Unit - 2 Date:-

Abstractions from Precipitation

Losses (or) Abstractions from precipitation:-

When precipitation takes place on land surface, whole of it is not available as runoff because of losses that takes place during (or) after the precipitation.

It consists of,

1. Interception
2. Evaporation
3. Transpiration
4. Infiltration
5. Depression storage
6. watershed leakage.

Out of these, evaporation, transpiration and Infiltration are the major losses.

precipitation - surface runoff = Total loss

∴ Total loss = Interception + Evaporation + Transpiration + Infiltration + Depression storage + watershed leakage.

1. Interception:-

Interception may be defind as that amount of precipitation water which is intercepted by vegetative foliage, buildings and other objects lying over the land surface.

The "interception storage" is the amount of precipitated water which wets the initially dried surface of the objects lying above the ground surface.

Various factors that affect interception are,

1). Storm factor.

2). Plant - factor

3). Season of the year

4). Prevailing wind.

2. Evaporation:-

Evaporation and Evapo-transpiration are the two most important phases of hydrologic cycle which redistribute the heat energy between surface and atmosphere.

Evaporation is the process in which liquid changes to gaseous state at the free surface, below the boiling point through the transfer of heat energy.

It is continuous natural process by which a substance changes from liquid to gaseous state.

The Main source of evaporation is the solar radiation. The loss due to evaporation may be as high as 90% of the annual precipitation

The rate of evaporation is dependent following factors are,

1) vapour pressure at the water surface and air above.
2) Air and water temperatures.
3) solar radiation.
4) wind speed.
5) Atmospheric pressure.
6) Nature and size of evaporating surface.
7) Quality of water.

Dalton's law of evaporation:-

From the dalton's law of evaporation, the rate of Evaporation (E) can be related to vapour pressure as,

$$E = c(e_s - e_a)$$
$$= (a+bv)(e_s - e_a).$$

where,

E = Evaporation loss (mm/day)

e_s = saturation vapour pressure at water surface in millibar.

e_a = Actual vapour pressure. of the air above.

c = a constant whose value depends upon wind velocity, humidity etc.

$c = a + bv$

For evaporation continue, e_a is less than e_s.

Evaporation will be high. $(e_s - e_a)$ is large.

→ Evaporation will be zero when $e_s = e_a$.

Factor's affecting evaporation losses:-

Evaporation losses depends upon

1) Nature of evaporating surface
2) Area of water surface
3) Depth of water in the water body
4) humidity
5) wind velocity
6) temperature.
7) Atmospheric pressure.
8) Quality of water.

1. Nature of evaporating surface:-

→ Different evaporating surfaces like soil, barren land, forest area, houses and lakes effect evaporation to the extent they have potential.

→ Black cotton soils help to evaporate the soil water faster than red soil because such soil have the potential to absorb incoming radiation more effectively.

→ Evaporation from wet soil is faster and it reduces gradually as the soil becomes drier.

2. Area of water surface:-

The evaporation loss directly depends upon the area of the water surface. greater the area, greater will be the water loss due to evaporation.

3. Depth of water in water body:-

Deep water bodies evaporate slower then shallow water bodies in summer while in winter season, they evaporate faster.

4. ~~Humidity:-~~ wind velocity:-

→ wind removes the overlying vapour from an evaporating body thereby increasing the rate of evaporation.

→ However, high wind speed may not necessarily remove water vapour from a small water body.

→ The relation between wind speed and size of water bodies (or) evaporating surface.

5. Humidity:-

Evaporation is inversely proportional to humidity. If the humidity in the atmosphere is more, evaporation will be less.

6. Temperature of air:-

→ Increase in air temperature increases the evaporation rate though not always proportionally.

→ For the same temperature, colder months have less evaporation then summer months due to combined effect of other environmental parameters.

7. Atmospheric pressure:-

As per Dalton's law, evaporation will be less if the atmospheric pressure (e_a) is more. Thus, at higher altitudes, evaporation loss is more while in deep valleys, evaporation is less.

