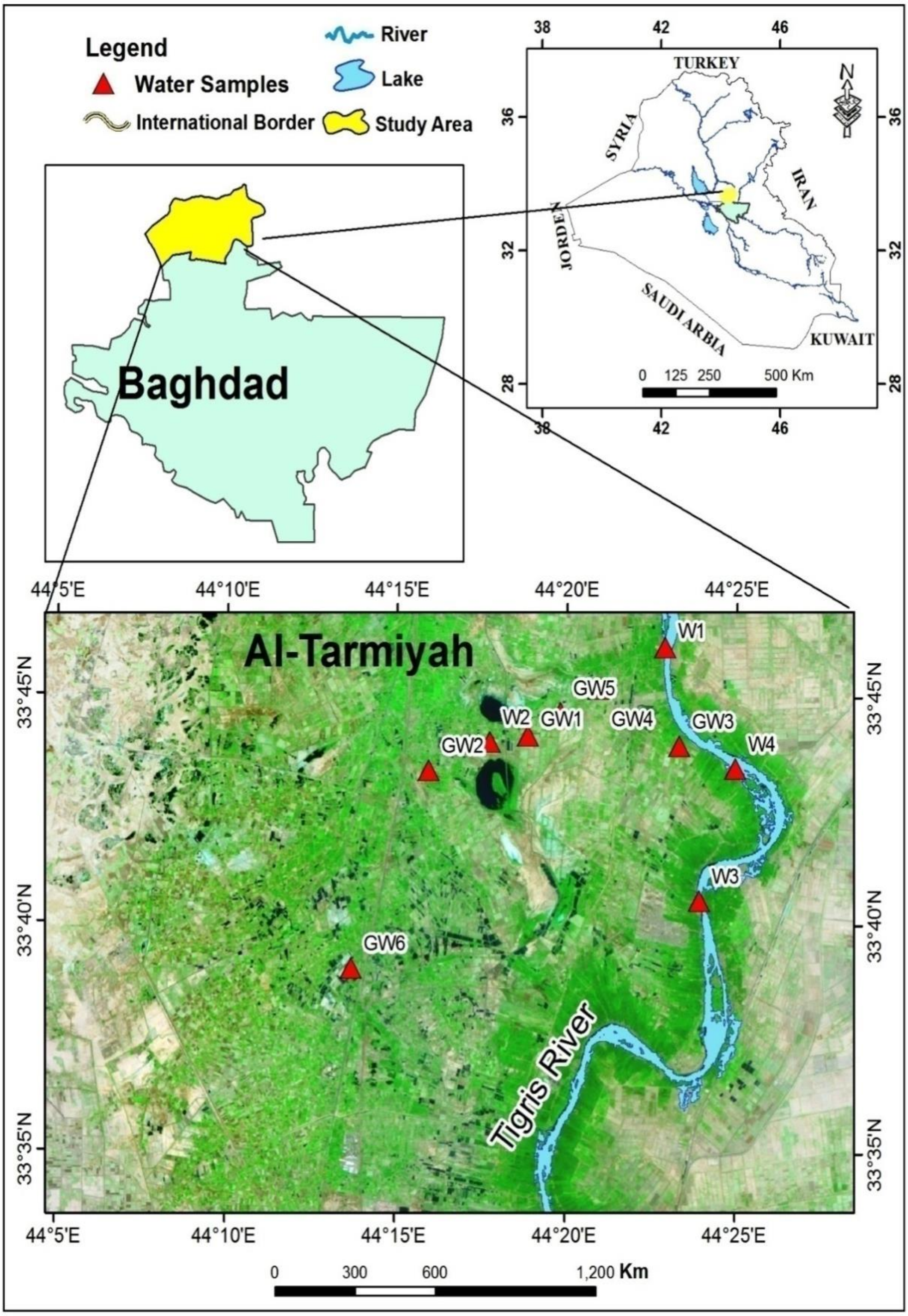

Figure 1-Location map of study area

4. Results and discussion

4.1. Physicochemical parameters

Physiochemical parameters result of Al-Tarmiyah area water samples during dry and wet seasons compared with Iraqi and WHO Standards [7, 8] as shown in Table-2. Generally, the mean temperature values for surface water of Tigris River were 21.64˚C and 21.84 ˚C, and groundwater samples were 22.7˚C and 23.03˚C while for irrigation channel the value was 20.4˚C and 23.2˚C in the dry and wet season respectively (Table-2).

Table 2-Physical parameter results of surface and groundwater samples

S.NO.	Wet season						Dry season					
Surface water												
	TDS ppm	EC µs/cm	TSS ppm	TH ppm	pH	T◦C	TDS ppm	EC µs/cm	TSS ppm	TH ppm	pH	T◦C
W1	361	391	0.99	290.84	8.1	24.1	342	372	0.76	303.9	8.4	22
W3	380	410	0.71	251.89	8.7	22.4	340	370	0.81	306.57	8.8	23.8
W4	387	415	0.75	285.85	8.6	18.8	337	366	0.78	271.74	8.7	19.8
Min.	361	391	0.71	251.89	8.1	18.8	337	366	0.76	271.74	8.4	19.8
Max.	387	415	0.99	290.84	8.7	24.1	342	372	0.81	306.57	8.8	23.8
Mean	375.2	404.4	0.83	274.26	8.44	21.64	339.6	369.2	0.78	292.1	8.62	21.84
W2*	2646	2675	0.82	1715.1	7.6	23.2	2346	2376	0.79	1831.8	7.9	20.4
Groundwater												
S.NO.	TDS ppm	EC µs/cm	TSS ppm	TH ppm	pH	T◦C	TDS ppm	EC µs/cm	TSS ppm	TH ppm	pH	T◦C
GW1	6205	7350	0.97	4991.2	7.1	21.9	6228	7380	0.94	5127.3	6.8	21.7
GW2	1809	2292	0.93	1389.6	7.6	23.8	1839	2340	0.88	1443.6	7.5	23.1
GW3	1080	1881	0.99	779.7	7.4	22.9	1095	1900	0.96	821.96	7.3	22.6
GW4	2351	3310	1.18	1706.2	7.5	21.8	2364	3350	1.08	1854.5	7.3	21.6
GW5	4835	6391	0.92	3707.9	7.4	24	4860	6411	0.85	3928.2	7.2	23.8
GW6	2611	4423	0.198	2651	7.9	23.8	3631	4451	0.192	2949.3	7.6	23.4
Min.	1080	1881	0.198	779.7	7.1	21.8	1095	1900	0.192	821.96	6.8	21.6
Max.	6205	7350	1.18	4991.2	7.9	24	6228	7380	1.08	5127.3	7.6	23.8
Mean	3148.5	4274.5	0.86	2537.6	7.48	23.03	3336.1	4305.3	0.82	2687.5	7.28	22.7
IQS (2009)	1000	1530	-	-	6.5-8.5	----	1000	1530	-	-	6.5-8.5	-
WHO (2008)	1000	-	-	-	6.5-8.5	-	1000	-	-	-	6.5-8.5	-
* W2: Surfce water sample from irrigation channel												

