LECTURE 05

Water Balance Method

- The Water Balance or Budget Method is a measurement of continuity of flow of water.
- This method consists of drawing up a balance sheet of all the water entering and leaving a particular catchment or drainage basin.
- The water balance equation can be written as:
- ET = I + P – RO – DP + CR + SF + SW
- Where: I is Irrigation, P is rainfall, RO is surface runoff, DP is deep percolation, CR is capillary rise, SF and SW are change in sub-surface flow and change in soil water content respectively

Lysimeter Method

- A water tight tank of cylindrical shape having dia about 2 m and depth about 3 m is placed vertically in ground.
- The tank is filled with sample soil.
- Bottom of the tank consists of sand layer and a pan for collecting surplus water.
- The consumptive use of water is measured by the amount of water required for the satisfactory growth of plants with in tank.
- Cu = Wa - Wd (Cu = consumptive use, Wa = water applied, Wd = Water drained off)

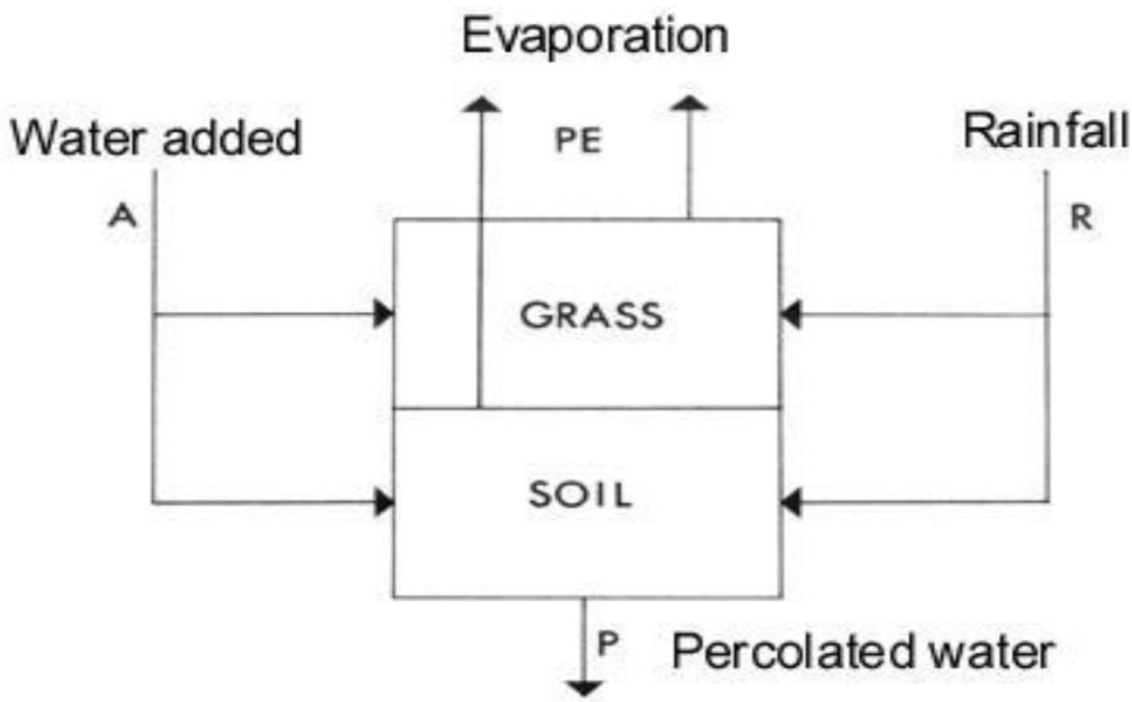


Fig 1. Simplified pathway of water in an evapotranspiration measuring apparatus

Field experimental method

- Some fields are selected for experiment.
- The quantity of water is applied in such a way that it is sufficient for satisfactory growth of crops.
- There should be no percolation or deep runoff.
- If there is any runoff it should be measured and deducted from the total quantity of water applied.

Soil Moisture Study

- Several plots of land are selected where irrigation water is to be supplied.
- The soil samples are taken from diff depths at the root zone of the plants before and after irrigation.
- Then water contents of the soil samples are determined by laboratory tests.
- The depth of water removed from soil determined by Dr = pwd/ 100
- (Dr= depth of water removed in m, p = % of water content, w = sp. Gr. Of soil, d= depth of soil in m)
- The total quantity of water removed in 30 days period is calculated.
- Then a curve of water consumption versus time is prepared.
- From this curve the water consumption for any period can be calculated.

