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Sec-B

Unit - III

Evaporation

Evaporation Process :- Evaporation is the process in which the liquid changes into the gaseous form at a free surface below the boiling point through the transfer of heat energy.

Thus,
it is the process by which water is returned to atmosphere.

Consider a body of water in a pond.

When heat applied in the solution the motion of molecules increases and molecules present in the surface overcome the surface tension of the liquid and it evaporates because surface molecules have less cohesive force than others.

(Factors) The rate of evaporation is dependent on
i) the vapour pressure at the water surface and air above ii) air and water temp.
iii) wind speed. iv) atmospheric pressure
v) quality of water.
vi) size of the water body.

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Factors Affecting Evaporation :-

There are many factors to affect evaporation

1) Temperature – The rate of evaporation is directly proportional to the temperature.
[evap. increases with an increase in temp. and vice-versa

2. Surface Area – The rate of evaporation is directly proportional to the surface area of the vessel exposed to evaporation.

3. Atmospheric vapour pressure –

The rate of evaporation is inversely proportional to the atmospheric aqueous vapour pressure.

4. Atmospheric pressure on the liquid under evaporation – inversely proportional.

5. Type of Product Required –

The selection of method and apparatus to be used for evaporation depends upon type of end product required.

6. Economic factors – When select the methods and apparatus for evap. the economic factors are important

120cm in dia

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Estimation of Rate of Evaporation :-

Evaporimeters :-

Estimation of evaporation is one of the most important in hydrologic problems. The amount of water evaporated from a water surface is estimated by the following methods —

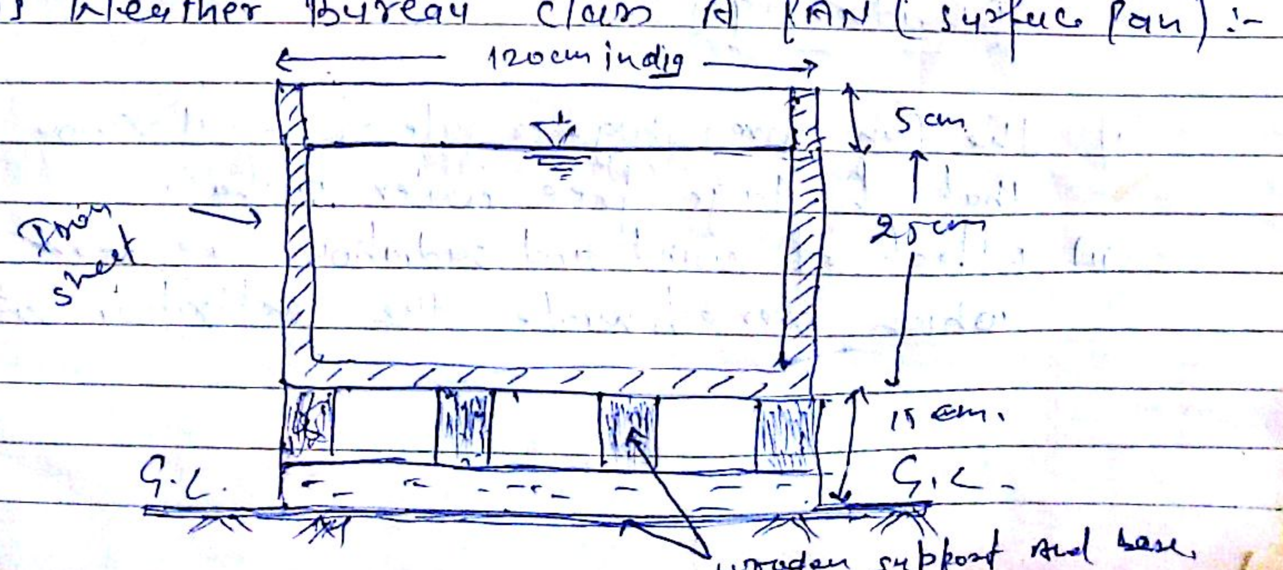
i) Evaporimeters -
ii) Empirical evaporation equations.
iii) Analytic methods —

Evaporimeters :-

Evaporimeter is an instrument that measures the rate of evaporation of water into the atmosphere.
Sometimes evaporimeter is also called as atmometer.

Evaporimeters are of two types, those that measure the rate of evaporation from a free water surface which are given below.

