HYDROCHEMISTRY OF SHALLOW GROUNDWATER IN WESTERN KARBALA CITY CENTRAL PART OF IRAQ

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ABSTRACT

This research deals with the hydrochemistry of groundwater in western part of Karbala city, which is located in the Mesopotamian plain, 100 Km southwest of Baghdad. The geological formations outcrop in Karbala city are, Injana, Dibdibba and Quaternary sediments. The climate is characterized as being continental, dry, and relatively hot in summer, cold and little rain in winter. The movement of groundwater is toward the center of the city in two directions. Water samples were analyzed to determine the major anions and cations, in addition to the heavy metals measurements that prove the contamination of groundwater by Al and Zn. The type of water in this area was believed to be of chloride and sulphatic and the water classification according to TDS quantity is brackish water. The groundwater is not suitable for any uses except some limited use in agriculture and live stocks.

هيدروكيميائية المياه الجوفية الضحلة في الجزء الغربي من مدينة كربلاء وسط العراق

سوسن عبد الرحمن إبراهيم و أيسر محمد الشماع

المستخلص

يتناول هذا البحث الخصائص الكيميائية للمياه الجوفية في الجزء الغربي من مدينة كربلاء والتي تقع ضمن منطقة السهل الرسوبي وتبعد عن بغداد 100 كم بالاتجاه الجنوبي الغربي. إن التكوينات الجيولوجية المنكشفة ضمن مدينة كربلاء هي تكوينات إنجانة والدبدبة وترسبات العصر الرباعي. يخضع مناخ المنطقة لظروف مناخ الصحراء الغربية من حيث عناصر المناخ والذي يمتاز بكونه قاري جاف حار صيفاً وبارد قليل الأمطار شتاءاً. تكون حركة المياه الجوفية باتجاه مركز المدينة وباتجاهين. تم قياس تراكيز الأيونات الموجبة والسالبة بالإضافة الى قياس المعادن الثقيلة وقد أثبتت التحاليل تلوث المياه الجوفية في منطقة الدراسة بعنصري الألمنيوم والزنك. نوعية المياه في المنطقة على الأغلب كلوريدية وكبريتاتية وقد تم تصنيف المياه اعتماداً على كمية TDS الى مياه ضعيفة الملوحة. أن المياه الجوفية في مدينة كربلاء لا تصلح لأي استخدام ماعدا لأغراض سقي الدواجن فقط واستخدامات محدودة في مجال الزراعة.

INTRODUCTION

The study area is located between Eastern Longitude (44° 25' 00" – 43° 45' 00") and Northern latitude (32° 40' 00" – 32° 20' 00") (Fig.1), and its suburbs are located on the edged interim between the stable shelf (Al-Salman sub-zone) and the unstable shelf (Mesopotamian sub-zone). Ten water samples were collected in two periods from wells ranged in depths within 12 m. for the reason of determining the chemical and physical characters of groundwater in Karbala city.

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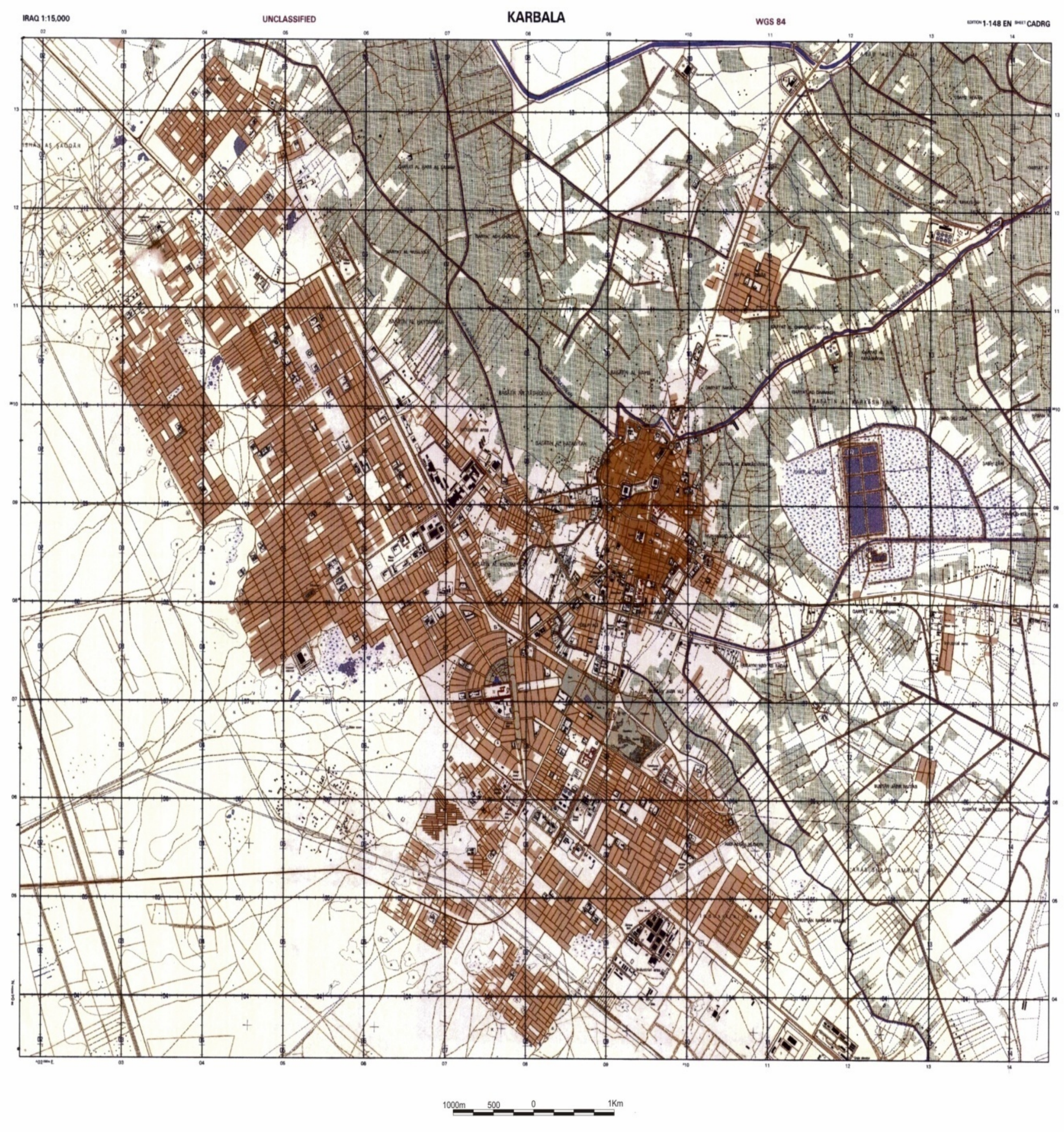

