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Chandrakar Harshana
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Pradhan Mukesh
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Sahu Khilesh Kumar
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author
Chandrakar Harshana
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Estimation of the potential evapotranspiration using empirical equations for Chhattisgarh plain agro climatic zone

Chandrakar Harshana, Pradhan Mukesh and Sahu Khilesh Kumar

Abstract
Evapotranspiration (ET) is one of the important parameter in hydrology and development of watershed. Concept of ET is crucial mainly in water requirements to crops and planning of any water resources structures. ET is the combined processes of evaporation from soil and plant surfaces and transpiration from plant tissues. Recently, the Food and Agricultural Organisation has suggested FAO-56 PM method (modified PM method) as a standard method for calculating reference evapotranspiration (ET0), because this method is applicable to all types of season and different climates and gives more accurate result when compared with the physical methods like Lysimeter and Class A Pan. Here nine different estimated PET methods are considered for present study, which are Modified Penman, Hargreaves, Turc, Blaney-criddle, Christiansen, Pet open Pan, Penman Monteith, Thornthwaite and Measured PET are the methods. Chhattisgarh plain agro climatic zone is selected for this research work from the period of 1993 to 2016. The objective of this study is to estimate the PET by different empirical equations on weekly, monthly, seasonal as well as annual basis. It is clear from this study that weekly and monthly PET value of Raipur station showed that the values obtained were lower during winter (Dec-Jan) and higher in summer (April-may). During the period (1993-2016) maximum annually average total PET was found for the Thornthwaite method (1958.8 mm). The minimum annually average total PET was found for Open pan method (1278.6 mm). The seasonal PET values were found minimum during winter followed by post-monsoon, monsoon and ultimately followed by pre-monsoon. Among all the methods Turc (459.5 mm), Hargreaves (575.8 mm) and Measured PET (550.3 mm) recorded the maximum value in the season of monsoon and rest were all methods recorded the maximum value in the pre monsoon season.

Keywords: potential evapotranspiration, empirical equations, plain agro climatic zone

1. Introduction
Evapotranspiration (ET) is the biological and physiological process whereby water escapes from the moist soil, water bodies and snow surface by evaporation and simultaneously from the vegetation of the same location by transpiration. Evaporation and transpiration are the important components of the hydrological cycle. This takes place continuous as natural phenomena. Over large land areas in tropical zones, about half of the annual precipitation is evaporated and transpired, while the remaining one third runoffs in rivers and oceans through the groundwater. In arid regions, evapotranspiration may be more and more significant which returned up to 90 percent of the annual precipitation into the atmosphere.
The evapotranspiration is a significant term in the water equilibrium of irrigated region. The information on ET_0 empowers irrigators to readily coordinate water systems with the necessities of effectively developing plants, in this way helping to accomplish more significant returns and improve water efficiency. A little, however normal improvement in irrigation scheduling can significantly increase over-all plant production and quality. The information of ET_0 can also be used for the critical need of water for different phenological stages of crops. With the knowledge of evaporation the interstate river water dispute could be solved. The agriculturists can quantify the effectiveness of agronomic practices with the knowledge of ET_0 and also research can be promoted.
Evapotranspiration of any crop can be obtained by direct method using lysimeter and indirect method by empirical equation. The installation of lysimeter are complex and costly to construct as well as time consuming as it needs complete a crop season to obtain seasonal evapotranspiration requirement of a crop and their operation, maintenance and repair require a special care. Therefore, their use is limited and for specific research purposes. To avoid this expenditure and time span, scientists suggested to use empirical equations to estimate the

evapotranspiration using different climatic data, many empirical equations have been developed to estimate the potential evapotranspiration.

2. Study area

Chhattisgarh is located in the centre-east of the country and Raipur is the capital city of the state of Chhattisgarh situated in the central part of Chhattisgarh. The gps coordinates of Raipur is 21° 15' 0.0000" N and 81° 37' 47.9892" E. The elevation of Raipur from the mean sea level is 298.15 m (978.18 ft).Raipur has a tropical wet and dry climate. Temperature remains moderate throughout the year, except in summers (Mar-June), which are extremely hot. The temperature in April–May sometimes rises above 47 °C.

3. Material and Methods

3.1 Data base

The daily weather parameters were collected from department of Agrometeorology, Indira Gandhi krishi Vishwavidyalaya, Raipur. The daily weather parameters are, air temperature (maximum and minimum), relative humidity, wind speed, sunshine hour and evaporation collected from 1993 - 2016. The data of lysimeter is additionally taken from the Department of Agrometeorology, Raipur from 1993-2016.