The mean pH values for surface water of Tigris River were 8.62 and 8.44, and groundwater samples were 7.28 and 7.48 while for drainage channel the value were 7.9 and 7.6 in the dry and wet season respectively (Table- 2). pH is measured directly in the field and indicates that the pH values of surface water for two seasons are within the acceptable range, which indicating that the river is healthy whereas pH values of the groundwater is neutral to slightly acidic in nature.

Electrical conductivity (EC) is an indirect measurement of salinity, and it is temperature dependent [9]. The mean EC values for surface water of Tigris River were 396.2 and 404.4 µs/cm, and groundwater samples were 4305.3 and 4274.5 µs/cm while for irrigation channel the value was 2376 and 2675 µs/cm in the dry and wet season respectively (Table-2). The EC value display limited seasonal variation. The mean TDS values for surface water of Tigris River were 339.6 and 375.2ppm, and groundwater samples were 3336.1and 3148.5 ppm while for drainage channel the value were 2346 and 2646ppm in the dry and wet season respectively (Table-2).

According to classifications of surface water TDS [10] show that the surface water of Tigris River is freshwater and irrigating channel is moderately saline water for both seasons. Ground water classification based on TDS value shows noticeable variation from Slightly Brackish to saline for the dry and wet season. The mean TH values for surface water of Tigris River were 292.1and 274.26ppm, and groundwater samples were 2687.5and 2537.6 ppm while for irrigation channel the value were 1831.8 and 1715.1ppm in the dry and wet season respectively (Table- 2). All surface water samples for both seasons lie within the hard class while the groundwater and drainage channel samples lie within the very hard class for both seasons [11]. The mean TSS values for surface water of Tigris River were 0.78 and 0.83 ppm, and groundwater samples were 0.82 and 0.86 ppm while for irrigation channel the value was 0.79 and 0.82 ppm in the dry and wet season respectively (Table- 2). The results of TSS show limited seasonal variation for all samples.

5. Major ions of surface and ground water

The chemistry of water is depended mainly on major ion concentrations. All water samples were analyzed for major cations (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}), major anions (SO_4^{-2} , Cl^{-} and HCO_3^{-}), and minor anions (NO_3^{-} and PO_4^{3-}). The results of the major and minor ions of water samples in both seasons are displayed in the Table-3.

Table 3-Major and nutrients ions results of surface water samples during dry and wet seasons

Surface water samples (Dry season)										
S.NO.	Unit	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{2-}	PO_4^{3-}	NO_3^{-}
W1	ppm	76	35	85	3	97	18.9	83	0.31	2.5
W3	ppm	70	32	79	2.8	92	17.8	78	0.33	2.8
W4	ppm	61	29	80	3.2	86	17.2	72	0.29	3
Min.	ppm	61	29	79	2.8	86	17.2	72	0.29	2.5
Max.	ppm	76	35	85	3.2	97	18.9	83	0.33	3
Mean	ppm	69	32	81.33	3	91.67	17.97	77.67	0.31	2.77
W2	ppm	412	195	513	19.2	518	169	451	0.5	14.6
Surface water samples (Wet season)										
S. NO.	Unit	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{2-}	PO_4^{3-}	NO_3^{-}
W1	ppm	67	30	78	6	79	26	71	0.47	6.2
W3	ppm	58	26	67	5.8	74	24.3	65	0.52	5.8
W4	ppm	65	30	75	4.9	80	22	67	0.43	5.3
Min.	ppm	58	26	67	4.9	74	22	65	0.43	5.3
Max.	ppm	67	30	78	6	80	26	71	0.52	6.2
Mean	ppm	63.33	28.67	73.33	5.57	77.67	24.1	67.67	0.47	5.77
W2	ppm	390	180	485	35.1	492	176.4	433	0.64	18.2
IQS (2009)	ppm	150	100	200	……	350	……	400	……	50
WHO (2008)	ppm	100	125	200	12	250	……	250	……	50

Table 4-Major and nutrients ions results of the groundwater samples during dry and wet seasons

Groundwater samples (Dry season)										
Well No.	Unit	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{2-}	PO_4^{3-}	NO_3^{-}
GW1	ppm	1209	512	1300	51.8	1408	315	1289	0.75	34.3
GW2	ppm	339	145	375	16.6	254	12.7	586	0.42	12.5
GW3	ppm	189	85	221	5.9	253	39.9	202	0.38	8.9
GW4	ppm	431	189	510	17	506	155	458	0.49	18.8
GW5	ppm	930	390	1025	48.1	1124	271	1031	0.68	28
GW6	ppm	693	296	756	26.3	805	198	718	0.59	24.3
Min	ppm	189	85	221	5.9	253	12.7	202	0.38	8.9
Max	ppm	1209	512	1300	51.8	1408	315	1289	0.75	34.3
Mean	ppm	631.83	269.5	697.83	27.62	725	165.27	714.00	0.55	21.13
Groundwater samples (Wet season)										
Well No.	Unit	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{2-}	PO_4^{3-}	NO_3^{-}
GW1	ppm	1171	502	1280	50.8	1385	271	1267	0.71	32.6
GW2	ppm	324	141	365	15.6	234	29.1	575	0.39	11.3
GW3	ppm	182	79	218	4.5	241	27.6	196	0.35	7.8
GW4	ppm	398	173	492	14.8	494	133	442	0.42	17.4
GW5	ppm	916	345	1005	45.2	1110	251	1011	0.63	26.6
GW6	ppm	623	266	745	24.1	790	181	712	0.49	23.1

