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COMPARATIVE STUDY OF TEMPERATURE BASED EQUATIONS IN ESTIMATION OF POTENTIAL EVAPORATION FOR ANGUNA-KOLAPELESSA IN THE ARID ZONE OF SOUTHERN SRI LANKA

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Abstract: The methods of Penman, Thornthwite, Linacre, and Ivanov were used to estimate potential evaporation for Angunakolapelessa. The estimates were compared with adjusted values of evaporation measured by the Class A evaporation pan. The Ivanov's equation gives reliable estimates of potential evaporation provided that the average wind speed of the area is $<$ 9 km/hr. The regression analysis indicated that in Angunakolapelessa where the fluctuation of air temperature in the annual cycle is low, the potential evaporation has a more significant relationship with relative humidity. A regression equation is proposed to measure the potential evaporation of the area including the relative humidity as the only climatic variable.

1. Introduction

Several dozens of empirical or semi-empirical temperature based methods have been applied with considerable success in various parts of the world for estimation of evapotranspiration.[2,3] All these methods work on the assumption that abundant water is available for free evaporation.

In the early stages, N.N. Ivanov[1] used the relationship between temperature and relative humidity to estimate the potential evaporation (PE). Blaney and Criddle[4] related PE to daytime hours and the mean monthly temperature; Thornthwite[6] has related PE to air temperature and the monthly heat index.

A much more complex effort demanding more meteorological data was suggested by Penman.[4,5] The equation which he developed links PE rate to the net flux of radiant energy at the surface and to the effective ventilation of the surface by air in motion over it. The Penman's equation is most widely used in hydrology today. A simplified Penman equation was suggested by Edward T. Linacre[3] relating PE to temperature, dewpoint and altitude.

Since all these equations have their limitations of application for a given location, work on the accuracy of estimation should be conducted in each hydrological region. Although the Penman approach is well established, investigations are still being conducted on the computation of Penman's potential estimates for tropical countries.[2] The aim of the present research is to evaluate the impact of meteorological factors on actual evaporation and to compare values of potential evaporation derived using Penman's with those of simpler equations and actual evaporation measured by the class A Evaporation Pan.

2. Materials and Methods

The monthly meteorological data measured by the AngunaKolapelessa Meteostation for 6 consecutive years (1977–1982) were used for the study.

In order to determine the individual effects of air temperature, wind speed and relative humidity of the location on actual evapotranspiration, a correlation analysis was conducted. The combined effect of each meteorological factor on potential evaporation was calculated by the multiple regression method.

The estimated values were correlated with pan evaporation data to select the most suitable method for the location. Data were analysed in the Computer Centre, Climatic Research Unit, University of East Anglia, U.K.

3. Results and Discussion

The rainfall distribution of the Angunakolapelessa area follows a well expressed bimodal pattern. The mean annual rainfall during 1977–1982 was 1091 mm. On the basis of rainfall January–March and July–September are comparatively dry months (Table 1). The highest rainfall is in November. January and February are normally associated with drought.

The mean average temperature of the region is 27.5°C. The lowest temperature (26°C) is recorded in December–February which is probably associated with the low solar radiation.

The amount of rainfall received in May and November exceeds the amount evaporated by free water surface (Table 1). The average annual climatological constant of the area according to N.N. Ivanov is 0.57. The climate of the area approaches the dry steppe, where agriculture may not be feasible without providing irrigation. Forest belts and soil moisture conservation methods are advisable in order to conserve soil moisture.

Table 1 : Meteorological data from Angunakolapelessa

	Jan	Feb.	Mar.	Apri.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Average Temperature C^{O}	25.0	25.9	27.1	28.2	28.4	28.1	28.2	28.0	28.0	28.6	27.5	26.6
Relative humidity	75.8	74.2	75.2	78.3	80.0	76.9	73.1	71.0	69.6	72.5	78.9	83.4
Average wind speed (km/hr)	7.0	7.6	7.1	6.2	6.9	9.7	10.0	11.4	10.2	10.7	6.6	5.2
Rainfall mm (P)	18.4	37.2	36.5	113.6	149.0	75.9	55.4	52.4	63.5	129.4	258.3	101.5
Pan Evaporation (E) mm	154.0	154	176	150	143	156	177	190	177	174	141	122
Climatological coefficient (P/E)	0.11	0.24	0.20	0.76	1.04	0.49	0.31	0.27	0.35	0.74	1.83	0.83

The estimated values of potential evaporation by Linacre, Penmann Thornthwite and Ivanov's methods were significantly larger than the measured Pan Evaporation by about 91.3%, 81.2%, 37.9% and 8.9% respectively and the estimates were significantly differed from the measured Pan Evaporation values.

The monthly estimates of Penman's and Ivanov's values with actual evaporation values is more similar. But the correlation between Penman's and actual values is less pronounced compared to the estimated values by Ivanov's equation (Table 3). Nevertheless it is noteworthy that PE estimated by Ivanov's equation has a significant high correlation with estimated values by Penman's method.

