Republic of Iraq
Ministry of Higher Education and Scientific Research
Babylon University/ Collage of Science
Applied Geology Department

Project of Research

GOUNDWATER QUALITY OF SOME PART FROM BABYLON GOVORNORATE/IRAQ

By Student

Zainab Hussain Salih Musa

B.Sc. Geology

Scholar Year 2023-2024

Supervised by

Assis. Prof. Dr. Haider Abaid Salomy Al-Amar

1445 Hijri **2024 Gregorian**

الملحق 3

إقرار السيد المشرف

اقرار المشرف

أشهد بان موضوع البحث الموسوم

GOUNDWATER QUALITY OF SOME PART FROM BABYLON GOVORNORATE/IRAQ

والمنجز من قبل الطالب **زينب حسين صالح موسى**. قد اجري تحت اشرافنا في قسم علم الأرض التطبيقي/ كلية العلوم/ جامعة بابل كمتطلب جزئي لنيل شهادة البكلوريوس في علوم علم الارض وذلك للفترة من 2023/10/1 ولغاية 2024/4/1.

التوقيع:

الاسم الثلاثي للسيد المشرف:

اللقب العلمي:

التاريخ:

بسم الله الرحمن الرحيم

وأنزلنا من السماء ماء بقدر فأسكنه في
الأرض وإنا على ذهاب به لقادرون ﴿١٨﴾
فأنشأنا لكم به جنت من نخيل وأعنب لكم
فيها فواكه كثيرة ومنها تأكلون ﴿١٩﴾

صدق الله العظيم

المؤمنون: آية ﴿١٨-١٩﴾

Dedication

To Whom, Allah deputed him mercy to the creation, our honorable prophet Mohammed, peace be upon him and his descendants I hope to gain his pure and chaste descendant's intercession on the day of Resurrection.

To my mother and father who supported me and lit up my life from my birth to this date.

To my brothers and Sisters for their efforts, moral support, and endless encouragement.

Zainab

Acknowledgments

Praise be to God, the Most Gracious, the Most Merciful, who gave me the ability and desire to complete this graduation research.

I would like to extend my sincere thanks and gratitude to my supervisor, Dr. Haider Obaid Salome Al-Ammar, for the guidance, support, fruitful suggestions, constructive criticism, and independent supervision that gave me more knowledge in the field of scientific research. Without his support and guidance, this work would not have been completed.

Abstract

The study area is located around the city of Hilla (Babylon Governorate), 100 km south of Baghdad, between longitude (44° 39' 31" - 44° 23' 46") east and latitude (32° 18' 23" - 32° 23 '46"'N. In the study area, there is only a source of surface water, which is the Shatt al-Hilla, which passes through the city of al-Hilla and divides it into two parts. There is a need at the university to demonstrate its quality for different uses within a year. Total dissolved solids (TDS) in shallow groundwater are in high concentrations and are classified as brackish water.The concentrations of the tested chemical ions (Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-}, Cl^{-}, HCO_3^{-}, NO_3^{-}, PO_4^{3-}) for all tested samples within the study area within the samples, which represents, with the exception of well 1, high concentrations for all chemical samples within the study area. Phosphate concentrations (PO_4^{3-}) are high in samples of the study area as a result of irrigation water inputs to the shallow groundwater system affected by agricultural uses of vegetation in the study area. The water sample in the study area is suitable for irrigation and agricultural purposes with values of SAR, Na% and RSC. From Sholler classification of the study area, it was observed that there were high concentrations of Na+K and SO_4 due to the hole formation containing gypsum, anhydrite and dolomite, and it is believed to be the main source of SO_4^{-2} and Mg in the water.

List of contents

Chapter one / Introduction

Paragraph	Title	Page no.
1.1	Introduction	1
1.2	Location of the Study Area	2
1.3	Aims of the Study	4
1.4	Previous studies	4
1.5	Geology and topography of the studied area	6
1.6	Field and laboratory work	9
1.6.1	Field work	9
1.7	Office work	11
Chapter two / The climate of study area		
2.1	Introduction	12
2.2	Rainfall	14
2.3	Temperature	15
2.4	Relative Humidity	16
2.5	Evaporation	17
2.6	Wind speed	18
Chapter Three / Hydrochemistry of study area		
3.1	Hydrochemical investigation	20
3.2	Physical properties	20
3.2.1	Color and Odor	20
3.2.2	Temperature	20
3.2.3	Total Dissolved Solids (TDS)	21
3.2.4	Electrical Conductivity (EC)	23
3.2.5	Hydrogen ion concentration (pH)	24
3.3	The Chemical properties	24
3.3.1	The Major elements	24
3.3.1 1.	Cat ions	24
3.3.1 1.1.	Sodium (Na^+)	24
3.3.1 1.2.	Potassium(K^+)	25
3.3.1 1.3.	Magnesium (Mg^{2+})	25

3.3.1 1.4.	Calcium (Ca^{2+})	26
3.3.1 2.	The Anions	26
3.3.1 2.1.	Chloride (Cl^{-})	26
3.3.1 2.2.	Bicarbonate Carbonate (HCO_3^{-1}), (CO_3)	26
3.3.1 2.3.	Sulfate (SO_4^{2-})	27
3.3.2	The Minor Elements	28
3.3.2 1.	Nitrate (NO_3^{-})	28
3.3.2 2.	Phosphate (PO_4)	28
3.4	Water classification	29
3.5	Water Quality of study area for different purposes.	30
3.5.1	Water Uses for Drinking Purpose	30
3.5.2	Water Uses for Livestock Purpose	32
3.5.3	Water Uses for Industrial Purpose	33
3.5.4	Water Uses for Building Purpose	34
3.5.5	Water Uses for Agricultural purpose	34
3.5.6	Water Uses for Irrigation purpose	36
3.5.6 1.	Sodium Adsorption Ratio (SAR)	37
3.5.6 2.	Sodium Percent Na%	38
3.5.6 3.	Residual Sodium Carbonate (RSC)	39
3.6	Conclusions and Recommendations	40
3.6.1	Conclusions	40
2.6.3	Recommendations	41
	References	42

List of figures

Figu res	Title	Page no.
1.1	Location of the studied area	3
1.2	Topographic map for study area (GCFGW,2010)	7
1.3	Geological map for the study area, modified, (GCFGW,2010)	8

2.1	Mean monthly Rain fall for years (1975-2011	14
2.2	Mean monthly temperature for years (1980- 2012)	15
2.3	Mean monthly relative humidity for years (1980-2012)	16
2.4	Mean monthly evaporation for years (1980-2012)	17
2.5	Mean monthly wind speed for years (1975-2011)	18
3.1	Showing the relationship between the TDS and EC in study area.	23

List of Tables

Tables	Title	Page
1.1	GPS Coordinates of study area	3
2.1	monthly values of climate elements for the period (1980-2012). (Iraqi meteorological organization- Al-Hilla station).	17
2.2	Classification of wind speed at 10 m high from the earth surface (Iraq meteorology and seismology organization, climatically section,2008), (Al- Khafaji ,2009)	18
3.1	Some of chemical analysis in(ppm)unit and some physical analysis for Al-water samples	20
3.2	classification of water depending on (TDS)according to (Davis and DeWiest, 1966), (Drever,1997), (Altoiviski,1962) and (Todd,1980)	22
3.3	Hydro chemical water types (Sholler, 1972)	29
3.4	The drinking water standards according to (WHO guidelines, (2004), Iraqi standard (1996) and USA public Health service (1972).	31
3.5	Classification of livestock water (Altoviski,1962)	32
3.6	The minimum values of livestock drinking water (Mckec and Wolf,1963)	32
3.7	Water evaluation for industrial purpose (Hem, 1985)	33
3.8	Evaluation of water for building purpose uses (Altoviski ,1962)	34
3.9	Relative tolerances of crops to EC concentrations (Todd,1980)	35
3.10	Classification of irrigation water according to salinity (Rhoades,1992) in (AL-Shammary,2008).	37
3.11	Classification of irrigation water based on SAR values (Todd,1980)	38

3.12	Shows the values of SAR, Na% and RSC in the study area	38
3.13	Classification of irrigation water based on Na % (Todd, 1980)	39
3.14	Classification of irrigation water based on RSC values (Eaton, 1950)	39

CHATER ONE

INTRODUCTION

1. Introduction

Groundwater is an important component of water resources management within the studied area. The shallow groundwater systems with good, meaningful and sustainable management can lead to overcoming the water scarcity situation. Understanding the chemistry of groundwater is vital to improve the agricultural productivity in the studied area (Al-Enezy, 2012).

However, the groundwater within the study area lies within the Mesopotamian area of the Quaternary deposits, which is composed of sequences of silt mixture of layers of sand and gravel in most sites. Silt and sand comprise the whole groundwater reservoir deposits in the studied area (Jubouri, 2003). The hydraulic connection of groundwater systems in the studied area is good. The quality of groundwater in the area varies spatially depending on the quantity of infiltrated water from Shatt Al-Hilla channel and the irrigation channel network. The groundwater levels are shallow and range between 0.40–1.25 m with poor quality in most cases where the salinity ranges between 1000 to 3000 ppm (Al-Ani, 1986). At some places groundwater appears on the surface of the ground, accordingly, water is exposed to many surfaces' pollution sources, such as. Fertilizers, pesticides and others (Elalfy et al., 2007). Shatt A1-Hilla is the only surface water resource within the study area. Hilla City depends totally on Shatt Al-Hilla to maintain all of its water needs but its supply is not enough to support these needs, accordingly, the local consumers compensate their needs from groundwater resources through drilling hand dug wells mainly by the farmers to sustain their irrigation activities especially that the shallow groundwater within the area is always available and shallow. Also, providing the groundwater supports the local inhabitants needs and local industries as well as supporting civil construction activities (Al-Enezy, 2012). However, Shatt Al-Hilla, is the only resource for recharging the shallow groundwater system within the studied areas (Lafta and Nayef, 1999). Inter-relationship between surface and shallow groundwater determines the quantity and quality of available water and its validity of groundwater for different human consumption, mainly agriculture activities.