Min.	ppm	182	79	218	4.5	234	27.6	196	0.35	7.8
Max.	ppm	1171	502	1280	50.8	1385	271	1267	0.71	32.6
Mean	ppm	602.33	251	684.17	25.83	709	148.78	700.5	0.5	19.8
IQS(2009)	ppm	150	100	200	……	350	……	400	……	50
WHO(2008)	ppm	100	125	200	12	250	……	250	……	50

5.1Calcium (Ca^{2+})

Evaporates rocks containing gypsum and anhydrite are among the most important sources of calcium soluble in water [9]. Ca^{2+} in the collected surface water samples during dry season ranged from 61-76 ppm with a mean of 69 ppm and for wet season ranged from 58-1171 ppm with a mean of 602.33 ppm while the drainage channel values were 412 and 390 ppm for dry and wet seasons respectively (Table-3).

Ca^{2+} in groundwater samples ranged from 189-1209 ppm, with a mean of 631.83 ppm during the dry season, while it ranged from 182-1171 ppm with a mean of 602.33 ppm during the wet season (Table- 4). In the dry season, Ca^{2+} concentrations were higher than wet season, this may be attributed to increase evaporation decrease water supply during the summer season.

5.2 Magnesium (Mg^{2+})

Magnesium is an essential nutrient for living organisms and it is typically considered as the major constituent of the dark-colored ferromagnesian minerals and carbonate rocks such as limestone, dolomite, magnesite and hydromagnesite [12]. Mg^{2+} concentration varies from 29-35 ppm with a mean of 32 ppm, and from 26-30 ppm with a mean of 28.67 ppm, while for the drainage channel values were 195 and 180 ppm for dry and wet seasons respectively (Table-3).

Mg^{2+} concentration in groundwater ranged from 85 ppm to 512 ppm with a mean of 269.5 ppm during dry season, and it ranged from 79 ppm to 502 ppm with a mean of 251 ppm during the wet season (Table-4).

The mean value of Mg^{2+}concentration for surface and ground water samples is slightly higher in dry season than in wet season. The general pattern of magnesium concentration shows a noticeable increase in the sample of drainage channel (W2) for both seasons. This increase can be attributed mainly to the effluent of wastewater from urban and agricultural lands.

5.3 Sodium (Na^{+})

Na^{+} concentration varies from 79 -85 ppm with a mean of 81.33 ppm, and from 67-78 ppm with a mean of 73.33 ppm for surface water samples, while for the drainage channel values were 513 and 485 ppm for dry and wet seasons respectively (Table-4).

Na^{+} concentration levels for ground water for both seasons were ranged from 221 ppm to 1300 ppm with a mean of 697.83 ppm during dry season, while it ranged from 218 ppm to 1280 ppm with a mean of 684.17 ppm during wet season (Table-4). The Na^{+} concentrations for surface and ground water are higher during the dry season than in the wet season. This could possibly be due to high dilution of water as a result of high rainfall during wet season, as well as increase evaporation. In general, the increase in Na^{+} concentrations above standards definitely due to the releasing of untreated wastewater from different anthropogenic sources directly into the river, which in turn lead to increase Na^{+} concentrations for both seasons.

5.4 Potassium (K^{+})

K^{+} concentration varies from 2.8 -3.2 ppm with a mean of 3 ppm, and from 4.9-6 ppm with a mean of 5.57 ppm for surface water samples while the values of drainage channel were 19.2 and 35.1during dry and wet seasons respectively (Table-3).

K^{+} concentration levels for ground water for both seasons were ranged from 5.9 ppm to 51.8 ppm with a mean of 27.62 ppm during dry period, while it ranged from 4.5 ppm to 50.8 ppm with a mean of 25.83 ppm during wet period (Table-4). High concentration values of K^{+} in ground water due to applying of chemical fertilizers (NPK) which lead to increase its concentration in ground water above the standard limits.

5.5 Chloride (Cl^{-})

Dissolution of evaporitic minerals such as halite (NaCl) and gypsum ($CaSO_4 \cdot 2H_2O$) is a major source of Cl^{-}, Na^{+} and SO_4^{2-}in river water [13]. Chloride in groundwater may be originated from natural and anthropogenic sources. Atmospheric precipitation, dissolution of salt deposits and weathering of halite and evaporate minerals can be considered as the major lithogenic source of chloride in the groundwater. The possible anthropogenic sources of chloride are septic system, industrial and animal wastes, fertilizers and leachates from landfill and waste dumps [14].

Cl^- concentration varies from 86-97 ppm with a mean of 91.67 ppm, and from 74-80 ppm with a mean of 77.67 ppm for surface water samples while for irrigation channel the value were 518 and 492 ppm during dry and wet seasons respectively (Table-3).Cl^- concentration in groundwater range from 253 ppm to 1408 ppm with a mean of 725 ppm during dry period, while it ranged from 234 ppm to 1385 ppm with a mean of 709 ppm during wet period (Table-4). The relatively high mean of Cl^- during dry and wet seasons attributes mainly to increasing river discharge beside of course the anthropogenic activities.

