I HYDROLOGICAL CYCLE

1.1 HYDROLOGY

Hydrology is the science, which deals with the occurrence, distribution and disposal of water on the planet earth.

Hydro=Water Logy=Science

1.2 HYDROLOGIC CYCLE

Hydrologic cycle is the water transfer cycle, which occurs continuously in nature; the three important phases of the hydrologic cycle are:

(a) Evaporation and evapotranspiration

(b) Precipitation and

(c) Runoff

Evaporation from the surfaces of ponds, lakes, reservoirs.ocean surfaces, etc. and transpiration from surface vegetation i.e., from plant leaves of cropped land and forests, etc. take place. These vapours rise to the sky and are condensed at higher altitudes by condensation nuclei and form clouds, resulting in droplet growth. The clouds melt and sometimes burst resulting in precipitation of different forms like rain, snow, hail, sleet, mist, dew and frost. A part of this precipitation flows over the land called runoff and part infilters into the soil which builds up the ground water table. The surface runoff joins the streams and the water is stored in reservoirs. A portion of surface runoff and ground water flows back to ocean. Again evaporation starts from the surfaces of lakes, reservoirs and ocean, and the cycle repeats. Of these three phases of the hydrologic cycle, namely, evaporation, precipitation and runoff, it is the 'runoff phase', which is important to a civil engineer since he is concerned with the storage of surface runoff in tanks and reservoirs for the purposes of irrigation, municipal water supply hydroelectric power etc.

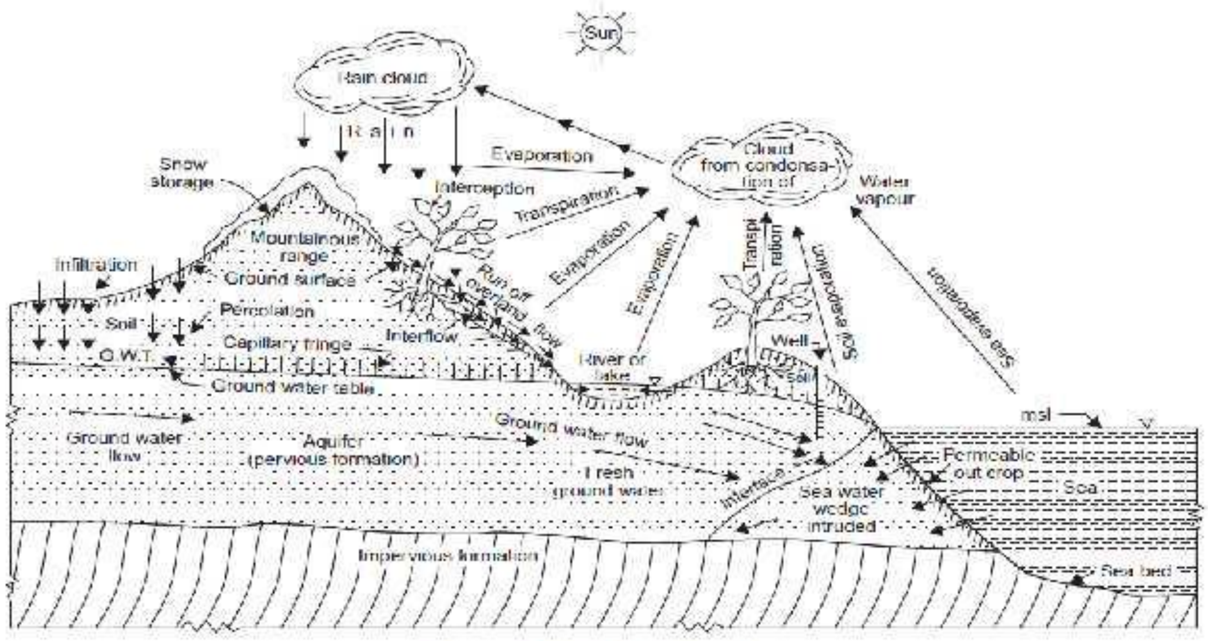


Fig. 1.7 The hydrologic cycle

1.3 FORMS OF PRECIPITATION

Drizzle — a light steady rain in fine drops (0.5 mm) and intensity <1 mm/hr

Rain — the condensed water vapour of the atmosphere falling in drops (>0.5 mm, maximum size—6 mm) from the clouds.

