

The Comparison Between Different Methods for Estimating Consumptive Use of Water in Iraq

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Abstract

There are many empirical methods which has been used in determining consumptive use of plants. The present study deals with using of three of these methods namely Blaney-Criddle ,Thorenthwet, and Penmans. These methods are used to calculate consumptive use in Karbala city for twelve months for period from 1980 to 1999.

The results of comparison showed that these methods give different results of consumptive use. The maximum values of consumptive use are(341.4,173.4,225.3) mm/month based on Blaney-Criddle,Thorenthwet,and Penmans methods respectively while these methods give minimum values of consumptive use of(49.5,38.7,155.40) mm/month respectively. It is worthy to note that the main aim of this paper is to show the expected variations of values of consumptive use estimated by these three methods rather than studying the consumptive use values of others Iraqis governorates.

It is recommended to use Blaney-Criddle method to calculate consumptive use in Iraq because it easy to apply and it provides seasonal and monthly estimates of actual consumptive use in terms of two main climatic parameters these are temperature and the number of sun shining hours .

الخلاصة

توجد عدة طرق وضعية لحساب الاستهلاك المائي للنباتات، وان الدراسة الحالية تتعلق باستخدام ثلاثة من هذه الطرق وهي طريقة بلاني -كردل، ثورنثويت وطريقة بنمان. تم استخدام هذه الطرق لحساب الاستهلاك المائي في مدينة كربلاء ولمدة اثني عشر شهرا وللفترة من ١٩٨٠-١٩٩٩.

أظهرت نتائج المقارنة أن هذه الطرق تعطي نتائج مختلفة في حساب الاستهلاك المائي وان أقصى قيم للاستهلاك المائي كانت (٣٤١,٤ و ٣٤١,٤ و ١٧٣,٤) حسب معادلات بلاني -كردل، ثورنثويت وبنمان على التوالي. أن من الضروري الإشارة إلى أن الهدف الرئيسي من هذه الدراسة هو لإظهار الاختلافات المتوقعة في نتائج الاستهلاك المائي باستخدام هذه الطرق أكثر من أهمية دراسة قيم الاستهلاك المائي لمحافظة أخرى في العراق.

يوصى باستخدام معادلة بلاني -كردل الاستهلاك المائي في العراق وذلك لأنها سهلة التطبيق وتعطي نتائج موسمية وشهرية قد تكون قريبة من القيم الحقيقية وذلك لأنها تعتمد على عاملين مناخيين مهمين هما درجة الحرارة وعدد ساعات سطوع الشمس.

Introduction:

Many studies had been conducted on plants to evaluate the quantity of consumptive use. **hristiansen and Hargreaves (1969)** developed a series of regression equations for estimating monthly grass ET based on pan evaporation ,air temperature and humidity. **Phelan (1962)** developed a procedure for adjusting monthly K values as a function of air temperature which latter became part of SCS population on the B-C method. **Frank et. al .(1970)** used Blaney – Criddle method of estimating consumptive use to provide guidelines of water use throughout Wyoming .They concluded that Blaney –Criddle is easy to use and utilizes readily available data. **Harry and Wayne (1959)** developed an empirical formula showing the relationship between temperature ,length of growing season, monthly percentage of annual day time hours ,and consumptive use of water.

Methods of Estimation

In present study three commonly used methods are used to estimate consumptive use .These include: Blaney –Criddle, Thorenthwet and Penmens methods. Hereafter brief description of these three methods.

Blaney-Criddle Method:

In investigation evapotranspiration ,the spatial variability of surface vegetation properties is important. The Blaney-Criddle formula addresses this need by including a seasonal crop coefficient in the formula that depends on sowing data, rate of crop development, length of growing season and climatic conditions. The method was initially used for estimating consumptive use of irrigated crops in the United States and the respective equation is applied to estimate potential evapotranspiration in agricultural fields of catchments with fairly uniform vegetation .It has the following form:(**Environmental Hydrology/Evapotranspiration**)

$$ETO=K.P.(0.46 C+8.13)$$

Where:

ETO=evapotranspiration (mm).

K=correction factor (0.03 C+0.24),

P= the ratio of mean daily daytime hours for a given month to the total daytime hours in the year as a percent,

C=the mean monthly temperature (C°).

