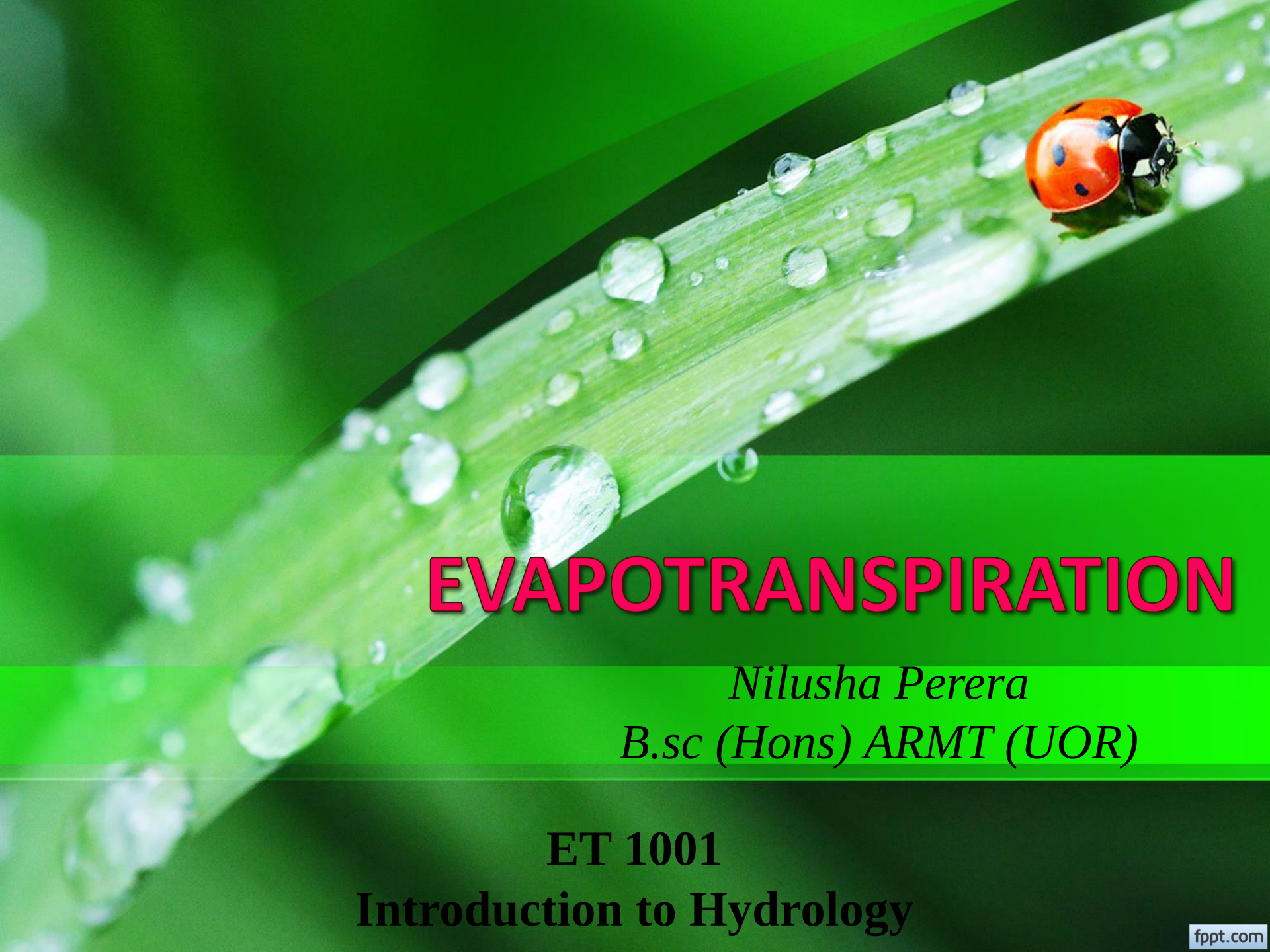




EVAPOTRANSPIRATION

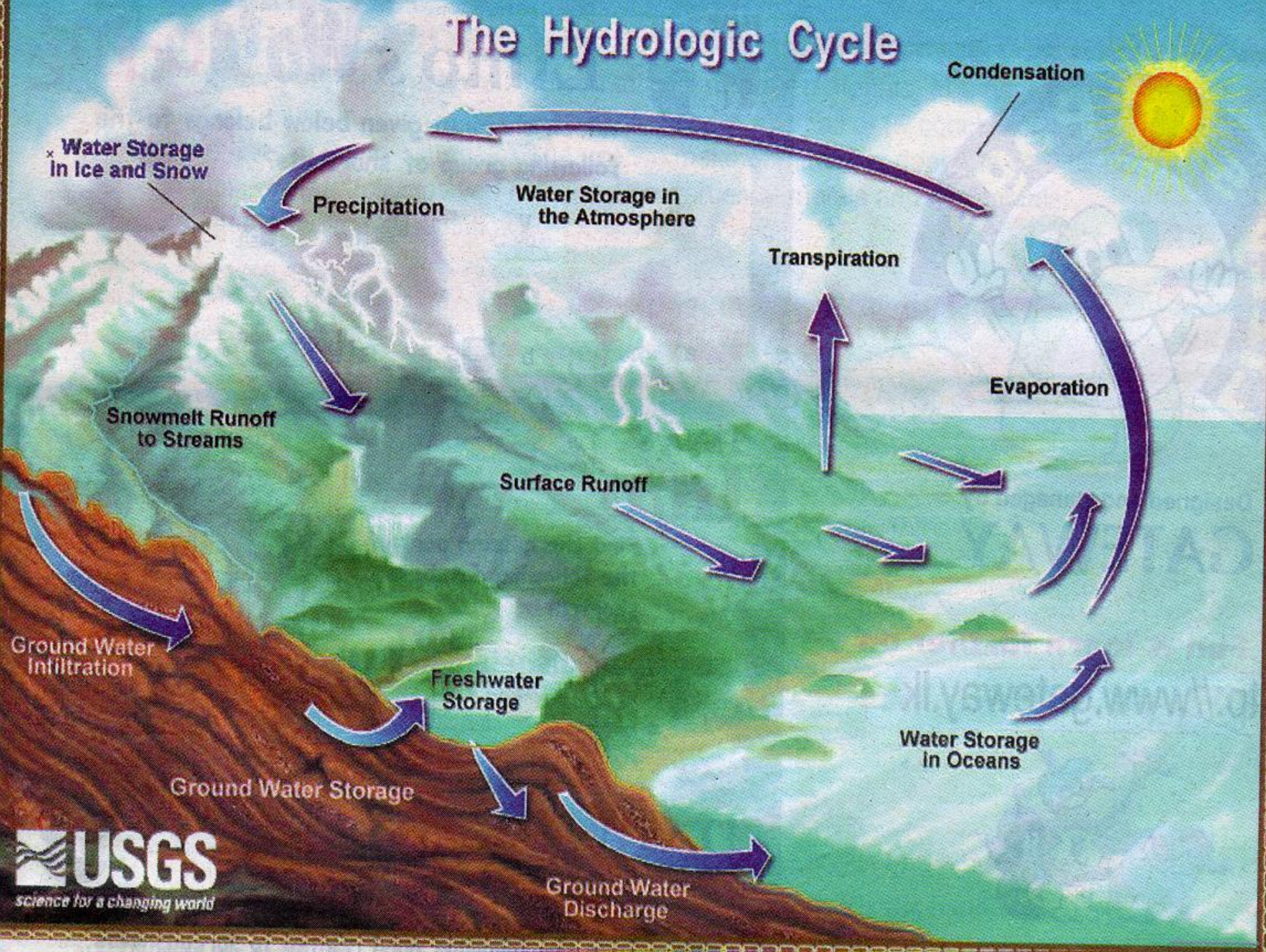
Nilusha Perera

B.sc (Hons) ARMT (UOR)

ET 1001

Introduction to Hydrology

The Hydrologic Cycle





Evaporation

Movement of water to the air from sources such as the soil, canopy interception, and water bodies.

Transpiration

Movement of water within a plant and the subsequent loss of water as vapor through stomata of the leaves.

