Q-1. (a) Define precipitation. Explain different forms of Precipitation.

→ Precipitation is the basic input to the hydrology. It can be defined as the return of moisture to the ground in the form of solids or liquids.

Following are the forms of precipitation-

(i) Rain - It is the principle form of precipitation, in India. The term rainfall used to describe the precipitation in the form of water drops of size larger than 0.5mm to the max^{m} size of about 6.0mm. Any drop of size larger than this tends to break up into smaller size, during its fall from clouds.

On the basis of Intensity, rainfall can be classified as-

- Light rain - 2.5 mm/h
- Moderate rain - 2.5 - 7.5 mm/h
- Heavy rain - > 7.5 mm/h

) Snow - It consists of ice crystals which usually combined to form flakes. When fresh snow has initial density varying from 0.06 to 0.15 g/cm^3. It is usually assumed as avg density

0.1 g/cm^3. eg- Himalayan region.

(III) Drizzle - It is a fine sprinkle of numerous water droplets of size less than 0.5 mm and intensity less than 1 mm/hr. In this, the drops are so small that they appear as floating in the air.

(IV) Glaze - When rain or drizzle comes in contact with cold ground at 0°c. The water drops freeze to form an ice coating called glaze or freezing rain.

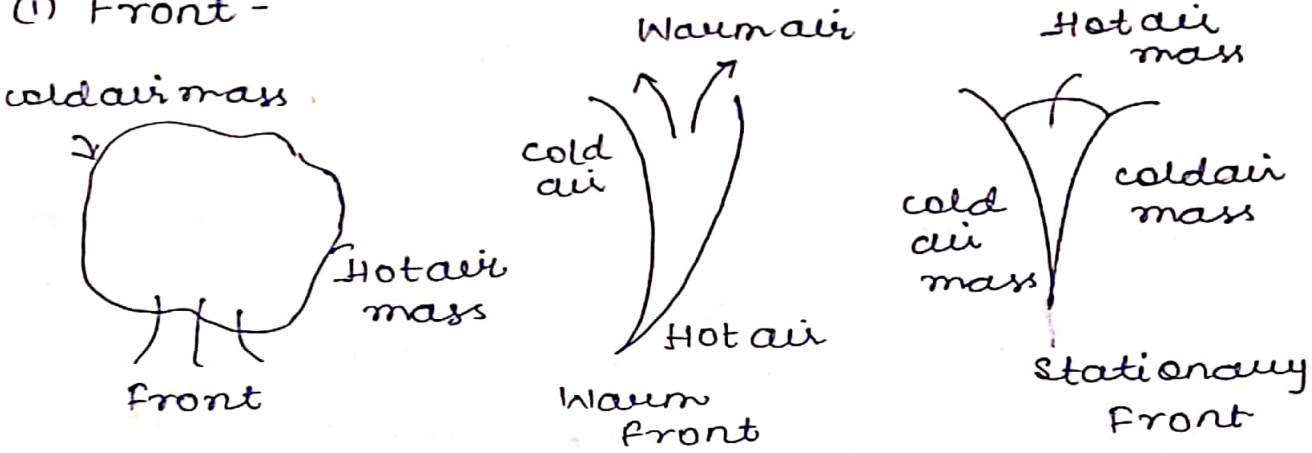
(V) Sleet - It is a frozen raindrop of transparent rain ~~in~~ which forms when rainfall s through air at subfreezing temperature.

(VI) Hail - It is a showery precipitation in the form of irregular pelets and lumps of ice size more than 8 mm occurs in violent under storms in which vertical currents are very strong.