Glaze — freezing of drizzle or rain when they come in contact with cold objects.

Sleet — frozen rain drops while falling through air at subfreezing temperature.

Snow — ice crystals resulting from sublimation (i.e., water vapour condenses to ice)

Snow flakes — ice crystals fused together.

Hail — small lumps of ice (>5 mm in diameter) formed by alternate freezing and melting, when they are carried up and down in highly turbulent air currents.

Dew — moisture condensed from the atmosphere in small drops upon cool surfaces.

Frost — a feathery deposit of ice formed on the ground or on the surface of exposed objects by dew or water vapour that has frozen

Fog — a thin cloud of varying size formed at the surface of the earth by condensation of atmospheric vapour (interfering with visibility)

Mist — a very thin fog

1.4 SCOPE OF HYDROLOGY

The study of hydrology helps us to know

(i) The maximum probable flood that may occur at a given site and its frequency; this is required for the safe designof drains and culverts, dams and reservoirs, channels and other flood control structures.

(ii) The water yield from a basin—its occurrence, quantity and frequency, etc; this is necessary for the design ofdams, municipal water supply, water power, river navigation, etc.

(iii) The ground water development for which a knowledge of the hydrogeology of the area, i.e., of theformation soil, recharge facilities like streams and reservoirs, rainfall pattern, climate, cropping pattern, etc. arerequired.

(iv) The maximum intensity of storm and its frequency for the design of a drainage project in the area.

1.5 TYPES OF PRECIPITATION

The precipitation may be due to

(i) Thermal convection (convectional precipitation)

This type of precipiation is in the form of local whirling thunder storms and is typical of the tropics.The air close to the warm earth gets heated and rises due to its low density, cools adiabatically toform a cauliflower shaped cloud, which finally bursts into a thunder storm. When accompanied bydestructive winds, they are called ‘tornados’.

(ii) Conflict between two air masses (frontal precipitation)

When two air masses due to contrasting temperatures and densities clash with each other, condensation and precipitation occur at the surface of contact, Fig. 2.1. This surface of contact is called a ‘front’ or ‘frontal surface’. If a cold air mass drives out a warm air mass’ it is called a ‘coldfront’ and if a warm air mass replaces the retreating cold air mass, it is called a ‘warm front’. On theother hand, if the two air masses are drawn simultaneously towards a low pressure area, the frontdeveloped is stationary and is called a ‘stationary front’. Cold front causes intense precipitation oncomparatively small areas, while the precipitation due to warm front is less intense but is spread overa comparatively larger area. Cold fronts move faster than warm fronts and usually overtake them, thefrontal surfaces of cold and warm air sliding against each other. This phenomenon is called ‘occlusion’and the resulting frontal surface is called an ‘occluded front’.

(iii) Orographic lifting (orographic precipitation)

The mechanical lifting of moist air over mountain barriers, causes heavy precipitation on the windward side (Fig. 2.2). For example Cherrapunji in the Himalayan range and Agumbe in the westernGhats of south India get very heavy orographic precipitation of 1250 cm and 900 cm (average annualrainfall), respectively.

(iv) Cyclonic (cyclonic precipitation)

This type of precipitation is due to lifting of moist air converging into a low pressure belt, i.e., due topressure differences created by the unequal heating of the earth's surface. Here the winds blowspirally inward counterclockwise in the northern hemisphere and clockwise in the southern hemisphere. There are two main types of cyclones—tropical cyclone (also called hurricane or typhoon)of comparatively small diameter of 300-1500 km causing high wind velocity and heavy precipitation,and the extra-tropical cyclone of large diameter up to 3000 km causing wide spread frontal typeprecipitation.