8. Quality of water:-

The presence of dissolved salts in water reduces the saturation vapour pressure (e_s) of water which consequently reduces the rate of evaporation.

Estimation of evaporation from surface of water bodies:-

The following are prominent methods of estimation loss from surfaces of large water bodies,

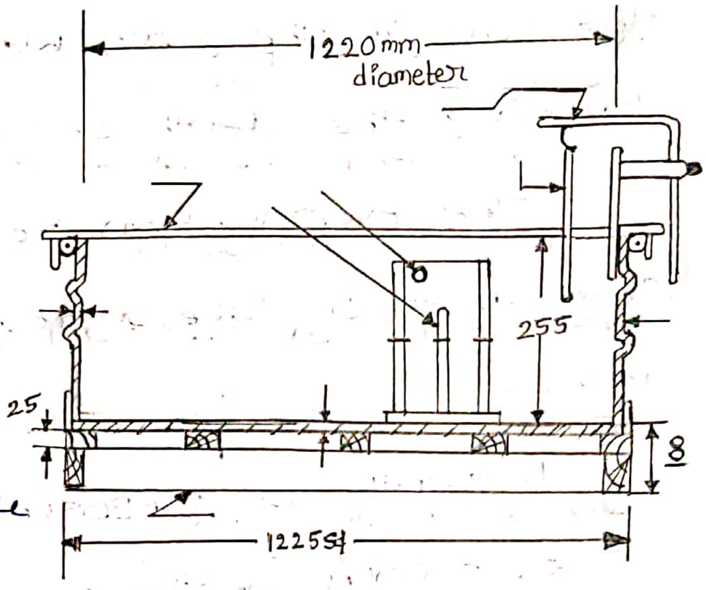
1) Measurement using evaporation pans.
2) Use of empirical equations.
3) Water Budget Method.
4) Energy Budget Method.

1. Measurement by evaporation pans:-

→ The most reliable method for the estimation of evaporation from large water bodies is that by measurements from evaporation pans.

→ Evaporation pan recommended by IS 5973 - 1970.

→ The evaporimeter is a modified version of US weather Bureau class - A pan.



→ The pan, 1.22m in diameter and 0.255m deep, is made of 0.9mm thick copper sheet with hexagonal wire netting of galvanised iron mesh covering it to protect water from birds, and also to make the water temperature more uniform during day and night.

→ The pan placed over a square wooden platform of 1.225 m width and 10cm height, so that circulation of air is possible all around the pan.

→ Water level in the pan is recorded by a point gauge arrangement placed inside a stilling basin.

→ Measurement is taken atleast once a day by adding water to the pan by a calibrated cylindrial glass jar to bring the water level to the previous position. This gives directly the evaporation depth over the time lapse.

→ similarly, if there is rainfall exceeding the depth of evaporation, the water is taken out of the pan in the same way by measuring jar and knowing the depth of rainfall.

The evaporation recorded by a pan differs from that of lake (or) reservoir due to following reasons.

1. Depth of exposure of pan above ground.
2. colour of the pan.
3. Height of the rim.
4. Heat storage
5. Pan diameter.
6. variation of vapour pressure, wind speed and water temperature.

∴ Lake evaporation = Pan co-efficient × Pan evaporation

→ The pan co-efficient for the indian evaporimeter is around 0.8.

2. Use of empirical equations:-

There are large number of empirical eq's for estimating the evaporation are,

1. Meyer's Formula
2. Rohwer's Formula.

1. Meyer's formula (1915):-

$$E = K_m (e_s - e_a)\left[1 + \frac{V_9}{16}\right]$$

where,

E = Evaporation from the water body in mm/day.

e_s = saturation vapour pressure.

e_a = Actual vapour pressure.

V_9 = Monthly mean wind velocity in km/h at height of 9m above the ground.

K_m = Co-efficient accounting for various factors,

= 0.36 for large deep waters

= 0.50 for small shallow waters.

