EVALUATION OF EVAPOTRANSPIRATION

M.D.Mata[1], K.A.Salunke[2], P.PBhangale[3]

[1]Lecturer, Civil Engineering Department, MET BKC IOE Nashik, Maharashtra, India
[2]Asstitant professor., Civil Engineering Department, SIEM Nashik, Maharashtra, India
[3]HOD, Civil Engineering Department, S.S.G.B COET Bhusawal, Maharashtra, India

Abstract

In designation water use by crops, evaporation and transpiration are combined in one term called evapo-transpiration (ET), as it is difficult to separate those two losses in crop field. Evaporation and transpiration are simultaneously and it is not easy to distinguish between the two processes. Evapotranspiration is a complex phenomenon it depends on various factors as pressure, wind speed, temperature, humidity, solar radiation, vapor etc.

Evapotranspiration can be measured by different five principles method viz. lysimeter method, Hargreaves class 'A' pan method, field plot method, Blaney-Criddle method and penman formula. ET can be measured by all methods above using different parameters involved. In this paper we discuss about measurement of ET by above all methods using software prepared by us in visual basic, this software takes the particular input from the user for particular methods and gives the output i.e. value of ET by that method. It also provides user the flexibility to compare the results of all the method. This provides great advantage by avoiding tedious calculations, user friendly, and easily comparing the results of various fields by various methods in almost no time. This software is in compact executable .exe file which avoids the process of installing it.

Different parameter involved in different methods may not be available all time so value of any parameter in any time that is required for particular method sufficient for calculating ET. Also it can provide the most optimum results.

Keywords: *Keyword: Evapotranspiration (ET).*

----------***----------

1. INTRODUCTION

In designation water use by crops, evaporation and transpiration are combined into one term called Evapotranspiration (ET), as it is difficult to separate these two losses in cropped fields. The relative amount of direct evaporation from land and water surfaces and transpiration depend on the amount of ground covered by crops.

For most crops covering the whole soil surface only a small amount of water is lost from ground surface under field conditions the incoming solar radiation supplies energy for evapotranspiration process. Usually a close relationship exists between net incoming solar radiation and evapotranspiration. In general the factors influencing evaporation and transpiration also govern the evapotranspiration process. Both occur simultaneously and it is not easy to distinguish between two processes. Apart from water availability in the top soil, the evaporation from cropped soil is mainly determined by fraction of solar radiation reaching the soil surface. It decreases over the growing period of crops as the crop develops and the crop canopy shades more and more of the ground area. During the initial stages of crop, water is lost mainly by soil evaporation but once the crop is well developed and completely covers the soil, transpiration is predominant process.

The evaporation plus transpiration from a vegetated surface with respect to water supply is known as Potential Evaporation or Potential Evapotranspiration (PE) and it constitutes the maximum possible rate due to the prevailing meteorological conditions. The problem of measuring evaporation from open water surfaces, and transpiration from different types of vegetation, has been a central problem in hydrology for many years. In terms of the hydrological cycle and the water balance, evaporation and transpiration make up the second largest component. Errors in estimating evaporative loss, therefore, assume great significance, for example, in the calculation of groundwater recharge. Difficulties in understanding the physical nature of the evaporation process, together with ambiguous results from the various types of instrument designed to measure evaporation directly (such as evaporation pans and evaporimeters) lead to the development of empirical techniques for estimating evaporation, using generally available climatic data. These techniques were recognized and acknowledged to give only approximate estimates, but in the presence of simple-to-apply, more theoretically and practically sound methods and comparing all it is possible to get most appropriate and optimum value of Evapotranspiration.

