Comparative Study Of Different Mathematical Models With Real Time Pan Evaporation

P. N. Dalavi[1]; P.A.Gawande[2] and A.N.Mankar[3]

[1]Post Graduate Student, Department of Irrigation and Drainage Engineering, Dr. PDKV, Akola, Maharashtra.
[2]Assistant Professor, Department of Agricultural Engineering, Dr. PDKV, Akola, Maharashtra.
[3]Assistant Professor, Department of Agricultural Engineering, Dr. PDKV, Akola, Maharashtra.

ABSTRACT :

The study was conducted to develop and evaluate different evaporation estimation models considering importance and difficulty in measurement of evaporation.Models were developed for predicting pan and pond evaporation on multiple linear regression, and energy balance method. For pan evaporation, model developed by energy balance method gave results with highest coefficient of determination (R^2 = 0.9473), lowest root mean square error (1.1403 mmday^{-1}) with closer association between estimated and observed evaporation. For pond evaporation the model developed by stepwise multiple linear regression analysis gave results with highest coefficient of determination (R^2 = 0.9638), lowest root mean square error (0.7377 mmday^{-1}) with closer association between estimated and observed evaporation.

Keywords: Pan evaporation,Linear regression, Pond

INTRODUCTION

Evaporation is a natural phenomenon, the process whereby liquid water is converted to water vapour (vaporization) and removed from the evaporating surface (vapour removal). Water evaporates from a variety of surfaces, such as lakes, rivers, pavements, soil and wet vegetation. Farm pond in rainfed agriculture ensure against drought, while increasing cropping intensity and sustaining crop productivity. Estimation of evaporative losses is of paramount importance for monitoring, survey and management of water resources, at a farm scale as well as at a regional or catchment scale. In the case of agricultural water reservoirs for irrigation (AWRIs), evaporation losses can represent a significant fraction of the total water stored during the irrigation season and could be a serious constraint for irrigation water-availability under arid and semi-arid conditions. Evaporation measurement made by the pan evaporimeter. The standard USWB Class A pan is the most widely used evaporation pan. It is made of 22 gauge galvanized iron, 120 cm in diameter and 25 cm in depth and is painted white and exposed on wooden frame in order that air may circulate beneath the pan. It is filled to a depth of about 20 cm. The water surface level is measured daily by means of a hook gauge in stilling well and evaporation is compared as difference between observed levels adjusted for any precipitation measured in standard rain gauge station.

MATERIAL AND METHODS

The study was conducted at All India Co-ordinated Research Project for Dryland Agriculture, Dr. PDKV Akola. The average precipitation is 750 mm.The climate of the area is semi arid, characterized by three distinct seasons, namely summer being hot and dry from March to May, the warm and rainy mansoon from June to October and winter with mild and cold from November to February. The combined effects of various meteorological factors were analyzed to develop estimation models for predicting pond evaporation rate on daily basis. For this purpose, daily meteorological data of Akola station for the period November 21, 2013 to March 15, 2014 were used for developing models. The estimates of evaporation rate were made from models developed based on (1) multiple linear regression and (2) energy balance. Comparison of same was made with pond evaporation measurements. Regression model has been developed by stepwise multiple linear regression analysis. For this, a number of combinations taking pond evaporation as dependent variable and other meteorological parameters as independent variables were tried upon.Thus, the multiple linear regression models took the form $E_{po} = a + b_1x_1 + b_2x_2 + b_3x_3 + \ldots\ldots + b_6x_6$ (1)

Where,

E_{po} = evaporation rate of farm pond, (mmday^{-1})

a = intercept on Y-axis

b_1 to b_z= respective partial regression coefficients and

x_1 to x_6= respective meteorological parameters

The data was analyzed by statistical package designed for data analysis on computer. Following existing evaporation models were evaluated in this study for Akola station.

1. Penman combination model
2. Priestley-Taylor model
3. Dalton model

It is necessary to develop the appropriate evaporation models under the prevailing climatological conditions to estimate evaporation directly from climatic data. Considering the above aspects study has been conducted with objectives as to estimate evaporation from the farm pond using different mathematical models and to compare different mathematical models with real time pan evaporation.

