

Evaluation of Groundwater Quality and its Usability in the Teeb Hydro geological Basin, East Iraq
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Abstract

Teeb Hydrogeological Basin is locating in east part of Iraq. The studied area is characterized by the presence of confined and unconfined aquifers which are represented by Tertiary (Mukdadiya Formation) and Quaternary deposits respectively. The climate is classified as dry to semidry.

The general flow direction of groundwater is concordance with the topography from north-northeast to south-south west.

Groundwater hydrochemical study in the basin depends upon (18) well samples where major cations and anions were obtained. The hydrochemical properties include the study of (pH, EC, TDS), the type of groundwater is sodium sulfate ($Na SO_4$).

The groundwater is generally of suitable chemical quality for livestock, irrigation, and unsuitable for drinking purpose.

المستخلص

تقدير نوعية وصلاحية استخدام المياه الجوفية في حوض الطيب الهيدروجيولوجي،

شرق العراق

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يقع حوض الطيب الهيدروجيولوجي في الجزء الشرقي من العراق. تتميز منطقة الدراسة بوجود خزائين للمياه الجوفية، محصور وغير محصور والتي تتمثل بتكوين المقدادية والترسبات الحديثة على التوالي. يتميز مناخ المنطقة بكونه مناخ جاف إلى شبه جاف. الاتجاه العام لحركة المياه الجوفية في الحوض، متوافق مع طبوغرافية الحوض، من الشمال والشمال الشرقي إلى الجنوب والجنوب الغربي.

اعتمدت الدراسة الهيدروكيميائية على (18) نموذج من الآبار إذ تم الحصول على تراكيز الكاتيونات والأنيونات في المياه. وتضمنت الخواص الهيدروكيميائية، دراسة (pH , EC, TDS), وان نوعية المياه الجوفية، هي كبريتات الصوديوم (Na SO_4). المياه الجوفية للحوض بصورة عامة، صالحة للاستخدام الحيواني ولري المزروعات وغير صالحة للاستخدام البشري .

INTRODUCTION

Location and Area

Teeb hydrogeological basin occupies an area of (1600 km²) in Maysan Governorate (Iraq), between latitudes (32° 05' - 32° 25') N and longitudes (47° 05' - 47° 35') E beside Iraq – Iran border (Himrene structure) from the east. Teeb town occupies the north part of basin, the Teeb river flows from north to south and discharging into Al-Sanaf marshes (Figure 1).

The study area has the semiarid of the Mediterranean sea region with amount of rainfall and high temperatures.

Objectives

The objectives of this study include studying the occurrence, movement, availability, quality, and uses of groundwater in the basin. The study is intended to aid in planning, development and management of the groundwater resources. The scope of the study included collection and analysis of groundwater samples, water levels and water use to describe the water resources status of the basin.

