Evaluate the Climatic Conditions for the *Al-Najaf –Ain-Al-Tamur Area (Middle of Iraq)*

Kamal K. Ali **Zainab A. Kadham**

Department of Geology, College of Science, Baghdad University, Baghdad, Iraq

Kkak1962@yahoo.com , zainab.ali93@yahoo.com

ARTICLE INFO

Submission date:5 / 7/2018
Acceptance date:5 / 8/2018
Publication date:14/10/2018

Abstract

This study includes determining the climatic conditions of the study area and the nature of the reservoirs in the region with the determination of the flow direction of the aquifer. The meteorological data for the Karbala station for the period 1976-2016 showed that the values of the monthly rates of temperature, precipitation, evaporation, relative humidity, wind speed and Sunshine duration are (24.19 C◦), (95.5 mm), (2828.6mm), (46.75%), (2.76 m/sec), and (8.61 h/day) respectively. Thorenthwait method was used to calculate the values of Potential Evapotranspiration (PE) then determine the annual value of Water Surplus(WS) and Water Deficit (WD) which equal(28.11mm) and (941.94mm) respectively. Mean monthly water surplus for the period (1976-2016) was recorded about (9.36mm) in December, (13.11mm) in January and (5.64mm) in February of the whole amount of Rainfall and Equal to (29.34mm) of the total rainfall. The flow net map is shown by mainly that the groundwater flow in the area, it is from the northwestern parts towards the Eastern and southeastern parts.

Keyword: Climatic conditions .Classification of Climate. Water balance. Water surplus. Karbala area.

Introduction

Climate is defined as the weather changes in a vast area for a period of time long enough to identify all it's statically features. Climate varies From place to place, depending on latitude, distance to the sea, vegetation presence or absence of mountains or other geographical factor. The climate is considered as an important factor affecting the amount of groundwater while the climate elements have a great role affecting water

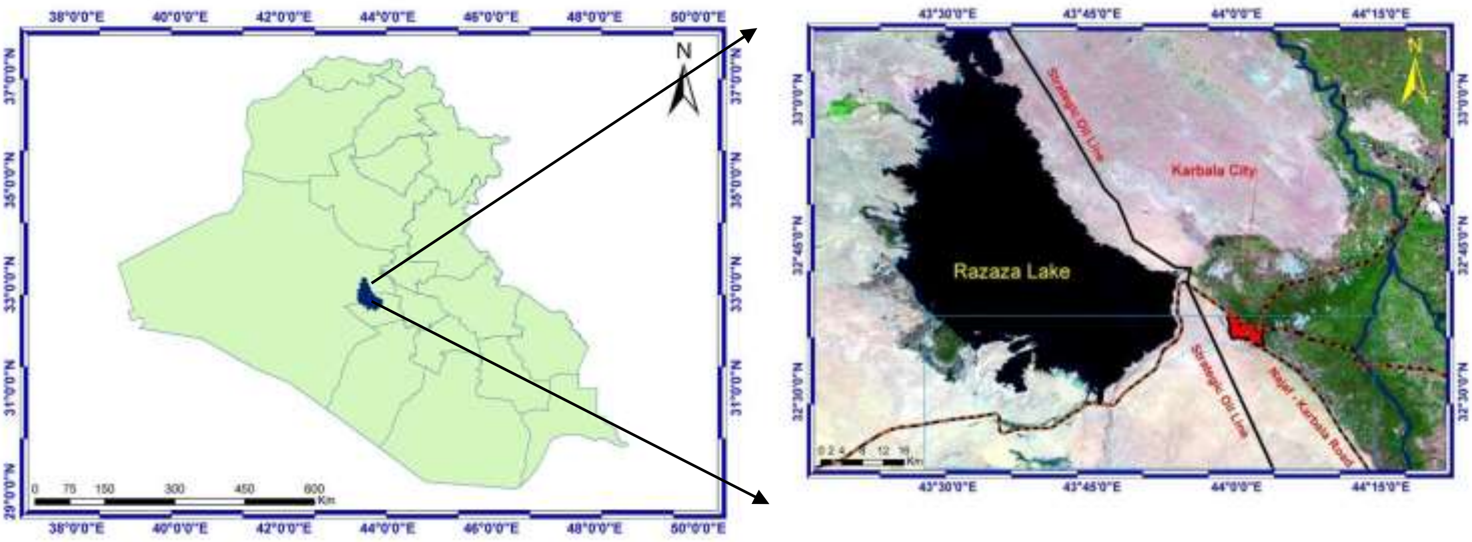


Figure 1: Location map of the study area

resources both surface and groundwater. The ionic composition of surface water and groundwater is strongly influenced by the change in climate elements [1].