1) US Weather Bureau class A PAN (surface pan) :-



US weather Bureau class A pan or surface pan evaporimeter along its dimensions is shown in fig.
It is made of ~~iron~~ galvanized iron sheet of hamp a white paint.
The pan is placed on the wooden platform of 15 cm height above the ground to allow free circulation of air.
Evaporation is measured by a hook gauge in a stilling well and also water level is measured daily.
A pan coefficient of 0.7 is taken thus, pan coefficient is

$$\text{Pan coefficient} = 0.7 = \frac{\text{Lake evaporation}}{\text{Pan evaporation}}$$

Advantages:

i) It gives stable pan coefficient (0.6 to 0.8)
ii) It is easy for observation i.e. measurment.
iii) Cost of installation is reasonably low.

Disadvantages :-

i) The pan gives higher rate of evaporation than that of large free water surface.
ii) Effect of wind and radiation are more which over estimate the expiration rate.

ISI standard Pan :-

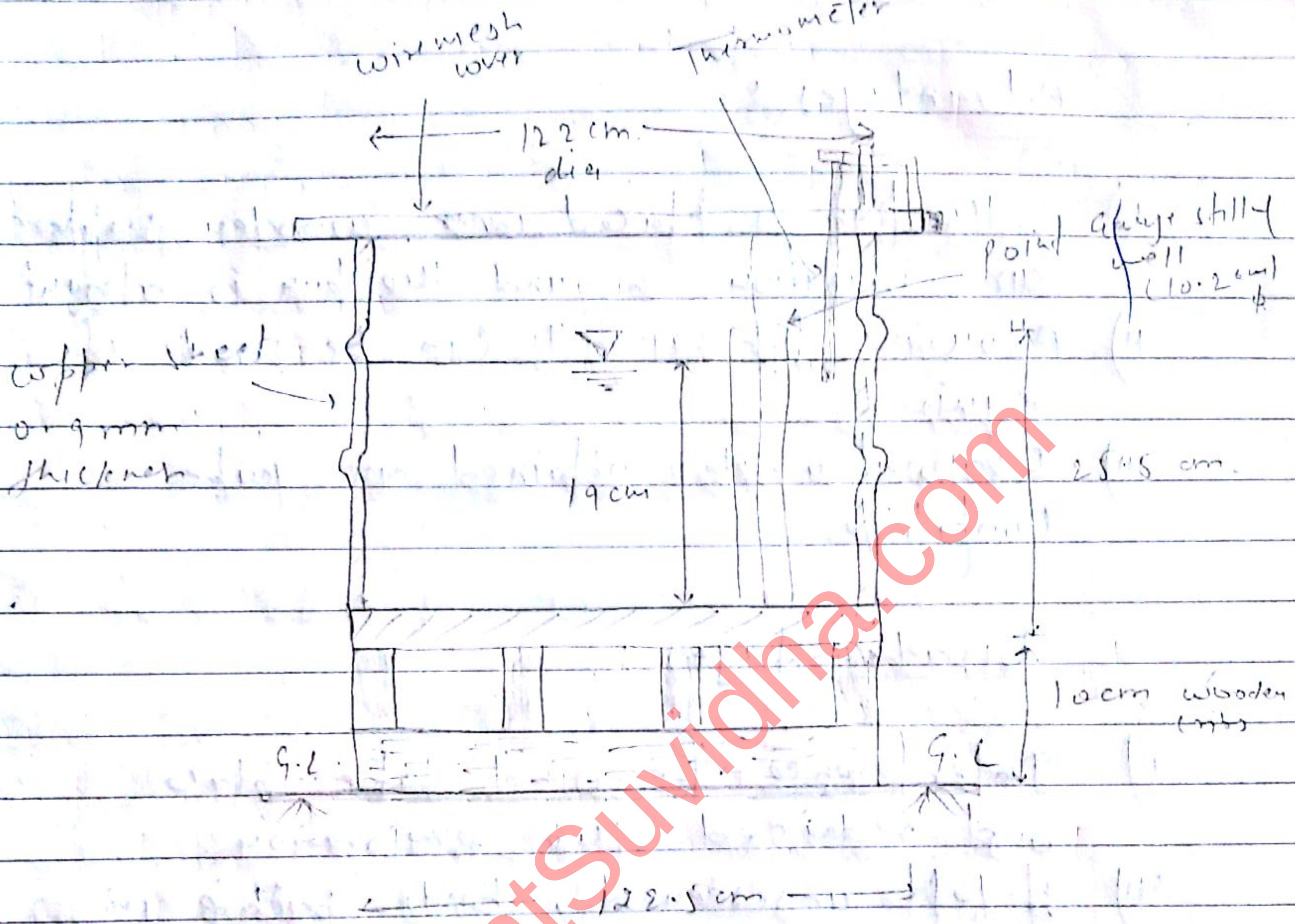


fig - ISI standard Pan

ISI standard Pan is shown in fig -
It is also known as modified class A Pan.
Dimensions of the Pan are shown in fig -
The Pan is made up of copper sheet of 0.9 mm thickness. It is covered with wire mesh of galvanized iron to protect the water in the Pan from birds.
~~Amount of~~ The Pan has a stilling well with the point gauge and thermometer

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The amount of water lost can be measured by the point gauge. The annual pan coefficient is 0.7.

Advantages :-

1) As the pan is placed over wooden support, air circulation around the pan is alright.
ii) Allowance for rainfall can be made if required.
iii) Evaporation rates obtained are quite compatible.

Disadvantages :-

1) Interference of wind takes place and reduced the evaporation.
ii) If left unscreened, birds bathing in the pan and drinking water from the pan may affect the evaporation.

$V_E = A E_{pm} C_p$ → Num → (7) → 4-6/(6)

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Empirical Evaporation Equations (Empirical formulae) :-

Based on Dalton's Theory, various empirical formulae have been developed to estimate the evaporation from free water surface.