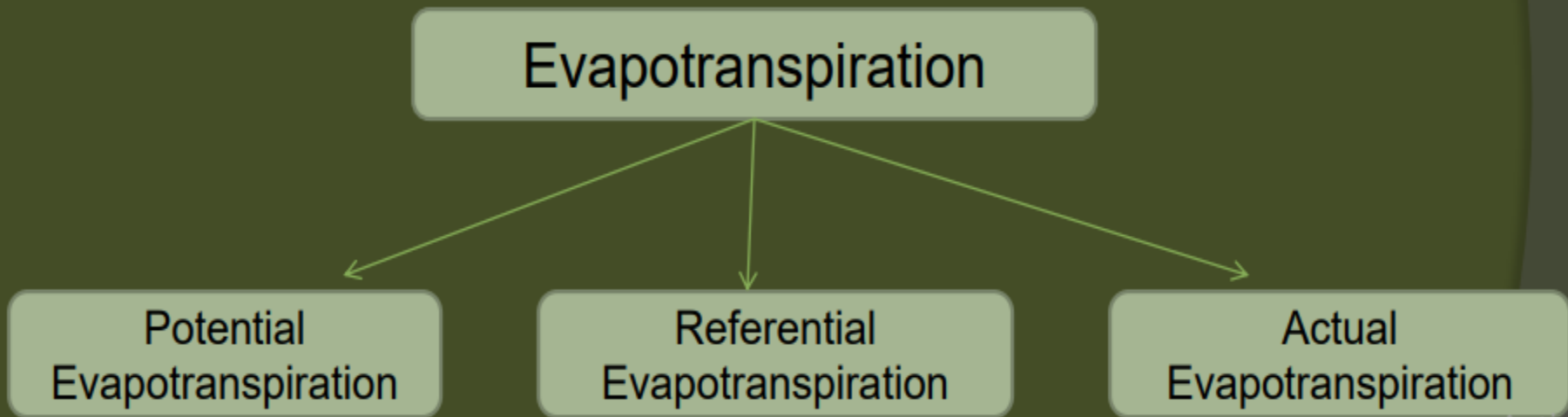
EVAPOTRANSPIRATION



- The total amount of water loss in the form of water vapors into the atmosphere from surface of the soil, canopy interception, water bodies as well as from the aerial parts of plants in a process known as evapotranspiration.

Types of evapotranspiration

- Evapotranspiration may be classified as:



1. Maximum / Potential Evapotranspiration

Amount of water, which will be lost by evaporation and transpiration, where there is sufficient water in the soil at all times for the use of vegetation

Consumptive Use

- Required for evapotranspiration and metabolic activities of the plants

$$\text{Consumptive Use} = \text{ET} + \text{Metabolic Activities}$$

- Water used for metabolic activities is very small, CU is generally taken as equivalent to ET

$$\text{Consumptive Use} = \text{ET}$$

2. Reference Evapotranspiration (ET_o)

Rate of evapotranspiration - From an extensive surface of 8 to 15cm tall green grass cover of uniform height, actively growing, completely shading the ground and not short of water.

3. Actual Evapotranspiration

It is the actual ET of a crop at particular locality and at particular time. It depends upon crop , soil , climate , and management factors

Evapotranspiration at the field environmental conditions

Crop Evapotranspiration (ET_{crop})

Evapotranspiration from -

- Disease free,
- Well fertilized crops,
- Grown in large fields,
- Under optimum soil water conditions,
- And achieving full production under the given climate conditions

Crop Water Requirement

- Water required to compensate the evapotranspiration needs of the crop field
- ET_{crop} and crop water requirements are identical

$$ET_{\text{crop}} = \text{Crop Water Requirement}$$

- Crop ET is loss of water from crop field
- Crop WR is the amount of water that needs to be supplied to the field

Factors Affecting Evapotranspiration

- Weather Factors
- Crop Factors
- Management and Environmental Conditions
- Soil factors

