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Annual and Seasonal Effects of Meteorological and Associated Parameters on Pan Evaporation

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ABSTRACT

This paper deals with an approach to establish a quantitative relationship between the pan evaporation and 8 different meteorological parameters using stepwise multiple regression analysis. The variables viz. evaporating power of the air (Ea) and solar radiation (Rs) were found to be the significant factors influencing pan evaporation for annual and seasonal basis while the weather parameters like air temperature, relative humidity and wind velocity showed a signigicant effect during summer season. The prediction equations fitted for different seasons and annual basis explained more than 91% variation in pan evaporation. With the help of the regression equations developed in this study it may be possible to estimate pan evaporation in South Saurashtra agroclimatic zone.

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INTRODUCTION

Evaporation from a free water surface is a good indication of the climatic condition of a region for crop production. It reflects the influence of several meteorological parameters like air temperature, sunshine hours, wind velocity, relative humidity, solar radiation, evaporating power of the air and vapour pressure deficit of a locality. It may be pointed out that pan evaporation data are mainly used for predicting evapotranspiration and water requirement of crops. Since actual measured pan evaporation data are not readily available in most of the locations, it becomes assertive to use formulae which can estimate pan evaporation from available climatic data. A number of empirical methods have therefore been proposed by several investigators (Penman, 1948; Fitzpatrick, 1963; Christiansen, 1968; Linacre, 1977; Singh *et al.* 1981; Senapati *et al.* 1985; Swan and Volum, 1986; and Cahoon *et al.* 1991) in different countries and India. The major limitation to the use of these formulae is that they can be used in the climates, seasons or environments from where they were evolved. Therefore, the present study is an attempt to investigate the influence of some meteorological and associated parameters on evaporation as measured in a class a type pan evaporimeter at Junagadh under South Saurashtra agroclimatic zone on annual as well as seasonal basis.

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MATERIALS AND METHODS

Daily meteorological data for 27 years (1965-91) was collected from the agro-meteorological observatory at Junagadh campus (21°30' N lat., 70°30' E long., 61 m msl). The location represents subtropical semi-arid type of climate with an annual average rainfall of 916.7 mm. The associated parameters such as (1) Evaporating power of the air (Ea), (2) Solar radiation (Rs), (3) vapour pressure deficit (VPD) were computed using standard meteorological formulae as described in FAO (1983) from the routinely recorded meteorological parameters viz., maximum and minimum temperature, morning and afternoon relative humidity, wind velocity in km/hr and bright sunshine hours. Mean air temperature (T) and temperature range (TR) were calculated using maximum and minimum temperature, and mean relative humidity (RH) by averaging morning and afternoon r.h. values. Weekly values of all the above variables were compiled and computed to a single estimate for 52 weeks of the years and used for further analysis.

The analysis of data was carried out in two steps. In the first step, the mean, coefficient of variation and correlation coefficients for all the variables were estimated and tested for significance to 5% level. In the second step, stepwise multiple regression analysis was undertaken to assess quantitatively the relative importance/influence of each variable on evaporation for each season separately. A software package MICROSTAT was used for the above purpose.

Considering uniformity in weather conditions the whole year was divided into four seasons (1) monsoon (June to September), (2) post monsoon (October-November), (3) winter (December-February) and (4) summer (March-May) to study the effect of weather variables on evaporation during each season.

RESULTS AND DISCUSSION

Mean and variability of weather variables

The mean, coefficient of variation (CV%) and correlation coefficients (r) between pan evaporation and weather variables are given in Table 1 indicating the effect of variables during different seasons and on annual basis. The daily mean evaporation rate is 7.1 mm with 29 per cent variability during the whole year. The rate of evaporation during monsoon, winter and summer seasons were 6.0 mm, 6.3 mm and 10.1 mm respectively with the highest variability of 29% during monsoon season. This may be attributed to the influence of other variables which show very high variability (Table 1). The high variability of weather variables indicates their responsibility to influence pan evaporation during different seasons (Fatzpatrick, 1963).

Correlation studies

From the correlation analysis it was observed that most of the correlation coefficients were highly significant at 1% level except for the 2 month period of post monsoon season. The relative humidity had negative correlation during all the seasons except summer season. All the weather variables except evaporating power of the air (Ea) and vapour pressure deficit (vpd) were found to be associated with evaporation significantly during summer season.

