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UTILITY OF EMPIRICAL FORMULAE FOR COMPUTING POTENTIAL EVAPOTRANSPIRATION

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ABSTRACT

Computing potential evapotranspiration (PET), which is generally influenced by various weather parameters, is an important step in estimation of water requirements of crops. An attempt was made to utilise four prediction methods, recommended by FAO, for computing PET for Anantapur region. Modified Penman method was more suitable since a number of weather parameters are taken into consideration. PET values from the other three methods can be converted into modified Penman values with the ratios worked out.

INTRODUCTION

Computing water requirement of crops is an essential step in the proper utilization of irrigation water. Water requirement can be estimated by differnt methods, the most accurate being the field method. But this method is laborious and time consuming. Estimation of potential evapotranspiration (PET) by using empirical formulae is one of the steps in computing water requirement. The FAO group of scientists have selected four such formulae as more suitable for computing PET (Doorenbos and Pruitt 1977). An attempt was made to estimate the PET values for Bapatla in Andhra Pradesh and padegaon in Maharashtra utilising the formulae recommended by the FAO (Ramachandra Reddy et al., 1984 and Chhabda et al., 1986). Anantapur in Andhra Pradesh receives an annual rainfall of less than 550 mm and its irrigation potential is less than 20% of the cultivated area. As the irrigation water availability is meagre, there is every need to utilise the irrigation water most economically for profitable crop production. Hence an attempt was made to estimate PET values for the Anantapur region utilizing the four prediction methods.

MATERIAL AND METHODS

Anantapur is located on the Deccan Plateau at 14°41'N latitude 77°40' E longitude and at an altitude of 350 m above mean sea level. Most of the rainfall is being received during south-west monsoon period (July to October). Delayed onset and early withdrawal of monsoon with prolonged dry spells is a common feature of the monsoon in this region. The weather data recorded at Agricultural Research Station, Anantapur (Table-1) were utilised for computing PET values. Four methods recommended by FAO (Doorenbos and Pruitt, 1977) were employed :

A. Blaney-Criddle method

$$PET = C\,[P\,(0.46\,T + 8)] \qquad \text{mm/day} \ldots\ldots\ldots\ldots(1)$$

where T = Mean daily temperature (°C) over the month,

P = Mean daily percentage of total annual day time hours which depends on latitude and the month.

C = Adjustment factor, which depends on minimum relative humidity, sunshine hours and day time wind

B. Radiation method

$$PET = C\,(w.\,Rs) \qquad \text{mm/day} \ldots\ldots\ldots\ldots(2)$$

where C = adjustment factor which depends on mean humidity and day time wind

w = weighting factor which depends on temperature and altitude

Rs= solar radiation in equivalent evaporation in mm/day, calculated by equation (3)

$$Rs = (0.25 + 0.50\,n/N)\,Ra \qquad \ldots\ldots\ldots\ldots(3)$$

where Ra= extra - terrestrial radiation which is a function of latitude and the month (Table-2)

n = actual sunshine hours per day

N = possible sunshine hours per day

The actual (n) and computed (N) sunshine hours are given in Tables 1 and 2, respectively.

C. Modified penman method

For the areas where measured data on temperature, humidity, wind and sunshine hours are available, modified penman method is more useful. The procedure to calculate PET by this method is rather complicated as it takes into consideration many weather parameters.

$$PET = C\,W.Rn + (1\text{-}W\,.\,f(u).\,(ea - ed) \quad \text{mm/day} \quad \ldots\ldots\ldots(4)$$

where W = Weighting factor which depends on temperature and altitude

Rn = net radiation mm/day in equivalent evaporation

f (u) = wind related function

(ea - ed) = difference between saturation vapour pressure at mean air temperature and mean actual vapour pressure of air, both in milli bar.

Table 1 : Meteorological data recorded at Anantapur (1977-'86)

Month	Mean temp (°C)	Relative Humidity (%)			Recorded bright sunshine hours	Pan evapo-transpiration (mm)	Wind velocity (2 m height) km/hr
		Max	Min	Mean			
January	23.84	83	44	64	9.38	5.6	8.39
February	26.57	74	38	56	10.00	7.5	8.01
March	29.53	64	29	47	10.08	9.87	7.77
April	32.41	62	29	46	10.11	11.05	8.58
May	32.36	66	34	50	9.78	11.18	12.80
June	29.66	73	47	60	6.43	10.24	19.72
July	28.59	78	51	75	5.32	8.86	19.69
August	28.02	81	55	68	5.72	8.27	19.56
September	27.52	82	56	69	6.86	6·84	10.87
October	26.94	83	52	68	7.78	5.75	5.81
November	24.65	85	53	69	7.90	4.94	5.90
December	23.43	84	49	67	8.45	4.91	7.09