Thorenthwet Method:

Thorenthwaites method calculates potential evapotranspiration using observed air temperature and duration of sunlight data. The rationale is that air temperature does, to a considerable extent, serve as a parameter of the net radiation. This is a shortcut of replacing a comprehensive atmospheric model, as well as some interactions by prescribing observed temperature and precipitation **Huang et al., 1966**).

This method for estimating PET requires only two variables; mean monthly temperature values, and the average monthly number of daylight hours.

The following formula is applied for the calculation

$$E=16(10 T/I)^a \mu N/360$$

Where:

E is monthly potential evapotranspiration (mm/month),

T is mean monthly temperature (C°),

I is an empirical annual heat index, the sum of 12 monthly index values *i*.The value of *i* for each month is derived from mean monthly temperatures according to the formula;

$$i_j=0.09 (T_j)^{1.5}, \text{ where subscript } j \text{ indicates the specific month under investigation,}$$

μ is the number of days in month,

N is the mean number of daylight hours in a particular month,

a is an empirically derived exponent which is a function of I ,and is given by the formula:

$$a=0.016 I +0.5$$

Panman Method:

This method is considered to be one of the most accurate method which has been used of estimating potential evapotranspiration because it depends on the most of weather parameters . Nowadays this method used in wet and dry regions. The

advantages of this method that it can be used to estimate evapotranspiration for short periods and can be written as follows (Svehlik ,977)

$$ET = \frac{\Delta}{\Delta + \gamma} R_n + \frac{\gamma}{\Delta + \gamma} (0.35) (1 + 0.0062 W_2) (e_a + e_d)$$

Where;

ET= potential evapotranspiration (mm/day)

Δ=slope of saturation vapor pressure versus temperature curve.

γ= psychometric constant; a relation between vapor pressure deficit and wet bulb depression.

R_n=net radiation (mm/day)

W₂=wind speed at 2 m from ground (km/day)

e_a=vapor pressure at saturation which corresponded to air temperature (mm mercury)

e_d=actual vapor pressure of air (mm mercury)

Cases study:

Case no. 1 :determination consumptive use by using Blany-Criddle method:

For July month

C° =36.60

P=10.22

K=0.03*36.6 +0.24=1.338

ETO=1.338*10.22*(0.46*36.6 +8.13)=341.4 mm/month

For October month

C° =26.60

P=7.75

K=0.03*26.6 +0.24=1.038

ETO=1.038*7.75*(0.46*26.6 +8.13)=163.8 mm/month

It was used the same above manner for the remaining other months and the results are presented in Table(1) below:

Table (1):consumptive use values estimated by using Blany-Criddle method

month	Jan	Feb	March	April	May	Jun	July	Aug	Sep	Oct	Nov	Dec
C	10.7	13.3	17.8	24.1	30	34.3	36.6	36.3	32.5	26.6	17.9	12.5
K	0.56	0.64	0.77	0.96	1.14	1.27	1.34	1.33	1.22	1.04	0.78	0.62
P	6.76	6.72	8.33	8.95	10.02	10.08	10.2	9.54	8.39	7.8	6.7	6.5
ETO	49.5	61.2	105.2	165.6	250.5	305.8	341.4	314.8	235.3	163.8	85.4	55.7

Case no.2 :determination consumptive use by using Thorenthwet Method:

For July month

T =36.60 C

μ=31 days

N= 11.57 hr

I=0.09Σ(26.6)^{1.5}+(17.9)^{1.5}+(12.5)^{1.5}+(10.7)^{1.5}+(13.3)^{1.5}+(17.8)^{1.5}+(24.1)^{1.5}+(30)^{1.5}+(34.3)^{1.5}+(36.6)^{1.5}+(36.3)^{1.5}+(32.5)^{1.5}=137.218

a=0.016 I+0.50

=0.016 *137.218 +0.50

=2.695

$$E=16 (10*36.6 / 137.218)^{2.695}*(31*11.57 / 360)$$

$$=224.27 \text{ mm/ month}$$

It was used the same above manner for the remaining other months and the results are presented in Table(2) below :