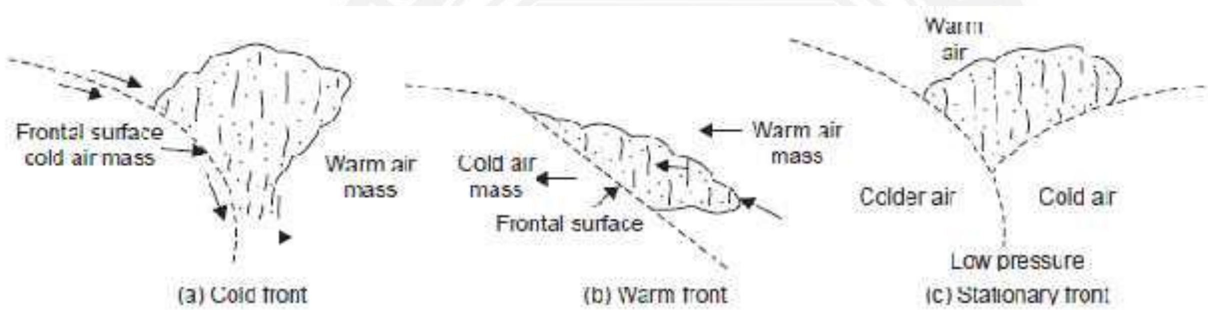


Fig. 2.1 Frontal precipitation

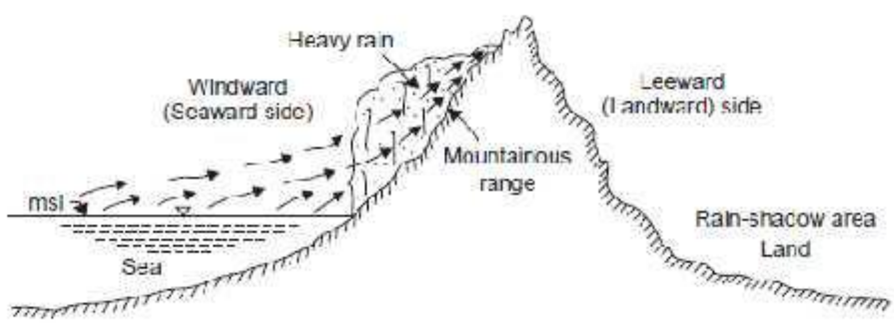
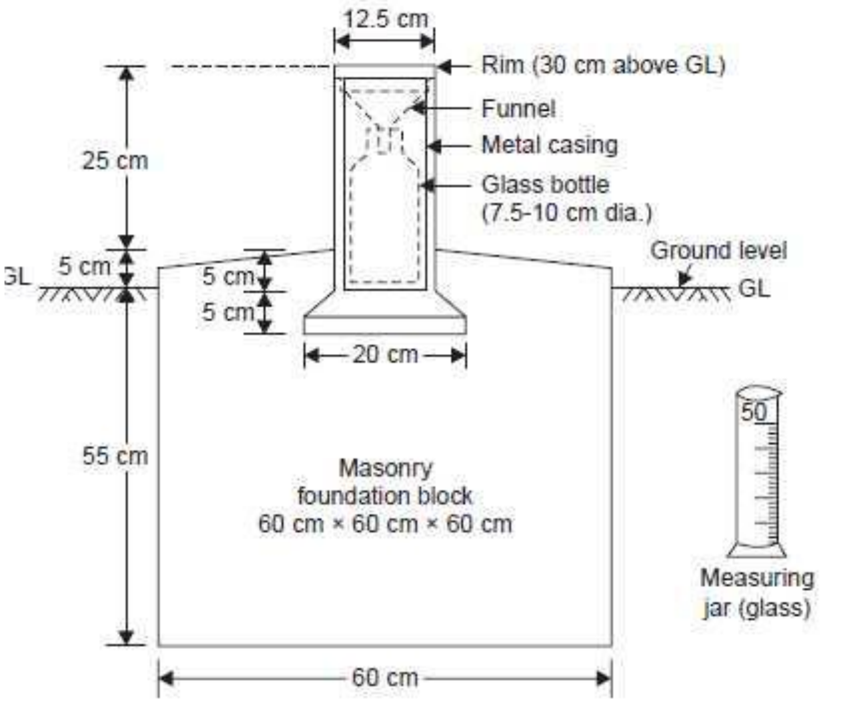


Fig. 2.2 Orographic precipitation

1.6 MEASUREMENT OF PRECIPITATION

Rainfall may be measured by a network of rain gauges which may either be of non-recording or recording type.



