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Water Balance for Ali AL-Gharbi-Northeast of Missan Governorate-Southeast of Iraq

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Abstract

Ali AL-Gharbi area lies to the northeast of Missan Governorate, southeast of Iraq. The meteorological data recorded in Ali AL-Gharbi station for the period (1994-2014) were used to assess the climatic condition of the study area, it was found that the monthly mean of rainfall is (15.35 mm), relative humidity (43.95 %), the temperature (24.50 C°), wind speed (4.35 m/sec) and the strongest and most frequent winds are the northwest, sunshine (8.54 h/day) and evaporation (305.73 mm).The results of the data analysis show that, the climate of study area is characterized by dry and relatively hot in summer, and cold with low rain in winter. This study shows that, there is water surplus of (35.69 %) of the total rainfall amount which is equivalent to (184.28 mm), and the amount of surface runoff is (5.12mm), and the amount of groundwater recharge is (60.65mm) from the total rainfall.

Keywords: Water balance, Potential evapotranspiration, Classification of climate.

الموازنة المائية لعلي الغربي– شمال شرق محافظة ميسان – جنوب شرق العراق

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

الخلاصة

تقع منطقة علي الغربي الى الشمال الشرقي من محافظة ميسان، جنوب شرق العراق. تم استخدام بيانات الارصاد الجوية المسجلة في محطة علي الغربي للفترة (1994–2014) لتقييم الظروف المناخية لمنطقة الدراسة. حيث تبين إن المعدل الشهري للساقط المطري يبلغ (15.35 mm)، والرطوبة النسبية (43.95%)، ودرجة الحرارة (24.50C°)، وسرعة الرياح (4.35m/sec) وان الرياح الاغلب شيوعا هي الشمالية الشرقية، والسطوع الشمسي(8.54 h/day) والتبخر (305.73 mm). وقد بينت نتائج تحاليل هذه المعطيات ان مناخ منطقة الدراسة يمتاز بأنه حار جاف صيفا، بارد قليل الامطار شتاءا. وأظهرت الدراسة وجود زيادة مائية بنسبة (35.69%) من كمية الساقط المطري الكلي الذي يعادل (184.28mm) وكان مقدار الجريان السطحي (5.12mm)، ومقدار تغذية المياه الجوفية (60.65mm) من كمية الساقط المطري الكلي.

Introduction:

Ali AL-Gharbi area lies to the northeast of Missan Governorate, southeast of Iraq, between latitudes (32°, 30′- 32°, 49′) north and longitudes (46°, 33′- 46°, 56′) east. Its occupy (894) km^2, and bounded from northeast to southeast by Iraqi-Iranian border, as shown in Figure-1. Study area is located at the eastern border of the Mesopotamian plain and is considered as a part of it [1]. More than 95% of the study area covered by Quaternary deposits, Pre-Quaternary rocks are exposed to the east and northeast of AL-Teeb town, represented by undifferentiated Mukdadiya and Bai Hassan formations, the two formations are represented in the study area as one geological unit [2]. The region containing of the accumulation geomorphic units, mainly of fluvial and aeolian origins such as, alluvial fan, sheet run-off, sand dunes and sand sheet, beside other geomorphic units.

