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Hydrology

HISTORY OF HYDROLOGY

Water is the prime necessity for all forms of life. Human civilisation has progressed from early era with utilisation of available water resources. Civilisation flourished wherever from Vedic Literature that ground water resources depleted.

THE HYDROLOGIC CYCLE

An irrigation engineer is not only concerned with the collection and distribution of water for irrigation, but it is also essential for him to know about the occurrence, distribution and movement of water on the earth, including that in the atmosphere and below the surface of the earth. Water occurs in the atmosphere in the form of vapour, on the surface as water, snow or ice and below the surface as ground water occupying all the voids within a geologic stratum.

Except for deep ground water, the total water supply of earth is in constant circulation from earth to atmosphere, and back to the earth. The earth's water circulatory system is known as the hydrologic cycle. Hydrologic cycle is the process of transfer of moisture from the atmosphere to the earth in the form of precipitation, conveyance of the precipitation water by streams and river as to ocean and lakes etc., and evaporation of water back to the atmosphere.

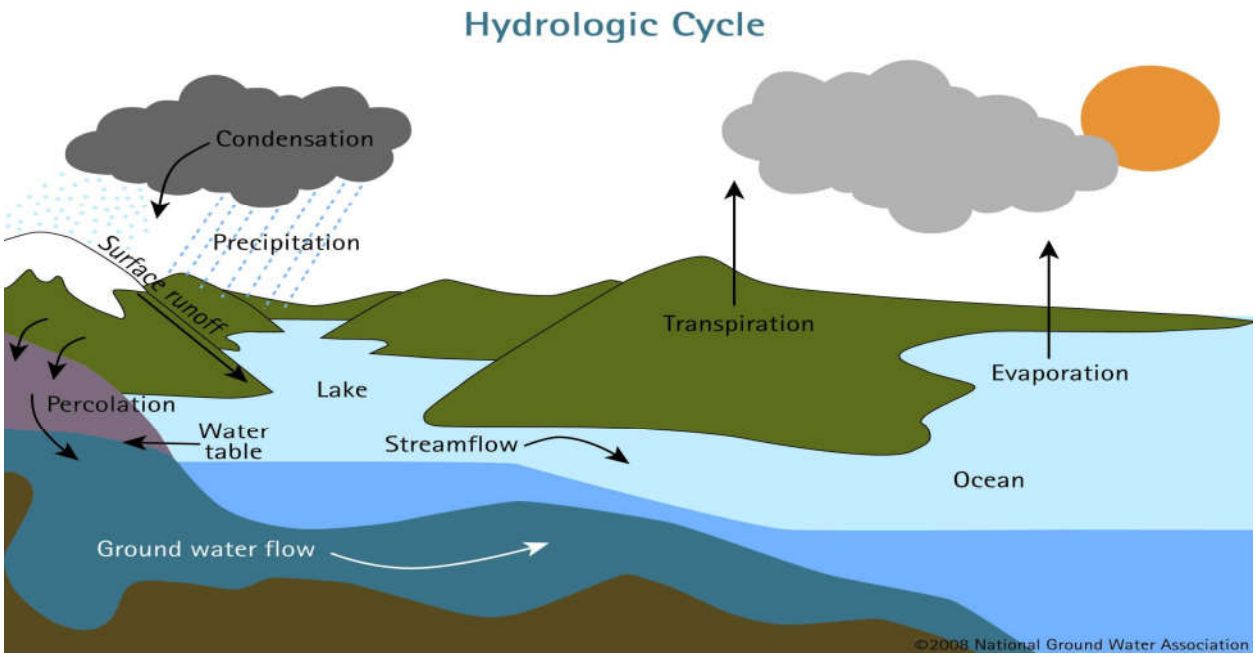

FIG - THE HYDROLOGIC CYCLE

The hydrologic cycle consists of the following processes:

1. Evaporation and transpiration (E)

The water from the surface of ocean, rivers, and lakes and also from the moist soil evaporates. The vapours are carried over the land by air in the form of clouds.

