I.CONSUMPTIVE USE OF WATER

1.1 Definition:

•It is the quantity of water used by the vegetation growth of a given area.

•It is the amount of water required by a crop for its vegetated growth to evapotranspiration and building of plant tissues plus evaporation from soils and intercepted precipitation.

•It is expressed in terms of depth of water. Consumptive use varies with temperature, humidity, wind speed, topography, sunlight hours, method of irrigation, moisture availability.

Mathematically,

Consumptive Use = Evapotranspiration = Evaporation + transpiration

•It is expressed in terms of depth of water.

1.2 Factors Affecting the Consumptive Use of Water

Consumptive use of water varies with:

1. Evaporation which depends on humidity
2. Mean Monthly temperature
3. Growing season of crops and cropping pattern
4. Monthly precipitation in area
5. Wind velocity in locality
6. Soil and topography
7. Irrigation practices and method of irrigation
8. Sunlight hours

1.3 Types of Consumptive Water Use

Following are the types of consumptive use,

1. Optimum Consumptive Use
2. Potential Consumptive Use
3. Seasonal Consumptive Use

1. Optimum Consumptive Use:

It is the consumptive use which produces a maximum crop yield.

2. Potential Consumptive Use:

If sufficient moisture is always available to completely meet the needs of vegetation fully

covering the entire area then resulting evapotranspiration is known as Potential Consumptive Use.

3. Seasonal Consumptive Use:

The total amount of water used in the evapo-transpiration by a cropped area during the entire growing

season.

1.4 Effective rainfall

Effective rainfall (or precipitation) is equal to the difference between total rainfall and actual evapotranspiration.

1.4.1 Types of Rainfall

- Convectional rainfall.
- Orographic or relief rainfall.
- Cyclonic or frontal rainfall.

1.5 WATER BALANCE METHOD

Soil-water balance is an accurate way to estimate effective rainfall. This approach requires evapotranspiration (ET), soil water storage (SWS) and runoff characterization.

1.6 EVAPOTRANSPIRATION

(ET), represents soil evaporation and the water used by a crop for growth and cooling purposes

1.6.1 Methods of Determination of Evapotranspiration

To measure or estimation the consumptive use there are three main methods:

1. Direct Methods/Field Methods
2. Empirical Methods
3. Pan evaporation method

1. Direct Methods:

In this method field observations are made and physical model is used for this purpose. This includes,

i. Vapour Transfer Method/Soil Moisture Studies

ii. Field Plot Method

iii.Tanks and Lysimeter

iv. Integration Method/Summation Method

v. Irrigation Method

vi.Inflow Outflow Method

i. Vapour Transfer Method:

In this method of estimation of water consumptive use, soil moisture measurements are taken before and after each irrigation. The quantity of water extracted per day from soil is computed for each period. A curve is drawn by plotting the rate of use against time and from this curve, the seasonal use can be estimated. This method is suitable in those areas where soil is fairly

uniform and ground water is deep enough so that it does not affect the fluctuations in the soil moisture within the root zone of the soil.

It is expressed in terms of volume i.e. **Acre-feet** or **Hectare-meter**

ii. Field Plot Method:

We select a representative plot of area and the accuracy depends upon the representativeness of plot (cropping intensity, exposure etc).It replicates the conditions of an actual sample field (field

plot). Less seepage should be there.

Inflow + Rain + Outflow = Evapotranspiration

The drawback in this method is that lateral movement of water takes place although more representative to field condition. Also some correction has to be applied for deep percolation as it cannot be ascertained in the field.

iii. Tanks and Lysimeter:

In this method of measurement of consumptive use of water, a watertight tank of cylindrical shape having diameter 2m and depth about 3m is placed vertically on the ground. The tank is filled

with sample of soil. The bottom of the tank consists of a sand layer and a pan for collecting the surplus water. The plants grown in the Lysimeter should be the same as in the surrounding field. The consumptive use of water is estimated by measuring the amount of water required for the satisfactory growth of the plants within the tanks. Consumptive use of water is given by,

Cu = Wa - Wd

Where,

Cu = Consuptive use of water

Wa = Water Applied

Wd = Water drained off

Lysimeter studies are time consuming and expensive. Methods 1 and 2 are the more reliable methods as compare to this method.

iv. Integration Method:

In this method, it is necessary to know the division of total area, i.e. under irrigated crops, natural native vegetation area, water surface area and bare land area. In this method, annual consumptive use for the whole area is found in terms of volume. It is expressed in Acre feet or Hectare meter.