1(b)- Explain with neat sketch about the types of precipitation-

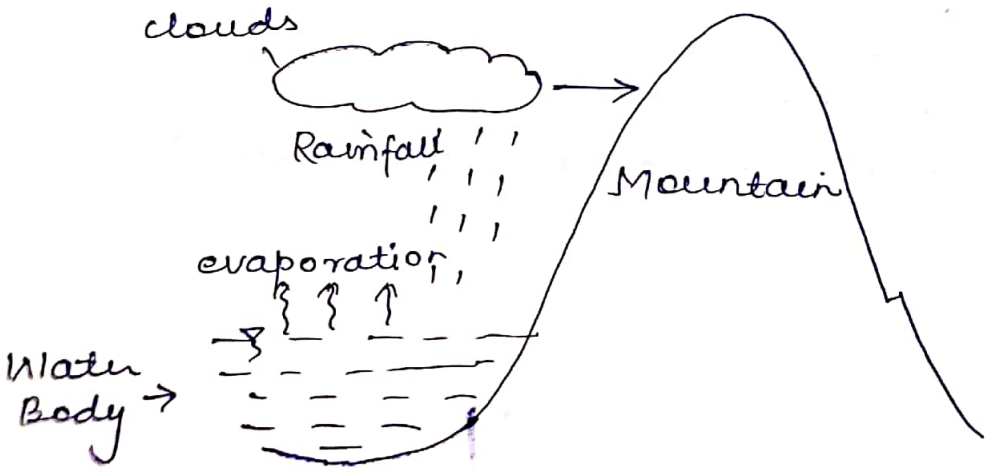
→ Following are the types of Precipitation.

(i) Front -



Front is a barrier region between two air masses having different temperature, densities, moisture, etc. When two air masses due to different temperature & density clashed together, condensation and precipitation occurs at the surface of contact. The surface of contact b/w cold and hot air mass is called Front or Frontal surface

(ii) orographic precipitation



The lifting of moist air from the water bodies or a mountain barriers and causes heavy precipitation on a windward direction is called orographic Precipitation. It is the most important precipitation and is responsible for most of heavy rains in India.

(III) conventional cyclonic precipitation-

~~This is the precipitation associated with cyclones or moving masses of air involves the presence of low pressure~~. In this type, air flows to the earth's surface and gets ~~hault~~ heated up & raises upward due to its low density. A pocket of air which is warmer than the surrounding air due to localised heating rises.

The Air from cooler surroundings flows to take up its place ~~does~~ setting convecting cell. The warmer air continued to rise under-goes cooling and resulting in precipitation.

(IV) cyclonic precipitation-

This is the precipitation associated with cyclones or moving masses of air involves the presence of low pressures.

→ Tropical - clockwise dir^{n}

→ Extra Tropical - anticlockwise dir^{n}

Q-2. Thiessen Weights for a network of 10 rain gauges in a river basin of area 6000 sq. km are 0.10, 0.16, 0.12, 0.11, 0.09, 0.08, 0.07, 0.11, 0.06, 0.11. The rainfall records at these rain gauges during a storm are 132, 119, 162, 138, 207, 156, 135, 158, 168 and 150 mm respectively. Determine the avg depth of rainfall by thiessen polygon method and arithmetic mean method.

→ (1) Arithmetic mean method-

$$P_{av} = \frac{P_1 + P_2 + \cdots P_n}{n}, \quad \text{where } n = 10$$

$$= \frac{132 + 119 + 162 + 138 + 207 + 156 + 135 + 158 + 168 + 150}{10}$$

$$= 152.5 \text{ mm}$$

(2) Thiessen Polygon Method

$$\bar{P} = \frac{P_1 A_1 + P_2 A_2 + \cdots P_n A_n}{A_1 + A_2 \cdots A_n}$$

$$= (132 \times 0.1) + (119 \times 0.16) + (162 \times 0.12) + (138 \times 0.11) + (207 \times 0.09) + (156 \times 0.08) + (135 \times 0.07) + (158 \times 0.11) + (168 \times 0.06) + (150 \times 0.11)$$

$$= 151.38 \text{ mm}$$

Q-3. A catchment has six rain gauge stations. In a year, the annual rainfall recorded by the rain gauges are

Stations	A	B	C	D	E	F
Rainfall (cm)	92.8	112.6	190.8	110.3	99.8	146.7

for a 10% error in the estimation of the mean rainfall, calculate the optimum number of stations in the catchment.