3.2 Methodology

After collecting the data it was organized systematically in MS Excel. After the collection of the daily weather data of the respective station it was checked in MS Excel. While the checking of the daily data, a wide variety of lacking values had been encountered which have been hindering the method of evaluation. For filling up those values normal for the various parameters were calculated. For the calculation of the normal, the weather cock software was used. After the quality of the data was once checked and blank values had been stuffed up the subsequent step is to calculate the PET. For this object PET software is used. Firstly, like all software want an enter file in exact layout so does the PET calculator. So we organized an enter file for character vicinity which additionally mentioned their latitude, longitude and altitude. All the necessary columns were added and at the end '&' were used. After that software was opened and the input file was browsed and processed to get the output. The output was obtained as PET values by seven different methods such as Modified penman, Turc, Penman Monthith, Blaney Criddle, Christiansen, Hargreves and PET open pan.

3.3 Conversion of PET data into monthly, weekly and annual values

Once PET was estimated with the help of software program it was converted into monthly, weekly, annual and seasonal values to carry out the further analysis. This was achieved with the help of Weather cock software.

3.4 Description of software used

Weather cock and PET calculator are the software's which were used to complete the objective of the title.

3.4.1 Weather cock

Weather cock is software developed by I Ramamohan, on AICRP of Agrometeorology CRIDA Hyderabad, which is used for many of objects example for checking data quality, data management and for the conversion of daily data. As for the run the software for those objects a specified layout of input file are required and those file were made in MS EXCEL in CSV format. So after filling the browse with input file that software did processing of the data and gave output as desired objects.

3.4.2 PET Calculator V.3

The PET Calculator V3.0 is freeware software developed by AICRPAM, CRIDA, Hyderabad to estimate PET using seven different approaches on daily, Weekly and Monthly Basis.

3.5 Different empirical equations used in this study

Different empirical equations used in this study

Different empirical equations	Formulas
Thornthwaite (1948) Method	$PET = 1.6(10T_m/ I)^a$
Hargreaves *et al.* (1985) Method	PET = 0.0023RA TD0.5 (Tm+17.8)
Turc (1961) Method	PET = 0.40 Tm (Rs+50) / (T+15)
Christiansen (1968) Method	PET = 0.755 EoCT2 CW2 CH2CS2
FAO-24 Blaney-Criddle (1977) Method	PET = a + bf
FAO-24 Modified Penman (1977) Method	PET = [WRn + (1-w) f(u)(ea-ed)] c
FAO-24 Open pan (1977) method	PET = KpEp
FAO Penman–Monteith Method	$PET = 0.408(R_n – G) + Y *900/T + 273 U_2 (e_a – e_d) \Delta + Y ((1+ 0.34 U_2)$

Above table represents various empirical formulas based on various parameters to estimate PET. Values of PET were estimated using above relations from 1993 to 2016. Thus, by the use of Ms – Excel and with the help of software's the potential evapotranspiration were estimated.

4. Results and Discussion

The Potential evapotranspiration was calculated in mm using various formulae with the help of different weather parameters such as minimum temperature, maximum temperature, rainfall, humidity and evaporation and sunshine hours for the period of 1993-2016. The different methods for which PET estimated on weekly, monthly, seasonal and annul basis are Modified Penman, Hargreaves, Turc, Blaney-criddle, Christiansen, Pet open Pan, Penman Monteith, Thornthwaite and Measured PET.

4.1 Weekly values of PET

The data on weekly PET worked out with the help of different methods are presented in Table 1 and depicted in Fig. 1. In general it was observed that the value of PET was high in the weeks of summer season and lower in the weeks of winter season. Out of weekly total PET of 52 SMW, the maximum value of PET was recorded in 21th SMW *i.e.* 95 mm with Thornthwaite equation followed by Christiansen method (64.1 mm) in 21th SMW followed by Blaney-criddle (60.6 mm) in the 20th SMW, Whereas minimum weekly PET was 7.7 mm in 51th SMW with Thornthwaite equation followed by open pan

method *i.e.* 13.5 mm under the 51th SMW.