Fig.1: Location map (GIS) of study area
(Engineer Detachment Topographic, 2003)

PREVIOUS STUDIES

- Fondedile (1982) studied the site of the Shrine of Al-Imam Al-Abbas and concluded that the internal and external walls of the shrine cause rising of groundwater level.
- Euphrates Center for Irrigation Studies and Designations prepared a study in (1995) about the area of Karbala that concludes in recommendation to lower the levels of groundwater in the city as the geology of the area has been examined.
- Barwary (1995) prepared an internal report, submitted to the State Company of Geological Survey and mining, on the geological board of Karbala.
- Al-Basrawi (2005). Hydrogeological and hydrochemical evaluation in Karbala governorate, this study determine groundwater quality, aquifer type in governorate, groundwater movement and suitability of water for purpose uses.
- Al-Ubayde (1997) studied the effect of groundwater on the level of groundwater in Karbala and estimated transporting values of the unconfined aquifer through studying the chemical changes in the aquifer; he concluded that the water are sulfuric and chloride.
- NCCL (1998) studied the Soil challenges in Imam Hussein's Shrine; it included the identification of the type of soil, its physical, mechanical and mineral properties, and the effect of the groundwater on the site.
- The Iraqi Human Resources Association (1998) prepared a study that included the presentation of proposals, studies, and designations that may decrease the levels of groundwater beneath the Imam Hussein and Imam Abbas Shrines. In addition, they suggested building a concrete wall around the two shrines.
- Al-Khalidy (2002), carried out Geo-Tectonic Assessment of Karbala's Soil study included the physical, Engineering, metallic and chemical characterizes for the soil and rock layer and exposited problems and groundwater effects.

FIELD WORK

The field work started in April (2008), 10 wells of 12 meters depth drilled by the General Company of water wells distributed in populated areas. Water sample were collected in two different periods, the first period is the water surplus period in April (2008) and the second period is the water deficit period in October (2008). Lap analysis of the water samples were carried out in the following places:

1. Environmental Analyses Section/ Ministry of Environment (Anion + Cation + Heavy metal)
2. Environmental Analyses Section/ Ministry of Science and Technology (Anion + Cation)

CLIMATE

The climate of the studied area characterized as being continental, dry and relatively hot in summer, cold and little rain in winter and believed to be influenced by the Mediterranean Sea climate (Al-Khateeb, 1998).

In addition to the remarkable difference in the temperature between day and night, the wind prevalent in the area is mostly northwest toward southeast accompanied by sand storms especially in summer and sometimes winds come from the south and south west (I MO, 2008). The rainfall period in the study area is restricted from October to January for the period from 1976 to 2007; the rainfall average recorded in January was 18.06 mm, while the lowest average has been recorded in July and August as zero mm. The rainfall is characterized as heavy for short periods of time (Iraqi meteorological organization, 2008).

GEOLOGY OF KARBALA

▪ Stratigraphy of the studied area

Sedimentary rocks of the Tertiary and Quaternary sediments are outcrops in Karbala province and include the followings from oldest to youngest:

─ **Injana Formation (Upper Miocene):** The formation is exposed along both ridges of Tar Al-Najaf and Tar Al-Sayid, and in the eastern bank of Al-Razzaza Lake to the west of Karbala city. While in the rest of the areas it is either covered by Dibdibba Formation or thick layers of recent sediments. This formation is basically composed of sandstone and claystone with different colors (Green, grey, and brown). The contact between the Injana Formation and the Diddibba Formation appears as a soft layer of gravel. The environment of deposition varies from being marine to continental (Buday and Jassim, 1987).

─ **Dibdibba Formation (Pliocene):** This formation is outcropped in the area between Al-Razzaza Lake and Karbala city from the northern west and west sides; it is mainly composed of sandstones, gravelly sandstones, and lenses of claystone. It forms a cover to Injana Formation deposits and the environment of deposition of this formation is continental (Buday and Jassim 1987). There is a gypcrete layer composed of sand, shale, gravel, and high percentage of gypsum are derived from the Quaternary sediments. Karbala represents a depocenter of the Dibdibba Formation along the Euphrates boundary fault (Jassim and Buday, 2006 in Jassim, and Goff, , 2006).

─ **Quaternary sediments:** These sediments are outcrop inside Karbala city and extend to the Euphrates River and are composed of sand, shale, clay and there is gravel in some areas especially of Pleistocene sediments that exist in the northern part of the studied area. The thickness of these sediments varies and increases toward the Euphrates River. The environment of deposition of these continental sediments is erosional and precipitational, (Buday and Jassim, 1987).

Karbala city is located on the line between the Quaternary sediments and the Tertiary (Dibdibba Formation) where the old city is located on the Quaternary deposits composed of shale and other river sediments, which represent the boundary of the Mesopotamia Plain. Part of the new neighborhoods is located in the west of the center of the city over the Dibdibba Formation is represented by sandstones and sandy gravel and clay layers. The land elevation of the sedimentary plain, in the eastern part of the city, is lower than the elevation in the Dibdibba Formation in the western part of the city. Thus, geologically, Karbala city can be divided into two parts and each of them differs from the other topographically and lithologically (Buday and Jassim, 1987).

