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Method for Finding Consumptive use for Irrigation Pipe Network

Drashti M. Shah[1], Gautam V. Dihora [2]
[1]P.G. student, Civil Engineering Department, SSEC, Bhavnagar
[2] Assistant Professor, Civil Engineering Department, SSEC, Bhavnagar

Abstract: Consumptive use (evapotranspiration) is a measure of crop water requirement. Crop water requirement is an essential parameter for the irrigation water supply scheme. Crop water requirement changes according to various weather parameters. Various methods are used to find consumptive use. Among Modified Pen Man method is very accurate to find crop water requirement. Pumping station, pumping mains, diameter of pipes, number of valves, location of valves etc are depends on water requirement of crops. So, consumptive use is the preliminary step for designing crop water requirement.

I. INTRODUCTION

Prediction methods for crop water requirements are used owing to the difficulty of obtaining

Accurate field measurements. The methods often need to be applied under climatic and agronomic conditions very different from those under which they were originally developed.

Crop water requirements are defined here as "the depth of water needed to meet the water

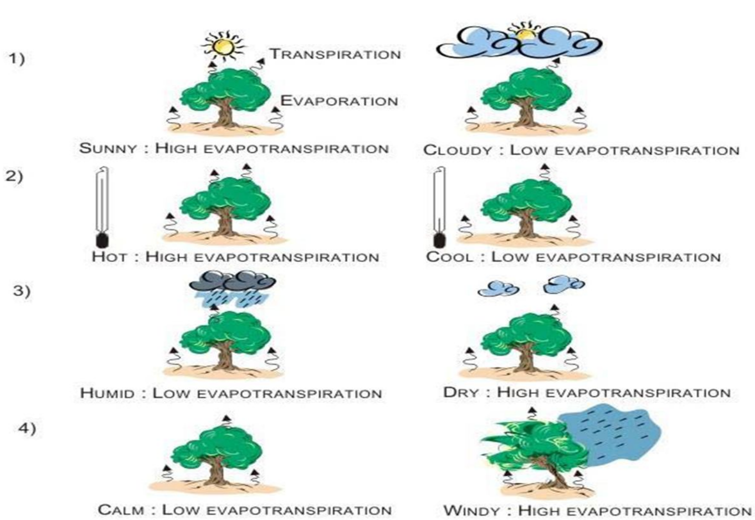
Loss through evapotranspiration (ETcrop) of a disease-free crop, growing in large fields under non restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment".

II. FACTORS AFFECTING

The effect of the major climatic factors on crop water needs may be summarized as follows:

A. Sunshine,
B. Temperature,
C. Humidity,
D. Wind speed

The variation of evapotranspiration upon these factors is illustrated in Fig Since the same crop grown in different climatic variations have different water Needs.



III. VARIOUS METHODS

Measurement of consumptive use of water can be done by following methods.

A. Direct Measurement Methods

Tank and Lysimeter method
Field experimental plots
Soil moisture studies
Integration method
Inflow and outflow studies for large area

B. Use of Empirical Formulae

Penman method
Jensen- Haise method
Blaney – Criddle method
Hargreaves method
Thornthwaite method
Hargreaves class A pan evaporation method
Concerning accuracy, only approximate possible errors can be given since no base-line type
of climate exists. The modified Penman method would offer the best results with minimum Possible error of plus or minus 10 percent in summer, and -up to 20 percent under low evaporative conditions[1].The Pan method can be graded next with possible error of 15 percent, depending on the location of the pan. The Radiation method, in extreme conditions, involves ETo will, however, vary from year to year and a frequency distribution analysis of ETo for each year of climatic record is recommended; the selected ETo value for planning is thus not based on average conditions but on the likely range of conditions and on an assessment of tolerable risk of not meeting crop water demands.

C. Modified Penman method [2]

Penman's equitation, incorporating some of the modifications suggested by the other

$$E_T = \frac{A*Hn+Ea*V}{A+V}$$

Where E_T = Daily potential evapo-transpiration
A = Slope of the saturation vapor pressure Vs Temp. at the mean air Temp. Values given in table 1
H_N = Net incoming solar radiation or energy expressed in mm of evaporable water per Day
E_a = A parameter including wind velocity and saturation deficit as given in equitation in mm/day
V = psychromatic constant = 0.49 mm of $H_{g/}$ °C

The net radiation H_n in the above equitation is estimated by the equitation

$H_{n=}$ Hc (1-r) (a+b (n/N)) - σ $T\alpha^4$ (0.56-0.092(e_a) ½) (0.10+ 0.90(n/N)) Where

Hc = mean incident solar radiation at the top of the atmosphere on a horizontal surface Expressed in mm of vapor able water per day. This value is a function of latitude the place and the period of the year as per the mean monthly value given in table 3
r = reflection coefficient (albedo) of the given area Usual Values of this coefficient for different types of areas are given in table 2
a = a constant depending upon the latitude and given as a = 0.29 cos ℂ
b = a constant having average value = 0.52
n = actual duration of bright sunshine in hours
N = maximum possible hours of bright sunshine. This value is function of latitude and its value are given in table 4 for each month of the year
σ = Stefan Bolzman Constant
= 2.01×10^{-9} mm/day
Tα = mean air temp in $^{O}K = 273 + {}^{O}C$
e_a = actual mean vapor pressure in the air in mm of Hg.