2. Rohwer's formula:- (1931)

$$E = 0.771\,(1.465 - 0.000732\,P_a)\,(0.44 + 0.0733\,V_{0.6})\,(e_s - e_a)$$

where,

$V_{0.6}$ = Mean wind velocity in km/h at 0.6m above the ground level.

3. Water Budget (or) Water Balance Method:-

This method balances all the incoming, outgoing and stored water in a lake (or) reservoir over a period of time, using the following eq,

$$\Sigma \text{Inflow} - \Sigma \text{outflow} = \text{chang in storage} + \text{Evaporation loss}$$

$$E = \Sigma I - \Sigma O \pm \Delta S$$

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The above eq can be generalised as under, taking all the factors of inflow and outflow,

$$E = (P + I_{sf} + I_{gf}) - (O_{sf} + O_{gf} + T) \pm \Delta s.$$

where,

P = precipitation.

I_{sf} = surface water inflow

I_{gf} = ground water inflow.

T = transpiration loss.

Δs = change in storage.

4. Energy Budget (or) energy Balance Method:-

This method uses the conservation of energy by incorporating all the incoming, outgoing and stored energy of a lake/reservoir.

$$H_n = H_a + H_e + H_g + H_s + H_i$$

where,

H_n = Net heat energy recieved by water surface.

$= H_c(1-\gamma) - H_b.$

H_b = Back radiation

H_a = sensible heat transfer from water surface to air.

H_e = heat energy used up in evaporation.

$= \rho_w L_a E$

The sensible heat term H_a can be estimated by using Bowen's ratio (β) by the following

Expression,

$$\beta = \frac{H_a}{\rho_w L_a E} = 6.1\times10^{4} P_a \frac{T_w - T_a}{e_s - e_a}$$

where,

T_w = temperature of water surface in °C

T_a = Temperature of air in °C.

Transpiration:-

Transpiration is the process in which water is lost through the living plants, during the respiration process, and back to atmosphere.

EvapoTranspiration:-

Evapo-Transpiration is combined term of evaporation and transpiration defind as the total loss of water through evaporation and transpiration from the plants.

1) A reservoir with average surface spread of $4.8 km^2$ in the first week of November has the water surface temperature of 30°c and relative humidity of 40%. wind velocity measured at 3.0m above the ground is 18 km/h. The mean barometer reading is 760mm of Hg. calculate the avg evaporation loss from the reservoir in mm/day and total depth and volume of evaporation loss in the first week of November. use

both Meyer's equation as well as Rohwer's eq.
Take saturation vapour pressure at 30°C as 31.81 mm of Hg.

Sol:-

Given data:-

Average surface $= 4.8\ km^2$

water surface temperature $(T_w) = 30°C$.

relative humidity $= 40\%$

(a) using Meyer's formula:-

$$E = K_m (e_s - e_a)\left[1 + \frac{V_9}{16}\right]$$

$e_s = 31.81$ mm Hg

R_H = Humidity $= 40\%$
$= 0.4$.

$e_a = e_s \cdot R_H = 31.81 \times 0.4$
$= 12.72$ mm Hg.

$$V_9 = V_2 \left(\frac{9}{3}\right)^{1/7}$$

$= 18 \times 1.169$

$= 21.06$ km/h

$K_m = 0.36$ for large deep waters.

$$\therefore\ E = 0.36\,(31.81 - 12.72)\left[1 + \frac{21.06}{16}\right]$$

$= 15.91$ mm/day.

$\therefore$ Total depth of evaporation in one week $= 7 \times 15.91$
$= 111.4$ mm.

Total volume of water evaporated $= (111.4 \times 4.8 \times 10^6) \cdot 10^{-3}$

$= 0.534 \times 10^6 m^3$.

$= 53.47$ hect-m.