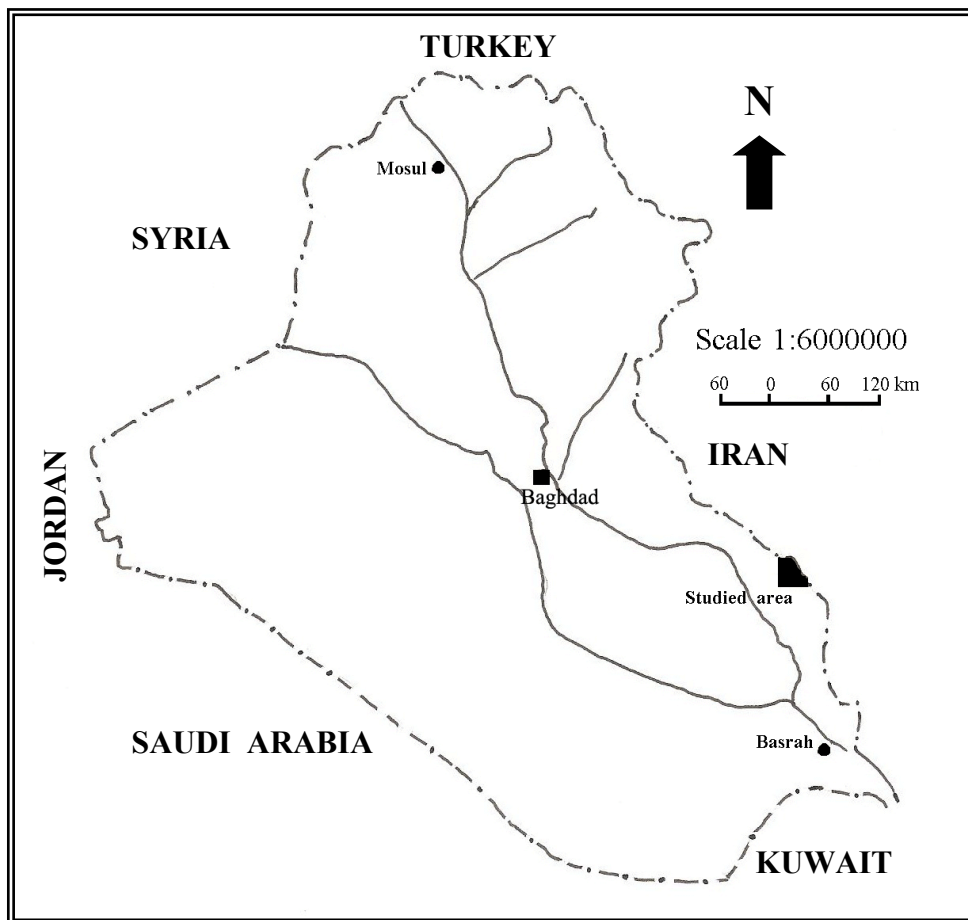


Figure 1 : Location of studied area

GEOLOGY AND HYDROGEOLOGY

Geological Setting

Geologically, the rock formations of the study area are classified as Pliocene Group (Mukdadiya Formation and Bai Hassan Formation), and Quaternary deposits.

Mukdadiya Formation:

The age of formation is mostly Pliocene and the formation was laid down in a fluviolacustrine environment (Lateef, 1975), (Enad, 2007).the formation is composed almost purely of terrigenous clastics from silt size to boulder conglomerates. In general, the grain size of the clastics increases upward (Buday and Jassim,1980). The lower contact of the formation is gradational and usually put at the base of the first pebbly or conglomeratic bed and /or alluvial deposits. The main areas of distribution of the formation are very variable due to primary differences and partly due to erosion too. The Mukdadiya sediments which were developed by the rapid erosion of the uplifted (Toruse- Zagros) mountains and the deposition in troughs. Petrographic study of the Mukdadiya sediments shows that they are immature sediments of litharenite type (in which rock fragments from the main constituents 64%). The immaturity and

composition of these sandstones requires by high relief or aridity (Ali and Khoshaba, 1981).

Mukdadiya formation forms continuous belt south of Himrene mountain. The formation consists of cyclic deposits of clastic materials coarsening upwards (Barwary, 1993).

The lower contact is marked by first appearance of pebbly sandstones, characteristic of the formation. The upper contact is marked by the appearance of first massive conglomerate (Jassim et al , 1984), (Figure 2).

Bai Hassan Formation:

The age of formation is upper Pliocene. The formation is cropping out in the east parts of the basin. The environmental deposits of the formation is fresh water. Lithologically, formation consists from sandstone, mudstone, and massive conglomerates (Barwary, 1993).

Mukdadiya and Bai Hassan formations are cropping out in north east and east of studied area as shown in (Figure 2).

Quaternary deposits:

The hydrogeological basin located within the foothill zone region and Mesopotamian plain. The foothill region is characterized by the widespread development of the fluvial sediments filling the broad, relatively shallow synclines between the narrow anticline ranges. Towards the anticlines, the gravels into deluvial sediments and out run which cover the slopes of the anticline ridges (Al-Jibuory, 2005). The Mesopotamian plain is built up mostly by deltaic, lacustrine and fluvial sediments connected mutually by much facial vitation and replacing each other both horizontally and vertically. The top part of the sequences is usually lithologically very monotonous being composed of fluvial flood silts with strong aeolian admixture (Buday and Jassim, 1980).

The quaternary deposits including, Pleistocene and recent deposits. They consist of alluvium deposits, which consist of a mixture of gravel , sand, silt, clay and conglomerates of post Pliocene deposits (Hamza et al, 1989).

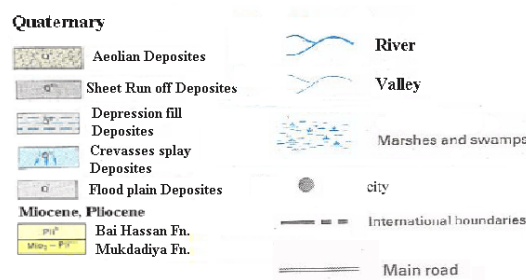
The contact between Mukdadiya formation and Quaternary deposits are of angular unconformity type (Mahmood, 1986).

Hydrogeolog

Generally, the groundwater Aquifers of Teeb basin are divided into two main hydraulic complexes, the deep Mukdadiya and Bai Hassan aquifers and quaternary aquifer (Al-Jibuory, 2005).

The water table map shows the elevation of the zone of saturation in the basin (Figure 3). The map was based on the water table levels measured by The Water Wells Drilling Company (2009), (table, 1).