1.1. Location of the Study Area

The study area occupies some of the central parts of the Mesopotamian plain. It is located within Babylon Governorate near Al-Hilla City center in the University of Babylon, the study area extends between longitudes (44° 39' 31" - 44° 23' 46") E and latitudes (32° 18' 23"- 32° 23' 46") N as in Fig. (1-1) and Table (1-1) .

Table 1-1. GPS device was used to determined stations

Wells	Easting	Northing
St. 1	44° 23' 55.7"	32°23'57.4"
St. 2	44° 23'56.7"	32° 23' 46.2"
St. 3	44° 23'59.6"	32° 23' 27.5"
St. 4	44° 26'29.5"	32° 29' 54.5"

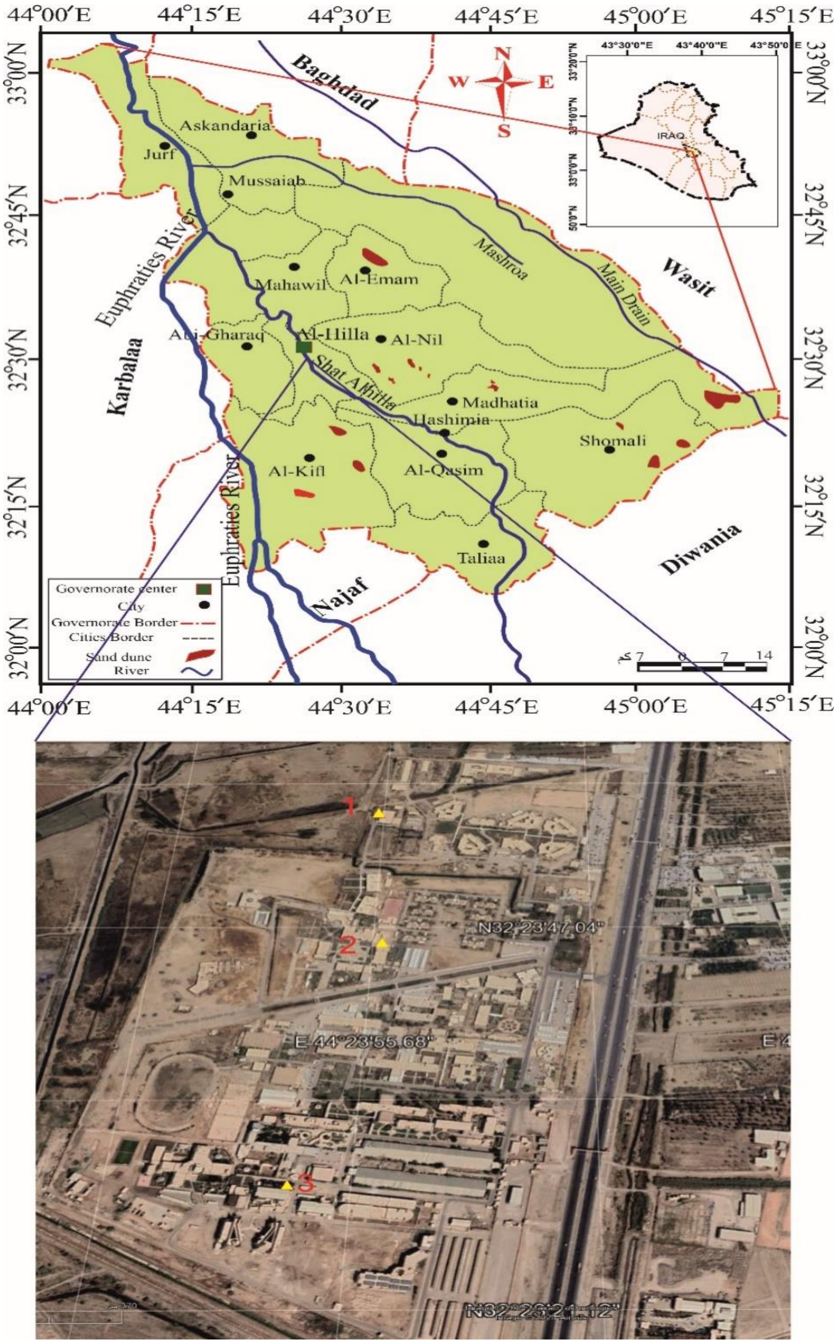

Figure 1-1. Location map of the study area in the central part of Iraq.

1.2. Aims of the Study

The examined area is characterized by shallow groundwater systems which lead to many negative impacts on the socio-economic, agricultural, and 1civil construction activities in addition to the negative impact on the health of inhabitants in the area .Shallow groundwater systems present another problem in the studied area i.e. (soil salinity and soil alkalization which affect the productivity of agricultural land in the area, affect building foundations by weakening the soil stability and reducing its bearing capacity) as well as sabotage the paved roads. The University of Babylon lands and gardens suffer from a noticeable deficit in the amount of water; accordingly, all users compensate for the water deficit from the shallow ground systems within the studied area by drilling many hands dig wells within the suited area. Thus, the study's main aim is to determine the hydrochemical characteristics of groundwater systems in the studied area to confirm the main finding of this study.

1.3. Previous studies

- Parsons (1957) provided large amount of hydrological information within all Iraq Governorates including Babylon Liwa.
- Al-Mussawi (1989) studied geography and irrigation activities within the Babylon Governorate. He studied soil samples taken from the banks of the irrigation canals. He found that soil type is mainly Silty loam and concluded that there were differences in the nature and characteristics of the soil from place to place as well as with depth.
- Al-Sam et al. (1990) studied the drainage and soil salinity in the Mesopotamia. He found and explained the existed increase in the salinity of the soil and shallow groundwater and pointed out the necessity to carry out systematic drainage network to control the increase of this phenomenon.
- Alani (1998) studied the geochemistry and hydrochemistry and regional sedimentary of AL-Sabkh within the central and southern of Iraq (including Musayib, Alskandaria, Diwaniyah, kifal, Samawah, Al Hillah, Hashemiate and Mahmudiyah sapkh).
- Lafta and Nayef (1999): They analyzing groundwater samples taken from many hand-dug wells within the Hilla City determine the water quality. They found that the water, in general, was saline of bicarbonate type and this increased in the direction of groundwater movement from adjacent areas to Al-Shatt Hilla channel course towards residential areas.

• Manah (2003) studied the hydro-chemical properties of the ground water and the mineralogy of the soil sediments in the open reservoirs within some selected areas within Babylon Governorate over two successive seasons and concluded that the water can be used for irrigation of most crop types.

• Al-Ammar (2004) studied the hydro-chemistry of shallow ground water, water drains and stream water within Babylon Governorate. He found that the water was hard with high concentrations of sulphate and chloride due to the high existing of gypsum in the soil.

• Nariman (2006) developed a mathematical model to represent the flow within Hilla. His model was used to manage hydrological controls when the discharge of Shatt Al-Hilla exceeds (303 m^3 /sec.) Comparing to the current discharge of (230 m^3 /sec.).

• Al-Enezy (2012) Relationship between surface and shallow groundwater in the eastern side of Shatt Al -Hilla, Iraq.

1.4. Geology and Topography of the Studied Area

The studied 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 and other (Buday, 1980 and Yacoub et. al.1983) Figure (2). The study area mainly lies within the alluvial plain of the recent sediments Quaternary in the period of Pleistocene - Holocene (Buday, 1980).Geologically, the study area includes, mainly, Quaternary sediments of both types (Pliocene to Miocene age) (Figure 3).Sediment logically, the area is characterized by flood plains deposits which consist of thin layers of fine sand and silt, clay and silt clay with succession layers of clay, sand and shale, and some gravel within deeper layers (Al-Jubouri, 2003).Babylon Governorates within the studied area characterized by plain surface with gentle gradient around 22 cm/km (Al-Jubori2002). The direction of the slope in the area is from NW toward E and SE parts. Some sand dunes in some isolated areas such as southern parts of Hilla City were found (Al-Sadoun, 1988). To the south of Musayib, Euphrates River is divided into two branches Shatt AL- Hindya to the west and Shatt Al-Hilla to the east. Shatt Al-Hilla, is the only and most important water resource within Babylon Governorate where it passes within its wide areas and several small streams courses came out of it to supply water to the agricultural land within the governorates (Sadoun, 1988).