The studied area is located within Al-Najaf- Karbala-Ain Al-Tamur, it extends from Razzaza Lake in the north bounded from the east by the Modern village project, from the west by Ain Al-tamur oasis, and from the south by Al-Najaf governorate, between the longitudes (43 30 to 44 12) and latitudes (32 36 to 32 23) ,The elevation ranges from (28-120m) above sea level fig (1)

General Geological Description

The geological formation outcrop in Karbala City is Tertiary and quaternary sediments ,The outcrop formation in the study area are configured from the oldest to the youngest by Euphrates, Injana to Dibdibba formation in addition to the Quaternary deposits (Pleistocene and Holocene) which appear south and southwest of Razzaza Lake represented by gypcrete , Aeolian deposits , sabkha sediments and valleys fill sediment in the region, all the studied area covered by gypcrete deposits except an area a rounded by Razzaza Lake and Tar-Alsayd, where Dibdibba, Injana and Al-Nfayil formations are out cropped [2].

Climate

Climate in the area stand up to envelops western desert climate, according to climatologically elements. The climate of Iraq is characterized by hot–dry summers and cold–rainy winters. Roughly 90% of the annual rainfall occurs between November and April. The climate is an important factor affecting the quality of ground water and change of their levels. In this study mead determine climatic water balance by analyzing the climatic parameters of Karbala Meteorological Station for period (1976- 2016).

Water resources are decreasing continuously due to increasing demand for water for different purposes, prompting researchers to conduct hydrogeological studies and researches of water reservoirs and ways of investing them, groundwater is found in the rocky openings that carry water called aquifers [3].

The geological, morphological, and climatic factors which determine Hydrogeological conditions from during knowledge the spatial distribution of hydrogeological bodies and determine the groundwater recharge and discharge zones and the depth of the water table, while climatic conditions have determined the rate of groundwater recharge, the intensity of groundwater flow and water loss due capillary effects, evaporation and transpiration [4].

Climate parameters

The meteorological data for the study area (Table 1) have been taken from Karbala Meteorological Station (IMO, 2016) for the period (1976-2016) to assess the climate condition of the study area. The climate of the studied area is generally characterized as being continental, dry and relatively hot in summer,cold and with little rain in winter,[2],[4].

Table1: Monthly averages of the climate elements for the period (1976-2016) of Karbala meteorological station.

Month	Rain fall (mm)	Relative Humidity %	Temperatures ◦C	Wind speed (m/sec)	Sunshine (h/day)	Evaporation (mm)
Jan	16.3	72.921	10.42	2.1	5.1	**61.831**
Feb	14	60.974	13.23	2.6	7.4	**94.19**
Mar	17.7	51.053	17.76	3	8	**167.4**
Apr	10.7	41.923	24.16	3.1	8.9	**236.74**
May	3.6	33.725	29.939	3.1	8.8	**324.4**
Jun	0.1	28.15	34.373	3.9	11.2	**413.025**
Jul	0	28.308	36.81	4	11.5	**452.9**
Aug	0	30.513	36.09	3.3	11.1	**409.89**
Sep	0.3	34.667	32.44	2.4	10.4	**303.4**
Oct	4	44.975	25.83	2	8.1	**200.43**
Nov	13.5	61.538	17.35	1.8	6.8	**100**
Dec	15.3	72.333	11.97	1.9	6.4	**64.257**
sum	95.5	561.08	290.372	33.2	103.7	**2828.463**
max	17.7	72.921	36.81	4	11.5	**452.9**
min	0	28.15	10.42	1.8	5.1	**61.831**

1. Rainfall

The increase of rainfall has a big influence on groundwater; it contributes To the leaching salts from the top soil to its lower parts. In the study area, rainfall events occur normally within the humid period between October and may. Rainfall average recorded in march was 17.7 mm while the lowest average have been recorded in July and august as it were (0) mm. the total annual rainfall was (95.5mm), (Fig 2 a). It should be mentioned that there is no rain during the period of this study.

2. Temperature

Temperature is one of the climate elements that has great role in the hydrological cycle, which may affect of groundwater Recharge, by its direct relation with evaporation and inversely with rainfall and relative humidity. Temperature represents an important factor in the evaporation and evapotranspration, which results in worming air The annual average temperature for the period (1976-2016) In study area is high in summer, where the maximum mean of monthly temperature is (36.81C) in July. The minimum mean of monthly temperature is (10.42C) in January, while the mean annual of temperature is (24.19C), (Fig 2b).

3. Relative Humidity

Relative humidity is the ratio of the partial pressure of water vapor to the Equilibrium vapor pressure of water at the same temperature [5]. Relative humidity is correlated inversely with the temperature and evaporation, and normally with the rainfall. The maximum and minimum mean monthly relative humidity are (72.921%) and (28.15%) in January and June respectively and the mean annual is (46.756%), (fig 2c).