Fitzgerald's Equation (1886)

$$E = (0.4 + 0.124 V)(e_s - e_a) \quad -(1)$$

where –

E = Evaporation in mm/day

V = Average wind speed in km/hr.

e_s = saturated vapour pressure of water.

e_a = Actual vapour pressure of air.

Meyer's Equation (1915) :-

$$E = c(1 + V/16)(e_s - e_a) \quad — (2)$$

c is the coefficient having a value of 0.36 for large deep water and 0.50 for small and shallow water.

Rohwer's equation (1931)

$$E = 0.771(1.465 - 0.000732 P_a)(0.44 + 0.0733 V)(e_s - e_a) \quad (3)$$

where

V = mean velocity of wind in km/hr.

P_a = Atmospheric pressure in mm of mercury.

Analytical methods of Evaporation Estimation –

1) Water Budget method or storage eqⁿ.

Evaporation E from a reservoir or water body can be determined by the following water budget eqⁿ –

$$E = P + I - O + O_u \pm \Delta S \quad \text{--- (4)}$$

where

P = Total precipitation,

I = Total Inflow

O = Total outflow

O_u = total underground inflow (which is net positive for inflow and negative for outflow.

ΔS = change in storage (+ve for increase in storage and –ve for decrease in storage),

② Energy Budget Method :-

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Reservior Evaporation :- And its Control :-

Evaporation from a water body is a continuous process.
In Indian conditions, annual evaporation varies from 1.5 m to 2.5 m.
multipurpose projects are always with a big reservior with bigger surface area, so loss due to evaporation is more.

various methods to reduce reservoir evaporation are discussed as below -

1) Reduction of surface Area of Reservoir -

Evaporation is directly proportional to the water surface area of the reservior. the reduction of surface area wherever feasible reduces evaporation losses.
Reservoirs in deep gorges are preferable.

2) Wind breakers -
As wind velocity over the surface

Mechanical Covers :- Small reservoirs are sometimes entirely covered to reduce evaporation. Cooley[23] (1970) suggested floating cover and Meyer and Frazier[24] (1970) advocated floating granular materials. Such methods are effective but expensive to apply to very small water bodies such as ponds etc.