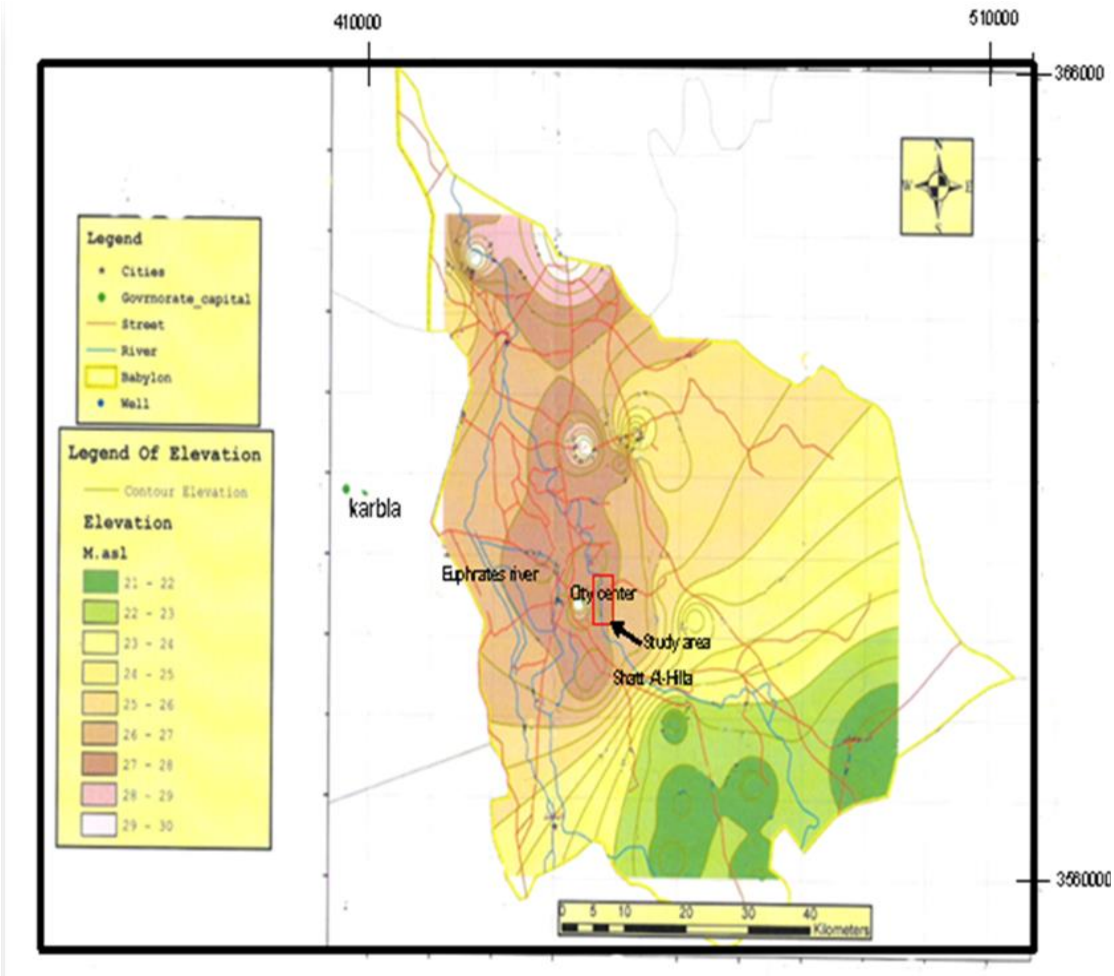

Figure 1-2. Topographic map for study area (GCFGW, 2010).

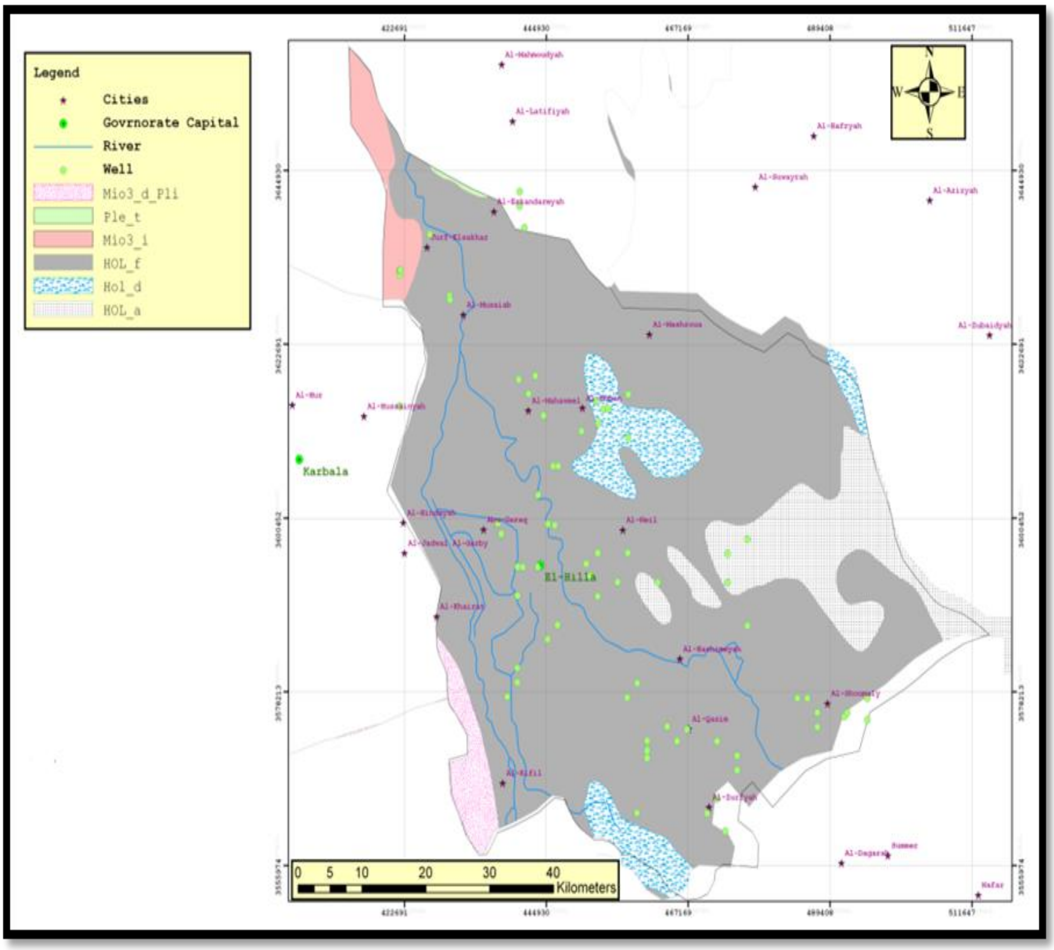

Figure 1-3. Geological map for the study area, modified (GCFGW,2010).

1.5. Field and laboratory work

1.5.1. Field work

The wells in the studied area are four distributed at the University of Babylon. Depth of these wells' ranges from 8 m to 13 m. The distance between wells ranged between 500 m to 1km approximately as shown in the Plate (1-1), the coordinate of wells is listed in Table 1-1. GPS instrument was used to locate these points in order to fix their exact locations.

Plate (1-1) Shows the wells of study area

1.5.2. Office work

- Reviewing the references and previous studies and collecting geological information's on the studied area.
- Collecting the climatic data about the studied area from the Hilla Meteorological Stations.
- Creating the topographic map of the studied area.
- Processing of calculations for water levels within the selected dug wells.
- Make interpretation for the data that is collected from the wells of study area.

1.5.3. Laboratory Works

The major cations and anions are analyzed in the laboratories of the Ministry of Environment/ Babylon Governorate to determine the concentrations for the main cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and main anions (HCO_3^{-}, CO_3^{2-}, SO_4^{2-}, Cl^{-}) and other important anions, i.e., Nitrate (NO_3^{-}) and (PO_4^{3-}), as in plate (1-4)

plate (1-4) Shows the Lab work

CHATER TWO

THE CLIMATE OF STUDY AREA

2. Introduction

The climate is one of the most important components of natural environment and has significant impact on the other environmental components, such as vegetation cover, soil, geomorphic features, precipitation and water quantity and quality also it is the cause of the substantive changes that take place within the local environment and it is linked to activities of living organism.

The study area lies within the dominantly prevailing arid and/or semi-arid desert climate characterized by very hot summer and limited seasonal rains, affected by global climatic change, as indicated by increases of the temperature, evaporation, and blowing in Iraq and the Middle East region (Al-Khafaji, 2009). The station of Hilla records the climatic elements used, such as rainfall, temperature, relative humidity, evaporation, wind speed, and evapo- transpiration, for the years 1985 -2015. These parameters are analyzed in three stations as in Table (2).

Table 2. Mean annual and monthly values of climate elements for the period (1985-2015). (Iraqi meteorological organization- Al-Hilla station).

Months	Temp	Rain Fall	Wind speed	Relative Humidity`	Evaporation	Sun Shine
	^{0}C	Mm	M/s	%	Mm	Hours
Oct	24.7	2.4	2.5	50.6	175	9
Nov	17.7	9.3	2.4	62.8	90	7
Dec	12.9	19.3	2.3	75	57	6.5
Jan	10.9	20.3	2.5	78.8	50	6
Feb	12.9	11.7	2.8	67.2	77	7.5
Mar	16.6	12.7	3.2	60.4	130	8.5
Apr	23.5	14.6	3.2	50.2	195	9
May	29.8	14.5	3.3	38	290	10.5
Jun	33.3	0.07	3.9	34.2	330	13
Jul	34.9	0	4.2	33.2	390	12
Aug	34.5	0	3.7	35.8	325	11.5
Sep	30.4	0.02	2.7	41.4	260	10.5

The main climatic elements affected the desertification phenomena in study area are:

2.1. Rainfall

The mean monthly rainfall (mm) for the period (1985-2015) varies with the season, being minimum (0mm) in (Jul. and Aug.). The maximum mean monthly rainfall values are in Jan., being 20.3 mm Fig. (4).

From the Table (1-2), it appears that the mean annual rainfall values for the period (1985 -2015) is (104.89 mm) so that the mean annual rainfall decreases in Hilla and, the mean annual rainfall value is low (around 100 mm), this indicates arid to semi-arid climate.