Transpiration is the process of water being lost from leaves of the plants from there pores. Thus , the total evaporation (E), inclusive of the transpiration consists of :

(i) Surface evaporation
(ii) Water surface evaporation
(iii) Evaporation from plants
(iv) Atmospheric evaporation

2. Precipitation (P)

Precipitation may be defined as the fall of moisture from the atmosphere to the earth surface in any form. Precipitation may be two forms:

(a) Liquid precipitation: i.e. rainfall.
(b) Frozen precipitation: This consists of:

(i) Snow	(ii) Hail
(iii) Sleet	(iv) Freezing rain

3. Run Off (R)

Runoff is that portion of precipitation that is not evaporated. When moisture falls to the earth's surface as precipitation, a part of it is evaporated from the water surface, soil and vegetation and through transpiration by plants, and the remainder precipitation is available as runoff which ultimately runs to ocean through surface or sub-surface streams. Thus runoff may be classified as follows:

(a) **Surface runoff** - Water flows over the land and is first to reach the streams and rivers, which ultimately discharge the water to the sea.
(b) **Inter-flow or sub-surface runoff** – a portion of precipitation infiltrates into the surface soil and depending upon the geology of the basins, runs as sub-surface runoff and reaches the streams and rivers.
(c) **ground water flow or base flow** – it is that portion of precipitation , which after infiltration , percolates down and joins the ground water reservoir which is ultimately connected to the ocean.

Thus, the hydrologic cycle may be expressed by the following equation:

PRECIPITATION = EVAPORATION + RUNOFF
(P) (E) (R)

Hydrologic system

The main components of the hydrologic cycle are (i) precipitation (ii) evaporation, including transpiration, and (iii) runoff, including direct runoff, infiltration and ground water runoff. The following hydrological data are required:

1. Weather and climate records: Data about temperature, humidity, radiation, wind etc, since these directly affect hydrological parameters.

2. Precipitation data: the study of precipitation forms a major portion of the subject of hydro-meteorology. The precipitation data helps in predicating runoff volume and its peak. It is also helpful in estimating the water-budget equation for the basin. It gives indication to the further potential for expansion of water needs and plan accordingly.

3. Stream flow data: This helps in the planning of reservoirs, design of spillways, bridges and water power development and installation.

4. Ground water characteristics: This helps in estimation and location of ground water reservoir, for ground water development.

5. Infiltration characteristics of the area: This data helps in determining rainfall excess and runoff computation.

Precipitation

Precipitation is the general term for all forms of moisture emanating from the clouds and falling to the ground. The following are the essential requirements for precipitation to occur:

1. Some mechanism is required to cool the air sufficiently to cause condensation and droplet growth.

2. Large scale cooling is essential for significant amount of precipitation. This is achieved by lifting by lifting of air.

Types of Precipitation. Precipitation is often classified according to the factors responsible for lifting. There are four types of precipitation:

(1) Cyclonic precipitation (2) Convective precipitation

(3) Orographic precipitation (4) Precipitation due to turbulent ascent.

(1) Cyclonic precipitation: Cyclonic precipitation results from lifting of air masses converging into low pressure area of cyclone. The cyclonic precipitation may be divided into (a) frontal precipitation and (b) non-frontal precipitation

(a) Frontal precipitation- a border region between two adjacent air masses having different characteristics such as temperature and humidity is called a front. When a flow of warm and moist air mass from the south meets cold air mass of polar region, the cold air being heavier, under run the warm air flow in the form of flat wedge forcing the warm air aloft.

(b) Non-frontal precipitation- In the case of non-frontal precipitation, the moist warm air is stationary and the moving cold air mass meets it. When the lifted warm air cools down at higher altitude precipitation occurs.

(2) Convective precipitation : Convective precipitation is caused by natural rising of warmer lighter air in colder, denser surroundings. The difference in temperature may result from unequal heating at the surface, unequal cooling at the top of the air layer, or mechanical lifting when air is forced to pass over denser colder air masses. Convective precipitation is spotty and its intensity may vary from light showers to cloud bursts.