→ $m = 6$

$\bar{P} = ?$

$$\bar{P} = \frac{1}{6}\{92.8 + 112.6 + 190.8 + 110.3 + 99.8 + 146.7\}$$

$$= 125.5 \text{ cm}$$

Now, $\sigma_{m-1} = \sqrt{\sum_{i=1}^{6} \frac{(P_i - \bar{P})^2}{m-1}}$

$$= \sqrt{\frac{(92.8-125.5)^2 + (112.6-125.5)^2 + (190.8-125.5)^2 + (110.3-125.5)^2 + (99.8-125.5)^2 + (146.7-125.5)^2}{5}}$$

$$= 36.98$$

$$CV = \frac{100 \times \sigma_{m-1}}{\bar{P}} = \frac{100 \times 36.98}{125.5} = 29.46$$

$$\therefore N = \left(\frac{CV}{\epsilon}\right)^2 = \left(\frac{29.46}{10}\right)^2 = 8.67 \simeq 9 \text{ stations.}$$

optimum — given

∴ There are 9 stations in the catchment area.

2-4. Explain with neat sketch Horton's engineering representation of hydrological cycle.

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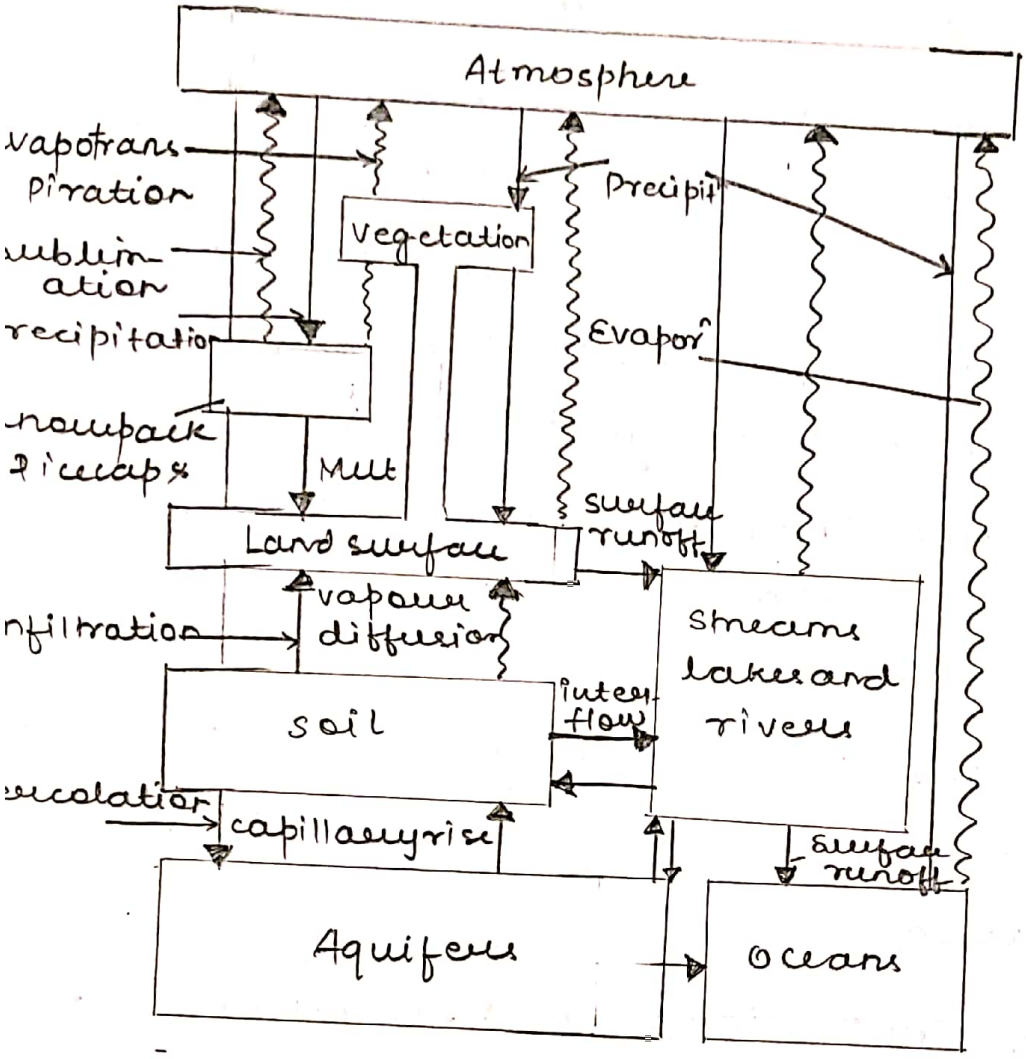


