Precipitation

Precipitation should be adequate because excessive precipitation leads to the generation of floods and becomes harmful to various lives. It depends on the several features of the topography and climatic condition of the catchment. The term precipitation completely differs from the term precipitation reaction, which means that the reaction involved forms various products that consist of a precipitate of at least one compound. Precipitation is an essential part of the growth of vegetation and the survival of lives.

Precipitation Meaning

Precipitation meaning refers to the amount of rainfall that occurs in a particular catchment area. Some portion of the precipitation converts to various losses, and the remaining portion results in runoff.

Various Indexes to Define Precipitation

Indexes are the parameters used to define a particular quantity. Precipitation in a catchment can be defined with the help of various indexes. Here a few are explained.

Index of Wetness

The wetness index is the ratio of rainfall in a given year at a given place to the average annual rainfall of that place.

- % Rain deficiency = 100 - % index of wetness

Aridity Index

Aridity Index (A.I.) = [(PET) - (AET)]/PET

Where

- A.I = Aridity index
- PET = Potential Evapotranspiration
- AET = Actual Evapotranspiration
- AI ≤ 0 → Non arid
- 1 ≤ A.I ≤ 25 → Mild Arid
- 26 ≤ A.I ≤ 50 → Moderate arid
- A.I > 50 → Severe Arid

Measurement of Precipitation

Precipitation in a catchment is measured with the help of rain gauges installed in the catchment area. These rain gauges are uniformly installed in the catchment to measure the uniform distribution of rainfall over the entire area. The total number of rain gauges to be installed in a particular area can be calculated with the help of the following expression:

Optimum Number of Rain Gauge (N)

$$N = \left(\frac{C_V}{\in}\right)^2$$

$$C_V = \frac{\sigma_{n-1}}{\bar{\bar{X}}} \times 100$$

$$\sigma_{n-1} = \sqrt{\frac{\Sigma(X - \bar{X})^2}{(n-1)}}$$

$$\bar{x} = \frac{\Sigma x}{n}$$

where

- C_v = Coefficient of variation,
- $\in$ = Allowable % Error,
- σ = Standard deviation of the data, n = Number of stations,
- $\bar{x}$ = mean of rainfall value

Estimation of Missing Rainfall Data

If any rainfall data in the catchment are missed to record on a particular day, then it can be estimated with the help of the rainfall data and the normal rainfall data of the rain gauge having missing rainfall.

Case 1:

If $N_1, N_2, N_3 \ldots N_n$ < 10% of N_x

Then, $P_x = [P_1 + P_2 + \ldots + P_n]/n$

where,

$N_1, N_2, \ldots N_x..N_n$ are normal annual precipitation of 1,2,…x…n respectively.

$P_1, P_2 \ldots P_n$ is rainfall at stations 1,2,…. n respectively.

And P_x is the rainfall of station x.

Case 2:

If any of N_1, N_2, N_3…N_n > 10% of N_x

P_x = [N_x/n][P_1N_1+ P_2N_2N + ... P_nN_n]

Measurement of Mean Rainfall

The rainfall measurement is required to know the rainfall values in the entire catchment basin. The following three methods are used to convert the point rainfall values at various rain gauges into an average value over a catchment.

(i) Arithmetic Avg Method

To calculate the mean rainfall with this method arithmetic average of all the rainfall value of all the rain gauge stations are considered. This method does not consider any affecting parameter of the rainfall and assumes the uniform variation of the rainfall; hence this method is the least accurate method. The average rainfall is calculated with the following expression.

$P_{avg} = (P_1+P_2+P_3+....+P_n)/n$

Where,

P_1, P_2… P_n is the rainfall value of stations 1, 2… n, respectively.

In practice, this method is used very rarely.

(ii) Thiessen Polygon Method

In this method, the rainfall recorded at each station is given a weightage based on the area closest to the station.