Chemical films (Monomolecular films) :-

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Transpiration :-

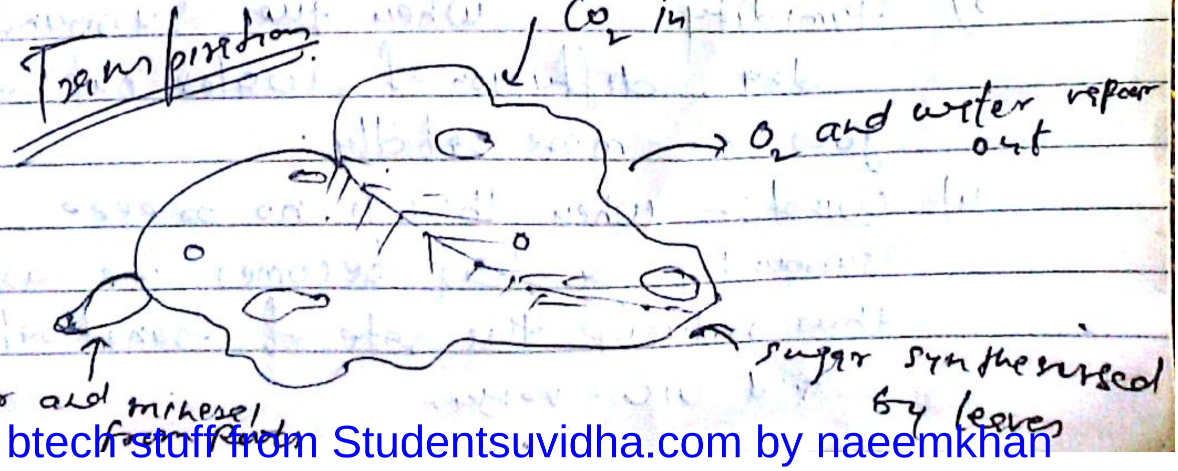
Transpiration is the evaporation of water from Plants. It occurs chiefly at the leaves while their stomata are open for passage of CO_2 and O_2 during photosynthesis.

The exchange of O_2 and CO_2 in the leaf (as well as the loss of water vapour in transpiration) occurs through pores called stomata.

Normally stomata open while when the light strikes the leaf in the morning and close during the night.

Rate of Transpiration :-

Time	Osmotic pressure (lb/in²)
7 Am	212
11 Am	456
5 pm	272
12 midnight	191



Importance :-

Transpiration is not simply a hazard of plant life. It is the engine that pulls water up from the roots to

* supply photosynthesis
* bring minerals from the roots ~~to~~ for biosynthesis within the leaf.
* cool the leaf.

Environmental factors that affect the Rate of Transpiration :-

1) Light
Plants transpire more rapidly in the light than in the dark. because the opening of stomata occurs in the light.

2) Temperature :-
Plants transpires more rapidly at higher temperature because water evaporates more rapidly as the temp. rises.

3) Humidity : when the surrounding air is dry, diffusion of water out of the leaf goes on more rapidly.

4) Wind :- when there is no breeze, the air surrounding a leaf becomes increasingly humid thus reducing the rate of transpiration

[Evapo-transpiration is an indicator of how much water your crops, lawns, garden, and trees need for healthy growth and productivity]

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Evapo- transpiration :-

Evapo- transpiration (ET) is the sum of evaporation and transpiration (plant transpiration) from the earth's surface to the atmosphere.

Evapo- transpiration is of two types -

1) Actual Evapo - transpiration
2) Potential - Evapo - transpiration.

Actual Evapo-transpiration :- The rate of water lost from plants, vegetation and soil ordinarily at a slower rate than the potential rate is known as Actual Evapo- transpiration. It is also known as real evapo-transpiration occuring in a specific situation.

Actual Evapo-transpiration largely depends upon the soil and plant factors but not on climatic factors.

Measurement of Evapo-transpiration :-

1) **Field Plots :-**

In special plots all the elements of the water budget in a known interval of time are measured and the evapo-transpiration is determined as

Evapo-transpiration (ET) =

Precipitation + Irrigation water − Run off − increase in soil moisture

The elements or parameters that are required to measure in the plot of a given period of time are precipitation, supply of irrigation, run-off, increase in soil storage and ground.

2) **Penman Equation :-**

The Penman equation describes potential evapo-transpiration (ET) from an open water surface and was developed by Howard Penman in 1948. Penman's equation requires daily mean temp., wind speed, humidity and solar radiation to predict evaporation.

The Penman formula is a semi-empirical equation combining mass transfer method (E_a) and energy budget method (H).

Acc. to Penman, the potential evapo-transpiration ~~EPT~~ $(ET)_p$ can be calculated as –

Penman equation of the evaporation is given by the equation given below which is combined Energy budget and mass-transfer approach method eq^n :—

$$E = \frac{(\Delta Q_{in}/L_e) + (0.00061 \, P \, E_a)}{\Delta + 0.00061 \, P} \quad \text{—(1)}$$

The above eq^n is based on theoretical approach. When this eq^n is multiplied by a coefficient k, it will yield potential evapo-transpiration (PET)

$$PET = KE \quad \text{—(2)}$$

where E is given by the eq^n of combined energy budget mass transfer method and the value of k depends on types of crop.