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Evaporation rates from different pans under humid tropical conditions

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सार — आर्द्र उष्णकटिबन्धीय परिस्थितियों में वर्ग ए कड़ाह, जी.जी. आई. 3000 तथा कोलोराडो गड्ढेदार कड़ाह से सापेक्ष वाष्पन दरों का अध्ययन किया गया था। परिष्कृत पेनमैन समीकरण का उपयोग करते हुए वाष्पन दरों की अनुमानित वाष्पन से तुलना की गई थी। सांख्यिकीय सहसंबंधों का उपयोग करते हुए वाष्पन मानों तथा वाष्पन पर मौसम परिमापकों से प्रभाव के बीच सहसंबंध का भी अध्ययन किया गया था।

कड़ाह सतहों द्वारा वाष्पन हेतु लगभग 88 से 93 प्रतिशत सूर्यातप सोख लिया गया। वाष्पन की मौसमी परिवर्तनशीलता 4 मि०मी० से 10 मि०मी० प्रतिदिन थी जबकि उपयोग किए गए कड़ाह की किस्म के कारण यह वाष्पन परिवर्तनशीलता 3 मि०मी० प्रतिदिन थी। अनुमानित वाष्पन-मान मापित वाष्पन मानों से 2 मि०मी० प्रति दिन कम या अधिक के मध्य रही। गड्ढेदार कड़ाह से होने वाला वाष्पन मान वर्ग "ए" से होने वाले वाष्पन मान से 1 से 3 मि०मी० प्रतिदिन अधिक था और ये परस्पर सहसंबंधित थे। वायुगतिकीय परिमापक गड्ढेदार कड़ाह की अपेक्षा वर्ग ए कड़ाह से अधिक सहसंबंधित थे। अक्तूबर से मई तक इस क्षेत्र में उच्च मृदा तापीय प्रवृत्ति ने गड्ढेदार कड़ाहों से वाष्पन में वृद्धि की है।

ABSTRACT. Under humid tropical conditions, the relative evaporation rates from Class A open pan, G.G.I. 3000 and Colorado sunken pans were studied. The recorded evaporation values were compared with evaporation estimated with a modified Penman equation. The inter-relationship between evaporation values and the influence of weather parameters on evaporation were also studied using statistical correlations.

About 88-93 per cent of insolation was absorbed from the pan surfaces for evaporation. The seasonal variation of evaporation was between 4 and 10 mm/day and the variation in evaporation due to type of pan used was upto 3 mm/day. The estimated evaporation values were within ± 2.0 mm/day from the measured values. The evaporation values from the sunken pans were higher than from Class A by 1-3 mm/day and they were also closely correlated. The aerodynamic parameters were closely correlated with evaporation from Class A than from the sunken pans. The high soil thermal regime in the area during October to May has increased the evaporation from the sunken pans.

1. Introduction

One of the major losses of water from irrigated fields and other water bodies occurs through evaporation. The weather parameters which influence the rate of evaporation are solar radiation, vapour pressure difference, temperature of both water and air, wind, atmospheric pressure and quality of water. Quantification of evaporation losses is always done with reference to potential evaporation measured from standard pans such as Class A, Colorado, G.G.I. 3000 etc.

Strangeways (1982) pointed out that the wide variation existing in the design of evaporation pans from the British, Soviet and United States is an example showing the need for standardisation of such instruments. Due to usage of different types of pans in different regions, a global comparison of evaporation rates is possible only if the inter-relationship between evaporation rates from various pans under varying climatic conditions is known. The India Meteorological Department adapts Class A pan for evaporation measurements for its extensive network in the Indian region. In this paper, the evaporation rates in a humid tropical climate from Class A, Colorado and G. G. I. 3000 pans were compared and the results are reported.

2. Materials and methodology

(a) *Experimental details*

Evaporation observations from Class A, Colorado and G. G. I. 3000 pans were taken during April 1981 to March 1983 in the meteorological observatory site of the Regional Agricultural Research Station, Pattambi (10° 48′ N, 76° 12′ E and 25 m above m.s.l.). The area experiences a humid tropical climate with a well defined dry period from December to May every year.

The design of different pans used are briefly described in the following.