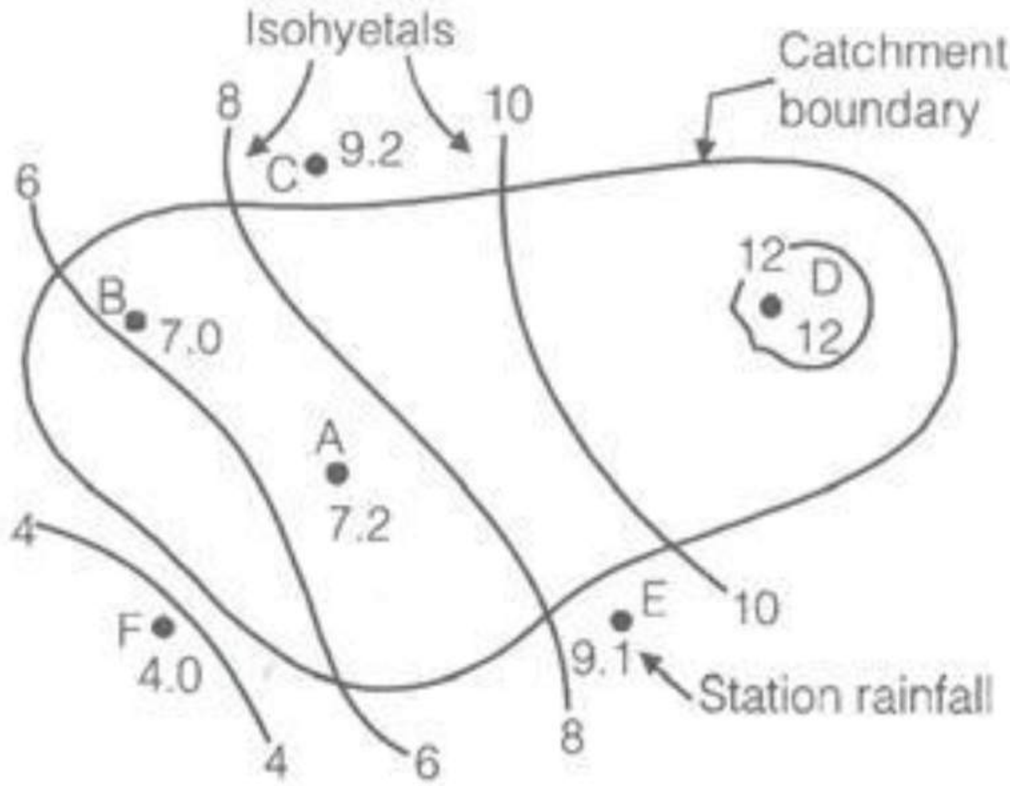
$$P_{avg} = \frac{P_1A_1 + P_2A_2 + ... + P_nA_n}{A_1 + A_2 + ... + A_n}$$

Where, P_1, P_2…P_n is the rainfall data of areas A_1, A_2…A_n.

The Thiessen-polygon method of calculating the average precipitation over an area is superior to the arithmetic average method.

(iii) Isohyetal Method

An isohyet is a line joining points of equal rainfall magnitude. The recorded values for which a real average P is to be determined are then marked on the plot at appropriate stations. Neighboring stations outside the catchment are also considered in this method of averaging.



$$P_{avg} = \frac{A_1 \frac{(P_1 + P_2)}{2} + A_2 \frac{(P_2 + P_3)}{2} + A_{n\text{-}1} \frac{(P_{n\text{-}1} + P_n)}{2}}{A_1 + A_2 + \ldots + A_{n\text{-}1}}$$

What is Evaporation?

Evaporation is the phenomenon of vaporization of water into vapors below its boiling point. Evaporation is a cooling process in which the water body provides the latent heat of evaporation. In this process, liquid changes into a gaseous phase at the free surface, below the boiling point, through the transfer of heat energy.

Dalton's Law

According to Dalton's law, the evaporation rate is proportional to the difference between the saturation vapor pressure at the water temperature and the actual vapor pressure in the air e_a

Thus,

$$E = K(e_s - e_a)$$

Where,

- E = Rate of evaporation (mm/day)
- e_s = Saturation vapor pressure of air (mm)
- e_a = Actual vapor pressure of air (mm)
- $e_s - e_a$ Saturation deficiency

Measurement of Evaporation

Measurement of evaporation is required for the analysis of the evaporation loss that occurred from the catchment area. It is indirectly measured with the help of the measurement of evaporation through the pan. Here various measurement techniques are given.

