Unit 1

Estimation of Evapotranspiration Using Experimental and Theoretical Method

Evapotranspiration (**ET**) is the **sum of water lost by evaporation from the soil surface and transpiration from plant leaves**. It is crucial for **irrigation planning and water resource management**.

1. Methods of Estimating Evapotranspiration

A. Experimental Methods (Field-Based)

1. **Lysimeter Method**
   - **Most accurate method** for measuring ET.
   - A **weighing or non-weighing lysimeter** is used to measure **changes in soil moisture**.
   - **Formula:**

$$ET = P - D - R + \Delta S$$

where:

- P = Precipitation (mm)
- D = Deep percolation (mm)
- R = Runoff (mm)
- ΔS = Change in soil moisture (mm)

2. **Pan Evaporation Method**
   - Uses an **evaporation pan** (e.g., **US Class A Pan**) to measure evaporation.
   - **ET is estimated using the pan coefficient K_p.**
   - **Formula:**

$$ET_c = K_p \times E_p$$

where:

- ET_c = Crop evapotranspiration (mm/day)
- K_p = Pan coefficient (0.6 - 0.8)
- E_p = Pan evaporation (mm/day)

B. Theoretical Methods (Empirical Formulas)

1. **Blaney-Criddle Method** *(Simplified Approach)*
   - Based on **temperature and sunshine duration.**
   - **Formula:**

$$ET_c = K \times P \times T$$

   where:

   - K = Crop coefficient (depends on crop type)
   - P = Mean daily percentage of annual daytime hours
   - T = Mean monthly temperature (°C)

2. **Penman-Monteith Equation** *(Most Reliable Theoretical Method)*
   - Uses **temperature, wind speed, humidity, and solar radiation** for ET estimation.
   - **Formula:**

$$ET = \frac{\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

   where:

   - R_n = Net radiation at the crop surface (MJ/m²/day)
   - G = Soil heat flux density (MJ/m²/day)
   - T = Air temperature (°C)
   - u_2 = Wind speed at 2m height (m/s)
   - e_s = Saturation vapor pressure (kPa)
   - e_a = Actual vapor pressure (kPa)
   - Δ = Slope of vapor pressure curve (kPa/°C)
   - γ = Psychrometric constant (kPa/°C)

Numerical Example Based on Santosh Kumar Garg's Book

Problem Statement:

A farmer wants to estimate **crop evapotranspiration (ETc)** for a **wheat field** using the **Blaney-Criddle method**. The given data are:

- Mean monthly temperature (**T**) = 25°C
- Mean daily percentage of annual daytime hours (**P**) = 30%
- Crop coefficient for wheat (**K**) = 0.85

Solution:

Using the **Blaney-Criddle formula**,

$$ET_c = K \times P \times T$$

Substituting the values:

$$ET_c = 0.85 \times 30 \times 25$$

$$ET_c = 637.5 \text{ mm for the season}$$

$$ET_c = \frac{637.5}{30} = 21.25 \text{ mm/day}$$

Interpretation:

- The crop requires **21.25 mm of water per day.**
- The total **evapotranspiration for the entire season** is **637.5 mm.**
- The **farmer must supply this amount through irrigation** if rainfall is insufficient.

Conclusion

- **Evapotranspiration estimation is essential for irrigation planning.**
- **Experimental methods (Lysimeter, Pan Evaporation) provide direct field data.**
- **Theoretical methods (Blaney-Criddle, Penman-Monteith) are widely used for practical calculations.**
- **For accurate results, a combination of methods is recommended.**

This helps farmers **optimize water use, prevent over-irrigation, and improve crop yield**!