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Water hyacinth canopy and pan evaporation

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सार—वाष्पन पर जल हाइसिन्थ कैनापी (वितान) के मात्रात्मक प्रभाव का अनंतिम तौर पर अनुमान करने के लिए एक जल हाइसिन्थ, अर्थात् एक प्रकार की जलीय खरपतवार से ढके खुले पैन वाला वाष्पमापक, और दूसरे खुले पैन वाले वाष्पमापक से जल में हुई कमी की तुलना की गई है। यह पाया गया कि जल हाइसिन्थ कैनापी जल की कमी को दुगना कर देती है क्योंकि उसकी वाष्पोत्सर्जन दर अधिक होती है। यहां जल हाइसिन्थ कैनापी का मात्रात्मक विवरण भी दिया गया है और बड़े जलाशयों से वाष्पन की गणना में इसकी उपयोगिता को भी समझाया गया है।

ABSTRACT. Water losses from open pan evaporimeter covered with water hyacinth, an aquatic weed, and from an open pan evaporimeter were compared to find out tentatively, the quantitative effect of water hyacinth canopy on evaporation. It was found that water hyacinth canopy doubles the water losses due to its higher transpiration rate. A quantitative description of water hyacinth canopy and its use in computation of evaporation from large water bodies is outlined.

1. Introduction

Water hyacinth (*Echhornea crassipes*), belonging to family pontedariaceae has been considered to be one of the worst weeds in many countries. A native of South America, it has now almost a global distribution. It was introduced in India from Brazil in 1896 and within a short span it topped the list of ten widely spread noxious weeds.

In the planning and management of any large water body, it is essential to have knowledge about its water losses, *i.e.*, through evaporation, evapotranspiration by the floating weeds, if present, and seepage etc. Evapotranspiration by water hyacinth comprises a large fraction of total water loss from any water body. The aim of the study is mainly to quantify this loss in comparison to water loss by evaporation from an open tank (evaporimeter)

2. Material and methods

Water hyacinth was grown in two open pan evaporimeters. Third evaporimeter was used for taking evaporation measurements from free water surface. The evaporimeters were installed as per standard procedure and were fitted with thermometers for measurement of water and canopy temperatures.

The experiment was conducted at Central Agricultural Meteorological observatory, Pune, which lies in AW climate (Koppen's classification). The Means of various meteorological parameters for the period of study (April, May and June 1981) are given in Table 1.

Observations were recorded twice a day at 0830 IST and 1400 IST. In addition to evaporation (E) and evapotranspiration (ET) following meteorological parameters were also recorded at the site :

(*a*) Wind speed at 0.5, 1.5 and 2.0 metres.

(*b*) Rainfall

(*c*) Air temperature

(*d*) Water temperature

(*e*) Canopy temperature

(*f*) Screen temperatures, *viz.*, maximum, minimum, dry bulb and wet bulb.

The Bowen ratio (β) was computed as

$$\beta = K.P. \left(\frac{T_s - T_a}{e_s - e_a}\right)$$

where,

K = Bowen ratio coefficient (taken as 6.1×10^{-4});
P = Atmospheric pressure in mb;
T_s = Temperature of water surface in °C;
T_a = Temperature of the air in °C;
e_s = Saturation vapour pressure in mb corresponding to the temperature of the water surface;
e_a = Vapour pressure in mb of the air at the height at which T_a is measured.