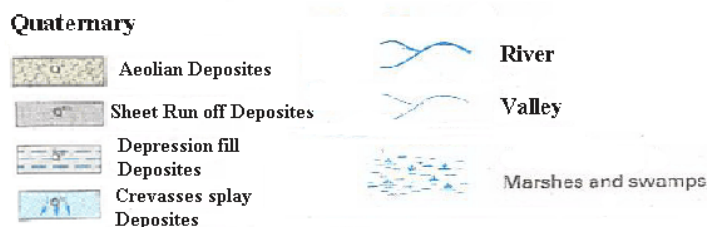




Legend

Figure 2 : Geological map of Teeb basin (Geological Survey 1996)
 Table 1: Well data for Teeb Basin

Well No.	Well name	Latitude 0 - =	Longitude 0 - =	Elevation, n,a.s.l (m)	s.w. t* (m)	w.t,a.s.l ** (m)
W1	Teeb village	47 08 51	32 23 51	75	9.5	65.5
W2	Teeb city	47 08 00	32 23 20	70	12	58
W3	Shokri	47 04 05	32 18 45	40	7	33
W4	Mudarra	47 08 39	32 19 08	45	11	34
W5	Acefah	47 12 00	32 21 46	70	12	58
W6	Azize Ajeel	47 14 25	32 21 40	80	10	70
W7	Zubaydate/1	47 19 10	32 23 20	95	1.5	93
			32 23 24	94	0	94
			32 23 45	60	13	47



W10	Im ceel/2	47 17 13	32 18 51	55	13	42
W11	Im ceel/3	47 16 53	32 18 44	52.5	4.5	48
W12	Jalabshoore	47 13 40	32 15 50	38	2	36
W13	Ramliya	47 11 40	32 11 45	30	6	24
W14	Im-alwawiya	47 16 00	32 12 34	30	2	28
W15	Imceel	47 17 00	32 14 22	40	1	39
W16	Bajleya	47 22 51	32 16 30	95	5	90
W17	Ayla	47 22 00	32 11 00	33	10	23
W18	Faka	47 29 02	32 08 10	36	13	24