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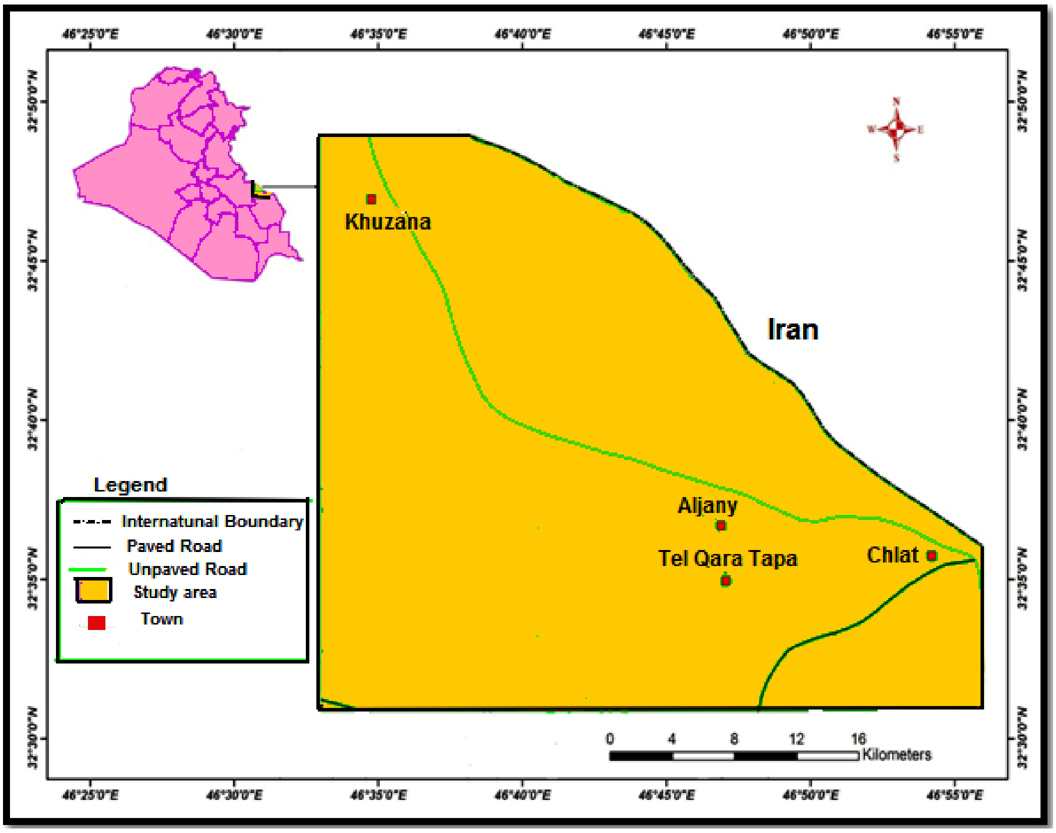

Figure 1-Location of study area.

This study is aimed to studying the climate parameters for the available data to calculate the water balance.

Method and Materials:

The climatic data for the study area was taken for the period (1994-2014) of Ali AL-Gharbi meteorological station and determine the monthly mean values of climatic parameters, as shown in Table-1 and Figure-2. Thornthwiat equation was used to determine the values of the potential evapotranspiration. After that, the values of evapotranspiration were corrected according to latitude for each month. The water balance of the study area calculated by using Lerner method, where the surface runoff of the study area was determined by using curve number method. In addition to, two of the climate classifications were used to delineate type of climate in the study area.

Results and Discussion:

Table 1- Monthly averages records of climatic parameters in Ali AL-Gharbi station for the period (1994-2014) [3].

Months	Rainfall (mm)	Relative Humidity %)(	Temperatures (C°)	Wind speed (m/sec)	Sunshine (h/day)	Evaporation (mm)
Oct.	5.58	39.53	26.71	3.53	8.34	260.12
Nov.	32.47	58.13	18.35	3.36	6.93	125.31
Dec.	29.89	75.73	13.14	2.88	5.97	68.04
Jan.	37.53	73.78	11.67	3.58	5.99	75.1
Feb.	21.47	63.14	14.17	3.83	7.20	107.57
Mar.	25.73	52.14	19.30	4.21	7.48	200.33
Apr.	18.93	41.78	24.81	4.53	7.97	292.22
May	12.30	28.92	31.60	4.42	9.55	435.81
June	0.08	22.15	36.02	6.11	11.24	594.16
July	0	21.30	38.14	6.01	10.90	566.26
Aug.	0	22.73	37.53	5.44	11.16	558.49
Sep.	0.3	28.13	32.72	4.44	9.78	385.46
Average	15.35	43.95	24.50	4.35	8.54	305.73
Total	184.28	527.46	294.09	52.28	102.51	3668.87

There are varies relationships between the climatic variables. Where, Relative humidity is correlated inversely with temperature, evaporation and wind speed; and normally with rainfall.

