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551.573 (540.53)

# Estimation of reference evapotranspiration (ETo) at Parbhani, Maharashtra

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**सार** - जलवायु विज्ञान और जल विज्ञान के अध्ययन के साथ-साथ सिंचाई योजना और प्रबंधन के लिए वाष्पोत्सर्जन (ET) एक महत्वपूर्ण प्राचल है। एफएओ पेनमैन-मोंटेइथ विधि (पी-एम) एफएओ - 56 द्वारा दुनिया भर में जलवायु परिस्थितियों की एक विस्तृत विविधता पर वाष्पोत्सर्जन (ETo) के आकलन के लिए अनुशंसित विधि है और इसके लिए कई प्रकार के जलवायु डेटा की आवश्यकता होती है।इस शोध पत्र में महाराष्ट्र के परभणी की औसत दैनिक वाष्पोत्सर्जन (ETo) विशेषताओं का अनुमान लगाने के लिए एक अध्ययन किया गया है। प्राप्त हुए परिणामों से पता चला है कि, अवधि (1982-2017) की औसत दैनिक वाष्पोत्सर्जन मूल्यों की भिन्नता 3.45 मिमी प्रतिदिन (26 दिसंबर) से 10.46 मिमी प्रतिदिन (29 मई) तक थी। साप्ताहिक माध्य वाष्पोत्सर्जन (ETo) 3.59 मिमी प्रतिदिन (52वें एसएमडब्ल्यू) से 10.17 मिमी प्रतिदिन (22वें एसएमडब्ल्यू) के बीच भिन्न-भिन्न होता है। कुल वाष्पोत्सर्जन मई के महीने में सबसे अधिक (292.46 मिमी) और उसके बाद जून में (244.13 मिमी) और सबसे कम दिसंबर में (114.47 मिमी) और उसके बाद जनवरी में (126.14 मिमी) है। यह देखा गया है कि, गर्मी के मौसम (फरवरी से मई) से खरीफ (जून से सितंबर) और रबी (अक्टूबर से जनवरी) के मौसम में कुल मौसमी वाष्पोत्सर्जन में उत्तरोत्तर कमी हुई है। औसत वार्षिक वाष्पोत्सर्जन 2155.85 मिमी रहा है।

**ABSTRACT**. Evapotranspiration (ET) is an important parameter for climatological and hydrological studies, as well as for irrigation planning and management. The FAO Penman-Monteith method (P-M) is the method recommended by FAO-56 for estimation of ETo over a wide variety of climatic situations over the world and it requires many types of climatic data. A study has been carried out to estimate the mean daily ETo characteristics of Parbhani in Maharashtra. The results showed that, the variation of average daily ETo values over the period (1982-2017) ranged from 3.45 mm day$^{-1}$ (26$^{th}$ December) to 10.46 mm day$^{-1}$ (29$^{th}$ May). The weekly mean ETo varied between 3.59 mm day$^{-1}$ (52$^{nd}$ SMW) to 10.17 mm day$^{-1}$ (22$^{nd}$ SMW). The total ETo is highest in the month of May (292.46 mm) followed by June (244.13 mm) and lowest in December (114.47 mm) followed by January (126.14 mm). It is observed that, there is progressively decrease in the total seasonal ETo from *summer* season (February to May) to *kharif* (June to September) and *rabi* (October to January) seasons. The average annual ETo was 2155.85 mm.

**Key words** – Reference Evapotranspiration (ETo), Penman-Monteith method.

## 1. Introduction

Water is one of the most essential natural resource which plays a vital role in maintaining biodiversity, besides our health, social welfare and our economic development (Donald, 1968). All plants also need water to grow and produce good yield. Reference evapotranspiration (ETo) which is the measure of the potential water requirement under a given environmental condition, is a major component in agricultural water management, irrigation scheduling as well as water resource planning. The reference crop evapotranspiration is defined as the rate of evapotranspiration from a large area, covered by green grass, 8 to 15 cm tall, growing actively, completely shading the ground and is not short of water (Penman, 1948). Here, grass has been taken as the reference crop. The reference evapotranspiration (ETo) flux occurring from cropped land surfaces are essential in studies relating to hydrology, climate and agricultural water management. The successful irrigation scheduling mainly depends upon the correct estimation of evapotranspiration.

Few empirical or semi-empirical methods have been developed for estimating reference evapotranspiration from weather parameters (Jensen *et al.*, 1990). The FAO Penman-Monteith method ranked as the best method for all climatic conditions (Allen *et al.*, 1998 and Jensen *et al.*, 1990). FAO of United Nations has recommended the use of the Penman-Monteith

method as the standard method for estimation of ETo. ETo is a complex and non-linear phenomenon since it depends on several interacting factors such as temperature, humidity, wind speed and radiation.