5.6 Bicarbonate (HCO_3^-)

HCO_3^- ion is the dominant species between pH 6.3 and 10.3 [15].The pH range of 7.6-8.8 for the surface water and range of 6.8-7.9 for the groundwater during dry and wet seasons indicate the dominant of bicarbonate ion. HCO_3^- concentration varies from 17.2-18.9 ppm with a mean of 17.97 ppm, and from 22-26 ppm with a mean of 24.1 ppm for surface water samples during dry and wet seasons respectively (Table-3). HCO_3^- concentration in drainage channel was 169 in the dry season and 176.4 in wet season.

HCO_3^- concentration levels for ground water for both seasons were ranged from 12.7ppm to 315 ppm with a mean of 165.27 ppm during dry season, while it ranged from 27 ppm to 271 ppm with a mean of 148.78 ppm during wet season (Table- 4).

5.7 Sulfate (SO_4^{2-})

Sulfate is one of the major dissolved components of rain [11]. The maximum level of sulfate suggested by WHO [12] for drinking water quality is 250 mg/l and 400 mg/l in IQS [4]. SO_4^{2-} concentration varies from72-83 ppm with a mean of 77.67 ppm, and from 65-71 ppm with a mean of 67.67 ppm for surface water samples during dry and wet seasons respectively (Table-3).

SO_4^{2-} concentration levels for ground water for both seasons were ranged from 202 ppm to 1289 ppm with a mean of 747.33 ppm during dry period, while it ranged from 196 ppm to 1267 ppm with a mean of 714 ppm during wet season (Table-4) .

6. Nutrients

6.1 Phosphate (PO_4^{3-})

Phosphate existed in water in a soluble form, is originated from rocks in addition to its existence in agricultural runoff, industrial wastes, municipal sewage. Sources of nutrients in the surface and groundwater samples are both anthropogenic and natural. The major anthropogenic sources of nitrogen and phosphorus are inorganic fertilizer and discharge of west water from the urban area [16]. PO_4^{3-} concentration varies from 0.29-0.33 ppm with a mean of 0.31 ppm, and from 0.43-0.52 ppm with a mean of 0.47 ppm for surface water samples during dry and wet periods respectively.

PO_4^{3-} for ground water for both seasons were ranged from 0.38 ppm to 0.75 ppm with a mean of 0.55 ppm during the dry period, while it ranged from 0.35 ppm to 0.71 ppm with a mean of 0.49 ppm during wet period.

6.2 Nitrate (NO_3^-)

NO_3^- concentration varies from 2.5-3 ppm with a mean of 2.77 ppm, and from 5.3-6.2 ppm with a mean of 5.77 ppm for surface water samples during dry and wet periods respectively.

NO_3^- for ground water for both seasons were ranged from 8.9 ppm to 34.3 ppm with a mean of 21.13 ppm during dry period, while it ranged from 7.8 ppm to 32.6 ppm with a mean of 19.8 ppm during wet period. High concentrations of NO_3^- were recorded in some samples near agricultural activity areas and animal grazing. Generally, NO_3^- concentrations of most water samples collected from study area water during both seasons are negligible or so small to be considered and lower than the above mentioned standards.

7: Trace elements of surface and groundwater

The contamination of waters with trace elements is very harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts [17]. Groundwater can be polluted with trace elements from a variety of sources, such as weathering, decomposed vegetative and animal matter, the fallout from air particulate and industrial activities [18].

The water samples were analyzed for trace elements (Fe, Al, Pb, Zn, Mn, Cr, Cu, Co, Ni and Cd). The results of trace elements concentration in ppb of Al-Tarmiyah area water samples during dry and wet seasons are systemized in the Tables- (5and6).

Table 5-Trace elements results in the surface water samples during dry and wet seasons

Surface water samples (Dry season)											
S. NO.	Unit	Fe	Mn	Zn	Cd	Cu	Co	Pb	Ni	Cr	Al
W1	ppb	513	230	184	56.1	253	0	298	72	82	86
W3	ppb	341	186	260	68	356	0	413	69	91	95
W4	ppb	460	273	315	73.1	181.9	65.1	256	57	125	91
Min	ppb	341	186	184	56.1	181.9	0	256	57	82	86
Max	ppb	513	273	315	73.1	356	65.1	413	72	125	95
Mean	ppb	438	229.67	253	65.7	263.6	-	322.3	66	99.33	90.67
*W2	ppb	226	905	396	91.8	601.2	139.5	1360	108	279	311
Surface water samples (Wet Season)											
W1	ppb	663	397	336	64.2	257.1	61	317	78	97	97
W3	ppb	658	1143	430	72.1	375.1	0	628	74	124	126
W4	ppb	863	690	542	92.1	278.1	78.1	454	88	196	135
Min	ppb	658	397	336	64.2	257.1	0	317	74	97	97
Max	ppb	863	1143	542	92.1	375.1	78.1	628	88	196	135
Mean	ppb	728	743.33	436	76.13	303.43	46.37	466.3	80	139	119.33
*W2	ppb	2560	1204	691	98.6	608.3	112.5	1514	142	332	341
IQS(2009)		300	100	3000	3	1000	……	10	20	50	100
WHO(2008)		<3000	400	3000	3	2000	…….	10	70	50	200
*W2 ; Drainage channel sample											

Table 6-Trace elements results in the groundwater samples during dry and wet seasons

