Evaporation

Evaporation is a term similar to that of the vaporization of the liquid. In hydrology, evaporation refers to the losses that occur due to precipitation. After precipitation, some water gets stored in the different water bodies or flows in the river. This water gets converted into the form of vapors when the surrounding temperature of the atmosphere rises.

The question "define evaporation" is one of the important questions to understand the meaning of evaporation. There are various losses studied, including evaporation in hydrology. These losses are infiltration, transpiration, evaporation, etc.

How Does Evaporation Occur?

Evaporation is the process by which a liquid changes into a gas or vapor state. This occurs when the temperature of the liquid rises above its boiling point, causing the molecules to gain enough energy to break away from their liquid bonds and become airborne. The rate of evaporation depends on several factors, including the surface area of the liquid, the temperature and humidity of the surrounding air, and the strength of the intermolecular forces within the liquid.

In addition to natural processes like the water cycle, evaporation has several important applications in industrial processes such as distillation, desalination, and the production of pharmaceuticals and chemicals.

Factors Affecting Evaporation Rate

Several factors affect the rate of evaporation of a liquid, including the surface area and temperature of the liquid, the humidity and temperature of the surrounding air, and the strength of the intermolecular forces within the liquid. A larger surface area of the liquid exposed to air allows for more molecules to escape and evaporate into the surrounding air. A higher temperature increases the kinetic energy of the molecules, making them more likely to break away from the liquid surface and evaporate. The humidity and temperature of the surrounding air also play a role in the rate of evaporation, as a higher humidity level decreases the rate of evaporation while a higher temperature increases it. Finally, the strength of the intermolecular forces within the liquid affects its ability to evaporate, with weaker forces allowing for easier evaporation.

Types of Losses due to Precipitation

Precipitation is the phenomenon of occurring rainfall over a catchment. This rainfall may get entrapped with vegetation, stored in the trenches, etc. These losses of water can be in different forms. The remaining portion of the water from these losses reaches the river or other streams. Loss of water also occurs from these streams, and it is termed

evaporation loss. The classification of different losses can be categorized in the following ways.

- Loss due to evaporation
- Transpiration loss
- Interception loss
- Depression storage
- Infiltration loss

Measurement of Evaporation

Evaporation is a cooling process in which the water body provides the latent heat of evaporation of about 585 cal/gm. In this process, liquid changes into a gaseous phase at the free surface, below the boiling point, through the transfer of heat energy.

Dalton's Law

The rate of evaporation is proportional to the difference between the saturation vapor pressure at the water temperature, e_s and the actual vapor pressure in the air e_a thus

$$E = K(e_s - e_a)$$

Where

- E = Rate of evaporation (mm/day)
- e_s = Saturation vapor pressure of air (mm)
- e_a = Actual vapor pressure of air (mm)
- $e_s - e_a$ = Saturation deficiency

Methods of Measurement of Evaporation

1. ISI standard pan
   Lake evaporation = $C_p \times$ pan evaporation
   Where C_p pan coefficient = 0.8 for ISI pan = 0.7 for class A-Pan
2. Empirical Evaporation Equations (Meyer's Formula)

   $$E = k_m (e_s - e_a)\left[1 + \frac{V_9}{16}\right]$$

   Where k_m = Coefficients which accounts for the size of the water body
   = 0.36 (for large deep water)
   $\simeq$ 0.50 (for small and shallow waters)
   e_s = Saturation vapour pressure of air in mm of Hg.
   e_a = Actual vapour pressure of overlying air in mm of Hg.
   V_9 = monthly mean wind velocity in km/hr at about 9 m above the ground level.

Water Budget Method

This is the simplest method, but it is the least reliable. It is used for rough calculation, and it is based on the mass conversation principle.

$$P + V_{is} + V_{ig} + V_{og} + E + \Delta S + T_L$$

Where

- P=Daily precipitation on the water surface.
- V_{is} = Daily surface inflow into the lake.
- V_{os} = Daily surface outflow from the lake.
- V_{ig} = Daily underground inflow into the lake.
- V_{og} = Daily underground outflow from the lake.
- E = Daily Evaporation
- Δ*S* = change in storage of lake
- = +ve if increase in storage
- = -ve if decrease in storage
- T_L = Daily transpiration loss from the plants on the lake.

