Some Water Properties and Suitability of Shatt Al-Hilla in Babil Governorate, Iraq

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Abstract

Shatt Al Hilla River within Babylon Governorate is one of the main water resources in Hilla citys which uses for different purposes. The object of this paper is studying the quality of surface water resources in the study area besides determining its suitability for different anthropogenic uses and classifying the water type. This study included the analysis of (9) surface water samples along the river, those analyses included chemical parameters such as (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and main anions ($HCO_3^{=}$, $CO_3^{=}$, SO_4^{2-}, Cl^{-}) and other important anions, i.e. Nitrate ($NO_3^{=}$) and (PO_4^{3-}), Total Hardness, Electrical Conductivity, Total Dissolved Salts. Results of Water quality index ranged from good to excellent type, Piper Diagram referred to water of class (c) which means the water of Earth Alkaline source with increasing in portions of Alakalis under prevailing sulfate and Chloride. Water suitability conducted by comparing with World health organization standers and Iraqi standers, the result of water suitable for different uses (drinking, irrigation, livestock, building purposes) except for industrial uses because of the high concentrations of the chemical parameters.
Keywords: water quality, suitability, major ions, minor ions.

1- Introduction

The water chemistry can provide better insights into the nature of the resource concerning residence time, flow paths, mixing, recharge, and discharge and aquifer characteristics. The study of the water chemical composition is of great importance in water resources in any area where it results from the geological processes, and any change in physical and chemical processes lead to a change in salinity, (pH) and other properties [1] .Traditionally, hydrology has been interested purely in the amount of water in a particular area. This is frequently referred to as physical hydrology. If, however, we take a wider remit for hydrology – to include the availability of water for human consumption – then issues of water quality are of equal importance to the quantity [2].Any physical, biological or chemical change in water quality that adversely affects living organisms or makes water unsuitable for desired uses can be considered pollution [3]. Human activities have a big role on chemical of water and concentration of elements, especially rare then the pollution problems will begin[4] and [5].

The chemical composition of water varies depending on the rock types pass through, and the speed of movement plays a role in determining the water quality, when the speed is high least ion exchange between water and rock passers-by means small concentration, while the slow motion reflect negatively on the quality, making it more salty, and leads to a change in chemical composition from one place to another [6].

The water resources (surface and ground water) in Babil governorate had suffered neglection. Shatt Al Hilla is one of these sources, it lacks attention since long time which caused wastes to accumulate on its banks, despite the fact that many government departments are located near it or overlooked it directly including Hilla municipality. In addition to several drainage channels which draws contaminated water into Shatt Al Hilla as a result of absorbing a lot of fertilizers and pesticides which began to increase as farmers using chemical fertilizers. As a consequence of that and since people use water in their livings, it is of prime importance to study the quality of surface water and its suitability for different uses.

Surface water displays a diverse range of quality and chemistry of the major ions reflecting the sources of water and the amount of soluble constituents present in the soil column, through which the water passes. Waste water from industrial, agricultural, sewage and drainage water is considered as an important source for pollution which degrades water quality. Accordingly, it is important to examine the physical and chemical characteristics of water in order to determine their suitability for different purposes.

2- Previous studies

- Lafta and Nayef,(1999): They analyzed groundwater samples taken from many hand dug wells within the Hilla city to determine the water quality[7].
- Al-Badri,(2000) examined the groundwater within the city of Hilla, the wells were distributed in most neighborhoods, the study showed that water has alkaline and very high hardness qualities[8].
- Manah, J. K., (2003): Studied the hydro-chemical properties of the ground water and the mineralogy of the soil sediments in the open aquifer within some selected areas in Babylon Governorate [9].
- AL-Ammar, (2004): Studied the hydro-chemistry of the shallow ground water, water drains and stream water within Babylon Governorate [10].

