DOI: 10.24996/ijs.2017.58.3A.8

Iraqi Journal of Science

ISSN: 0067-2904

Climatic Analysis and Climatic Water Balance Determination for Al-Yusufiyah Area, Southern Baghdad, Iraq

Moutaz A. Al-Dabbas, Saad M. Abdul Razzaq*

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

Abstract

The Climatic parameters for the years (1985-2015) were collected from Baghdad meteorological station and then were applied to evaluate the climatic conditions for the Al-Yusufyiah area south Baghdad. The total annual rainfall is (119.65 mm), while the total annual evaporation is (3201.7 mm), relative humidity is (43.62%), sunshine (8.76 h/day), temperature (23.28 C◦) and wind speed (3.06 m/sec). Climate of the study area is described as an arid according to classification of (Kettaneh and Gangopadhyaya, 1974), (Mather, 1973), and (Al-Kubaisi, 2004). Mean monthly water surplus for the period (1985-2015) was recorded in the study area about (4.7 mm) in November, (11.67 mm) in December, (20.56 mm) in January and (6.51mm) in February of the whole amount of Rainfall and equivalent to (119.65 mm).

Keywords: Potential evapotranspiration, Classification of climate, Water balance, water surplus, Water Deficit.

التحليل المناخي وتعيين الموازنة المائية المناخية لمنطقة اليوسفية – جنوب بغداد – العراق

معتز عبد الستار الدباس، سعد محمد عبد الرزاق*

قسم علم الأرض، كلية العلوم، جامعة بغداد، بغداد، العراق.

الخلاصة

دائرة الانواء الجوية في بغداد سجلت بيانات مناخية للسنوات (1985–2015) وتم اجراء التحاليل اللازمة عليها لتقييم الظروف المناخية لمنطقة اليوسفية جنوب بغداد. تبين من خلال التحاليل ان المجموع السنوي للساقط المطري هو (119.65ملم) بينما المجموع السنوي للتبخر فهو (3201.7ملم) وللرطوبة النسبية هو (43.62%) والشروق الشمسي هو (8.76 ساعة / يوم) ودرجة الحرارة (23.28 م°) وسرعة الرياح (3.06م/ثا). مناخ منطقة الدراسة يوصف بانه جاف او جاف بصورة شديدة حسب تصنيف كل من (كيتانا وكانكوبادیایا، 1974) و(ماذر، 1973) و(الكبيسي، 2004). سجل المعدل الشهري للزيادة المائية في منطقة الدراسة في الفترة (1985–2015) بحوالي (4.7ملم) و(11.67ملم) و(20.56ملم) و(6.51ملم) في الاشهر تشرين الثاني وكانون الاول وكانون الثاني وشباط على التوالي والتي تكافئ معدل الساقط المطري (119.65ملم).

*Email :saadgeo93@gmail.com

Introduction

Al-Yusufiyah area (32 km south of Baghdad), is located between the longitude (44° 25'-44° 20') E and latitude (33° 15' -33° 5') N (Fig.1). The Yusufiyah area located on the east side of Euphrates River and the Yusufiyah canal is a branch of the river. Climate change is one of the most important environmental issues to be studied and evaluated because of its significant impact in several sectors such as water, agriculture, marine resources and others. Climate change may cause droughts intensity, increase flood risk, increase soil salinity, decrease groundwater level, etc. Lack of water security and water scarcity affect large parts of the developing world. The past century has seen a sixfold increase in world water demand. Nearly three billion people (about 40% of the world's population) live in areas where demand for available water supplies is increasing [1]. Climate is an important environmental component because it plays a major role in influencing other environmental components such as water quality, weathering and erosion activities, transportation, sedimentation, and the relationship between geochemical variables and then living organisms [2]. The climate is an important factor affecting the quality of ground water and change of their levels. The increase in the amount of rainfall leads to the filtration of water within the soil layers and thus the increase in groundwater levels, as well as the reduction of concentrations of some chemical elements in water, while increased summer temperatures lead to water evaporation and soil dryness, thereby reducing groundwater levels and increasing salts [3]. The aim of the study is to determine climatic water balance by analyzing the climatic parameters of Baghdad Meteorological Station for period (1985-2015):