HYDRGEOLOGY OF GROUNDWATER IN KARBALA CITY

Two aquifers are distinguished within the west regions of Karbala plain which is adjacent to the Mesopotamia Plain. The lower aquifer is within carbonate rocks, exists on a depth of (70 – 300) m between Karbala and Al-Najaf and also it extends within Shithatha plain to the west of the region, while the upper aquifer is composed of sand and gravel sediments with small amount of clay, which form the desert surface region within the surrounded area between Karbala and Al-Najaf. The thickness of the aquifer is about 70 m in the middle part of the area. Probably there is a hydraulic connection between these two aquifers with the aquifer that lies within the Mesopotamia Plain region.

In general the Mesopotamia Plain sediments are composed of sequence beds of clay, silt, sand and gravel. The water bearing beds are composed mainly of sand and gravel mixtures which are range between small and large extensions (Krasny, 1982).

The groundwater aquifers in the studied area exist within the layers of the Dibdibba Formation and the Quaternary sediments, and each of them has distinctive features as follows:

- **Injana aquifer**

Injana Formation is exposed along Tar Al-Najaf and Al-Sayid and on the east side of Al-Razzaza Lake. It composed mainly of sandstone, silt and clay.

This formation represents the main aquifer with the clastic rock in the desert flat region (Dibdibba flat), where most of the bore holes of small depths produce water from this formation. Pumping test shows that the transmissibility ranged between (21 – 927) m^2/day, permeability ranged between (0.8 – 40.2) m/day, discharge of boreholes ranged between (72 – 720) m^3/day, and the static water level ranged between (0 – 19.5) meter below ground surface. The groundwater recharge in this aquifer is from rainfall, which penetrated through the clastic rocks within the flat desert region and from the adjacent higher region, also may be from the groundwater of carbonate rocks aquifer which lay below Injana aquifer. The groundwater discharge within these sediments may be towards the low land located along the western side of the Euphrates River or may be to the river valley itself (ECFISAD, 1995).

- **Quaternary Aquifer (Mesopotamia Plain)**

In general the Quaternary sediments are composed of sequence of clay, silt, sand, shale and a little of gravel in Karbala plain. These sediments covered most regions of the plain especially to the east of the Euphrates river regions. Hydrogeologically, the upper part of Quaternary sediments are composed mainly of silt and shale represented the impermeable beds. While, sand, gravel mixed with silt and shale represent the Quaternary aquifer within the Mesopotamia plain of thickness about (10 – 20) m, below the depth (20 – 25) m. Extension of hydrogeological bodies can be estimated according to deep drilled geological wells during the geological investigation of the Mesopotamia plain. Pumping test of boreholes gives a transmissibility values ranged between (10 – 165) m^2/day, the permeability is between (1 – 27) m/day, the discharge of borehole ranged between (35 – 596) m^3/day and the static water level ranged between (0 – 7) m below ground surface. Karsny (1982) mentioned that hydraulic parameters, as estimated on the basis of performed pumping test, reflect that the transmissibility along Hilla River region within the Mesopotamia Plain ranges between (100 – 200) m^2/day, to reaches to depth about tenths of meters. While, Al-Sam and others refer that the transmissibility within Babylon region reach (300 – 400) m^2/day and storage coefficient varying considerably from (0.0004 – 0.13) m^2/day (Krasny, 1982). Generally, ground water flow direction is from west to east and south east, and the aquifer recharged from the elevated desert plain in the west, in addition to rainfall infiltration. The discharge area is represented by an aligned springs located east of the study area and the Al-Razzaza Lake in addition to the Euphrates River and other depressions and valleys that spread in the region (Fig.2).