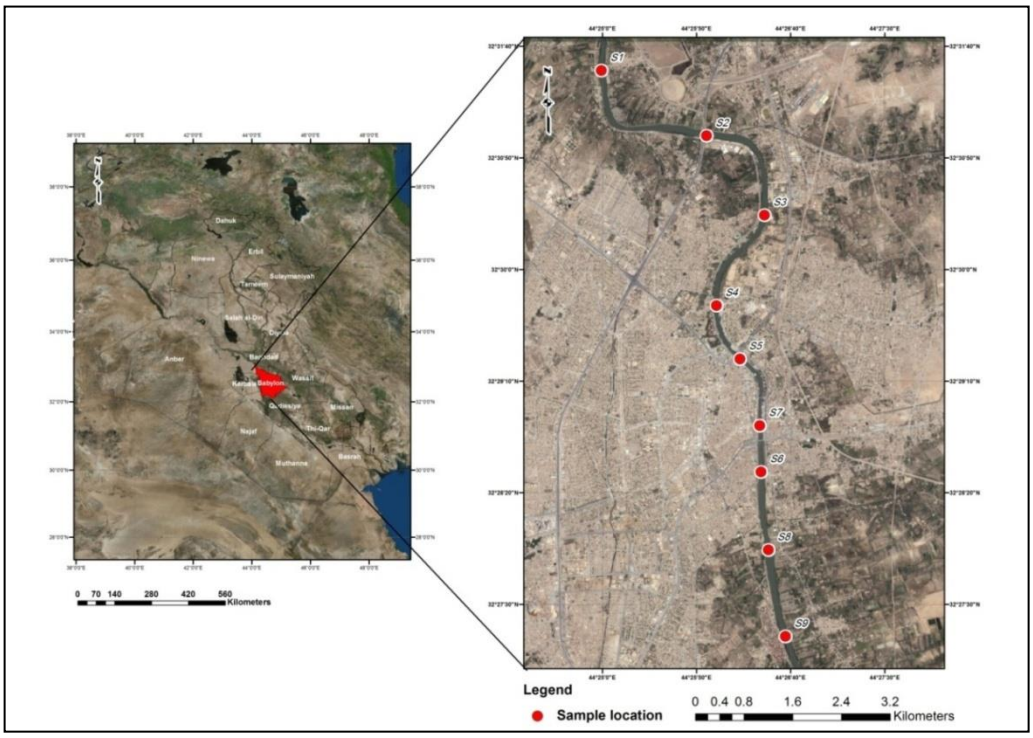

Figure1: Location map of the study area and sampling location

3 - The study area

The study or research area is located within Hilla district, which represent the center of Babil Governorate 100 km south Baghdad city covering an area about (1406 km²). The study area is bounded by (440 15' 0") (440 45' 0") longitude and (32035' 0") (320 10' 0") latitude . The study area extends on both sides of Hilla River (Shatt Al Hilla) with a designed discharge of 220 m3/sec. covering wide agricultural areas and the center of Hilla city. Shatt Al-Hilla is recharging the shallow groundwater system within the studied area by different rates and different means [7].

4- Geological setting:

The study area is within the Mesopotamian plain in the unstable shelf also named Mesopotamian zone within the Geosyncline Basin between Zagroos in the North east and the Stable Arabian plateau in the south west [11]. The area is generally covered with recent sediments of the Quaternary in Pleistocene and Holocene which is characterized by Flood Plain Deposit for the Euphrates river and its branches [12] .The area is affected by the regional tectonic movements that created a symmetric concave fold of the sedimentary

plain and continues to land filling the tub with the river sediments [13] , in addition to the deposits of the branches and Depression Fill Deposit which been produced by floods and mainly compose of a thin layer of fine sand , clay ,silt and silty clay [14].Aeolian deposits found in the eastern parts of the governorate, and dry marsh deposits are found also in different locations in the study area [15] .

Deposits produced by human activities such as the old canals and small historical hills represents old civilizations residential settlements which represent important natural geomorphological formations in the flat lands of the Mesopotamian nowadays [16].