Hydrological cycle is defined as the circulation of water from the sea to the land through the atmosphere back to the sea often with delays, through the process like precipitation, interception, runoff, infiltration, percolation, ground water storage, evaporation, transpiration, also water that returns to the atmosphere without reaching the sea.

- Precipitation- It is the return of atmospheric moisture to the ground in the form of solid or liquid. eg- snow, rain, mist, drizzle, hail etc
- Evaporation- It is the process of turning from liquid into vapour to the atmosphere.
- Transpiration- The process in which plants contribute some part of water. It is the exhalation of water vapour through the stomata.
- Percolation- The slow movement of water through the pores in soil or permeable rock is called percolation.
- Infiltration- The process by which water on the ground surface enters the soil, is called Infiltration
- Runoff- The portion of the precipitation which by variety of paths above and below the earth's surface reaches the stream channel, is called Runoff. once, it enters stream channel runoff becomes stream flow.

Q-5. Explain with formulae to find the optimum number of raingauge stations.

→ If there are already some raingauge stations in a catchment area, the optimum number of station that should exist to have an assigned percentage of error in the estimation of mean rainfall is obtained by statistical analysis.

$$N = \left(\frac{Cv}{\epsilon}\right)^2$$

Where N = optimum no. of stations

ϵ = 10% = allowable degree of errors in the estimation of mean rainfall.

Cv = coefficient of variation of the rainfall values at the existing 'm' stations

If there are 'm' stations in the catchment each recording rainfall values, $P_1, P_2 \cdots P_m$ in a known time

Where m = total no. of raingauge stations

$$Cv = \frac{100 \times \sigma_{m-1}}{\bar{P}}$$

Where, σ_{m-1} = standard deviation

$$= \sqrt{\sum_{i=1}^{m} \frac{(P_i - \bar{P})^2}{m-1}}$$

Where, P_i = Precipitation magnitude in the ith station.

∴ It is seen that if the value of ϵ' is small, the no. of raingauge stations will be more

$\bar{P}$ = mean precipitation

$$= \frac{1}{m}\left(\sum_{i=1}^{m} P_i\right)$$

Q-6. Write brief notes on importance of hydrology and its practical applications.

→ The importantance of Hydrology are-

(i) Design of Hydraulic structure- structures such as bridge, causeway, dams, spillways etc are in contact with water. Accurate hydrological predictions are necessary for their proper functioning.

(II) Municipal and Industrial Water Supply- proper estimation of water resources in a place will help planning and implementation of facilities for municipal and industrial water supply.

(III) Irrigation- Dams are constructed to store water for multiple uses. For estimating max^m storage capacity seepage, evaporation and other losses should be properly estimated.

(IV) Hydroelectric power generation- Proper estimation of river flow and also flood occurences will help to construct efficient

balancing reservoirs and these will supply water to turbins at a constant rate

(V) Flood control in rivers - controlling flood in a river is a complicated task. The flow occuring due to storm ~~rain~~ can be predicted if the catchment characteristics are properly known.