Weather Factors

- Solar Radiation
- Air Temperature
- Wind Speed and
- Relative Humidity

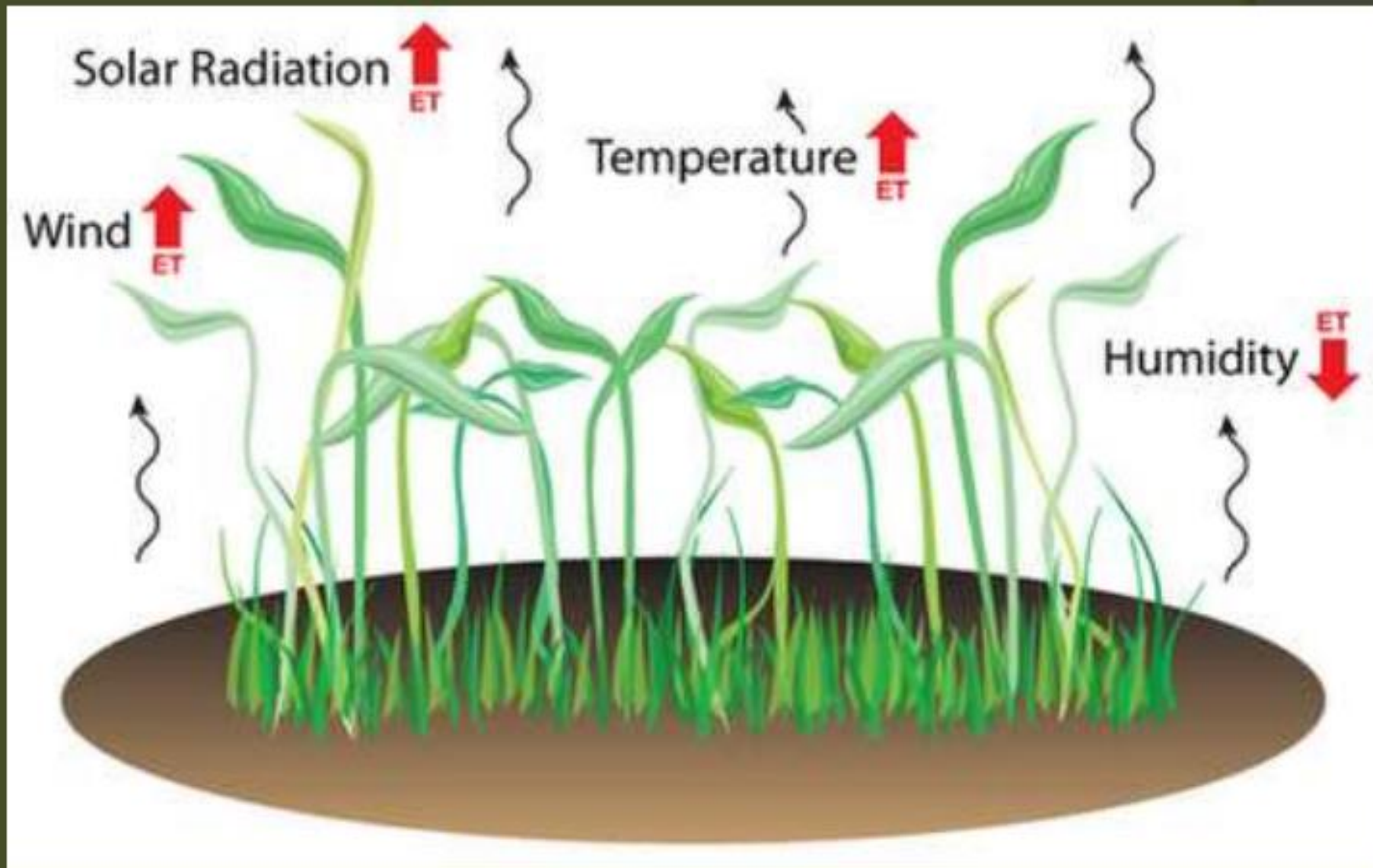


Figure: ET is an energy driven process, increases with temperature, solar radiation and wind speed. ET decreases with increasing humidity.

Crop Factors

- Crop Type
- Variety
- Growth (Development) Stage
- Crop Duration
- Plant Population
- Growing Season

Management & Environmental Conditions

- Soil Salinity
- Land Fertility
- Fertilizer Application
- Disease and Pests
- Soil Management
- Hard or impenetrable soil horizons

Soil Factors

- Soil Texture
- Structure
- Depth
- Topography etc

Why ET Measurements.....?

- Irrigation scheduling
- Planning of farm irrigation systems
- Design of irrigation projects
- Water resource development project