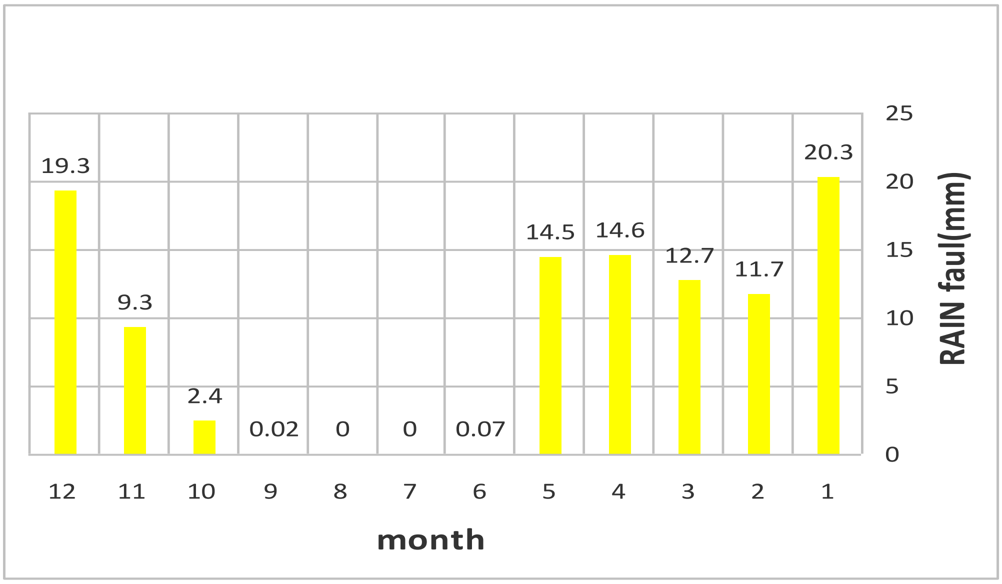

Figure 4. Mean monthly Rain fall for years (1975-2011)

2.2. Temperature

According to meteorological stations in the study area, the mean monthly temperature (in $^{\circ}$C) for years from 1980 to 2012 reflects that the maximum mean monthly temperature values lie in July (34.9 $^{\circ}$C), and lowest the minimum mean monthly temperature values lie in January (10.9 $^{\circ}$C) Fig. (5)

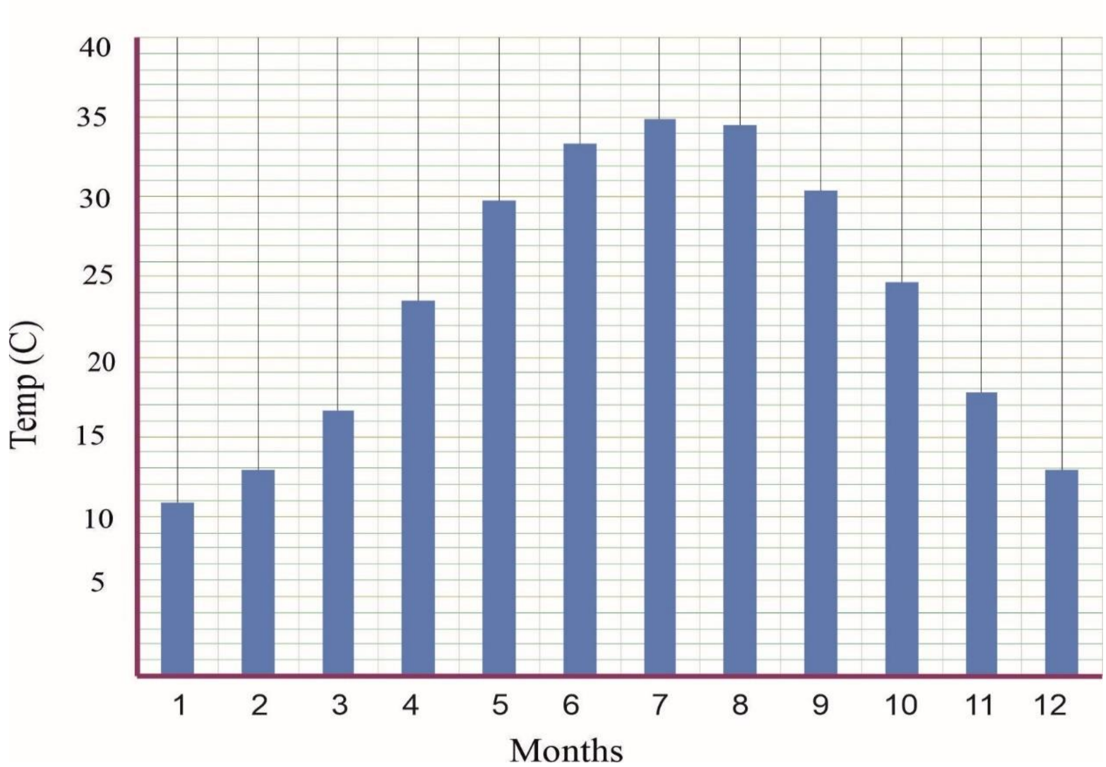

Figure 5. Mean monthly temperature for years (1985- 2015)

2.3. Relative Humidity

The Mean Monthly Relative Humidity percentage for the period (1985 to 2015) varies from minimum values in July (33.2 %) to maximum values in January (78.8%) Fig. (6).

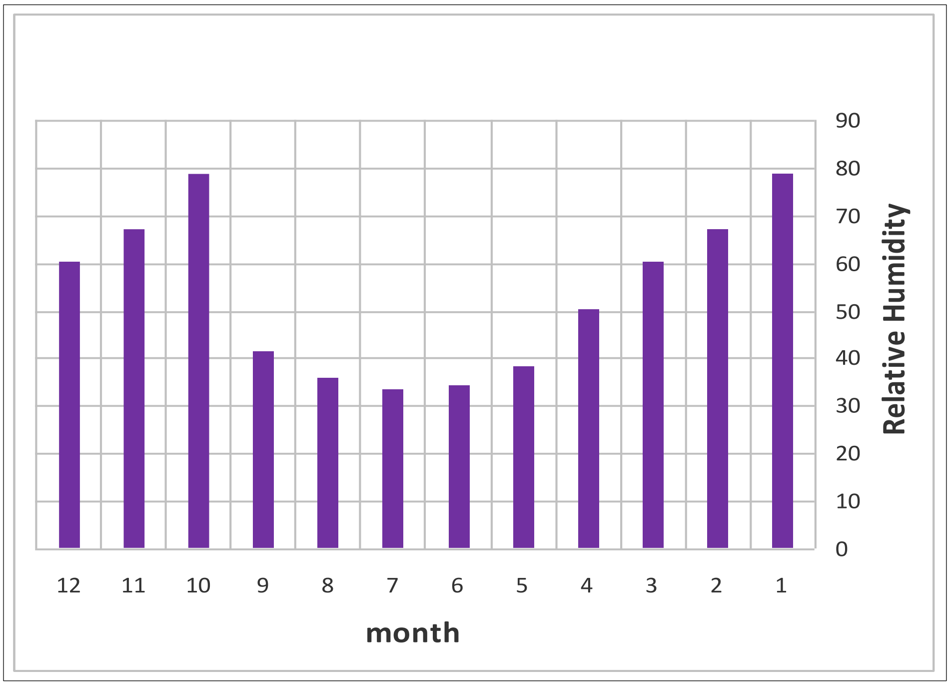

Figure 6. Mean monthly relative humidity for years (1985 - 2015)

2.4. Evaporation

The average mean values are considerably increased during the summer months due to high temperature, clear sky that makes a direct effect, in addition the activity of the sun rays is intensified during the longer day time, in the summer than in winter.

The mean monthly evaporation for the period (1985 to 2015) in the study area shows the lowest values (minimum) evaporation values during January (50 mm) and the maximum evaporation during July is (390 mm) as in Fig. (7)

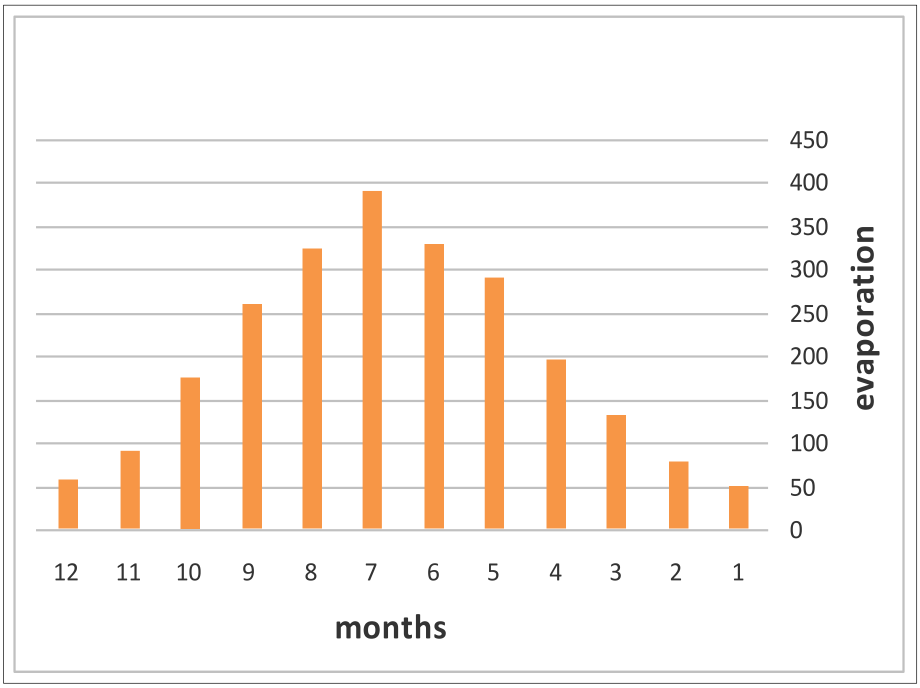

Figure 7. Mean monthly evaporation for years (1980-2012)

2.5. Wind speed

The mean monthly wind speed (m/s) for years from (1985-2015) Shows minimum values in December (2.3) and maximum values in July (4.2) for Hilla meteorological Stations Fig. (8). It is noticed from Table (2), that the mean monthly wind speed in Hilla, ranges from Calm wind during December when their wind speed is less than 3.3m/s, that is increased during July to be less than 5.4 m/s which is classified as Low speed wind.