## 2. Materials and method

The present study was carried out for Parbhani, Maharashtra which is characterized by semi-arid and tropical climate. It is intersected by 18°45' N latitude to 20°10' and 76°13' to 77°39' E longitude and altitude of 423.50 m above mean sea level. The daily weather data for 35 years (1982-2017) were collected from IMD recognized observatory at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The collected weather data (maximum and minimum temperature (°C), morning and evening relative humidity (%), bright sunshine hours (Hour day$^{-1}$), wind speed (m s$^{-1}$) and evaporation (mm day$^{-1}$) were used to work out daily mean data of all parameters and to calculate reference evapotranspiration (ETo).

### 2.1. *Estimation of reference evapotranspiration (ETo)*

#### 2.1.1. *FAO Penman-Monteith method*

In FAO Irrigation and Drainage Paper 56 (Allen *et al.*, 1998), Penman-Monteith equation has been recommended as a standard method of ETo estimation worldwide, by defining the reference surface as a hypothetical grass surface with an assumed height of 0.12 m, with surface resistance of 70 s m$^{-1}$ and albedo of 0.23 closely resembling the evaporation from extensive green grass of uniform height, actively growing, and sufficiently watered. The FAO-56 paper provides guidelines for computation of ETo which involves estimating meteorological data and a standardized calculation procedure depending upon available weather data. The FAO Penman-Monteith method is given as:

$$\text{ETo} = \frac{0.408\,\Delta(Rn-G)+\gamma\frac{900}{T+273}u2(es-ea)}{\Delta+\gamma(1+0.34\,u2)}$$

where,

ETo = Reference evapotranspiration [mm day$^{-1}$]

$R_n$ = Net radiation at the crop surface [MJ m$^{-2}$ day$^{-1}$]

$G$ = Soil heat flux density [MJ m$^{-2}$ day$^{-1}$]

$T$ = Mean daily air temperature at 2 m height [°C]

$u_2$ = Wind speed at 2 m height [m s$^{-1}$]

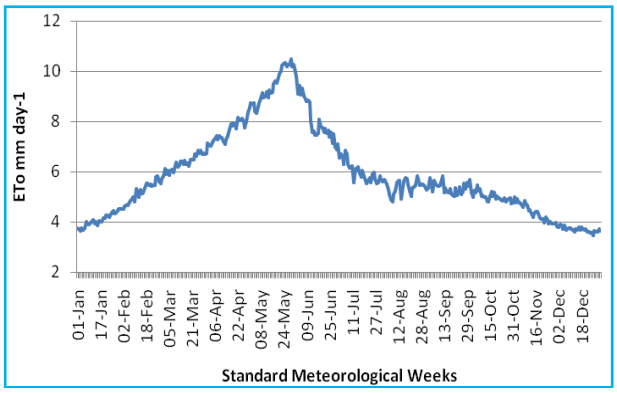


**Fig. 1.** Daily average ETo at Parbhani, estimated by FAO Penman-Monteith method

$e_s$= Saturation vapours pressure [kPa]

$e_a$= Actual vapour pressure [kPa]

Δ=Slope vapour pressure curve [kPa °C$^{-1}$]

$\gamma$ = Psychrometric constant [kPa °C$^{-1}$]

The mean of six weather parameters ($T_{max}$, $T_{min}$, $RH_{max}$, $RH_{min}$, n and $u_2$), altitudes and latitudes were used to compute each parameter required for FAO Penman-Monteith model, through a program developed in MS-Excel.

## 3. Results and discussion

### 3.1. *Variation of ETo on daily basis*

It is observed that there is large fluctuation in daily ETo at Parbhan. The daily ETo increases continuously from January and reaches to its maximum during May. The ETo reaches to its peak values during 16$^{th}$ April to 1$^{st}$ June. During June ETo decreases sharply (with the onset of monsoon) and remains low during July and August and with a slight increase during month of September (associated with withdrawal of monsoon), October and early November where after, it decreases as winter sets in. ETo was found (Mehta and Pandey, 2015) to be in the range of 3.45 mm day$^{-1}$ (26$^{th}$ December) to 10.46 mm day$^{-1}$ (29$^{th}$ May) with mean annual value of 5.89 mm day$^{-1}$ (Fig. 1).