(b) Using Rohwer's formula:-

$$E = 0.771\,(1.465 - 0.000732 P_a)\,(0.44 + 0.0733 V_{0.6})\,(e_s - e_a)$$

where,

$e_s = 31.81$ mm Hg

$e_a = 12.72$ mm Hg , $P_a = 760$ mm Hg.

$$V_{0.6} = \left[\frac{0.6}{2}\right]^{1/7} \times 18$$

$= 15.16$ km/hr.

$$E = 0.771 \times [1.465 - 0.000732 \times 760)\,(0.44 + 0.0733 \times 15.16)\,(31.81 - 12.724)$$

$= 20.74$ mm/day.

$\therefore$ Total evaporation for one week $= 20.74 \times 7$

$= 145.2$ mm

$\therefore$ Total volume of water evaporated $= (145.2 \times 4.8 \times 10^6) 10^{-3}$

$= 0.697 \times 10^6 m^3$

$= 69.7$ hect-m.

Thus, we find that Rohwer's formula gives about 30% higher results ~~t~~ than Meyer's formula.

Infiltration:-

Infiltration may be defined as the downward movement of water from soil surface, into the soil mass through the pores of the soil.

When rain water falls on the ground, a small part of it, initially absorbed by the top thin layer of soil so as to replenish the soil-moisture deficiency. and thereafter, excess water infiltrates downwards to join ground water.

Infiltration is the entry (or) Passage of water into the soil through soil surface. once water enters into the soil, the process of transmission of water in the soil, known as "Percolation" takes place thus removing of water from near the surface to down below.

(or)

Infiltration may be defind as the process by which water enters the surface strata of the earth. The infiltrated water first meets the soil moisture deficiency, if any and thereafter the excess water moves vertically downwards to reach the ground water table. This vertical movement is called "Percolation".

Factors affecting Infiltration:-

Following the various factors, both

Meteorological as well as the characteristics of soil media, on which infiltration rate and infiltration capacity depends, factors are,

1. condition of entry surface : vegetation cover versus bare land.
2. Permeability/percolation characteristics of soil formation.
3. Antecedent moisture conditions in soil
4. Temperature.
5. Intensity and duration of rainfall
6. Movement of man and animals.
7. change due to human activities.
8. Quality of water.
9. Presence of ground water table.
10. size and characteristics of soil particles.
11. catchment parameters.

1. condition of entry surface : vegetation cover versus bare land:-

→ If the area is covered by grass, vegetation and bushy plants, infiltration capacity will be more.

→ on the contary if the soil surface is bare, the impact of rain drops fallings on the surface will cause in washing of finer particles of the soil and will clog the surface, thus resulting in the ~~radiation~~ retardation of infiltration.

→ The vegetation cover also provides a layer of decaying organic matter, which promotes activities of burrowing insects etc.

→ which in turn produce spongy permeable soil structure resulting in increased infiltration

→ The vegetation cover removes ~~with~~ soil moisture through transpiration thus tending to reduce the infiltration during initial periods of rain.

2. Permeability characteristics of soil formation:-

→ The infiltration will continue only when percolation continues. the infiltrated water must be transmitted down by the force of gravity and capillary action.

→ Percolation depends on upon several factors such as soil and it's composition, permeability and porosity, stratification, presence of organic matter and presence of salts.

3. Antecedent moisture conditions in soil:-

→ Infiltration rate will depend on initial moisture conditions of soil, when the soil moisture is high, the infiltration rate (f_t) will be low.

→ When water falls on a dry surface, the upper surface becomes wet while the lower parts of the soil remain comparatively dry initially.

→ This results in a large difference of capillary potential, due to which a downward force will act on the water, in addition to the normal force of gravity.

→ This will result in rapid infiltration, For the storm in succession, the soil will have lesser rate of infiltration then the storm of season.

4. Temperature:-

→ The viscosity of water changes with temperature the flow of water with in the body of soil is laminar, and the flow is directly related to viscosity

→ In summer, the infiltration will be higher due to loss viscous water, in comparision to winter.

→ In zero temperature, crystallisation of water in the pores blocks the passage, thus reducing (or) even stopping the infiltration.

5. Intensity and duration of rainfall:-

→ when the precipitation takes place with heavy intensity, the impact of water causes mechanical compaction and in-vash of fine particles, resulting in ~~higher~~ ~~infilt~~ faster decreases in the rate of infiltration.

