RPSC 2024

Rajasthan Public Service Commission

Assistant Engineer

CIVIL ENGINEERING

Engineering Hydrology

CONTENTS

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PRECIPITATION AND GENERAL ASPECTS OF HYDROLOGY

1

Hydrology is the science which deals with the occurrence, distribution and movement of the water in the earth, including that in atmosphere and below the surface of the earth.

FORMS OF PRECIPITATION

- Rain, Snow, Drizzle, Glaze, Sleet and Hail.

Rain

- It is the principal form of precipitation in India. The term rainfall is used to describe precipitations in the form of water drops of sizes larger than 0.5 mm. The maximum size of a raindrop is about 6 mm.
- This term is used when water drops are of sizes between 0.5 mm to 6 mm.

	Types	Intensity
1.	Light rain	trace to 2.5 mm/h
2.	Moderate rain	2.5 mm/h to 7.5 mm/h
3.	Heavy rain	>7.5 mm/h

- Rainfall is measured at 8.30 A.M. and recording the rainfall of the past 24 hours is common throughout the country.
- When the rainfall on a given day exceeds 2.5 mm, then that day is called a rainy day.

Snow

- Snow consists of ice crystals. Snow has an average density of 0.1 gm/cm^3.
- When fresh, snow has an initial density varying from 0.06 to 0.15 g/cm^3 and it is usual to assume an average density of 0.1 g/cm^3. In India, snow occurs only in the Himalayan regions.

Drizzle

- A fine sprinkle of droplets of sizes less than 0.5 mm and intensity less than 1 mm/h is known as drizzle.

Glaze

- When rain or drizzle comes in contact with cold ground at around 0°C. The water drops freeze to form an ice, coating called glaze or freezing rain.

Sleet

- Sleet is frozen raindrops of transparent grains, which form when rain falls through air at subfreezing temperature.

Hail

- These are lumps of ice of size more than 8 mm. These are formed due to vertical movement of air current at sub-freezing temperature.

Computation of Average Annual Rainfall Over a Basin

- The amount of rain collected by given rain gauge in 24 hours is known as daily rainfall, and the amount collected in one year is known as annual rainfall.
- The annual rainfall at a given station should be averaged over a period of 35 years or so, it is therefore known as average annual rainfall or normal annual rainfall.

Index of Wetness

- The ratio of the actual rainfall in a particular year at a given place to the normal rainfall of the place is known as "index of wetness".

$$\text{Index of water} = \frac{\text{Actual rainfall in a given year at a given place}}{\text{Average annual rainfall of that place}} \times 100$$

- Index of wetness gives the idea of the wetness of the year and hence it indicates the deficiency of the rain.

For example: 60% index of wetness means rain deficiency of 40%.
If deficiency
= 30 to 45%, It is known as large deficiency.
= 45 to 60%, It is known as serious deficiency.
= over 60%, It is disastrous deficiency.

Do you know?
- *The year in which the rainfall is less than average annual rainfall it is called a bad or subnormal year.*
- *If the rain fall is more than the average annual rainfall, it is known as a good year.*
- *If the rainfall is equal to the average annual, it is known as a normal year or average year.*

DROUGHTS

- Drought is a climatic anomaly, characterized by deficit supply of moisture. Droughts can be classified on the following basis.

1. Meteorological Drought

- It is a situation where, there is more than 25% decrease in precipitation from the normal precipitation over an area.
- The drought is classified as moderate if the seasonal deficiency is 26 to 50% and the drought is said to be severe if this deficiency is more than 50% of the normal value.
- A year is said to be drought year in case the area affected by severe or moderate drought is more than 20% of the total area of the country.
- If the drought occurs in an area with a probability of $0.2 \le P \le 0.4$, then the area is classified as a drought prone area. If the probability of occurrence of drought at an area is greater than 0.4 then such an area is called chronologically drought prone area.
- In India about 33% area is drought prone.

Do you know?
Drought phenomenon is a hydrological extreme like flood and is a natural disaster. However, unlike floods the droughts are of the creeping kind; they develop in a region over a length of time and sometimes may extend to continental scale.

