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SHORT NOTE

Factors affecting Pan Evaporation in the hyper arid region of the Sudan and the quality of the data of National Institute of Desert Studies meteorological station

Habiballa A. Mohamed

National Institute of Desert Studies, University of Gezira,Wad Medani, Sudan

Evaporation is an important climate element for agricultural production, particularly in the hyper arid and arid regions where irrigation water becomes the most limiting factor in terms of availability and cost (Mohamed, 2015).The magnitude of evaporation depends on other climate elements like air temperature, relative humidity, wind speed and solar radiation (Liu *et al*., 2011; Mohamed and Mohamed, 2011).The water needs of crops, on the other hand, depends on evapotranspiration and on the crop factor, where evapotranspiration includes both evaporation and transpiration (Brouwer and Heibloem,1986).

Determination of the exact crop water requirement depends on the correct measurements and estimation of evapotranspiration. Precise estimation of evapotranspiration is vital in agriculture and hydrology (ElAlafandi and Abdrabbo, 2015). There are numerous methods for the estimation of evapotranspiration including energy budget, aerodynamic and numerical methods in addition to various methods of measurements including atmometers, lysimeters, Class (A) Pan and Piche tube. One of the simplest and reliable methods of measurements is the use of Class (A) pan. Because of the importance of these measurements, the National Institute of Desert Studies (NIDS)established in 2008 a meteorological station within its experimental farm, (17.92° N, 31.17° E).The station measures air and soil temperatures; wet and dry bulb temperatures; wind speed and direction, rainfall, Piche evaporation and Class Pan evaporation.

This study investigates the effects of air temperature, relative humidity and wind speed and their combinations on Class A pan evaporation and develops prediction equations of evaporation using the data sets for March 2008 to December, 2010. The study also investigates the quality of NIDS meteorological station data for the full years 2009 to 2011 through comparison with the nearest meteorological stations. Table 1. shows the mean of the daily elements for each of the complete years 2009 to 2011.

Table 1. Climate elements of NIDS for 2009 to 2011.

Year	Mean temp.(° C)	Wind speed (km/day)	Relative humidity (%)	Class (A) pan evap. (mm/day)	Piche evap. (mm/da)
2009	27.5	201.7	27.6	16.6	20.1
2010	27.6	199.3	34.9	16.6	21.0
2011	26.6	189.3	44.5	16.9	20.4
Mean	27.2	196.7	35.6	16.7	20.5

It is observed that the means for Pan and Piche evaporation for the three years were almost similar and also the means of wind speed and air temperature. There was a clear and successive increase in the percentage relative humidity through the years. The increase in the percentage relative humidity could be attributed to the existence of the lake of Marowe dam. Such increase may have a negative impact on the productivity and quality of dry dates which is produced mainly in northern Sudan. In fact, farmers have reported a decline in productivity, but this remains to be investigated.

When compared to either of Karima, (18.56° N, 31.58° E) and Dongola, (19.17° N, 30.48° E) data normals of 1961/1990, 1971/2000 and 1981/2010, (Table 2) show that mean air temperature was higher in Karima, while that of Dongola was comparable to the air temperature of NIDS which lied at almost an equidistance from both Karima and Dongola. Mean air temperature increased progressively with time in either of Karima and Dongola due to global warming.

Wind speed was lower in NIDS compared to both Dongola and Karima. Piche evaporation was higher in both Karima and Dongola compared to NIDS, and this might be due to the higher wind speeds in both stations, and also to the higher air temperature in Karima, and the higher relative humidity in NIDS.

Table 2. Climate normals for Karima and Dongola for various periods.

Period	Mean temp.(°c)	Wind speed (km/day)	Relative humidiy (%)	Piche evaporation (mm/day)
		Karima		
1961/1990	29.0	371.5	23.0	20.3
1971/2000	29.2	368.0	22.0	20.7
1981/2010	29.5	499.2	na	20.0
		Dongola		
1961/1990	27.3	380.2	25.0	18.9
1971/2000	27.6	390.4	24.0	20.7
1981/2010	27.6	345.6	na	18.9

na: not available

These differences justify the establishment of NIDS meteorological station which was supposed to serve NIDS experimental purposes and also to avail data for other needs.