The Parameter Ea of Penman's equitation is estimated as:

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$Ea=0.35(1+(V2/160))(e_s - e_a)N$ Where
V_2 = mean wind speed at 2 m above the ground in km/d
e_s = saturation vapor pressure at mean air temp. in mm of Hg (Table 1)
e_a = actual mean vapor pressure of air in mm of Hg
With the help of the above equitation and using the values of A, e, r, Hc and N from tables Et or Cu can be determined for given area. This equation can also be used to compute the evaporation from a water surface by using r = 0.05. Due to its general applicability this equation is widely used these days in India, UK , Australia and some parts of USA.

Table: 1 Saturation Vapor Pressure (es) and Slope of Saturation Vapor Pressure Vs Temperature Curve A

TEMPERATURE	SATURATION VAPOUR PRESSURE (es) IN mm of Hg	SLOPE A IN mm/°C
0	4.58	0.30
5.5	6.54	0.45
7.5	7.78	0.54
10.0	9.21	0.60
12.5	10.87	0.71
15.0	12.79	0.80
17.5	15.00	0.95
20.0	17.54	1.05
22.5	20.44	1.24
25.0	23.76	1.40
27.5	27.54	1.61
30.0	31.82	1.85
32.5	36.68	2.07
35.0	42.81	2.35
37.5	48.36	2.62
40.0	55.32	2.95
45.0	71.20	3.66

Table 2: Values of Reflection Coefficient r

Surface	Range of r value
Close grained crops	0.15 – 0.25
Bare lands	0.05 – 0.45
Water Surface	0.05
Snow	0.45 – 0.90

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Table 3: Mean Monthly Solar Radiation at Top of Atmosphere Hc in mm of evaporable water/day

North Latitude	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
0°	14.5	15.0	15.2	14.7	13.9	13.4	13.5	14.2	14.9	15.0	14.6	14.3
10°	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4
20°	10.8	12.3	13.9	15.2	15.7	15.8	15.7	15.3	14.4	12.9	11.2	10.3
30°	8.5	10.5	12.7	14.8	16.0	16.5	16.2	15.3	13.5	11.3	9.1	7.8
40°	6.0	8.3	11.0	13.9	15.9	16.7	16.3	14.8	12.2	9.3	6.7	5.4
50°	3.6	5.9	9.1	12.7	15.4	16.7	16.1	13.9	10.5	7.1	4.3	3.0

Table 4: Mean Monthly Values of Possible Sunshine Hours (N)

North Latitude	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
0°	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
10°	11.6	11.8	12.1	12.4	12.6	12.7	12.6	12.4	12.9	11.9	11.7	11.5
20°	11.1	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
30°	10.4	11.1	12.0	12.9	13.7	14.1	13.9	13.2	12.4	11.5	10.6	10.2
40°	9.6	10.7	11.9	13.2	14.4	15.0	14.7	13.8	12.5	11.2	10.0	9.4
50°	8.6	10.1	11.8	13.8	15.4	16.4	16.0	14.5	12.7	10.8	9.1	8.1

D. *Effect of Rainfall*[3]

The effective rainfall (Re) is that part of precipitation falling during the growth period of crop that is available to meet to evapotranspiration needs of the crop.

The following approximate formulae can be used to estimate the effective rainfall from the total monthly rainfall (P):

If P > 7.5 cm/month   Re = 0.8 P – 2.5 cm/month

If P < 7.5 cm/month   Re = 0.6 P-1.0 cm/month

E. *Irrigation Requirements of crops*

1) *Consumptive Irrigation Requirement(CIR):* The Consumptive irrigation requirement is the quantity of water required by the plant to meet the evapotranspiration needs of a crop during its full growth.

CIR=Cu-Re

Cu = consumptive use of water

Re = effective rainfall

2) *Net irrigation requirement(NIR):* It is defined as the amount of irrigation water required for evapotranspiration needs of a crop as well as other needs such as leaching of alkaline or salty soils.

NIR= CIR+Le

Le= water required for leaching and other purposes

3) *Field irrigation requirement(FIR):* It is defined as the amount of water required to meet the NIR plus the amount of water lost as surface runoff and through deep percolation.