RESULTS AND DISCUSSION

Evaluation of pan evaporation estimation models

Different investigations have proposed a number of models for estimation of evaporation under specific range of data type and climatic conditions. In this study, three most commonly used evaporation estimation models viz., (1) Penman combination model (2) Priestley–Taylor model and (3) Dalton model were selected for evaluating their suitability under the semi-arid climatic conditions of Akola.

Evaporation models have been screened through testing their accuracy in predicting the evaporation rate from open water surface. Evaluation of selected models was carried out by using them for meteorological data from the period 21 November 2013 to 15 March 2014. Estimated evaporation rate were compared with observed evaporation rate. To screen the models, the present study used a highest coefficient of determination, lower Root mean square error, minimum percent deviation, and highest index of agreement. The screened models were further used to predict the evaporation from farm pond.

4.2.1 Penman combination model

Using Penman combination model the daily pan evaporation was estimated for Akola. The results are evaluated for its suitability to Akola region. Daily estimated and observed pan evaporation were compared and presented in Fig.1 and Fig. 2.

Fig.4.1shows the variation between daily observed and estimated pan evaporation during period 21 November 2013 to 15 March 2014. It is evident from Fig.1 that pan evaporation rate was underestimated throughout the period. These results are in conformity with those obtained by Shitole *et al*. (2004).

It is seen from Fig. 2 that the distribution of data points was considerably below1:1line. Coefficient of determination is high (R^2= 0.9443) between observed and estimated evaporation rate. The model error, as evidenced through the RMSE (1.8870 $mmday^{-1}$), is high with large variation in means. Similarly, percent deviation of modeled values (-31.2465 %) is also very high. On the other hand, index of agreement of modeled values (0.6273) is on lower side. Going through 1:1 line graph (Fig. 2) shows that the model is underestimating the evaporation throughout the study period. Based on error statistics, the model is unsuitable for evaporation studies under the climatic condition of Akola.

4.2.2 Priestley–Taylor model

Priestley–Taylor model was evaluated for predicting pan evaporation of Akola for the period 21 November 2013 to 15 March 2014. The

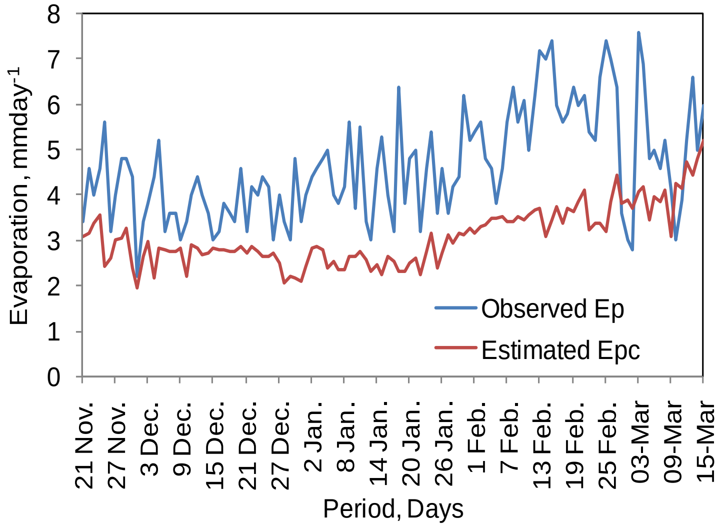

Fig. 1 Variation of daily observed (Ep) and estimated pan evaporation by Penman model (Epc)

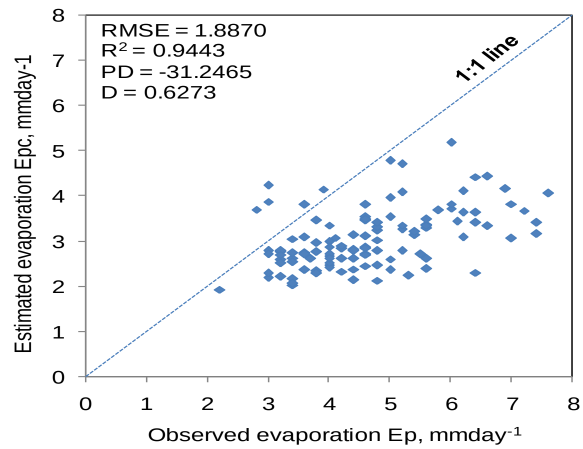

Fig. 2 Daily distribution of observed (Ep) andestimated pan evaporation (Epc) around 1:1 line

estimates were compared with observed data on daily basis. Variation and distribution of observed and estimated daily pan evaporation for Akola are represented in Fig.3 and Fig. 4.