The modified Penman, Turc, Blaney-criddle, Penman Monteith showed maximum total PET value in the 20th SMW whereas Hargreaves, Christiansen and Open pan showed highest value in the 21th SMW. The measured value of PET was maximum (37.3 mm) in the 24th SMW. The minimum PET value was recorded in 51th SMW by modified Penman, Turc, Christiansen, Open Pan, Thornthwaite, Penman Monteith and Measured PET and Hargreaves method recorded minimum value in 2nd SMW while in Blaney-Criddle method the minimum value of total PET was in 33ed SMW.

Table 1: Weekly values of PET computed by different equation at Raipur

Week	Modified Penman	Hargreaves	Turc	Blaney Criddle	Christiansen	Pet Open pan	Penman Montieth	Thornthwaite	Measured PET
1	32.0	28.6	24.1	36.4	38.3	30.3	27.6	46.0	30.0
2	21.0	22.1	20.5	22.8	18.4	15.9	17.8	22.3	28.9
3	22.0	25.8	22.2	25.7	16.9	15.4	18.8	9.3	22.1
4	22.7	26.7	22.7	26.4	16.7	15.4	19.2	9.2	26.5
5	26.2	28.8	24.2	29.8	22.4	19.8	22.3	17.5	27.6
6	32.2	27.2	23.9	30.7	35.8	27.8	28.4	51.7	31.4
7	28.1	30.9	26.6	30.8	21.7	19.2	24.1	16.8	33.3
8	31.2	33.7	28.7	35.1	24.8	21.7	26.7	19.9	34.8
9	37.3	40.4	32.8	40.4	30.0	26.0	32.2	26.6	38.2
10	34.9	31.4	26.0	31.0	34.5	27.2	30.6	50.6	34.2
11	36.2	39.3	30.6	38.6	28.7	24.8	31.2	27.5	36.9
12	41.8	43.9	33.3	45.5	36.4	31.3	35.8	36.8	37.2
13	41.6	43.9	32.8	43.7	35.7	30.5	36.2	36.5	31.7
14	42.2	39.9	31.2	39.5	40.6	32.2	37.1	51.3	34.1
15	39.3	39.6	31.7	38.1	32.5	26.9	34.8	40.4	30.1
16	53.1	48.9	37.1	54.3	51.3	41.4	46.7	64.5	28.7
17	56.3	51.6	38.2	57.9	54.2	43.7	49.9	71.4	28.6
18	46.6	46.0	33.7	45.3	40.3	32.9	41.1	50.4	30.7
19	35.3	35.8	28.6	31.6	27.1	22.2	30.9	38.6	29.6
20	61.4	52.2	37.5	60.6	62.9	49.2	54.5	92.3	30.1
21	61.0	52.5	36.6	59.6	64.1	49.9	54.4	95.0	31.1