MEASUREMENT OF EVAPOTRANSPIRATION

INDIRECT METHODS

DIRECT METHODS

USING EVAPORATING DATA

USING CLIMATOLOGICAL DATA

LYSIMETER METHOD

FIELD EXPERIMENTAL PLOT METHOD

SOIL MOISTURE DEPLETION METHOD

WATER BALANCE METHOD

BLANNEY CRIDDLE

THORNTHWAITE

LINACAR

RADIATION

PENMAN

USING CLASS "A" PAN

EMPIRICAL ESTIMATION

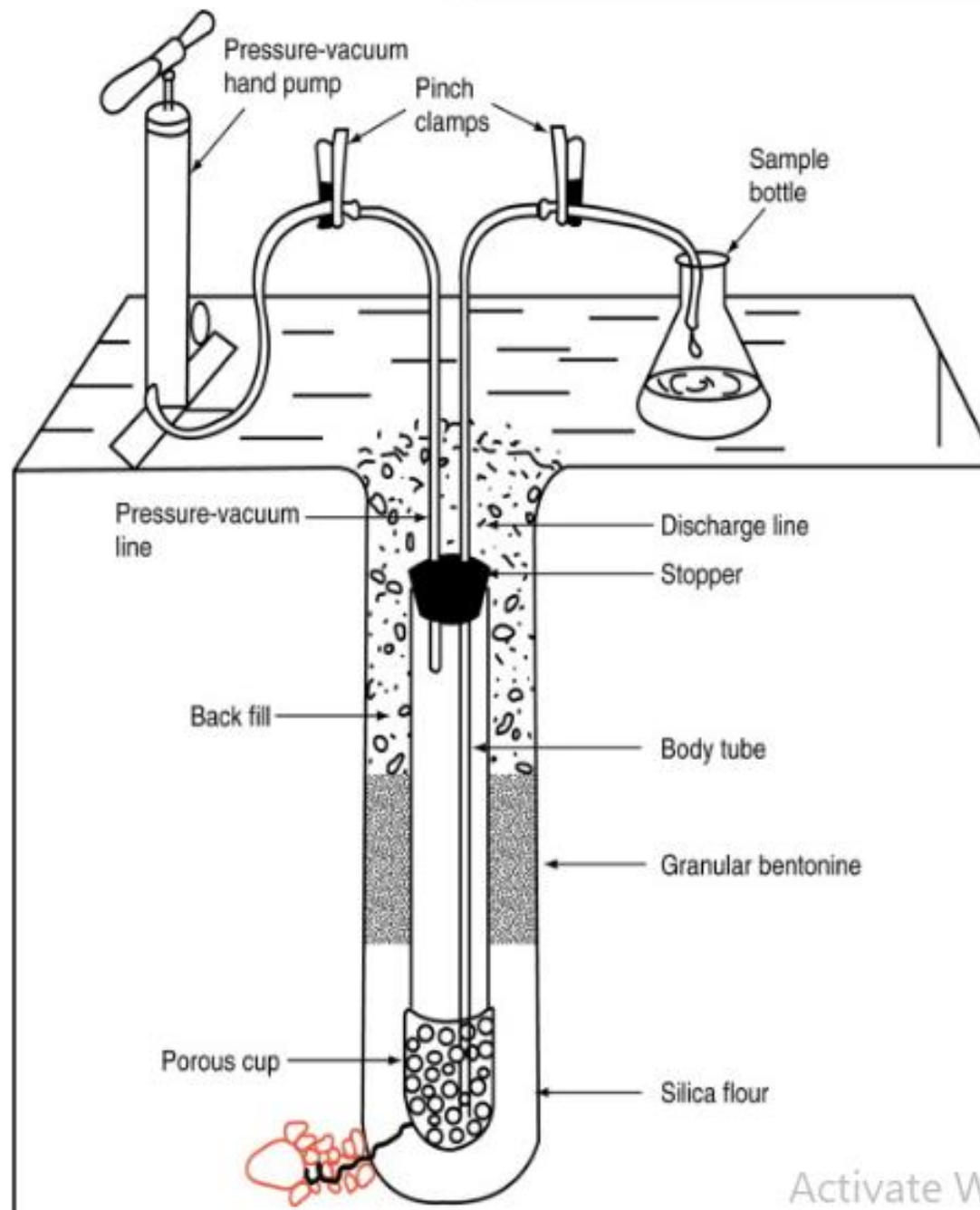
DALTON METHOD

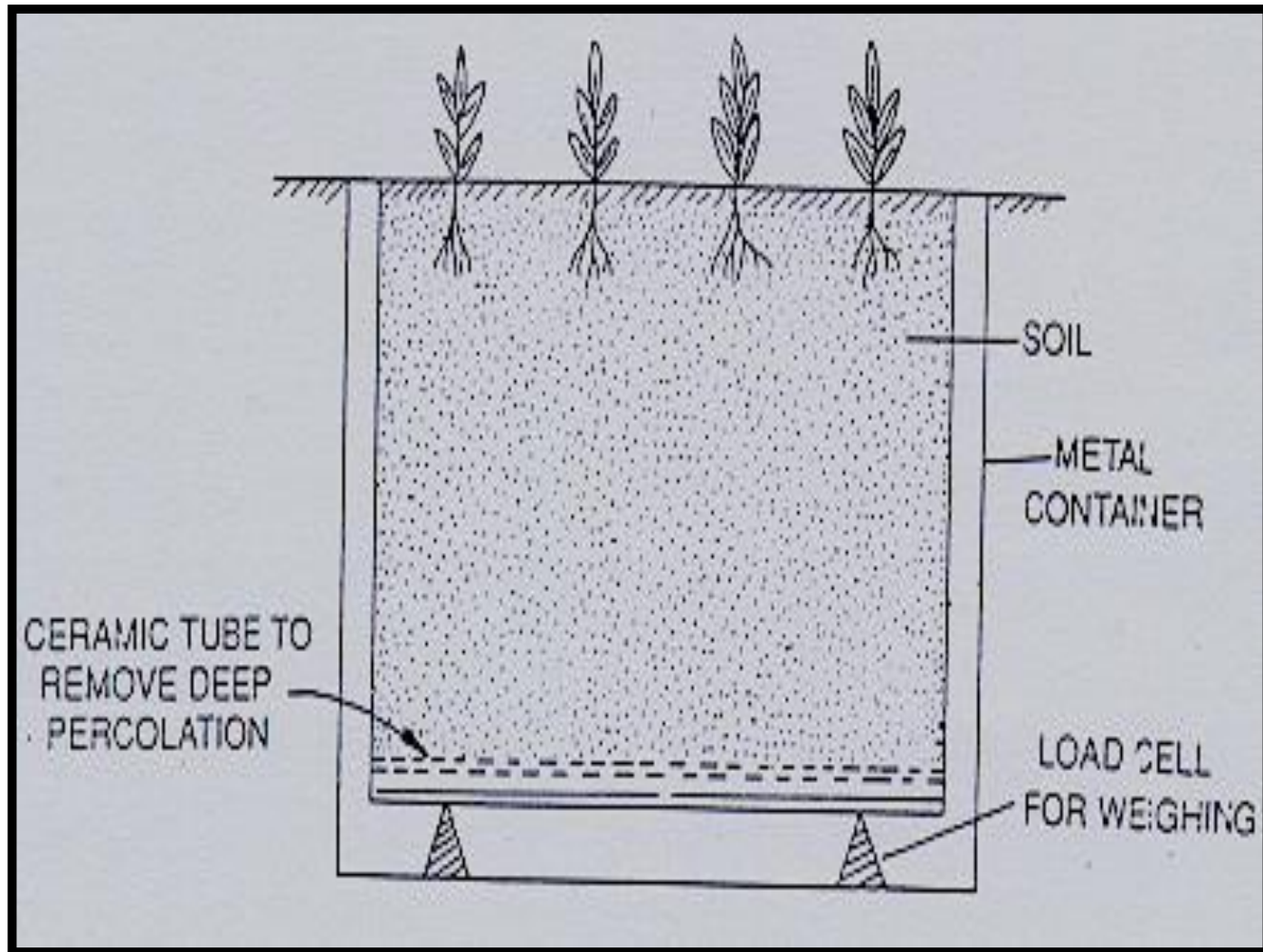
IVANOV METHOD

Measurement of Evapotranspiration – Direct Method

Lysimeter Methods

- A large container filled with soil
- Soil or crop or whatever in the Lysimeter is same as outside
- Represent the field environmental conditions
- Used to determine ET_{crop} , ET_o or evaporation from bare soils





- Should be isolated from surrounding soil to
 - Prevent lateral movement of water
 - Prevent downward movement of water from it
- Principle - to study the water balance of the Lysimeter

$$P + I \pm RO = ET + D \pm \Delta W$$

P = Precipitation

I = Irrigation

RO = Surface runoff to or out

ET = Evapotranspiration

D = Deep percolation or Drainage

ΔW = Change of water content of isolated soil mass over a given period

Following data were obtained from a Lysimeter study. Estimate the ET for the study period.