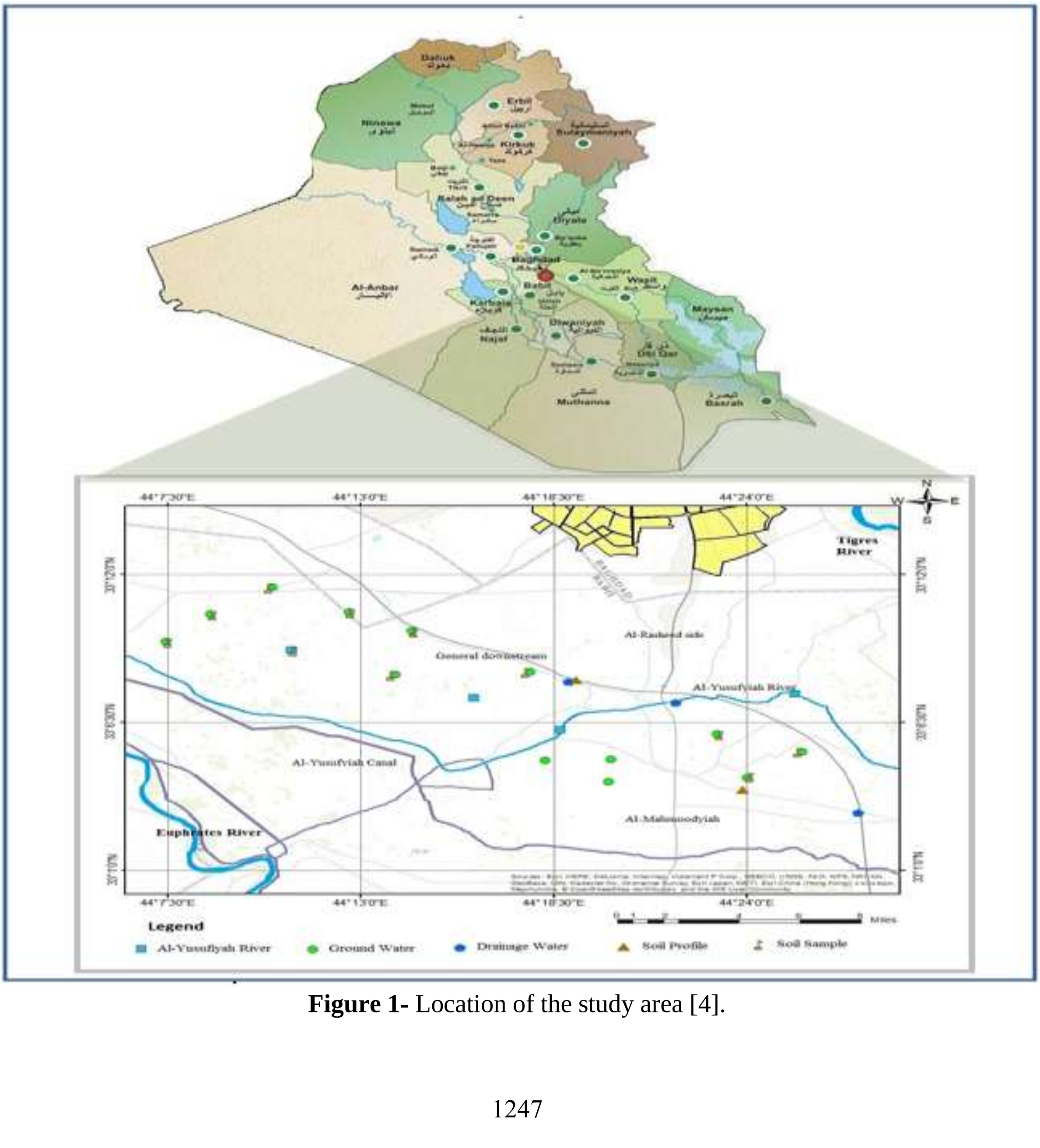

Figure 1- Location of the study area [4].

Materials and Methods

From Baghdad meteorological station the climatic data of the study area was determined for the period (1985-2015) with calculation the mean monthly climatic parameters. Values of potential evapotranspiration were determined by utilizing Thornthwiat equation. Lerner method was applied to computation water balance in the study area. Type of climate in the study area was determined by applying three climate classifications.