22	49.1	47.4	34.2	49.0	44.1	35.6	43.5	59.8	31.5
23	41.2	39.0	29.7	37.5	37.2	29.6	36.0	53.4	33.8
24	42.4	41.3	29.3	37.3	41.6	31.5	37.4	53.6	37.3
25	38.4	35.9	24.5	30.3	39.6	29.5	33.3	56.2	29.4
26	35.3	34.7	24.6	28.7	31.2	23.8	30.7	45.3	29.3
27	42.2	42.3	30.8	40.5	38.7	31.2	37.2	48.5	32.6
28	29.9	33.2	26.1	26.0	22.1	18.5	26.3	31.3	32.7
29	26.4	27.7	21.4	20.1	22.9	18.2	22.6	38.2	29.5
30	27.8	27.4	22.1	21.0	22.6	18.0	24.0	37.3	33.5
31	37.9	39.4	29.8	36.3	30.5	25.5	32.9	37.9	30.2
32	34.4	33.9	27.9	30.1	27.6	22.1	30.4	38.3	30.0
33	26.2	26.4	21.8	19.2	22.7	18.3	22.5	35.8	27.9
34	26.9	26.3	23.4	20.5	21.3	17.5	23.6	36.5	28.2
35	27.3	29.1	24.7	22.6	20.9	17.7	24.0	29.8	29.9
36	39.6	36.7	28.3	35.9	39.9	31.5	34.6	53.6	32.4
37	28.8	30.1	26.8	25.0	20.2	17.2	25.4	30.3	32.3
38	28.5	27.0	26.6	23.8	23.1	19.0	25.6	38.2	35.1
39	30.1	27.9	28.6	26.8	24.2	20.2	27.1	38.3	34.0
40	38.0	35.2	27.6	36.4	37.9	30.1	33.0	46.1	30.7
41	26.9	27.3	25.2	25.9	20.1	17.1	23.3	27.6	33.4
42	28.4	28.1	27.8	29.1	21.8	18.4	24.9	27.2	35.8
43	26.6	27.9	26.3	28.7	21.0	18.1	23.0	22.7	37.0
44	28.2	29.1	25.4	31.4	24.0	20.6	24.0	24.6	32.5
45	30.3	26.3	22.6	28.6	33.8	26.2	26.6	48.3	35.5
46	23.5	26.5	23.7	27.9	17.5	15.6	19.9	15.5	26.7
47	23.2	26.5	23.9	28.8	17.3	15.4	19.4	13.9	24.5
48	22.4	26.0	22.9	27.9	17.4	15.6	18.6	12.9	23.8
49	30.7	25.4	21.8	31.6	38.1	30.0	26.6	52.7	33.2
50	21.0	24.1	21.5	25.6	16.2	14.6	17.7	13.9	25.7
51	19.7	24.1	20.5	24.7	14.2	13.5	16.4	7.7	20.6
52	22.2	27.4	23.0	27.1	15.9	14.8	18.5	8.8	23.3
Total	1755.9	1748.8	1415.8	1728.1	1558.9	1278.6	1529.3	1958.8	1608.1
Mean	33.8	33.6	27.2	33.2	30.0	24.6	29.4	37.7	30.9
SD	10.1	8.2	4.7	10.0	11.8	8.8	9.2	19.3	4.0
CV	29.9	24.4	17.3	30.1	39.4	35.7	31.2	51.3	12.9

