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Climatic Water Balance in AL-Amaid Area/ Muthana Governorate/ Southwest Iraq

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Abstract

Ground water is a vital source for agricultural sector and rural communities. The global climate change is expected to change the hydrometeorological processes parameters. The climate considered as part of the southern Iraqi desert general climate with long, extremely hot, and dry summer and short wet period with little rain. So it is vital to investigate the groundwater quality for irrigation purposes. The meteorological data of Samawa meteorological station for the period 1980-2015 was used to evaluate the climatic conditions for Muthana Governorate. It was found that the averages of annual rainfall was 105.7mm and the everages of evaporation is 3182 mm, while the mean monthly relative humidity % , mean temperature, wind speed and sunshine were 40.9 %, 25.3 C^{o}, 5.2m/sec and 9 h/day respectively. The results show that the mean evapotranspiration is 1717 mm, while the correct evapotranspiration is 1520 mm and the climate of the study area is classified as dry. And water deficit equals to (72%) of the total rainfall amount, and water surplus formed (28%) of the total rainfall amount.

Keywords: Water balance, climatic condition, AL-Amaid area, Classification of climate.

ألموازنة ألمائية المناخية في منطقة ألعميد/محافظة المثنى/شرق العراق

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الخلاصة

تعتبر المياه الجوفية مصدرا" حيويا" للقطاع الزراعي و للمجتمعات الريفية بشكل عام في الصحراء الجنوبية من العراق. و من المتوقع أن التغير المناخي العالمي يؤثر على المعاملات الهايدرولوجية. يعتبر مناخ منطقة العميد جزءا" من المناخ ألصحراوي العام لجنوب العراق، حيث يكون الصيف طويل و جاف و حار جدا" و تكون الفترة الرطبة قصيرة مع قلة ألأمطار. تم استخدام بيانات ألأرصاد الجوية للفترة (1980− 2015) و المسجلة في محطة أنواء السماوى في محافظة المثنى جنوب شرق العراق لتقييم الظروف المناخية لمنطقة الدراسة. و كان المعدل السنوي للأمطار(105.7) و التبخر(3182) . و كان معدل المعدل لكل من الرطوبة النسبية (40.9) و متوسط الحرارة (25.3) والرياح (5.2) و مدة السطوع الشمسي (9). كانت قيمة التبخر نتح حقيقي (1717) و التبخر نتح المصحح (1520). تم إختيلر نوعين من التصانيف كل منهما يعكس حالة عن مناخ منطقة الدراسةو قد صنف المناخ إعتمادا" على تحليل البيانات كمناخ قاري جاف، وكان العجز مائي بنسبة (72%) من مجموع ألساقط المطري السنوية، و كانت الزيادة مائية قليلة ونسبتها (28 %) من

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مجموع الساقط الطري السنوي. لوحظ وجود أرتفاع تدريجية في المعدل الحرار السنوي مقداره (0.6 C°) لكل
عشرة سنوات. كذلك وجود نقص في المعدل الساقط المطري السنوي بواقع (3.2 mm) لكل عشر سنوات.

1. Introduction

Ground water is a vital source for all sectors, the irrigation sector and rural communities. It is the main domestic water supply in much rural area. Rainfall is the main sources of ground water recharge. Water resources' planning depends on groundwater supply and information about water use and demand for a better understanding of the hydrogeological conditions [1 and 2].

The population community needs urgently water for live purposes; one of these necessary purposes is irrigation. At the study area, there is no any further source of water except the groundwater. Climate is an important environmental component because it plys 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 [1].

Thus investigation of the climate parameters is recommended due to the effects of the global climate change which is expected to change the hydrometeorological processes. Iraq is located in an arid to semi-arid area where the dominant continental climate is typically cold in winter and hot in summer and characterized by limited rainfall, a high evaporation rate and water scarcity. The annual rainfall in Iraq ranging from 800 to 1200 mm in the north and going down reaching 50 to 100 mm in the south. Study area is AL-Amaid area is located in Muthana Governorate, southwest Iraq, between latitudes (30^{o} 10^{-} - 22^{o} 00^{-}) N and longitudes (44^{o} 45^{-} - 45^{o} 45^{-})E, (Figure-1).