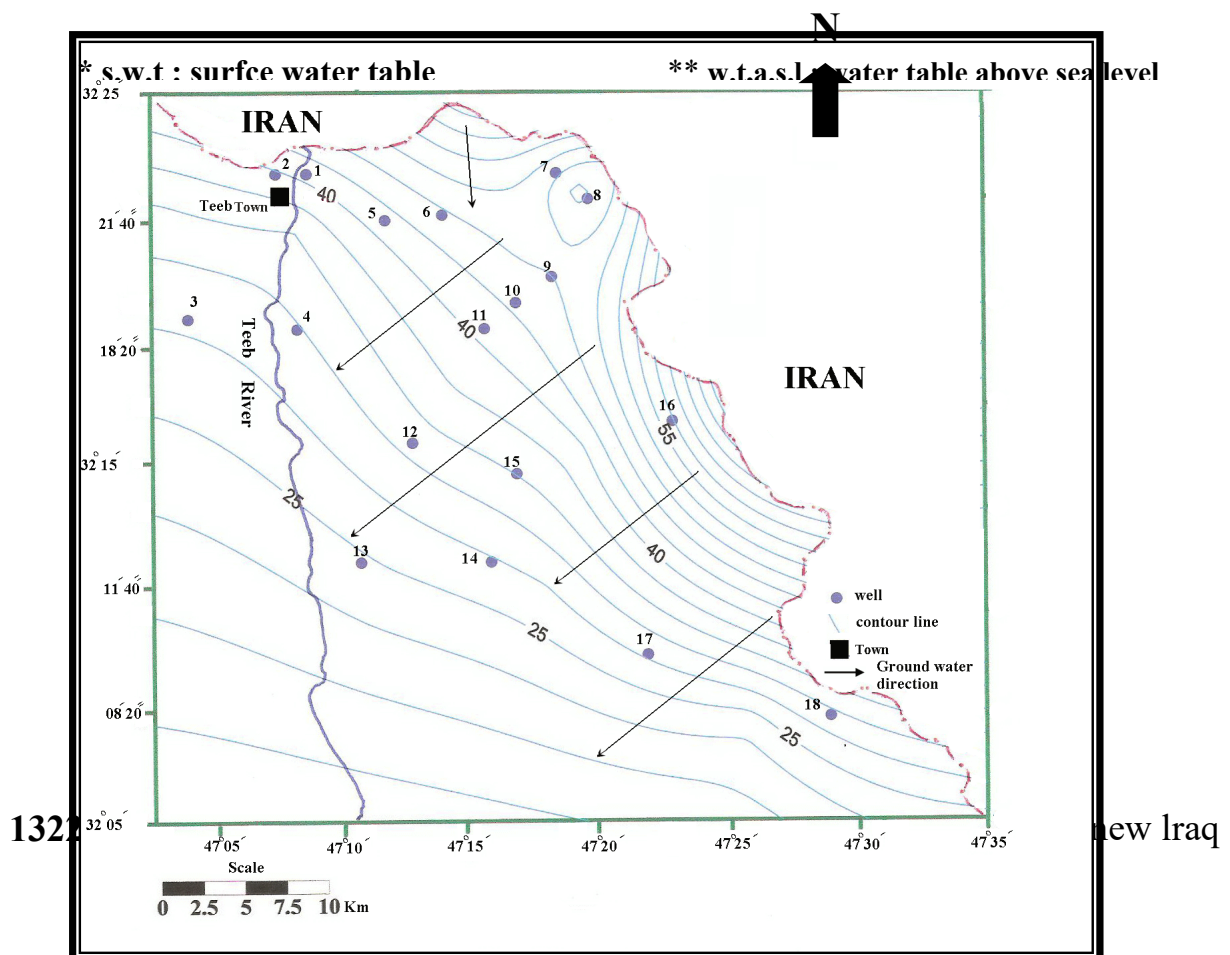


Figure 3 : Location of wells and water table levels for Teeb basin.

SAMPLING AND ANALYTICAL PROCEDURE

Sampling

Sampling of groundwater within the study area was carried out in 2009, eighteen samples were collected from the wells in the basin (Figure 3).the samples were collected in polyethylene bottles were previously washed with distilled water and diluted hydrochloric acid.

Analytical methods

The hydrogen ion concentration (pH) and electrical conductivity (EC, $\mu\text{S cm}^{-1}$) were measured in the field by using a pH meter, portable EC meter respectively . chemical analysis for the cations, calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K) was accomplished in the laboratory using an atomic absorption spectrophotometer. The anions, nitrate (NO_3^-) and sulfate (SO_4^{2-}) were measured by spectrophotometer techniques. Titration methods were used to determine the concentrations of chloride (Cl^-) and bicarbonate (HCO_3^-); Cl^- was measured by using potassium chromate (K_2CrO_4) as an indicator and silver nitrate (AgNO_3) as titration solution; HCO_3^- was measured by titrating the samples with $0.02 \text{ N NH}_2\text{SO}_4$, using methyl orange as an indicator. Results of chemical analysis are given in (table 4) and (table 5).

RESULT AND DISCUSSION

Physical Properties

Odor, Color and Taste:

The groundwater in studied area is odorless and colorless, while it was brackish or salty taste in all of the water samples because elevated TDS causes to be salty or brackish taste.

pH-Values:

the hydrogen ion concentration is expressed as pH, which is the reciprocal of the logarithm (base 10) of the hydrogen ion concentration in moles per liter. Natural water has a pH value of (7.0), pH of an alkaline water is more than (7.0) and an acidic less than (7.0) (Al-Shablaq, 1998).

The pH values of the groundwater samples were ranged between (7.2- 7.8) with average value (7.4), (table, 2).

Total Dissolved Solid (TDS):

Total dissolved solids comprises inorganic salt (Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride, Sulfate)and small amounts of organic matter that are dissolved in water (WHO, 2004).

According to (Davies and De Wiest, 1966), (Drever, 1997) classification, water on the basis of the (TDS), as shown in (table, 3).

Table 2: Physical parameters of groundwater samples of Teeb Basin

The (TDS) values of water samples were ranged between (2230 – 7615) mg l^{-1} with a mean of (4940.8) mg l^{-1} . All groundwater samples in Teeb basin area is classified on the basis of the TDS, (table 2). The values of TDS are high more than the Maximum Permissible Level (MPL), recommended by Water Health Organization (WHO, 2004). All water samples considered to be of brackish water (TDS 1000-10000 mg l^{-1}).

The salinity contour map for the Teeb basin area is shown in (Figure 4). The map shows that the salinity increase from the recharge area in the north east towards the inner parts of the basin given rise to high saline water in the south west parts.

Electrical Conductivity (EC):

The Electrical Conductivity of a solution is a measure of its ability to carry an electrical current (Awni et al , 2007).

The (EC) of groundwater samples were measured at the field with Digital device that adjusted to (25 C⁰). The (EC)values ranged between (2787- 9640) $\mu\text{s cm}^{-1}$ with a mean of (6190) $\mu\text{s cm}^{-1}$ (table 2).