The non-recording rain gauge used in India is the Symon's rain gauge (Fig. 2.3). It consists of a funnel with a circularrim of 12.7 cm diameter and a glass bottle as a receiver. The cylindrical metal casing is fixed vertically to themasonry foundation with the level rim 30.5 cm above the ground surface. The rain falling into the funnel iscollected in the receiver and is measured in a special measuring glass graduated in mm of rainfall; when full it canmeasure 1.25 cm of rain. The rainfall is measured every day at 08.30 hours IST. During heavy rains, it must bemeasured three or four times in the day, lest the receiver fill and overflow, but the last measurement should be at08.30 hours IST and the sum total of all the measurements during the previous 24 hours entered as the rainfall ofthe day in the register. Usually, rainfall measurements are made at 08.30 hr IST and sometimes at 17.30 hr IST also.Thus the non-recording or the Symon's rain gauge gives only the total depth of rainfall for the previous 24 hours(i.e., daily rainfall) and does not give the intensity and duration of rainfall during different time intervals of the day.

It is often desirable to protect the gauge from being damaged by cattle and for this purpose a barbed wire fencemay be erected around it.

1.6.1 Recording Rain Gauge

This is also called self-recording, automatic or integrating rain gauge. This type of rain gauge Figs. 2.4, 2.5 and 2.6,has an automatic mechanical arrangement consisting of a clockwork, a drum with a graph paper fixed around itand a pencil point, which draws the mass curve of rainfall Fig. 2.7. From this mass curve, the depth of rainfall in agiven time, the rate or intensity of rainfall at any instant during a storm, time of onset and cessation of rainfall, canbe determined. The gauge is installed on a concrete or masonry platform 45 cm square in the observatory enclosureby the side of the ordinary rain gauge at a distance of 2-3 m from it. The gauge is so installed that the rim of thefunnel is horizontal and at a height of exactly 75 cm above ground surface. The self-recording rain gauge isgenerally used in conjunction with an ordinary rain gauge exposed close by, for use as standard, by means of whichthe readings of the recording rain gauge can be checked and if necessary adjusted.

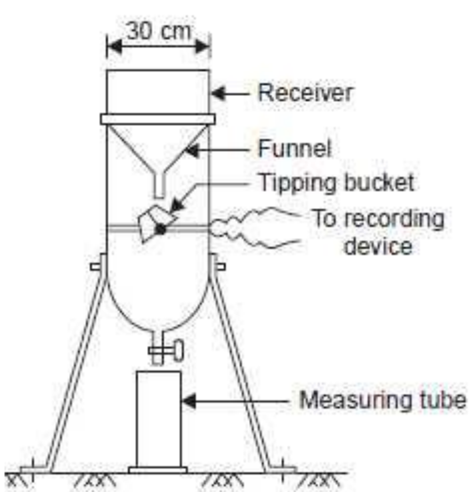


Fig. 2.4 Tipping bucket gauge

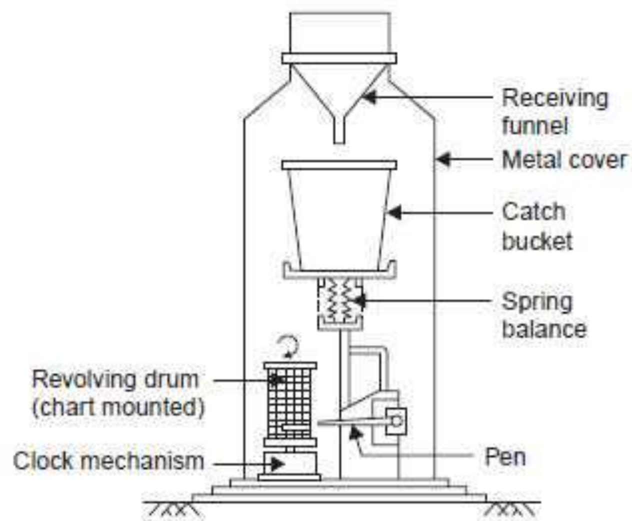


Fig. 2.5 Weighing type rain gauge

1.6.2Tipping bucket rain gauge.