Results and Discussion

The available data on the climatic conditions of Baghdad are: Rainfall, relative humidity, temperature, wind speed, sunshine and evaporation are as follows:

1. Rainfall

Rainfall is one of the most important climatic elements in hydrological studies, determines its abundance or decrease according to other elements and is the main source of flow or drought of rivers and the growth or lack of agriculture in some areas [3]. The maximum and minimum mean monthly rainfall are (24.5 mm) and (0.1mm) in January and September respectively (Table-1). The total annual rainfall was (119.65 mm) for the period (1985-2015).

2. Relative Humidity

Relative humidity is defined as the ratio between the amount of water vapor in the air and the amount of water vapor when the air is saturated at the same Temperature level. Relative humidity controls the rate of evaporation from water surfaces, soil and transpiration of plant leaves, where the greater the relative humidity, the less evaporation and transpiration [3]. The maximum and minimum mean monthly relative humidity are (69.85%) and (24.14%) in January and July respectively (Table-1), and the mean annual is (43.62%).

3. Temperature

Temperature is an important factor in governing the evaporation and evapotranspiration, where increased temperature will heat the air. There is an important relationship between plant growth and temperature, where plants adapt to certain temperature limits through which the can perform its activities [5]. In the study area the maximum and minimum mean monthly temperature are (35.5C◦) and (9.8C◦) in July and January respectively (Table-1), while the mean annual of temperature is (23.28C◦).

4. Wind Speed

Prevailing winds generally in the study area are blows from the northwest to the south-east and are sometimes accompanied by dust storms, especially in the summer when the wind blows from the south and southwest [6]. The mean monthly wind speed in the study area is ranged between (4.0 m/sec-2.5 m/sec). The maximum mean monthly of wind speed was recorded in July while the minimum mean monthly was recorded in months November, December and January (Table-1). The mean annual wind speed is (3.06 m/sec).

5. Sunshine

Sunshine is an important component of climatic elements as it influences relative humidity, evapotranspiration and temperature. The number of hour's brightness considered functions as solar influence on the temperature and relative humidity and then it is effects on the real evapotranspiration [7]. The maximum mean monthly sunshine in study area is (11.65 h/day) in June and minimum mean monthly is (6.02 h/day) in December (Table-1), whereas the mean annual sunshine is (8.76 h/day).

6. Evaporation

Evaporation is influenced by several factors such as: Sunshine, air temperature, evaporation surface, saturation deficit, wind speed, atmospheric pressure, and surface evaporation nature [6]. Evaporation affects groundwater chemistry as extreme evaporation leads to deposition of minerals such as gypsum, calcite, and chloride salts in soils. The water then penetrates through these soils, thus enriching the water with these elements. The maximum mean monthly evaporation is (522.9 mm) in July but the minimum mean monthly is (67.8 mm) in January (Table-1), while the total annual evaporation is (3201.7 mm).

Different relationships are occurring between climatic variables. Temperature, wind speed and evaporation are inversely proportional with relative humidity and directly proportional with the rainfall (Figure-2), (Table-1).

Table 1- Values of mean monthly of climatic parameters in Baghdad station for period (1985-2015) in Al-Ysufiyah area.

Months	Rainfall (mm)	Relative Humidity %))	Temperatures (C°)	Wind speed (m/sec)	Sunshine (h/day)	Evaporation (mm)
Oct.	7.2	41.82	24.9	2.7	8.08	229.3
Nov.	21.67	58.35	16.5	2.5	7.00	110.8
Dec.	17.52	68.25	11.5	2.5	6.02	75.6
Jan.	24.5	69.85	9.8	2.5	6.10	67.8
Feb.	14.66	58.57	12.6	2.9	7.21	100.5
Mar.	16.48	49.03	17.0	3.2	7.78	178.6
Apr.	14.36	40.5	23.3	3.2	8.63	256.2
May	3.16	30.96	29.3	3.2	9.81	362.1
June	0.000	24.64	33.1	3.9	11.65	475.7
July	0.000	24.14	35.5	4.0	11.57	522.9
Aug.	0.000	26.10	35.0	3.4	11.36	470.2
Sep.	0.1	31.28	30.9	2.8	10.01	352.0
Average		43.62	23.28	3.06	8.76	
Total	119.65	523.49	279.4	36.8	105.22	3201.7