The tectonic of the study area have been described by [17], the Mesopotamian is a giant Depositional Synclinorium tectonically active and passing through a subsidence movement with Local Minor uplift, geological setting of the study area shown in Figure (2).

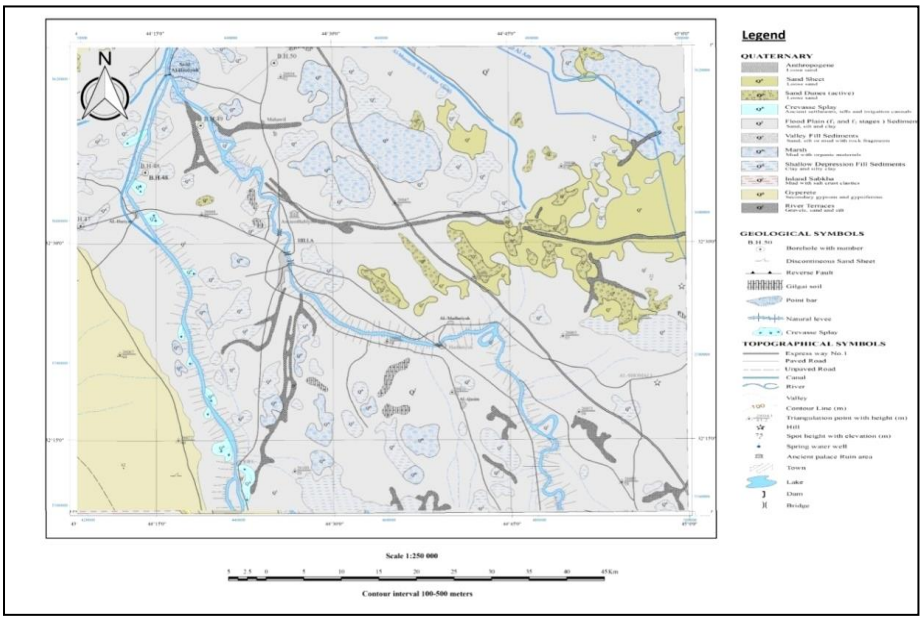

Figure 2: Geological map of the study area [16]

5- Materials, Method and programs:

The following material and programs has been used in this study for investigating and illustrating the results in the study area:

1. Geological map of the study area.
2. Satellite images (QuickBird ,2013) with high resolution for the study area .
3. GPS to locate the samples collected in the study area

4. Digital pH Meter, Digital TDS Meter, Conductivity meter and Thermometer for field measurements
5. Arc GIS 10.1 for data illustrating on location maps
6. Microsoft office 2010 (excel) to produce diagram to preview the variation and connection for some of the data.
7. AquaChem 2011 software for producing Piper Diagram.

6- Methodology

The work procedure conducted within four steps as follows:

First step pre-field office work: This study was carried out in October in 2016, included collecting all the information and data of the study area and previous studies regarding the water quality for different periods of time and also to diagnose theoretically the possible pollution sources. Also, using high resolution images to specify sampling locations according to human activities along the river.

Step two Field work: included surface water samples collecting from selected locations in the study area, 9 surface water samples have been collected along Shatt Al –Hilla for the in 8-9/10/2016. Physical parameters have been measured in the field (pH, Electrical Conductivity (Ec), total dissolved solids (TDS), Temperature) using a waterproof portable meter (Digital pH Meter) (Digital TDS Meter) (Conductivity meter) and (Thermometer). Some other physical properties have been described and recorded in the field as color and odor for each sample. Surface water sampling conducted by following a track along Shatt Al Hilla the length of the track from the first sample location to the last sample location is about (12 Km) the average distance between samples is about (1.5-2Km), the locations were selected according to the existence of human activities, as the local market in the center of the city, hospital, slaughter houses, etc.

Surface water samples have been collected using 1.5 liter Polyethylene bottles, following the right sampling procedure for chemical analysis.