This consists of a cylindrical receiver 30 cm diameterwith a funnel inside (Fig. 2.4). Just below the funnel a pair oftipping buckets is pivoted such that when one of the bucket receives a rainfall of 0.25 mm it tips and empties into atankbelow, while the other bucket takes its position and the process is repeated. The tipping of the bucket actuates on electric circuit which causes a pen to move on a chart wrapped round a drum which revolves by a clockmechanism. This type cannot record snow.

1.6.3 Weighing type rain gauge. In this type of rain-gauge, when a certain weight of rainfall is collected in a tank, whichrests on a spring-lever balance, it makes a pen to move on a chart wrapped round a clock driven drum. Therotation of the drum sets the time scale while the vertical motion of the pen records the cumulative precipitation.

1.6.4 Float type rain gauge. In this type, as the rain is collected in a float chamber, the float moves up which makes apen to move on a chart wrapped round a clock driven drum (Fig. 2.6). When the float chamber fills up, the watersiphons out automatically through a siphon tube kept in an interconnected siphon chamber. The clockwork revolvesthe drum once in 24 hours. The clock mechanism needs rewinding once in a week when the chart wrapped roundthe drum is also replaced. This type of gauge is used by IMD.

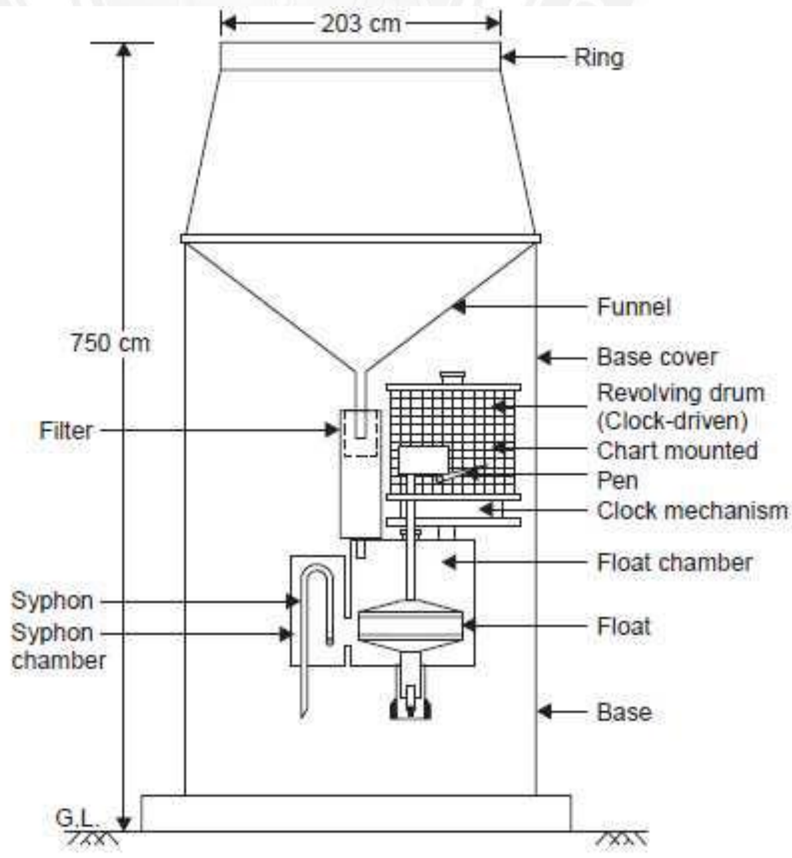


Fig. 2.6 Float type rain gauge