→ Rainfall of lesser intensity result in higher infiltration rate.

→ The rainfall with higher duration will result lower infiltration in comparision to the same quantity of rain falling as n number of isolated storms.

6. Movement of man and animals:-

→ When there is heavy movement of man and animals, the soil gets compacted, resulting in reduction in the infiltration rate.

7. change due to human activities:-

→ Cultivation of barren land, by growing crops and grass over, results in increased rate of infiltration.

→ On the other hand, construction of roads, houses, factories, play grounds, including over-grazing of pastures results in reduction in infiltration capacity.

8. Quality of water:-

→ Silts and other impurities present in incoming water result in retardation of infiltration rate due to clogging of soil pores.

→ The salt present in water affect the viscosity of water and may react with soil to form complexes that reduce the porosity of soil.

9. Presence of ground water table:-

→ Presence of ground water table reduces infiltration. For infiltration to continue the position of ground water table should not be very close.

10. Size and characteristics of soil particles:-

→ The infiltration rate is directly proportional to the grain/diameter, for granular soils.

→ If the soil has swelling minerals like illite and montmorillonite, the infiltration rate will reduce drastically.

11. Catchment Parameters:-

→ It is well known now, from exhaustive studies, that the infiltration capacity decrease with increase in drainage density.

→ similarly, the infiltration capacity (cm/hour) decreases with increase in the run off rate.

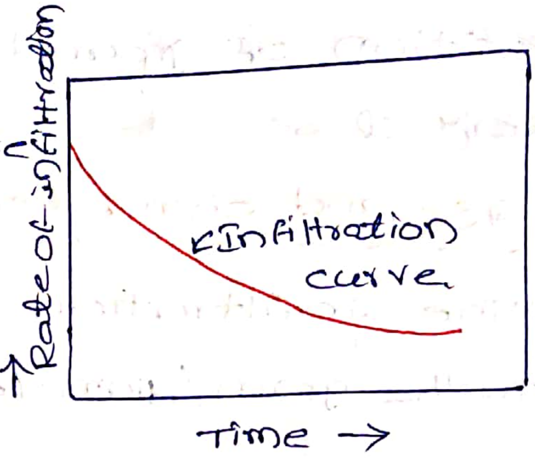
→ similarly, the infiltration capacity (cm/h) decrease with increase in sediment yield rate (m^3/sq.km).

Infiltration capacity:-

→ The capacity of any soil to absorb water from rain falling continuously at an excessive rate goes on decreasing with time, until a minimum rate is reached.

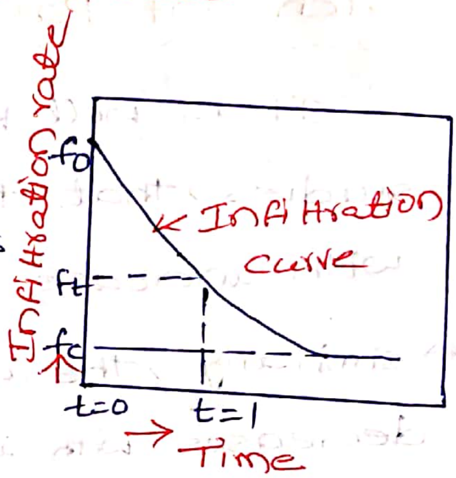
→ Infiltration capacity (f_0) of a soil is the maximum rate at which water will enter the soil in a given condition.

→ The infiltration rate at any instant is the rate at which water actually enters the soil during a storm and is equal to infiltration capacity (f_0) and rainfall rate, which ever is less.



Infiltration capacity curve (I.C curve):-

→ Infiltration capacity curve for a given soil formation graphically represents the variation of infiltration capacity (f_t) with time during.



→ Infiltration rate is maximum (f_0) as the begining of the rainfall and thereafter infiltration rate decreases exponentially with time.