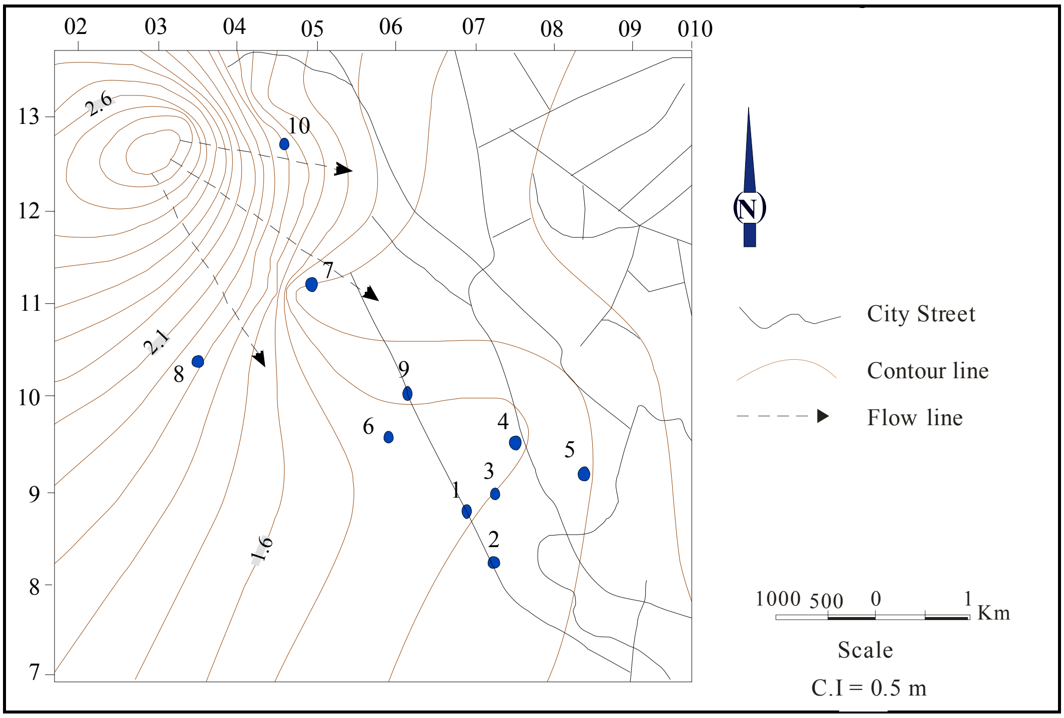

Fig.2: Groundwater flow in the study area

- **Hydrochemistry of Groundwater**

In any evaluation of groundwater resources, the quality of water is almost of equal importance as its quantity. The chemical analysis of groundwater includes determination of the major and minor constituents and the field measurements of electrical conductance, hydrogen ions activity as well as the water temperature and the total dissolved solids (Karanth, 2008). Generally all the anions and cations exceed the permissible values for drinking water (WHO, 2009) the Ca^{+2} concentration was the largest value among cations and the SO_4^{-2} among anions (Tables 1and 2).

The increase of Ca^{+2} concentration resulted from the mixing of groundwater with waste water in urban area, where waste water contains high organic material which through oxidation, it releases CO_2 concentration (Langmuir, 1997). The increase of SO_4^{-2} concentration in the groundwater in the presence of reduction bacteria and organic material, results high quantities of CO_2 and H_2S, which lead to sulphate and carbonate minerals deposition and then decrease the porosity and increase the second porosity as a consequence of the presence of organic acid which lead to increase the dissolved minerals (McMahon, 2001). The groundwater also shows pollution with the nitrate due to of agricultural activities or from human or animal wastes because of the oxidation ammonia and similar sources (WHO, 2006). Sewage disposal represents another source for nitrate pollution (Yuce *et al.*, 2006). Heavy metals analyzed in this study (using the atomic absorption) show that the samples are contaminated with Zn and Al. The main source for Zn pollution are industries and the use of liquid manure, composed materials and an agrochemicals such as fertilizers and pesticides in agricultural projects (Krishna and Govil, 2005), whereas, the pollution with Al contributes to the Al metal in waste water defecating factories (Mane, 2001).

Table 1: Hydrochemical analysis for water samples in wet season

S. No.	Water temp. (˚C)	pH	EC (µs/cm)	TDS (ppm)	Unit	Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	SUM	$SO_4^{=}$	Cl^{-}	HCO_3^{-}	$CO_3^{=}$	SUM
1	23.5	7.14	3100	2334	ppm	490	85	20	109	704	925	390	310	n.d	1625
					epm	24.5	7.02	0.51	4.73	36.76	19.27	10.89	5.08	n.d	35.33
					epm%	67	19	13.5	1.5	100	54	31	14	n.d	100
2	23.8	7.31	3220	2483	ppm	495	85.9	62	160	802.9	910	377	377	n.d	1664
					epm	24.75	7.09	1.58	6.95	40.37	18.95	10.61	6.18	n.d	35.74
					epm%	61	18	4	17	100	53	30	17	n.d	100
3	22.1	7.30	3190	2349	ppm	436	99.3	103.4	86	724.7	830	505	279	n.d	1614
					epm	21.8	8.20	2.65	3.73	38.38	17.29	14.22	4.57	n.d	36.08
					epm%	58.5	22.5	8	11	100	48	39	13	n.d	100
4	23.3	7.44	3080	2298	ppm	487	70.8	86.3	130	774.1	505	665	350	n.d	1520
					epm	24.35	5.85	2.21	5.65	38.06	10.52	18.73	5.73	n.d	34098
					epm%	64	15	6	15	100	30	54	16	n.d	100
5	23.2	7.51	3095	2389	ppm	475	89	79.4	155	798.4	509	672	375	n.d	1556
					epm	23.75	7.35	2.03	6073	39.89	10.60	18.92	6.14	n.d	35.66
					epm%	60	18	5	17	100	30	53	17	n.d	100
6	24.3	7.08	3390	2580	ppm	469	85	75.9	152	781.9	906	436	305	n.d	1647
					epm	23.45	7.02	1.94	6.60	39.01	18.87	12.28	5	n.d	36.15
					epm%	60	18	5	17	100	52	34	14	n.d	100
7	24.2	6.90	3385	2579	ppm	441	86.2	40	203	770.2	945	425	353	n.d	1723
					epm	22.05	7.12	1.02	8.82	39.01	19.68	11.97	5.78	n.d	37.43
					epm%	56	18	3	23	100	53.5	32.3	14.2	n.d	100
8	25.1	7.03	3400	2643	ppm	436	86	68.2	270	860.2	969	415	389	n.d	1773
					epm	21.8	7.10	1.74	11.73	42.37	20.18	11.69	6.37	n.d	38.24
					epm%	51	17	4	28	100	53	30	17	n.d	100
9	25.3	7.43	3419	2741	ppm	475	82	51.7	265	873.7	955	395	387	n.d	1737
					epm	23.75	6.77	1.32	11.52	43.36	19.89	11.07	6.34	n.d	37.3
					epm%	55	16	3	26	100	53	30	17	n.d	100
10	25.4	6062	3422	2670	ppm	485	85	80	245	895	935	390	360	n.d	1685
					epm	24.25	7.02	2.05	10.65	43.97	19.47	10.98	5.90	n.d	36.35
					epm%	55	16	5	24	100	54	30	16	n.d	100