4. Wind Speed

Wind speed is important due to its effect on the rate of evaporation. Winds are firmly connected with temperature and air pressure, the wind speed increases with the high temperatures and thus increasing its power to evaporate soil water from the surface which helps in raising water to The surface [6].From the monthly rate of wind speed, the highest rate is in July (4.0m/s), while in November it is lowest (1.8m/s).The dominate wind direction in the studied area is northwest, While western, eastern, and southern winds are of low frequency [7] (figure 2d) .The monthly rate of wind speed , the heights rate is in July 4.0(m/s).
While in November it is lowest 1.8 (m/s), (figure 2-e).

5. Sunshine

It's the total duration coming from the sun for the unit of time. Sunshine is an important component of climatic parameters as it affects relative humidity, Evapotranspiration and temperature. The period of sunshine with the increasing of temperature will lead to the evaporation excess; thus affecting the amount of underground water recharge; in addition to affecting the actual evaporation proportions. The maximum mean monthly sunshine in study area is (11.5 h/day) in July and minimum mean monthly is (5.1 h/day) in January, whereas the mean annual sunshine is (8.61 h/day). Sunshine is strongly connected to the seasons of the year, where the sun hours, in general, are longer in summer.

6. Evaporation

Evaporation is one of the significantly main climatologically factors that influence environment and is strongly connected to the other factors (temperature, relative humidity, wind speed, air pressure, evaporation surfaces, and nature of evaporation surface).Evaporation affects groundwater chemistry as extreme evaporation leads to deposition of minerals such as gypsum, calcite, and chloride salts in soils [5].The maximum mean monthly evaporation is (452.9 mm) in July but the minimum mean monthly is (61.831 mm) in January, while the total annual evaporation is (2828.6 mm). Different relationships are occurring between climatic variables. The process of evaporation is normally related with the temperatures, wind speed, where it increases as the temperature, wind speed increase, and inversely with the rainfall and the relative humidity (Fig.2f).