FIR=NIR+ water application losses

The water application efficiency (ηa) accounts for the loss of irrigation water by surface runoff and deep percolation. Hence,

FIR= NIR/ ηa

4) *Gross irrigation requirement (GIR):* It is defined as the amount of water required to meet the FIR plus the amount of water lost in conveyance through the canal system by evaporation and

by seepage.

GIR =FIR / η_c η_c= water conveyance efficiency

IV. CONCLUSION

Daily consumptive is found by dividing GIR (max of all month) to days in that month. This analysis required various types of data like rainfall data, weather data (max temperature, min temperature) and sun-shine data. This method is very useful in pipe network designing to estimate the max total capacity of pipe network. Pipe diameter, pump selection, valve installation etc can be decided based on the total capacity. So, we can say that the consumptive use of plant is the primary requirement of designing irrigation pipe network.

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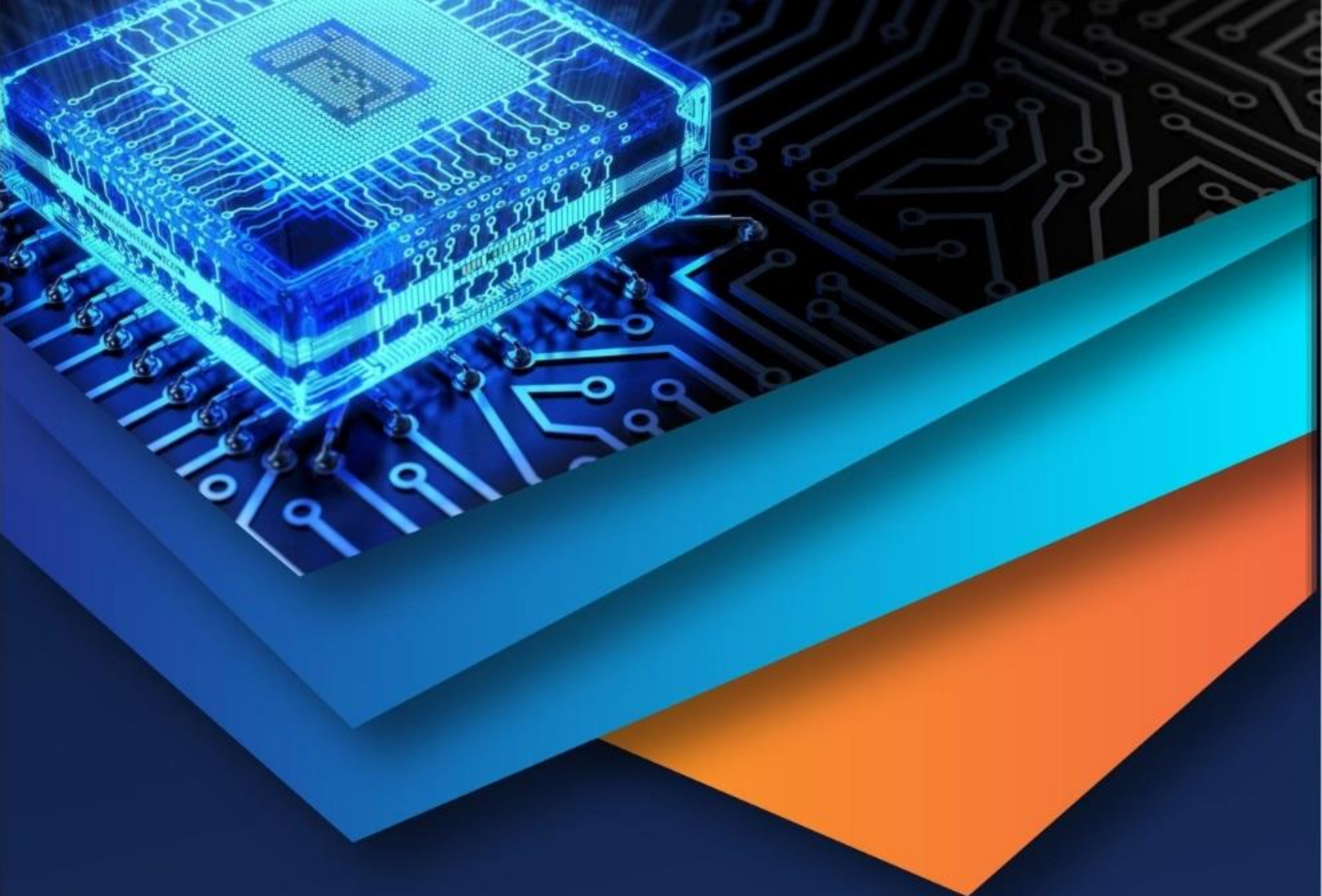

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