The relation ship between values of TDS and EC shown in (Figure 5). The following mathematical relation can represent them :

$$\text{TDS (mg l}^{-1}\text{)} = 0.7967 * \text{EC (}\mu\text{s cm}^{-1}\text{)} + 8.461 \quad \text{-----(1)}$$

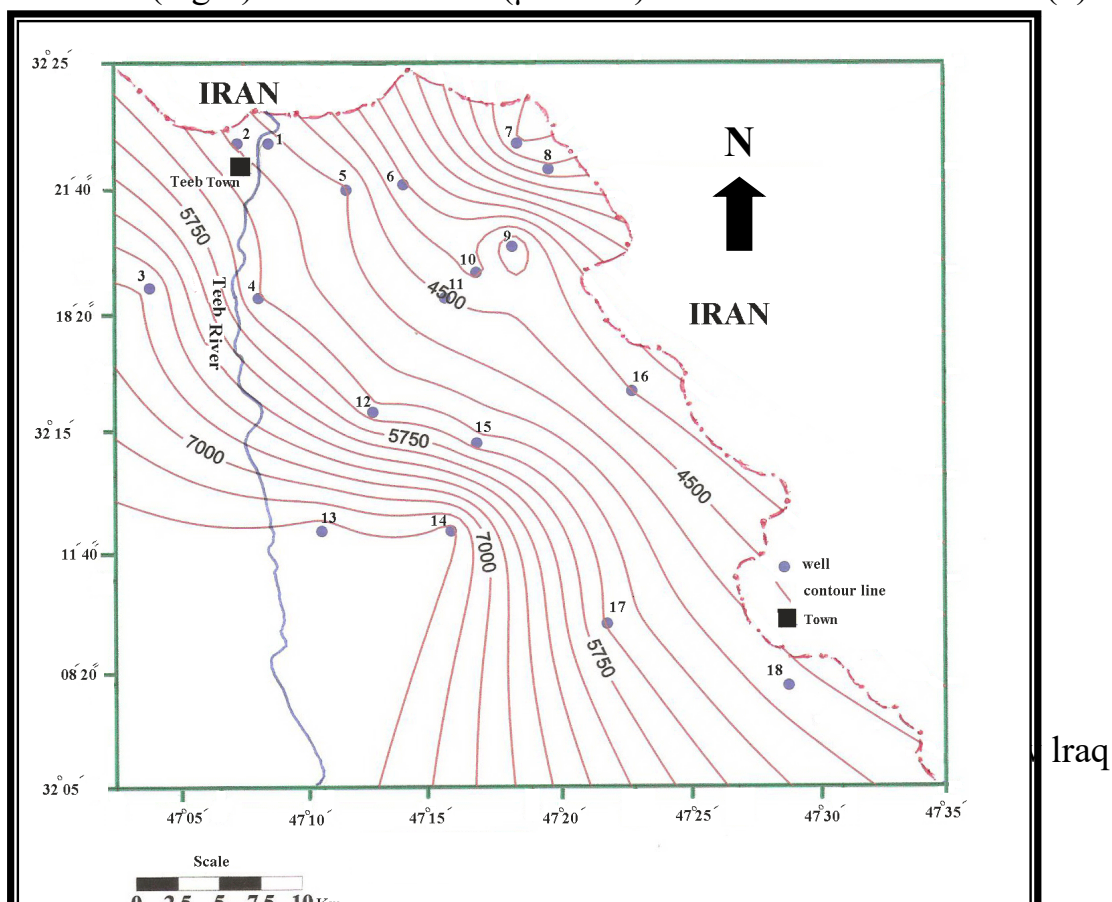


Figure 4 : Contour map of Salinity .

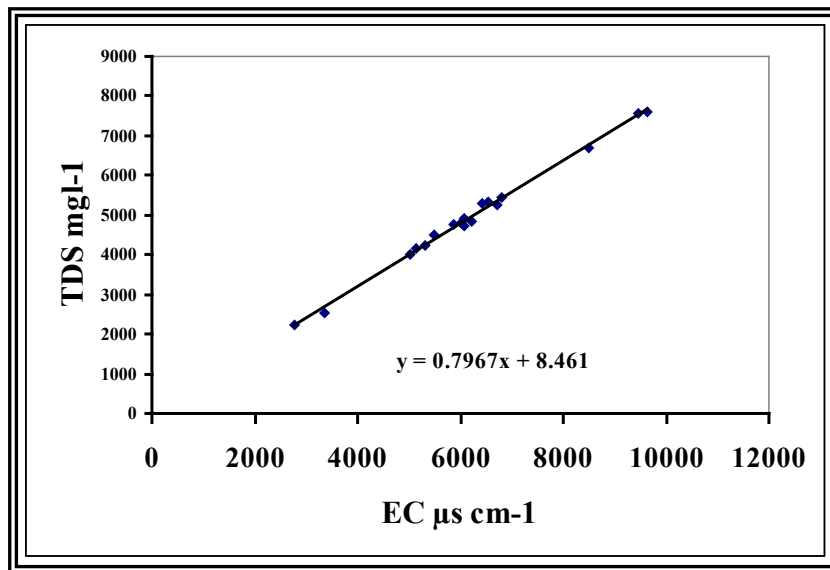


Figure 5: The relation between EC($\mu\text{s cm}^{-1}$) and TDS (mg l^{-1}) for (18)water samples of Teeb Basin.