Third step Laboratory work: After collecting samples they carried out to the laboratory for analysis and testing, in the laboratory of the chemistry department in university of Baghdad -college of sciences to determine the concentrations for the main cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and main anions ($HCO_3^{=}$, $CO_3^{=}$, SO_4^{2-}, Cl^{-}) and other important anions, i.e. Nitrate ($NO_3^{=}$) and (PO_4^{3-}) Table (1).

Fourth step office work: After the chemical and physical analysis, accounting the Water Quality Index Basic parameters (PH, TH, Ca, Mg, K, HCO_3, Cl, NO_3, and SO_4) used to calculate the index. WQI (Water Quality Index) using the standards of drinking water quality recommended by [18] and [19] Using the weighted arithmetic index method [20]. There are three steps for computing WQI .Chemical classification has been accounted

during this study using Piper diagram (or Trilinear diagram) [21]. Water suitability for different uses been accounted depending on limits to [18], [19] and [22].

Table 1: Water constituents of study area and methods of their analyses.

parameters	Method of analyses
Temperature, EC, TDS and pH	Field electrode meter device (HANA instruments)
TDS	Evaporation and drying [23]
TH (Ca^{2+} and Mg^{2+})	Titration with Na_2-EDTA using Eriochrome black-T Indicator
Na^+ and K^+	Flame Photometry
HCO_3^{2-}	Titration with HCl using phenolphthalein + Methanol 60%
SO_4^{2-}	Titration with $BaCl_2$-EDTA using Eriochrome black-T indicator [23]
Cl^-	Titration with $AgNO_3$ using potassium Di chromate Indicator
NO_3^-	UV-Spectrophotometric method (λ =500 nm)
PO_4^{3-}	Stanous Chloride Method (Spectrophotometer)

7- Results and discussion

- Piper Diagram figure (3) used as an effective graphical representation of chemistry in water samples in hydro-geological studies. All samples are located in the upper half of the rhombic-shaped (class c) as shown in figure (3) [21].

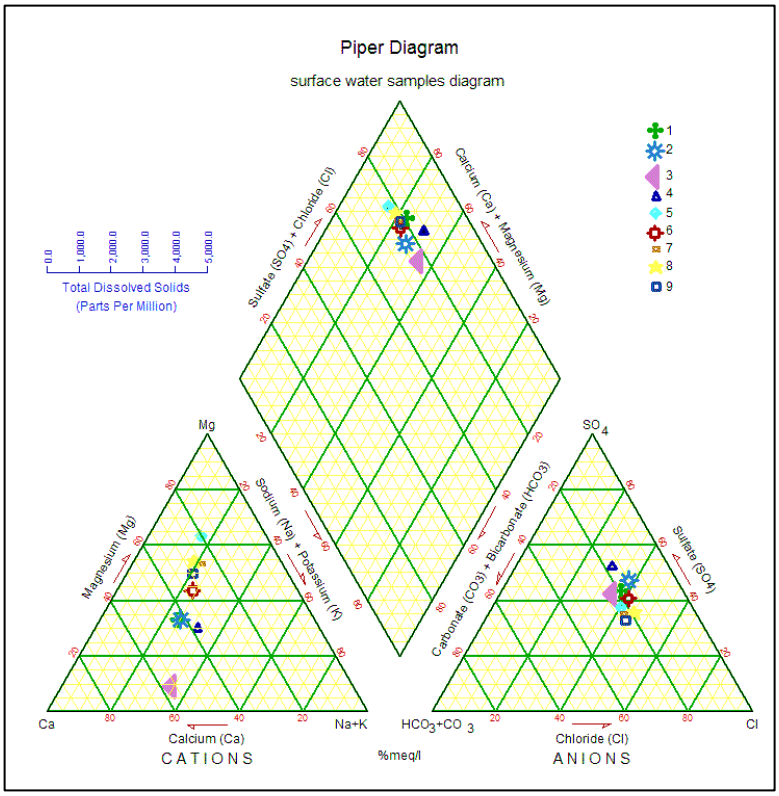

Figure 3: Piper diagram shows the quality of surface water samples in the study area.