Average weekly PET data of 24 years indicated that the maximum value of yearly PET was associated with Thornthwaite method *i.e.* 1958.8 mm followed by Modified penman *i.e.* 1755.9 mm while the minimum yearly PET recorded with Open pan method *i.e.* 1278.6 followed by Turc method *i.e.* 1415.8 mm. Thornthwaite method showed the highest SD and CV during the study whereas measured PET showed the minimum SD and CV during the study (Table 1).

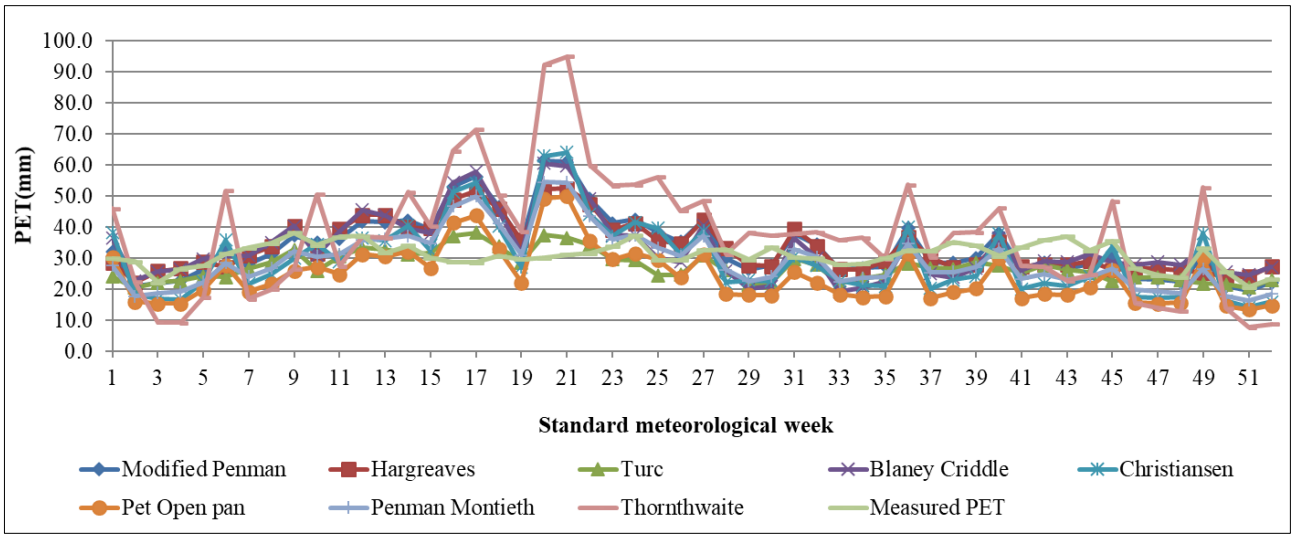

Fig 1: Weekly pattern of PET derived from different equation at Raipur

4.1.1 Monthly value of PET

The value of PET in mm obtained by different formulae based equation, are presented in Table 2 and depicted in Figure 2. Various weather parameters such as minimum temperature, maximum temperature, rainfall, humidity and evaporation and sunshine hours were used to calculate monthly PET value through various methods. In general the values obtained were lower during the month of winter (Dec-Jan) and higher in the month of summer (April-may). Out of 12 months, the maximum monthly PET value was found 318.5 mm in the month of May with Thronthwaite equation followed by Modified penman method *i.e.* 230.7 mm in the month of May. Whereas minimum monthly PET was found 77.7 mm in the month of December with PET Open Pan method followed by Penman Monteith with value of 84.5 mm in the month of December. The maximum PET was recorded in the month of May by all applied methods while the measured PET was reported maximum in the month of March. It was also noticed that the minimum PET value was recorded in the month of December with all methods used including measured PET.

The monthly average PET value recorded during 1993-2016 was maximum in the Thornthwaite method *i.e.* 1958.8 followed by Modified Penman *i.e.* 1755.9 mm and the minimum PET was recorded with Open pan method *i.e.* 1278.6 mm followed by Turc method *i.e.* 1415.8 mm. Among the all method applied, the Thornthwaite method showed the highest SD and CV during the study whereas measured PET showed the minimum SD and CV during the study (Table 2).

Table 2: Monthly values of PET computed by different equation at Raipur

Month	Modified Penman	Hargreaves	Turc	Blaney Criddle	Christiansen	Pet Open pan	Penman Montieth	Thornthwaite	Measured PET
1	107.5	114.6	99.1	122.3	97.8	83.9	91.7	91	118.3
2	126.6	129.3	110.6	136	112.2	94.6	109.3	114.8	137.9
3	169.2	173.9	135.1	175	148.3	124.9	146.5	163.8	153.4
4	202.8	192.4	147.1	201.4	188.4	152.3	178.9	239.8	129.1
5	230.7	208.9	152.2	223.2	221.8	175.5	204.4	318.5	136.4
6	168	163.1	117.6	144.9	156.5	120.6	146.9	213.9	139.3
7	138.4	143.9	110.6	117.5	115.4	93.4	120.5	167.7	140.8
8	135.9	136.9	113.1	114.2	110.9	90.9	118.9	163.7	128.5
9	135.7	131.9	118.2	119.9	112.4	92.5	120.3	163.7	141.7
10	130.9	129.9	117.7	131.8	108.9	90.7	113.7	132.5	151.3
11	110.2	115.7	101.4	125.2	96.5	81.6	93.7	102.8	121.2
12	100	108.3	93.1	116.7	89.8	77.7	84.5	86.6	110.2
Total	1755.9	1748.8	1415.8	1728.1	1558.9	1278.6	1529.3	1958.8	1608.1
Mean	146.3	145.7	118.0	144.0	129.9	106.6	127.4	163.2	134.0
SD	39.5	32.1	18.3	36.3	40.8	30.7	36.0	67.8	13.0
CV	27.00	22.02	15.54	25.20	31.40	28.80	28.25	41.55	9.71

