SEASONAL VARIATION OF EVAPORATION RATE WITH SOME METEOROLOGICAL PARAMETERS IN UYO, NIGERIA

ISSN: 2141 – 3290

BILLY, U. A., UTAH, E. U.
AND *AKPAN, U. E.
Department of Physics,
University of Uyo, Uyo, Nigeria
**Corresponding author: +2348132335245,*
e-mail: udosenakpan@yahoo.com

ABSTRACT: The seasonal variation of evaporation rate with some meteorological parameters has been examined. The data used were that of Uyo, Nigeria located on latitude 5o18’53.7’’N and longitude 7o59’39.3’’E. The parameters include solar radiation, relative humidity, temperature, pressure and wind speed. The data covered a period of five years (2004 to 2008) and were collected from Nigeria Meteorological Agency in Uyo, Akwa Ibom State. The correlation coefficients of 0.99, 0.98.0.85, 0.54 and 0.71 were obtained for solar radiation, relative humidity, temperature, pressure and wind speed respectively. The dry and wet season were also observed to have affected the evaporation rate.

INTRODUCTION

The rate of evaporation at any time and place depends on some meteorological factors such as wind, temperature, pressure, relative humidity and solar radiation. Several empirical models have been developed to estimate the rate of evaporation. Shuttleworth (1993) modified and adapted the foremost Penman equation by using SI unit to calculate evaporation. Iruthayaraj and Morachan (1977) developed appropriate relationship between a sunken screen open pan evaporimeter and a can evaporimeter in order to determine the relationship between meteorological parameters and evaporation. It was observed that the sunken screen open pan evaporimeter recorded much lower values of evaporation than the can evaporimeter. Johnson and Sharma (2008) analyzing evaporation records in Australia observed that pan evaporation trends were mainly negative with a significant level of 5% while Penman evaporation trend was positive with no statistical significance. Rim (2004) in his study observed that solar radiation was the most sensitive meteorological factor affecting evaporation while wind speed was the least sensitive factor. Other studies on the estimation of the rate of evaporation include that of Surinder and Mahesh (2008) and Ahonsi (2004). The parameters used in estimating evaporation rate include average temperature, relative humidity, wind speed, sunshine hour, solar radiation and air pressure. In this study we examine seasonal variation of evaporation rate with some meteorological parameters.

METHODOLOGY

Daily evaporation, solar radiation, relative humidity, maximum and minimum temperature, pressure and wind speed were obtained from Nigeria Meteorological Agency in Uyo. The data covered the period of five years (2004 t0 2008). Uyo is located on latitude $5^{o}18'53.7''$N, longitude $7^{o}59'39.29''$E and altitude of 180m above the sea level. It has equatorial climate season having much rain between March and October and dryness between November and February. Monthly averages of the data were computed and used for the analyses. The estimated evaporation rate obtained by using Penman equation modified by Shuttleworth (1993) was compared with the observed evaporation. The equation is given by

$$E_{mass} = \frac{m\,R_n + \gamma \times 6.43\ (1+0.536 \times u_2)\ \delta_e}{\lambda_v\ (m+\gamma)} \tag{1}$$

where

E_{mass} = Evaporation rate (mm day^{-1})
m = Slope of the saturation vapour pressure curve ($kPaK^{-1}$)
R_n = Net irradiance (MJ m^{-2} day^{-1})
γ = Psychrometric constant = $\frac{0.0016286 \times P}{\lambda_v}$ ($kPaK^{-1}$)
U_2 = Wind speed at 2m height (m s^{-1})
δ_e = Vapour pressure deficit (kPa)
λ_v = Latent Heat of Vapourisation (MJ kg^{-1})

Using the data obtained the average estimated evaporation rate was computed to be 2.08mm/day. The average observed evaporation was 2.07mm/day. Regression analysis was done to determine the effect of each parameter on the evaporation. The resulting regression equations are presented in equ. 2 to equ. 6.

RESULTS AND DISCUSSION

The results of the monthly estimation of the evaporation with different meteorological parameters are presented in Table 1.The correlation of these values is presented in Fig.1 showing a high correlation coefficient of 0.98.