Fig. 3 indicates underestimation of pan evaporation by Priestley–Taylor model for most of the days during the study period. These results are in conformity with those obtained by Cohen *et al.* (2007) and Arasteh and Tajrishy (2008). The curve of pan evaporation shows high deviation from that of predicted evaporation. Fig. 4 shows that almost all data points plotting below the 1:1 line indicating underestimation of evaporation rate by the model. Though the significant coefficient of determination (R^2 = 0.9463) is obtained, model error as expressed through the RMSE, is high (1.4607mmday^{-1}).

The percent deviation of modeled values (-18.3986%) is within an acceptable range. Index of agreement of modeled values (0.6923) is on lower side. The poorpredictability of the model is also evidenced from the 1:1 line graph, which shows that the modelunderestimates for a long period and overestimates for a very short period (Fig. 4). Therefore, the Priestley–Taylor model cannot be accepted as a reliable model for estimating evaporation under the prevailing climatic condition of Akola region.

4.2.3 Dalton model

Dalton model was evaluated for predicting pan evaporation of Akola for the period 21 November 2013 to 15 March 2014.The estimates were compared with observed data on daily basis. Daily estimated pan evaporation by Dalton model were compared with observed pan evaporation for Akola and presented in Fig.5 and Fig.6.

Fig. 5 indicates the overestimation of evaporation rate by Dalton model almost throughout the study period. These results are in conformity with those obtained by Shitole*et al*. (2004). The scatter plot of the daily evaporation rates predicted by the Dalton model and the corresponding observed values shows that the model is overestimating the parameter throughout the observation period (Fig. 6). However, the higher coefficient of determination (R^2 = 0.9510) is obtained. In addition, the model error, as expressed through the RMSE, is lower (1.4367mmday^{-1}) as compared to other models.

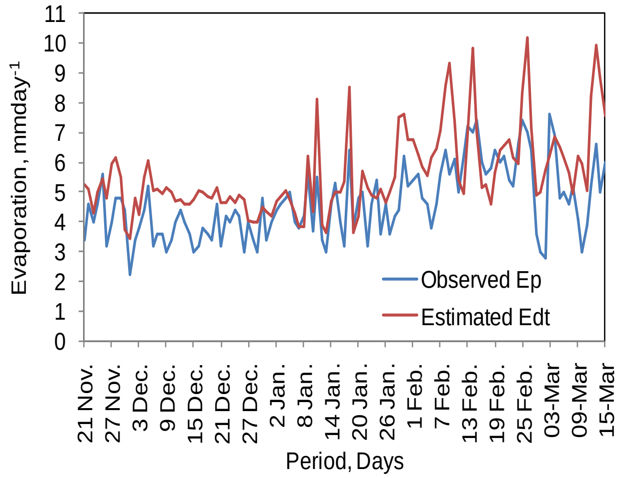

Fig. 3 Variation of daily observed (Ep) and estimatedpan evaporation by Priestly-Taylor model (Ept)

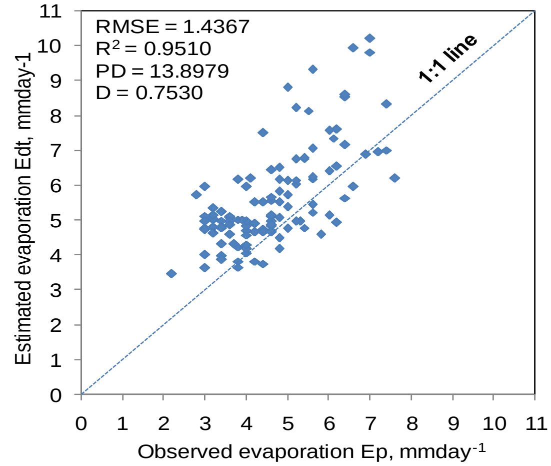

Fig. 4 Daily distribution of observed (Ep) and estimated pan evaporation (Ept)around 1:1 line

The percent deviation of the modeled values from the observed values (13.8979 %) is indicative of a model error within an acceptable range. Also an index of agreement D of modeled values (0.7530) is on higher side. Hence, the Dalton model provides reasonably adequate estimate of evaporation during the study period for climatic condition of Akola.