### 3.2. *Variation of ETo on weekly basis*

It is observed that, weekly ETo increases continuously from 1$^{st}$ SMW and reaches to its maximum during 17$^{th}$-20$^{th}$ SMW and it decreases afterwards (Hajare *et al.*, 2009). The weekly mean ETo

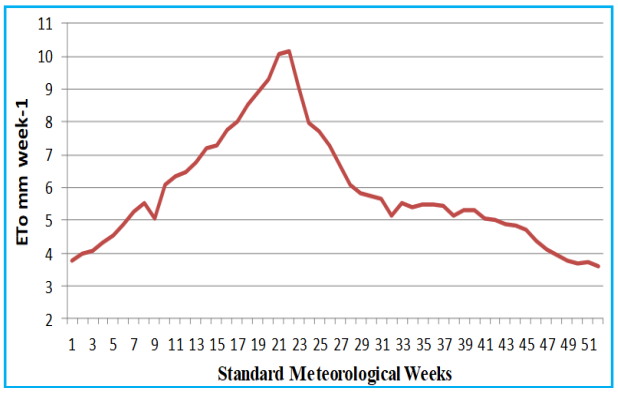


**Fig. 2.** Weekly average ETo at Parbhani, estimated by FAO Penman-Monteith method

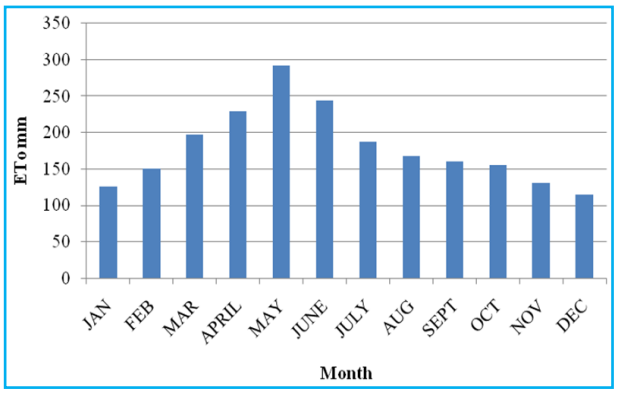


**Fig. 3.** Mean monthly ETo at Parbhani, estimated by FAO Penman-Monteith method

varied between 3.59 mm day$^{-1}$ (52$^{nd}$ SMW) to 10.17 mm day$^{-1}$ (22$^{nd}$ SMW) (Fig. 2)

### 3.3. *Variation of ETo on monthly basis*

The monthly total and mean values of reference evapotranspiration (ETo) increases continuously from January and reaches to its peak in the month of May. During June, July and August ETo decreases continuously. The ETo slightly increases in the months of September, October and it decreases afterwards. During May, the maximum ETo varies from 292.46 mm with mean monthly value of 9.43 mm day$^{-1}$. During December, the minimum ETo varies from 114.47 mm with mean monthly value of 3.69 mm day$^{-1}$. The total ETo (Hajare *et al.*, 2009) is highest in the month of May (292.46 mm) followed by June (244.13 mm) and lowest in December (114.47 mm) followed by 126.14 mm in January (Fig. 3).

### 3.4. *Variation of ETo on seasonal basis*

It is observed that there is progressively a decreasing trend in the total seasonal ETo from *summer* season (February to May) to *kharif* (June to September) and *rabi* (October to January) seasons. At Parbhani the total seasonal ETo was 868.98 mm, 759.66 mm and 527.21 mm with mean seasonal value of 7.18 mm day$^{-1}$, 6.23 mm day$^{-1}$ and 4.29 mm day$^{-1}$ in *summer*, *kharif* and *rabi* seasons respectively (Bhere, 2012)

### 3.5. *Variation of ETo on annual basis*

The average annual ETo for Parbhani based on Penman-Monteith method was 2155.85 mm (Bhere, 2012).

## 4. Conclusions

ETo was found to vary with time and season. The average daily reference evapotranspiration (ETo) is 5.89 mm per day. The month of May records the highest temperature and also higher wind speed, hence more evapotranspiration, but in the month of June, July and August ETo is less due to the occurrence of rain and associated cloudy conditions. We found that in *summer* season when the temperature and wind speed both are highest, the total ETo was maximum, while in *kharif* season, though the wind speed is high, but temperature comparatively being lower than the summer due to rainfall, the ETo is lower. In *rabi* season the temperature as well wind speed both are low so total ETo was lowest among all these three seasons This study provides the necessary information on atmospheric demand on water requirements for growing different crops in different season. This information will be very important for researchers and farmers in planning irrigation scheduling, irrigation water management studies in different seasons in Parbhani.

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The contents and views expressed in this research paper/article are the views of the authors and do not necessarily reflect the views of the organizations they belong to.

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