- Results of chemical parameters and water quality index in the study area were illustrated in the Table (2).
- **Ca^{+2}** concentration range between (150-215) ppm, average value (178) ppm, which exceeded the [19] standard value is 150ppm, [18] standard is 100ppm, the highest calcium ion is of sample no.2. **Mg^{+2}** the concentration of this ion within surface water samples range between (10-185) ppm, average value (90) ppm,which did not exceed the [19] the standard value is 100ppm [18] standard is 125pp. The highest concentration is of sample no.5.
- Concentration of **K^{+}** within surface water samples range between (3.95-5.2) ppm average values (4.7) ppm, which did not exceed the [18] standard value is12ppm, the highest concentration is of sample no.7.
- **Na^{+}** concentration range between (90-124) ppm, an average value of (99) ppm, it did not exceed the [19] and [18] the standard value is 200ppm. The highest concentration is of sample no.7.

- **Cl^-** Concentration range between (111-119) ppm an average value of (115) ppm, did not exceed the [18] standard value 350ppm and [18] standard value is 250ppm, the highest concentration is of sample no.4. The concentrations of (**SO_4^{2-}**) within surface water samples range between (186 -382) ppm an average value of (224) ppm concentration did not exceeded [19] standard value 400ppm, [18] standard is 250ppm, highest concentration is of sample no. (4).
- Concentrations of Bicarbonates **(HCO_3^{2-})** within surface water samples range between (156-204) ppm with an average value of (183) ppm which did not exceed the [19] the standard value is 200ppm, the highest concentration is of sample no. (7).
- The concentrations of Nitrate ion **(NO_3^-)** within surface water samples range between (0.04-2.262) ppm an average value of (0.7) ppm, the concentration did not exceed the [19] and [18] standards value is 50ppm, highest concentration is of sample no. (3) next to Merjan Hospital.
- Phosphate **(PO_4^{3-})** concentrations of this ion within surface water samples range between (0.004-0.086) ppm, with an average value of (0.04) ppm, the concentration did not exceed the [18] standards 0.4ppm, the highest concentration is in sample no. (3) the nearest reference point is Merjan Hospital.

Table2: The concentration of chemical parameters with WQI and water quality classification for the surface water samples in the study area.

Sample no.	1	2	3	4	5	6	7	8	9	Mean (ppm)	permissible limits after[24]	Exceeding limits
Na^{+}	92.655	94.7	97.4	98.6	98.4	99.1	123.9	95.7	90.19	98.96	200	not exceed
K^{+}	3.95	4.8	4.9	4.8	4.8	4.9	5.2	4.7	4.655	4.745	12	not exceed
Ca^{+2}	212	215	190	150	165	175	175	165	160	178.55	100	exceed
Mg^{+2}	60.32	62.5	10	45	185	85	140	125	100	90.313	125	not exceed
HCO_3^{-}	155.6	161.65	186.05	186.05	189.1	192.15	204.35	189.1	185.96	183.334	200	not exceed
SO_4^{-2}	209.6	213.79	195.87	381.59	186.35	189.52	219.68	211.75	209.99	224.237	250	not exceed
Cl^{-}	111.59	113.6	113.6	118.93	117.15	118.57	118.22	115.38	114.56	115.733	250	not exceed
NO_3^{-}	0.46	0.488	2.262	1.375	1.224	0.044	0.266	0.045	0.05	0.69	50	not exceed
T.D.S	554.32	556.29	563.85	560.07	564.48	564.48	556.22	563.22	565.32	560.916	1000	not exceed
PH	6.7	6.5	7.1	7.3	6.6	6.8	6.9	7.4	7.4	6.966	6.5-8.5	not exceed
WQI	49.94	50.81	49.48	57.16	58.98	53.06	59.28	56.81	54.7	54.468		
Water quality	Excellent	good water	Excellent	good water	good water	good water	good water	good water	good water			

- **Suitability of water for different uses been conducted according to the comparison with different standards as below** :

1-Suitability for drinking: Generally the surface water in the study area was exceeding permissible parameters limits for drinking purposes according to [18], [19] and [22] table (3).