The Class A pan is circular 1225 mm in diameter and 25 mm deep made up of galvanized iron sheet mounted

TABLE 1

Mean weather conditions (April 1981-March 1983) at Pattambi

Weather parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Duration of sunshine (hr/day)	9.7	9.8	9.4	8.9	7.6	2.2	3.6	3.9	5.9	6.4	7.2	8.9
Maximum air temperature (°C)	34.3	35.8	36.6	36.2	34.7	29.7	29.6	37.4	30.5	32.1	32.6	33.3
Minimum air temperature (°C)	20.2	21.4	23.4	25.3	24.7	23.5	23.4	23.2	23.4	23.2	26.4	25.1
Soil temperature (°C) (5 cm, 1400 IST)	31.9	34.2	36.8	36.6	34.9	28.8	28.8	28.1	30.5	31.0	31.0	31.9
Relative humidity (%)	58	63	66	70	74	88	87	87	83	81	74	62
Wind speed (km ph)	4.7	3.4	3.7	3.9	3.3	2.1	2.7	3.5	2.8	2.0	2.5	5.0
Rainfall (mm)	0.0	0.0	31.4	70.1	184.9	943.6	555.8	617.0	220.4	211.4	73.1	0.3

TABLE 2

Mean evaporation (mm/day) at pattambi

Mean evaporation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Class A pan												
Measured	6.3	6.0	7.2	6.8	6.1	3.6	3.9	3.7	4.5	4.2	4.2	5.9
Estimted	6.5	6.9	7.3	7.7	6.8	4.2	4.7	5.2	5.7	5.5	5.9	6.2
Difference	+0.2	+0.9	+0.1	+0.9	+0.7	+0.6	+0.8	+1.5	+1.2	+1.3	+1.7	+0.3
Colorado pan												
Measured	7.1	7.2	8.0	7.2	6.8	4.8	4.2	4.0	5.0	4.8	5.0	6.6
Estimated	6.9	7.3	7.7	8.1	5.9	4.4	4.9	5.5	6.1	5.8	6.3	6.6
Difference	—0.2	+0.1	—0.3	+0.9	—0.9	—0.4	+0.7	+1.5	+1.1	+1.0	+1.3	0
G. G. I. 3000 pan												
Measured	8.3	8.8	9.5	9.0	8.2	4.6	4.5	3.4	4.8	5.2	5.8	8.2
Estimated	6.7	7.2	7.5	8.0	7.0	4.3	4.8	5.4	6.0	5.7	6.1	6.4
Difference	—1.6	—1.6	—2.0	—1.0	—1.2	—0.3	+0.3	+2.0	+1.2	+0.5	+0.3	—1.8

TABLE 3

Simple correlation coefficients between evaporation values at Pattambi

Type of pan	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Class A *vs.* Colorado	0.241	0.093	0.142	0.399*	0.555*	0.264	0.528*	0.361	0.196	0.127	0.473*	0.428*
Class A *vs.* G.G.I. 3000	0.299*	0.128	0.287**	0.283	0.200	0.492*	0.283	0.518**	0.082	0.028	0.557*	0.393*
Colorado *vs.* G.G.I. 3000	0.537*	0.406*	0.578*	0.495*	0.420*	0.693*	0.277	0.392**	0.264	0.261	0.563*	0.520*

*Significant at 0.01 level. ** Significant at 0.05 level.

TABLE 4

Simple correlation coefficients between evaporation values and weather parameters at Pattambi

Weather parameters	Summer (Mar-May)	Southwest monsoon (Jun-Sep)	Northeast monsoon (Oct-Nov)	Winter (Dec-Feb)
Class A pan evaporation (mm/day)				
Duration of sunshine (hr/day)	0.238*	0.483*	0.032	0.063
Mean air temperature (°C)	0.444*	0.216**	0.406*	0.388*
Mean relative humidity (%)	—0.690*	—0.495*	—0.664*	—0.611*
Wind speed (km/hr)	0.478*	0.650*	0.111	0.680
Colorado sunken pan evaporation (mm/day)				
Duration of sunshine (h/day)	0.147	0.055	0.308	0.063
Mean air temperature (°C)	0.188	0.265*	0.575*	0.206**
Mean relative humidity (%)	—0.456*	—0.120	—0.403*	—0.234**
Wind speed (km/hr)	0.307*	0.205**	0.626*	0.243**
Soil temperature (5 cm depth, 1400 IST) in °C	0.728*	0.210**	0.724*	0.645*
G. G. I. 3000 sunken pan evaporation (mm/day)				
Duration of sunshine (hr/day)	0.210**	0.196**	0.112	0.030
Mean air temperature (°C)	0.143	0.133	0.165	0.080
Mean relative humidity (%)	—0.381*	—0.223**	—0.448*	—0.445*
Windspeed (km/hr)	0.318*	0.192	0.488*	0.475*
Soil temperature (5 cm depth, 1400 IST) in °C	0.670*	0.196**	0.700*	0.585*

* Significant at 0.01 level. ** Significant at 0.05 level.

on a wooden grill about 100 mm above the ground. The pan is covered with a wire netting of 0.7 mm mesh hexagonal, 19 mm across with the link between stretching wire and staywire twisted twice.

The Colorado sunken pan is 1000 mm square and 450 mm deep made up of galvanized iron of 22 gauge embedded in the soil with the rim 50 mm above.