2. LITERATURE REVIEW

Robert (2002) has studied crop coefficient and irrigation scheduling resources. The objective of irrigation scheduling is to apply only the water that the crop needs, taking into account seepage, runoff losses, and leaching requirements. Scheduling is especially important to pump irrigators if

power costs are high [1]. Zhang *et al*. (2003) studied the effect of soil water deficit on Evapotranspiration, crop yield, and water use efficiency in the North China Plain has founded a new methodology to estimate daily Evapotranspiration from high resolution remotely sensed data. It was a modification of the surface energy balance model simplified surface balance index, which allows the retrieval of daily Evapotranspiration from the evaporative fraction and the daily net radiation flux, for which the relative humidity measured in situ is needed [3]. J.A.Tariq *et al.* (2003) conducted a study to investigate the effect of different irrigation depths on yield of maize, statistical analysis showed there was significant affect of irrigation depth on crop yield [4]. Son Hong Vu, *et.al* (2005) used FAO-56 for evaluating Evapotranspiration in simulation of pollutant runoff from paddy rice field in Japan. Applicability of FAO-56 method in estimation of Evapotranspiration for the simulation of pollutant runoff from rice paddy field in Japan was investigated. Crop Evapotranspiration and crop coefficient recommended by FAO-56 method relative to those values obtained in the field monitoring for three Japanese rice varieties, namely, Nihonbare, Mangetsumochi and Koganemochi during first three growing stages were compared [5]. Sobrino *et. al* (2005) have proposed methodology to estimate Evapotranspiration using the surface energy balance model S-SEBI (Simplified Surface Energy Balance Index) and the evaporative fraction. The method was applicable under the assumptions of constant atmospheric conditions and sufficient wet and dry pixels over the image. The model uses remotely sensed parameters such as albedo, MSAVI (Modified Soil Adjusted Vegetation Index) and surface temperature and emissivity images. The methodology has been applied over the Barrax test site, located in the province of Albacete [6]. Quazi.K.Hasan (2006), ET as a key economical variable calculated at a Canadian province and provides a simplified protocol for analysis that can be readily used for Canada and other forest areas [7]. Dr. Awchi (2007) investigated the potential of radial basis function (RBF) neural networks for the prediction of reference Evapotranspiration. That study showed that the RBF network is seen to emulate the feed forward-back propagation in its performance and can be effectively used for Evapotranspiration prediction [8].

In present study an attempt has been made to develop the software for the estimation of Evapotranspiration under the Visual Basic environment. Five principle methods are used for the determination of ET. Software provides flexibility to use any or all methods of ET and respective results can be compared thereby achieving accurate results for crop. Study is conducted in Nasik of sugarcane crop and ET is calculated for year 2013.

3. METHEDOLOGY

Evapotranspiration (ET) is the process of transmission of water to environment from plants body and ground surface together. Methods widely use for determination of ET are Lysimeter Method, Hargreaves class 'A' pan method, Field plot method, Blaney-Criddle method Penman formula. Each method includes different parameters and involves the time consuming calculation, so the successful attempts made and Software developed in Visual Basic to calculate ET by any or all methods and it enables the comparative results.

3.1 Methods of Evapotranspiration

The principle methods of estimating Evapotranspiration are as given below:-
a. Lysimeter method
b. Hargreaves Class 'A' Pan Method
c. Field Plot Method
d. Blaney-Criddle Method
e. Penman Formula.

3.1.1 Lysimeter Method

Potential evaporation, the evaporation plus transpiration from a vegetated surface when water supply is unlimited, can be measured using irrigated lysimeters.

The installations used, shown in following figure, closely looks like a percolation gauge. The principal difference is in the operation of the apparatus, with the contained soil being kept at field capacity (the water content of the soil after the saturated soil has drained under gravity to equilibrium) by sprinkling a known quantity of water on the tank when rainfall is deficient.

Lysimeter equations:-

$$E_T = R_W + I_W - Q_D \pm \Delta S \qquad (1)$$

Where,
ET= Evapotranspiration
Rw= Rainfall Water
Iw= Irrigation Water
QD=Quantity of water drained
Δs=Surface & Subsurface changes in Storage
Difficulties Involved

One of the disadvantages of these gauges is that the soil sample is disturbed.

In winter with snow cover and freezing temperatures, certain difficulties in operating the gauges are encountered, but discrepancies are not of great importance since evaporation losses are low and often negligible under such conditions.