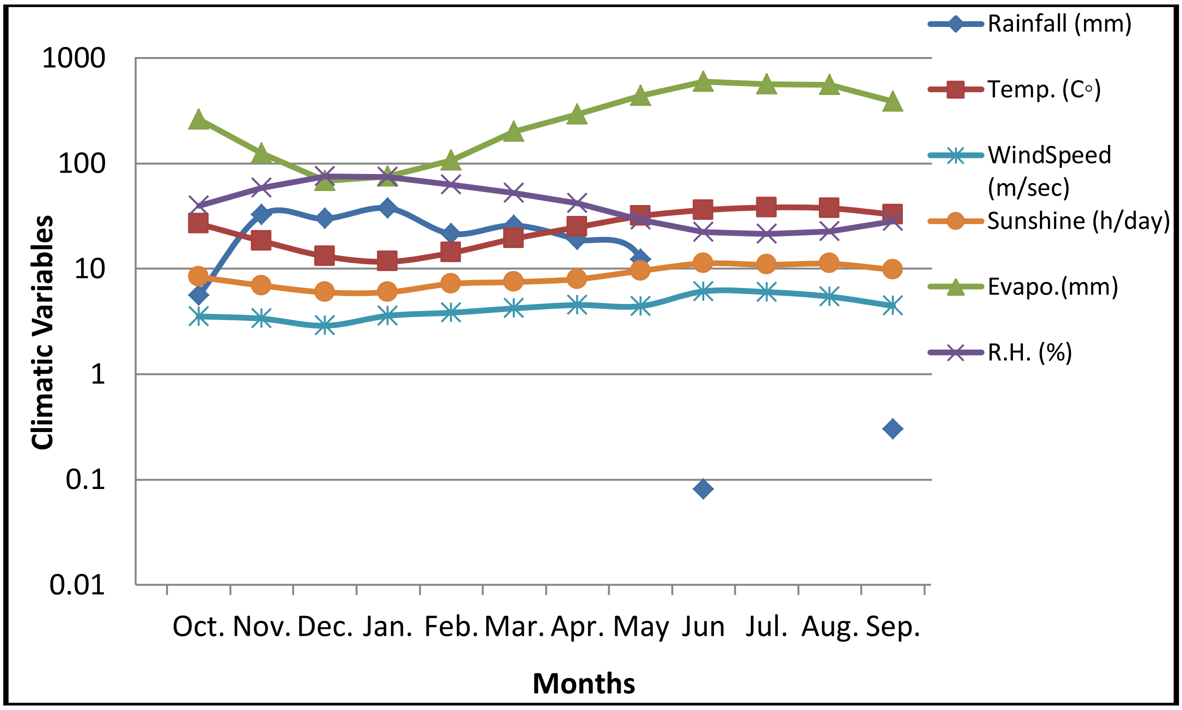

Figure 2- Relationships between the climatic variables.

Evapotranspiration:

The potential evapotranspiration is a combine term of evaporation and transpiration, defines as the total loss of water through evaporation and transpiration from the soil plant system. Thornthwiate suggested an equation to calculate the potential evapotranspiration after conducting several experiments on various semi-wet and semi-arid climate types depending on the temperature only [4]. The evapotranspiration in study area is calculated for each month as the follows:

$PE = 16\,[10t / J]^{a}$

$J = \sum_{j=1}^{12} j$ (for the 12 month)

$j = [tn / 5]^{1.514}$

$a = 0.016\,J + 0.5$

$PEc = K * PE$

Where:

PE = Potential evapotranspiration (mm).

PEc = Correct evapotranspiration (mm).

t = Monthly mean air temperature (C°).

n = Number of monthly measurement.

J = Annual heat index (C°).

j = Monthly temperature parameter (C°).

a = Constant.

K=correction coefficient related to hours between sunrise and sunset in the month [5].

Then:

$a = 0.016 * J + 0.5$

$a = 0.016 * 147.72 + 0.5 = 2.86$

K= my study area on latitude 32˚ 30' 00"

After determine the values of potential evapotranspiration and correcting them according to the latitude for each month due to variation sunshine hours between day and night. It is clear in Table-2.