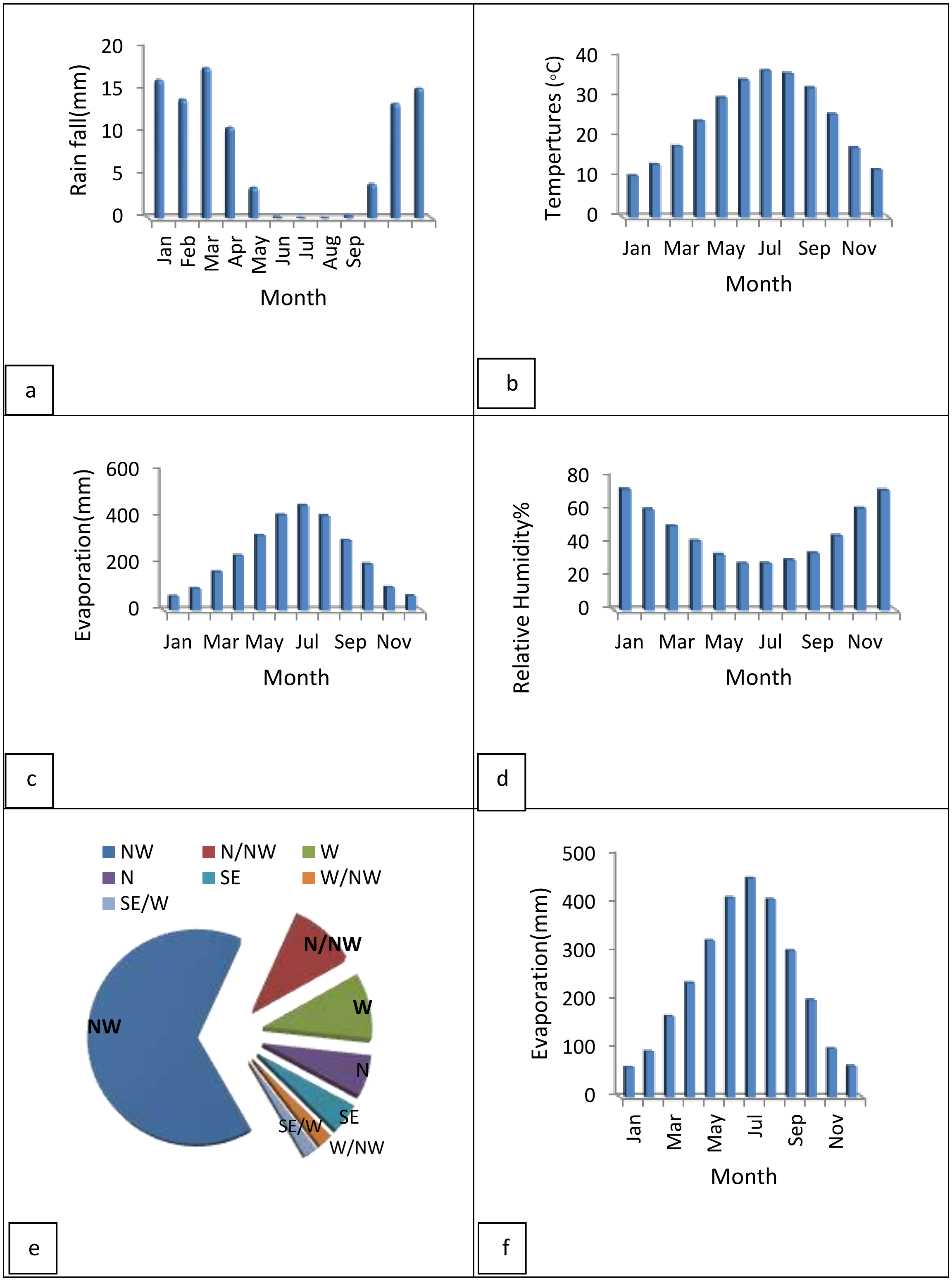


Figure 2: shows the climatic parameters during months for period (1976-2016) in the study area

7-Evapotranspiration

It's the term that refers to both of evaporation and transpiration, and it refers to the total loss of water through evaporation and transpiration from the soil plant system [8].

There are many factors affecting of evaporation such as:-

Soil factor, plant factor, atmospheric factor and cultural factor. Estimation of evaporation has several importance's such as planning and design of irrigation scheduling, Thornthwiate ,(1944) assumed that the amount of water lost through Evapotranspiration from a soil surface covered with vegetation is governed by climatic factors.

Evapotranspiration was computed by Thornthwiate through making a number of experiments on different types of climate based on temperature only. The correlation graph of each actual and corrected potential Evapotranspiration (PEx-PEc) is shown in (fig 3). Potential Evapotranspiration is calculated in Table (2) for each month using Thronthwaits formula, (1947) in [8], [9] as follows:-

$PEx=16[10t/J]^{a}$ ……………………………….(1)

$J = \sum_{j=1}^{12} j$ For (12 months) … (2)

$j=[tn/5]^{1.514}$…………………………………..…(3)

$a=0.016J + 0.5$……………………………..…(4)

$PEc = PEx * \frac{DT}{360}$……………………………(5)

Where

PEc=Corrected potential evapotranspiration (mm).

PEx=Actual potential evapotranspiration (mm).

D=The number of days in the month.

t= Monthly mean air temperature (◦C).

n=Number of monthly measurement.

J=Annual heat index (◦C).

j= Monthly temperature parameter (◦C).

a=Constant (an empirically derived exponent).

The

a=0.016*J+0.5

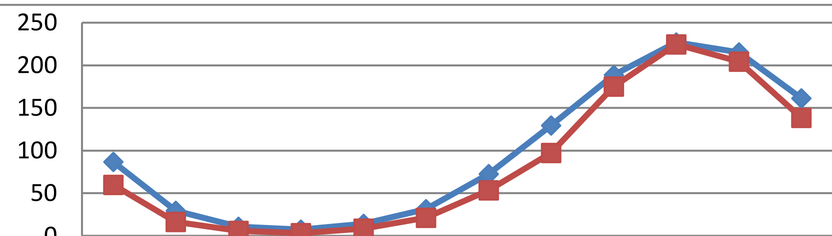
a=0.016*(138.33)+0.5=2.71

Number of days during months and sunshine hours has affected potential Evapotranspiration values.

Values of Potential Evapotranspiration were calculated theoretically at assumption the number of days in the month 30 days and the number of hours the sunshine 12 hours per day, they are not compatible with reality. Therefore, can be using equation to obtaining values of the corrected potential Evapotranspiration as shown in Table 2. By using equations below:

Table 2: PEC values for the period (1976-2016) by Thornthwiate (1948) method

Epan (mm)	PEc (mm)	PEx (mm)	DT/360	$j=(tn/5)^{1.514}$	t (°C)	Months
200.43	59.96	86.91	0.69	12.01	25.83	Oct.
100.0	16.55	29.56	0.56	6.57	17.35	Nov.
64.257	5.94	10.81	0.55	3.74	11.97	Dec.
61.831	3.19	7.42	0.43	3.03	10.42	Jan.
94.19	8.36	14.17	0.59	4.36	13.23	Feb.
167.4	21.41	31.49	0.68	6.81	17.76	Mar.
236.74	53.65	72.51	0.74	10.85	24.16	Apr.
324.4	97.25	129.67	0.75	15.02	29.939	May
413.025	175.33	188.53	0.93	18.51	34.373	Jun.
452.9	224.71	226.98	0.99	20.54	36.81	Jul.
409.89	204.39	215.15	0.95	19.93	36.09	Aug.
303.4	138.59	161.16	0.86	16.96	32.44	Sep.
2828.6	1009.33	1174.36	DT/360	J= 138.33	290.398	Total



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PEX(mm)	86.9	29.6	10.8	7.42	14.2	31.5	72.5	130	189	227	215	161
Pec(mm)	60	16.6	5.94	3.19	8.36	21.4	53.7	97.3	175	225	204	139

Figure 3: Graph show evaporation, PEX and PEC correlation during months for period (1976-2016) in Karbala City.

Climatic Setting

The climate if the study area characterized as being continental, dry and relatively hot in summer,cold and little rain in winter and believed to be influenced by the Mediterranean Sea climate, In addition to the remarkable difference in the temperature between day and night, the wind prevalent in the area is mostly north-northwest toward southeast accompanied by sand storms especially in summer and sometimes winds come from the south and south west [5]. The climatologically variables are temperature, rainfall, evaporation, relative humidity, wind speed and sunshine depend on the climate data recorded at the Karbala meteorological station during the period (1976-2016) where values of the annual and monthly averages of these variables through 40 year shown in the Table1. The climate of the study area was characterized with a summer dry and hot, which begins from May to September, with winter cold and rainfall, which begin from October to April. Temperature has directly relationship with evaporation and sunshine duration while the relationship is inverse with rainfall and relative Humidity **Hydrogeology Setting**

Karbala city is dependent on irrigation, drinking and agriculture on the rivers and streams of the Euphrates River, in addition to rainwater, which is an important factor in agriculture. The most famous of these rivers is the Husseiniya, the main source of water in Karbala [10].

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

Generally ground water flows direction is from west to east and southeast. The aquifer is recharged from the elevated desert plain in the west, in addition to rainfall infiltration. As shown in figure 4. The discharge area is represented by an aligned springs located east of the study area and the Razzaza lake in addition to the Euphrates River and other depressions and valleys that spread in the region.

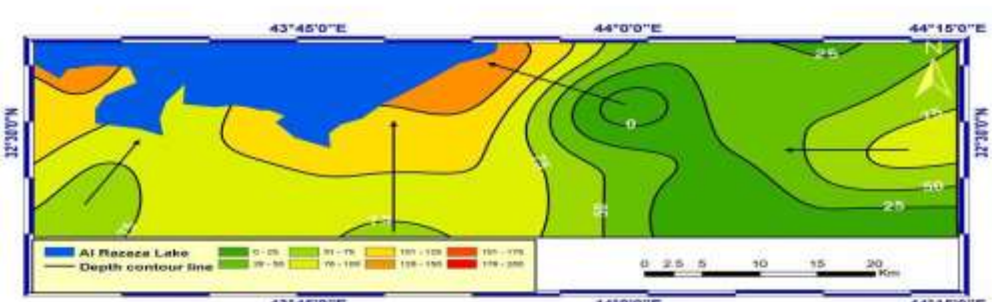


Figure4: Groundwater flow direction map of the study area

Materials and methods

From Karbala meteorological station the climatic data of the study area was determined for the period (1976-2016) with calculation the mean monthly climatic parameters. Values of potential Evapotranspiration were determined by utilizing (Thornthwiate1948 equation, [11]. method was applied to calculation water balance in the study area [12].Type of climate in the study area was determined by applying five climate classification (Thornthwiate1948, Lerner 1990, Al-Kubaisi2004, Mather1974,Kettaneh and Gangopadhyaya,1974).Climate elements used to calculate the water balance of the study area are temperature, precipitation, evaporation, relative humidity, wind speed and sunshine, which taken from the Karbala meteorological station for the period from 1976 to 2016 with monthly averages as shown in (Table1)The Thorenthwait method was used to estimate the value potential Evapotranspiration (PE), which depends on the air temperature (ºC), and then calculate the value of water surplus and water deficit in the study area by depending on this value. X

Water Deficit (WD) & Water Surplus (WS):

1-Water Surplus can be defined according to [11] as: It represented the excess of rainfall that exceeds the corrected potential Evapotranspiration values during specific months of the year, or has been defined as the part of the precipitation which does not evaporate and therefore contributes to the water resources (surface and groundwater flow). Water surplus either infiltrates to recharge aquifers or runs off into rivers.