Table 2: Hydrochemical analysis for water samples in dry season

S. No.	Water temp. (˚C)	pH	EC (µs/cm)	T.D.S (ppm)	Unit	Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	SUM	$SO_4^{=}$	Cl^{-}	HCO_3^{-}	$CO_3^{=}$	SUM
1	24.3	7.27	3590	2680	ppm	508	100	32	221	861	955	455	350	n.d	1760
					epm	24.5	8.62	0.85	9.60	44.08	19.89	12.81	5.73	n.d	38.43
					epm%	57	19	2	22	100	52	33	15	n.d	100
2	24.5	7.97	3636	2830	ppm	515	101.9	125	220	961.9	935	485	395	n.d	1815
					epm	25.75	8.42	3.20	9.56	46.93	19.47	13.66	6.47	n.d	39.6
					epm%	55	18	7	20	100	49	35	16	n.d	100
3	24.1	7.38	3488	2777	ppm	580	120	115	115	930	850	630	318	n.d	1798
					epm	29	9.91	2.94	5	46.85	17.70	17.74	5.21	n.d	40.65
					epm%	62	21	6	11	100	43	44	13	n.d	100
4	23.2	7.63	3215	2614	ppm	498	86	103.3	150	837.3	605	685	370	n.d	1660
					epm	24.9	7.10	2.64	6.52	41.16	12.60	19.29	6.06	n.d	37.95
					epm%	60.5	17.5	6	16	100	33	51	16	n.d	100
5	23.1	7.51	3217	2599	ppm	480	93.5	95	175	843.5	602	685	385	n.d	1672
					epm	24	7.72	2.43	7.60	41.75	12.54	19.29	6.31	n.d	38.14
					epm%	57.5	18.5	6	18	100	33	50	17	n.d	100
6	25.5	7.83	3690	2850	ppm	502	106	103	192	903	965	510	389	n.d	1864
					epm	25.1	8.76	2.64	8.34	44.84	20.10	14.36	6.37	n.d	40.83
					epm%	56	19	6	18.599	100	49	35	16	n.d	100
7	25.4	7.06	3688	2914	ppm	474	97.2	50.3	11.69	890.5	975	525	395	n.d	1895
					epm	23.7	8.03	1.28	26	44.70	20.31	14.78	6.47	n.d	41.56
					epm%	53	18	3	58.166	100	49	35	16	n.d	100
8	26.2	7.5	3810	3020	ppm	450	90	75.2	12.60	905.2	975	490	392	n.d	1857
					epm	22.5	7.43	1.92	28	44.4	20.31	13.80	6.4	n.d	40.51
					epm%	51	17	4	63.063	100	50	34	16	n.d	100
9	26.5	7.99	3836	3066	ppm	490	92	55	15.43	992	978	498	395	n.d	1871
					epm	24.5	7.60	1.41	32	48.94	20.37	14.02	6.45	n.d	40.84
					epm%	50	15	3	65.38	100	50	34	16	n.d	100
10	27	7.54	3840	3030	ppm	495	97	95	1.95	962	975	465	395	n.d	1835
					epm	24.75	8.01	2.43	25	47.14	20.31	13.09	6.57	n.d	39.87
					epm%	53	17	5	53.034	100	51	33	16	n.d	100

GROUNDWATER CLASSIFICATION

There are lots of ways to classify water and determine their quality. The basis, which these methods depend on, is the absolute value of cations and anions in unit (epm%, epm) and the ions concentrations, upon which groundwater are classified. Accordingly, two methods were used in this study to classify the water:

- **Chadha Diagram (1999)**

According to Chadha diagram (Fig.3) all the water samples fall in Zone 6 (Fig.4), which indicate that the terrestrial alkalinity exceeds the metallic alkalinity and strong acids ions exceeds anions of weak acids. This type has permanent hardness and never leaves sodium carbonate remaining, and represent Ca – Mg – CL type.

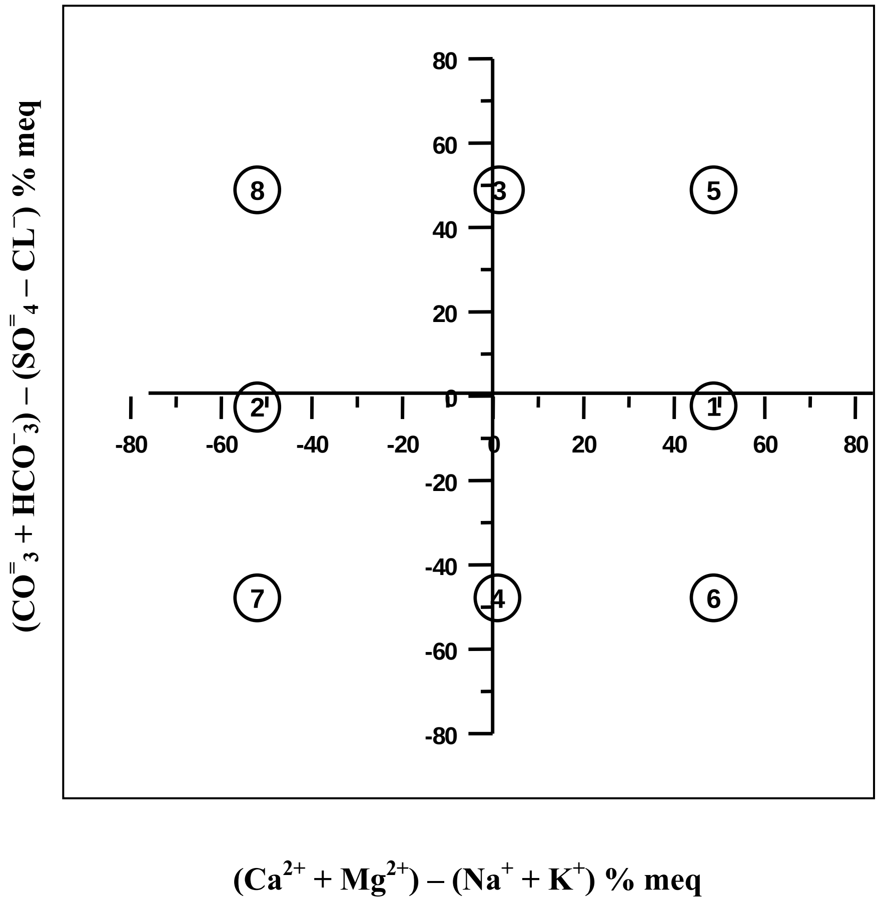

Fig.3: Chadha Diagram (1999)