Table 3: water samples in comparison with the permissible limits for drinking water purposes according to [18],[19]and [22].

Chemical parameters of samples	Range (ppm)	Mean (ppm)	[19] (ppm)	[18] (ppm)	[22], 2011 (ppm)	Exceeding limits
Ca^{2+}	150-215	178.56	150	100	--------	Exceed
Mg^{2+}	10-185	90.31	100	125	--------	Not exceed
Na^{+}	90-123	98.96	200	200	--------	Not exceed
K^{+}	3.9-5.2	4.75	-------	12	--------	Not exceed
Cl^{-}	111.5-118.9	115.73	350	250	250	Not exceed
SO_4^{2-}	186-381	224.24	400	250	250	Not exceed
HCO_3^{-}	155-204	183.33	-------	--------	--------	------
NO_3^{-}	0.05-2.26	0.69	50	50	10	Not exceed
PO_4^{3-}	0.004-0.086	0.04	--------	0.4	-------	Not exceed

2- Suitability for livestock was a very good type after [25] and regarding EC parameter EC value ranged (881-897) µs/cm and the water results of excellent type for Livestock purpose table (4).

Table 4: Guide for Water Quality Parameters and limits in (ppm) for the livestock uses of surface water samples in the study area after [25].

Parameter (ppm)	Very good	Good	Permissible	Can be used	Maximum limit	Present study	
						water samples mean value	Suitability
Na+	800	1500	2000	2500	4000	98	Very Good
Ca^{2}+	350	700	800	900	1000	178	Very good
Mg^{2}+	150	350	500	600	700	90	Very good
Cl^{-}	900	2000	3000	4000	6000	115	Very good
SO_4^{2-}	1000	2500	3000	4000	6000	224	Very good
TDS	3000	5000	7000	10000	15000	560	Very good
TH	1500	3200	4000	4700	5400	817	Very good

3- Suitability for irrigation: According to [26] water class of all surface water samples was (permissible) and SAR values were considered of excellent type according to [27] table(5).

Table 5: Permissible Limits for the Irrigation Water after [27].

Ec µS/cm	TDS	Water classes	Study area	
			Water samples	
			Ec µS/cm	TDS
250	175	Excellent		
250 – 750	175 – 525	Good		
750 - 2000	525 – 1400	Permissible	**881-897**	**565-554**
2000 - 3000	1400 – 2100	Doubtful		
> 3000	> 2100	Unsuitable		

4-Building purposes: According to [25], all surface water samples are within the permissible limits table (6).

Table 6: Water Quality Standards for Building Uses after [25].

Parameters (ppm)	Na^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-
Permissible limits	1160	437	271	2187	1460	350
Sample average values	98	178	90	115	224	183

5- Suitability for industrial purposes: according to [28] the suitability for industrial purposes illustrated in (Table 7).

Table 7: Average values of water samples in the study area and Water Quality Standards for Industrial uses after [28].

Parameters (ppm)	Surface water sample average	Chemical pulp and paper		Textile	Wood chemicals	Synthetic rubber	Petroleum products	Canned, dried, frozen fruits and vegetables	Soft-drinking bottling	Leather tanning	Hydraulic cement manufacture
		Unbleached	Bleached								
Ca^{2+}	178	20	20	----	100	80	75	---	100	----	---
Mg^{2+}	90	12	12	----	50	36	30	----	----	---	---
HCO_3^-	183	----	----	----	250	---	---	----	-----	---	---
SO_4^{2-}	224	----	----	---	100	----	---	250	500	250	250
NO_3^-	0.690	----	----	---	5	----	----	10	----	----	----
Cu(µg/l)	0.025	----	---	0.01	----	---	-----	----	---	----	----
TDS	560	----	----	100	1000	----	1000	500	----	---	600
pH	6.96	6-10	6-10	2.5-10.5	6.5-8	6.5-8.3	6-9	6.5-8.5	---	6-8	6.5-8.5
Cl^-	128	200	200	----	500	---	300	250	500	250	250