Table 2: Monthly observed and estimated values of the evaporation with different meteorological parameters

Month	Evaporation Observed (mm/day)	Evaporation Estimated (mm/day)	Average Temperature (^oC)	Pressure (mb)	Relative Humidity (%)	Solar radiation $MJm^{-2}day^{-1}$	Wind speed (m/s)
January	3.72	3.67	28.3	29.6	70.6	31.6	36.9
February	3.54	3.64	29.7	29.3	72	29.9	41.5
March	2.74	2.74	29.3	29.4	79.6	28.5	45.1
April	1.98	2.1	28.3	29.7	82.8	17.1	43.1
May	1.64	1.88	27.7	29.8	83.6	13.7	32.9
June	1.36	1.43	26.9	30	86.2	12	26.1
July	1.1	1.03	26.3	29.7	89.2	9.4	22.9
August	1.28	1.12	26.1	30	88.4	11.1	21.7
September	1.24	1.33	26.7	30	86.4	10.25	21.7
October	1.48	1.62	27.4	29.8	84.8	12.8	23
November	2.2	2.01	28	30.1	82.2	17.1	24.5
December	2.5	2.34	28.2	30.2	80.8	21.35	28.5

The regression equations are obtained as follows.

$$E = -16.767 + 0.679\ T\ (R = 0.85,\ \sigma = 0.495) \tag{2}$$

$$E = 54.64 - 1.764P\ (R = 0.54,\ \sigma = 0.789) \tag{3}$$

$$E = 14.41 - 0.15\ RH\ (R = 0.98,\ \sigma = 0.179) \tag{4}$$

$$E = -0.108 + 0.071WS \ (R = 0.708, \sigma = 0.664) \quad (5)$$

$$E = -0.003 + 1.013 \ SR \ (R = 0.998, \sigma = 0.064) \quad (6)$$

Where E is the evaporation, T is temperature, P is pressure, RH is relative humidity, WS is wind speed and R is solar radiation.

It is observed that solar radiation, relative humidity and temperature have high regression coefficients of 0.998, 0.98 and 0.85 respectively, while pressure and wind speed have low regression coefficients of 0.54 and 0.708 respectively.

