Unit 1

Case-Based Problem on Duty, Delta, and Base Period

Case Scenario:

A farmer is cultivating **wheat** in an irrigated field. The **base period** of wheat is **120 days**, and the crop requires **60 cm (0.6 m) of water** over the entire growing period. The available water supply is **1 cubic meter per second (cumec)**, and the field area is **800 hectares**.

The farmer needs to understand:

1. The **duty** of water for wheat.
2. The **delta** (total water depth needed).
3. The significance of these values for irrigation planning.

Concepts Explained

1. Duty (D)

- **Definition:** Duty is the area of land (in hectares) that can be irrigated by **1 cumec of water** continuously throughout the base period of the crop.
- **Formula:** D=8.64×BΔD = \frac{8.64 \times B}{Δ}D=Δ8.64×B where:
  - DDD = Duty in hectares per cumec
  - BBB = Base period in days
  - ΔΔΔ = Delta (depth of water required in meters)

2. Delta (Δ)

- **Definition:** Delta is the total depth of water required by a crop during its growth period.
- **Given:** Delta for wheat = **0.6 m**

3. Base Period (B)

- **Definition:** The base period is the total time (in days) from the first watering to the last watering of the crop.
- **Given:** Base period for wheat = **120 days**

Numerical Solution

Step 1: Calculate the Duty

Using the duty formula:

$$D = \frac{8.64 \times 120}{0.6}$$

$$D = \frac{1036.8}{0.6}$$

$$D = 1728 \text{ hectares per cumec}$$

Interpretation:
This means **1 cumec of water can irrigate 1728 hectares of wheat** over the entire base period of 120 days.

Step 2: Compare with Available Land

- Given farm size = **800 hectares**
- Water available = **1 cumec**
- Since **Duty (1728 ha per cumec) > Required (800 ha)**, the available water supply is sufficient to irrigate the field.

Final Explanation & Importance

- **Why is Duty Important?**
    - It helps in determining **how much land can be irrigated with a given water supply**.
    - It is **inversely proportional to delta** (i.e., if a crop requires more water, its duty will be lower).
- **Why is Delta Important?**
    - It helps in calculating **the total water requirement** of a crop.
    - It allows engineers to design proper water storage and irrigation schedules.

- **Why is Base Period Important?**
    - It determines the **continuous flow duration** needed in the irrigation system.
    - A longer base period means **a lower discharge rate** can be used over time.

Practical Application

- **If duty is too high**, water is used efficiently, and irrigation canals need **lower capacity**.
- **If delta is high**, more water is needed, and irrigation systems must be designed for **higher flow rates**.
- **For planning an irrigation schedule**, farmers and engineers use these values to optimize water distribution.

Conclusion

- **Duty for wheat = 1728 hectares per cumec**
- **Delta for wheat = 0.6 m**
- **Base period = 120 days**
- The farmer **has sufficient water** to irrigate the 800-hectare field using 1 cumec supply.

This approach ensures **optimal water use, reduced wastage, and better crop yield**!

Consumptive Use of Crops

1. Definition of Consumptive Use

Consumptive use of water (CU) refers to the **total quantity of water used by plants for transpiration and evaporation** from the soil and plant surfaces. It is also known as **evapotranspiration (ET)**.

Formula:

$$CU = \text{Evaporation} + \text{Transpiration}$$

2. Factors Affecting Consumptive Use

1. **Climatic Factors**
   - Temperature (Higher temperature → More transpiration)
   - Humidity (Lower humidity → More evaporation)
   - Wind Speed (Stronger winds → Higher water loss)
   - Solar Radiation (More sunlight → More water demand)
2. **Crop Factors**
   - Type of crop (Water-intensive vs. drought-resistant crops)
   - Growth stage (Young plants use less water than mature ones)
   - Root depth (Deeper roots extract more water)
3. **Soil Factors**
   - Soil texture (Sandy soils drain quickly, leading to higher CU)
   - Soil moisture availability
   - Organic matter content
4. **Agricultural Practices**
   - Irrigation method (Drip irrigation reduces CU compared to surface irrigation)
   - Mulching (Reduces evaporation losses)
   - Plant density (Higher density → More transpiration)

---

3. Methods to Estimate Consumptive Use

A. Experimental Methods

1. **Lysimeter Method:**
    - Measures actual water loss from the soil and plants.
    - Provides accurate field data.
2. **Field Observations:**
    - Measures soil moisture depletion.
    - Uses pan evaporation method to estimate CU.

B. Theoretical Methods

1. **Blaney-Criddle Formula:**
    - Based on temperature and sunshine hours.

$$CU = K \times P \times T$$

where:

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

3. **Penman-Monteith Equation:**
    - Uses multiple weather parameters for accurate ET estimation.

Case-Based Explanation

Case Scenario: Wheat Cultivation in a Semi-Arid Region

A farmer is growing **wheat** in a **semi-arid region** where temperatures are high and rainfall is low. He notices that his crops require frequent irrigation, but water availability is limited. He wants to understand **how much water his crops are consuming** and how to manage it effectively.

Analysis:

- **Given Data:**
  - **Temperature:** 30°C
  - **Crop Growth Stage:** Mid-growth
  - **Soil Type:** Sandy loam
  - **Irrigation Method:** Surface irrigation
  - **Estimated ET (Evapotranspiration) per day:** 5 mm
- **Problems Observed:**
  - High **evaporation** due to high temperature.
  - Frequent **transpiration** from crops.
  - **Water loss is high**, leading to inefficient irrigation.

Solution Approach:

1. **Estimate Consumptive Use Using Blaney-Criddle Formula:**

$$CU = K \times P \times T$$

- Assume $K = 0.85$ (for wheat)
- $P = 30\%$ (based on seasonal sunshine hours)
- $T = 30^{\circ}C$

$$CU = 0.85 \times 30 \times 30$$

$$CU = 765 \text{ mm over the season}$$

2. **Water Management Recommendations:**
   - Switch to **drip irrigation** to reduce evaporation losses.
   - Use **mulching** to minimize soil evaporation.
   - Adjust **irrigation scheduling** to water during cooler parts of the day.

Conclusion

- **Consumptive use determines total water needs for crops.**
- **Estimating CU helps in water management and irrigation planning.**
- **Using efficient irrigation methods can reduce water loss and improve crop yield.**

This approach helps **optimize water usage and increase agricultural productivity** in water-scarce regions!