According to [12] the actual Evapotranspiration PEx could be derived as:

-When water surplus period values of rainfall is greater than PEc, the PEx is equal the value PEc .

PEx = PEc when $P \geq PEc$.

WS = P – PEc (P > PEx)………………………..(6)

Where:

WS = Water Surplus (mm)

P = Rainfall (mm)

PEc = Corrected potential Evapotranspiration (mm).

PEx =Actual potential Evapotranspiration (mm).

Surplus water it confined between (February-December) months, and the value of evaporation -transpiration is equal to the value of real evapo -transpiration potential.

2-Water deficit

When amount of corrected potential Evapotranspiration values exceeding the amount of rainfall during the remaining months of that year during specific months of the year is called as Water deficit.

According to [10] the actual Evapotranspiration PEx could be derived as:

-When water deficit period PEc is greater than rainfall; the PEx is equal to rainfall values.

PEx = P when $P < PEc$

WD = PEc – P (P < PEc) ………………(7)

Where:
WD = Water deficit(mm).
In the period of water deficit occurs from (March to November), rainfall values are less than values of correct Evapotranspiration; therefore rainfall values are equal actual Evapotranspiration values. The values of monthly averages PEX, WD and WS are illustrated in (Tab.3).

Table (3): Calculated monthly averages of water surplus and water deficit

Months	P mm	PET =PEc mm	WS (P-PET)	WD (PET-P)
Jan	16.3	3.19	13.11	0
Feb	14	8.36	5.64	0
Mar	17.7	21.41	0	3.71
Apr	10.7	53.65	0	42.95
May	3.6	97.25	0	93.65
Jun	0.1	175.33	0	175.23
Jul	0	224.71	0	224.71
Aug	0	204.39	0	204.39
Sep	0.3	138.59	0	138.29
Oct	4	59.96	0	55.96
Nov	13.5	16.55	0	3.05
Dec	15.3	5.94	9.36	0
∑	95.5	1009.33	28.11	941.9

Total value of annual water surplus equal (28.11mm) from total value of the rainfall, it's confined between (December-February) due to rainfall is more than corrected Evapotranspiration (PEc).

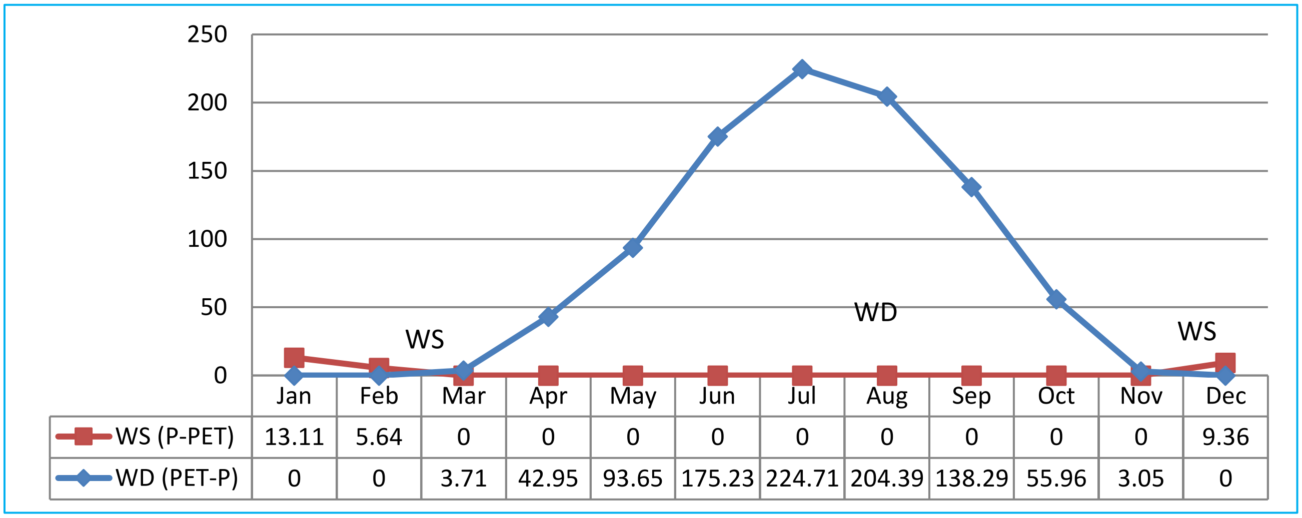


Figure 5: Graph show water surplus and water deficit for study area during months for period (1976-2016) in Karbala City.