Electrical Conductivity (EC) depends on the concentration of total dissolved solids (TDS) , therefore it can be use to estimate the concentration of total dissolved solids in the groundwater of basin by use the formula (1).

Total Hardness (TH):

The main source of Hardness in water is the concentration of calcium and magnesium ions. Hardness computed by mg l^{-1} unite according to following equation (Pedro and Evan, 2007):

$$\text{TH (mg l}^{-1}\text{)} = 2.497 \text{ Ca}^{+2} + 4.115 \text{ Mg}^{+2} \text{ ----- (2)}$$

The TH values ranged between (943.4- 3250.7) mg l^{-1} with a mean of (2037.4) mg l^{-1} ,(table,2).

The high TH values in the basin, due to lithology of plio-pleistocene rocks and overlain alluvium affected on the TH of the water samples, since the pebbles of Mukdadiya and Bai Hassan Formations are mostly of limestone and dolomite.

Table (3): Classification of water depending on (TDS) according to (Davies and DE Wiest, 1966) and Drever, 1997)

Water class	TDS mg ^l ⁻¹ Davies and De Wies 1966	TDS mg ^l ⁻¹ Drever 1997	Range of TDS in Teeb Basin Mgl ⁻¹	Class of water in Basin
Fresh water	0-1000	<1000	2230 - 7615	Brackish water
Brackish water	1000-10000	1000-2000		
Salty water	10000- 100000			
Saline water		35000		
Brine water	> 100000	> 35000		

Ions

Cations:

Calcium values of groundwater samples were ranged between (234.0 in W8- 673.2 in W14)mg^l⁻¹ with average value (449.0mg^l⁻¹), Magnesium (61.8 in W16- 461.0 in W1) with average value (214.5mg^l⁻¹), Sodium (612.0 in W1- 1353.0 in W3)mhl⁻¹ with average value (845.8mg^l⁻¹), Potassium (2.6 in W8- 28.0 in W5), with average value (12.8mg^l⁻¹).

Anions:

Chlorides values of groundwater samples were ranged between (161.7 in W7- 2212.0 in W13)mg^l⁻¹ with average (1098.0 mg^l⁻¹), sulfate (1132 in W7- 2844.0 in W3)mg^l⁻¹ with average value (1996.8mg^l⁻¹), Bicarbonates (55.6 in W8- 442.5 in W13)mg^l⁻¹ with average value (154.3 mg^l⁻¹), Nitrates (14.5 in W8- 107.6 in W5)mg^l⁻¹ with average value (43.4mg^l⁻¹).

Sodium and Calcium are the dominant cations in the groundwater in this basin, while sulfate is the most abundant of the anions (tables, 4, 5).

The high concentrations of sodium and sulfate in groundwater are due to the chemical weathering of rocks and soil in the basin.

Table 4: Major chemical cations in groundwater samples of Teeb Basin.

Well No.	Ca mg ^l ⁻¹	Ca epm	Mg mg ^l ⁻¹	Mg epm	Na mg ^l ⁻¹	Na epm	K mg ^l ⁻¹	K epm	SAR
W1	259.0	12.9	461.0	38.4	612.0	26.6	9.0	0.2	5.25

W2	479.0	23.9	115.2	9.6	992.2	43.1	6.7	0.17	10.5
W3	653.0	32.6	157.0	13.1	1353.0	58.8	9.2	0.2	12.5
W4	242.5	12.1	433.0	36.0	913.3	39.7	8.2	0.2	8.1
W5	617.7	30.8	206.0	17.1	711.3	30.9	28.0	0.7	6.3
W6	518.7	25.9	173.0	14.4	597.3	26.0	23.5	0.6	5.8
W7	273.0	13.6	100.8	8.4	205.8	8.9	3.5	0.09	2.6
W8	234.0	11.7	89.4	7.4	406.0	17.6	2.6	0.06	5.7
W9	490.0	24.5	180.0	15.0	805.6	35.0	13.0	0.3	7.8
W10	404.0	20.2	126.4	10.5	640.5	27.8	5.3	0.1	7.1
W11	502.0	25.1	167.5	13.9	736.4	32.0	19.8	0.5	7.2
W12	400.0	20.0	130.0	10.8	1196.0	52.0	8.8	0.2	13.2
W13	637.5	31.8	337.5	28.1	1245.0	54.1	26.2	0.6	11.8
W14	673.2	33.6	381.5	31.8	1122.0	48.7	26.1	0.67	9.4
W15	455.4	22.7	183.2	15.2	1151.7	50.0	8.9	0.22	11.5
W16	276.0	13.8	61.8	5.15	1030.0	44.7	7.0	0.17	14.4
W17	532.7	26.6	213.1	17.7	857.6	37.2	18.6	0.4	7.9
W18	435.0	21.7	345.3	28.7	643.2	27.9	6.6	0.16	5.5
Mean	449.0	22.4	214.5	18.0	845.8	36.7	12.8	0.3	

Table 5: Major chemical anions in groundwater samples of Teeb Basin.