(3) **Orographic precipitation :** Orographic precipitation is due to the lifting of warm moisture laden air masses due to topographic barriers (such as mountains). As it reaches higher elevation, it comes in contact with cold air and precipitation occurs. All the precipitation we have in Himalayan region is because of the Orographic ascent of air masses, rich in moisture content because of their long travel over oceans.

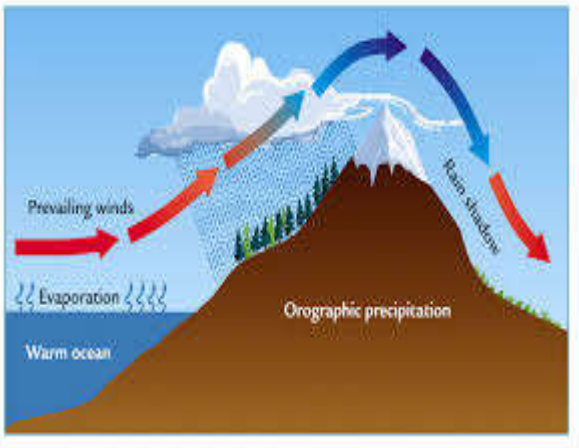

FIG – OROGRAPHIC PRECIPITATION

All the precipitation we have in Himalayan region is because of the Orographic ascent of air masses, rich in moisture content because of their long travel over oceans.

(4) Precipitation due to turbulent ascent: Air mass is forced to rise up due to greater friction of earth surface after its travel over ocean. The air mass rises up because of increased turbulence and friction, when it ultimately condenses and precipitation occurs.

Forms of precipitation

The various forms of precipitation are: Drizzle, rain, glaze, sleet, snow, snowflakes and hail.

Drizzle: When the size of water droplets is under 0.5 mm, and its intensity is <1 mm per hour. Because of the lightness, the droplets appear to be floating in air.

Rain: When the size of the drops is more than 0.5 mm. The upper size of water drop is generally 6.25 mm, as drops greater than this tend to break up as they fall through the air.

Glaze: When the drizzle or rain freezes as it comes in contact with cold objects, it is known as glaze.

Sleet: it is frozen rain drops cooled to the ice stage while falling through air at sub-freezing temperature.

Snow: Precipitation in the form of ice crystals resulting from sublimations (i.e. water vapour changed directly to ice).

Snowflakes: Number of ice crystals fused together from snowflakes.

Hail: Hail is lumps or bulbs of ice over 5 mm diameter formed by alternate freezing or melting as they are carried up and down in highly turbulent air currents.

Evaporation

Evaporation and evapo-transporation are the two most important phases of hydrologic cycle which redistribute the heat energy between surfaces and atmosphere. Evaporation is the process in which liquid changes to gaseous state at the free surface, below the boiling point through the transfer of heat energy. It is a continuous natural process by which a substance changes from liquid to gaseous state. The main source of evaporation is the solar radiation.

The rate of evaporation is dependent on the following factors:

(i) Vapour pressure at the water surface and air
(ii) Air and water temperatures
(iii) Solar radiation
(iv) Wind speed
(v) Atmospheric pressure

Factors affecting evaporation losses

Evaporation losses depend upon

(i) Nature of evaporating surface: Different evaporating surface like soil, barren land, forest area, houses and lakes affect evaporation to the extend they have the potential. Black cotton soil help to evaporate the soil water faster than red soil because such soils have the potential to absorb incoming radiation more effectively.

(ii) Area of water surface: The evaporation loss directly depends upon the area of the water surface-- greater the area; greater will be the water loss due to evaporation.

(iv) Depth of water in water body: Deep water bodies evaporate slower than shallow water bodies in summer while in winter season, they evaporate faster.

(v) Humidity: Evaporation is inversely proportional to humidity. If the humidity in the atmosphere is more, evaporation is less.

(vi) Temperature of air: Increase in air temperature increases the evaporation rate though not always proportionately. For the same temperature, colder months have less evaporation than summer months due to combined effect of other environmental parameters.

(vii) Quality of water: The presence of dissolved salts in water reduces the saturation vapour pressure of water which consequently reduces the rate of evaporation.

Reference:

Irrigation & Water Power Engineering by B. C. Punmia and Pande B. B. Lal.

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