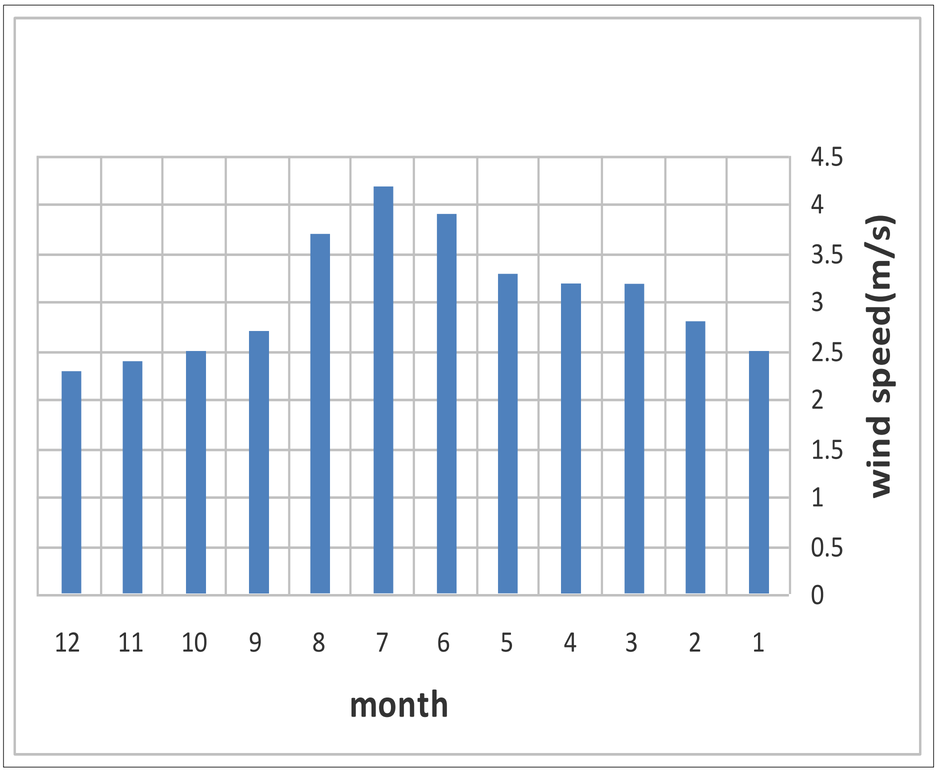

Figure (8) Mean monthly wind speed for years (1985-2015)

Table 2. Classification of wind speed at 10 m high from the earth surface (Iraq meteorology and seismology organization, climatically section, 2008; Al- Khafaji ,2009)

Class of wind	Knot	m/sec.	Km/h
Calm wind	45297.00	0-3.3	>11-0
Low speed wind	45483.00	3.4-4.5	12-19
Medium wind	45612.00	5.5-7.9	20-28
Active wind	17-21	8-10.7	29- 38
Very active wind	22-27	10.8 - 13.7	39-49
Uncompleted	28-33	13.9-17.1	50- 61
Storm	34-40	17.2-20.7	62-74
Active storm	41-47	20.8- 24.4	75-88

CHAPTER THREE

HYDROCHEMISTRY OF STUDY AREA

3. Hydrochemical Investigation

Four ground water samples were selected as random distribution in order to cover the study area. The locations of the selected water samples are shown in Fig. (1-1)

3.1. Physical properties

3.1.1. Color and Odor

Color and Odor generally originated from organic matter, humans activates and dissolved components, which is enhanced at high water temperature (WHO, 2004). All the water samples of the study area are colorless and odorless.

3.1.2. Temperature

The temperature of water is important for geochemical reactions and the life of organism (Hem, 1985). The Water temperatures of the study area as in Table (3) ranges between the maximum value is 32ºC in well (4), the minimum value is 30 ºC in well (2) and the average values is 31 ºC.

Table 3. some of chemical analysis in (ppm) unit and some physical analysis for Al- water samples.

St	Ca^+	Mg^{+2}	Na^+	K^+	Cl^-	$SO_{4^-}^{2}$	HCO_3^-	NO_3	PO_4	TDS	T	pH	EC
	ppm										ºC		µm/s
1	148	119.1	320	8	132	1095	0.058	3.52	0.24	3460	31	7.6	4870
2	124	90.9	260	5	127	996	0.038	2.21	0.29	992	30	7.7	1400
3	108	61.8	303	3	130	870	0.08	4.3	0.32	1871	31	7.6	2640
4	98	93.8	208	5.2	122	730	2.074	1.11	0.38	1722	32	7.4	2430
AV	119.5	91.4	272.75	5.3	127.75	922.75	0.5625	2.79	0.3075	2011.3	31	7.58	2835

3.1.3. Total Dissolved Solids (TDS)

Total dissolved solid is a measure of the total amount of minerals dissolved in water and is a very useful parameter in the evaluation of water quality (Heath, 1983). It is named salinity (WHO, 1996). Dissolved solids also come from inorganic materials such as, rocks, air and may contain calcium bicarbonate, nitrogen, iron phosphorous, Sulphur, and other elements. Many of these materials form salts, which are compounds that contain both a metal and a nonmetal. Salts usually dissolve in water forming ions. Ions are particles that have a positive or negative charge (Hem,1989 in Al-Amar, 2014). According to Altoiviski (1962); Davies and Dewiest (1966); Todd (1980) and Drever (1997) the classification of water on the basis of the (TDS), is shown in Table (4).

Table 4. classification of water depending on (TDS) according to (Davis and DeWiest,1966), (Drever,1997), (Altoiviski,1962) and (Todd,1980)

Water Class	Altoiviski, 1962	Davies and De wiest, 1966	Todd, 1980	Drever,1980
	TDS (ppm)			
Fresh water	0-1000	0-1000	1000-10	>1000
Slightly-Brackish water	3000-1000	-	-	-----
Brackish water	10000-3000	10000-1000	-1000 10000	20000-1000
Salty water	-10000 100000	100000-10000	-10000 100000	
Saline water	-	-	-	-20000 35000
Brine water	<100000	<100000	<100000	<35000

The TDS values of study area samples as in Table (3) ranges between the maximum value is 3460 ppm in well (1), the minimum value is 992 ppm in well (2), and the average values is 2011.3 ppm. According to Table (3) and Table (4), the water samples in study area considered fresh water the other classified between brackish and salty water.

3.1.4. Electrical Conductivity (EC)

Electrical conductivity is the ability of one cm^3 of water to conduct electrical current, at temperature of 25 °C measured by micromohs/cm (µhs/cm).EC depends on the concentration of soluble salts and the temperature of the water (Hem, 1985). The EC values of study area samples as shown in Table (3) ranges between the maximum value is 4870 µhs/cm in well (1), the minimum value is 1400 µhs/cm in well (2), and the average values is 2835 µhs/cm. The increase in TDS values causing the increase of EC along the study area.

3.1.5. Hydrogen ion concentration (pH)

The pH of water is controlled by the equilibrium achieved by dissolved compounds in the system. The pH parameter used as indicator of the acidity or alkalinity of a solution, depends respectively on whether its value is less or greater than 7. The dissolution and mobility of metals in natural water are greatly influenced by the pH (Thompson et al, 2007). The PH values of Water of the study area as in Table (3) ranges between the maximum value 7.7 in well (4), and the minimum value 7.4 in well (4), and the average value 7.58.

3.2. The Chemical properties

3.2.1. The Major elements

3.2.1.1. Cations

3.2.1.1.1 Sodium (Na^+)

The primary sources of most sodium in natural water are from the release of soluble products during the weathering of plagioclase feldspars (Hem, 1958). All-natural water contains measurable amounts of sodium. Actual concentrations range from about (0.2 ppm) in some rain and snow to more than (100000 ppm) in brines in contact with salt beds (Langmuir, 1997). The Sodium (Na^+) concentration of the study area as in Table (3) ranges between the maximum value 320 ppm in well (1) and, the minimum value of 280 ppm in well (4), and the average value is 273 ppm.

3.2.1.1.2 Potassium (K^+)

Although potassium is an abundant element and its common salts are highly soluble, it seldom occurs in high concentrations in natural waters. Chemical mechanisms that might be expected to bring about high concentration, however, are not of a type that are readily quantified. The broad generalizations already suggest that potassium concentrations in water are low partly because of the high degree of stability of potassium-bearing alum inosilicate minerals (Hem, 1989).

The Potassium (K^+) concentration of the study area as in Table (3) ranges between the maximum value of 8 ppm in well (1), and the minimum value of 3 ppm in well (3), and the average value is 5.3 ppm.

3.2.1.1.3 Magnesium (Mg^{2+})

Magnesium is the eighth most abundant natural element. It makes up to 2.5 percent of the Earth's crust and is commonly found in such minerals as magnetite, dolomite, olivine, talc, and asbestos. It is present in all natural waters and is a major contributor to water hardness. Ferromagnesian mineral igneous rocks and magnesium carbonates in sedimentary rocks are generally considered the principal sources of magnesium in natural waters. One of the most abundant elements of the alkaline earth group of metals, magnesium makes up about 2.1% weight of the earth crust (Collins, 1975).The Magnesium (Mg^{2+}) concentration of the study area as in Table (3) ranges between the maximum value of 119.1 ppm in well (1), and the minimum value of 61.8 ppm in well (3), and the average values is 91.4 ppm.According to Todd (1980), the sources of Mg^{2+} are the weathering of Mg-bearing rocks and minerals such as, dolomite, magnesite, olivine, pyroxene and clay minerals.

3.2.1.1.4 Calcium (Ca^{2+})

Calcium is the most abundant of the alkaline earth metals and is a major constituent of many common rock minerals. It is essential elements for plant and animal life form, and is major component of solutes in most natural water (Hem,1989). Calcium (Ca^{2+}) concentration of the study area as in Table (3) ranges between the maximum value 148 ppm in well (1) and, the minimum value of 98 ppm in well (4), and the average value is 119.5 ppm.

3.2.1.2 The Anions

3.2.1.2.1 Chloride (Cl^-)

Chloride is the anion of the element chlorine. Chlorine seldom occurs in nature, but is usually found as chloride. The chlorides of alkaline and alkaline earth metals are all highly soluble in water, for example, sodium, potassium, calcium, and magnesium (Hem, 1992). The Chloride (Cl^-) concentration of the study area as in Table (3) ranges between the maximum value of 132 ppm in well (1) and the minimum value of 122 ppm in well (4), and the average value is 127.75 ppm.