Table (2):consumptive use values estimated by using Thorenthwet method

month	Jan	Feb	March	April	May	Jun	July	Aug	Sep	Oct	Nov	Dec
T	10.7	13.3	17.8	24.1	30	34.3	36.6	36.3	32.5	26.6	17.9	12.5
μ	31	28	31	30	31	30	31	31	30	31	30	31
N	4.04	7.39	8.02	8.56	9.48	11.63	11.57	11.17	10.29	8.54	7.21	6.12
I	3.15	4.37	6.8	10.65	14.8	18.1	19.93	19.7	16.7	12.35	6.8	3.98
a	0.55	0.57	0.61	0.67	0.74	0.79	0.82	0.81	0.77	0.7	0.61	0.56
E	38.7	64.4	81	92.3	121	158.43	173.40	163	135	100.9	70.7	58.11

Case no. 3 :determination consumptive use by using Penmans Method:

For July month

$$\Delta/\Delta+\gamma=0.819$$

$$R_n, \text{MJ/m}^2 \cdot \text{day}=13.37=0.408 \text{ mm/day}$$

$$\gamma/\Delta+\gamma=0.181$$

$$W_2, \text{ m/s}=4.2=4.2*3600*24/1000 \text{ km/day}$$

$$e_a, \text{ kpa}=1.394=7.5 \text{ mmHg}$$

$$RH, \%=29.7$$

$$e_a+e_d=e_a(1+RH/100)$$

$$ET=0.819*13.37*0.408$$

$$+0.181*0.35(1+0.0062*4.2*3600*24/1000)*1.394(1+29.7/100)*7.5$$

$$=225.3 \text{ mm/month}$$

It was used the same above manner for the remaining other months and the results are presented in Table(3) below:

Table (3):consumptive use values estimated by using Penmans method

month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$\Delta/\Delta+\gamma$	0.552	0.621	0.682	0.735	0.781	0.819	0.819	0.819	0.781	0.735	0.682	0.552
$R_n, \text{MJ/m}^2 \cdot \text{day}$	4.25	6.12	8.51	10.92	12.45	13.66	13.37	12.35	9.94	7.01	4.73	3.65
$\gamma/\Delta+\gamma$	0.448	0.379	0.318	0.265	0.219	0.181	0.181	0.181	0.219	2.65	0.318	0.448
$W_2, \text{ m/s}$	2.2	2.7	3.0	3.2	3.2	4.1	4.2	3.4	2.5	2.1	1.9	2.0
$e_a, \text{ kpa}$	0.947	0.94	1.061	1.331	1.422	1.338	1.394	1.399	1.433	1.395	1.211	1.043
RH, %	73.75	61.43	52.5	43.3	34.0	28.9	29.7	31.65	35.7	45.7	61.4	73.0
ET,mm/month	155.4	157.3	182.5	206.1	208.2	215.6	225.3	201.5	173.6	153.3	138.8	156.5

Results and Discussion

As previously stated ,various methods have been used to measure the amount of water consumed by plants. It has been used these methods on monthly consumptive use. And in general monthly consumptive use do not vary too widely from month to month and from day to day.

Many factors influence the amount of water consumed by plants. The more important natural influences are climate ,water supply ,soil ,and topography. The climatic factors believed to have the greatest effect on consumptive use on which data are generally available are temperature, precipitation , humidity ,wind movement t ,and growing season (**Harry and Wayne, 1962**).

The climatic data that to be necessary for using methods adopted in the present paper haven collected for meteorological stations in Karbala and governorate and due to missing some of climatic parameters then it has been taken from previous studies which has been conducted on the same region of Iraq. The results of this study are presented in the form of plots and also in form of histograms to clearly show the variation of results of methods used in terms of months.

Considering the present study the temperature appears as a parameter of major importance as regards determination of consumptive use. The results are presented in figures (1 to 3) and also in figures (4 to 6).