Measured values of PE using these irrigated gauges can be exaggerated in very dry periods and hot climates

3.1.2 Hargreaves Class a Pan Method

The pan is circular with a diameter of 1.21 m and depth of 255 mm which gives it a volume of about 0.3 m3. The basin is put on a 150 mm high wooden frame due to air circulation around the basin. The water level is kept about 50 mm below the rim, due to allowance of percolation and the need of water. The water level is measured every day, either you measure the difference between the present and the origin water level or if you have chosen to obtain the water level in

the pan, you measure the amount of water you've put into the pan

This equation proposed and established by Hargreaves in 1979.

$$E_T = K\,E_P \qquad (2)$$

Where,
ET= Evapotranspiration
EP= Evaporation from the pan
K= Monthly Consumptive use of Crop Coefficient obtained from table A1 in Appendix

3.1.3 Field Plot Method

Measurements of water supplies to the field and changes in the soil moisture contents of field plots are sometimes more dependable for computing seasonal water requirement for crops than measurement with lysimeter which do not simulate field condition. The seasonal eater requirements are computed by adding measured quantities of irrigation water, the effective rainfall received during the season, and contribution of water from the soil. It is expressed by following relation-

Field Plot equation-

$$E_T = PPT + I_W - S_R - DPW \qquad (3)$$

Where,
ET= Evapotranspiration
PPT=Precipitation
IW= Irrigation Water
SR= Surface Run-off
DPW= Deep Percolation to Ground Water

3.1.4 Blaney-Criddle Method

Blaney and Criddle (1950) observed that the amount of water consumptively used by crops during their growing seasons was closely correlated with mean monthly temperatures and daylight hours and the length of the growing seasons. The correlation coefficients are then applied to determine the ET for other areas where only climate data are available. Blaney-Criddle formula is one of the best known procedures for estimating Potential Evapotranspiration (PET) and is widely used. The popularity of the procedure is due to its simplicity and its use of readily available data. It requires the use of only two factors, namely, temperature which is readily available from the weather stations and information on daylight hours which is a factor based purely on the latitude of the place. Using Blaney-Criddle approach, PET can be expressed as follows, in metric units:

$$E_T = 0.46\,P\,(T + 17.8) \qquad (4)$$

Where,
ET = Evapotranspiration in mm/m.
P = Percentage of day light in hours in a year.
T = temperature in degree Celsius.

3.1.5 Penman formula

Penman(1948) proposed an equation for evaporation from open water surface, based on a combination of energy balance and sink strength which is given below with changes in certain symbols in view of the recent trends.

$$E_T = (\Delta \times Q_n + Y \times E_A) / (\Delta \times Y) \qquad (5)$$

Where,
ET = evapotranspiration form open water surface (mm/day)
EA = evaporation form water surface
Δ = slope of saturation vapour pressure vs. temperature curve at the mean air temperature ta mm per ° C.
Qn= net radiation (mm of water)
Y = Psychrometric constant or the ratio of specific heat of air to the latent heat of evaporation of water.
The value of k is obtained from table depends on type of crop and particular month in a year.

4. SOFTWARE DEVELOPMENT

There are various principle methods namely lysimeter methods, Hargreaves class 'A' pan method, field plot method, Blaney-Criddle method and penman formula. These involving various parameters, various conditions, and different accuracy so study of all methods is important for various different conditions, simplicity and optimality. To achieve this software is developed in visual basic environment involving all equations. User can give input in any one or all of the methods and obtain the result of evapotranspiration by that particular method. This software is so developed that even a non technical person can use with ease. It also provides the comparative result of all the equations to obtain the most optimum value of evapotranspiration. It is in form of executable format so problem of installation is simplified. The parameter of particular field can be obtained by and its case study regarding evapotranspiration can be done easily by avoiding tedious calculations.

4.1 Advantages

Easier – easy to use understand and handle by the user extremely easy to give input and obtain the output else the job would have been tedious. It has extremely user friendly wizard

Comparison of various methods- software provides the facility of comparing result of all the methods and giving the most optimum value of all.

Avoiding tedious calculation- all the methods involve lengthy equations and tedious calculations which involves waste of time and energy. Now software nullifies the time and it is saved for more research study.

Easy Installation- It is been modified into an executable file which need not to be installed and use directly.

Planned irrigation – This provides a step further to planned irrigation and helps estimating the optimum requirement of water in the field.

5. RESULTS AND DISCUSSION

The Sugarcane crop grown in Nasik region situated at latitude 20°N by using Blaney-Criddle method consumptive use of water is calculated of year 2010.