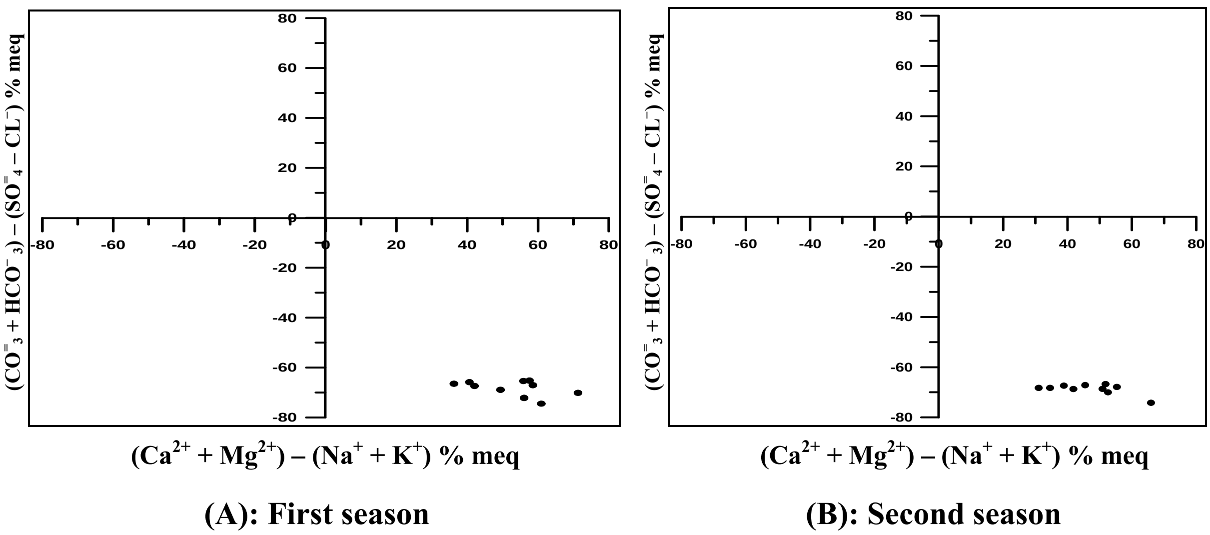

Fig.4: water samples classification according to Chadha (1999)
for two seasons A and B

▪ **Piper Diagram (1944)**

According to Piper classification, water points fall in the upper half of rhombic form represent water of secondary salinity, and if they falls in the lower half of the rhombic represent water of primary-secondary alkalinity and primary salinity. Applying Piper classification on water samples of the studied area (Figure 5) shows that all samples fall within zone (6), which means that the groundwater is of secondary salinity (Non carbonate hardness) of more than 50% (Figure 6), and the water type is Ca-sulphate.

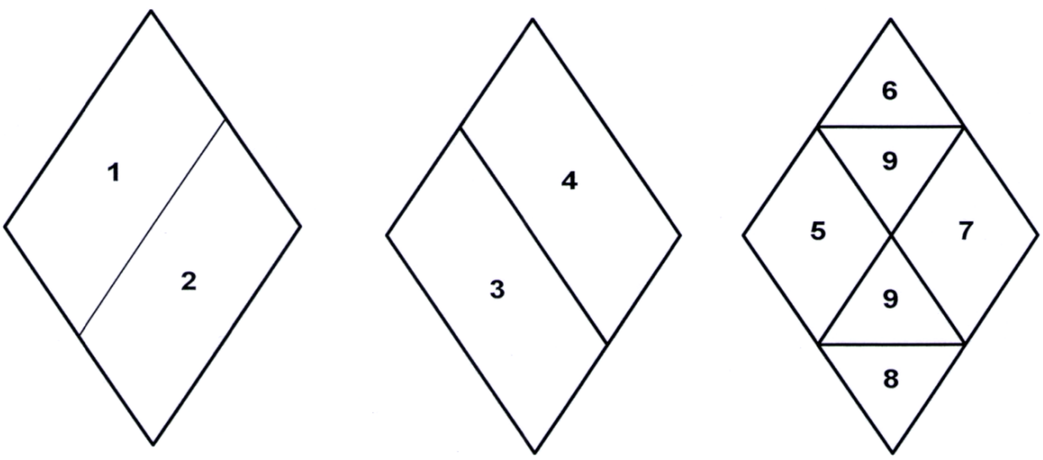

Fig.5: Represents Piper Trilinear diagram (piper, 1944)