Horton's equation:-

Horton's equation the followine eq for finding infiltration rate (f_t) and any time period(t)

$$f_t = f_c + (f_0 - f_c)e^{-kt}.$$

where,

f_t = Infiltration rate at any time 't'.

f_c = constant infiltration rate at time $t=T$

f_0 = Infiltration rate at begining ($t=0$)

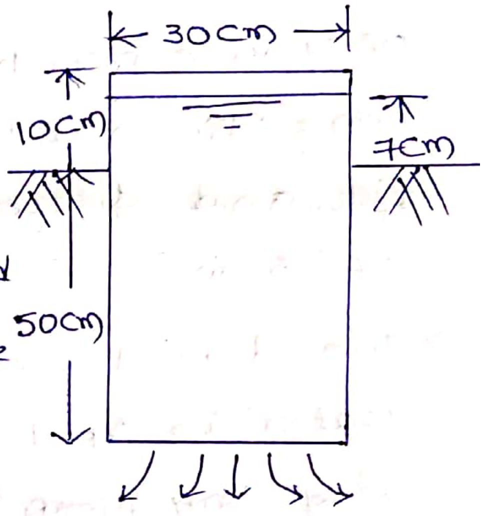
k = a constant depends on soil and vegetation.

Field Measurement of infiltration Rate:-

Infiltration in the field can be measured with the help of two types of infiltrometers.

1. single tube infiltrometer
2. Double ring infiltrometer.

Single tube infiltrometer:-



→ It consists of a hollow metal cylinder of 30cm diameter and 60cm length with both ends open.

→ The cylinder driven in the ground such that 10cm of it projects above the ground.

→ The cylinder is filled with water, such that a head of 7cm within the infiltrometer is maintained above ground level.

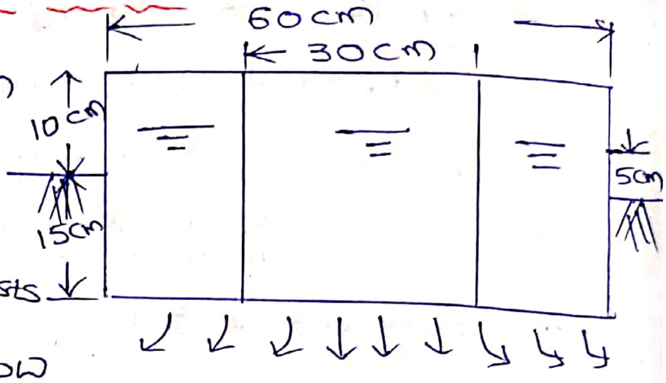
→ Due to infiltration of water, the water level in the cylinder will go on decreasing. water is added to the cylinder, through graduate jar (or) burette, so as to maintain constant level.

→ The volume of water added over a predetermined time interval gives the infiltration rate for that time interval.

→ The observations are continued till almost uniform infiltration rate is obtained, which may take about 3 to 6 hours, depending type up on soil.

→ The major draw back of the single tube infiltrometer is that infiltrated water percolates laterally at the bottom of the ring. Hence it does not truly represents the area through which infiltration takes place.

2. Double tube infiltrometer:-



→ The lateral percolation of water is rectified in the double tube infiltrometer which consists of two concentric hollow rings driven into the soil uniformly without any tilt and disturbing the soil, to the least depth of 15cm.

→ The diameter of the rings may very form 25to60cm water is applied in both the inner and outer rings ~~may vary from~~ to maintain a constant depth of about 5cm.

→ water is replenised after the level falls by about 1cm. The water depth in the inner and outer rings should be kept the same during the observation period.

→ The measurement includes the recording of volume of water added into the inner compartment to maintain the constant water level and the corresponding elapsed time.

→ As the purpose of the outer ring is to suppress the lateral percolation of water from the inner ring, the water added it to need to be measured through water is added to it maintain the same depth as the inner ring.

Infiltration indices:-

Infiltration Index is the avg rate of loss such that the volume of rainfall in excess of that rate will be equal to the direct runoff.

! Estimate of runoff volume from large areas having heterogeneous infiltration loss and rainfall.