Figure1 shows the regression of Class (A) pan evaporation on mean daily air temperature. Evaporation increased with increase in air temperature throughout the period, with high correlation, ($R=0.86$), high significance, ($P<0.001$) and a standard error of 2.1. Because of its great effects on the magnitude of evaporation, particularly in the arid regions, air temperature was used in some studies as a single factor to predict pan evaporation (Manoj and Mrugen , 2013).

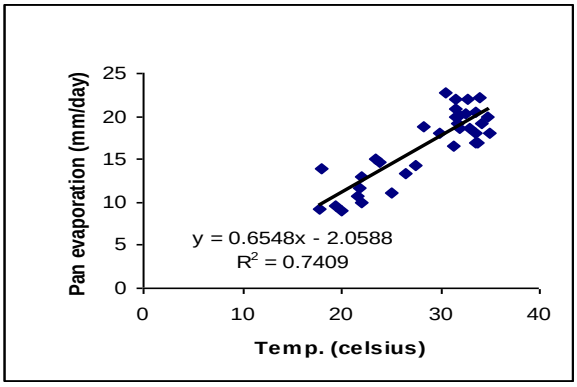
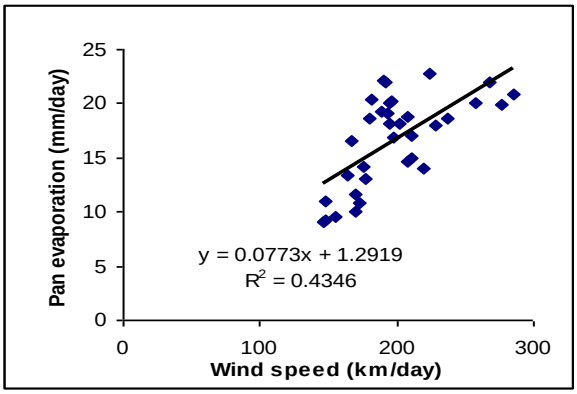


Figure 1. Pan evaporation *vs.* mean temperature.

Figure 2 shows the regression of Class (A) Pan evaporation on wind speed, (WS). The effect is also highly significant (P<0.001), with an (R) of 0.65 and a SE of 3.1. Pan evaporation increased as wind speed increased.



. Figure 2. Pan evaporation *vs.* wind speed .

Figure 3 shows the effect of relative humidity on Class (A) pan evaporation. There was a highly significant, (P< 0.001), negative correlation, (R = 0.75) where evaporation decreased with the increase in relative humidity percentage. When the pan evaporation was correlated to both mean air temperature (T), and percentage relative humidity (RH%), the correlation was even higher, with an R of 0.91 and a SE of as low as 1.7 so that Class (A) pan evaporation (PE) can be estimated from the equation:

$$PE=7.9+0.48T-0.15RH \quad \text{……..(1)}$$

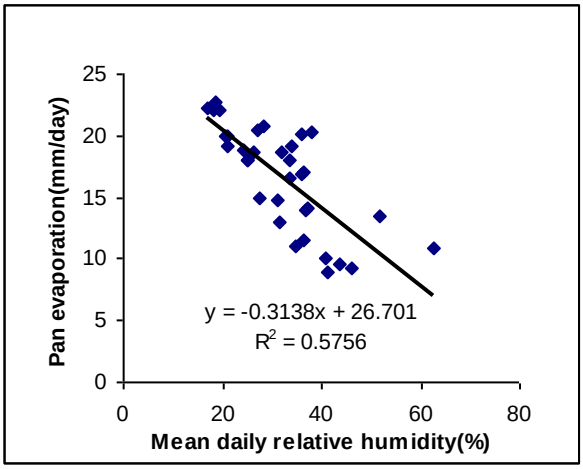


Figure 3. Pan evaporation *vs.* Relative humidity.