In view of various effects of meteorological parameters with evaporation, stepwise multiple regression analysis was carried out to

TABLE 1

Mean, coefficient of variation (CV) and correlation coefficient (r) of weather variable for different seasons at Junagadh.

Variables	Annual			Monsoon			Post monsoon			Winter			Summer		
	Mean	CV%	r	Mean	CV%	r	Mean	CV%	r	Mean	CV%	r	Mean	CV%	r
EO mm/day	7.1	29	_	6.0	29	_	6.0	8	_	6.3	15	_	10.1	7	_
Ea mm/day	5.6	36	0.868**	3.7	49	0.947**	5.5	16	0.366	5.6	15	0.920**	8.1	6	-0.198
Rs mm/day	8.6	14	0.849**	8.1	9	0.551*	7.8	8	0.600	7.4	10	0.965**	9.8	5	0.862**
Td°C	15.6	30	0.193	9.6	19	0.048	17.4	9	0.470	20.5	3	-0.551*	17.4	13	-0.75**
T°C	26.6	14	0.513**	28.5	6	0.939**	26.8	7	0.415	21.3	6	0.649*	29.3	7	0.880**
RH %	59	25	-0.374**	78	8	-0.667**	55	12	-0.016	46	9	-0.834**	51	15	0.781**
W, km/hr	7.7	34	0.501**	9.4	32	0.833**	5.0	16	0.190	6.4	10	0.625*	8.8	16	0.803**
BSS hr/day	7.9	33	0.460**	4.7	48	0.221	8.9	5	0.697*	9.5	5	0.834**	9.8	4	0.647*
VPD mm Hg/day	10.5	34	0.777**	6.6	38	0.784**	11.8	10	0.518	10.3	14	0.912**	14.8	8	-0.164

* Significant at 5% and ** at 1% levels

find out the most influensive parameters for different seasons and on annual basis at Junagadh.

Multiple regression analysis

In the multiple regression analysis six variables out of eight were found to influence the pan evaporation significantly in different seasons and annual basis. The linear models derived for different seasons are given below :

(1) Annual (52 weeks)

$$E_0 = -3.7629 + 0.5983\ Ea + 0.7218\ Rs + 0.1949\ W$$

(14.95) (9.36) (7.22)

$$r^2 = -0.9561$$

(2) Monsoon (June-September) 17 weeks

$$E_0 = -8.0459 + 1.2750\ Ea + 0.1203\ RH$$

(13.1) (4.55)

$$r^2 = 0.9585$$

(3) Post monsoon (October-November) 9 weeks

$$E_0 = -0.7654 + 0.6207\ Ea + 1.0909\ Rs + 0.1178\ TD - 0.8056\ BSS$$

(4.12) (5.98)

$$r^2 = 0.9484$$

(4) Winter (December - February) 13 weeks

$$E_0 = -3.2445 + 0.6740\ Ea + 1.5569\ Rs - 0.5683\ VPD$$

(3.38) (6.00) (3.16)

$$r^2 = 0.9722$$

(5) Summer season (March - May) 13 weeks

$$E_0 = 2.5079 - 0.4892\ Ea + 0.5190\ T - 0.1816\ RH + 0.6348\ W$$

(4.32) (3.04) (3.30)

$$r^2 = 0.9077$$

Numbers written in the brackets are 't' values of corresponding parameters indicating their significant contribution in the equations. Evaporating power of the air (Ea) was found to be the most common factor influencing pan evaporation in association with either relative humidity in monsoon season, or solar radiation and vapour pressure deficit in winter season or with wind velocity on annual basis at Junagadh station. The linear models derived in this study

showed more than 96 per cent predictability with nearly 98% of total variation in evaporation on annual basis.

The analysis reveals that the meteorological parameters have selective and significant influence on pan evaporation seasonally and annually under South Saurashtra agroclimatic conditions prevailing at Junagadh. The estimation equations developed in this paper can successfully be used to predict evaporation in this zone. However, it is necessary to make similar studies at other stations located in different agroclimatic zones.

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