Comparison of different Models to Measure Actual Evaporation Rates from Farm Pond

Pradip Dalavi[1], A.N. Mankar[2] and Priyanka Sharma[3]

[1,2]*Dept. of Irrigation and Drainage Engineering, Dr. PDKV, Akola, MS, India*
[3]*Dept. of Soil and Water Engineering, CTAE, MPUAT, Udaipur, RJ, India*

Abstract—*Evaporation has major role in water resources management. Now days, many forms of the equations have been developed for estimating daily evaporation worldwide. This paper presents the results of modeling the evaporation from farm pond. Three evaporation models namely Penman combination Model, Priestley-Taylor model and Dalton model were selected in order to predict the evaporation from the farm pond. The daily meteorological data were used as input to those selected models. Estimated evaporation values compared with observed pan values on daily basis. Statistical analysis was conducted to check the accuracy of the models predictions and the tests showed that there was significant difference among the three models. The comparison of daily values shows that the evaporation estimated by Dalton model gave good correlation with corrected pan values.*

Keywords*: Evaporation, Model, Priestley-Taylor, Statistical analysis.*

1. 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. Energy is required to change the state of the molecules of water from liquid to vapour. Direct solar radiation and, to a lesser extent, the ambient temperature of the air provide this energy. Solar radiation, air temperature, air humidity and wind speed are climatological parameters to consider while assessing the evaporation process**.**

Evaporation has to be considered before any water resource project planning. Information on evaporation is also required for planning of irrigation scheduling, irrigation system design, for calculating water requirement of crops and in planning, for conservation of water in agriculture. Of all the components of hydrologic cycle, evaporation is perhaps the most difficult to estimate owing to complex interaction between the components of land-plant-atmosphere system. Measurement of evaporation with accuracy is difficult task because of variations in size and shape of pans, their exposure, the growth of algae in water, incorrect water level, weed growth nearby, splashing of water in or out of the pan during rainfall, the protection against use of water by birds and animals and specific methods of measuring the loss of water from the pans. In this regard, a number of models for estimation of evaporation have been proposed and developed by several investigators for different locations. Accurate estimation of evaporation is required for efficient irrigation management.

The objective of this study is to compare the performance of internationally accepted equations for estimating evaporation from farm pond. Using Penman combination Model, Priestley-Taylor model, Dalton model, evaporation was estimated. Their values were compared with the actual evaporation recorded by a class A pan evaporimeter.

2. MATERIALS AND METHODS

The research was carried out at AICRP for Dryland Agriculture, Dr. PDKV, Akola, India, 20^0 42' North latitude and 77^0 2' East longitudes, in subtropical zone at an altitude of 307.42 m above mean sea level (MSL). The mean annual maximum and minimum air temperature are 34.80^0C and 18.49^0C respectively. In this study, meteorological dada and pan evaporation were collected from Agricultural Meteorological Observatory of Dr. PDKV, Akola, India.

There are many equations available to estimate evaporation for specific climatic regions. In this research work, most popular three models for estimating evaporation were selected to analyze and evaluate the evaporation from farm pond. These models are (1) Penman combination model (2) Priestley-Taylor model (3) Dalton model. The comparison was based on daily evaporation rates.

3. PENMAN COMBINATION MODEL

Penman (1948) presented the equation for the estimation of evaporation from open water surface. The Penman equation can be written as followers:

$$E = \left(\frac{\Delta}{\Delta+\gamma}\right) \times Rn + \left(\frac{\gamma}{\Delta+\gamma}\right) \times E_a \qquad \ldots(1)$$

Where, E=Open water-evaporation, (mmday^{-1})**;** Δ=Slope of the saturation vapor pressure curve, (kPa°C^{-1})**;** R_n= Net radiation, ($MJm^{-2}day^{-1}$); γ=Psychrometric coefficient, ($kPa°C^{-1}$);E_a= Drying power of the air, ($mmday^{-1}$);U_2=Wind speed at 2m above ground surface, (ms^{-1});e_s= Saturation vapor pressure, (kPa);e_a= Actual vapor pressure, (kPa).

3.1 Priestley–Taylor model

Priestley and Taylor proposed a simplified version of Penman's combination equation. for large bodies of water β was found to tend to 1.26. Therefore, it is possible to write Priestley and Taylor equation as:

$$E = \beta \left(\frac{\Delta}{\Delta+\gamma} \times \frac{R_n}{\lambda}\right) \qquad ...(2)$$

Where, E=Open water-evaporation, ($mmday^{-1}$); β= Priestley-Taylor coefficient.

3.2 Dalton model

Dalton (1882) enunciated the fundamental principle of evaporation from a free surface. Dalton's model is expressed as follows

$$E = f(u)\,(e_s - e_a) \qquad ...(3)$$

Where, f(u) = Function of wind speed;U_2= Wind speed at 2 m above ground surface,(ms^{-1})

3.3 Pan Evaporation

The evaporation rate from the pan estimated by using equation:

$$E_{ws} = E_{pan} \times K_{pan} \qquad ...(4)$$

Where, K_{pan} = Pan coefficient; E_{pan} = Pan evaporation rate, ($mmday^{-1}$); E_{ws} = Evaporation from the water surface, ($mmday^{-1}$).

The value of K_{pan} in the present study was found to be 0.8.

3.4 Statistical Analysis

The estimated values are subjected to statistical analysis to check the adaptability of methods for estimation of evaporation. These three evaporation models were evaluated using the statistical parameters namely, root mean square error (RMSE), Percent Deviation and index of agreement.

4. RESULTS AND DISCUSSION

Three evaporation models have been screened through testing their accuracy in predicting the evaporation rate from farm pond. Estimated evaporation rate were compared with observed evaporation rate.