They are two types of infiltration indices.

1. W - Index
2. ϕ - Index.

1. ϕ - Index:-

It is the average rainfall above which the rainfall volume is equal to the runoff volume. ϕ - Index is derived from the rainfall hyetograph. It is given by,

$$\phi\text{-Index} = \frac{P-R}{t_e}$$

where,

P - Precipitation

R - Runoff

t_e = Duration of storm.

2. W - Index:-

W - Index is defined as the refines the ϕ - Index the infiltration losses are separated from the total abstractions and and average value of infiltration rate are called as

W-Index.

It is given as,

$$W\text{-Index} = \frac{P - R - t_a}{t_e}$$

Where,

P - Precipitation

R - Runoff.

t_e - Duration of storm

t_a - Intial abstractions.

Types of Evapotranspiration:-

Evapotranspiration is classified into two types are,

1. Potential Evapotranspiration (PET)
2. Actual Evapotranspiration (AET).

1. Potential Evapotranspiration:-

Potential evapotranspiration is controlled essentially by Meterological factors.

→ In PET tends to increase the temperature, sunshine and wind speed increase.

→ Potential evapotranspiration is defined as the evapotranspiration which would occur if there was always an adequate water supply available to a fully vegetated surface.

2. Actual Evapotranspiration:-

Actual evapotranspiration is defined as the which would occure at a particular point (or) at a particular place.

Factor's affecting Evapotranspiration :-

In general the factors that govern the evaporation and transpiration are,

1. Temperature
2. Humidity
3. Sunshine
4. Wind velocity
5. Type of crop
6. Type of Irrigation Method.

·Temperature:-

→ Temperature increases the evapotranspiration increases.

·. Humidity :-

→ Humidity value is different from coastal areas and dry lands.

> Because of in coastal areas the humidity value or is more in some what moist condition in air is saturated in the warmer.

> Because Humidity is inversly proportional to the evapotranspiration.

. Sunshine:-

Evaporation and transpiration will occure in day time. Evapotranspiration is more the sunshine hour is also more.

4. Wind speed:-

→ Wind speed increases will also evapotranspiration increases which depend on crop.

5. Type of crop:-

→ If the type of the crop of water increases the evapotranspiration is increases.

6. Type of Irrigation Method:-

Type of Irrigation method is mainly depend upon the sprinkler irrigation, Drip Irrigation.

→ If the type of Irrigation supply of water to the crop the increase evapotranspiration also increases.

Measurement of Evapotranspiration:-

There are mainly four methods of direct measurement of evapotranspiration, They are,

1. Lysimeter.
2. Water Budget Method
3. Field experimental plots
4. soil moisture depletion studies.

1. Lysimeter:-

→ A lysimeter consists of a circular tank about 60 to 90cm in diameter and 180cm deep. Some times larger diameter 3m with 3m depth are also used.

→ The lysimeter is filled with soil and individual crops (or) natural vegetation, for which evapotranspiration is required.

→ It is buried so that it's top in flush with the surrounding ground surface.

→ The sides of the lysimeter are impervious whereas the bottom is pervious. water is passing through the soil column is collected at the bottom and conducted through a small tube to a measuring gauge.

→ soil moisture measurements may be obtained from moisture sampling, weighing.

→ In weighing type, the tank is mounted on a self recording scale. In the hydraulic method the tank is floated on water or a suitable heavy liquid and changes is weight are recorded through pressure changes observed in a manometer.

→ The limitation of Lysimeter method is that differen may exist between the lysimeter and natural conditions of soil profile, soil moisture regime, plant rooting characteristics.

2. Field Experimental Plots:-

→ In this method a field plot is choosen and the amount of water added to the irrigation plot under observation by way of precipitation and irrigation are measured along with runoff.