The increase in the amount of rainfall leads to the filtration of water within the soil layers and thus the increase in groundwater levels, this lead to 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 [2].

The study area is characterized by simple valleys; these valleys often end up with Fayadat such as (AL-Selhubia, AL-Soffia, AL-Remetha, etc) [3].

The intensive farming such as wheat and barley are distributed through AL-Amaid basin,which depends mainly on rainfall and groundwater.

The aim of this study is to evaluate the climate by study and analyzing the climate parameters for the AL-Samawa meteorological station for the period (1980-2017), as well as fending the water surplus and water deficit.

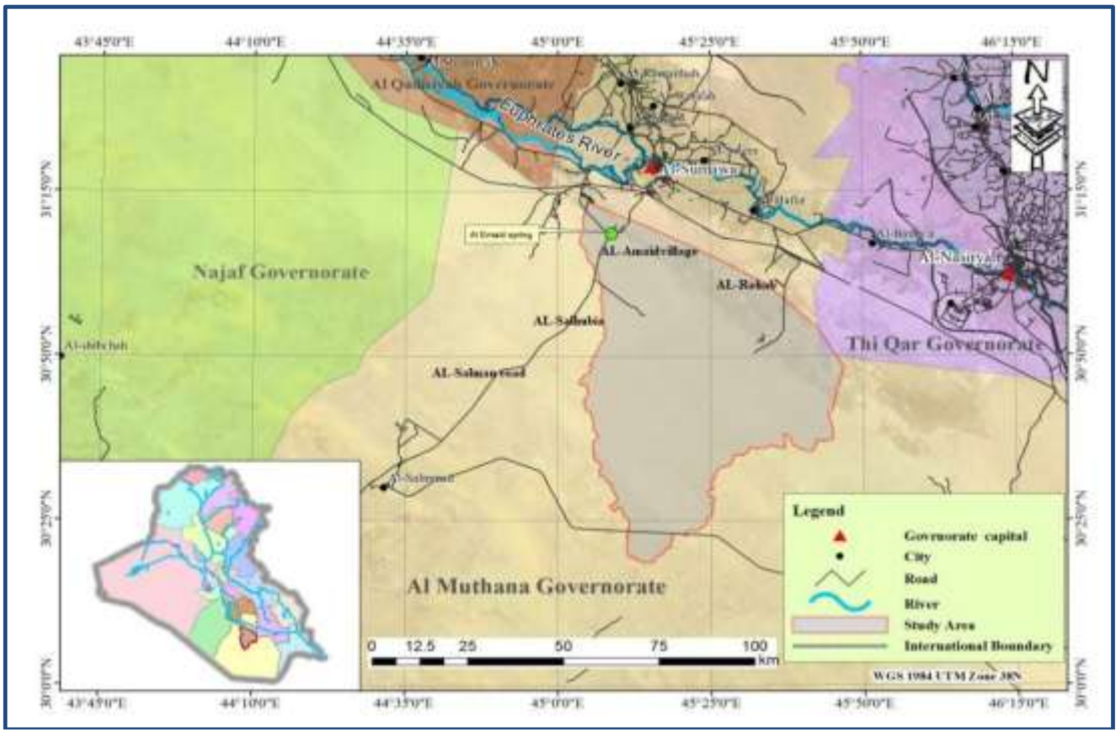

Figure 1-Location landsat image of the studied area.

2. Methodology

To determine the climatic elements that were adopted upon the information recorded in (Samawa meteorological station [5] for the period (1980-2017), and calculated the monthly mean values of climatic parameters, Table-1 and Figure-5. An equation was used to calculated the values of the potential evapotranspiration (PE) and evapotranspiration correct (EPc) according to latitude for each month (Thornthwait, 1948) [6]. The climate was classified according to the methods of (Ketanah and Gangopadhyaya, 1974) [7], (Mather, 948) [8], and (Al-Kubaisi, 2004) [9]. The water surplus and water deficit were calculated from (PE and PEc) which calculated by (Thornthwait, 1948) method [6].