Equation used is as

$$ET = 0.46\ P\ (T+17.8)$$

Where ET = evapotranspiration in mm/m.
P = percentage of day light in hrs in a year.

It is obtained from table giving monthly percentage of day light in hours in a year according to particular latitude and month. The value of P is directly obtained from software with giving latitude and month since it is directly synchronized with software.

T = temperature in degree Celsius

Temperature is obtained directly from GPS system and mean monthly temperature.

ET is obtained from software by giving input

Input month eg. "January"
Input latitude eg. "20 °N

Table 5.1 Monthly Evapotranspiration by Blaney-Criddle Method

Month	Mean Monthly Temp. (Celsius)	Percentage Day Light In Hours (p)	Monthly Evapotranspiration In cms.(ET)
Jan	20	7.73	134.409
Feb	22	7.26	132.916
Mar	25	8.20	161.441
Apr	28	8.52	179.499
May	30	9.14	200.970
Jun	27	9.22	190.005
Jul	26	9.25	186.369
Aug	25	8.95	176.207
Sep	25	8.30	163.410
Oct	24	8.19	157.477
Nov	22	7.58	138.774
Dec	21	7.88	140.642
Consumptive Use Of Sugarcane Crop in Nasik In Year 2010			1962.104

6. CONCLUSIONS

The knowledge of evapotranspiration has become more and more important during the last decades because of the increased use of irrigation on farmlands.

Estimating an exact value for evaporation over an area is very hard due to the unsecure parameters you have to take into account. Many models have been made, but most of them are based on empirical models and are therefore not very accurate.

So, the software developed calculates the value of Evapotranspiration, it enables the user to choose the appropriate method depending on the parameters available e.g. mean monthly temperature, runoff, etc. Evapotranspiration can also be calculated by all the available methods and obtain the accurate value of Evapotranspiration.

The software provides the user the easy handling estimating and calculating Evapotranspiration.

REFERENCES

[1]. Michael A.M., Irrigation: Theory and Practice, Vikas Publication, Second Edition, 2008, pp. 478-490.
[2]. Robert W, Using Evapotranspiration data to schedule irrigation for forages, Western Alfalfa and Forage conference, 13th December 2002.
[3]. Y. Zhang, L.K. Vu, Effect of soil water deficit on Evapotranspiration, agriculture water management 64 (2004) pp.107-122, Nov. 2003.
[4]. J.A. Tariq, M. J. Khan, Irrigation scheduling of maize crop by pan evaporation method, Pakistan, Journal of Water Resources vol.7 (2) Dec.2003.
[5]. Son Hong Vu, Application of FAO-56 for evaluating Evapotranspiration in simulation of pollutant runoff from paddy rice field in Japan, paper presented in Tokyo university of agriculture and technology,2005.
[6]. J. Sobrino, M. Gomeza, A simple algorithm to estimate Evapotranspiration, journal of hydrology 315 (2005) pp.117-125, Nov. 2005.
[7]. Q.K. Hassan, Estimating daily Evapotranspiration for forest in Atlantic maritime Canada, ASPRAS annual conference, 2006.
[8]. Donna May, Incidental recharge in the lower Flinth River basin agriculture and consumptive use, Georgia water resources conference march 29, 2007.
[9]. T.A. Awachi & T.K. Shang, application of radial basis function neural networks, paper no. 24 Evapotranspiration predictions, 2007.
[10]. H.P. Chris & W.H. Murray, Visual Basic 6 The Complete Reference, McGraw-Hill Publication, 1998.
[11]. Holzner S., Visual Basic 6. Black Book, Library of Congress cataloguing of Publication Data, 1998

BIOGRAPHIES

Mata Manish Dharamdas B.E Civil, SNJB'S COE Chandwad (Nashik) India, M.E. Construction Technology and Management (Per) at S.S.G.B COET Bhusawal, Lecturer MET BKC IOE Nashik, India

Ketan A.Salunke Assistant Professor, Civil Engineering Department, Sandip Institute of Engineering & Management, Trimbak Road, Mahiravani, Nashik 422003,India

Prof. P.P.Bhangale, H.O.D, Civil Engineering Department**,** S.S.G.B COET Bhusawal, India