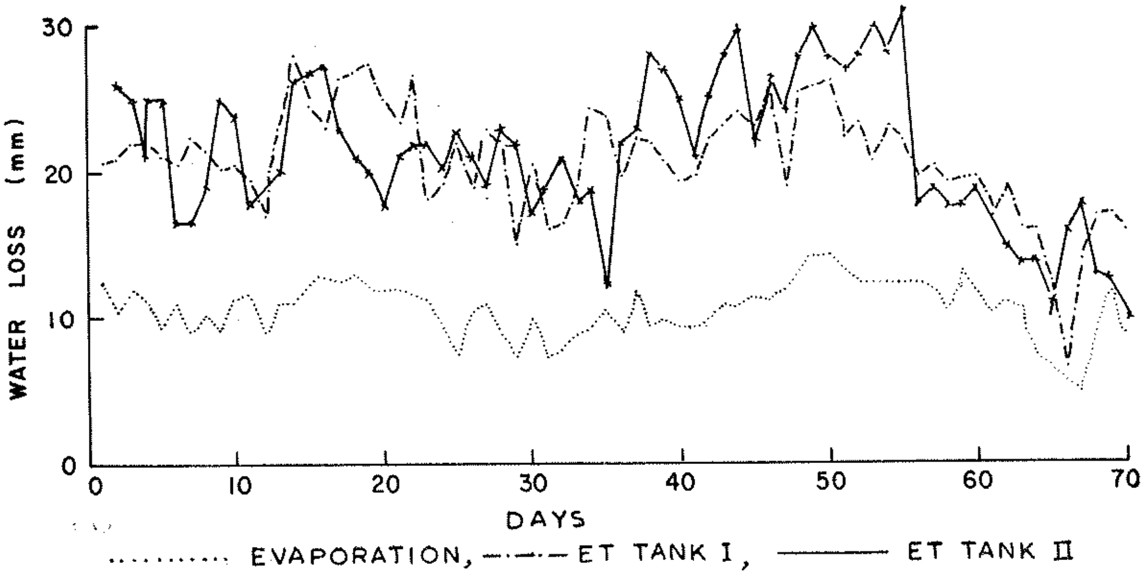

Fig. 1. Daily evapotranspiration from water hyacinth and evaporation from free water surface

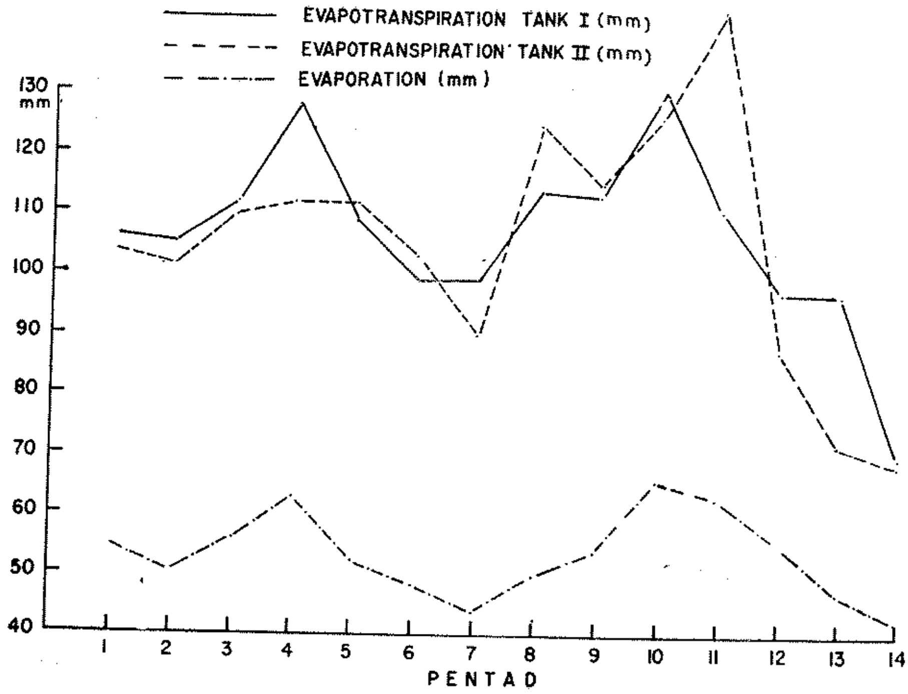

Fig. 2. Pentad evaporation and evapotranspiration

TABLE 1

Parameter	April	May	June
Mean maximum temperature (°C)	37.9	36.7	32.9
Mean minimum temperature (°C)	19.5	22.8	23.5
Mean relative humidity (%) at			
0830 hr	47	58	76
1730 hr	23	33	66
Mean wind speed at 2 m height (km/hr)	7.5	8.3	13.7
Total rainfall (mm)	08.2	36.7	58.8