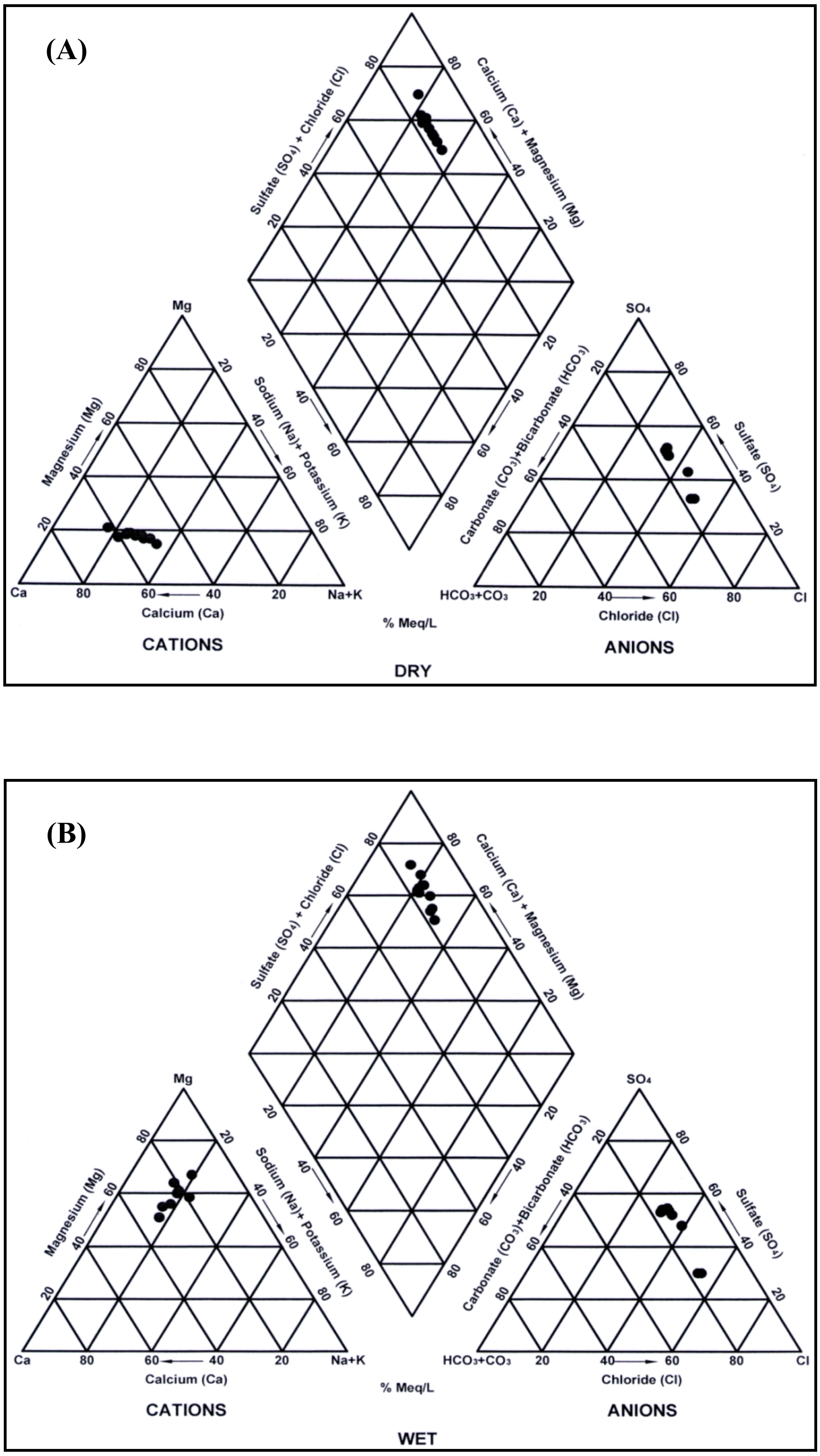

Fig.6: Piper Diagram for two seasons (A and B)

GROUNDWATER USES

Groundwater is used for several purposes depending on the type of the water and its contents of anions and cations, which change it from one type to another. So it is necessary to evaluate the water according to the local and word standard specifications to determine the suitability of water to the different uses (Domestic, Industrial, and agricultural).

▪ Usage of Water For Drinking

According to the standard specification of WHO (1999) and IQS (2000) (Table 3), it was found that all the samples exceed the permissible limits in addition to its physical in appropriation, so this water cannot be used for drinking unless treatment.

Table 3: Standard specifications for drinking water according to
WHO (1999) and IQS (2000)

NO.	Component	IQS (2000)	WHO (1999)	Wet season	Dry season
1	Ca (ppm)	50	75	436 – 495	450 – 580
2	Mg (ppm)	50	125	70.8 – 99.3	86 – 120
3	Na (ppm)	200	200	86 – 270	115 – 355
4	K (ppm)	–	12	20 – 103.4	32 – 125
5	Cl (ppm)	250	250	377 – 672	455 – 685
6	SO_4 (ppm)	250	250	505 – 969	602 – 978
7	Zn (ppm)	3	3	0.49 – 41.00	–
8	Pb (ppm)	0.01	0.01	–	–
9	Cd (ppm)	0.003	0.003	–	–
10	Fe (ppm)	–	–	0.22	–
11	TH (ppm)	500	–	1443 – 1590	1494 – 1943
12	T.D.S (ppm)	1000	1000	2364 – 2741	2599 – 3066
13	pH	6.5 – 8.5	6.5 – 8.5	6.62 – 7.51	7.06 – 7.99

▪ Groundwater Uses for Industrial Purposes

Groundwater uses for Industrial purposes required water that have several characters from the quality side because any mistake in determining its composition will be reflected negatively on the production quality for a certain Industry (Hem, 1985) (Table 4). Comparing the water samples of the study area, show that the entire samples are not suitable for Industrial uses.

Table.4: Water quality uses for Industrial purposes (Hem, 1985)

Ions	Cement Industry	Fells Industry	Boxing and vermouths Industry	Boxing fruit and freezer	Oil production	Plastic Industry	Tissue Industry	Paper Industry		Draperies Industry
								Minor	Dis minor	
Ca (ppm)	–	–	100	–	75	80	100	20	20	0
Mg (ppm)	–	–	–	–	30	36	50	12	12	0
Cl (ppm)	250	250	500	250	300	–	500	200	200	0
HCO_3 (ppm)	–	–	–	–	–	–	250	–	–	0
SO_4 (ppm)	20	250	500	250	–	–	100	–	–	0
NO_3 (ppm)	–	–	–	10	–	–	5	–	–	0
Cu (ppm)	–	–	500	–	–	–	–	–	–	0.01
Zn (ppm)	–	–	–	–	–	–	–	–	–	–
TH (ppm)	–	soft	–	250	350	350	900	100	100	25
T.D.S (ppm)	600	–	–	500	1000		1000	–	–	100
pH	6.5 – 8.5	6.8	–	6.5 – 8.5	6 – 9	6.5 – 8.5	6.5 – 8	6 – 10	6 – 10	2.5 – 10.5
T(°F)	–	–	–		–	–	–	95	–	–
TSS (ppm)	500	–	–	10	10	5	30	10	10	5
	All the samples are not suitable	All the samples are not suitable	All the samples are not suitable	All the samples are not suitable	All the samples are not suitable	All the samples are not suitable	All the samples are not suitable	All the samples are not suitable	All the samples are not suitable	All the samples are not suitable

- **Groundwater Uses for Livestocks**

Using the suggested standards of (Altoviski, 1962 and Crist and Lowry, 1972), which depends on anion and cation to total hardness and TDS (Table 5), it showed that water can be used for all animals (Table 6).