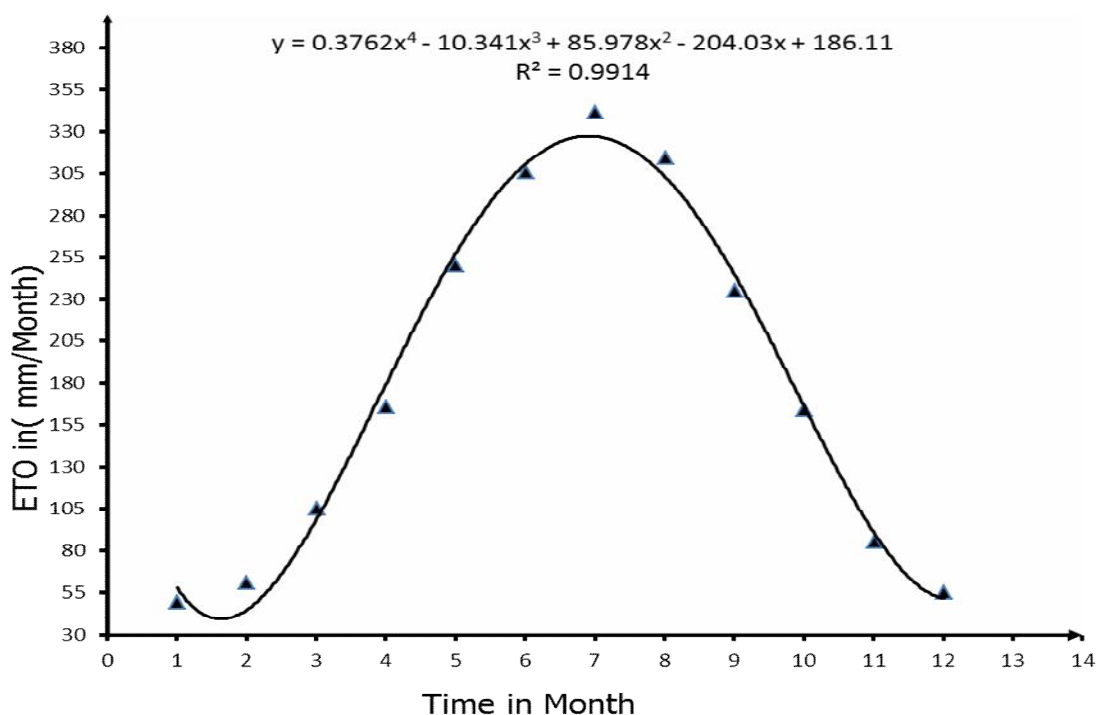


Fig. (1): Consumptive Use Values Estimated by Blaney-Criddle Method

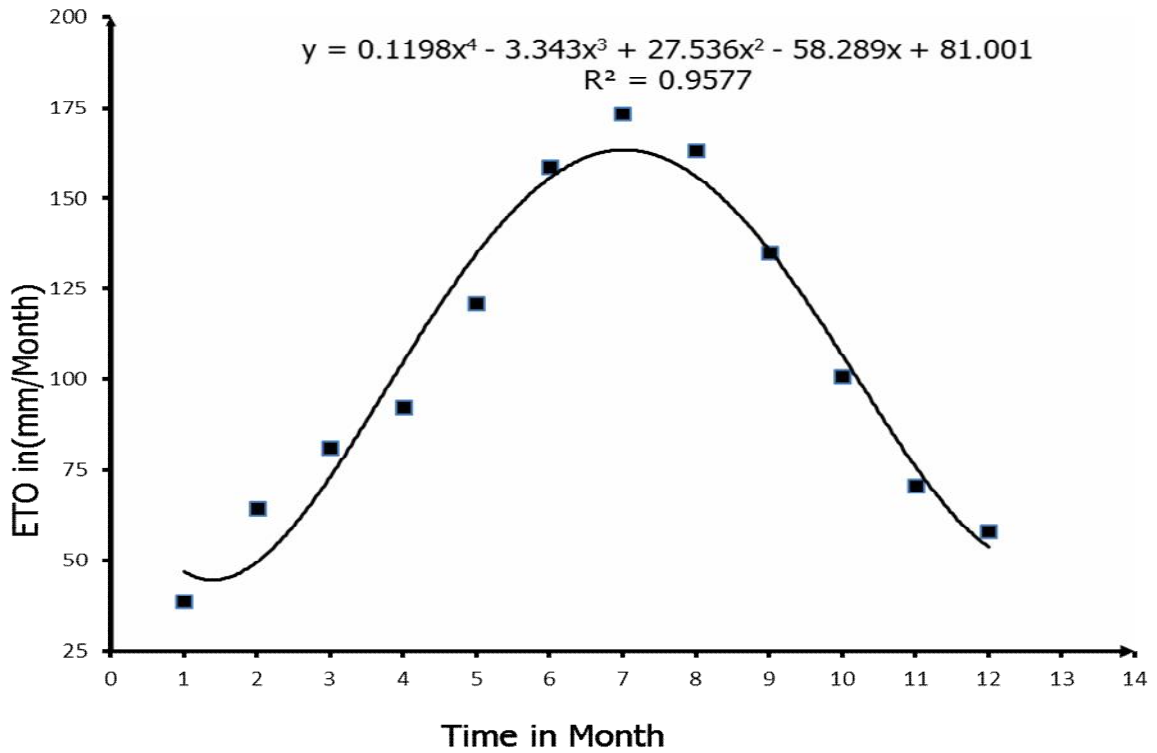


Fig.(2): Consumptive Use Values Estimated by Thorenthwet Method

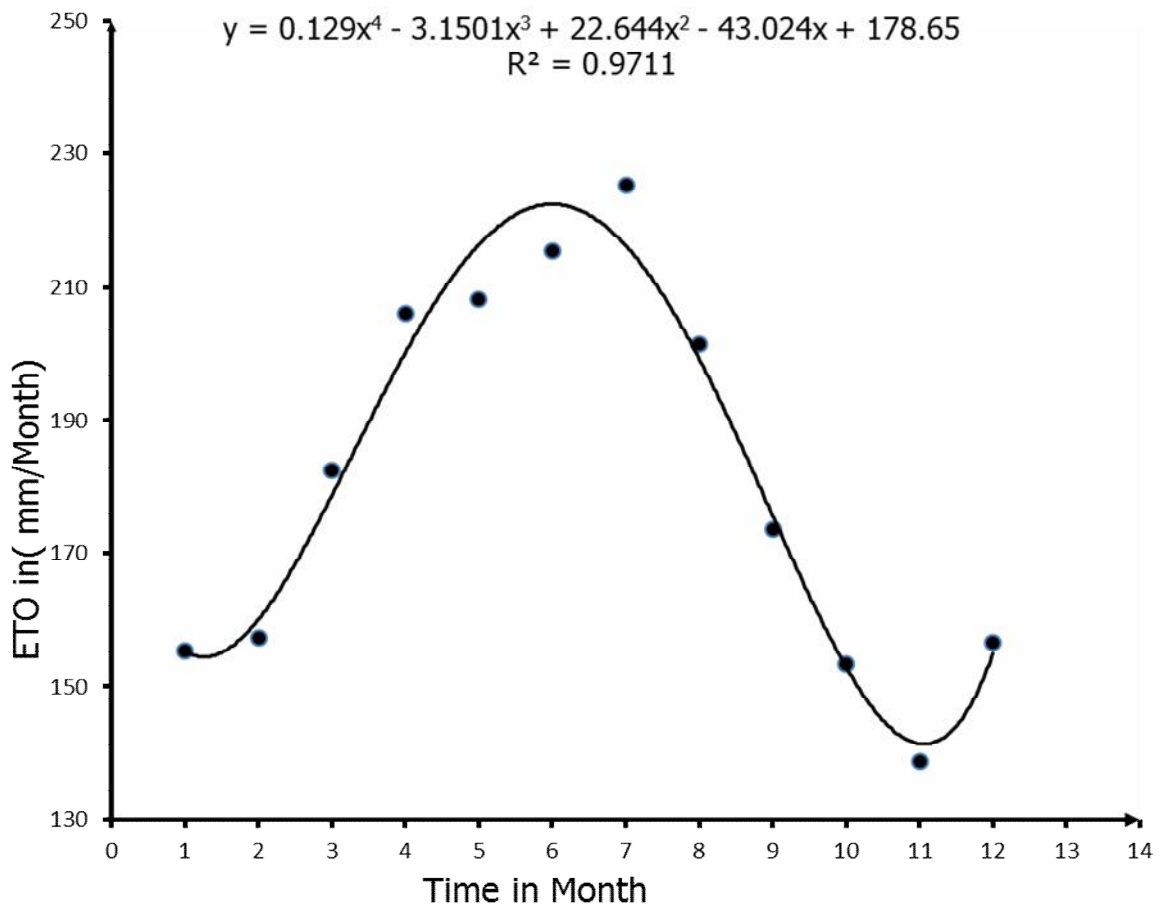


Fig.(3): Consumptive Use Values Estimated by Penmans Method

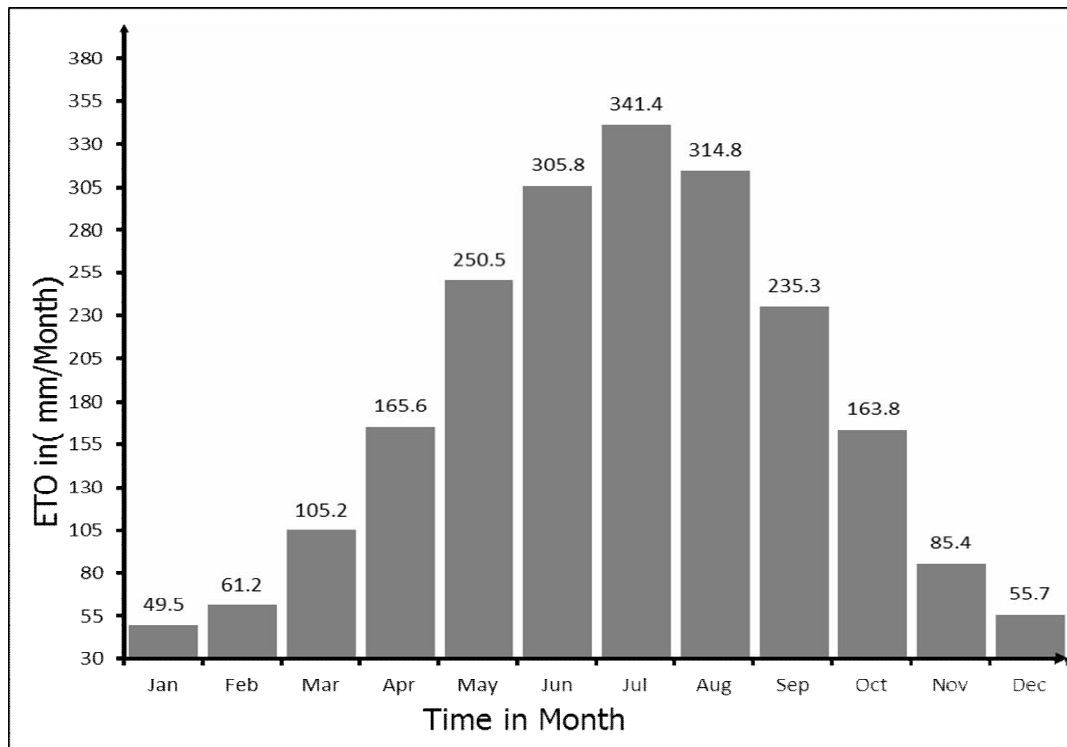


Fig.(4):Histogram of Consumptive Use Values Estimated by Blaney-Criddle Method

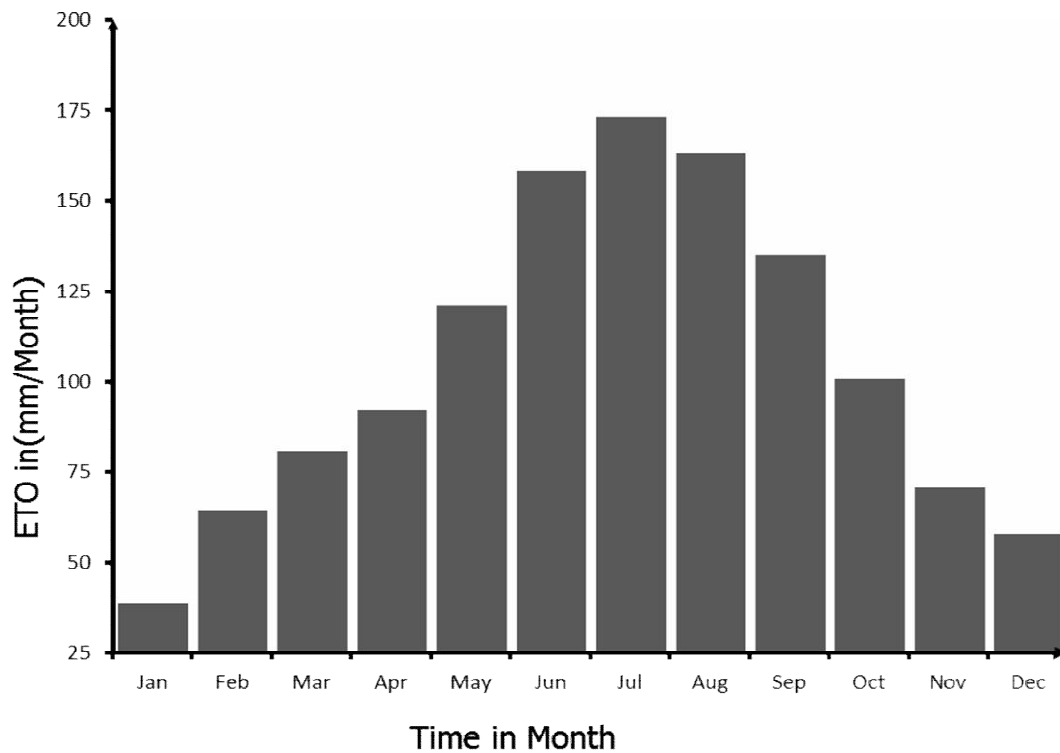


Fig.(5):Histogram of Consumptive Use Values Estimated by Thorenthwet Method

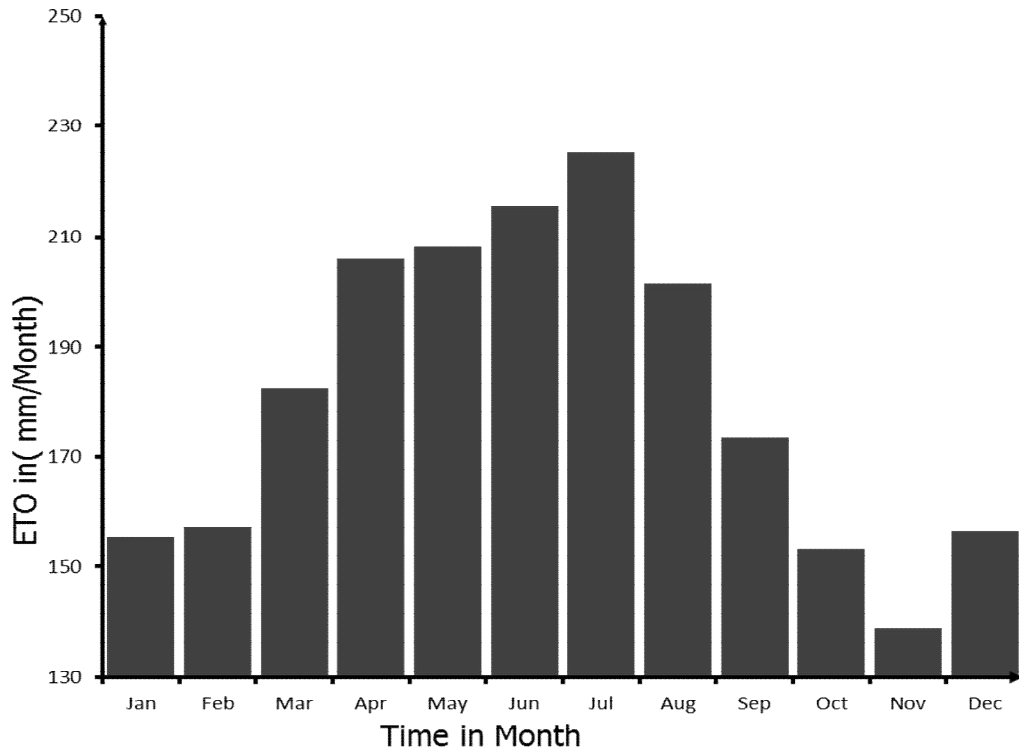