Table 2- Potential evapotranspiration (PE) mm for Ali AL-Gharbi by Thornthwiate

Months	t (C°)	J	PE (mm)	K	PE_c (mm)	Evaporation (mm)
Oct.	26.71	12.63	87.05	0.98	85.30	260.12
Nov.	18.35	7.15	29.75	0.88	26.18	125.31
Dec.	13.14	4.31	11.44	0.87	9.95	68.04
Jan.	11.67	3.60	8.15	o.89	7.25	75.1
Feb.	14.17	4.84	14.20	0.86	12.21	107.57
Mar.	19.30	7.72	34.37	1.03	35.40	200.33
Apr.	24.81	11.30	70.49	1.08	76.12	292.22
May	31.60	16.30	140.80	1.19	167.55	435.81
Jun.	36.02	19.87	204.75	1.19	243.65	594.16
Jul.	38.14	21.67	241.14	1.21	291.77	566.26
Aug.	37.53	21.15	230.27	1.15	264.81	558.49
Sep.	32.72	17.18	155.55	1.03	160.21	385.46
Total		J=147.72	1227.96		1380.4	3668.87

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

Water surplus is define as the excess of rainfall values over the corrected evapotransipiration values during specific months of the year, while water deficit is the excess of corrected evapotransipiration values over rainfall values during the remaining months of that year. The actual potential evapotranspirtion (APE) could be derived as follows [6]:

WS = P – PEc

PEc = APE, when P > PEc

WD = PEc – P

P = APE, when P < PEc

In the first case (water surplus period) values of rainfall is greater than correct evapotranspiration, therefore the actual evapotranspiration equals the correct evapotranspiration. The water surplus represents the surface runoff plus the groundwater recharge after the soil is fully saturated. The soil moisture is consumed either by evaporation from the soil or by plant. Therefore it is considered as a part of the water losses as that of potential evapotranspiration [7-8]. In the second case (water deficit period) correct evapotranspiration is greater than rainfall; where the actual evapotranspiration is equal the rainfall. The monthly averages of APE, WS and WD are shown in Table-3.

Table 3- Water surplus and water deficit for the study area.

Month	P(mm)	PE_c(mm)	APE(mm)	WS(mm)	WD(mm)
Oct.	5.58	85.30	5.58	0	79.72
Nov.	32.47	26.18	26.18	6.29	0
Dec.	29.89	9.95	9.95	19.94	0
Jan.	37.53	7.25	7.25	30.28	0
Feb.	21.47	12.21	12.21	9.26	0
Mar.	25.73	35.40	25.73	0	9.67
Apr.	18.93	76.12	18.93	0	57.19
May	12.30	167.55	12.30	0	155.25
Jun.	0.08	243.65	0.08	0	243.57
Jul.	0.0	291.77	0	0	291.77
Aug.	0.0	264.81	0	0	264.81
Sep.	0.3	160.21	0.3	0	159.91
Total	184.28			65.77	1261.89

Where:

WS: Water surplus (mm).

WD: Water deficit (mm).

APE: Actual Evapotranspiration (mm).

The total annual value of water surplus is (65.77 mm) from total rainfall and it is limited between November and February because rainfall exceeds PEc. The water surplus ratio from the yearly rainfall can be represented as:

WS % = WS/P ×100

WS% = 65.77 /184.28 ×100 = 35.69%

WD% = 100 – WS%

WD% = 100 – 35.69% = 64.31 %

Figure-3 shows the relationship between the monthly means of rainfall and corrected evapotranspiration, which shows the water surplus and water deficit periods.