On the other hand, the three elements together showed a higher effect on pan evaporation, with an (R) of 0.93, P of <0.001 and a SE of 1.5. The equation connecting the three elements is:

$$PE=3.2+0.42T-0.13RH+0.02WS \quad \ldots(2)$$

The latter equation has a better predictability if the data on wind speed were also available. However, the former equation is equally sufficient if there are no wind speed data.

Figure 4 shows the regression of Class A pan evaporation on Piche evaporation throughout the period. The correlation coefficient is 0.97 and the significance is P< 0.001.

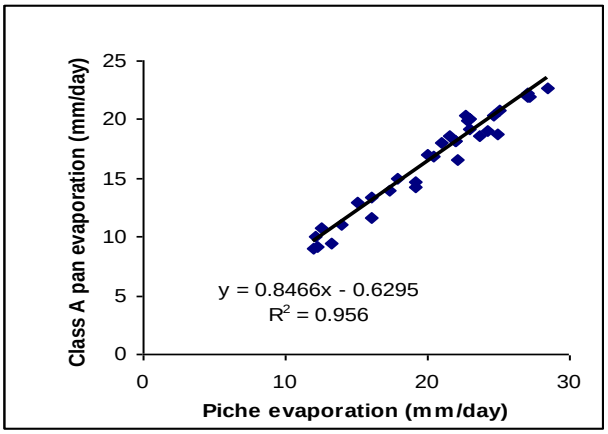


Figure 4. Pan evaporation *vs.* Piche evaporation.

Accordingly, an equation for the prediction of Class (A) pan Evaporation from that of the Piche(Pi) data can be written as follows:

$$PE=0.84\ Pi.E - 0.62 \quad \text{.....(3)}$$

This equation can be used in the hyper arid region in areas where no Pan evaporation data are available. Piche evaporation data while can easily be obtained, they are of lesser quality because the Piche atmometer usually overestimates evaporation by varying degrees depending on climatic zone under consideration. In the Sudan, the difference between the Class (A) pan reading and that of the Piche becomes larger as latitude increases northward.

It is concluded from this study that, NIDS meteorological station data generally lies with an acceptable magnitude and although not too far from those of Karima and Dongola, they are still different, which justify the importance of the station. It is also clear that pan evaporation is affected positively by the mean temperature and wind speed and negatively by the relative humidity, and that it can be estimated from regression equations.

It is recommended to strengthen the station by addition of equipments for measurements of pressure, solar radiation (incident, reflected and net) and sunshine duration and to replace the old instruments.

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العوامل المؤثرة على خزان البخر في الاقليم فوق القاحل بالسودان وجودة معلومات محطة الارصاد التابعة للمعهد القومي لدراسات الصحراء

حبيب الله عبد الحفيظ محمد

المعهد القومي لدراسات الصحراء، جامعة الجزيرة، ود مدنى، السودان

الخلاصة

تم تحليل معلومات الأرصاد الخاصة بمحطة المعهد القومي لدراسات الصحراء للفترة 2009والى 2011 و ذلك لدراسة اثر درجة حرارة الهواء و الرطوبة النسبية و سرعة الرياح على معدل البخر من خزان البخر الأمريكي (Class A Pan) لما للبخر من أهمية في تحديد الاحتياجات المائية للمحاصيل. كما هدفت الدراسة للتأكد من جودة المعلومات و ذلك من خلال مقارنتها مع متوسطات طويلة المدى(Normals) لمعلومات المحطات القريبة و هي محطات دنقلا وكريمة. أوضحت نتائج الدراسة الارتباط الوثيق بين البخر من جهة و درجة الحرارة و الرطوبة النسبية و سرعة الرياح من الجهة الأخرى و أوضحت مدى إمكانية تقدير البخر من هذه العوامل باستخدام المعادلات المختلفة. كذلك أوضحت نتائج الدراسة و مقارنة مع متوسطات معلومات المحطات القريبة الموجودة في دنقلا وكريمة أن المعلومات الإرصادية تقع في إطار المدى المتوقع في مثل هذا المناخ مع وجود الاختلافات الخاصة بالمحطة مما يبرر أهميتها العلمية و العملية للمعهد و لكل المؤسسات العلمية الأخرى.