1. Hydrology is the science which deals with the occurrence, circulation and distribution of water on the earth's surface and its atmosphere. Engineering representation of hydrologic cycle:

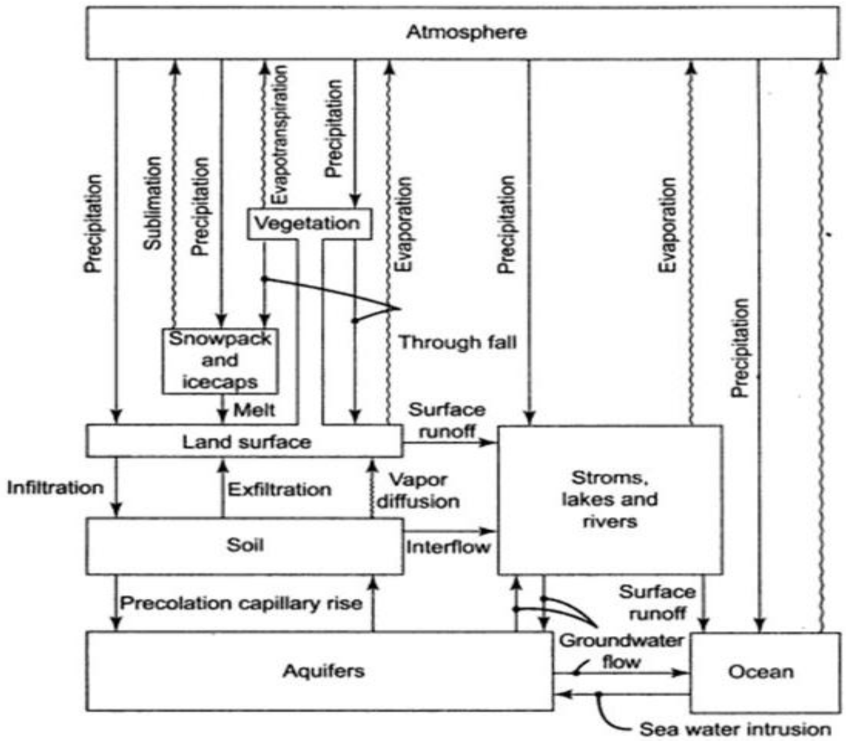


Fig. 1.1 Engineering representation of the hydrological cycle

2. Precipitation types:

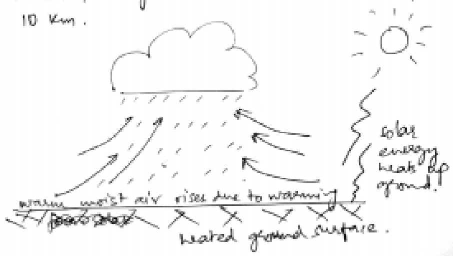
Types of precipitation.

(1) Convectional Precipitation.

* In this type, a packet of air which is warmer than the surrounding air due to localised heating rises because of its lesser density. Air from cooler surroundings flows to take up its place, thus setting up a convective cell.

* The warm air continues to rise, undergoes cooling & results in precipitation.

* Usually the areal extent of such rains is small, being limited to a diameter of 10 km.



(2) Orographic precipitation

* The moist air masses may get lifted-up to higher altitudes due to the presence of mountain barriers and consequently undergo cooling, condensation & precipitation. Such precipitation is known as orographic precip.

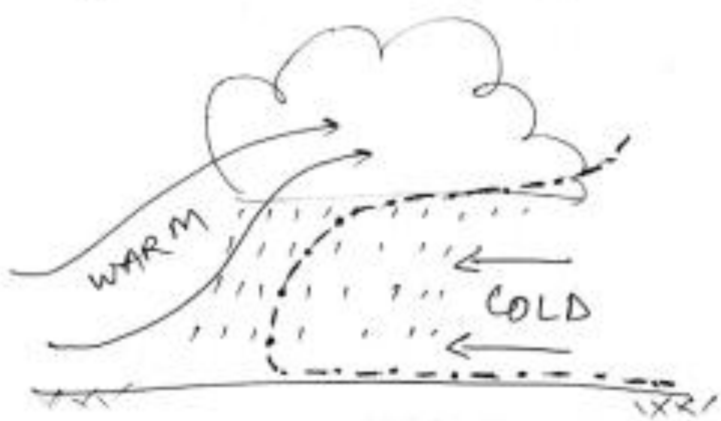
* Thus, in mountain ranges, windward slopes have heavy precipitation and leeward slopes light rainfall

(3) Frontal precipitation :

* A front is the interface between two distinct air masses. ~~Under~~

* Under certain favourable conditions when warm air mass & cold air mass meet, the warmer air mass is lifted over the colder one with formation of a front.

* The ascending warmer air cools adiabatically with ~~respects to~~ consequent formation of clouds and precipitation.