Classification of the climate

Climate is classified according to the different targets, which are, the variation of the climatic elements on which they depend, and the difficulty to gather them in one classification [13]. There are a lot of methods use to determining the type of the prevailing climate depending on number of coefficients such as moisture, aridity and humidity factors [14],[15],[16]. To identify the type of climate, in the study area there are three classifications had been used:

1- Kettaneh and Gangopadhyaya (1974) Classification

This classification is depending on Humidity Index (HI) to determine the climate type, which represents the ratio between the rainfalls (P) to correct potential Evapotranspiration (PEc), as shown in the (Table 5).

HI = P / PEc …..(8)

HI: Humidity Index.

P: rainfall (mm).

PEc: Corrected Potential Evapotranspiration (mm).

Table (4): Climatic classification, based on Kettaneh and Gangopadhyaya (1974).

Humidity Index	Climate type
H.I > 1	Humid
H.I < 1 < 2H.I	Moist
2 H.I < 1 < 10H.I	Moderate to dry
10 H.I < 1	Very dry

Depending on the climatic information which were taken from Karbala Meteorological Station for the period (1976-2016) and applying the equation of classification the kind of dominated climate during the months of the year of the study area and from observing table (4), the results will be as shown in the table (5).

Table (5): Climatic classification in the study area for the period (1976-2016) based on Kettaneh and Gangopadhyaya (1974).

Months	P(mm)	PEc(mm)	H.I	Kettaneh and Gangopadhyaya (1974)
Jan	16.3	3.19	5.109	Humid
Feb	14	8.36	1.674	Humid
Mar	17.7	21.41	0.826	Moist
Apr	10.7	53.65	0.199	Moderate to Dry
May	3.6	97.25	0.037	Dry
Jun	0.1	175.33	0.001	Dry
Jul	0	224.71	0.000	Dry
Aug	0	204.39	0.000	Dry
Sep	0.3	138.59	0.002	Dry
Oct	4	59.96	0.066	Dry
Nov	13.5	16.55	0.815	Moist
Dec	15.3	5.94	2.575	Humid

2-Mather (1974) classification

Mather, suggested a classification depending on Aridity index (AI), which represents the ratio between rainfall and Evapotranspiration, as in the following equation (2-7).and the results are shown in table (2-5).

The Aridity index is given as:

$AI = \{(P/PE) - 1\} * 100$…………...(9)

Where:

AI = Aridity Index

P = rainfall mm

PEc = Evapotranspiration mm

Table (6): Climate classification according to (Mather, 1974).

Climate type	Range of AI	AI on Studied area
Dry-sub humid	0.0 to -33.3	-91.93
Semi-Arid	-33.3 to -66.6	
Arid	-66.6 to 100	

3- Al- Kubaisi, (2004) Classification

have suggested other application to determine the climate type, according to the amount of rainfall P and temperature T, by using the following equations:

AI.1 = [1 * P/11.525 * t]   (t not equal zero)……..(10)

AI.2 = $\sqrt{p}/t$……………………………………………………(11)

Where:

AI= aridity index .

P= average annual rainfall (mm) .

t= average temperature (°C) .

AI.1 is used to define the zone of climate.

AI.2 is used to evaluate the sub-zone.

The option AI.1 is used to define the zone of climate ,while AI.2 is used to evaluate the sub-zone .depending on the average annual rainfall and average temperature ,the aridity index :

$$AI.1 = \frac{1*95.5}{11.525*290.39} = 0.029\ ,\quad AI.2 = \frac{2}{290.39} = 0.007$$

- According to this classification the values of (AI-1) and (AI-2) indicates that the type one of climate is Sub-arid to arid and arid in type two,The classification values of AI.1and AI.2 show in (Table 7)

Table (7): Classification of the climate according to (Al-Kubaisi,2004)in Karbala City for period (1976-2016).

Type.1	Evaluation	Type.2	Evaluation
AI.1 > 1.0	Humid to moist	AI.>4.5	**Humid**
		2.5<AI.2<4.5	**Humid to moist**
		1.85<AI.2<2.5	**Moist**
		1.5<AI.2<1.85	**Moist to sub arid**
		AI.<1.5	**sub arid**
AI.1 < 1.0	Sub arid To Arid	AI.2 > 1.0	**Sub arid**
		AI.2 < 1.0	**Arid**

Conclusions

- By conducting analyzes and calculating the annual averages of the climatic parameters it is shown that the total annual rainfall is (95.5 mm), evaporation is (2828.6mm), relative humidity is (46.756%), sunshine (8.61 h/day), temperature (24.19C◦) and wind speed (2.76m/sec).
- There is water surplus in study area of (9.36mm), (13.11mm), (5.64mm) in December, January and February respectively, that type of climate in the study area is arid. The water surplus (WS) was calculated equal to 28.11mm, equal to 29.43% from total annual rainfall.
- Through comparison between of the annual rainfall rate for each year from 1976 to 2016 with total annual rainfall (95.5mm), this means that the climate of the region tends to drought.
- Climate of study area is concept as an arid according to(Al-Kubaisi,2004,Ketanah and Gangopadhyaya,1974, Mather, 1974) climatic classification.
- The direction of the groundwater movement is from the recharge area (west) to the discharge area (east and southeast). The aquifer is recharged from the elevated desert plain in the west, in addition to rainfall infiltration.