8- Conclusion

1- All samples are type (class c) which means water is (earth alkaline with increasing in the portions of alkalis under prevailing sulfate and chloride).
2- Surface water samples in the study area all of the chemical parameters analysis are within the permissible limits of [18][19][22], which means the lake of chemical pollution , except for Ca exceeded the permissible standards.
3- Surface water suitability: Generally the surface water in the study area it was exceeding permissible parameters limits for drinking purposes.
4- All samples were very good for livestock.
5- All surface water samples were (permissible) for irrigation purposes.
6- Building purposes: all surface water samples are within the permissible limits.
7- The water type is not suitable for almost all industries uses because of the high concentration of some chemical parameters like Ca, Mg and TDS.

CONFLICT OF INTERESTS
There are no conflicts of interest.

9-References

[1] Ivanov , V.V, Barbaonov, L.N. and Plaotinkova,G.N,"The Main genetic types of the Earths Crust". Mineral waters and their Distribution in the USSR, in Alkovisky and G.Kacuraceds genesis of Mineral and Thermal Water,3rd,International Geol. congress Vol.17 , P.33 -39. 1984.

[2] Davie,T."Fundamentals of Hydrology routledge fundamentals of physical geography" .2nd ERdition.Taylor & Francis .221p. 2008.

[3] Cunningham W.P and Cunningham M.A., "Principles of Environmental Science Inquiry and Applications". 6th Edition. McGraw-Hill, Inc. 458p. 2011.

[4] Montgomery, C.W., Environmental Geology .5th ed., McGraw – Hill ,P.246. 1997.

[5] Keller, E.A., :Environmental Geology .8th ed., prentice- hall, P.562. 2000.

[6] Cast any, G.,: Principle et method de Hydrogeological, Paris , Ed , Dunod ,P.236. 1982.

[7]Lafta and Nayef, Hydrochemistry of ground water in Hilla region , Babylon University,Vol.4,bound.5,1999.

[8] Al-Badri,N.K., the study of the chemical properties of groundwater in the city of Hilla and find out their sources, magazine Babylon University, Engineering Science, Vol. 5, No. 5. S22-36. 2000.

[9]Manah, J. K., Hydrochemical ground water and deposits mineral of unconfined aquifer for chosen area of Babel city. M.Sc . Thesis. Collage of science. University of Baghdad. (In Arabic).p.190. 2003.

[10]Al-Ammar, H. A.,. The Hydrochemical Description of Shallow Groundwater & Drainage water& schedule water for Al-Neel Area\ Babylon Governorate, M. Sc. Thesis, College of Science, Uni. of Baghdad, 121p. (In Arabic). 2004.

[11] Al-Hety E. A. Microseismicity of Ga'ara Area – Western Desert. M.Sc. thesis, University of Baghdad. 1985.

[12] Sisskian, V.K., (editor). Geological map of Iraq ,central company of geological survey and mineralization ,GEOSURF. 2000.

[13] Buday, T. "Regional Geology of Iraq: vol. 1, Stratigraphy, I.I.M Kassab and S.Z. Jassim (Eds) D. G. Geol. Surv. Min. Invest. Publ. 445p. 1980.

[14] Parsones, R.M.," Ground water resource of Iraq" ,vol.11, Mesopotamian plain . Ministry of development ,development board ,Baghdad,p157. 1957.

[15] Al-Jubouri, H.H., Rating geotechnical soil in the province of Babylon, Master's thesis, unpublished, University of Baghdad College of Sciences p.183, 2002.