Derivation of actual potential evaporation (Table 2) from evaporation data when the pan coefficient is considered as 0.7 will enable the Ivanov's equation to be used with more confidence. Nevertheless there is a significant difference in computed values by the Ivanov method over the measured values when high winds are prevailing during June-October. This indicates that the Ivanov method gives reliable estimates of potential evaporation on the monthly basis provided that the average wind speed is less than 9 km/hr.

In Angunakolapelessa where the fluctuation of air temperature in the annual cycle is low the potential evaporation has a more significant relationship with relative humidity (Table 4) than with temperature or other environmental factors.

4. Discussion

The actual evaporation values measured by the Class A pan evaporimeter agree with the potential evaporation values calculated by N.N. Ivanov's method. Nevertheless Ivanov's model would operate satisfactorily if the wind speed of the area is low.

The calculated correlation coefficients (Table 4) give an idea of the probable effect of wind and other meteorological factors on the actual evaporation of the area.

The possible regressions of each meteorological factor over the evaporation in different possible combinations are given in Table 5. The analysis of variance of the data indicates that the effect of relative humidity (x3) on evaporation is highly significant whether or not the temperature (x4) and wind (x2) have an effect on it. If relative humidity is assumed to have an effect on evaporation, then the effect of temperature and wind speed is non-significant even at the 10% level. Similarly if relative humidity and temperature have an effect on evaporation then the influence of wind is non-

Table 2 : Potential *Evaporation for Angunakolapelessa*
Estimated and Actual values. (mm/month)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1. Actual ET	108	108	123	105	100	109	124	133	124	122	98	85	1339
2. Penmann	183	180	199	191	201	214	223	235	220	221	185	174	2426
3. Linacre	187	178	212	218	230	220	229	225	216	232	210	205	2562
4. Thornthwite	105	119	144	166	175	170	173	166	163	180	153	132	1846
5. Ivanov.	109	121	123	110	103	118	138	147	154	143	105	87	1458

Table 3 : Simultaneous Correlation coefficient of Potential *Evaporation* Estimated by different Methods (n=60)

Method	1	2	3	4	5
1. Actual	1.000	0.376	0.388	0.533	0.736
2. Linacre		1.000	0.954	0.680	0.554
3. Thornthwite			1.000	0.656	0.420
4. Penmann				1.000	0.757
5. Ivanov.					1.000

Table 4 : Correlation coefficients between actual Evaporation and Environmental Factors.

Meteo Readings	1	2	3	4
1. Evaporation	1.000	0.528	−0.739	0.384
2. Wind speed		1.000	−0.735	0.448
3. Relative humidity			1.000	−0.387
4. Air temperature				1.000

Table 5 : Analysis of variance of the different meteorological factors over the evaporation

S.V.	S.S.	D.F.	M.S.	F. Value
Regression of X_2 X_3 X_4	14273.3	3	4745.76	23.65*
X_2 X_3 ignoring X_4	13905.3	2	6952.65	34.65*
X_2 X_4 ignoring X_3	7773.8	2	3886.9	19.37*
X_3 X_4 ignoring X_2	14169.4	2	7084.7	35.31*
X_2 ignoring X_3 X_4	7089.3	1	7089.3	35.33*
X_3 ignoring X_2 X_4	13892.3	1	13892.3	69.24*
X_4 ignoring X_3 X_2	3746.61	1	3746.61	18.67*
X_2 assuming X_3 ignoring X_4	13.0	1	13.0	0.064
X_4 assuming X_2 ignoring X_3	684.5	1	684.5	3.41
X_2 assuming X_4 ignoring X_3	4027.19	1	4027.19	20.07*
X_4 assuming X_3 ignoring X_2	277.1	1	277.1	1.38
X_2, X_4 assuming X_3	345.0	2	172.5	0.85
Error	11235.7	56	200.6375	
Total	25473	59		

X_2 Average wind speed Km/hr
X_3 Relative humidity, %
X_4 Air temperature C

significant. Therefore it is clear that the relative humidity alone is sufficient to explain the variation of potential evaporation at the 1% level.

The regression line with relative humidity alone in the model would read as

$$y = 346.69 - 3.1185\, x_3 \quad (x_3 = \text{Relative humidity})$$

This regression line would be a useful tool in estimating potential evaporation for Angunakolapelessa.

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References

1. BESMENOV, A.I., ROSIN, V.A. (1974). Selsko. Hasyast Vennaya Melioratia; Moscow.

2. Institute of Hydrology Research Report 1978–81. Water use by Tropical crops pp. 69–70.

3. LINACRE, E.T. (1977). A simple formula for estimating evapotranspiration rates in various climates, using temperature data alone. *Agric. Meteorology* **18**: 409–424.

4. PENMAN, H.L. (1963). *Vegetation and Hydrology. Technical Communication* No. 53. C.A.B. 1963.

5. PENMAN, H.L. (1948). Natural Evaporation from open water, bare soil and grass. *Proc. Roy. Soc. Lond.* (A) **193** : 120 – 145.

6. THORNTHWITE, C.W. (1948). An approach toward a rational classification of climate. *Geogrl. Rev.* **38**: 85–94.