Groundwater samples (Dry Season)											
S.ID.	Unit	Fe	Mn	Zn	Cd	Cu	Co	Pb	Ni	Cr	Al
GW1	ppb	4910	3550	2420	190.6	896.3	148.6	1715	183	780	655
GW2	ppb	1250	1410	750	169.3	517.1	92.5	738	136	396	258
GW3	ppb	1730	1150	630	89.8	481.3	88.6	683	89	188	93
GW4	ppb	908	2280	1490	97.6	566.2	126.6	591	151	410	451
GW5	ppb	5060	3200	2830	175.8	783.3	160.5	1686	174	603	610
GW6	ppb	2180	2630	1760	139.5	905.1	96.2	1422	158	576	546
Min	ppb	908	1150	630	89.8	481.3	88.6	591	89	188	93
Max	ppb	5060	3550	2830	190.6	905.1	160.5	1715	183	780	655
Mean	ppb	2673	2370	1646.7	143.8	691.6	118.8	1139.2	148.5	492.2	435.5
Groundwater samples (Wet Season)											
GW1	ppb	5420	3860	2510	197.6	898.7	147.5	1756	191	787	676
GW2	ppb	1520	1910	820	170.3	523.1	93.6	767	145	399	267
GW3	ppb	1980	1320	690	91.1	487.2	86.2	692	94	196	98
GW4	ppb	951	2610	1610	99.1	568.6	127.1	621	158	423	462
GW5	ppb	5670	3430	2940	178.2	787.4	158.6	1713	182	631	623
GW6	ppb	2760	2910	1870	140.6	912.3	97.1	1431	167	591	557
Min	ppb	951	1320	690	91.1	487.2	86.2	621	94	196	98
Max	ppb	5670	3860	2940	197.6	912.3	158.6	1756	191	787	676
Mean	ppb	3050.2	2673.3	1740	146.15	696.2	118.35	1163.3	156.2	504.5	447.2
IQS (2009)	ppb	300	100	3000	3	1000	……	10	20	50	100
WHO (2008)	ppb	<3000	400	3000	3	2000	…….	10	70	50	200

Iron is naturally released into the water by weathering of pyritic ores containing iron sulfide (FeS_2) and other iron-bearing minerals in igneous, sedimentary, and metamorphic rocks and also comes from many human sources [19]. The removal of dissolved oxygen by organic matter resulted in reduced conditions leading to increasing the solubility of iron bearing minerals in groundwater [16]**.**The concentration of Fe for surface water samples varies between 341 - 513 with a mean of 438 ppb and between 951-5670 with a mean of 3050.2 ppb for dry and wet seasons respectively (Table- 5). The concentration of Fe in drainage channel sample (W2) varies between 226-2560 ppb for dry and wet season respectively. The concentration of Fe in the groundwater samples range from 908 ppm to 5060 ppb with a mean of 2673 ppb, in the dry season and from 951 ppb to 5670 ppb, with a mean of 3050 ppb, in the wet season (Table- 6)**.** The mean concentrations for Fe at wet season are higher than dry season, the presence of iron in the water can be attributed to the fact that iron can be found in the organic waste and the remnants of decaying plants in the soil.

Manganese is one of the most abundant and widely distributed metals in nature. The major anthropogenic sources of environmental manganese include municipal wastewater discharges, sewage sludge, mining and mineral processing, combustion of fossil fuels [20].Concentrations of dissolved Mn in surface water samples vary between 186- 273 with a mean of 229.67 ppb for dry season, and between 397-1143 with a mean of 743.33 ppb for wet season (Table- 5). The concentrations of manganese in the drainage channel were 905 and 1204 ppb for dry and wet seasons respectively. The measured concentration of Mn in the groundwater samples range from 1150- 3550 with a mean of 2370 ppb, during the dry season and from 951- 5670 with a mean of 3050.2 ppb during the wet season (Table- 6).The mean concentration is higher in wet season than in dry season for surface and ground water samples, due to the human activities.

Zinc: The most important source of Zn in the environment is automotive tires wear and other sources include road surfaces, roofs, paint, waste incineration, and untreated sewage effluent [21]. Zn concentration of surface water samples varies between 336-542 with a mean of 436 ppb for dry and wet seasons respectively (Table- 5). The concentration of Zn for drainage channel samples were 396 and 691 for dry and wet seasons respectively.

The concentration of zinc in the groundwater samples range from 630-2830 with a mean of 1646.7 ppb, during the dry season and 690- 2940 with a mean of 1740 ppb, during the wet season (Table-6). The mean concentrations for surface and ground water samples are higher in wet season than in dry season, this can be attributed to agricultural events and the use of fertilizers.

Cadmium enters the environment mostly from industrial activities including the production of alloys, pigments, and batteries, especially those associated fossil fuels and also from domestic wastes, phosphate fertilizer, as well as atmospheric deposition [22, 23]. Concentrations of Cd in surface water samples range from 56.1 to 73.1 ppb with a mean of 65.7 ppb in the dry season, and from 64.2 to 92.1 ppb with a mean of 76.1 ppb in the wet season. The concentration of Cd for drainage channel samples were 91.8 and 98.6 ppb for dry and wet seasons respectively (Table-5). Cadmium of groundwater samples ranged from 89.8 ppb to 190.6 ppb with a mean of 143.8 ppb, during the dry season and from 91.1 ppb to 197.6 ppb, with a mean of 146.15 ppb, during the wet season (Table-6). The concentration of Cd has exceeded the limits of Iraq standards [7] and WHO [8], this can be explained by its presence in the rocks and river sediments, such as shale (1.4 ppm), limestone (0.05) ppm, and sand rocks (0.05) ppm. And may be polluted by industrial pollutants in cadmium (electroplating, dyes, printing ink) and burning fossil fuels. This element is collected in the plants during the lifetime.

Copper: The weathering of copper deposits is the main natural source in the aquatic environment, but dissolved copper rarely occurs in unpolluted source water above 10 mg/l, limited by the solubility of copper hydroxide ($Cu(OH)_2$), coprecipitation with less soluble metal hydroxides, and adsorption [19]. The concentration of Cu in surface water samples varies between 181.9 and 356 ppb with a mean of 263.6 ppb, and between 257.1 and 375.1 ppb with a mean of 303.43 ppb for dry and wet seasons respectively. The concentration of Cu for drainage channel samples were601.2 and 608.3 ppb for dry and wet seasons respectively (Table-5). The concentration of Cu in the groundwater samples ranged from 481.3 ppb to 905.1 ppb with a mean of 691.6 ppb, during the dry season and from 487.2 ppm to 912.3 ppb, with a mean of 696.2 ppb, during the wet season (Table-6). Co concentration is low in the studied samples and shows no regular increase or decrease during both seasons.