[16] Berwari, A.M., Salioh, C.A., (),"report on the geological plate of Karbala", the General Company for Geological Survey and Mining p. 0.15. 1995.

[17] Lees, G.M. and N. Falcon, . The geographical history of the Mesopotamian plains. Geographical Journal, v. 118, p. 24-38. 1952.

[18]WHO,. "Guidelines for drinking-water quality". 4th edition. World Health Organization. P.564,2011.

[19] Iraqi Standard, "Iraqi standard of drinking water". No.417; modification No.2. 2009.

[20] Brown, R.M., McClelland, N.I., Deininger, R.A. and Tozer, R.G.. "A water Quality index-Do We Dare?." Water Sewage Works, 339-343. 1970.

[21] Piper, A. M.," A graphic procedure in the geochemical interpretation of water analyses", Transition, American Geophysical Union, Vol. 25, PP. 914-928. 1944.

[22] USEPA (US Environmental Protection Agency), "2011 Edition of the Drinking Water Standards and Health Advisories". Office of Water. U.S. Environmental Protection Agency. Washington, DC. 18p. 2011.

[23]American Public Health Association (APHA),. Standard method for the examination of water and waste water Washington D.C, 20th ed , P.759. (20 edition) Washington D.C. 1998.

[24] Ramakrishnalah, C.R; Sadas hivalah C. and Ranganna G,. Assessment of water quality index for the groundwater in Tumkur Taluk , Karnataka state, India, E Journal of chemistry, 6(2), pp.523-530. 2009.

[25] Altoviski , M.E., "Handbook of Hydrogeology", Gosgoelitzdat, Moscow, USSR, (in Russian), 614p. 1962.

[26] Fipps G, "Irrigation Water Quality Standards and Salinity Management". Texas Cooperation Extension. 20 p. 1996.

[27] Todd, D.K. Groundwater Hydrology. 3rd edition. John Wiley and Sons New York, USA, p.650 , 2005.

[28] Hem, J.D., "Study and interpretation of the chemical characteristics of natural water". U.S. Geological Survey, Water Supply, paper- 2254, 263p. 1991.

الخلاصة

يعتبر شط الحلة في محافظة بابل احد المصادر الرئيسية للماء في مدينة الحلة ويستخدم لاغراض مختلفة. الهدف من البحث هو دراسة نوعية المياه السطحية ضمن منطقة الدراسة ومدى ملائمتها للاغراض المذكورة سابقا ,كذلك تصنيف نوعية المياه. تضمنت الدراسة تحليل 9 نماذج للمياه السطحية على طول شط الحلة, من العناصر الكيميائية التي تم تحليلها (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) و ($HCO_3^{=}$, $CO_3^{=}$, SO_4^{2-}, Cl^{-}) ومن العناصر الاخرى ($NO_3^{=}$) و (PO_4^{3-}) وكذلك قياس العسرة الكلية و التوصيلية الكهربائية والاملاح الكلية الذائبة . اظهرت نتائج مؤشر نوعية المياه ان المياه تراوحت بين الجيد الى الممتاز, مخطط بابيير اظهر نوع المياه من النوع c والذي يدل المياه ذات اصل قلوي ارضي مع زيادة القلوية بزيادة الكبريتات والكلورديات. تم قياس ملائمة المياه للاغراض المختلفة وذلك بمقارنتها مع مقياس منظمة الصحة العالمية ومع المقياس العراقي وقد اظهرت نتائج المقارنة ان المياه ملائمة للاغراض والاستخدامات المختلفة (لغرض الشرب, الري, للمواشي, لغرض البناء) عدا عن استخدامها للاغراض الصناعية وذلك لزيادة تراكيز العناصر الكيميائية عن الحد المسموح به.

الكلمات الدالة: نوعية المياه, الملائمة, الايونات الرئيسية, الايونات الثانوية.