References

1. **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.
2. **Al-Shamari , M. M,(2014)** Groundwater Evaluation for Dammam Formation in South Razzaza Lake ,M.Sc. thesis, collage of Scince, University of Baghdad ,Iraq, 138 p.
3. **Wilson, E.M.,** (**1971**) Engineering hydrology, McGraw-Hill Press. Ltd. P. 182.
4. **Al-Khateeb, A. A.,** (**1988**) Geomorphology of Karbala hill, M.Sc. thesis, collage of science, University of Baghdad, Iraq, (In Arabic), P. 120.
5. **Shaw, E.M.,(1999)***Hydrology in practice 3rd. Ed.* Stanley Thornes Publ. U.K.569 p.
6. **Viessman, W.J. and Lewis, G.L., (2007)** Introduction to Hydrology, 5th ed., Person Education, Inc. and Dorling Kindcrsly, Inc. India, 612p.
7. **Al-Ghanimy, M. A., (2013)** The hydrogeology of Dammam aquifer in the west and southwest of Karbala city, M.Sc. thesis, Collage of Science, University of Baghdad, Iraq, 139p.
8. **Suresh. R., (2008)** water shed hydrology. 2nd ed. Standard publication distributors. Delhi . 114-174p.
9. **Ponce, V.M. ,(1995)** Engineering Hydrology, Practices and Principles.1st ed.,Prentice-Hall, P.545.
10. **Jassim S.Z., (1987)** The regional Geology of Iraq. Vol. 2, Tectonism, Magmatism and Metamorphism, 352p.
11. **Thornthwait, C.W. (1948)** An Approach toward a Relation Classification of Climate, Geographical Review, Vol.32, P.55.
12. **Lerner, N.D., Issar A.S. and Simmers, I. ,(1990**) *Groundwater recharge-a Guide to understanding and estimating natural recharge*, Vol.8, association of hydrologist, Hanover, ISBN, 3-922705-91P. 570.
13. **Brown, L. H. and Cocheme, J., (1973)** A study at the agromeleorblogy of the High Land of eastern Africa. WHO. Geneva, Tech. Note, No. 125, 197p
14. **Kettaneh, M.S., and Gangopadhyaya, M.**,(**1974**) *Climatologic water budget and water availability periods of Iraq*, IARNR, Baghdad. Tech. No. 65, P. 19.

15. **Mather, J. R., (1974**) *Climatology Fundamentals and Applications*, McGraw-Hill Book Co., New York. P. 412.
16. **Al-Kubaisi, Q.Y.,(2004**) Annual aridity index of type.1 and type.2 mode options climate classification, *Science Journal*, Vol.45c, No.1, P. 32-40.

الخلاصة

تضمنت هذه الدراسة تحديد الظروف المناخية وطبيعة الخزانات في المنطقة مع تحديد اتجاه الجريان للخزان الجوفي . بيانات الارصاد الجوية لمحطة كربلاء للفترة من (2016-1976) تبين ان قيم المعدلات الشهرية لدرجة الحرارة والامطار والتبخر والرطوبة النسبية وسرعة الرياح ومدة السطوع الشمسي هي ,(2.76 m/sec), (46.75%), (2828.6mm), (95.5 mm), (24.19 C◦)و 8.61h) (على التوالي .تم حساب قيم التبخر -نتح الكامن (PE) بحسب طريقة ثورنثويت ثم تحديد قيمة الزيادة المائية السنوية (WS) وهي ,(28.11mm)والنقصان المائي السنوي (WD) وهي (941.94mm) سجل المعدل الشهري للزيادة المائية في منطقة الدراسة في الفترة(1976 -2016)بحوالي (9.36 mm) و (13.11mm) و (5.64mm) في الاشهر كانون الاول وكانون الثاني وشباط على التوالي والتي تساوي (29.34) من المجموع الكلي للامطار. وان خارطة شبكة الجريان تبين وبشكل رئيسي ان اتجاه جريان المياه الجوفية هي من الاجزاء الشمالية الغربية باتجاه الاجزاء الشرقيه والجنوبيه الشرقيه .

الكلمات الدالة: الظروف المناخية ,تصنيف المناخ, الموازنة المائية, الزيادة المائية , منطقة كربلاء.