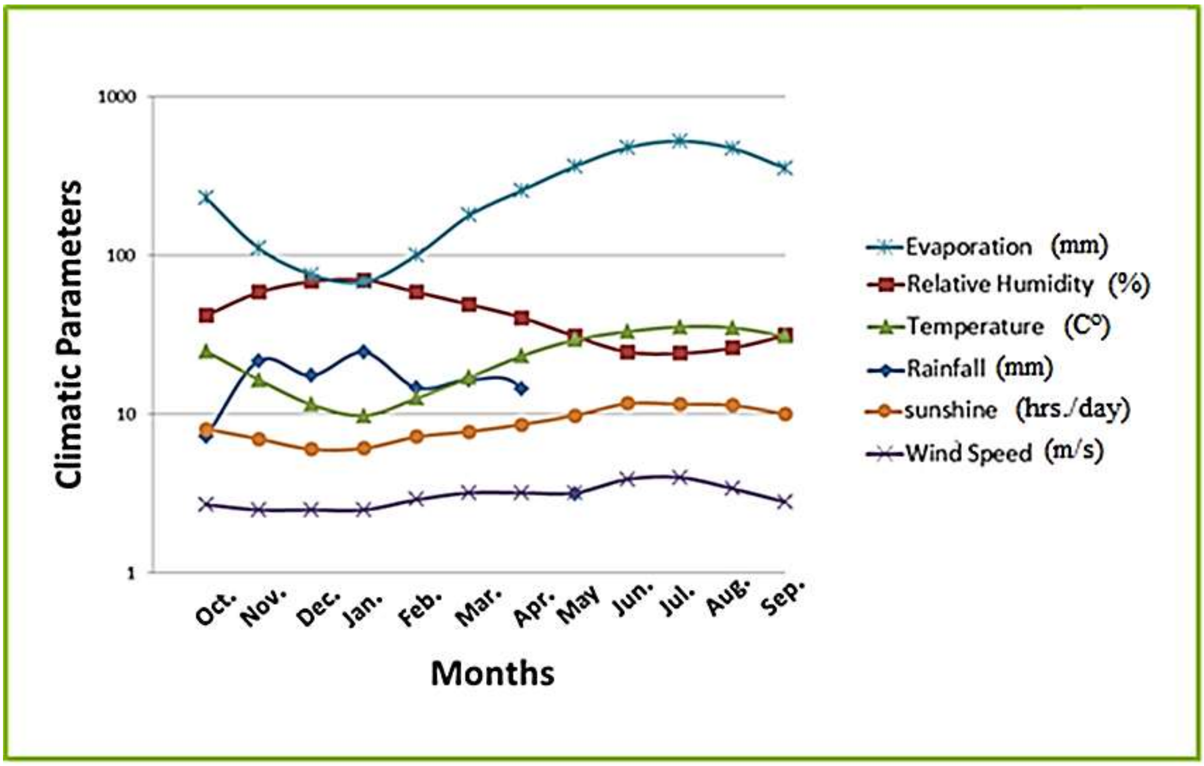

Figure 2- Graph show relationships between the climatic parameters during months for period (1985-2015) in Al-Ysufiyah area.

Evapotranspiration

Potential Evapotranspiration is a collection concept for both transpiration and evaporation and mean the aggregate lack of water from soil plants by transpiration and evaporation. Evapotranspiration was computed by Thornthwiate through making a number of experiments on different types of climate based on temperature only. Evapotranspiration is computed for each month in the year [5].

$PE = 16\ [10t\ /\ J]^{a}$ ………….... 1

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

$j =\ [tn\ /\ 5]^{1.514}$ ………….... 3

$a\ =\ 0.016\,J + 0.5$ ………….... 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.
Then:
a = 0.016*130.67 + 0.5 = 2.59
Number of days during months and sunshine hours are affect potential evapotranspiration values, Table-2.

Table 2- Calculation of Actual and Corrected Potential Evapotranspiration (PEx-PEc) in Al-Yusufiyah area for period (1985-2015) by Thornthwiate (1948).