Cobalt precipitation or adsorption of Co by oxides of manganese and iron appears to be an important factor in controlling the amounts that can occur in solution in natural water [9]. Co concentration of surface water samples ranges from 0 to 65.1 ppb during dry season and from 0 to 78.1 ppb with a mean of 46.37 ppb during wet season. The concentration of Co for drainage channel samples were139.5 and 112.5 ppb for dry and wet seasons respectively (Table-5). The concentration of Co in the studied groundwater is ranging from 88.6 ppb to 160.5 ppb with a mean of 118.8 ppb, during the dry season and from 86.2 ppb to 158.6 ppb, with a mean of 118.35 ppb, during the wet season (Table-6). Co concentration is low in the studied samples and shows no regular increase or decrease during both seasons. The high presence in the environment is attributed to human activity especially agricultural, for its presence in Iraqi fertilizers.

Lead minerals are found mostly in igneous, metamorphic and sedimentary rocks, even though some lead enters the environment from natural sources by weathering of minerals, particularly galena, anthropogenic sources are about 100 times greater [19]. Pb concentration of surface water samples varies between 256 and 413 ppb with a mean of 322.3 ppb and between 317 and 628 ppb with a mean of 466.3 ppb for dry and wet seasons respectively. The concentration of Pb for drainage channel samples were 1360 and 1514 ppb for dry and wet seasons respectively (Table-5). Pb is detected in all studied ground water samples and ranged in concentration from 591 ppb to 1715 ppb with a mean of 1139.2 ppb, during the dry season and from 621 ppb to 1756 ppb, with a mean of 1163.3 ppb, during the wet season (Table-6), the mean concentration of Pb in the wet season are higher than the dry season. Lead concentrations in aquatic samples of the study area were high and exceeded the permissible limits for drinking water, this increases in concentrations can be attributed to agricultural processes and land use.

Nickel is an important industrial metal, industrial waste streams can be a major source of environmental nickel and it is one of the most mobile heavy metals in the aquatic system [19]. The range for Ni for surface water samples is 57 to 72 ppb with a mean of 66 ppb and from74 to 88 ppb with a mean of 80 ppb during dry and wet seasons respectively. The concentration of Ni for drainage channel samples were108 and 142 ppb for dry and wet seasons respectively (Table-5). Ni concentration in the groundwater samples is ranged from 089 ppb to 183 ppb with a mean of 148.5 ppb, during the dry season and from 94 ppb to 191 ppb, with a mean of 156.2 ppb, during the wet season (Table- 6). The values for the wet season are higher than for dry season and that all values have exceeded the permissible limit for drinking water. The high presence in the environment is attributed to human activity [5] especially agricultural, for its presence in Iraqi fertilizers.

Chromium in the aquatic phase occurs in the soluble state or as suspended solids adsorbed onto clayish materials, organics, or iron oxides [24]. Concentrations of Cr in surface water samples range from 82 to 125 ppb with a mean of 99.33 ppb and 97 to 196 ppb with a mean of 139 ppb during dry and wet seasons respectively. The concentration of Cr for drainage channel samples were279 and 332 ppb for dry and wet seasons respectively (Table-5). Ni concentration in the groundwater samples was ranged from 188 ppb to 780 ppb with a mean of 492.2 ppb and from 196 ppb to 787 ppb, with a mean of 504.5 ppb, for dry and wet seasons respectively (Table-6). All the results of Cr exceeded the permissible limits for drinking water, this increases in concentrations can be attributed to the untreated sewage water, drainage runoff from agricultural land.

Aluminum is liberated naturally into the environment by the weathering of rocks and minerals such as bauxite, clays and also from all type of soil [19]. The value of pH affecting the hydrolysis of Al ions is the most crucial factor that accounts for the form of Al occurrence [25]. The concentration of Al for surface water samples varies between 86 and 95 ppb, with a mean of 90.67 ppb and between 97 and 135 ppb, with a mean of 119.33 ppb for dry and wet seasons respectively. The concentration of Al for drainage channel samples were311 and 341 ppb for dry and wet seasons respectively (Table-5). Aluminum concentrations in the groundwater samples is ranged from 93 ppm to 655 ppb with a mean of 435.5 ppb and from 98 ppb to 676 ppb, with a mean of 447.2 ppb , for dry and wet seasons respectively (Table-6). The mean concentration of Al in the wet season is slightly higher than the dry season.

8. Hydrochemical formula

Hydrochemical formula of surface and groundwater in the study area is determined according to Kurlolov’s formula. This formula depends on the ratio of the main ions, (cations and anions) expressed by equivalents per million %, that are arranged in descending order which have more than (15%) ratio of availability [26]. The descending arrangement of ions in the formula is utilized to recognize the basic water type. Applying Kurlolov’s formula for the dry and the wet seasons of surface water data, shows that the two of Tigris river samples W1and W3 have (Ca^{+2} - Na^{+} - Mg^{+2} - SO_4^{-2} – Cl^{-}) and one sample W4 as well irrigation channel sample has(Na^{+} -Ca^{+2} - Mg^{+2} - SO_4^{-2} -Cl^{-}) in dry season and classified as $CaCl_2$-water type and NaCl-water type respectively. while the data of the surface water samples for wet season shows that (Na^{+} -Ca^{+2} - Mg^{+2} - SO_4^{-2} - Cl^{-}) are the hydrochemical formula for all samples and classified as NaCl-water type.

The hydrochemical formula of groundwater shows that three ground water samples Gw1, Gw5 and Gw6 during dry season and two samples Gw1 and Gw5 during wet season classified as $CaCl_2$ water type. Groundwater samples Gw3 and Gw4 during dry season and Gw3 and Gw4 and Gw6 during wet season classified as NaCl water type. There is only one groundwater sample Gw2 during wet season was classified as $CaSO_4$ water type.

9. Water classification using Piper Diagram

Piper diagrams allow for both anions (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}) and cation (HCO_3^{2-}, SO_4^{2-} and Cl^{-})compositions to be represented on a single graph. These diagrams are also useful for visually describing the differences in major ions chemistry in water flow systems [27].