TABLE 2

Pentad total of evaporation & evapotranspiration

Pentad	ET tank I	ET tank II	Evaporation
1	106.1	103.5	55.0
2	104.6	101.1	50.2
3	112.2	109.7	57.0
4	128.0	111.0	62.8
5	109.1	110.7	51.8
6	99.1	103.0	48.4
7	99.4	89.6	44.3
8	114.3	125.0	50.4
9	113.1	117.1	53.8
10	136.2	125.9	50.4
11	110.9	144.7	62.8
12	98.0	87.8	56.9
13	98.0	72.5	46.7
14	71.2	67.9	41.4

3. Results

The influence of water hyacinth canopy on water losses from free water surface is demonstrated by results obtained from evaporation tank (henceforth called as E-tank) and evapotranspiration tanks (henceforth called as ET I and ET II tanks). The sensitivity of the estimates of evaporation to different input variables is much dependent on the values of aerodynamic and canopy resistance parameters that introduce the influence of coverage. Dependent on these parameters all the input variables exhibit high day-time sensitivity coefficients, being a summer period, when E and ET rates are high.

3.1. *Evaporation (E) from free water surface and evapotranspiration (ET) of water hyacinth*

The results obtained from E tank and ET tanks are presented in Table 2 and Figs. 1 and 2. Comparing the ET with E, it can be seen that cumulated ET or E values per pentad ranged between 71.2 and 136.2 mm; 67.9 and 144.7 mm; 41.7 and 65.3 mm, respectively for ET I, ET II and E tanks. The total E for entire period is 746.8 mm. It is about half of the ET from water hyacinth which were found to be 1500.5 and 1469.5 mm respectively for ET I and ET II tanks. Figs. 1 and 2 exhibit a good correlative picture between E curve and ET curves. These results demonstrate the equal effects of available energy on E and ET, however, ET curve is of the order twice higher than E curve. This difference has been found to decrease at the later part of experimental period which can be attributed to the organic acids and hydrogen sulphide, released during the decay of dead weeds and also to the reduced water requirements of old plants.

3.2. *Influence of various meteorological parameters on E and ET*

The pentad means of air temperature, water temperature, canopy temperatures and wind velocity profile over the pans are presented in Figs. 3 and 4 to demonstrate the effect of available energy on E and ET. From these results impression is gained that various meteorological parameters influence E and ET in the same way. Water hyacinth being an aquatic weed, does not suffer moisture deficiency at any stage of growth period. Therefore, E and ET change in the same fashion with change in meteorological variables. Air temperature effect E and ET directly by determining the water vapour demand of atmosphere. Water temperature and canopy temperature influence water losses indirectly by conveying radiation energy. They themselves are affected by ET losses, therefore, should not be considered to be very important factors affecting water losses from water bodies.

The rate of loss of water vapour from aquatic vegetation, *i.e.*, transpiration varies through 24 hours of the day. It also varies from day to day depending upon the temperature, sunlight, moisture available and other atmospheric conditions and also the stage of crop development. The rate of E from free water surface is lower at night than in day time, the reduction is principally due to lower night temperatures of the air and to the resulting increase in relative humidity. Transpiration rates, however, experiences a much greater variation between day and night, principally because transpiration varies directly with plant growth, which is almost wholly dependent on sunlight. As a result transpiration is vitually restricted to, day light hours. The pentadic variation of E and ET is in close proximity of the trends of air temperature and wind velocity fluctuations, especially, the wind velocity curves if superimposed over E and ET curves show a similarity of high degree indicating that wind plays major role in evaporative water losses.