3. Climatic elements

The monthly averages values of the climate elements shown in the Table-1. The rainfall and the Relative humidity are represented as water surplus elements, while temperature, sun shine, wind speed, and evaporation are represented as water losses elements [4].

Table 1- The mean monthly values of the climate elements for the period (1980- 2015), in Samawa metrological station [5].

Months	Rainfall (mm)	Relative Humidity (%)	Temp. (°C)	Wind speed (m/s)	Sunshine (hrs.)	E A pan (mm)
Oct.	5.4	37.3	27	2.7	8.6	247.7
Nov.	19.2	53.6	19	2.4	7.4	131.3
Dec.	14.3	62.4	15	2.5	6.4	85.1
Jan.	21.7	67.1	12	27	6.8	86.7
Feb.	15.3	58.6	15	3.2	7.5	114.9
Mar.	15.2	48.2	19	3.5	7.9	192
Apr.	9.4	37.7	25	3.6	8.5	261.5
May	6.5	30	31	3.6	9.3	360.2
Jun.	0.0	23	35	3.9	11.8	445.8
Jul.	0.0	21.7	36	3.8	11.9	482.6
Aug.	0.0	24	36	3.3	11.6	450.2
Sep.	0.2	27.2	33	3	10.2	343.9
Total	105.7					3182.0
Mean		40.9	25.3	5.2	9	

3.1. Rainfall (P)

In rainyl months the maximum & minimum mean monthly rainfall were 21.7mm in January and 5.4mm in October. The mean annual rainfall was 93.5mm, as it shows in Table-1.

According to this annual average rainfall, the years (1980-2016) are classified into two periods; wet periods (above the average line), which are (1991-2000) & (2011-2014), and dry periods (under the average line), which are (1980-1990), (2001-2010), & (2014- 2017) with the exception for the years 2006 Figure-2. There is a decrease in the average annual rainfall rate of 3.2 mm per 10 years

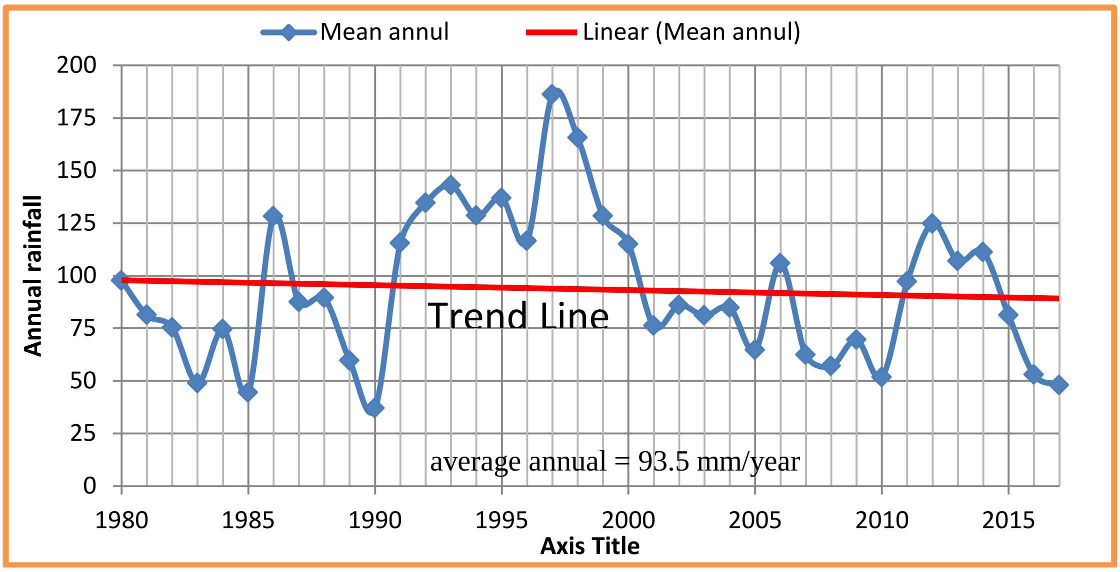

Figure 2-Annul average rainfall in study area.