Fig.(6): Histograms Consumptive Use Values Estimated by Penmans Method

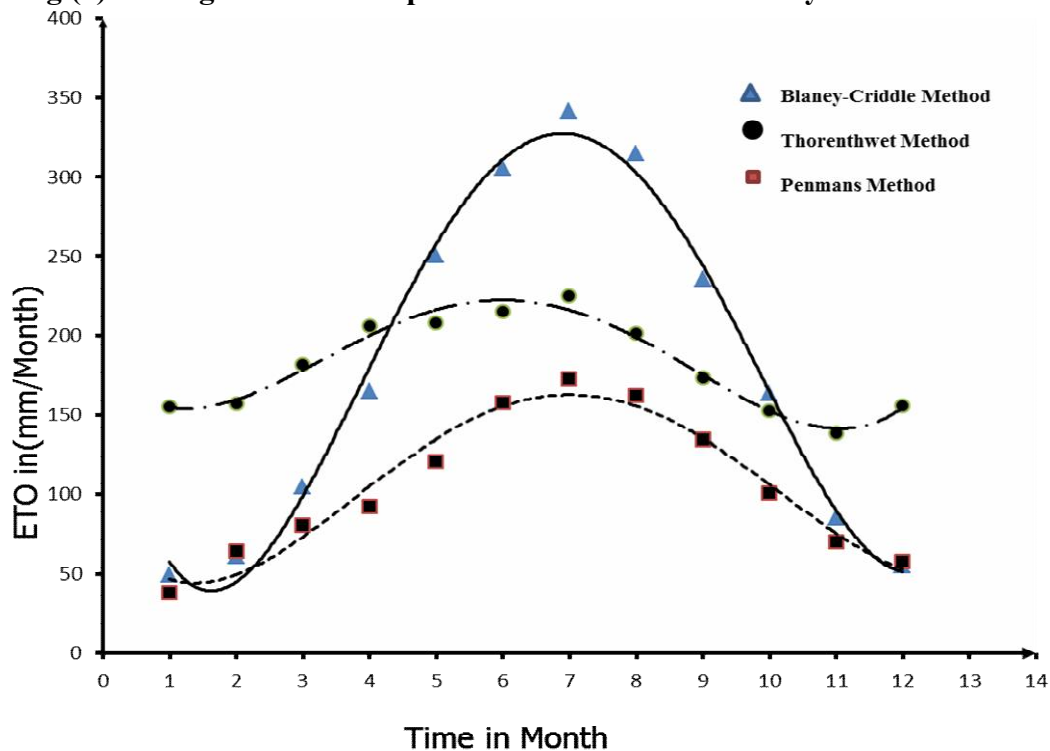


Fig.(7): Consumptive Use Values Estimated by Blaney-Criddle ,Penmans and Thorenthwet Methods

To show the variation of consumptive use resulted by each method separately or as the presentation as individual calculated results .It is apparent from these figures and histograms that the maximum consumptive uses calculated by Blaney –Criddle, horenthwet and Penmans methods are (341.4,173.4,225.3) mm/month respectively

occurred in July month due to reason of high temperature as main parameter while these methods give the minimum values of consumptive