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Technical Note- Study of Evapotranspiration for Pune District

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Abstract the evapotranspiration is nothing but combined effect of evaporation and transpiration. The conversion of water into gaseous state with the help of sun heat is called evaporation. The process of loss of moisture from tree at the time of photosynthesis is called transpiration. It is essential to know optimum amount of water required for crop to have its full growth. The exact quantities of water will help to design irrigation scheme and all necessary forecasting is done to have safe water storage. So, to know the same we have to use proper methods to determine evapotranspiration. The methods are such that, it should be feasible one and it required as possible as minimum raw data. The number of logistic methods are used which gives the correlation and regression between different hydrological parameters.

the current research work consist the study of different technique or formula to measure evapotranspiration. The ultimate aim of the study is to know, the method which estimates the optimum evapotranspiration for pune region (maharashtra). In this work the observations were recorded at pune meteorological station. The observations are used to calculate the evapotranspiration with the methods like blaney-criddle, hargreaves method, and penman equation method. The results of evapotranspiration are compared with all above method and come to final better method.
Key-words: water use efficiency, evapotranspiration, precipitations, penman method, blaney-criddle, hargreaves method.

I. INTRODUCTION

The Evaporation and transpiration are the process going on in field simultaneously. To estimate separately evaporation or the transpiration is quite difficult job. Consumptive use (Evapotranspiration) for a particular crop may be defined as total amount of water used by plants in transpiration (building of plants tissue etc.) and evaporation from adjacent soil, in an any instant. The value of consumptive use is different for different crops.

The evapotranspiration for given crop at given place may be vary throughout the day, throughout the month and the crop period. The values of daily consumptive use or monthly consumptive use are generally determined for a given crop and at a given place. The actual evapotranspiration in the field can be measured by an instrument called a lysimeter. A lysimeter, like a phytometer is special water tank, containing a block of soil, and is installed in a field of growing plants.

The rate of evapotranspiration is rapid at sowing stage and decreases with growing crops. The measurement of evapotranspiration is carried by either direct or by analyzing hydrological data. The direct measurement is of expensive and required more accuracy. In actual practice there is no such method which is globally adaptable in all climatic conditions. Therefore use of specific method for specific regime is essential. So some time available data itself is a limitation for the work.

This research work deals with study of evapotranspiration of Pune by different methods. By studying evapotranspiration and interrelationship of various method come to know which is best method.

II. NEED OF WORK

The optimum amount of water required by crop is essential information for the design of irrigation project. The general tendency of the farmers, if we use more water there is more crop yield. The actual practice is that over irrigation resulting in water logging. So it is necessary to know what quantity of water must be given to field to have good growth of crop. So for same the study of evapotranspiration is required. There are number of formulae used for estimation of evapotranspiration. The current study imperates on the formula which can best suitable in all climatic condition. Hence need of work not only to have optimum quantity but also remedial measure on water scarcity problem.

III. LITERATURE REVIEW

A Study of Evaporation and Evapotranspiration in Peru by Fernando Chanduvi-Acuña (1969). The objectives of this study were: (a)

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to determine which formula best fits Peruvian climatic data in order to estimate evaporation and/or potential evapotranspiration. (b) To compare the measured Piche evaporation with the values given by the formulas above mentioned. (c) To determine the effect of altitude on the computed evaporation, since there are many agricultural areas at high altitudes in Peru. Climatic data from 12 stations in Peru were analyzed. Some unavailable climatic factors were estimated in order to use these formulas. 3. A total of 24 formulas for computing evaporation and/or potential evapotranspiration were used in this study. Hydrological impacts of changes in evapotranspiration and precipitation: two case studies in semi-arid and humid climates by Markus Möller & Gerald Stanhill. (2007) This study examined the impact of changes in pan evaporation and precipitation on water yield, evapotranspiration and irrigation water requirements using more than 40 years of Class A pan evaporation and precipitation data at sites with humid and semiarid climates, Valentia (Ireland) and Bet Dagan (Israel), respectively. At Valentia, the combined effects of a linear increase in precipitation P and a linear decrease in regional evapotranspiration E caused a linear trend in water yield Y that was larger than precipitation data alone would suggest, a finding that is also supported by the observed increased inter-annual variability of Y when using the water balance. Kannpan et al. (2002) developed a “reference evapotranspiration model” for certain locations in Tamilnadu with PMM as the standard method. Bhakar and Singh (2004) concluded that air temperature is the main factor influencing evaporation. The study also indicated that the influence of relative humidity on evaporation is negative whereas that of wind speed is positive.