Mathematically,

Total Evapotranspiration = Total consumptive usex

Total Area Annual Consumptive Use = Total Evapotranspiration = A+B+C+D

Where,

A = Unit consumptive use for each cropxits area

B = Unit consumptive use of native vegetation xits area

C = Water surface evaporationxits area

D = Bare land evaporationxits area

v. Irrigation Method:

In this method, unit consumption is multiplied by some factor. The multiplication values depend upon the type of crops in certain area. This method requires an Engineer judgment as these

factors are to be investigated by the Engineers of certain area.

vi. Inflow Outflow Method:

In this method annual consumptive use is found for large areas. If U is the valley consumptive use its value is given by,

U = (I+P) + (Gs - Ge) - R

Where,

U = Valley consumptive use (in acre feet or hectare meter)

I = Total inflow during a year

P = Yearly precipitation on valley floor

Gs = Ground Storage at the beginning of the year

Ge = Ground Storage at the end of the year

R = Yearly Outflow

2. Empirical Methods:

Empirical equations are given for the estimation of water requirement. These are,

a) Blaney-Criddle method

b) Lowry Johnson Method

c) Penman Equation

d) Hargreave's Method

a. Blaney-Criddle method:

•Blaney and Criddle (1950) observed that the amount of water consumptively used by crops during their growing seasons was closely correlated with mean monthly temperatures and daylight hours and the length of the growing seasons.

•The correlation coefficients are then applied to determine the ET for other areas where only climate data are available.

•Blaney-Criddle formula is one of the best known procedures for estimating Potential Evapotranspiration (PET) and is widely used.

•The popularity of the procedure is due to its simplicity and its use of readily available data.

•It requires the use of only two factors, namely, temperature which is readily available from the weather stations and information on daylight hours which is a factor based purely on the latitude of the place.

•Blaney-Criddle equation expresses the consumptive use in terms of temperature and day time hours.

If CU is monthly consumptive use, its value is given by Cu= K.f.(inches)

Where, k = crop factor to be determined for each crop; its value depends upon Certain environmental conditions

f= monthly consumptive use factor

= t×(p/100)

t = mean temperature in oF.

p = percentage of day time hours of the year, occurring during the period.

If Expressed in metric units, the above formula becomes:

$$C_u = k.\frac{P}{40}[1.8t + 32] = k.f$$

Where,

t = temperature in oC

Cu= monthly consumptive use in cm

b. Lowry Johnson Method:

The equation for this method is,

U = 0.0015 H + 0.9 (Over specified)

U = Consumptive Use

H = Accumulated degree days during the growing season computed from maximum temperature above 32 °F

c. Penman Equation:

Penman(1948) proposed an equation for evaporation from open water surface, based on a combination of energy balance and sink strength which is given below with changes in certain symbols in view of the recent trends.

According to this method,

U = ET = AH + 0.27 EaA - 0.27

ET = Evapotranspiration or consumptive use in mm Ea = Evaporation (mm/day)

H = Daily head budget at surface (mm/day)

H is a function of radiation, sunshine hours, wind speed, vapour pressure and other climatic factors.

A = Slope of saturated vapour pressure curve of air at absolute temperature in °F

d. Hargreave's Method:

•It is a very simple method.

•The pan is circular with a diameter of 1.21 m and depth of 255 mm which gives it a volume of about 0.3 m3.

•The basin is put on a 150 mm high wooden frame due to air circulation around the basin. The water level is kept about 50 mm below the rim, due to allowance of percolation and the need of water.

•The water level is measured every day, either you measure the difference between the present and the origin water level or if you have chosen to obtain the water level in the pan, you measure the amount of water you have put into the pan.

According to this method,

Cu = KEp

Where,

Cu = Consumptive Use coefficient (varies from crop to crop)

Ep = Evapotranspiration

K = Coefficient

****