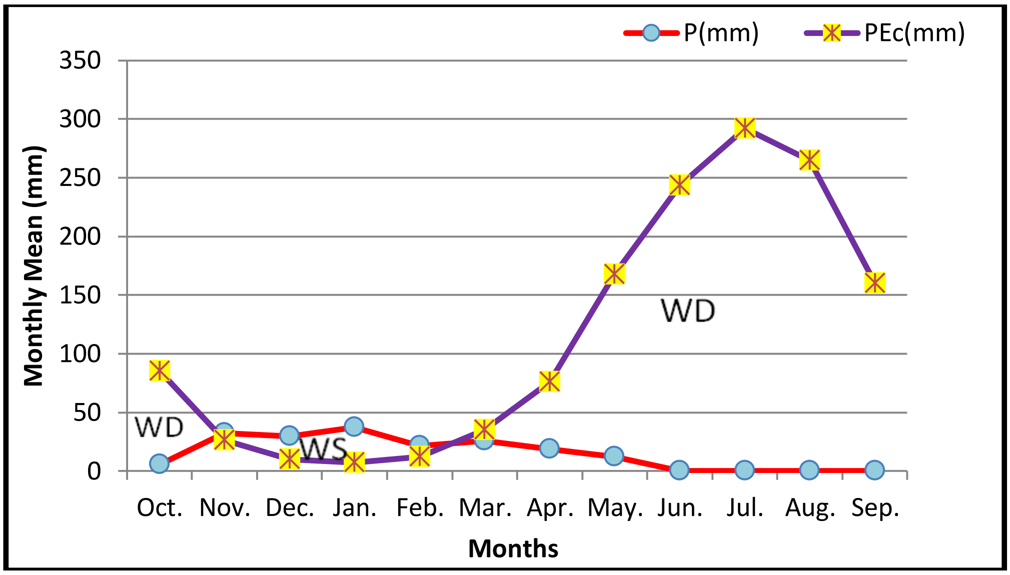

Figure 3- The relationship between monthly averages of rainfall (P) and corrected potential evapotranspiration, shows water surplus (WS) and the water deficit (WD) for the study area.

The soil conservation service (SCS) method has been used for calculating surface runoff value from the available rainfall data in the study area. The empirical rainfall-runoff relation is [9]:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \quad P > 0.2S$$

$$CN = \frac{1000}{10 + \frac{S}{25.4}} \quad (S) in\ (millimeter)$$

Where:

Q = runoff depth (mm).

P = total rainfall (mm).

S = maximum potential retention (mm).

CN = Curve Number.

According to the Table-4 runoff curve number for arid and semiarid rangelands the soil of study area characterized by curve number is (72). According to this model the total surface runoff is (5.12mm) which represent (2.78%) of the total rainfall. Where, The maximum rate of surface runoff is (2.71mm) during January, which reflecting the maximum monthly mean of precipitation (37.53 mm) as shown in Table-5.

Table 4- Runoff curve number for arid and semiarid rangelands [10].

Cover type	Hydrologic condition*	Hydrological soil group			
		A	B	C	D
Herbaceous-mixture of grass, weeds and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen-mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper- pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sage-grass-sage with an understory of grass.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub-major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, paloverde, mesquite and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

Table 5- Monthly mean values of surface runoff in the study area.

Months	Precipitation (mm)	Water Surplus (mm)	Weighted CN	S	Surface runoff (mm)
Oct.	5.58	0		0	0
Nov.	32.47	6.29		98.77	1.45
Dec.	29.89	19.94		98.77	0.94
Jan.	37.53	30.28		98.77	2.71
Feb.	21.47	9.26		98.77	0.02
Mar.	25.73	0		0	0
Apr.	18.93	0	72	0	0
May	12.30	0		0	0
Jun.	0.08	0		0	0
Jul.	0	0		0	0
Aug.	0	0		0	0
Sep.	0.3	0		0	0
Total	184.28	65.77			5.12

WS = Rs + Re
Re = WS – Rs
Re = 65.77 – 5.12
Re = 60.65 (mm)
Re %= (60.65/184.28)*100 = 32.91%, represents the percentage of groundwater recharge from the total rainfall.
Where:
Rs: Surface runoff (mm).
Re: Groundwater recharges (mm).

Classification of Climate:

There are many classifications for climate complied and proposed by many scientists and researchers to find and determine the type of the climate. Two of these classifications will be used to delineate type of climate in the study area as follows:

[11] suggested a classification depended on humidity index (H.I) which represents the ratio between the rainfalls to correct potential Evapotranspiration, as shown in the Table-6.

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

Table 6- Evaluation of monthly climate averages in the study area after [11].