3.2 Relative humidity (%)

The maximum and minimum mean Relative humidity (%) is (67.1) and (23) in January and June respectively. The mean annual Relative humidity (40.9%) Table-1 and the Figure-5 shows the actually relation shape between the rainfall and relative humidity

3.3 Temperature (T)

The maximum average of monthly temperature is (36.3 ^{o}C) in July and August and the minimum is (12 ^{o}C) in January, Table-1. The annual average of the mean temperature is (25.3 ^{o}C).
Most years during the period (1980-2016) have shown an increasing increase in temperature over the annual average value. The increases about 2.1 ^{o}C in mean temperature during the last years, Figure-3. This means that there is an annual increase about 0.6 ^{o}C for each ten years.

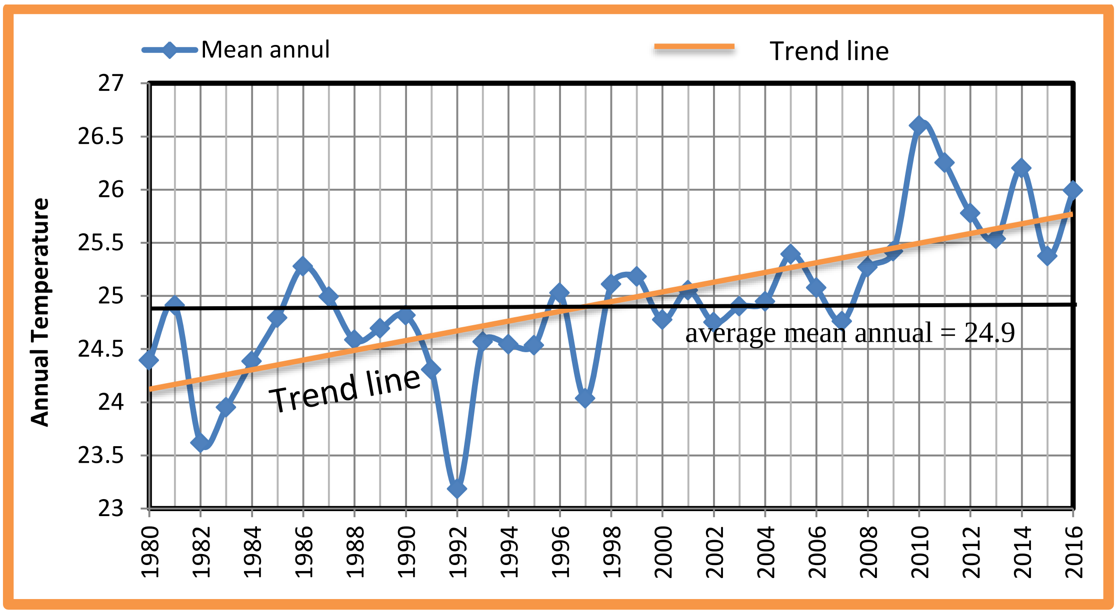

Figure 3-The temperature distribution (condition) for years (1980-2016) in Al-Samawa metrological station.

3.4 Wind speed

The maximum monthly average of wind speed is 3.9 m/sec in June and the minimum is (2.4 m / sec) in November. The annual average is about (5.2 m/sec) Table-1.

The analyses of winds directions data of the period (1980-2015) showed (in a percentage of contribution) that the prevailing directions along the year were NW with 69%, W direction (9 %), and W/NW and NW/W direction (5%), Figure-4.

3.5 Sun shine

The maximum monthly average of sunshine duration was 11.9 h/d, occurs in July, while the minimum monthly average is 6.4 h/d during December, and the annual average was (9 hour/day). The evaporation values are high in summer, and less in winter Table-1.

3.6 Class A pan evaporation (AE)

It is defined as the process by which water is converted from its liquid form to its vapor form by vaporization, thus transferred from land and water masses to the atmosphere [4].

The maximum average of monthly evaporation is about (482.6 mm) in July and the minimum was (85.1 mm) in December. The annual evaporation average of class A pan evaporation is about (3182 mm), Table-1.