4.1 Penman combination model

Using Penman combination model the daily pond evaporation was estimated for Akola. The results are evaluated for its suitability to Akola region. Daily estimation and observed pond evaporation were compared and presented in fig. 1. It is seen from fig. 1 that the model values have good degree of association (R^2= 0.9431) with observed data. The model error, as evidenced through the RMSE (0.9189$mmday^{-1}$), is also not very high. The percent deviation within 5.1938 % reveals that error is on lower side. In addition, index of agreement D (0.8965) is on higher side. Therefore, the Penman model may be used for estimating evaporation from farm pond under climatic conditions of Akola region.

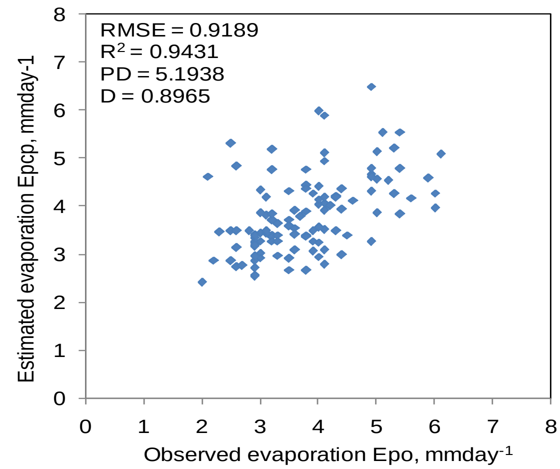

Fig. 1: Daily distribution of observed (Epo) and estimated pond evaporation (Epcp) around 1:1 line

4.2 Priestley–Taylor model

Priestley–Taylor model was evaluated for pond evaporation at Akola. Daily distribution of observed and estimated pond evaporation is represented in Fig. 2. Fig. 2 shows fair distribution of data points around 1:1 line. Regression analysis between the evaporation rates predicted by the Priestly-Taylor model and the corresponding observed values shows that the model values have strong R^2 values (0.9412).

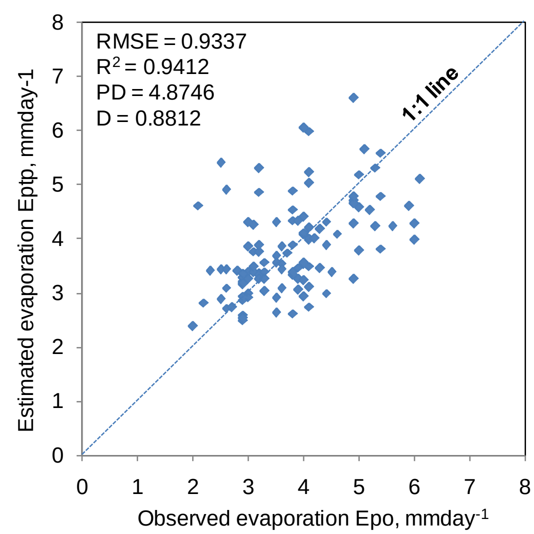

Fig. 2: Daily distribution of observed (Epo) and estimated pond evaporation (Eptp) around 1:1 line

The model error, as evidenced through the RMSE, is lower (0.9337mmday^{-1}). The percent deviation of error, (4.8746 %) reveals the suitability of model for evaporation studies. In addition, index of agreement of modeled values, D (0.8812) is on higher side. Therefore, the Priestley–Taylor model is suitable for evaporation studies in climatic conditions of Akola

4.3 Dalton model

Dalton model was applied to predict the evaporation at Akola. The estimates were compared with observed and tested its suitability. Daily estimated pond evaporation by Dalton model were compared with observed pond evaporation for Akola and presented in Fig. 3. The scatter plot of the modeled and the observed values (Fig. 3) shows that the predicted values have close association with the corresponding observed values (R^2= 0.9533). In addition, the lower RMSE (0.8615 mmday^{-1}) demonstrates the predictive ability of model. The percent deviation of the model prediction is, as expected, on lower side (5.4479 %). In addition, an index of agreement of modeled values, D (0.9146) is on higher side. Therefore, the Dalton model is suitable for estimating pond evaporation from farm pond under semi-arid conditions of Akola.

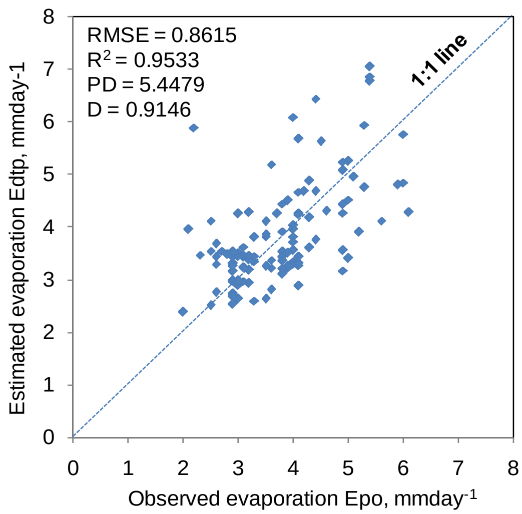

Fig. 3: Daily distribution of observed (Epo) and estimated pond evaporation (Edtp) around 1:1 line

5. SUMMARY AND CONCLUSION

From research work it is concluded that all three models can be used to estimate pond evaporation at Akola. After comparing these three different models for estimating pond evaporation it is concluded that, considering the simplicity in using and calculating daily pond evaporation, the Dalton model is having very much advantage over other two models. Therefore, it is found that Dalton model is simple and easy to use for predicting daily pond evaporation with better degree of accuracy for Akola region.

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