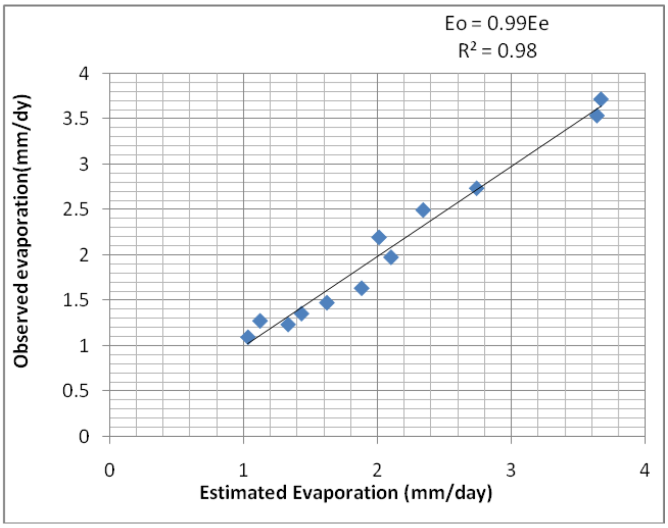

Figure1: Correlation between observed (Eo) and estimated (Ee) evaporation

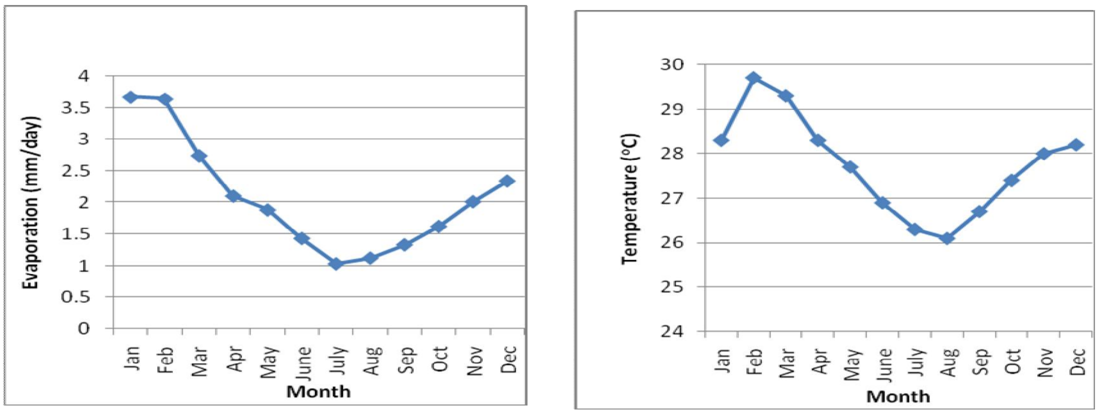

Figure 2: Variation of evaporation with temperature

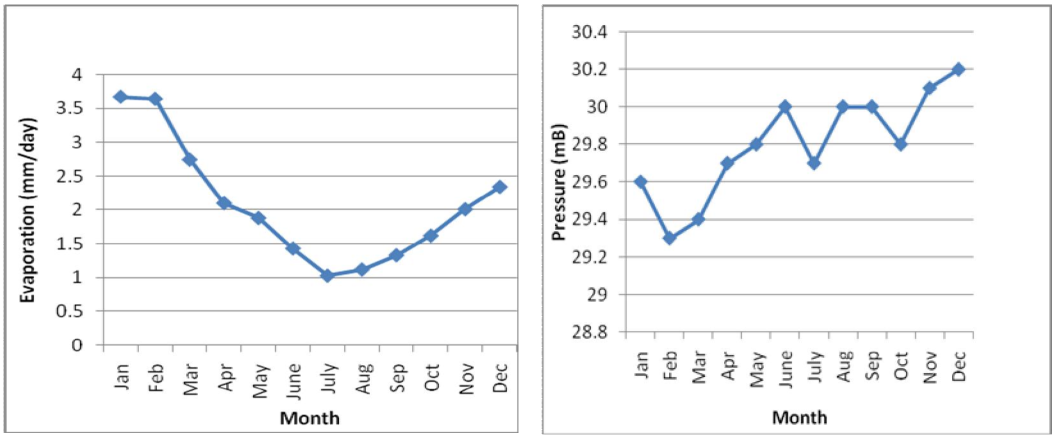

Figure 3: Variation of evaporation with pressure

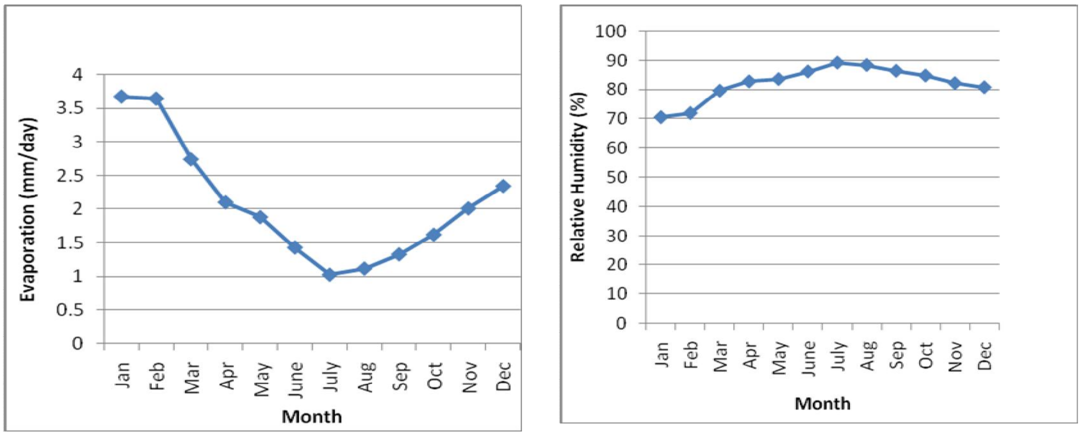

Figure 4: Variation of evaporation with relative humidity

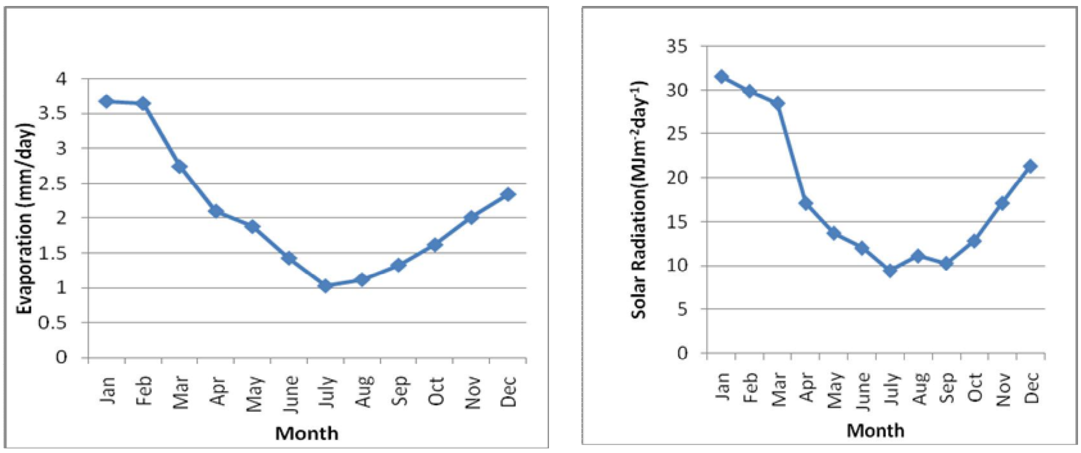

Figure 5: Variation of evaporation with solar radiation

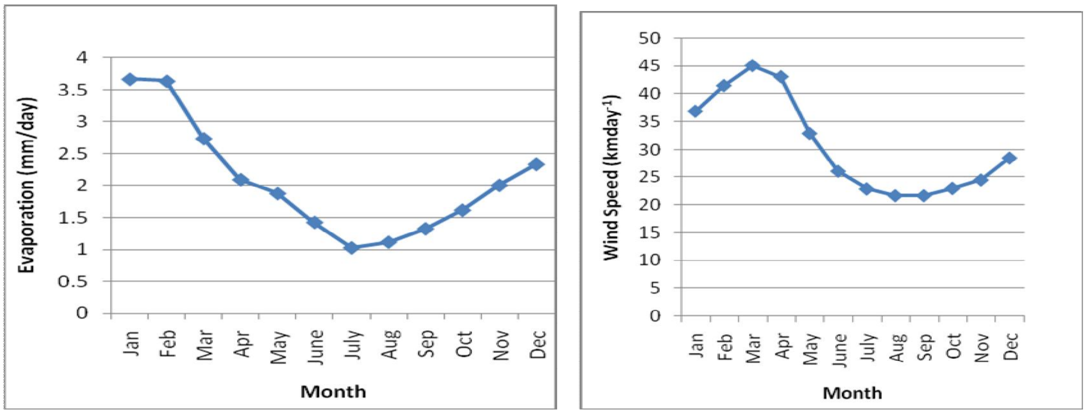

Figure 6: Variation of evaporation with solar radiation

It is observed that during the wet season which falls within the months of May and October the average rate of observed evaporation is low with the value of 1.35 ± 0.03mm/day, while that of estimated value of 1.40 ± 0.01mm/day is equally low. The low evaporation recorded during this season can be attributed to the prevailing meteorological factors of the season. These include low solar radiation, high relative humidity, and low temperature and pressure. The situation during the dry season is different. The average observed and estimated values of rate of evaporation are 2.78 ± 0.42mm/day and 2.75 ± 0.46mm/day respectively for the dry season which spands from November to April. These large values are also attributed to the prevailing meteorological factor during the period with high solar radiation, low relative humidity, and high temperature and pressure.

Temperature of the location is observed to be low because of large cloud cover in the atmosphere and less sunshine thus reducing the evaporation rate as seen in Fig 2. In the rainy season the relative humidity is high as a result of the high percentage of water vapour in the atmosphere which greatly reduces the rate of evaporation in the atmosphere as shown in Fig 4. During this season, solar radiation is observed to be low and there is a corresponding reduction in evaporation rate as shown in Fig 5. The effect of wind speed is also observed to influence the rate of evaporation. As observed in Fig.6, the low wind speed also reduces the rate of evaporation.