Months	t (C°)	$j=(tn/5)^{1.514}$	DT/360	PEx (mm)	PEc (mm)	Epan (mm)
Oct.	24.9	11.36	0.69	84.99	58.64	229.3
Nov.	16.5	6.09	0.58	29.27	16.97	110.8
Dec.	11.5	3.52	0.51	11.49	5.85	75.6
Jan.	9.8	2.76	0.52	7.59	3.94	67.8
Feb.	12.6	4.05	0.56	14.56	8.15	100.5
Mar.	17.0	6.37	0.66	31.62	20.86	178.6
Apr.	23.3	10.27	0.71	71.56	50.80	256.2
May	29.3	14.54	0.84	129.54	108.81	362.1
Jun.	33.1	17.48	0.97	177.65	172.32	475.7
Jul.	35.5	19.44	0.99	212.96	210.83	522.9
Aug.	35.0	19.03	0.97	205.28	199.12	470.2
Sep.	30.9	15.76	0.83	148.66	123.38	352.0
Total	279.4	J= 130.67	DT/360	1125.17	979.67	3201.7

The correlation graph of each of Evaporation, PEx, PEc is shown in (Figure-3).

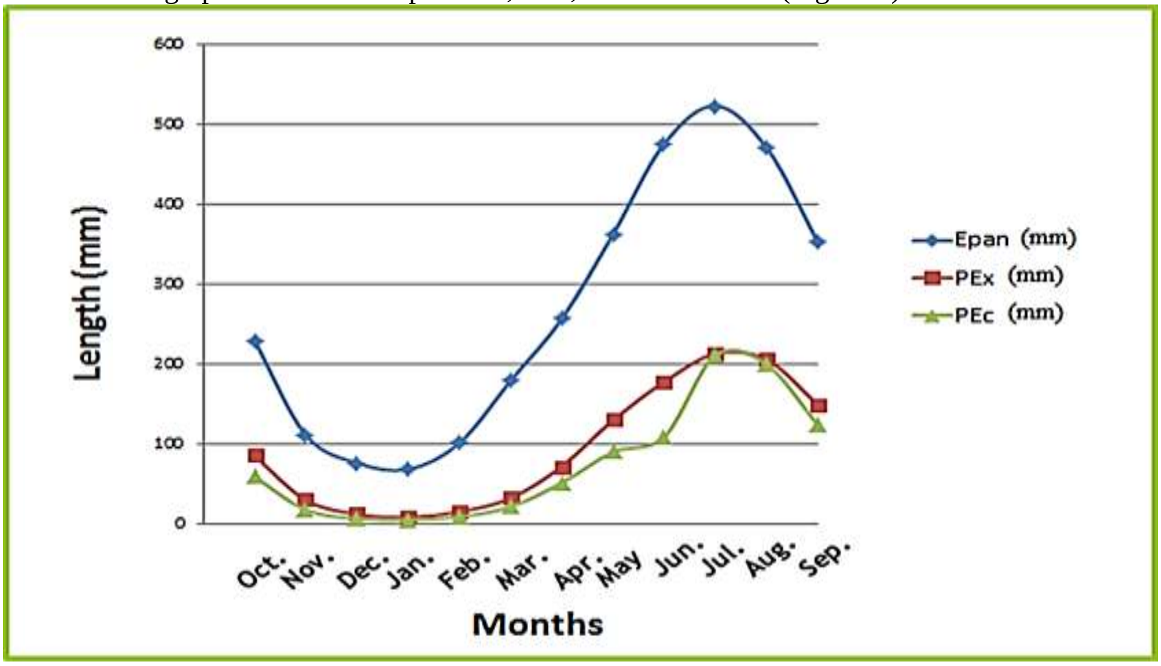

Figure 3- Graph show evaporation, PEx and PEc correlation during months for period (1985-2015) in Al-Ysufiyah area.

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

The water surplus is mean increasing the values of rainfall up the values of corrected evapotransipiration through given months in the year (WS = P > PEc), whilst the Water Deficit is the decreasing of rainfall values related to the values of corrected evapotransipiration through the residual months in the same year (WS = P < PEc). Actual Potential Evapotranspiration (PEx) can be derived as following [8]:

$WS = P - PEc$ ……..... 6

$PEc = PEx, \text{when } P > PEc$

$WD = PEc - P$ ……..... 7

$P = PEx, \text{when } P < PEc$

In the period of water surplus, rainfall values are more than the corrected evapotranspiration, thus the corrected evapotranspiration values are equal the values of actual evapotranspiration. Water surplus is mean recharge of groundwater plus surface runoff after saturation of the soil. Moisture of the soil was depleted either through plant or evaporation from soil [9]. Thus it was taken in account missing portion of water which is potential evapotranspiration [10]. In the period of water deficit, 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 (Table-3).