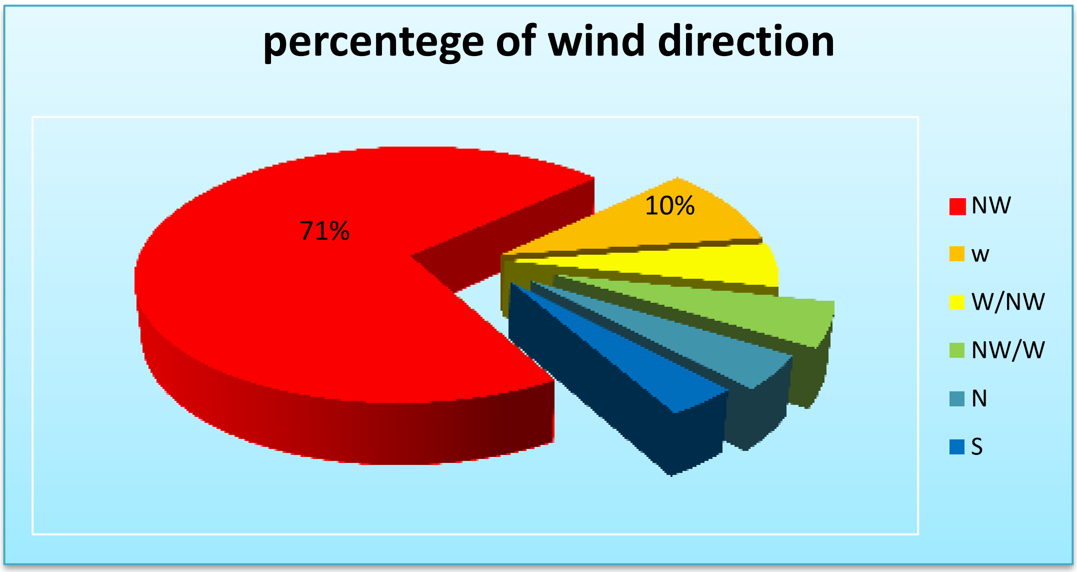

Figure 4-Wind direction (in a percentage of contribution) for the period (1980-2015) in Al-Samawa metrological station [5].

3.7 Potential Evapotranspiration (PE):

Thornthwait, (1948) defined potential evapotranspiration (PE) as the water loss which will occur if at any time there is a deficiency of water in the soil for the use of vegetation should be the difference between the amount of the actual evaporation and the evaporation capacity [6].

Thornthwiate, (1948) developed a relationship for calculating the consumptive use of the crop on the basis of the mean daily temperature, latitude of the zone and month of the year. It assumes that there is a good correlation between the mean temperature and the other variables. The relationship is shown in the following equations ([5]:

$$PE = 16\,[10t_{(n)} / J]^{a} \text{ mm/month} \quad (1)$$

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

$$j = [tn / 5]^{1.514} \quad \text{for each month} \quad (3)$$

Where:

PE = Potential evapotranspiration for each month (mm /month).

t = Monthly mean air temperature (°C).

n = Number of monthly measurement.

J = Annual heat index (°C).

j = Monthly temperature parameter (°C).

a = Constant.

$$a = (675 \times 10^{-9})\,J^{3} - (771 \times 10^{-7})\,J^{2} + (179 \times 10^{-4})\,J + 0.492 \quad (4)$$

The (a) values equal to (3.32).

However the values of the corrected potential evapotranspiration (PEc) could be determined from the following equation [5]:

PEc = PE *(DT/360) (5)

Where:

PEc: Corrected potential evapotranspiration (mm).
PE: potential evapotranspiration (mm).
D: number of days in the month.
T: Mean month sunshine.

The monthly potential evapotranspiration values are the higher during the period (May- October), and has moderate values in the period of (November- April) Table-2.

The years are characterized in all months by the following relation: E pan > PE > PEc. Where; the evaporation from ground EA pan is (3182 mm). and the rate of evaporation of the corrected potential evapotranspiration (PEc) is (1520.5 mm), while the rate of the potential evapotranspiration (PE) is (1717 mm) Table -2. The observed difference between the three values shows the different in the measuring ways (field values and calculated values).