3.2.1.2.2 Bicarbonate Carbonate (HCO_3^-)(CO_3^-)

Alkalinity is reliable measure of carbonate and bicarbonate ions for most natural water. Most carbonate and bicarbonate ions in ground water are derived from the carbon dioxide in the soil and solution of carbonate rocks. Some groundwater probably obtains bicarbonate from the carbon dioxide generated by digenesis of organic compounds. The principal source of carbon dioxide species that product alkalinity in surface or groundwater is the CO_2 gas fraction of the atmosphere, or the atmospheric gases present in the soil or in the unsaturated zone lying between the surface of the land and the water table (Ljungberg, 2004). In the studied area, the total alkalinity is due to the bicarbonate ions, because if the (pH) value of the water samples are less than (8.2) and above (4.5) then the alkalinity is due to bicarbonates only (Davis and Deweist, 1966). The Bicarbonate concentration of the study areas in Table (3) ranges between the max value of 2.074 ppm in well (4) and the min value is 0.038 ppm in well (2), and the average value is 0.5625 ppm.

3.2.1.2.3 Sulfate (SO_4^{2-})

Gypsum ($CaSO_4.2H_2O$) is the most important source for sulfate (Gypsum is one of the more common minerals in sedimentary environments.

The sulfate (SO_4^{2-}) concentration of the study area as in Table (1-3) ranges between the maximum value 1095 ppm in well (1) and the minimum value is 730 ppm in well (4), and the average value is 922.75 ppm. The lithological units of the Fatha Formation, which contains gypsum and anhydrite, are believed to be the major source of SO_4^{2-} in the water. Although SO_4^{2-} precipitates with Ca^{2+} to form gypsum, SO_4^{2-} concentration is still high compared with other ions and with locations worldwide. Frederick et al. (1975) demonstrated that the decomposition of organic sulfur compounds in soil and sediment could be a potential source of SO_4^{2-} in the water. Therefore, the biological activity could be responsible for the high sulfate.

3.2.2. The Minor Elements

3.2.2.1 Nitrate (NO_3^-)

Nitrate is a stable ion over a considerable range of conditions and is very mobile in water (Hem, 1985). Nitrate has a significant influence on plant growth and may present a hazard for drinking water sources if its levels exceeded 10 ppm (Lands hoot, 2007). Nitrate originates mainly from fertilizers used in agricultural activities (Al-Qaraghuli, 2005). The Nitrate (NO_3^-) concentration of the study area as in Table (3) ranges between the maximum value of 3.52 ppm in well (1) and the minimum value of 1.11ppm in well (4), and the average value is 2.79 ppm.

3.2.2.2 Phosphate (PO_4^{3-})

Phosphate is one of the most common minerals in the soil and originates from the fertilizer used within the agricultural activities and sewage systems. The Phosphate (PO_4) concentration of the study area as in table (1-3) ranges between the maximum value of 0.38 ppm in well (4) and, the minimum value 0.27 ppm in well (4), and the average value is 0.3075 ppm.

3.3. Water Classification

There are many methods to classify the water samples into homogeneous groups (Piper, 1944; Sulin,1946; Johns, 1968; Sholler, 1972; Collins, 1975; Shoeller and Sulin, 1981; and Chadha,1999). All these classifications depend on the main cat ions and anions concentrations by unit equivalent weight of ion (epm) or milli equivalent per liter (meq/l).

Sholler (1972) classified water according to the relation among the major cations and anions in (epm), he used the decreasing order of the ionic concentration for cations and anions, and he arrived at (6x6) Ionic order as shown in Table (5).

Table 5. Hydrochemical water types (Sholler, 1972)

Code index	Cataions	Code index	Anions
1	r(Na+K) > rMg > rCa	1	rCl > rSO_4> $rHCO_3$
2	r(Na+K) > rCa > rMg	2	rCl > $rHCO_3$> rSO_4
3	rMg > r(Na+K) > r Ca	3	rSO_4> rCl > $rHCO_3$
4	rMg >rCa > r(Na+K)	4	rSO_4> $rHCO_3$> rCl
5	rCa > r(Na+K) > rMg	5	$rHCO_3$> rCl > rSO_4
6	rCa > rMg > r(Na+K)	6	$rHCO_3$> rSO_4> rCl

These (6x6) order of ionic concentration led to (36) combinations of water type. Where the water sample is illustrated by two numbers, one on the left represents the cation and the other one on the right represents the anion, for example when the water sample code index (61) that means the water type is:

rCa^{+2} , rMg^{+2} , $r(Na^{+} + K^{+})$: rCl^{-} , rSO_4^{-2}, $rHCO_3^{-}$

And the water family represents by greatest value from Cat ions and Anions as in the example above the water family as below: Ca-Bicarbonates.

According to Sholler's classification in Table (4), the water samples in study area as in table (3-3) classify as follows:

A-code index (21) for well (1), and the family Na +K -chloride.

B-code index (23) for Well (2) and the family Na +k – Sulfate.

C-code index (53) for well (3) and the family ca- Sulfate.

D-code index (21) for well (4) and the family Na +K –chloride.

F-code index (23) for well (5) and the family Na +K – Sulfate.

From Sholler classification of study area high concentration of Na +K and SO_4, is observed because of the Fatha Formation, which contains gypsum, and anhydrite and dolomite, are believed to be the major source of SO_4^{2-} and Mg in the water.

3.4. Water Quality of study area for different purposes.

Whether a water of given quality is suitable for a particular purpose depends on the criteria or standards of acceptable quality for that use. Quality limits of water supplies for drinking water, industrial purpose and irrigation apply to water because of its extensive development for this purpose (Todd, 1980). The water in the study area may be utilized for different purposes, therefore it is necessary to check its suitability for the different purposes.

3.4.1. Water Uses for Drinking Purpose

Water quality can be defined and standardized by means of indications expressing the limiting concentrations of relevant components and other water properties with regard to their health effect. There values have to be derived from the character and intensity of impact of the relevant components of human organism (Jermar, 1987).

The Iraqi standard (1996), WHO (2006) standard, and USA public Health service (1972) have been used as guides for the water quality evaluation for drinking purpose (Table3- 6).

Table3- 6. The drinking water standards according to (WHO guidelines (2004), Iraqi standard (1996) and USA public Health service (1972).

Components	(I.G.W.Q,1996)	(WHO,2006)	(UPHS,1972)
	(ppm)	(ppm)	(ppm)
Mg^{++}	50	50	125
Na^{+}	200	200	200
Ca^{++}	50	75	200
Cl^{-}	250	250	250
$SO_4^{=}$	250	250	250
NO_3^{-}	50	50	-
HCO_3^{-}	-	200	500
F^{-}	-	1.5	-
As	-	0.01	-
Co	-	0.1	-
Al	-	0.2	-
Mn	-	0.05	-
Fe	-	0.2	0.2

Ni	0.02	-	-
Cu	1	2	0.1
Zn	3	3	3
Cd	0.003	0.005	0.01
Pb	0.01	0.01	0.01
Cr	-	0.05	-
Hg	-	0.001	0.001
PH	6.5-8.5	6.5-8.5	-
TDS	1000	1000	1000
EC		1530	1500
TH	500	500-1000	500

According to Tables (3-3 and 3-5), all the water samples of the study area considered to be not suitable for human drinking purpose, because most of the components are out of the recommended guide levels excluding well 2 is suitable for human drinking purpose.

3.4.2. Water Uses for Livestock Purpose

The water of Study area had been evaluated for livestock uses depending on the classification proposed by Altoviski (1962) as shown in Table (7). This classification is based on some of the major elements (cations and anions), their values for the study area are shown in Table (1-3), all the samples are very good –permissible for livestock except the W2 and W3 which cannot be used for livestock drinking because of high TDS and SO_4 respectively.

Table 7. Classification of livestock water (Altoviski, 1962)

Elements	Very Good water	Good Water	permissible	Can be used	Cannot be used
	ppm				
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
TDS	3000	5000	7000	10000	15000
TH	1500	3200	4000	4700	54000
Na	800	1500	2000	2500	4000

While Mckec and Wolf (1963) classification depends on TDS concentration for specific kind of animals as in Table (8)

Table 8. The minimum values of livestock drinking water (Mckec and Wolf, 1963)

NO.	The Animal Kind	(TDS) in (ppm)
1	Poultry	2860
2	Horses	6435
3	Cattle of Beef	7150
4	Cattle of Milk	10100
5	Sheep adult	12900
6	Donkey	15000

According to Tables (3 and 8), all water samples of study area are not suitable for poultry drinking purpose are suitable, while all the stations considered to be suitable for Horses drinking purpose; all the water samples suitable for other animals drinking water.

3.4.3. Water Uses for Industrial Purpose

Hem (1985) mentioned the water quality for various industries, as shown in Table (1-9). These standard water qualities represent the maximum permissible limits for the industries.

Table 1-9. Water evaluation for industrial purpose (Hem, 1985)

Industry type		Ca	Mg	Cl	HCO_3	SO_4	NO_3	TH	TDS	pH
		ppm								
Petroleum Products		75	30	300				300	1000	9-6
Cement Industry				250		250			600	8.5-6.5
Wood Chemical		100	50	500	250	100	5	900	1000	8-6.5
Leathers Industry				250		250		Soft		45451
Soft drinking bottling		100		500		500				
Fruit Icing				250		250	10	250	500	8.5-6.5
Synthetic rubber		80	36					350		8.5-6.5
Unbleached		20	12	200				100		10-6
Bleached	Chemical Pulp &Papers	20	12	200				100		10-6

According to Table (1-3) and Table (1-9), all water samples of study area are not suitable for industrial purpose because of TDS high values.

3.4.4. Water Uses for Building Purpose

Altoviski (1962) classification for building purposes is depending on the most of the major cations and anions. This classification had been used to evaluate the water samples of study area for building purpose.

According to Table (1-3) and Table (1-10), all water samples of study area can be used for building purpose, except W1, because the high concentration of SO_4^{2-}.