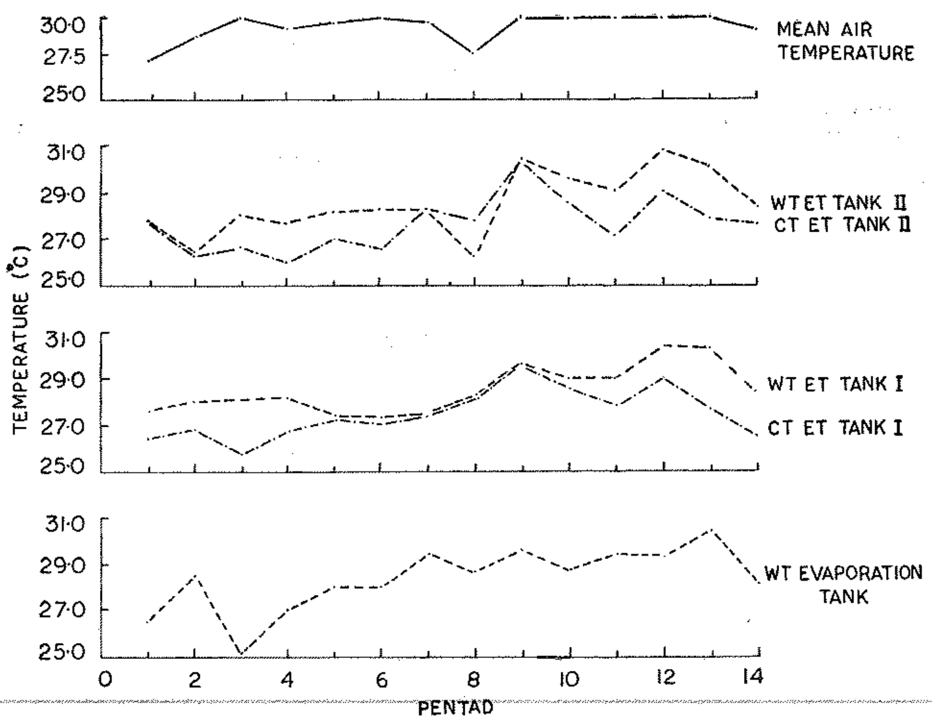

Fig. 3

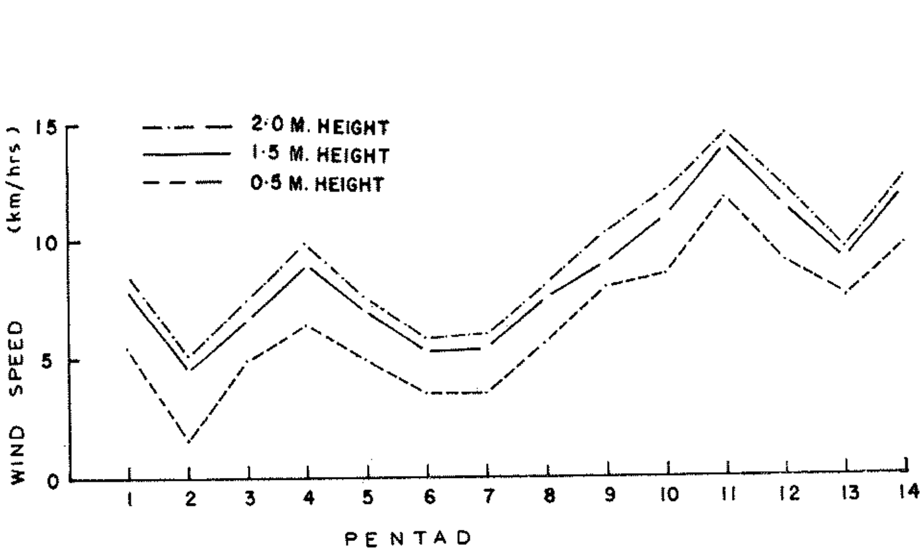

Fig. 4. Wind profile over the pans

TABLE 3

Bowen ratios for ET tanks and open pan

Pentad No.	ET tank I	ET tank II	Evaporation tank
1	0.1178	0.0091	—0.0362
2	0.0586	0.0049	0.0098
3	0.1294	0.0647	—0.3291
4	0.5887	0.0085	—0.0616
5	0.0047	0.0904	—0.0822
6	0.0298	0.1491	—0.2684
7	—0.0286	—0.0560	—0.0350
8	—0.0104	0.0239	0.1250
9	0.0341	0.0113	—0.0569
10	0.0337	0.0472	—0.1552
11	0.1446	0.2289	—0.1566
12	0.3780	0.4016	—0.3071
13	0.8431	0.8047	—0.1916
14	0.4292	1.0218	—1.2262

TABLE 4

Ratio of evapotranspiration from water hyacinth and evaporation from free water surface

Pentad	ET I/E	ET II/E
1	1.93	1.88
2	2.08	2.01
3	1.97	1.93
4	2.04	1.77
5	2.11	2.14
6	2.04	2.13
7	2.24	2.02
8	2.27	2.48
9	2.10	2.17
10	2.09	1.93
11	1.77	2.30
12	1.72	1.54
13	2.10	1.55
14	1.72	1.64