Table 2- Potential evapotranspiration and evapotranspiration correct values calculated for the period (1980-2015) using Thornthwaite (1948) method [5].

		j		PE			PEc
Month	t c	(t/5)^1.514	J	[(10*t)/J]^a	D	T	[PE*(DT/365)]
Oct.	27	12.85	is	124.04	31	8.7	91.86
Nov.	19	7.55	sum	38.63	30	7.4	23.41
Dec.	15	5.28	j	17.62	31	6.4	9.61
Jan.	12	3.76		8.40	31	6.8	4.87
Feb.	15	5.28	145.7	17.62	28	7.6	10.23
Mar.	19	7.55		38.63	31	7.9	26.06
Apr.	25	11.44		96.07	30	8.6	67.79
May	31	15.84		196.23	31	9.4	156.79
Jun.	35	19.03		293.59	30	11.8	283.74
Jul.	36	19.86		322.37	31	11.9	324.76
Aug.	36	19.86		322.37	31	11.6	317.81
Sep.	33	17.41		241.49	30	10.3	203.60
Total		1717			365		1520.52
Average	25.3			143.09			119.68

a=3.32.

4. The relationship between climatic elements

Sunshine is the basis on raising the temperature values, the temperature values causes an increase in wind speed and evaporation. The curves of each of rainfall and relative humidity have Parallel motion. Also, the temperature curve has a parallel motion with the sunshine duration curve, and both have a reverse relation with the first group, Figure -5.

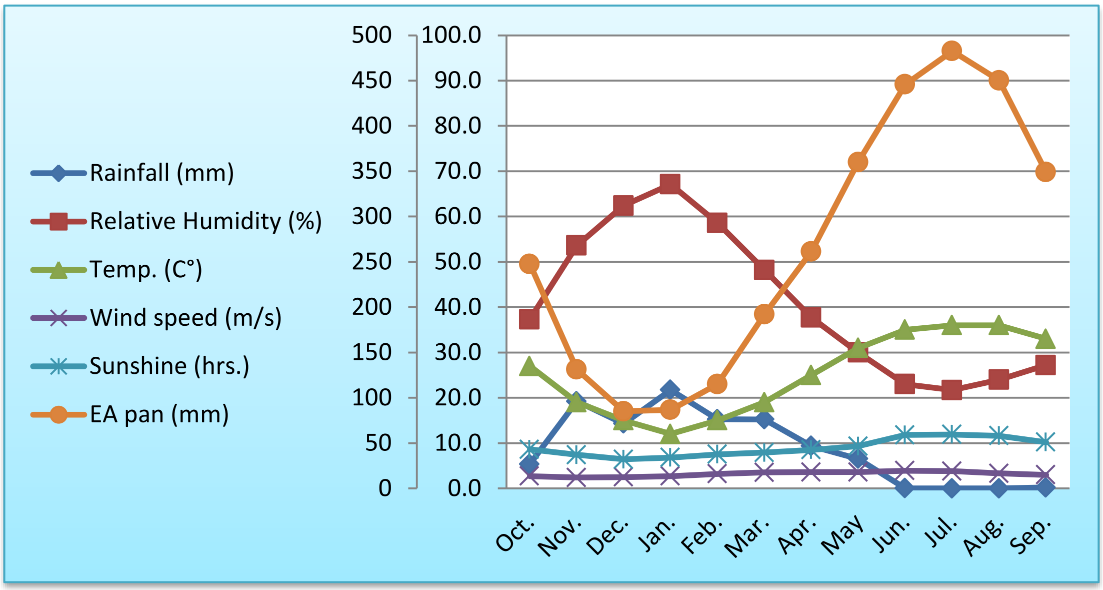

Figure 5-Climatic elements of the study area for the period (1980-2015).

5. Type of Climate

To determine the type of climate in Al-Amaid will be used three classifications as following: (Kettaneh and Gangopadhyaya, (1974) [7] was proposed classification based on humidity index (H.I) which indicate the ratio of rainfall to corrected potential evapotranspiration according to the equation (7), and comports the value with the Tables-(3 & 4):

H.I.= P/ PEc (7)

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

Table 3- Classification of (Ketanah and Gangopadhyaya, 1974) [7].