Table 10. Evaluation of water for building purposes uses (Altoviski, 1962)

Ions	Permissible Limit
Na^{+}	1160
Ca^{+2}	437
Mg^{+2}	271
Cl^{-}	2187
SO_4^{-2}	1460
HCO_3^{-}	350

3.4.5. Water Uses for Agricultural purpose

The tolerance of plants for TDS and EC are different from plant kind to another as in Todd, (1980) classification as in Table (1-11).

Table 11. Relative tolerances of crops to EC concentrations (Todd, 1980)

Crop division	Low EC Tolerance	Medium EC Tolerance	High EC Tolerance
	(µm/s)	(µm/s)	(µm/s)
	3000-0	4000-3000	4000-1000
Fruits	Avacado, lemon, Strawberry, Peacch, Almond, plum, Prune, orange, apple	Olive, Date, Cantaloupe, Fig, Pomegranate	Date Palm
Vegetable	4000-3000	4000-10000	10000-12000
	Green beans, celery, Radish	Onion, Carrot, Potatos, Sweet, tomato Coron, bell pepper, Peas, and squash	Spinach, Asparagus, Kale, Garden beets
Forage	4000-6000	10000-6000	10000-100000
	Burnet, Ladino clover, red clover, Alasike clover,	Sour Clover, Cicer milk vetch, tall meadow oatgrass, smooth brome	Barley, Cotton, Western wheat grass, Bermuda grass

	White Dutch, Clover		

According to Table (3 and 11), the tolerance of crops for water samples of the study area is as below:

1. Well 1 (suitable for agriculture Olive‹ Date, Cantaloupe, Fig, and pomegranate‹, green beans, celery, Radish.
2. well (2) suitable for agriculture of barley‹cotton ‹western wheat grass ‹ Bermuda grass.
3. well (3) suitable for agriculture Avocado ‹lemon ‹Strawberry ‹Peach, Almond, plum, Prune, orange, apple.
4. well (4) suitable for agriculture Olive‹ Date ‹Cantaloupe ‹Fig, pomegranate ‹green beans‹celery ‹Radish.

3.4.6. Water Uses for Irrigation purpose

Irrigation water criteria depend on the types of plants amount of irrigation water, soil and climate (Davis and Deweist, 1966). The suitability of water for irrigation depends upon its own quality as well as upon the other factors, the same quality of water may be considered as suitable for a certain type of soil or crop but is unsuitable for other (Al-Shammary, 2008).

The quality of irrigation water, which is considered the most important factor, is determined by their soluble component, which includes its total salt content ionic composition, and presence of minor elements.

Groundwater is classified it is salinity by FAO classification for irrigation water lies in (6) categories after (Rhoades, 1992), as shown in Table (1-12).

Table 12. Classification of irrigation water according to salinity (Rhoades, 1992) in (Al-Shammary, 2008).

Water Class	EC ds/m	TDS (mg/l)	Type of water
Non-Saline	<0.7	<500	Drinking and irrigation water
Slightly Saline	0.7-2	500-1500	Irrigation water
Moderately Saline	2- 10	1500-7000	Primary drainage water and groundwater

Highly Saline	10-25	7000-15000	Secondary drainage water and groundwater
Very highly Saline	25-45	15000-35000	Very Saline groundwater
Brine	> 45	> 35000	Sea water

According to Table (1-3) and Table (1-12), the salinity of water samples of the study area is of class (Slightly saline, moderately Saline to highly saline) and type of water Irrigation water, Primary drainage water and groundwater to Secondary drainage water and groundwater.

3.4.6.1. Sodium Adsorption Ratio (SAR)

The sodium hazard is determined by the absolute and relative concentrations of the cataions and can be evaluated through the sodium adsorption ratio (SAR), because of its direct relation to the absorption of sodium by soil (Todd, 1980), it is defined by:

$$\mathrm{SAR} = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$$

Classification of irrigation water based on SAR values is shown in table (1-13) after (Todd, 1980).

Table (13) Classification of irrigation water based on SAR values (Todd, 1980)

SAR	Water Class
<10	Excellent
10-18	Good
18- 26	Fair
>26	Poor

Table (14) Shows the values of SAR, Na% and RSC in the study area.

Station No.	SAR (epm)	Na%	RSC (epm)
1	22.15811	41.87536	-489.24
2	25.35999	45.88101	- 466.9
3	17.79547	37.8654	- 448.46
4	21.24302	43.25768	-418.9

According to Table (1-13) and Table (1-14), the water samples of study area are between fair water class to good water class.

3.4.6.2 Sodium Percent Na%

Sodium content is usually expressed in term of percent sodium (also known as soluble sodium percentage SSP), it is an estimation of the sodium hazard of irrigation water, and it expresses sodium out of the total citations. Na% is calculated by the following formula (Todd, 1980):

$$\text{Na\%} = \frac{(Na + K) * 100}{\text{Ca} + \text{Mg} + \text{Na} + \text{K}}$$

The concentrations are expressed in mill equivalents per liter based on Todd (1980), classification of irrigation water according to the percent sodium, as shown in Table (1-15). According to Table (1-14) and Table (1-15), all the water samples of the study area are between permissible irrigation water classes to good irrigation water class.

Table (15) Classification of irrigation water based on Na % (Todd, 1980)

Water Class	Na %	Ec µ/cm
Excellent	< 20	<250
Good	20-40	250-750
Permissible	40-60	750-2000
Doubtful	60-80	2000-3000
Unsuitable	>80	>3000

3.4.6.3 Residual Sodium Carbonate (RSC)

A high concentration of bicarbonate in irrigation water may lead to precipitation of calcium and magnesium in the soil and thus to a relative increase of sodium concentration. Thus, the sodium hazard will increase (Van Hoorn, 1970). The bicarbonate hazard expressed by residual sodium carbonate (RSC) which introduced by Eaton (1950):

$RSC = (CO_3^{2-} + HCO_3^{-}) – (Ca^{2+} + Mg^{2+})$

RSC=Residual sodium carbonate.

The Classification of irrigation water based on RSC values shown in Table (1-16) after (Eaton, 1950).

Table (1-16) Classification of irrigation water based on RSC values (Eaton, 1950)

RSC (epm)	Water Class
< 1.25	Safe
1.25 -2.5	Marginal
>2.5	Unsuitable

According to Table (1-14) and Table (1-16), all the water samples of study area, all the (RSC) values less than zero, therefore, all the samples are Safe water class and it is suitable for irrigation uses.

CHATER FOURE

CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

The total dissolved solid salt TDS within shallow groundwater system are high concentrations and classified as brackish water.

The concentrations of the examined chemical ions (Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-}, Cl^{-}, HCO_3^{-}, NO_3^{-}, PO_4^{3-}) for all examined samples within the studied area are higher within samples representing excluding the well No.2 is low concentration for all chemical samples within the study area.

The concentrations of phosphate (PO_4^{3-}) Is high within samples of study area due to the irrigation water inputs to the shallow groundwater system effected by the agriculture uses for the vegetation's in the study area.

All groundwater samples within the studied area examined water conditions within the Sholler classification and shows the water class as following ,shallow groundwater system does not recharge surface water system because of declining in the water level within the shallow groundwater systems in the area, thus, the re- charging groundwater by rain in the winter, or to increase the river's water level by leaking water from the river, or from improper irrigation land excessively.

The water sample in the study area suitable for irrigation purpose, on SAR, Na% and RSC value

4.2. Recommendations

Using all available climatologically data in the area to implement a comprehensive research plan concerning the climatic changes in the area in order to explore all feasible adaptation and mitigation process which can be implemented in the area.

To control one of the main sources of pollution within the area I recommend construction of a sewage network and proper water treatment plan for recycling of sewage followed by reusing this treated water again in the agricultural activities.

Solving the problem of drinking water in the villages (near the wells of study) by establishing a main water treatment plan positioned on some wells of study area where the surface water cannot arrive to those villages.

4Preventing (by law) any new drilling of new shallow wells in other locations in the distracts and city of Hilla for discharging the sewage water to the shallow groundwater in the area.

Establishing drainage network for collecting water from the agricultural activities for reusing after some treatment for far away land irrigations.

References

Appelo, C. A. J. and Postma, D, .1999: Geochemistry, ground water and pollution Rotterdam: A. A. Balkama, 536p.

Al-Ammar, H. A., 2004. 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).

Al-ani, J. M., (1998), Theoretical and Application Consideration for the effect of the geometry on Schlumberger and dipole configuration. Unpublished, Ph.D. Thesis, Unv. Of Baghdad, college of science, 144p.

Al-Furat Center for Studies and Designs of Irrigation Projects

(FCSDIP), 1989, "Lowering of groundwater level in Babylon city", UN published Report, Baghdad, Iraq.

Al-Janabi, M. A., 2008. Hydrochemistry of the unconfined aquifer and the relationship of unsaturated zone sediments on the groundwater quality in Tikrit-Samara basin, Ph. D., Thesis, College of Science, Uni. of Baghdad, 163p. (In Arabic).

Al-Jabouri, 2002, the geotectonic evaluation for the soil in the Babylon Governorates. Thesis. Collage of science. University of Baghdad. (In Arabic). p.183.

Al-Jabouri, A. A., 2003; Preliminary investigation of groundwater

pollution due to saline intrusion and agricultural activitiesin Musandam Peninsula-North Oman, International Hydrological Program, Published by UNESCO Cairo Office, Vol. 5, pp:72-80.

Al-khatteb, A.A. (1988), Geomarphology of Najaf hill. UN published M.Sc. thesis. Collage of science. University of Baghdad. (In Arabic). p.120.

Al-Mussawi, S. N. and Salman, H. H., 1989, Heavy Metals distribution in Khor Al-Zubair sediments NW Arabian Gulf, marina.

Al-Qaraghuli, N. A., 2005, Contents of nutrient elements (Total, water soluble and available) in the fertilizers (TSP, MAP, NP & NPK) produced from AL-Qaim plant, Iraq, Iraqi Journal of Agricultural Sciences, Vol. 36, No. 5, pp 35-41.