Table 3- Calculation of water deficit and Water surplus in Al-Yusufiyah area for period (1985-2015) by (Lerner, et. al., 1990).

Month	P (mm)	PEc(mm)	APE(mm)	WS(mm)	WD(mm)
Oct.	7.2	58.64	7.2	0	51.44
Nov.	21.67	16.97	16.97	4.7	0
Dec.	17.52	5.85	5.85	11.67	0
Jan.	24.5	3.94	3.94	20.56	0
Feb.	14.66	8.15	8.15	6.51	0
Mar.	16.48	20.86	16.48	0	4.38
Apr.	14.36	50.80	14.36	0	36.44
May	3.16	108.81	3.16	0	105.65
Jun.	0.000	172.32	0.000	0	172.32
Jul.	0.000	210.83	0.000	0	210.83
Aug.	0.000	199.12	0.000	0	199.12
Sep.	0.1	123.38	0.1	0	123.28
Total	119.65	979.67	76.21	43.44	903.46

Where:
WS: Water surplus (mm).
WD: Water deficit (mm).
PEx: Actual Evapotranspiration (mm).

Total value of annual water surplus equal (43.44 mm) from total value of the rainfall, it's confined between (February - November) due to rainfall is more than corrected evapotranspiration (PEc). Annual rainfall and (WS) value used to calculate the ratio of water surplus as the equations:

$$WS\,\% = WS/P \times 100 \qquad \ldots\ldots\ldots.8$$

$$WS\% = 43.44 / 119.65 \times 100 = 36.3\%$$

$$WD\% = 100 - WS\% \qquad \ldots\ldots\ldots 9$$

$$WD\% = 100 - 36.3\,\% = 63.7\,\%$$

Figure 4- Graph show water surplus and water deficit for study area during months for period (1985-2015) in Al-Ysufiyah area.

CLASSIFICATION OF THE CLIMATE

Various techniques (methods) are used for classification of climate including the difference elements of climate, and it is difficult to collect them in one classification of (Kettaneh and

Gangopadhyaya, 1974). Three classifications will be used to determine the type of climate in Al-Yusufiyah as following:

Classification was proposed by (Kettaneh and Gangopadhyaya, 1974) based on humidity index (H.I) which indicate the ratio of rainfalls to corrected potential evapotranspiration, as illustrated in Tables- 4 and 5.

$H.I. = P/PEc$ ………. 10

Where:
H.I: Humidity index.
P: rainfall (mm).
PEc: Corrected potential evapotranspiration (mm).

Table 4- Classification of (Ketanah and Gangopadhyaya, 1974) [11].

Climatic Zone	**Range HI**
Humid	HI ≥ 1
Moist	2HI > 1 > HI
Moderate to Dry	10 HI > 1 > 2HI
Dry	10 HI ≥ 1

Table 5- Calculation of Humidity index (H.I) According to classification of (Kettaneh and Gangopadhyaya, 1974) in Al-Yusufiyah area for period (1985-2015).

Months	**P (mm)**	**PEc (mm)**	**H.I**	**Kettaneh and Gangopadhyaya,1974**
Oct.	7.2	58.53	0.123	Moderate to Dry
Nov.	21.67	16.94	1.279	Humid
Des.	17.52	5.84	3.0	Humid
Jan.	24.5	3.94	6.218	Humid
Feb.	14.66	8.13	1.803	Humid
Mar.	16.48	20.83	0.791	Moist
Apr.	14.36	50.71	0.283	Moderate to Dry
May	3.16	89.41	0.035	Very Dry
Jun.	0.000	108.62	0	Very Dry
July.	0.000	210.45	0	Very Dry
Aug.	0.000	198.77	0	Very Dry
Sep.	0.1	123.17	0.0008	Very Dry

The second classification is for (Mather, 1974) were the climate type is based on the value of climate index to find three classes which related to the rainfall and evapotranspiration as in the following equation:

$CI = [(P/PE) - 1] * 100$ ……… 11

Where:
CI = Climate index
P = Rainfall

PE = Potential evapotranspiration.