uses of (49.5,38.70,155.40) mm/month respectively and such these minimum values happened in January month And this can be attributed to decreasing of low temperature at this month in Iraq.

In order to do easy examination of difference in results given by the three methods used Fig. 7 is also presented. It is obvious from this figure that the three methods have the same behavior and the same tendency .Blaney-Criddle method gives the maximum values of consumptive use while Thorenthwet method gives the minimum values of consumptive use. The results and behavior are in acceptable agreement with previous studies **(Huang et al., 1993)**

It is important to note the Blaney-Criddle could be considered as most suitable method in Karbala because it gives more realistic and logic results and such conclusion can be demonstrated by comparing with results obtained from previous results which has conducted in Karbala city.

Conclusions

Based on the results of the present paper the following conclusions can be obtained :

- 1-The maximum values of consumptive use are (341.4,173.4,225.3) in July month based on methods of Bla Blaney –Criddle ,Thorenthwet and Penmans methods respectively. While the minimum values of cosumptive use calculated by these methods are (49.5,38.7,155.40) mm/month in January month.
- 2- It is recommended to use Blaney-Criddle method to determine consumptive use in Karbala because it depends mainly on temperature And meets the dry weather .

Recommendations

- 1-conducting field study to adopt the best method that to be more closest to field study results.
- 2-apply these methods for many Iraqi governorates to show the expected variations of values of consumptive use related to these governorates.
- 3-use of other methods of estimating consumptive use for many Iraqi governorates to cover the subject in a broad final form.

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