When comparing the values of cations and anions of the water samples for two season Figure-(2 A ,B) with the hydrochemical classification diagram [28] it is clear that most of surface and groundwater samples fall in class (e), this means that the type of water in most study area samples for wet and dry periods is "Earth alkaline water with increased portions of alkalis with prevailing sulfate or chloride".

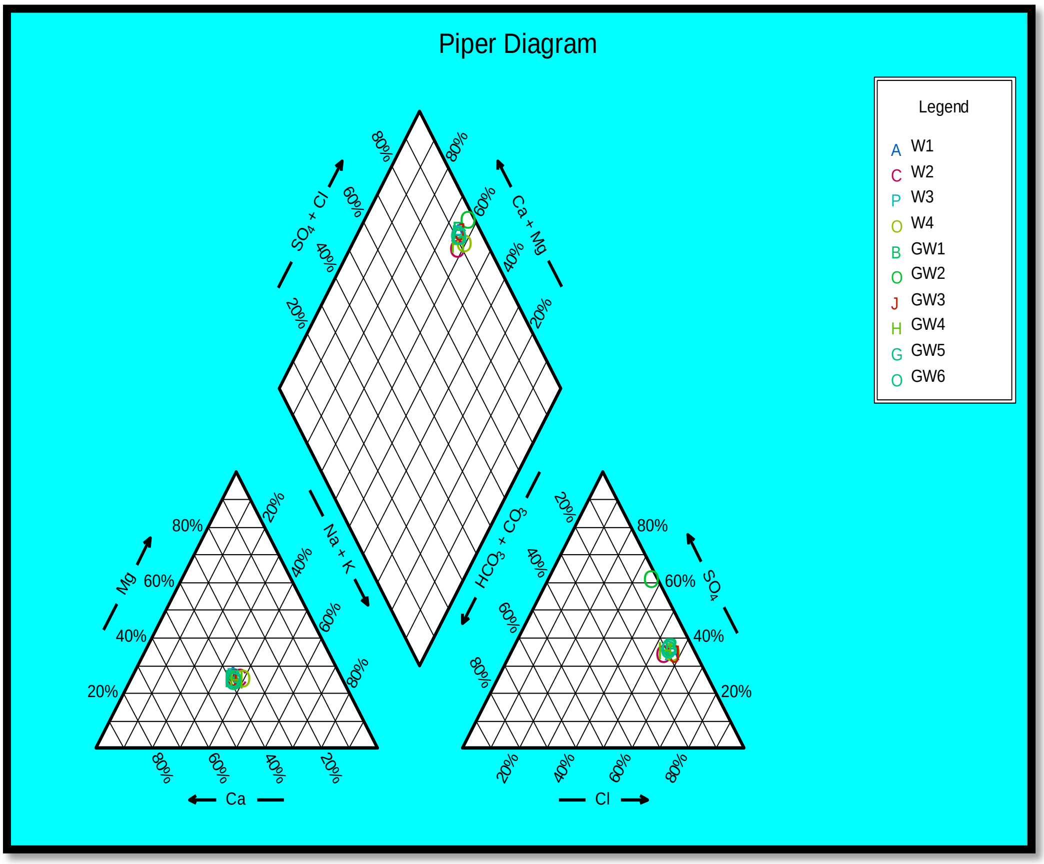

Figure 2 (A)-Piper diagram of the water samples in the dry season.

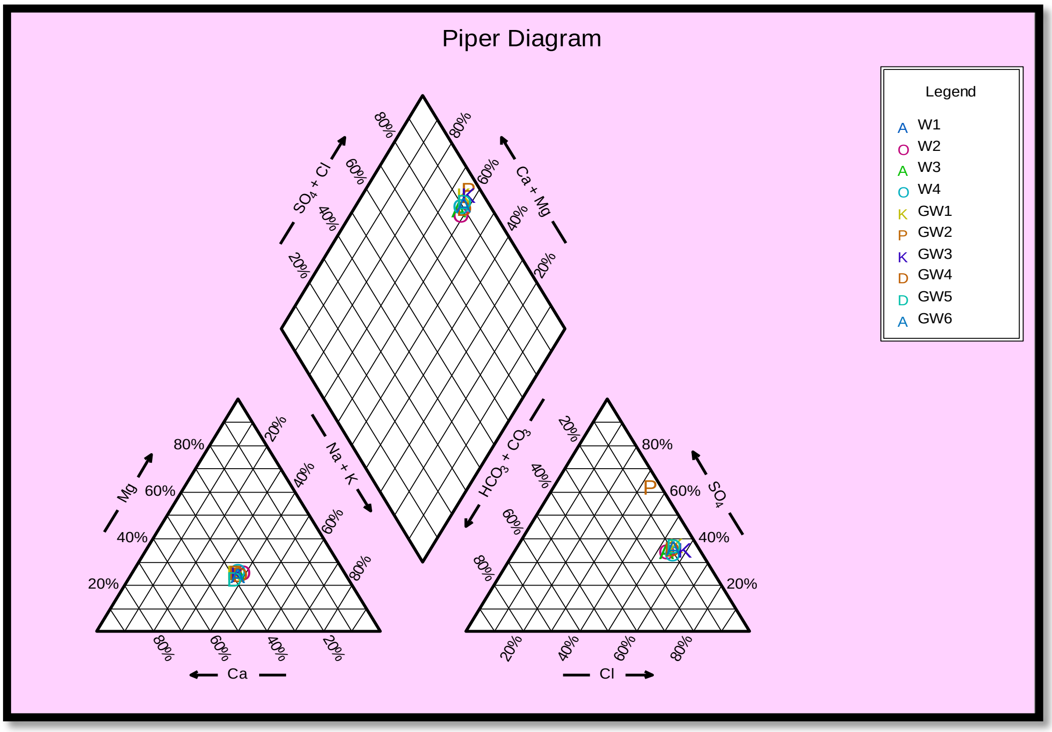

Figure 2 (B)-Piper diagram of the water samples in the wet season.