Study period = one month

Precipitation = 50mm

Irrigation = 25mm

Runoff = 0mm

Deep Percolation = 15mm

Moisture % at the beginning of the study = 20%

Moisture % at the end of the study = 16%

Bulk density of the soil = 1.5g/cm³

Depth of the Lysimeter = 1.5m

- Weighing Type
- Non Weighing Type

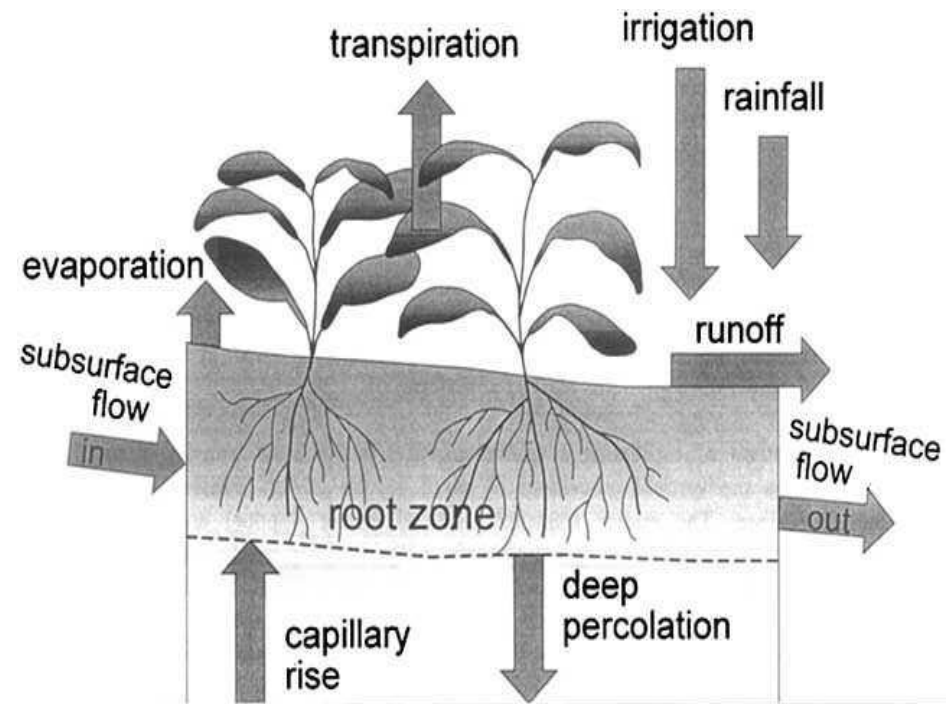
Factors to be considered in Lysimeter studies.

- Should be large and deep to reduce boundary effects and to avoid restricting root development
- Physical condition within the Lysimeter should be same as outside
- Plant height, density and arrangements should be similar inside and outside
- A large guard ring or buffer area should be maintained surround the Lysimeter

Measurement of Evapotranspiration – Direct Method

Water Balance Method

- ET from a large area like a watershed can be estimated.
- Incoming and outgoing water from an area are considered.