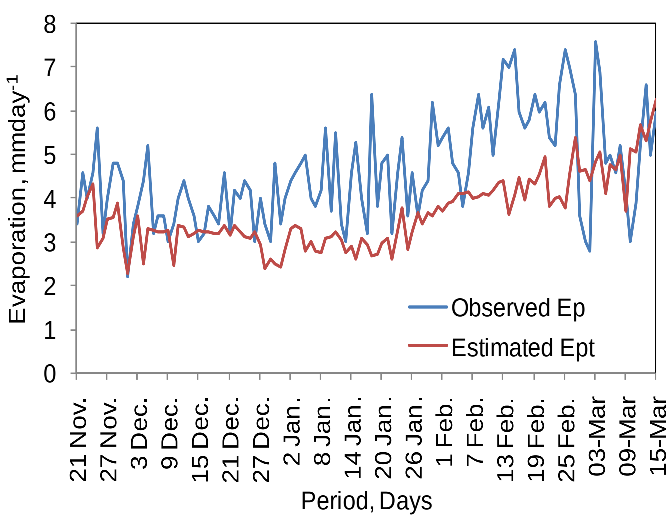

Fig. 5 Variation of daily observed (Ep) and estimated pan evaporation by Dalton model (Edt)

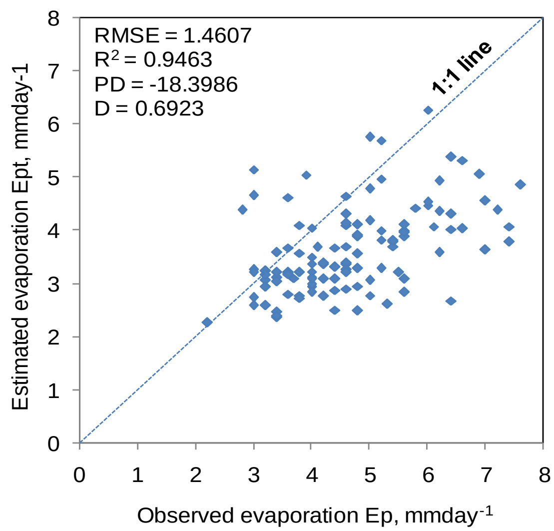

Fig. 6 Daily distribution of observed (Ep) and estimatedpan evaporation (Edt) around 1:1 line

Conclusion:

From the results, it is concluded that Multiple linear regression and Dalton models were found suitable for estimating pond evaporation at Akola. However, considering the simplicity in using and calculating daily pond evaporation, the developed model based on multiple linear regressions is having very much advantage over Dalton model. Thus, the developed empirical model is found to be simple and easy to use for predicting daily pond evaporation with better degree of accuracy for Akola region.

References:

Arasteh PD, and Tajrishy M, (2008).Calibrating Priestley-Taylor Model to estimate open water evaporation under regional advection using volume balance method-case study: Chahnimeh Reservoir, Iran.*J. Applied Sci.*, :1-10.

Benzaghta MA, Mohammed TA and Ekhmaj AI, (2012).Prediction of Evaporation from Algardabiya Reservoir.*Libyan Agriculture Research Center Journal International,* 3 (3): 120-128.

Cohen S, Assouline S, Tanny J, Berger D, Teltch B, Mekhmandarov Y, Bahar M and Katul GG (2007). Direct measurements and estimates evaporation from a small water reservoir. *Journal of Hydrology*, 351: 218-229.

Doyle P, (1990). Modeling catchments evaporation : An objective comparison of the Penman and Morton Application. *J. Hydrol.* 121(1-4): 257-276.

Khan MA, (1992).Evaporation of water from free water surface influence.*Indian J. Soil Cons.* 20(1 &2): 22-27.

Shitole AB and Deshmukh MM, (2004). Estimation of pan evaporation from meteorological parameters. M.Tech. Thesis (unpublished), Dr. P.D.K.V., Dept. of Irrigation and Drainage Engineering, Akola: 23-34.