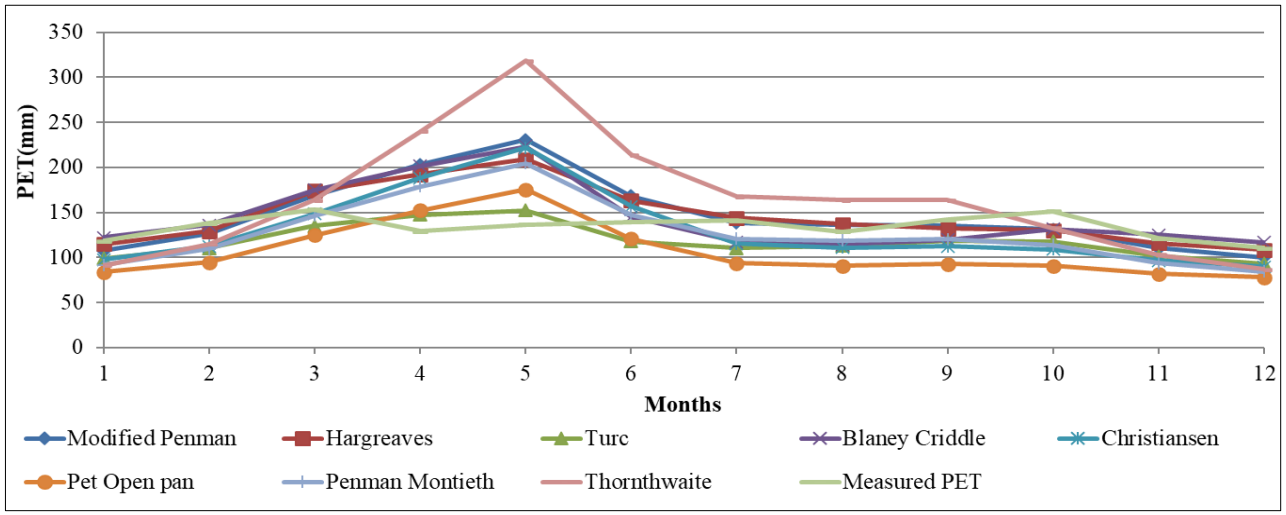

Fig 2: Monthly pattern of PET derived from different empirical equation at Raipur

4.1.2 Seasonal value of PET

As per IMD a year have been classified into four seasons *viz.* winter (jan and feb), Pre monsoon (Mar-April and May), Monsoon (June, July, Aug and Sep) and Post Monsoon (Oct-Nov and Dec). After the calculation of the weekly and monthly PET it was converted in the seasonal PET.

The seasonal data of PET are presented in Table 3 and depicted through Figure 3. The seasonal total value of PET was calculated in mm using various formulae based on different weather parameters such as minimum temperature, maximum temperature, rainfall, humidity, evaporation and sunshine hours for the period of 1993-2016. It is quite clear from the table that the PET value obtained was lower during the winters seasons (Jan-Feb) and higher in Pre-monsoon season (Mar-may). The maximum PET value was found 722.1 mm in Pre monsoon season with Thronthwaite equation followed by Modified Penman 602.7 mm. Open pan method recorded minimum value of PET *i.e.* 178.5 mm followed by Penman Monteith *i.e.* 201 mm. Among all methods applied the Turc, Hargreaves and measured PET indicated highest value of PET in the monsoon season and rest all methods reported the highest value in the pre-monsoon season. The lower value of PET was recorded in winter season in the all methods.

When seasonal PET was summed up to find out annual PET it was found that Thornthwaite method recorded highest PET *i.e.* 1958.8 mm followed by Modified penman *i.e.* 1755.9 mm while the minimum PET was associated with Open pan method *i.e.* 1278.6 mm followed by Turc method with PET value of 1415.8 mm. Among all the methods Thornthwaite method showed the highest SD and CV values during the study period whereas measured PET showed the minimum SD and CV value during the study period (Table 3).

Table 3: Seasonal values of PET computed by different equation at Raipur

Season	Modified Penman	Hargreaves	Turc	Blaney Criddle	Christiansen	Pet Open pan	Penman Montieth	Thornthwaite	Measured PET
Winter (Jan-Feb)	234.1	243.9	209.7	258.3	210	178.5	201	205.8	256.2
Pre-Monsoon (Mar-May)	602.7	575.2	434.4	599.6	558.5	452.7	529.8	722.1	418.9
Monsoon (Jun-Sep)	578	575.8	459.5	496.5	495.2	397.4	506.6	709	550.3
Post Monsoon (Oct-Dec)	341.1	353.9	312.2	373.7	295.2	250	291.9	321.9	382.7
Total	1755.9	1748.8	1416	1728.1	1558.9	1278.6	1529.3	1958.8	1608.1
Mean	439.0	437.2	354.0	432.0	389.7	319.7	382.3	489.7	402.0
SD	180.5	165.9	115.7	148.1	164.2	127.2	161.5	265.1	121.0
CV	41.1	37.9	32.7	34.3	42.1	39.8	42.2	54.1	30.1