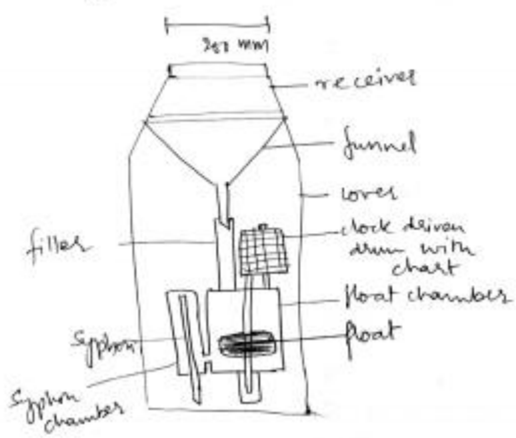


Natural Syphon type rainguage

* It is a recording rainguage, also known as 'float-type' rainguage.
* The rainfall collected by a funnel-shaped collector is led into a float chamber causing float to rise. As the float rises, a pen attached to the float through a lever system records the elevation of the float on a rotating drum driven by a clock-work mechanism.
* A 'syphon' arrangement empties the float chamber when the float has reached a pre-set max. level

* This type of rainguage is adopted as the standard recording type rainguage in India.
* A typical chart obtained from this rainguage is shown: ~~as mass curve~~. It is developed into a mass curve.

Siphon rain guage:



Factors affecting evaporation:

Rate of evaporation is dependent on :-

(1) vapour pressure

E is proportional to difference b/w saturation vapour pressure at the water temperature, e_w and the actual vapour pressure in the air, e_a.

$$\boxed{E_L = C\,(e_w - e_a)}$$ — Dalton's law of evaporation

E_L: mm/day; e_w, e_a: mm of Hg

· Evaporation continues till $e_w \geq e_a$. [illegible]

(2) Temperature

$E_L \propto$ Temperature of water.

$\propto$ temperature of air.

(3) Wind

* wind aids in removing evaporated water vapour from zone of evaporation, consequently increasing scope of evaporation.
* No further increase in E_L if wind velocity is large enough to remove all vapour.

(4) Atmospheric pressure

A decrease in barometric pressure, as in high altitudes, increases E_L.

(5) Soluble salts

When solute is dissolved, vapour pressure of solution is less than pure liquid, Hence reduction in E_L.

(6) Heat storage in water bodies

* Deep water bodies have more heat storage that shallow ones.
* A deep lake may store more radiation energy received in summer and release it in winter causing less evaporation in summer & more evaporation in winter, compared to a shallow lake.

3.

For a given lake, pan evaporation is measured using either Class-A pan, ISI std. pan or collorado sunken pan, by installing it near the lake.

Lake evaporation = pan evaporation ×pan coefficient

4. Measurement of evapotranspiration:

LYSIMETERS

A lysimeter is a special watertight tank containing a block of soil and set in a field of growing plants. The plants grown in the lysimeter are the same as in the surrounding field. Evapotranspiration is estimated in terms of the amount of water required to maintain constant moisture conditions within the tank measured either volumetrically or gravimetrically through an arrangement made in the lysimeter. Lysimeters should be designed to accurately reproduce the soil conditions, moisture content, type and size of the vegetation of the surrounding area. They should be so buried that the soil is at the same level inside and outside the container. Lysimeter studies are time-consuming and expensive.

FIELD PLOTS

In special plots all the elements of the water budget in a known interval of time are measured and the evapotranspiration determined as

Evapotranspiration = [precipitation + irrigation input − runoff − increase in soil storage groundwater loss]

Measurements are usually confined to precipitation, irrigation input, surface runoff and soil moisture. Groundwater loss due to deep percolation is difficult to measure and can be minimised by keeping the moisture condition of the plot at the field capacity. This method provides fairly reliable results.

Difference between AET and PET:

- If sufficient moisture is always available to completely meet the needs of vegetation fully covering the area, the resulting evapotranspiration is called potential evapotranspiration or PET.
- PET doesn't critically depend on soil and plant factors but depends essentially on meteorological conditions.
- The real evapotranspiration occurring in a specific situation is called actual evapotranspiration. It depends on soil, plant and other factors alongwith the meteorological factors.