IV. MATERIALS AND THEORY

A. *Estimation of consumptive use*

The numbers of methods have been developed in order to estimate evapotranspiration (consumptive use). These methods are useful to find value of evapotranspiration of crop in different area or for areas vegetated with the same cropping pattern. The most simple and commonly used methods are as follows,

1) Blaney-Criddle Equation
2) Hargreaves Class A pan Evaporation Method
3) Christiansen Formula
4) Penman’s Equation

1) Blaney-Criddle Formula:

It states that the monthly consumptive use is given by,

$$C_u = \frac{k.p}{40}[1.8\,t + 32] \qquad \text{………………………} (1)$$

Where, C_u= Monthly consumptive use in cm.
k= Crop factors, determined by experiments for each crop.
t= Mean monthly temperature in ^{0}C.
p= Monthly per cent of annual day light hours that occurs during the period

If $\frac{p}{40}[1.8t + 32]$ is represented by f, we get

$$C_u = k.f \qquad \text{…..…………………..} (2)$$

This formula has been extensively used throughout the world for estimating seasonal water requirement. However, it was found that the values of k based on seasonal determination were too low for the short periods between irrigations. This led to further development and finally the formula was expressed as,

$$C_u = k \sum f \qquad \text{……………………….} (3)$$

Where C_u = Seasonal consumptive use, i.e. consumptive use during the period of growth for a given crop in a given area.

The above formula involves the use of crop factor, the value of which is to be determined for each crop and different places.
Moreover, this formula does not take into consideration the factors such as humidity, wind velocity, elevation etc. on which consumptive use depends. Hargreaves class A Pan evaporation method is therefore generally used in India.
This method is useful where only the temperature data is available. The ETo should be adjusted 10% downward for each 1000m altitude changes above sea level.

2) Hargreaves class A Pan Evaporation method

In this method, evapotranspiration (consumptive use) is related to pan evaporation called consumptive use coefficient. The formula

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can be written as

$$\frac{\text{Evapotranspiration (Et or Cu)}}{\text{Pan Evaporation (Ep)}} = K$$

Or E_t or $C_u = K.E_p$ ……………………… (4)

Consumptive use coefficient (K) is different for the different crops and is different for the same crop at different places. It also varies with the crop growth and is different at different crop stage for the same crop. The above relationship is now available for various crops from many countries such as Israel, Philippines, USA and India. Research stations constantly go on reporting more and more data. Where specific data are not available, average value can be used as recommended by Hargreaves and these values are given in table.

a) Group A the important crop includes:
Sugar, Beats, Maize, Cotton, Jowar, Bean, Group Beas, Potatoes, etc.
b) Group B the important crop includes:
Tomatoes, Hybrid Walnuts, Plumes, Olives, some crop falls under maximum vegetative cover from group A.
c) Group C the important crop includes: Melons, Onions, Carrots, Hops, Grapes, etc.
d) Paddy or Rice

Table: 1. Hargreaves Average Values of Consumptive Use Coefficient K (Et = KEp)

% of crop growing season	Consumptive Use Coefficient (K) to be multiplied by class A pan Evaporation (Ep) i.e. (Et = K.Ep)			
	Group A	Group B	Group C	Rice
(1)	(2)	(3)	(4)	(5)
0	0.20	0.15	0.12	0.80
10	0.36	0.27	0.22	0.95
20	0.64	0.48	0.38	1.05
30	0.84	0.63	0.50	1.14
40	0.97	0.73	0.58	1.21
50	1.00	0.75	0.60	1.30
60	0.99	0.74	0.60	1.30
70	0.91	0.68	0.55	1.20
80	0.75	0.56	0.45	1.10
90	0.46	0.35	0.28	0.90
100	0.20	0.20	0.17	0.20

Table: 2. Values of K for certain Indian Crops (E_t = K.Ep)

% of crop growing season	Wheat (Ludhiana) India	Wheat (Poona) India	Cotton (Poona) India	Maize(Ludhiana) India
(1)	(2)	(3)	(4)	(5)
0	0.14	0.30	0.22	0.40
10	0.23	0.51	0.23	0.47
20	0.45	0.73	0.26	0.63
30	0.72	0.92	0.58	0.85
40	0.88	1.10	0.95	1.04
50	0.91	1.0	1.08	1.09
60	0.89	0.80	1.07	1.11
70	0.83	0.51	1.0	1.07
80	0.76	0.30	0.85	1.0
90	0.65	0.12	0.62	0.89
100	0.51	0.10	0.40	0.70
Seasonal value of K	0.61	0.61	0.68	0.86

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3) Christiansen Formula

$E_p = 0.459\ R.\ C_t.\ C_w.C_h.C_sC_e$ …………………………. (5)

Where R = Extra- terrestrial radiation in the same units as Ep in cm or mm.

Ct = Coefficient for temperature, and is given by

$C_t = 0.393 + 0.02796\ Tc + 0.0001189\ Tc^2$ …………….. …………… (6)

Where, Tc = the mean temperature in °C

$C_w = 0.708 + 0.0034\ W – 0.0000038W^2$ ………………………………. (7)

Cw = Coefficient of Wind velocity

W is mean wind velocity at 0.5m above the ground in km/day

C_h = 1.250 - 0.0087H + 0.75 X 104 H2 – 0.85 X 10-8H4 …………………………. (8)

H = mean percentage relative humidity at noon or average relative humidity for 11 and 18 hours.