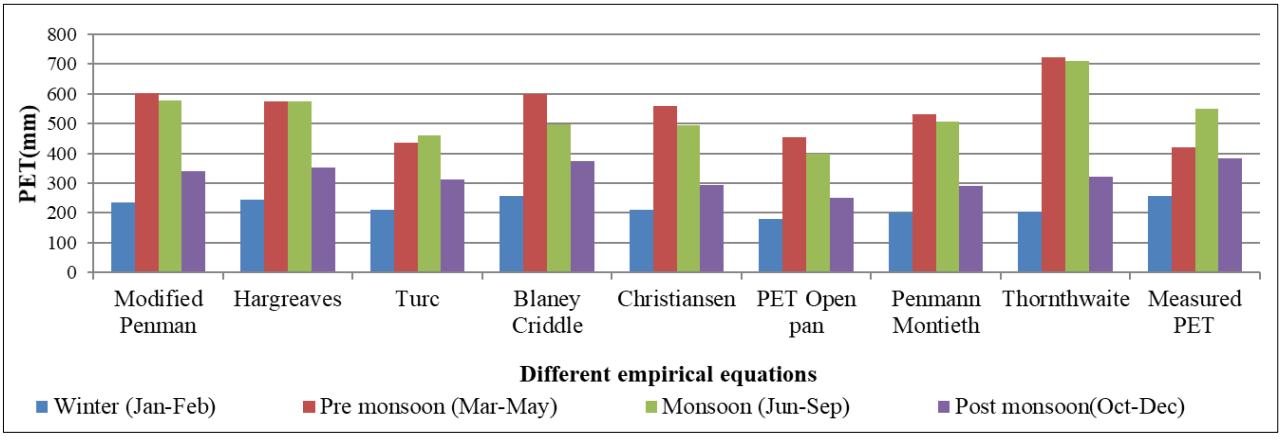

Fig 3: Seasonally pattern of PET derived from different equation at Raipur

4.1.3 Annual value of PET

The data presenting to annual value of PET calculated by various methods are presented in table 4 and depicted in figure 4. All weather parameters such as minimum temperature, maximum temperature, rainfall, humidity, evaporation and sunshine hours were used to work out PET with the help of different methods. A close observation of table indicates that the highest value of PET *i.e.* 1958.8 mm was associated with Thornthwaite method followed by Modified Penman *i.e.* 1755.9 mm while Open pan method reported lowest value of yearly PET *i.e.* 1278.6 mm followed by Turc method *i.e.* 1415.8 mm.

The highest SD and CV was recorded in measured PET during the study period followed by Thornthwaite method whereas Turc method showed the minimum SD value while Hargreaves method showed minimum CV during the study (Table 4).

Table 4: Annual PET (mm) of Raipur

Years	Modified Penman	Hargreaves	Turc	Blaney Criddle	Christiansen	Pet Open pan	Penman Montieth	Thornthwaite	Measured PET
1993	1860.0	1821.5	1472.8	1823.6	1699.6	1381.3	1643.6	1823.7	1909.6
1994	1711.0	1727.1	1377.0	1664.4	1573.3	1289.8	1489.4	1663.0	1925.5
1995	1771.1	1725.6	1432.6	1700.8	1412.1	1141.9	1556.7	1849.0	1808.5
1996	1844.1	1809.9	1467.8	1835.2	1627.1	1332.2	1609.4	2044.1	2016.3
1997	1650.8	1746.6	1400.1	1638.7	1488.4	1259.3	1441.0	1775.2	1796.7
1998	1663.7	1699.4	1403.7	1600.5	1405.6	1152.1	1464.4	1938.1	1813.3
1999	1711.3	1751.5	1378.2	1675.4	1329.1	1084.3	1486.9	1827.0	1346.6
2000	1790.7	1804.1	1456.3	1784.8	1275.2	1036.3	1565.9	1830.2	1965.3
2001	1772.5	1741.7	1413.5	1738.7	1609.8	1314.8	1543.3	1911.9	1398.6
2002	1893.7	1817.9	1458.9	1834.8	1846.6	1475.5	1660.6	2076.1	1529.2
2003	1777.3	1742.7	1410.6	1714.3	1614.2	1321.6	1548.9	2034.1	1431.2
2004	1799.6	1759.2	1446.1	1755.5	1640.5	1321.3	1580.1	1900.7	1666.6
2005	1731.6	1733.5	1369.5	1695.7	1518.6	1262.3	1501.5	1985.9	1690.6
2006	1760.1	1727.8	1403.8	1713.8	1542.9	1256.9	1525.3	1902.6	1763.0
2007	1750.7	1731.4	1402.7	1718.7	1564.0	1290.3	1521.9	1936.4	1824.5
2008	1725.6	1752.4	1354.3	1668.3	1578.1	1314.4	1494.2	1903.3	1428.4
2009	1855.1	1811.4	1431.5	1846.2	1686.6	1390.2	1603.7	2242.5	1434.7
2010	1822.0	1734.6	1471.8	1833.3	1675.1	1365.4	1588.9	2267.0	1291.7
2011	1723.2	1719.1	1455.0	1755.9	1550.6	1278.0	1493.0	1865.5	1599.2
2012	1672.6	1717.1	1387.1	1710.4	1574.7	1325.9	1432.5	2025.2	1450.7
2013	1627.8	1685.5	1372.9	1623.6	1508.2	1259.4	1400.0	1948.4	1528.5
2014	1713.9	1722.9	1382.2	1679.3	1564.0	1282.9	1487.6	2046.2	1332.1
2015	1745.0	1729.7	1409.2	1687.7	1577.5	1272.7	1529.5	2037.3	1492.3
2016	1768.2	1758.9	1421.7	1774.7	1551.9	1277.4	1535.1	2178.0	1150.2
Mean	1755.9	1748.8	1415.8	1728.1	1558.9	1278.6	1529.3	1958.8	1608.1
SD	68.3	37.7	35.5	71.1	121.3	96.4	65.2	143.9	240.2
CV	3.9	2.2	2.5	4.1	7.8	7.5	4.3	7.3	14.9