2. Hydrological Drought

- Hydrological drought means, below average value of stream flow contents in lakes, ground water etc.
- Hydrological drought has 4 components.
  (a) Magnitude (Amount of deficiency)
  (b) Duration
  (c) Severity (Cumulative amount of deficiency)
  (d) Frequency of occurrence.
- In the studies on hydrological drought different techniques have to be adopted for study of (i) surface water deficit, and (ii) groundwater deficit. The surface water aspect of drought studies is essentially related to the stream and following techniques are commonly adopted.
  (a) Low-flow duration curve
  (b) Low-flow frequency analysis and
  (c) Stream flow modelling

3. Agricultural Drought

- This is mainly characterized by deficiency of rainfall. Agricultural drought can be defined with the help of different indices, for example- Aridity Index, Palmar Index and Moisture availability index etc.

$$AI = \frac{P.E.T. - A.E.T.}{P.E.T.} \times 100$$

Where, PET = Potential Evapotranspiration.
AET = Actual Evapotranspiration.

(a) PET refers to the amount of water consumed by the plant consumptively if sufficient moisture is available.
(b) AET refers to the actual amount of water consumed by the plant under existing conditions.

AI anomaly	Severity class
Zero or negative	Non-arid
1-25	Mild arid
26-50	Moderate arid
>50	Severe arid

Do you know?
- *AET is calculated according to Thornthwite's water balance technique, taking in to account PET, actual rainfall and field capacity of the soil.*

- *AI is used as an indicator of possible moisture stress experienced by crops.*
- *The departure of AI from its corresponding normal value, known as AI anomaly.*
- *IMD produces aridity index (AI) anomaly maps of India on a bi-weekly basis based on data from 210 stations representing different agro-climatic zones in the country.*
- *Remote sensing techniques using imageries offer excellent possibilities for monitoring agricultural drought over large areas.*

Average Rainfall

- In order to find "average rainfall" over a basin, the rainfall is measured at a number of rain gauge stations suitably located in the area. The network density depends on the accuracy required. Following are the general guide lines of network stations required.

Area (km^2)	No. of rain gauge stations
0 – 80	1
80 – 160	2
160 – 320	3
800 – 1200	6

Design of Rain Gauge Network

- For analyzing storms, fixing design floods, fore casting floods in a river, reservoir regulations etc., for all studies and investigations, a well distribution network of rain gauge stations within the catchment is essential.
- The areal distribution of raingauges, may vary considerably from region to region in any country. This density also depends upon the basic purpose behind their installation.

For Example

- Less density is required for studies of large general storm.
- Large density is required for study of rainfall pattern in the thunder storms.
- In India at present about 600 km^2 area contains one station, however this density is insufficient and more gauges are required.
- General requirements according to "World Metrological Department".
  - (a) For flat regions of temperate Mediterranean and tropical zones, one station per 600-900 km^2 area is required.
  - (b) For mountainous region of temperate and tropical zones, one station per 100-250 km^2 area is suitable.
  - (c) For arid and polar zones, one station for 1500 to 10000 km^2 is required.
  - (d) This requirement for India has been recommended as 1 station for 520 km^2 area.
- Israel has maximum number of raingauges = 37 stations per 1000 km^2 area, as against. India 1.7 stations per 1000 km^2 area.

Optimum Number of Raingauges

- "If allowable percentage errors is more, lesser number of gauges would be required".
  Based upon this concept, the optimum number of raingauges (N), can be obtained by the following equation.

$$N = \left[\frac{C_v}{E}\right]^2$$

Where, C_v = Coefficient of variation of the rainfall values on the existing stations (%).
E = Allowable % error in the estimate of basic mean rainfall.

Calculation of C_v

1. Calculate mean average annual rainfall

$$\bar{P} = \frac{\Sigma P}{n}.$$

Where n is the number of rain gauge stations.

2. Calculate the mean of squares $\overline{P^2} = \frac{\Sigma P^2}{n}$.
3. Calculate sample standard deviation, 's'

$$\sigma = \sqrt{\frac{n}{(n-1)}[(\overline{P^2}) - (\bar{P})^2]}.$$

4. Calculate % coefficient of variation,

i.e., $C_v = \frac{100\sigma}{\bar{P}} \times 100$

- σ can also be calculated as

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