Energy Budget Method

The energy budget method is an application of the energy conservation law. The energy available for evaporation is determined by considering the incoming energy. Outgoing energy and energy stored in the water body over a known time interval.

$$E = \frac{H_n - H_g - H_s - H_i}{\delta \cdot L(1+\beta)}$$

Where

- H_n = Net heat energy received by the water surface
- $H_n = H_c(1-r)-H_b$
- $H_c(1-r)$ = incoming solar radiation into a surface of reflection coefficient, r
- H_b = Back radiation from the water body
- H_g = Heat flux into the ground
- H_S = heat stored in the water body
- H_i = Net heat conducted out the system by water flow (advected energy)
- β = Bowen's ratio
- δ = Density of water
- L = Latent heat of evaporation.

What is Evapotranspiration?

While transpiration occurs, the land in which plants stand also loses moisture through the evaporation of water from soil and water bodies. In hydrology and irrigation practice, it is found that evaporation and transpiration processes can be considered advantageously under one head as evapotranspiration.

The real evapotranspiration occurring in a specific situation is called actual evapotranspiration (AET).

Method of Measurement of Evapotranspiration

Penman's equation is based on sound theoretical reasoning and is obtained by combining the energy balance and mass transfer approach.

$$PET = (AH_n + E_a\gamma)/(A + \gamma)$$

Where

- PET = daily evaporation in mm/day.
- A = slope of the saturation vapour pressure v/s temperature curve at the mean air temperature in mm of Hg per °C.
- H_n = Net radiation in mm of evaporable water per day
- E_a = Parameter including wind velocity and saturation deficit.
- γ = Psychometric constant
- = 0.49 mm of Hg/°C
- It is based on mass transfer and energy balance.

Methods of Stream Flow Measurement

Streamflow representing the runoff phase of the hydrologic cycle is the most important basic data for hydrologic studies.

Streamflow measurement techniques can be broadly classified into two categories:

- Direct determination and
- Indirect determination

Under each category, there are a lot of methods. The important ones are listed below:

1. Direct determination of stream discharge
    1. Area velocity methods
    2. Dilution techniques
    3. Electromagnetic method and
    4. ultrasonic method
2. Indirect determination of streamflow
    1. Hydraulic structures, such as weirs, flumes and gated structures, and
    2. Slope-area method

Velocity Determination Method

Velocity is one of the important parameters of stream flow measurement. With the help of velocity, many other analysis parameters are determined. These include the

discharge of the stream, the Area of the cross-section, etc. The velocity of the stream can be determined with the help of different methods, and these are explained below:

1. **Float Method:** Float is generally used to determine the approximate velocity of the surface. These floating devices are passed with the water along with the stream's flow.
   $V_s = L/t$ Here, V_s = surface velocity.
   L= Distance travelled by the float in time 't'.
2. **Current Meters Method:** These consist of rotating elements that rotate due to reactions of stream currents. The number of revolutions per second is counted. This can be used to measure point velocity at any depth.
   $V = aN_s + b$
   Where, V = point velocity
   N_s = Number of revolutions per sec. a and b are current meters constant.

Evaporation vs. Boiling: What's the Difference?

While both evaporation and boiling involve the transformation of a liquid into a gaseous state, there are several key differences between the two processes. Evaporation occurs at the surface of a liquid when the temperature rises above the boiling point while boiling occurs throughout the liquid when the temperature reaches its boiling point.

Evaporation is a slower process than boiling, as it only occurs at the surface of the liquid while boiling involves the rapid formation and release of bubbles throughout the liquid. Finally, boiling requires a constant source of heat, while evaporation can occur at any time when the temperature and other conditions are favorable.

Applications of Evaporation in Daily Life

Evaporation has several important applications in our daily lives, including in the natural water cycle, food and beverage processing, and air conditioning systems. In the water cycle, evaporation occurs when heat from the sun causes water to evaporate from bodies of water and enter the atmosphere, leading to precipitation in other areas.

In food and beverage processing, evaporation is used to remove excess moisture from foods such as fruits, vegetables, and grains, as well as to concentrate liquids such as juices and syrups. Finally, evaporative cooling is used in air conditioning systems, where water is evaporated into the air to reduce its temperature and create a more comfortable environment.