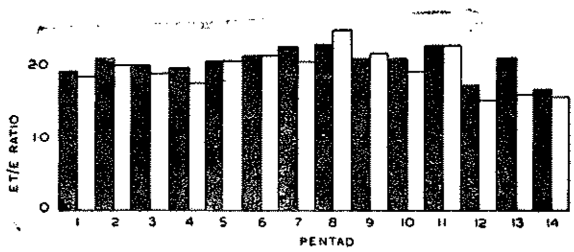

Fig. 5. Histogram of ratio of evapotranspiration to evaporation

The Bowen ratio, which has been widely used as a measure of the ratio of the sensible heat to latent heat flux over the water surface as a proportion of the energy utilized for evaporation, were obtained for each pentad using average pentad values of the different elements and is given in Table 3. It is apparent from the results that the values of Bowen ratio for ET tanks are much higher than that of E tank indicating that much of sensible heat has been utilized for the evaporation process. The higher values of for E Tanks proves that water loss is more due to transpiration than evaporation, when water surface is camouflaged by hyacinth canopy, because not much sensible heat has been utilized for water loss. The physiological loss (transpiration) does not involve much of sensible heat.

3.3. *ET/E ratio*

Fig. 5 and data presented in Table 4 indicate that, this ratio ranges from 1.72 and 2.27, for Tank I and 1.55 to 2.48 for Tank II. However, majority of the values are close to 2.0 which is also the average for all the pentads.

Linacre *et al.* (1970) compared several investigations on ET of water plants. It seemed the ratio of ET/E of different species ranges between approximately 0.6 and 2.5. Penfound and Earle (1948) found a value of 3.2. The wide range of ET/E values that appear in literature is not surprising because of difference in plant characteristics (mainly aerodynamic roughness and diffusion resistance of canopy). Besides, it is likely that ET/E ratio differs from climate to climate.

3.4. *Quantitative description of aquatic weed canopy and its use in computation of evaporation from large water bodies*

The quantitative description of vegetation which can be related to ET presents a major problem in developing a feasible method for estimating ET from lakes possessing water hyacinth.

The three factors controlling E,

(*i*) energy for phase change from liquid to water vapour,

(*ii*) unsaturated moving air to remove vapour and

(*iii*) water available at the interface between air and water,

are all to some degree affected by weed canopy floating over lake surface. Weed conopy over lake surface cause variation in albedo, which in turn affect the quantity of solar energy available for vaporisation of water. The surface resistance to wind and the turbulence produced by vegetation affect the vapour transport. The primary function of aquatic vegetation is to absorb the water by roots and to convey it to evaporative surfaces of the plants. Thus, the importance of vegetation description is readily apparent. However, the problem of quantifying these various affects is quite complex. Satisfactory estimate of these effects can be obtained by relating a coefficient which describe, these various effects to the species of vegetation. In this case the vegetation is fairly uniform and proceeds through a standard life cycle. However, seasonal and other temporal changes do occur which cannot be defined conveniently. As we have seen that the water losses are doubled from the lake areas which are covered by floating water hyacinth. Therefore, the computed values of E should be multiplied by a factor 2.0 to get actual water losses from a water body.

The correction factor (*i.e.,* 2.0) should be applied to the computed evaporation only for the part of water body covered by water hyacinth. The volume of the transpiring vegetation in the project area can be determined from these measurements :

(*i*) The total area occupied by vegetation,

(*ii*) Percentage of the area actually covered by plant crowns and

(*iii*) The height of the plants.

The area occupied by plants can be determined by use of black and white aerial photography at a suitable scale. With area known the percentage of coverage can be determined by using a dissecting binocular, microscope or by plannimeter. Coverage of plant crowns in the sample area can be estimated according to procedure described by Daubenmire (1959). It can also be determined by colour infrared photography. The delineation of vegetation can be greatly improved and difference in foliation is more accurately defined by using this photography instead of black and white photography.

The application of water budget to the canopy covered area provides the quantity of water vaporised from it during particular budget period. The actual values of water losses (after applying the correction) will be additive tool in water management, irrigation and other agricultural operations. However, this result is very tentative because of shorter length of record and inaccuracy due to canopy replication.

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