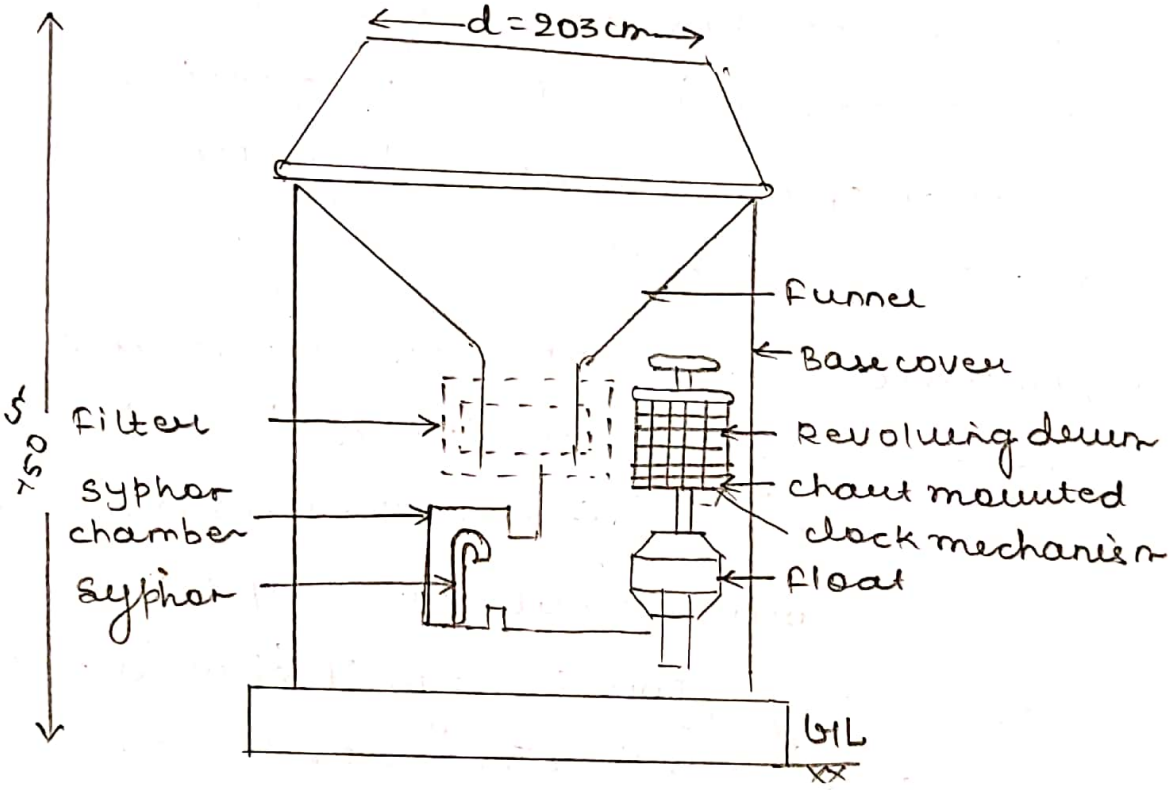
(Vi) Navigation - Big canals in an irrigation scheme can be used for inland Navigation. The depth of water should be maintained at a constant level.

(VII) Pollution control - It is an easy way to dispose sewage generated in a city or town into streams and rivers. The problem arises when each flow are not properly estimated. In case sewage flow is high it should be treated before disposal into a river or stream

Q-7. List out various types of measuring raingauges. Explain with neat sketch of syphon's rain gauge.

→ Following are the various types of measuring rain gauges -

(1) Weighing Bucket Raingauge
(2) Tipping Bucket Raingauge
(3) Syphon or float Type.



- There are two chambers present i.e Syphon and float
- The working is similar to Weighing bucket raingauge.
- It is also called as integrated gauge because it depicts an integrated graph from chart clock driven.

- A funnel receives the rainfall which is collected in a rectangular container.
- float is provided at the bottom of the container the level of float increases at the water level increases.
- Its movement is recorded by a pen moving on a recording drum actuated by a clock work.
- When water rises, this float reaches to the top floating in water, then syphon comes into operation and releases the water outwards through the connecting pipe, thus all water in box is drained out.
- This raingauge is adopted as standard and the curve drawn is called mass curve of rainfall.