10. Suitability of water for different uses

10.1. Evaluation of water quality for drinking

Drinking water standards of WHO [8] and Iraqi Standard [7] are used as a basis for the water quality evaluation of the present study samples for drinking use. All surface water samples during dry and wet seasons are unsuitable for drinking and not within the standard quality criteria for most of physiochemical parameters and trace elements. All groundwater samples during dry and wet periods are not suitable for drinking according to recommended limits of WHO [8] and Iraqi Standard [7].

10.2. Evaluation of water quality for livestock

Criteria for livestock suitability usually takes into account the type of livestock, daily water requirements of each species as well as information on the toxicity of specific substances to the different species. The recommendations levels of toxic substances in drinking water for livestock according to Ayers and Westcot, 1985 classification [29], include an appropriate margin of safety with the exception for Cd, Pb concentrations where they exceed the standard limit for all surface and groundwater samples. All surface and groundwater samples for dry and wet periods are within excellent type concerning water salinity (EC) with the exception of surface water sample W2 which lies within very satisfactory and with the exception of groundwater samples GW1, GW5 which lies within Satisfactory for Livestock (Unfit for Poultry).

10.3 Evaluation of water quality for irrigation

The evaluation of water quality is necessary for the planning, design, and operation of irrigation systems to ensure that no deleterious salts or compounds occur in the irrigation water [30]. There are many criteria established to evaluate and classify irrigation water:

10.3.1 Salinity Hazard

The most influential water quality guideline on crop productivity is the salinity hazard as measured by electrical conductivity (EC). Almost all surface water samples of the dry and wet seasons lie within Good class based on Suggested limits of EC value for irrigation (Table-7). There is only one surface water sample W2 (for both seasons) lie within the doubtful class. Most groundwater samples are within the unsuitable class and only two samples (GW2 and GW3) within the doubtful class and permissible class respectively.

Table 7-Classification the suitability of water for irrigation according to electrical conductivity [31]

Classes of water	Electrical Conductivity (dS/m)*
Class 1, Excellent	< 0.25
Class 2, Good	0.25-0.75
Class 3, Permissible[1]	0.76- 2.00
Class 4, Doubtful[2]	2.01 – 3.00
Class 5, Unsuitable[2]	>3.00
* decisiemen/m,(dS/m)at 25° C = millimho/cm, mmho/cm, 1 dS/m = 1000 µS/cm. [1]Leaching needed if used. [2]Good drainage needed and sensitive plants	

10.3.2 Sodium Hazard

While EC is an assessment of all soluble salts in a sample, sodium hazard is defined separately because of sodium's specific detrimental effects on soil physical properties. Classification of irrigation waters with respect to SAR is based primarily on the effect of exchangeable sodium on the physical condition of the soil. In addition, sodium sensitive plants may suffer damage as a result of sodium accumulation in plant tissues. The Sodium Adsorption Ratio (SAR) calculated based on the following formula [29] :

$$SAR = \frac{(Na^+)}{\sqrt{1/_2\,[(Ca^{2+}) + (Mg^{2+})]}}$$

According to the classification of the irrigation water according to sodium hazard based on SAR values [31], all surface water samples and groundwater samples for dry and wet seasons (Table-8) lies within low hazard class.

Table 8-SAR value of Al-Tarmiyaharea water samples during wet and dry seasons

Sample	SAR	
	Dry season	Wet season
W1	1.99	1.96
W2	5.13	4.96
W3	1.93	1.86
W4	1.38	1.45
GW1	7.77	7.71
GW2	4.22	4.35
GW3	2.33	2.15
GW4	5.06	5.22
GW5	7.0	7.13
GW6	5.96	5.86

Conclusions:

Al-Tarmiyaharea surface water samples Characterized as category highly mineralized water while for ground water samples Characterized as category excessively mineralized water for dry and wet seasons based on electric conductivity results. Applying Kurlolov's formula for the dry and the wet seasons of surface water data, shows that (Ca^{+2} - Na^{+} - Mg^{+2} - SO_4^{-2} – Cl^{-}) and (Na^{+} -Ca^{+2} - Mg^{+2} - SO_4^{-2} -Cl^{-}) are the dominant hydrochemical formula in surface water samples of the dry season and classified as $CaCl_2$-water type and NaCl-water type respectively while the data of the surface water samples for wet season shows that (Na^{+} -Ca^{+2} - Mg^{+2} - SO_4^{-2} - Cl^{-}) are the dominant hydrochemical formula and classified as NaCl-water type. Most groundwater samples during dry and wet seasons are classified as $CaCl_2$-water type and NaCl water type. There is only one groundwater sample (GW2) is classified as $CaSO_4$ water type. According to water classification based on the Piper diagram, most of surface and groundwater samples fall in class (e), this means that the type of water in most study area samples for wet and dry seasons is "Earth alkaline water with increased portions of alkalis with prevailing sulfate or chloride". Surface water data, shows that the maximum value of calcium , magnesium, and Sulfate (major ions) exceeded the limits of Iraq standards(IQS 2009) and WHO

(WHO,2008) at dry and wet seasons .While ground water data, show that the maximum and minimum value of calcium and sodium and the maximum value of magnesium, potassium, Sulfate and chloride exceeded the limits of Iraq standards(IQS 2009) and WHO (WHO,2008) at dry and wet seasons . So all water samples from Al-Tarmiyaharea during the wet and dry seasons are not suitable for drinking purposes according according to results of anions and cations and trace elements. All studied water samples for the dry and wet seasons were within "excellent type" According to Water quality for livestock and poultry. Almost all surface water samples of the dry and wet seasons lies within Good class based on Suggested limits of EC value for irrigation. There are only one surface water sample W2 (for both seasons) lie within doubtful class. Most groundwater samples are within unsuitable class and only two samples (GW2 and GW3) within the doubtful class and permissible class respectively. All surface water samples and groundwater samples for dry and wet seasons lies within low hazard class of the irrigation water based on SAR values.

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