The dry season, spanning from the months of November to April is observed to record large values of evaporation rate with the estimated and observed values of 2.78±0.42mm/day and 2.75±0.46mm/day respectively. These large values are also attributed to the influence of meteorological parameters in this season. Solar radiation is observed to be intense during this season and it is also recorded that it correlates very well with evaporation thus influencing positively the rate of evaporation as observed in Fig 5. Relative humidity is seen to be low during the dry season thus enhancing rapid evaporation as any little energy on the earth's surface can be used for evaporation. Fig 4 shows their relative values. Temperature and pressure of the location is observed to be high as there are little or less clouds in the atmosphere thus enhancing the rate of evaporation as seen in Figs 2 and 3 respectively. During this season, high wind speed is recorded and this contributes to an increase in the rate of evaporation as seen in Fig 6.

CONCLUSION:

The seasonal variation of evaporation rate in Uyo reveals that a low valuae of average evaporation of 1.32 mm/day was observed for wet season while evaporation of 2.78 mm/day was observed for the dry season. It is also observed that some meteorological factors such as temperature. Solaar radiation. relative humidity pressure and wind speed contributed differently to the evaporation rate of the area.

REFERENCES

Ahonsi, G. E. (2004). *The Effect of Solar Radiation on Evaporation at Jos, Nigeria. Unpublished Msc. Thesis*, University of Jos, Nigeria.

FAO (2008). *Irrigation and Drainage Paper* No. 24., Viale Delle Terme di Caracalla, 00100 Rome, Itally.

Iruthayaraj, M. R. and Morachan, Y. B. (1977) Evaporation using different evaporimeters. *Journal of Agriculture in the Tropics* (2^{nd} Edition) Metheun and Co. Ltd., London, pp 141 – 161.

Johnson, F. M. and Sharma A. (2008) Estimating Evaporation – Issues and challenges, *School of Civil and Environmental Journal, University of New South Wales, Australia.* 3 221 – 237.

Rim, C. S. (2004). A sensitivity and error analysis for the Penman Evapotranspiration Model, *KSCE Jornal of Civil Engineering*, 8, (2): 249 - 254.

Shuttleworth, W. J., (1993); Evaporation. *Handbook of Hydrology*. D.R. Maidment (ed) McGrew - Hill, New York, pp 4.1 - 4.53

Surinder, D. and Mahesh, P. (2008): Environmental weather processes, *Engineering and Technology* 39, 13: 62-63.