Al-sam, S. I., Jassim, S. Z. and Hanna, F. (1990), Water balance of Iraq: stage 2, geological and hydrogeological condition. Manuscript report, Ministry of Irrigation, Iraq.

Al-toviski, M. E., 1962, Handbook of hydrogeology, Gosgeolitzdat, Moscow, USSR, (in Russian) pp.614.

Barawari, A.M. and Slewa, Naser A. (1995), Geological board of Karbala, The General company of geological survey and mineral, internal report. p.22.

Bateras, 2002. National program for ideal using for water resources in Euphrates basin. Ministry of irrigation. Final report. p.77.

BGS, 2003, Water Quality Fact Sheet: Nitrate, British Geological Survey, NERC, 6 p.

Boyd,C. E.,2000, Water quality an introduction, Kluwer Academic Publisher, USA.330p.

Buday, T., 1980, Regional Geology of Iraq stratigraphy and paleogeography state organization of minerals, Baghdad, 445 p.

Buringh, p., 1960, soil and soil conditions of Iraq. Ministry of agriculture, Baghdad, 322p.

BWRD (Babylon Water Resources Department, (2011), personal connection.

Chada D. K., 1999, a Proposed New Diagram for Geochemical Classification of Natural Waters and Interpretation of Chemical Data, Hydrogeology Jour., Vol.7, pp. (431-439).

Davis S. N. and DeWiest R. J. M., 1966, Hydrogeology, John Wiley and Sons, New York, 463p.

Detay, M. (1997): Water Wells. Implementation, Maintenance and Restoration. John Wiley & Sons, London, PP:

Domas, J., 1983, The geology of Karbala –Kut and Ali-Gharbi area, Rep. No.4, The Mesopotamia plain project, GEOSVRU Lib, Unpublished Report No. 1384; 206p.

Faure, G, 1998, Principles and application of geochemistry (2nd Ed.).

Prentic Hall, Inc., USA, 600p.

Freeze, R.A. and Cherry, J.A., 1979, Ground water. Prentic Hall Inc., New Jersey.

Hassan, A. M., 2007, Hydrogeochemical of groundwater for Mandli Fan aquifers and hydrochemical model Ph. D. thesis submitted to geol., college of science, Baghdad University, Iraq. (In Arabic).

Hamza, N.M., 1997, Geomorphologic map of Iraq, series of geological maps of Iraq, (GEOSURV). Publication, Baghdad, Iraq.

Hem, J. D., 1989, Study and interpretation of the chemical characteristics of natural water U.S geological survey, water supply paper 2254, 246p.

Hem J. D., 1985, Study and interpretation of the chemical characteristics of natural water. 3rd. ed. U.S.G.S. water supply paper. 2254. 263p.

Himida, I. H., 1995, Hydrological and ground water. Desert research center, Ciaro University Center, 343p.

Iraqi meteorological organization, 2011, Climatic elements data of recorded in Al-Hilla station for period from (1985-2009).

Ivanov V. V., Barvanov L. N. and Plotnikova G. N., 1968, The Main Genetic Type of The Eart's Crust Mineral Water and Their Distribution in USSR, Inter. Geol. Cong. Of 23rd Sessions, Czecholoslovakia, Vol.12, 33p.

GCDWQ (Guidelines for Canadian Drinking Water Quality) (2007), Chemical analysis interpretation of domestic farm water supplies.-www.agric.gov.ab.ca/ app84/ rwqit.1-August-2007.

GCFGW /2010.General Corporation for ground water. Personal connection.

Karanth K R 2008, Groundwater Assessment Development and Management, Tata McGraw-Hill Offices, New Delhi. p.720.

Land schoot, P., 200, Irrigation Water Quality Guidelines for Turfgrass Sites, College of Agricultural sciences The Pennsylvania State University, USA.

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

Langmuir, D., 1997, Aqueous environmental Geochemistry, Prentice Hall, USA, 600p.

Manah, J. K. (2003), 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.

Magazine, Sciences of Engineering, bound 4, 1999.

Nariman.Y.O.2006. Hydraulic control of Shatt Al-Hilla within Hilla City. M.SC.W.R. Engineering, Thesis. Collage of Engineering. University of Babylon. p.109.

Parsons, R.M.1957 Groundwater resource of Iraqe, vol.11, Mesopotamian plain. ministry of development, development board

, Baghdad, 157p.

Piper, A. M., 1944, Graphical procedure in geochemical interpretation of water analysis. Trans-American Geophysical Union, 25: 914-928.

Rankama, K. and Sahama, TH. G., 1950, Geochemistry, The University of Chicago press, 910 p.

Rock Work, 2008.Software, Rock Ware Incorporated, ttp://www.rockware.com.

Salar, S. G., 2006, Hydrogeology and Hydro geochemistry of Kifri Area, M. Sc. Thesis, College of Science, Uni. of Baghdad, 106p. (In Arabic).

Sissakian, V.; Ibrahim, E.; Ibrahim, F. and Al-Ani, N. (2000). Geologic Map of Iraq, 3rd ed., Geosurv, Baghdad, Iraq.

Skipton, S.O. and Dvorak, B.I. (2009). Drinking water hard water (calcium and magnesium). Division of institute of agriculture and nature resource. University of Nebraska - Lincoln. July-2009.

Sosa. Ahmed, 1945. Euphrates vale and Al-Hendia Barrage Project, second part, first print, Baghdad.

Suresh, R., 2008, Watershed Hydrology; Principles of hydrology, Lomus offset press, Delhi, India, 692p.

Swiss CONSUL TANS, 1985, Hilla KIFL PROJECT General Establishment of Design and Research, state Organize for land Reclamation, Republic of Iraq, Main Drain sheet (1-5), no. P.894-1.

Shaw, E.M. (1999). Hydrology in practice. 3rd ed. Stanly Thornespubl. Ltd, U.K, p.:569.

Thompson, T., Fawell, J., Kunikane, S., Jackson, D., Appleyard, S., Callan, Ph., Bartram, J. and Kingston, ph., 2007, Chemical safety of drinking water: assessing priorities for risk management, WHO, Geneva, 142 p.

Thornthwaite, C. W., 1948, Approach toward a relation classification of climate geographical, Rev.3, 55-94pp.

Todd, D. K., 2007, Groundwater hydrology second edition, Jhon Wiley

And Sous,Third Reprint. Inc. India. 535p.

Todd D. K., 1980, Groundwater Hydrology, 2nd Edition, John Wiley and Sons, New York 535p.

Turcan. J. S. 1946, Saqlaliyah Experimental plots. Note on shitw Crops, Grown 1945/46. Irrig. Dept. Baghdad.

Viessman, W. J., and Lewis, G. L. 2007, Introduction to Hydrology, 5thed., Person Education, Inc. and Dorling Kindcrsly, Inc. India,612p.

Walton, W. C. 1970, Groundwater Resources Evaluation, McGraw-Hill, New York, 664p.

WHO (2009), Calcium and magnesium in drinking water public health significance. Geneva. Spain. p.165.

WHO, 2006, Guidelines for Drinking-water Quality, 1st Addendum to the 3rd ed., volume 1: Recommendations, World Health Organization, Geneva, 515p.

WHO, 2004, Guideline for Drinking Water Quality, 3rd Edition, Vol.1: Recommendations, World Health Organization, Geneva, 515p.

الخلاصة

تقع منطقة الدراسة بالقرب من مدينة الحلة (محافظة بابل) على بعد 100 كم جنوب بغداد، ضمن جامعة بابل، بين خطي الطول (44° 39' 31" - 44° 23' 46") شرقاً وخطي العرض (32° 18'). 23" - 32° 23'46"'شمالاً). يوجد في منطقة الدراسة مصدر واحد فقط للمياه السطحية وهو شط الحلة الذي يمر بمدينة الحلة ويقسمها إلى قسمين. هناك حاجة في الجامعة لري الحدائق بالمياه الجوفية وامكانية استخدامها للأغراض المختلفة . لذلك من الضروري إثبات جودة المياه للاستخدامات المختلفة خلال عام من تاريخ اخذ النماذج. توجد المواد الصلبة الذائبة الكلية (TDS) في المياه الجوفية الضحلة بتركيزات عالية وتصنف على أنها مياه قليلة الملوحة.

تراكيز الأيونات الكيميائية المختبرة (Mg2+, Na+, K+, SO42-, Cl-, HCO3-, NO3-, PO43-) لجميع العينات المختبرة داخل منطقة الدراسة ضمن العينات والتي تمثل باستثناء البئر 1 تراكيز عالية لجميع العينات الكيميائية داخل منطقة الدراسة.

ترتفع تراكيز الفوسفات (PO43-) في عينات منطقة الدراسة نتيجة مدخلات مياه الري إلى نظام المياه الجوفية الضحلة وتأثرها بالاستخدامات الزراعية للغطاء النباتي في منطقة الدراسة. عينة المياه في منطقة الدراسة مناسبة للري والأغراض الزراعية بقيم SAR و Na%وRSC

ومن تصنيف شولر لمنطقة الدراسة لوحظ وجود تراكيز عالية من Na+K وSO4 بسبب تكوين الحفرة التي تحتوي على الجبس والأنهيدريت والدولوميت، ويعتقد أنها المصدر الرئيسي لـSO4-2 وMg. في الماء.

جمهوريـــــة العـــــراق

وزارة التعليم العالي والبحث العلمي

جامعة بابـــــل/ كلية العلـــــــوم

قسـم علـم الارض التطبيـــــــــقي

مشروع بحث التخرج

استخدامات المياه الجوفية لأغراض المختلفة في جامعة بابل محافظة بابل/ العراق

للطالب

زينب حسين صالح موسى

بكلوريوس علوم علم الارض

العام الدراسي 2023-2024

بأشراف

ا. م. د. حيدر عبيد سلومي العمار

1445 هجري

2024 ميلادي