5. Existing no. of rain-guages = 5

Optimum no. of rain-guages= N= $(C_v/\varepsilon)^2$

Additional no. of rain gauges = Optimum no. – existing no. of rain gauges

$C_v=(\sigma/\mu)\times100$

μ=mean= 56.8, n= no. of observations

$\sigma=\sqrt{(\Sigma(x_i-\mu)^2/n-1)}$ = 18.95

$C_v=(\sigma/\mu)\times100=(18.95/56.8)\times100=33.37$

$N=(C_v/\varepsilon)^2=(33.37/10)^2=11.13$ or 12 stations

Additional no. = 12-5=7

6. 10% of NX= 75.7

Nx-Na=69

Nx-Nb=139

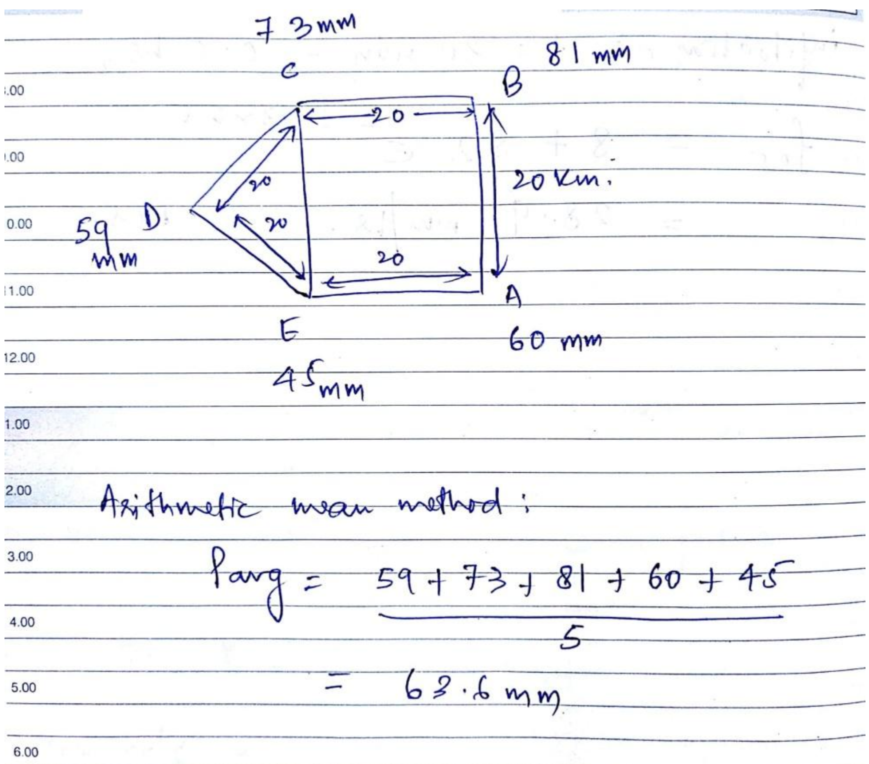
Nx-Nc=275

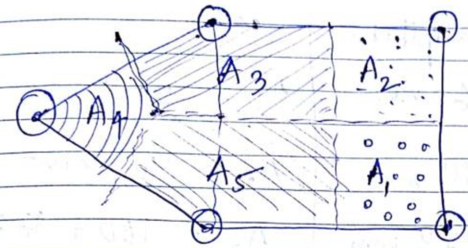
Since the majority of differences between normal rainfalls of station X and other stations don’t lie within 10% of Nx, we will use normal ratio method.

Px/Nx = (1/m)((Pa/Na)+(Pb/Nb)+(Pc/Nc)) where m=3

Thus, Px=71.198 mm

7. The diagram of the catchment can be developed as under:





(Thiessen mean method)

Areas can be divided among raingauge stations as shown above.

pentagon is made up of an equilateral triangle and a square of side 20 km.

Three rain gauges are there at the corners of the triangle. ∴ we need to divide the triangle into 3 equal subparts.

Area of equilateral triangle $= \frac{\sqrt{3}}{4} a^2$

$= \frac{\sqrt{3}}{4} \times 20^2$

$= 173.20 \ km^2$

each sub area $= \frac{173.20}{3} = 57.73 \ km^2$

Stations.	Precipitation	area
A	$P_1 = 60$ mm	$A_1 = 100$ km^2
B	$P_2 = 81$ mm	$A_2 = 100$ km^2
C	$P_3 = 73$ mm	$A_3 = 100 + 57.73 = 157.73$ km^2
D	$P_4 = 59$ mm	$A_4 = 57.73$ km^2
E	$P_5 = 45$ mm	$A_5 = 100 + 57.73 = 157.73$ km^2

Theissen's method:

$$P_{avg} = \frac{P_1A_1 + P_2A_2 + P_3A_3 + P_4A_4 + P_5A_5}{A}$$

$$= \frac{(60\times100) + (81\times100) + (73\times157.73) + (59\times57.73) + (45\times157.73)}{573.2}$$

$$= \frac{6000 + 8100 + 11514.29 + 3406.07 + 7097.85}{573.2}$$

$$= 63.01 \text{ mm}$$

EXAMPLE 3.9 *The infiltration capacity of soil in a small watershed was found to be 6 cm/h before a rainfall event. It was found to be 1.2 cm/h at the end of 8 hours of storm. If the total infiltration during the 8 hours period of storm was 15 cm, estimate the value of the decay coefficient K_h in Horton's infiltration capacity equation.*

SOLUTION: Horton's equation is $f_p = f_c + (f_0 - f_c)\, e^{-K_h t}$

and

$$F_p = \int_0^t f_p(t)\, dt = f_c t + (f_0 - f_c) \int_0^t e^{-K_h t}\, dt$$

As $t \to \infty$, $\int_0^\infty e^{-K_h t}\, dt \to \dfrac{1}{K_h}$. Hence for large t values

$$F_p = f_c t + \frac{(f_0 - f_c)}{K_h}$$

Here $F_p = 15.0$ cm, $f_0 = 6.0$ cm, $f_c = 1.2$ cm and $t = 8$ hours.

$$15.0 = (1.2 \times 8) + (6.0 - 1.2)/K_h$$

8.

$$K_h = 4.8/5.4 = 0.888\ \text{h}^{-1}$$