1. ISI standard Pan

Lake evaporation = C_p × pan Evaporation
Where

- $C_p \Rightarrow$ pan coefficient
  = 0.8 for ISI pan
  = 0.7 for class A-Pan

2. Empirical Evaporation Equations (Meyer's Formula)

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

Where

- k_m = Coefficients which accounts for the size of the water body.
  = 0.36 (for large deep water)
  $\simeq$ 0.50 (for small and shallow waters)
  e_s= Saturation vapor pressure of air in mm of Hg.
  e_a = Actual vapor pressure of overlying air in mm at Hg at the specified height of 8 m.
  V_9 = monthly mean wind velocity in km/hr at about 9 m above the ground level.

3. Water Budget Method

This is the simplest method, but it is the least reliable. It is used for rough calculation, and it is based on the mass conversation principle.

$$P + V_{is} + V_{ig} = V_{og} + V_{os} + E + \Delta S + T_L$$

Where,

- P=Daily precipitation on the water surface.
- V_{is} = Daily surface inflow into the lake.
- V_{os} = Daily surface outflow from the lake.
- V_{ig} = Daily underground inflow into the lake.
- V_{og} = Daily underground outflow from the lake.
- E = Daily Evaporation
- TL= Daily transpiration loss from the plants on the lake.

ΔS = change in storage of lake

= +ve if there is an increase in storage = -ve if decrease in storage

4. Energy Budget Method

The energy budget method is an application of the energy conservation law. The energy available for evaporation is determined by considering the incoming energy. Outgoing energy and energy stored in the water body over a known time interval.

$$E = \frac{H_n - H_g - H_s - H_i}{\delta \cdot L(1+\beta)}$$

Where,

- H_n = Net heat energy received by the water surface
- $H_n = H_c(1-r) - H_b$
- $H_c(1-r)$ = incoming solar radiation into a surface of reflection coefficient, r
- H_b= Back radiation from the water body
- H_g= Heat flux into the ground
- H_S = Heat stored in the water body
- H_i = Net heat conducted out the system by water flow (advected energy)
- β = Bowen's ratio
- δ = Density of water
- L = Latent heat of evaporation.

What is Evapotranspiration?

While transpiration takes place, the land area in which plants stand, also loses moisture by the evaporation of water from soil and water bodies. In hydrology and irrigation practice, it is found that evaporation and transpiration processes can be considered advantageously under one head as evapotranspiration.

The real evapotranspiration occurring in a specific situation is called actual evapotranspiration (AET).

Measurement of Evapotranspiration

Evapotranspiration can be measured with the help of Penman's Method. It is based on sound theoretical reasoning and is obtained by combining the energy balance and mass transfer approach.

$$PET = (AH_n+E_a\gamma)/(A+\gamma)$$

Where

- PET = daily evaporation in mm/day.
- A = slope of the saturation vapor pressure v/s temperature curve at the mean air temperature in mm of Hg per °C.
- H_n = Net radiation in mm of evaporable water per day
- E_a = Parameter including wind velocity and saturation deficit.
- γ = Psychometric constant = 0.49 mm of Hg/°C

It is based on mass transfer and energy balance.

Transpiration Loss (T)

$$T = (w_1+w_2)-W$$

Where,

- w_1 = Initial weight of the instrument
- W = Total weight of water added for full growth of the plant.
- w_2 = Final weight of instruction, including plant and water
- T = Transpiration loss.

What is Stream Flow Measurement?

Stream flow representing the runoff phase of the hydrologic cycle is the most important basic data for hydrologic studies. Stream flow measurement techniques can be broadly classified into two categories:

1. **Direct Determination**
2. **Indirect Determination**

Under each category, there are various methods. The important ones are listed below

1. Direct determination of stream discharge
    1. Area velocity methods
    2. Dilution techniques
    3. Electromagnetic method and
    4. ultrasonic method
2. Indirect determination of streamflow
    1. Hydraulic structures, such as weirs, flumes and gated structures, and
    2. Slope-area method

Determination of Velocity in Stream Flow

Surface velocity in stream flow is required for the analysis of the discharge in the river water. It can be measured in the following way.

1. Float Method: Float is generally used to determine the approximate velocity of the surface. These are floating devices passed through the water along the stream's flow. It can be mathematically expressed as $V_s = L/t$

Here,

- V_s = surface velocity
- L= Distance traveled by the float in time 't'.

2. Current Meters Method: These consist of rotating elements that rotate due to reactions of stream currents. The number of revolutions per second is counted. This can be used to measure point velocity of any depth.

$$\mathbf{V = aN_s + b}$$

Where,

- V = point velocity
- N_s = Number of revolutions per sec. And a and b are current meters constant.