The positive value of the (C.I) is indicating to humid climate while Negative value indicates to dry climate. This classification refer to that the climate type is arid in study area due to the climate index value (C.I) = - 86.63, as exhibited in (Table-6).

Table 6- Classification of the climate in the study area, according to (Mather, 1974) in Al-Yusufiyah area for period (1985-2015) [12].

Claimant Type	Range of C.I	C.I in studied area
Dry-sub humid	0.0 to -33.3	-86.63
Semi-Arid	-33.3 to -66.7	
Arid	-66.7 to -100	

Classification proposed by (Al-Kubaisi, 2004) to define the type of the climate by applying the treatment of annual dryness which based on temperature and quantities of rainfall, as the following equations:

$$AI - 1 = (1.0 \times P) / (11.525 \times t) \ \ (t\ not\ equal\ zero) \quad \ldots\ldots 12$$

$$AI - 2 = \sqrt[2]{P} \ / t \quad \ldots\ldots 13$$

Where:

AI: Aridity index

P: Annual rainfall (mm)

t: Temperature (C°).

Value of (AI-1) considered the classification of prevailed type of climate, whereas (AI-2) value considered the classification after amendment as shown in Table-6.

$$AI - 1 = (1 \times 119.65) / (11.525 \times 23.28) = 0.45$$

$$AI - 2 = \sqrt[2]{119.65} \ \backslash 23.28 = 0.46$$

According to this classification the values of (AI-1) and (AI-2) indicates that the type of climate is arid (Table-7).

Table 7- Classification of the climate according to (Al-Kubaisi, 2004) in Al-Yusufiyah area for period (1985-2015) [13].

Type.1	Evaluation	Type.2	Evaluation
AI-1>1.0	Humid to moist	AI-2>4.5	Humid
		2.5 <AI-2< 4.0	Humid to moist
		1.85<AI-2<2.5	Moist
		1.5<AI-2<1.85	Moist to sub arid
AI-1<1.0	Sub arid to arid	1.0 ≤ AI-2<1.5	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 (119.65 mm), evaporation is (3201.7 mm), relative humidity is (43.62%), sunshine (8.76 h/day), temperature (23.28 C◦) and wind speed (3.06 m/sec).
- There is water surplus in study area of (4.7 mm), (11.67 mm), (20.56 mm), (6.51 mm) in November, December, January and February respectively which is valent with the mean annual rainfall (119.65 mm).
- Climate of study area is depicted as an arid according to climatic classification.

References

1. Al-khateeb, A. A. **1988**. Geomorphology of Najaf hill. M.Sc. Thesis, Collage of Science, University of Baghdad, Iraq, (In Arabic), P. 120.
2. Faure, G. **1998**. *Principles and application of geochemistry*. *2nd Ed*., Prentic Hall, Inc., USA, P. 600.
3. Wilson, E. M. **1971**. *Engineering hydrology*. McGraw-Hill Press. Ltd. P. 182.
4. GEOSURV, **1993**. Geological map of Al-Yusufiyah Quadrangle, sheet N-38-16. Scale 1:250000.
5. Thornthwait, C.W. **1948**. *An Approach toward a Relation Classification of Climate*, Geographical Review, Vol.32, P.55.
6. Shaw, E. M. **1999**; *Hydrology in practice*. 3rd Ed. Stanley Thornes Publ. U.K.569 p.
7. Chow, V. T. **1964**. *Handbook of applied Hydrology*. A compendium of water resources technology McGraw. Hill Book Company, New York, P.1454.
8. 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.
9. Hassan, H. A. **1981**. Hydrogeological conditions of the central art of the Erbil Basin. Ph.D. Thesis, Baghdad University, Iraq, P.180.
10. Hassan, I. O. **1998**. Urban Hydrology of Erbil City Region. Ph.D. Thesis, Baghdad University, Iraq, P. 121.
11. Kettaneh, M.S. and Gangopadhyaya, M. **1974**. *Climatologic water budget and water availability periods of Iraq*, IARNR, Baghdad. Tech. No. 65, P. 19.
12. Mather, J. R.**1974**. *Climatology Fundamentals and Applications*, McGraw-Hill Book Co., New York. P. 412.
13. Al-Kubaisi, Q.Y. **2004**. Annual aridity index of type.1 and type.2 mode options climate classification. *Science Journal*, **45c**(1): 32-40.