MODULE # 3(a)

Evaporation:-

The few terms related to evaporation are defined below:-

Vaporization:- It is aphysical process in which liquid changes to gaseous state with out boiling from free surfaces of water bodies and wet Soil masses are returns to atmosphere due to high temperature effects.

Evaporation:- Water Losses due to vaporization is called evaporation. It is measured in depth units.

Transpiration:- The process by which water is returned to the atmosphere by evaporation from the Surface of the leaves after movement from the Soil through the root and stem System of the plant is Called transpiration.

Evapo-transpiration:-

It is combined evaporation & transpiration. The total water loss of Soil or free water Surface and from trees and plants is termed as evapo-transpiration.

Factors Affecting Evaporation:-

① Temperature:- Evaporation is highly dependent upon temperature. Higher the temperature greater will be the evaporation.

② Surface Area of water body:-
Evaporation takes place from free Surface of water body. Larger the area exposed to atmosphere, greater will be evaporation.

③ Humidity:- Greater the humidity, lesser will be evaporation.

④ Wind speed:- Higher the wind speed more will be evaporation.

⑤ Solar Radiation:- Evaporation increases with increasing Solar radiation.

⑥ Atmospheric Pressure:-

Evaporation decreases with increasing atmospheric pressure.

⑦ Depth of water:-

Greater the depth of water, lesser will be the evaporation.

Measurement of Evaporation:-

Evaporation can be estimated by:

(a) Indirect or Theoretical Method.
(b) Direct Measurement

(a) Indirect or theoretical Method:-

From theoretical point of view there are three recognized approaches and are named as:

(i) — Water budget approach.
(ii) — Energy budget approach
(iii) — Mass transfer Approach.

(i) Water Budget Approach:-

The water budget approach is the least Complicated method of estimating evaporation but results obtained from it are not so accurate.

It is based on the assumptions that change in storage "ΔS" and all components of inflow "I" (Mainly precipitation "P") and outflow "O" (Run off "R") along with Losses "L" except evaporation "E" can be measured and evaporation is the quantity of water required to balance the continuity equation.

$$E = P - R - L - \Delta S$$

Problem:- From a 50mm rainfall 35mm of runoff is generated that was measured at stream gauging station. If infiltration Losses are estimated as 10mm - determine the evaporation Loss assume there is no storage is system.

Solution:-

$P = 50mm$

$R = 35mm$

$L = 10mm$

$\Delta S = 0.$

$$E = P - R - L - \Delta S$$

$$E = 50 - 35 - 10 - 0$$

$$\boxed{E = 5mm}$$

(ii) Energy Budget Approach:-

This method is based on the application of the Conservation of energy.
The continuity equation for energy budget approach is given below.

$$Q_e = Q_s - Q_r - Q_b - Q_h - Q_t \pm Q_v.$$

Q_e = The energy available for evaporation.
Q_s = The solar radiation Energy
Q_r = Reflected Solar Energy.
Q_b = Long wave Loss.
Q_h = (Unused) Latent heat between the water Surface and the atmosphere.
Q_t = Heat transfer to and from the Lake
Q_v = Increases in stored Energy.

All these Quantities can be measured or estimated indirectly. The evaporation then is estimated by some relationship b/w heat available for evaporation and evaporated water quantity.
Many Researchers have worked on relationship
As;

$$E_r = \frac{R_n}{(l_v \rho_w)}$$

E_r = Evaporation Rate

R_n = Net Radiation at Earth's Surface.
l_v = Latent Heat of Vaporization.
ρ_w = Density of water.

Problem:-

Calculate the evaporation rate from an open water Surface using Bowen's Equation from the following Data:

$R_n = 200 \frac{Watt}{m^2}$ $I_v = 2500 \times 10^3 \frac{Joule}{Kg}$ $\rho_w = 1000 \frac{kg}{m^3}$

Solution:-

$$E_r = \frac{R_n}{I_v \rho_w}$$

$$E_r = \frac{200}{2500 \times 10^3 \times 1000}$$

$$E_r = 8 \times 10^{-8} \ m/sec.$$

$$E_r = 8 \times 10^{-8} \times 1000 \times (1 \times 60 \times 60 \times 24)$$

$$\boxed{E_r = 7 \frac{mm}{day}}$$

(iii) Mass Transfer Approach:-

The Mass transfer approach contain Dalton's Equation

$$E = C \cdot (e_s - e_a)$$

e_a = Air vapour pressure (m bar).
e_s = Saturation Vapour pressure (m bar)
C = Constant of Dalton.

$$C = \frac{0.622\, k^2 \rho_a V}{P \rho_w \left[\ln\left(\frac{z}{z_0}\right) \right]^2}$$

k = Von Karman Constant = 0.4

ρ_a = Density of air.

V = Velocity of wind at elevation z above the water surface.

P = Air pressure.