Climatic zone	Range H.I.
Humid	HI ≥ 1
Moist	2HI > 1 > HI
Moderate to Dry	10 HI > 1 > 2HI
Dry	10 HI < 1

According to the classification above most of the months of the years are dry and three months yet are humid Table-5.

According to the (Mather, 1974) [8] classification, which depended upon the relationship between the rainfall factor (P) and Potential Evapotranspiration factor (PE), according to the fallowing equation:

Im = [(P – PE) -1] / 100 (8)

Im: climate index.
PE: Potential Evapotranspiration factor. Table-2
P: rainfall factor. This equals to (105.7) Table-1
If Im is manias, it wellbe (Dry climate)
Or Im is positive, it well be (Moist climate).
By applying (Mather, 1974) equations [8], Im becomes as follows:
Im = [(105.7 – 1628) -1] / 100
Im = -22.1

According to Im value the type of climate is classified as a Dry climate.

The Table-5 shows climatic divide according to the Mather, (1974). After applied climatic factors (P) and (PE) according to theThornthwiate, (1948), (Im) is (**Semi- Arid**).

Table 4- Calculation of Humidity index (H.I) According to classification of (Kettaneh and Gangopadhyaya, 1974) in Al-Amaid area for period (1980-2015).

Months	P (mm)	PEc (mm)	H.I.	Kettaneh and Gangopadhyaya, 1974
Oct.	5.4	91.86	0.06	Dry
Nov.	19.2	23.41	0.82	Moist
Dec.	14.3	9.61	1.49	Humid
Jan.	21.7	4.87	4.46	Humid
Feb.	15.3	10.23	1.50	Humid
Mar.	15.2	26.06	0.58	Moist
Apr.	9.4	67.79	0.14	Moderate to Dry
May	6.5	156.79	0.04	Dry
Jun.	0.0	283.74	0.00	Dry
Jul.	0.0	324.76	0.00	Dry
Aug.	0.0	317.81	0.00	Dry
Sep.	0.2	203.60	0.00	Dry

Table 5-Shows climatic divide according to (Mather, 1974).

Climate type	**Range Of Im**	**(Im) in the study area**
		Where (PE) according to (thornthwaite, 1984)
Dry – Sub humid	0.0 to – 33.3	
Semi - Arid	- 33.3 to – 66.7	-22.1
Arid	66.7 - 100	

The classification suggested by Al-Kubaisi, (2004) [9] is used to determine the climate type and the aridity index by using the yearly dryness treatment depending on the amount of rainfall and temperature according to the following equation:

$$AI=1.0 * P \ /11.525 * t \quad (9)$$

$$AI.2=2\sqrt{P}/t \quad (10)$$

Where:
AI: Aridity index
P: Yearly rainfall (mm)
t: Temperature ratio (C°)

The value of the (AI-1) represents the classification of the dominated climate, where the value (AI-2) represents a modification down the classification and as it is discerned in the Table-4.

By applying the two equations, (9) and (10), the value of (AI-1) and (AI-2) becomes as follows:

AI= (1.0 * 93.5) /(11.525 * 25.7)
A I. 1 = 3.29
AI.2= (2*10.3)/25.7
A I. 2 = 0.8

According to AI.1 value the climate is classified as (sub arid to arid), while it is classified as (arid) climate according to AI.2 value Table-6.

Table 6-Climatic classification according to Al-Kubaisi (2004)

Type.1	Evaluation	Type.2	Evaluation
AI-1>1.0	Humid to moist	AI-2>4.5	Humid
		2.0<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-2<1.5	Sub arid
AI-1<1.0	Sub arid to arid	AI-2>1.0	Sub arid
		AI-2<1.0	Arid

6. Climatic water balance

Water surplus is defined as the values of rainfall are greater than the potential evapotranspiration during specific months of the year, while water deficit defined as the values of the potential evapotranspiration are greater than rainfall in anther specific months of the year (Lerner *et al*., 1990) [10].