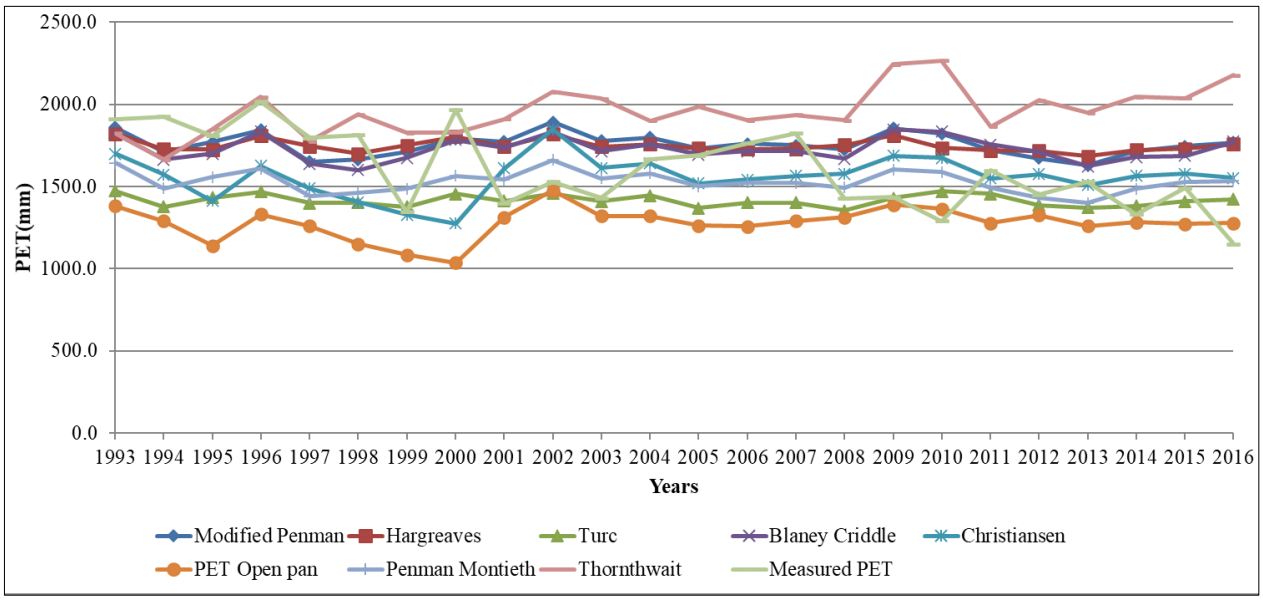

Fig 4: Annual pattern of PET derived from different equation at Raipur

5. Conclusion

1. The value of PET estimated by different empirical equations was recorded minimum during winter such as December and January. On the reverse the values of PET obtained was recorded maximum during summer such as May and June on the monthly and weekly basis.
2. On seasonal basis the value of PET obtained by different empirical equations was found minimum during winter

followed by post-monsoon, monsoon and ultimately followed by pre- monsoon.
3. The average PET value recorded during study was found maximum in the Thornthwaite method and the minimum PET was recorded with Open pan method.

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