ρ_a = Density of water.

z = Elevation at which "V" is measured

z_0 = Height of Roughness

Problem:- Calculate evaporation from an open water surface in a region where air pressure is 105 $\frac{KN}{m^2}$. The vapour pressure of water is 3.167 $\frac{KN}{m^2}$ and that of air is 1.583 $\frac{KN}{m^2}$. The wind speed measured at elevation of 1.75 m above water surface is 2.7 m/sec. Assume height of surface roughness as 0.3 mm. The density of water and air may be taken as 1000 $\frac{Kg}{m^3}$ and 1.2 $\frac{Kg}{m^3}$ and the Von Karman Constant is 0.4.

Solution :-

$K = 0.4$ $\rho_a = 1.2\ kg/m^3$

$V = 2.7\ m/sec$ $P = 105 \times 10^3\ N/m^2$

$\rho_w = 1000\ kg/m^3$ $Z = 1.75\ m$

$Z_0 = 0.0003\ m$ $e_0 = 3167\ N/m^2$

$e_a = 1583\ N/m^2$

As we know that.

$$C = \frac{0.622\ K^2 \rho_a V}{P \rho_w \left[\ln\left(\frac{Z}{Z_0}\right)^2\right]} = \frac{0.622 \times (0.4)^2 \times 1.2 \times 2.7}{105 \times 10^3 \times 1000 \left[\left[\ln\left(\frac{1.75}{0.0003}\right)\right]^2\right]}$$

$$C = \frac{0.3224448}{105 \times 10^3 \times 1000 \times (8.67)^2}$$

$$C = \frac{0.3224448}{7892734500}$$

$$C = 4.19 \times 10^{-11}$$

$$E = C\ (e_0 - e_a) = 4.19 \times 10^{-11} (3167 - 1583)$$

$$E = 6.63 \times 10^{-8}\ m/sec$$

$$E = 6.63 \times 10^{-8} \times 1000 \times (1 \times 60 \times 60 \times 24)$$

$$\boxed{E = 5.7\ mm/day}$$ Answer.

Measuring Evaporation by pans

Pan Evaporation Method

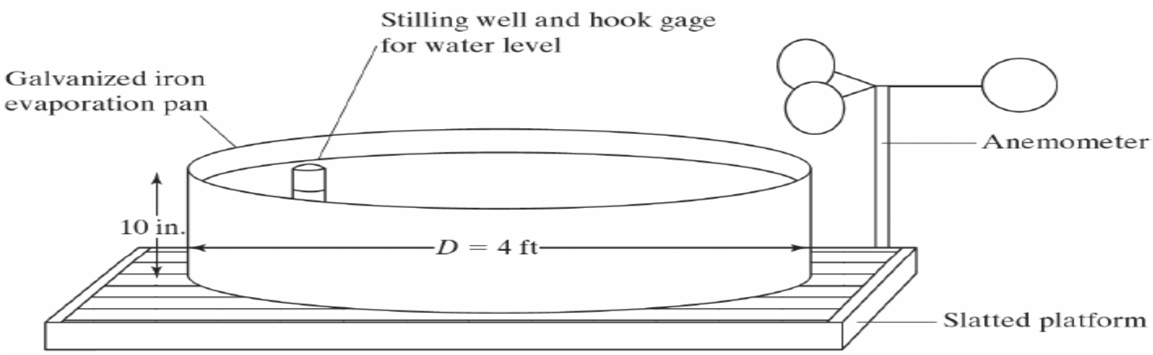

Figure 1.18
Standard Class A evaporation pan with cup anemometer and rain gage.

Pan evaporation values are higher than the actual lake evaporation.

$$E_{actual} = E_{pan} \times K$$

K = Adjustment Factor (Pan Coefficient).
K = 0.60 to 0.81

Problem:- The rainfall during a particular day was 10mm. Class-A pan is installed in this area. If water added to pan on that particular day was 12mm. Find the evaporation. Take the pan coefficient as 0.60.

Solution:-

Rainfall = 10 mm
water added = 12 mm

Depth of water evaporated from pan = 10+12
= 22 mm

$E_{actual} = E_{pan} \times K = 22 \times 0.60$

$E_{actual} = 13$ mm

Measurement of Evapotranspiration :-

There are many methods of measuring evapotranspiration. The instrument most commonly used for the measurement of evapotranspiration is known as "Lysimeter"

Lysimeter :-

- The Lysimeter consists of a small tank filled with soil and having the same vegetation cover as that of the adjacent area.
- It contains a drain and all facilities for measuring the quantity of water entering and leaving the tank.
- The vegetation in the tank is either watered from lower side of the tank by maintaining a constant water table or from above.

Some Common uses.

(1) To provide direct measurement of evapotranspiration from soil surfaces on which plants are grown, for use in studies of factors affecting this process.

(2) To provide accurate measures of water loss from soil in studies of upward movement of water in soil as a result of surface drying.