Table 2 : Computed weather parameters at Anantapur

Month	Ky	N h/day	Ra mm/day	W	1-W	P (%)	ea (millibar)	f (t)	f (ed)	f (n/N)	Correction factor for Penman	f (u)
January	0.6	11.3	12.4	0.78	0.27	0 26	29.528	15 368	0.146	0.85	1 04	0.813
February	0.6	11.6	13.6	0.75	0.25	0.26	34.797	16.014	0.143	0.88	1.08	0.786
March	0.6	12.0	14.9	0·78	0.22	0.27	41,319	16.606	0,143	0.86	1.08	0.772
April	0.6	12.5	15.7	0.80	0.20	0.28	48.707	17.384	0.129	0.82	1.03	0 828
May	0.6	12.8	15.8	0.80	0,20	0.29	48.428	17.362	0.124	0.79	1.03	1.101
June	0.6	13.0	15.7	0.78	0.22	0.29	41.618	16.632	0,123	0.54	0 94	1.549
July	0.55	12.9	15.7	0.77	0.23	0,29	39.157	16.418	0.121	0.47	0.94	1.546
August	0.55	12.6	15.7	0.77	0.23	0.28	37.800	16.300	0.121	0.51	0.94	1.557
September	0.65	12.2	15.1	0.76	0.24	0.28	36.792	16.604	0.121	0.61	1.01	0 973
October	0.70	11.8	14.1	0.76	0.24	0.27	35.574	16.088	0,125	0.70	0.01	06 47
November	0.70	11.2	12.8	0.73	0.27	0.26	31.035	15.562	0.133	0.72	0.98	0.654
December	0.70	11.4	12.0	0.72	0.28	0,25	28 837	15.286	0.143	0.78	0.98	0.730

C = adjustment factor to compensate for the effect of day and night weather conditions

Calculations of Rn

Rn = Rns - Rnl

Rns (Net short wave radiation)

= (1 - 0.25) Rs

Rnl (Net long wave radiation)

= f (t). f (ed). f (n/N) which are correction factors for temperature, vapour pressure and the ratio of actual to maximum sunshine hours, respectively.

Calculation of (ea-ed)

ea = saturation vapur pressure at mean air temperature in milli bar

$$ed = ea \times \frac{RH\ mean}{100}$$

D. Pan Evaporation method

Evaporation pans provide a measurement of integrated effect of radiation, wind, temperature and humidity on evaporation from open water surface.

PET = Kp. E. pan

E pan = pan evaporation in mm/day from US class A pan

Kp = pan co-efficient which depends on humidity, wind and pan environment

RESULTS AND DISCUSSION

The estimated PET values for all four methods for each month in the year are presented in Tabel-3. High PET values were recorded during the summer (March to May) and early kharif (June to August) in all the methods due to high temperature, low relative humidity and strong wind conditions prevailing at that time. Low PET values were recorded during rabi and winter season (October to December) due to mild climatic conditions. It is an established fact that temperature, relative humidity and wind velocity are the major factors which influence evapotranspiration. Highest PET values were recorded in modified Penman method because it took into consideration various weather parameters influencing evapotranspiration. Ratios of estimated PET from the three methods with modified Penman method were also calculated and are presented in Table-3. The ratios are helpful in converting the PET values from the other three methods into values by the modified Penman method. Pan evaporation data can be utilised for computing PET as as it is the easiest of all the four methods. By multiplying the PET data from Pan evaporation method with the concerned ratio, we can arrive at the PET value by modified Penman method.

Table 3 : Potential evapotranspiration (mm/day) at Anantapur calculated by four different methods and their ratios to modified Penman method

Month	Blaney Criddle (BC)	Radiation (R)	Pan evaporation (PE)	Modified (MP)	Ratios		
					MP/BC	MP/R	MP/BE
January	5.1	5.0	3.36	5.67	1.111	1.134	1.687
February	6.0	5.9	4.50	7.24	1.206	1.227	1.608
March	6.8	7.2	5.92	8.60	1.264	1.194	1.452
April	8.0	7.9	6.63	9.28	1.160	1.174	1.399
May	7.4	7.8	6.71	10.24	1.383	1.312	1.526
June	6.2	5.3	5.12	8.80	1.419	1.660	1.718
July	4.1	5.2	4.87	7.78	1.897	1.496	1.597
August	4.2	5.4	4.55	7.34	1.747	1.359	1.613
September	3.8	5.1	4.45	6.36	1.673	1.247	1.429
October	3.2	5.2	4.03	5.41	1.690	1.040	1.342
November	3.0	4.4	3.46	4.68	1.560	1.063	3.52
December	3.9	4.2	3.44	4.97	1.197	1.111	1.357

The correlation co-efficients between modified Penman and rest of the methods were calculated. Their values were 0.9460, 0.8559 and 0.8534 between modified Penman and Pan evaporation method, modified Penman and radiation method and modified Penman and Blaney-Criddle method, respectively which were highly significant. The highly significant correlation between PET values from modified Penman method to those of other methods indicates the suitability of all the methods for computing PET values. Depending on the availability of climatic data, any of the four prediction methods can be utilised for computing potential evapotranspiration for a given place.

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