Table 5: Standards suggested by (Altoviski, 1962) for livestock uses

Elements (ppm)	Very good water	Good	Recommended uses water acceptable	Can be use	Upper limit
Na	800	1500	2000	2500	4000
Ca	350	700	800	900	1000
Mg	150	350	500	600	700
Cl	900	2000	3000	4000	6000
SO_4	1000	2500	3000	4000	6000
T.D.S	3000	5000	7000	10000	15000
TH	1500	3200	4000	4700	54000

Table 6: Standard specifications for animal drinking (Crist and Lowry, 1972)

T.D.S (ppm)	Animal type
2860	Livestock
6435	Horses
7150	Milk cattle
10000	Meat cattle
12900	Sheep

- **Groundwater Uses for Building**

Limited suggestion by Altoviski for the building uses (Table 7)

Table 7: Limited suggestion (Altoviski, 1962)

Cations (ppm)	Concentration (mg/l)	Anions (ppm)	Concentration (mg/l)
Na	1160	Cl	2187
Ca	437	SO_4	1460
Mg	271	HCO_3	150

Comparing the ions concentration analysis results with Altoviski (1962) for building, showed that all the water samples in the area is unsuitable for building uses, because bicarbonate concentration exceeds the recommended limit.

- **Groundwater Uses for Agricultural and Irrigation Purposes**

The use of water for agricultural purposes depends on how much the plants could bear the concentration of the salts in addition to soil type (Table 8). Water classification system for irrigation and agricultural purposes depend on following variables EC, TDS, SAR, N%, CL^{-} and $SO_4^{=}$ (Karanth, 2008).

Table 8: Necessary components to evaluate irrigation and agricultural water type problems (Ayers and Westcot, 1989)

Changing	Symbol	Unit	Normal range for irrigation water
Salinity			
1- Electrical Conductivity	EC	µ mohs/ cm	0 – 3000
2- Total dissolved solid	T.D.S	mg/ l	0 – 2000
Cation and Anion			
Calcium	Ca^{2+}	epm	0 – 20
Magnesium	Mg^{2+}	epm	0 – 5
Sodium	Na^{+}	epm	0 – 40
Carbonate	$CO^{=}_{3}$	epm	0 – 0.1
Bicarbonate	HCO^{-}_{3}	epm	0 – 10
Chloride	Cl^{-}	epm	0 – 30
Sulphate	$SO^{=}_{4}$	epm	0 – 20
Nitrate			
Nitrate – nitrogen	$NO^{-}_{3} – N$	epm	0 – 10
Ammonia – nitrogen	$NH^{+}_{4} – N$	epm	0 – 5
Phosphate – phosphor	$PO^{3-}_{4} – P$	epm	0 – 2
Potassium	K^{+}	epm	0 – 2
Miscellanea			
Boron	B	mg/ l	0.2
Hydrogen ion concentration	pH	1 – 14	6 – 8.5
Sodium Adsorption Ratio	SAR	epm	0 – 15

CONCLUSIONS AND RECOMMENDATION

- Groundwater samples were analyzed to measure the major and minor constituents in addition to heavy metals. It is shown that the Ca^{+2} concentration is predominate major cation and the sulphate concentration is the predominant major anion, also the dry season samples are characterized by higher concentration of Ions than the wet season samples.
- Groundwater samples show contamination with (Zn and Al) metals. Wells no. (2, 6, 7 and 10) were exceeding the permissible limits of Zn concentration in drinking water. All the samples are contaminated with Al metal because of the possibility of groundwater to mix with wastewater and the factory disposals that include high concentration of Zn, Al are responsible for these pollution.
- The hydrochemical formula and chemical analysis showed that the groundwater type of the area is Sulphate and chloride. The water type in most samples in the first season is Ca – Cl – Sulphate, while in the second season three of the sample was Ca – SO_4 – Cloride and the rest changing between Ca – Cl – Sulphate, Ca – Na – Cl – Sulphate and Ca – Mg – Cl – Sulphate.

- Chadha classification (1999) indicates that the terrestrial alkalinity exceeds metallic alkalinity and strong acid ions exceed anions of weak acid. This type has permanent hardness and doesn't leave sodium carbonate behind through using water for irrigation, and represent type Ca – Mg – Cl type. According to piper diagram (1944) the samples indicate secondary salinity (non carbonate hardness) more than 50% with water type Ca-sulphate.
- Classification the groundwater type depending on the TDS show the water samples in the area study is brackish type.
- The water samples of the study area are not suitable for drinking, Industrial, building and Irrigation uses. It must be treated before uses for several purposes. Groundwater can be used for animal drinking.
- It should be mentioned that there is no big difference between the ionic concentrations in dry and wet seasons and groundwater is mostly recharged by surface water percolation as a result of irrigation processes and waste water that cause high contamination. Therefore, it is recommended to treat and purify groundwater before use in different aspects like domestic, industrial, building, livestock, agriculture and irrigation, in addition to construct new sewage systems and discharged away from urban area of Karbala city especially in areas that lack the sewage net work.
- Regular annual analysis of groundwater is needed to monitor the quality of water and a regular biological analysis to the groundwater in Karbala city is essential to determine the microbial pollution. It is very important to propagate environmental awareness in the community using different types of media.
- The climatical changing in the area most be considered because it may be effect of the shallow groundwater quality.

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