$$P + I + S = E + T + D + R$$

P = Precipitation

I = Irrigation

S = Ground water contribution

E = Evaporation

T = Transpiration

D = Deep percolation

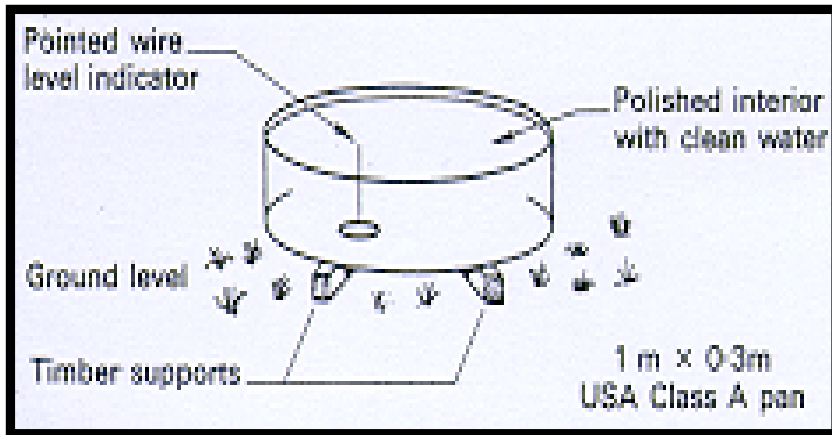
R = Surface runoff

Measurement of Evapotranspiration – Indirect Method Based on Evaporation Data

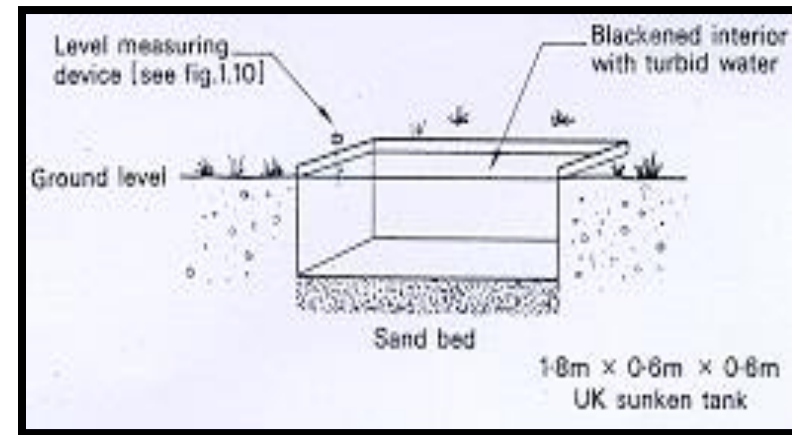
- Close relationship between the rate of evaporation and ET
- Evaporation data successfully can be used
- Basically two methods
 - Using actual evaporation data
 - Using evaporation data derived from empirical equations

Measurement of Evapotranspiration – Indirect Method Based on Evaporation Data – Actual Evaporation Data

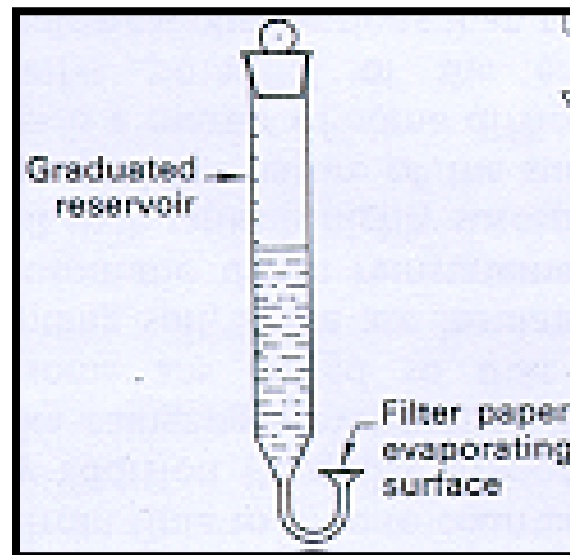
- Evaporation – in “mm”
- Popular methods
 - US class “A” pan,
 - UK sunken tank evaporimeter,
 - Piche evaporimeter and
 - Jones and Rothwell’s glasshouse evaporimeter



Class "A" Pan



U.K sunken tank



Piche Evaporimeter



- Class “A” pan - most common and accurate
- Made of galvanized iron, 120cm diameter and 25cm depth
- Painted in white
- Put on a wooden frame height of 15cm from the ground - get better air circulation
- Water is filled to 20cm depth
- Evaporation - measured daily
- Each day add water to bring the level to the fixed point

- Gives higher rate than free water surface
- Correction factor (normally 0.7) is used to adjust it to a free water surface evaporation
- Pan evaporation and crop ET – not equal
 - Non similarity of reflectance
 - Non similarity of wind over crop and pan
 - High heat storage in the pan
 - Pans continues evaporation at night but most plants close stomata during darkness
 - No stomata resistance to moisture loss in Pan as in the plant

- Pan evaporation is only correlated with potential ET

Potential ET = Pan Evaporation x Crop coefficient (C)

- Crop coefficient
 - Varies with stages of the crop growth
 - Unique to that pan, crop and location
- Experimental “C” values of one area should be used with carefully in other areas

Measurement of Evapotranspiration – Indirect Method Based on Evaporation Data

Empirical Estimation of Evaporation – Dalton Method

Rate of evaporation is a function of the difference in the vapour pressure in water surface and air

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

E = Rate of evaporation (mm/day)

C = Constant

e_s = Saturated vapor pressure at water surface temperature (mmHg)

e_a = Actual vapor pressure of the air (mmHg)

$$C = 0.35 (0.5 + 0.54 u_2)$$

U_2 = Wind speed at 2m height (m/s)

Measurement of Evapotranspiration – Indirect Method Based on Evaporation Data

Empirical Estimation of Evaporation – Ivanov Method

- Empirical equation
- Suggested by NN IVANOV

$$E = 0.0018 (25+t)^2 (100-\alpha)$$

E = Evaporation mm/month
t = Mean monthly temperature (°C)
 α = Relative humidity

Ex

Estimate the evaporation using Ivanov method for May in which mean monthly temperature and relative humidity is 32 and 80% respectively

Measurement of Evapotranspiration

Indirect Method

Climatological Approaches



*Thank
you!*