To determine the monthly water surplus and water deficit for the period of (1980-2017), Thornthwait method was used to calculate (PE) values [6]. The water surplus period of (December-February) with total of (19.9 mm), while water deficit was (Marc-October) with total was (1440 mm) in year, Table-7 and Figure-6.

The water surplus represents (28%) of annually rainfall according to the following equation:

$$WS\ \% = WS / P \times 100 \qquad (11)$$

$WS\% = (26.6/107.7) \times 100 = 28\%$

And the water deficit was (72%) according the following equation:

$$WD\ \% = 100 - WS\ \% \qquad (12)$$

$WD\ \% = 100 - 28\% = 72\%$.

Table 7- mean monthly of water surplus and water deficit area

Month	P (mm)	PEc (mm)	AE (mm)	WS (mm)	WD (mm)
Oct.	5.4	91.9	5.3		86.5
Nov.	19.2	23.4	19.2		4.2
Dec.	14.3	9.6	8.4	4.7	
Jan.	21.7	4.9	7.6	16.8	
Feb.	15.3	10.2	14.6	5.1	
Mar.	15.2	26.1	15.2		10.9
Apr.	9.4	67.8	8.9		58.4
May	6.5	156.8	6.5		150.3
Jun.	0.0	283.7	0.0		283.7
Jul.	0.0	324.8	0.0		324.8
Aug.	0.0	317.8	0.0		317.8
Sep.	0.2	203.6	0.1		203.4
Total	107.2	1520.6		26.6	1440.0
Average		127.7			

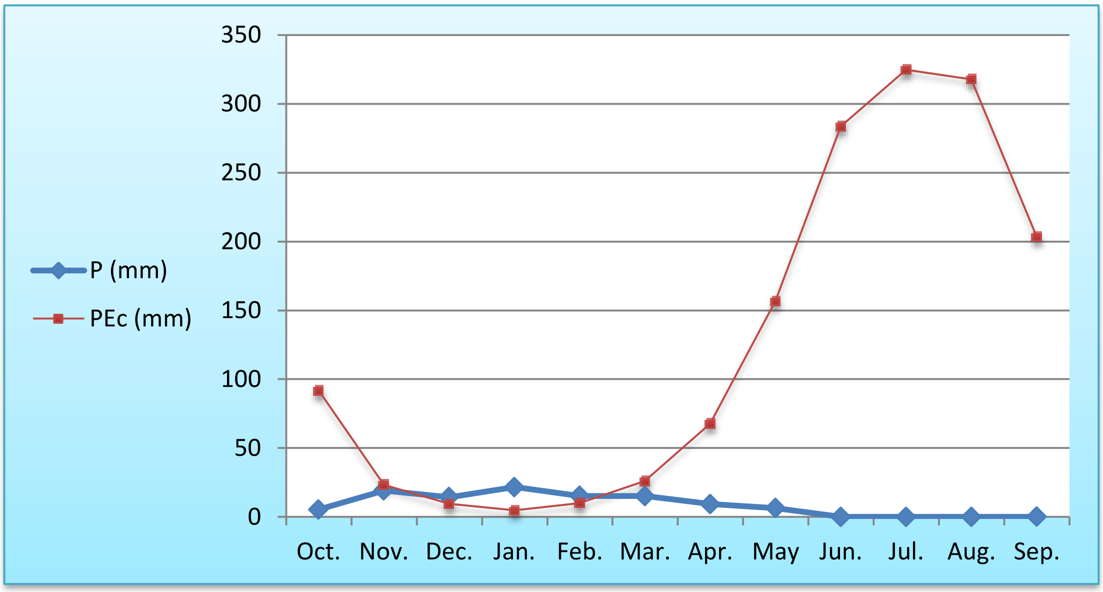

Figure 6-water surplus curve and water surplus.

Conclusion

The global climate change is expected to change the hydrometeorological processes parameters, so that it was found according to the climate classifications the climate of study area was continental and dry climates as well as the region has a great water deficit up to 72% of the total rainfall values.
The contributions of this research to knowledge is one of the most effective tools to provide feedback on the climate of the area and accordingly the quality of groundwater to the policy makers and environmentalists.

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