The evapotranspiration is computed as,

$$ET = I - Q - \Delta s.$$

Where,

I = Total inflow in mm including precipitation

Q = Total surface runoff

Δs = soil moisture storage in mm, is computed from the following eq.

$$\Delta s = \sum_{i=1}^{n} \frac{M_{bi} - M_{ei}}{100} \times G_i D_i$$

3. soil moisture Depletion studies:-

→ The studies involve measurement of soil moisture from various depth at as frequent intervals of time as possible throughout the growth period of a crop.

The evaporation and transpiration for any time period b/w the two successive samplings is obtained as,

$$u = \sum_{i=1}^{n} \frac{M_{1i} - M_{2i}}{100} \times C_i D_i$$

Blaney -criddle eq:-

Blaney -criddle eq developed a simple eq for estimating evapotranspiration.

The monthly consumptive use factor 'f' is defined as $f = \frac{P.\ T_m}{100}$

Infiltration rate:-

Infiltration rate is defined as the avg percentage of infiltration rate depend upon the soil moisture condition.

1) The total observed runoff volume during a 6h storm with a uniform intensity of 1.5 cm/h is $21.6 \times 10^6 m^3$. If the area of the basin is 300 km^2. Find the avg. Infiltration rate for the basin?

Sol:-

Total Rainfall = Intensity of rainfall x Duration

$= 1.5 \times 6$

$= 9 cm$

Volume of runoff $= 21.6 \times 10^6 m^3$.

Area of the basin $= 300 km^2$

$= 300 \times 10^6 m^2$.

Depth of runoff $= \frac{\text{Volume of runoff}}{\text{Area of the basin}}$

$= \frac{21.6 \times 10^6}{300 \times 10^6}$

$= 0.072 m = 7.2 cm$.

$\therefore$ Total infiltration $= 9 - 7.2 = 1.8 cm$

Avg. Infiltration rate $= \frac{1.8}{6} = 0.3 cm/hr$.

2) A 6h storm produced rainfall intensities of 7, 18, 25, 12, 10 and 3 mm/h in successive one hour intervals over a basin of 800 sq. km. The resulting runoff is observed to be 2640 Hectare-meters.

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Determine ϕ-Index for the basin?

sol:

Total volume of runoff $= 2640 \text{ H-m}$

$= 2640 \times 10000$

$= 264 \times 10^5 \text{ m}^3$.

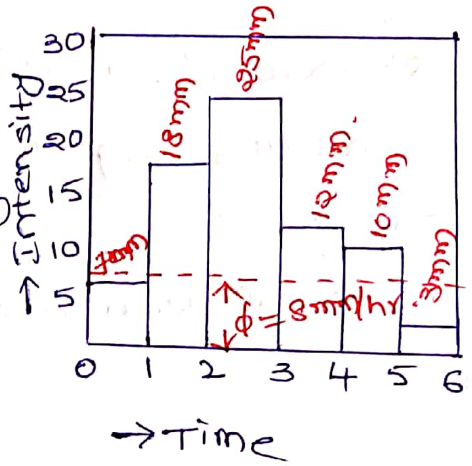
Area of the basin $= 800 \text{ km}^2$

$= 800 \times 10^6 \text{ m}^2$

The depth of runoff $= \dfrac{264 \times 10^5}{800 \times 10^6}$

$= 0.033 \text{ m}$

$= 33 \text{ mm}$



By trial and error of ϕ-Index

the rainfall volume of ϕ-Index

can be, $\phi = 8$ mm/hr

$\Rightarrow 0 + (18-8) + (25-8) + (12-8) + (10-8) + 0$

$\Rightarrow 0 + 10 + 17 + 4 + 2 + 0$

$\Rightarrow 33 \text{ mm}$

Hence we satishfied the eq.

Evapotranspiration control:-

Evapotranspiration may possibly be reduced from a region through the following measures.

→ By destorying the unwanted plants that transpire efficiently.

→ By breeding plant varieties that transpire less.

→ By reducing air movement over a crop by wind breaks of interplanted rows of taller plants.

→ By applying chemical antitranspirants.

→ By placing watertight moisture barries (or) water-retardant mulches on the soil surface.

→ By appropriate land use changes in the catchment which increase streamflow.