Well No.	Cl mg ^l ⁻¹	Cl epm	SO ₄ mg ^l ⁻¹	SO ₄ epm	HCO ₃ mg ^l ⁻¹	HCO ₃ epm	NO ₃ mg ^l ⁻¹	NO ₃ epm	Accu .
W1	1068	30.1	2010	41.8	108.0	1.7	28.3	0.4	2.9
W2	1087	30.6	2086	43.4	56.6	0.9	18.4	0.3	1.03
W3	1483	41.7	2844	59.2	77.2	1.26	25.1	0.4	1.03
W4	1068	30.0	2373	66.8	103.2	1.7	10.3	0.16	5.6
W5	1212	34.0	1684	35.0	107.6	1.71	107.6	1.7	4.6
W6	1017	28.6	1387	28.9	118.0	1.9	90.4	1.4	4.7
W7	161.7	4.5	1132	23.6	138.6	2.2	75.6	1.22	0.8
W8	195.7	5.5	1416	29.5	55.6	0.9	14.5	0.2	0.9
W9	1180	33.2	1796	37.4	83.3	1.4	69.4	1.1	1.15
W10	338.0	9.6	2419	50.4	73.4	1.2	57.1	0.9	2.8
W11	996	28.0	1865	38.8	92.6	1.5	17.6	0.2	2.14
W12	1112	31.3	2220	46.2	109.2	1.8	20.8	0.3	2.1
W13	2212	62.3	2452	51.1	442.5	7.2	60.0	0.9	2.9
W14	2206	62.1	2483	51.7	441.3	7.1	59.8	0.9	3.0
W15	1120	31.5	2183	45.4	89.0	1.4	41.8	0.6	5.5
W16	881.6	24.8	1759	36.6	70.0	1.14	32.9	0.5	0.6
W17	1571	44.2	1715	35.7	314.3	5.1	42.6	0.6	2.2

W18	856	24.1	2119	44.1	298.0	4.8	9.46	0.15	3.5
Mean	1098.	30.8	1996.8	42.5	154.3	2.5	43.4	0.6	

Groundwater Use

Groundwater uses for human drinking purpose:

The WHO standard has been used as guides for the water quality evaluation for drinking purpose. The groundwater quality in studied area is unsuitable as drinking because most of the parameters are out of the recommended guide levels (table, 6).

Table 6:WHO guidelines for drinking water and range of values of chemical species in the groundwater of the Teeb basin, east Iraq.

parameters	WHO standard (2004)		Teeb Basin	
	Acceptable level	MPL	Range	Mean
Ca (mg ^l ⁻¹)	75.0	200.0	234.0-673.2	449.0
Mg(mg ^l ⁻¹)		50.0	61.8-461.0	214.5
Na(mg ^l ⁻¹)	20.0	175.0	612.0-1353.0	845.8
K(mg ^l ⁻¹)			2.6-28.0	12.8
HCO ₃ (mg ^l ⁻¹)			55.6-442.5	154.3
SO ₄ (mg ^l ⁻¹)		250.0	1132-2844.0	1996.0
Cl (mg ^l ⁻¹)		300.0	161.7-2212.0	1098.0
NO ₃ (mg ^l ⁻¹)		50.0	14.5-107.6	43.4
TDS(mg ^l ⁻¹)		1000.	2230-7615.0	4940.0
pH	6.5	8.0	7.2-7.8	7.4
TH(mg ^l ⁻¹)	100.0	500.0	943.4- 3250.7	2037.4

Groundwater uses for Livestock purpose:

On the basis on Altoviski (1962) classification, all of the groundwater

samples are good for livestock use (table 7).

Table 7: classification of livestock water (Altoviski, 1962)

Parameter s	Very good water mg ^l ⁻¹	Good water mg ^l ⁻¹	Permeable Mgl ⁻¹	Can be use mg ^l ⁻¹	Threshold Mgl ⁻¹	Water of Teeb Basin mg ^l ⁻¹
Na	800	1500	2000	2500	4000	612-1353
Ca	350	700	800	900	1000	234-673.2
Mg	150	350	500	600	700	61.8-461
Cl	900	2000	3000	4000	6000	161.7-2212
SO ₄	1000	2500	3000	4000	6000	1132-2844
TDS	3000	5000	7000	10000	15000	2230-7615
TH	1500	3200	4000	4700	54000	943.3-3250.