Months	P (mm)	PEc (mm)	H.I	Kettaneh and Gangopadhyaya,1974
Oct.	5.58	66.403	0.084	Very dry
Nov.	32.47	18.883	1.719	Humid
Des.	29.89	6.677	4.476	Humid
Jan.	37.53	4.825	7.778	Humid
Feb.	21.47	8.96	2.396	Humid
Mar.	25.73	24.235	1.061	Humid
Apr.	18.93	50.060	0.378	Moderate to Dry
May	12.30	121.024	0.101	Moderate to Dry
Jun.	0.08	197.967	0.00040	Very Dry
July.	0	232.413	0	Very Dry
Aug.	0	227.718	0	Very Dry
Sep.	0.3	132.147	0.0022	Very Dry

The classification suggested by [12] for determining the climate type by using the annual dryness treatment depending on the amount of rainfall and temperature, according to the following equations:

$AI - 1 = (1.0 \times P) / (11.525 \times t)$ …………..(t not equal zero)

$AI - 2 = 2\sqrt{P} / t$

Where:

AI: Aridity index

P: Annual rainfall (mm)

t: Temperature (C°).

The value of (AI-1) represents the classification of the dominated climate, while the value of (AI-2) represents a modification of the latter classification as shown in Table-7. The values of AI-1 and AI-2 becomes as follows:

$AI - 1 = (1 \times 184.28) / (11.525 \times 24.50) = 0.652$

$$AI - 2 = \frac{2 * \sqrt{184.28}}{24.50} = 1.108$$

When comparing the values of (AI-1) and (AI-2) with the type of the climate reveals that the dominated climate in the area is Sub arid to arid-Sub arid.

Table 7- Climate classification depending on values of annual dryness treatment (A-I.1 and A-I.2) after [12].

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:

1. This study showed that there is water surplus of (35.69%) of the total rainfall (184.28mm).
2. The water surplus is divided into surface runoff (5.12mm) with a rate of (2.78%) and groundwater recharge of (60.65 mm) with a rate of (32.91%) of the total rainfall. The water deficit represents (1261.89mm) of the corrected potential evapotranspiration.
3. The climate of the study area is between the wet climates in winter to the dry climate in summer and in general, it can be considered that the climate of the region is Sub arid to arid-Sub arid.

References:

1. Al-Jiburi, H. K. S. **2005.** Hydrogeological and Hydrochemical study of Ali AL-Gharbi Quadrangle sheet (NI-38-16), GEOSURV, Baghdad, Iraq, p:25.
2. Barwary, A. M. **1993**. The geology of Ali Al-Gharbi Quadrangle, GEOSURV library, Rept. No. 2226, Baghdad, Iraq.
3. Iraqi Meteorological Organization. **2015**. Climatic data for Ali AL-Gharbi station, for period from (1994-2014).

4. Thornthwait, C.W. **1948**. An Approach toward a Relation Classification of Climate, *Geographical Review*, 32, p:55.

5. Kijne, J. W. **1974.** Determining evapotranspiration, Drainage principles and application- III, Surveys and Investigation, III(16), International Institute for Land Reclamation and Improvement, pp: 53-111.

6. Lerner, N.D., Issar A.S. and Simmers, I. **1990**. Groundwater recharge-a Guide to understanding and estimating natural recharge, 8, association of hydrologist, Hanover, ISBN, 3-922705, p:91.

7. Hassan, H. A. **1981**. Hydrogeological conditions of the central art of the Erbil Basin, Ph.D. Thesis, Baghdad University, Iraq, p:180.

8. Hassan, I. O., **1998**. Urban Hydrology of Erbil City Region, Ph.D. Thesis, Baghdad University, Iraq, p:121.

9. U. S. Department of Agriculture, Soil Conservation Service (USDA-SCS). **2004.** *Estimation of direct runoff from storm rainfall*, National Engineering Handbook Series, Part 630, Chapter 10, Washington, D. C.

10. U. S. Department of Agriculture (USDA). **1986.** Urban hydrology for small watersheds, Technical Release No. 55, Washington, D. C.

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. Al-Kubaisi, Q.Y. **2004**. Annual aridity index of type.1 and type.2 mode options climate classification, *Science Journal*, 45c(1), pp:32-40.