G.G.I. 3000 is a cylindrical tank made up of galvanized iron sheet of 22 gauge with a conical base. The diameter of the pan is set 618 mm with a surface area of 3000 sq. cm. The depth is 600 mm at the wall of the tank and 685 mm at the centre.

Analyses

The measured evaporation from the pans were compared with the evaporation estimated using a modified Penman equation. The modified Penman equation used in the present study was earlier described by Rao *et al.* (1971) and Brown and Cocheme (1973). The mean albedo of the pans was recorded using an albedometer. The inter-relationship of evaporation from different pans and the influence of weather parameters on evaporation from these pans were studied by working out statistical correlations.

3. Results and discussion

(a) *Weather conditions at Pattambi (April 1981-April 1983)*

Solar radiation during summer has reached to 1200 Wm^{-2} at noon at the station with the daily values varying from 550 to 60 Wm^{-2} in a year. The weather conditions during the period are given in Table 1. The duration of sunshine was between 2 and 10 hr/day. The air temperatures were varying between 28° C & 37° C and soil temperatures at 5 cm depth (1400 IST) were between 28° C and 37° C. The daily mean relative humidity was from 58 to 88% and the wind speeds were below 5 kmph. The station received 3370 mm of rainfall in 142 days during May-November 1981 whereas 2445 mm in 115 days during the same period in 1982.

(b) *Albedo from pan surfaces*

The variation in volume of water contained and in surface area exposed for evaporation from pan to pan and the use of mesh cover for certain pans caused differences in the absorption of insolation for evaporation. The mean albedo from surfaces of Colorado sunken pan, G.G.I. 3000 sunken pan and Class A open pan were 0.07, 0.09 and 0.12. The bare lateritic soil during the dry period in the area has an albedo of 0.20.

(c) *Evaporation from different pans*

Under humid tropical conditions in the area, the evaporation rates from the pans were between 4 and 10 mm/day (Table 2). The difference in evaporation rates due to variation in the type of pan used was only 1-3 mm/day. Evaporation from the sunken pans was higher than from the Class A open pan. High evaporation rates from the sunken pans may be due to the availability of thermal energy even in night time released from the stored soil surface. Out of the two sunken pans, G.G.I. 3000 pan recorded higher evaporation than the Colorado pan during October to May. This may be because the lateral heatflux per unit volume of available water is high into G.G.I. 3000 than into Colorado. The apparent differences in evaporation rates from the two sunken pans were low during the rainy period due to regulation of soil temperature by soil water.

The estimated evaporation according to the modified Penman equation was varying by ±2.0 mm/day from the measured values (Table 2). The estimated evaporation was higher than the measured values by 1.2-2.0 mm/day during August and September in case of all the pans. Relatively, the deviations from the measured evaporation were maximum in case of G.G.I. 3000 sunken pan evaporation.

(d) *Inter-relationships between evaporation values*

Simple correlation coefficients obtained between evaporation values from different evaporimeters are given in Table 3.

Evaporation values from the sunken pans were more closely correlated than the values from any two pans. Also, the correlation coefficients between the sunken pan evaporation values were consistent for a prolonged and consecutive period during November to May. Due to the heterogenity of aerodynamic and energy conditions between open pan and sunken pans, the correlation coefficients between their evaporation values were not consistent.

(e) *Influence of meteorological parameters on evaporation*

The correlation coefficients obtained between evaporation values and weather parameters are presented in Table 4. In general, all the weather parameters were closely correlated with Class A pan evaporation than with the evaporation from sunken pans. The wind speeds and relative humidity have significantly influenced the evaporation from Class A pan than from the sunken pans. This may be due to aerodynamic effect on the water levels which were kept at a higher level in open pan Class A than in the sunken pans. The mean air temperature and duration of sunshine gave lower correlations with evaporation values than with the relative humidity and wind speeds. Soil temperatures have influenced significantly the evaporation from the sunken pans during October to May. This shows that the sunken pans installed in irrigated fields can record lower evaporation than the pans installed in unirrigated fields.

4. Summary and conclusions

The differential evaporation rates from Class A, Colorado and G.G.I. 3000 pans under a humid tropical climate were quantified. The seasonal evaporation was between 4 and 10 mm/day and the variation in evaporation from one pan to other pan was 1-3 mm/day. The evaporation estimated with Penman equation was closer to the evaporation from Class A than the evaporation from the sunken pans. Due to similar energy and aerodynamic conditions, a close relationship between the evaporation values from the two sunken pans was observed. The high soil temperatures prevailed during October to May in the area have influenced the evaporation from the sunken pans. The influence of various weather parameters on evaporation from different pans were quantified to enable to apply suitable corrections for estimating areal evaporation in humid tropical areas.

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