Groundwater use for irrigation:

The groundwater was evaluated for irrigation using the Sodium Absorption Ratio (SAR) values to determine its suitability. The SAR was computed using the expression developed by (Todd, 1980) as :

$$SAR = r Na / [r(Ca + Mg) / 2]^{0.5}$$

Classification of irrigation water based on SAR values is shown in (table, 8).

Table 8 : Classification of irrigation based on SAR values (Todd, 1980).

Grad	SAR
Excellent	<10
Good	10-18
Fair	18-26
Poor	> 26

On the basis of this classification all of the groundwater samples belong to excellent and good water class for irrigation purpose (SAR < 10, SAR 10-18).

CONCLUSION

The groundwater resources of the Teeb Basin, east Iraq were evaluated and studied to aid in planning, development and management. The principal sources of groundwater in this basin are classified as Pliocene and Quaternary Aquifers systems.

The lowest TDS values is 2230 mg^l⁻¹ and the highest is 7615 mg^l⁻¹. The dominant cations in the basin are Sodium and Calcium while Sulfates is the most abundant of the anions. Hence, groundwater from this basin is of the Na + Ca – SO₄ type. Based on this chemical quality, the groundwater of the Teeb basin is not suitable for drinking, and suitable for livestock and irrigation purposes.

REFERENCES

- Ali, J. A, and Khoshaba, B. N., 1981, Petrography and heavy mineral studies of lower Bakhtiari Formation, Jour. of Geo.Soc. of Iraq , Vol.14, No.1,pp.15-24*
Al-Jibuory, H.K., 2005, Hydrogeological and Hydrochemical study for Ali Al-Gharbi

- area international report, Geosur Library, Baghdad, No. (NI-38-16).*
- Al Shablaq, M.M., and Ammar, A., 1998, Application Hydrology, Ummar Al Mukhtar University, Al Baydha, 661 p.*
- Altoviski, M.E., 1962, Handbook of Hydrogeology, Gosgoelitzdat, Moscow USSR. 614p.*
- Awni T.B., Idrees F., Rasheed A., Muheeb, M., AbdelMonem, M., R, 2008, Weathering processes effects on the chemistry of the main springs of the Yarmouk Basin, north Jordan, Journal of Environmental Hydrology, vol. 16, (1-11)p.*
- Barwary, A.M., 1993, The geology of Ali Al-Gharbi quadrangle, unpublished report No.2226, NL-38-16 (GM 28), State Establishment of Geological Survey and Mining GEOSURV.*
- Budy, T. and Jassim, S., 1980, The regional geology of Iraq. Vol. 1, stratigraphy and paleogeography. I.I.M. Kassab and S.Z. Jassim (ed) SOM. Baghdad, 445p.*
- Davis S. N. and Dewiest R.J.M., 1966, Hydrogeology. John Wiley & Sons. Inc., New York. 463p.*
- Drever, J.I., 1997, The Geochemistry of natural water, surface and groundwater environments (3rd ed). Prentice hall, USA, 436p.*
- Enad, T. H., 2007, Stratigraphic and sedimentologic study of the Mukdadiya Formation in Badra area Wasit Provinance, MSc. Thesis, Baghdad University Unpublished, 136p.*
- Hamza, N. M., Lawi, F. A., Yaqoub, S. Y., Mousa, A., Fouad, S. F., 1989, Regional Geological Report, S.Co.G. S. M. I. Library, Unpublished Report, No.2023, Baghdad, 107p.*
- Jassim, S. Z. , Karim, S. A., Basi, M. A., Al-Mubarak. M. A., Muner, J., 1984, Final Report on the Regional Geological Survey of Iraq. State Organization for minerals directorate general of Geological Survey and Mineral investigation Vol. 3, Stratigraphy.*
- Lateef, A. A., 1975, Report on the Regional Geological Mapping of Hemrin-Range from Al- Fatha to Ain Layla Area, Sco. G.S.M.I. Library, Unpublished Report, Baghdad No. 772, 54 p.*
- Mahmood, R. M., 1986, Sedimentologic and stratigraphic study of the Upper Backhtiari conglomerate in northern Iraq, M. Sc. Thesis, University of Baghdad, 127 p.*
- Pedro, F.J., and Evan, K.N., 2007, Water Encyclopedia: Hydrologic Data and International Resources, 3^{ed} edition, CRC press, Taylor & Francis Group, USA,*

Todd, D. K., 1980, Groundwater Hydrology, John Wiley, New York, USA, 535 p.

*World Health Organization (WHO), 2004, Guidelines for Drinking Water Quality
(3rd ed.)Vol.1, Recommendations, Geneva, 595 p.*

*Water Wells Drilling Company, 2009, Well Data (total depth, water table
elevation),Teeb area, Maysan Governorate, Iraq.*