C_s = 0.542+ 0.008 S – 0.78 X 10-4 S2 + 0.62 X 10-6 S3 ……………………… (9)

Cs = Coefficient for percent of possible sunshine

$C_e = 0.97 + 0.00984\ E$ ……………………………….. (10)

Ce= Coefficient of Elevation, Where E = Elevation in 100m.

4) Penman's Equation: The Penman's equation (1998) has, however more recently been introduced for determining the consumptive use of different areas of different segment of basin depending upon vegetation.

$$E_t = \frac{A.Hn+Ea.\gamma}{A+\gamma} \quad \text{……………………….. (11)}$$

Where, E_t= Daily potential Evapotranspiration

A= Slope of saturation vapor pressure V_s Temp

H_n= Net incoming solar radiation or energy.

E_a= A parameter including wind velocity mm/day.

γ= Psychromatic constant

= 0.49 mm of Hg/0C

The parameter Ea of Penman's equation is given as,

$$E_a = 0.35(1 + \frac{V2}{160})\ (e_s - e_a)\ \text{mm/day.} \quad \text{………………………………. (12)}$$

Where, V_2= Mean wind speed at 2m above ground in km/day.

e_s= saturation vapour pressure at mean air temperature in mm of Hg.

e_a= actual mean vapour pressure of air in mm of Hg.

Table: 3 Saturation Vapour pressure (es) and slope of saturation vapour pressure Vs Temperature Curve (A)

Temperature	Saturation vapour pressure (e_s) mm of Hg	Slope A in mm/^{0}C
(1)	(2)	(3)
0	4.58	0.30
10	9.21	0.60
15	12.79	0.80
20	17.54	0.95
25	23.76	1.24
30	31.82	1.61
35	42.81	2.35
40	55.32	2.95
45	71.20	3.66

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Table: 4 Values of reflection Coefficient r (albedo)

Surface	Range of r values
Close grained crops	0.15-0.25
Bare Lands	0.05-0.45
Water Surface	0.05
Snow	0.45-0.90

With the help of above equation, and using values of A, e, r, Hc and N from table 3 and 4, Et and Cu can be determined for given area. This equation can also help in used to compute evaporation from water surface like Lake etc.

V. METHODOLOGY ADOPTED

A. Study Area

The study has been conducted for "Pune District" of Maharashtra state with Longitude 18° 31′ 13″ N Degree and 73° 51′ 24″ E is 560 m from mean sea level. The monthly average climatic data of PUNE for the period of was taken for calculation purpose. The data collected are maximum and minimum temperature, maximum and minimum relative humidity, sunshine hours, wind velocity.

B. Data collection

The station characteristics and hydro metrology data

Table No.1Average climatic Data for Pune.

Month	Max Temp	Min Temp	Max RH	Min RH	Win Velo	n
Jan	23.15	12.34	38.60	15.53	2.49	7.62
Feb	27.30	14.05	45.86	17.62	3.08	8.61
Mar	31.30	18.20	53.18	19.47	5.21	9.12
Apr	35.18	22.30	64.17	19.70	6.12	8.46
May	37.20	26.30	71.21	21.66	5.23	8.99
June	35.12	27.20	66.88	23.86	5.23	6.23
July	27.20	22.13	52.17	24.50	4.63	3.23
Aug	26.23	23.10	52.54	23.15	5.63	3.14
Sept	27.23	22.12	53.23	22.32	4.56	5.26
Oct	26.30	18.23	52.44	21.00	3.96	6.41
Nov	24.20	10.23	40.70	16.23	3.28	8.78
Dec	23.50	10.11	37.83	14.52	3.59	8.38

Table No.2 ET_0 Values using different methods in mm/day

Month	MPM	HGM	BCM	RDM	THM	CNM
Jan	2.40	3.55	3.23	2.09	1.70	3.56
Feb	2.30	4.19	4.39	2.56	1.81	4.23
Mar	3.23	4.63	5.81	3.23	2.93	4.62
Apr	4.20	5.99	6.28	3.26	2.63	5.23
May	4.50	6.52	7.03	3.45	3.36	6.28
June	5.02	6.30	5.58	3.91	3.15	3.26
July	4.56	5.63	3.88	3.23	2.63	1.52
Aug	4.16	5.14	3.39	3.24	2.50	1.96
Sept	3.92	5.23	3.63	2.96	2.31	2.31
Oct	3.21	4.59	3.26	2.85	2.36	3.56
Nov	2.31	4.00	3.56	2.30	1.86	4.15
Dec	2.89	3.29	3.65	2.16	1.56	4.09
Average	3.51	4.92	4.47	2.93	2.4	3.73

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V. RESULT AND DISCUSSION

A. It is observed that from table,

It is observed that from table, MPM gives average 36.85%, 27.15%. 18.09%lower value of ETo than by BCM, HGM and CNM respectively while RDM and THM gives lower value of ETo than MPM Average daily ETo values for each month is determined by using ETo equations from the available climatologically data by different method as in table [2] The values are then used to develop interrelationship among different empirical methods considering MPM as standard method.

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