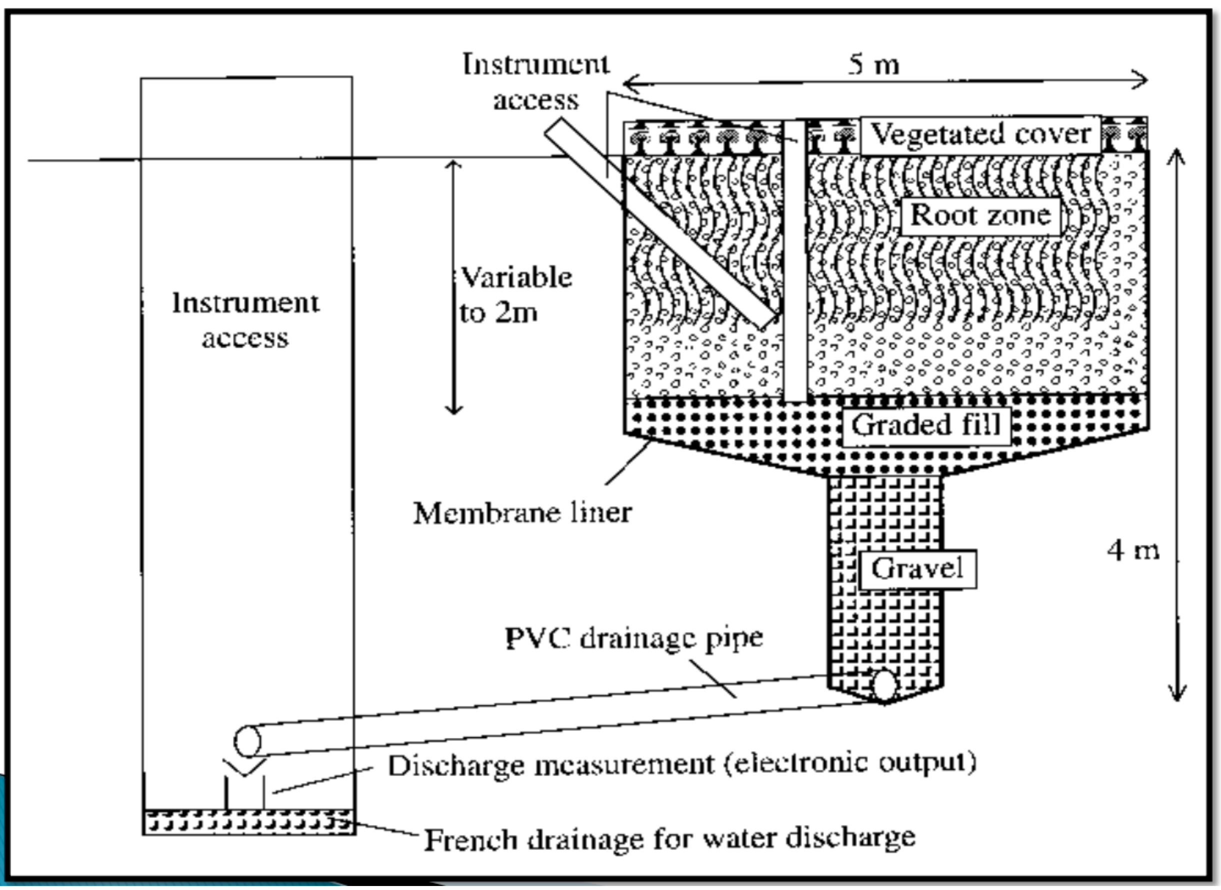
Penman-montieth Method

$$ET_0 = (\frac{1}{\lambda})[(\frac{\Delta}{\Delta+\gamma^*})(R_n - G) + (\frac{\gamma}{\Delta+\gamma^*})(.622\frac{K_1\lambda\rho}{BP})\frac{(e_z^0 - e_z)}{r_a}]$$

•More reliable for any length period daily, monthly, or seasonal.

AET_0 = The evapotranspiration for grass reference crop
λ = heat of vaporization
R_n = net radiation
G = soil heat flux
Δ = slope of the vapor pressure curve
γ = psychrometric constant
ρ = density of air
BP = mean barometric pressure
e^0_z = average saturated vapor pressure
e_z = actual vapor pressure
$\gamma^* = \gamma(1+r_c/r_a)$
r_c = surface resistance to vapor transport
r_a = aerodynamic resistance to sensible heat a
vapor transport
K_1 = the dimension coefficient

Tank and Lysimeter Method



Irrigation Efficiencies

- These irrigation efficiencies are brought about by the desire not to waste irrigation water, no matter how cheap or abundant it is.

- The objective of irrigation efficiency concept is to determine whether improvements can be made in both the irrigation system and the management of the operation programmes, which will lead to an efficient irrigation water use.

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- The objective of irrigation efficiency concept is to determine whether improvements can be made in both the irrigation system and the management of the operation programmes, which will lead to an efficient irrigation water use.

- Not all water available at the head works of an irrigation project is available to fulfill the net irrigation requirements. Losses to deep percolation, evaporation, and surface runoff, as leaching requirements, must be accounted for in the conveyance system sand in the farm application system.

Application Efficiency

$$E_a = \frac{Water\ in\ root\ zone\ after\ irrigation}{Total\ volume\ of\ \ water\ applied}$$

$$\frac{Total\ vol.of\ \ water\ applied - (Vol.of\ \ Tailwater + Vol.of\ \ deep\ percolation)}{Total\ water\ applied}$$

E_a is inadequate in describing the overall quantity of water since it does not indicate the actual uniformity of irrigation, the amount of deep percolation or the magnitude of under-irrigation.

EXAMPLE

- Delivery of 10 m^3/s to a 32 ha farm is continued for 4 hours. The tail water is 0.27 m^3/s. Soil probing after irrigation indicates that 30 cm of water has been stored in the root zone. Compute the Application Efficiency.

- **Solution:**
  Total volume of water applied
  $= 10\ m^3/s \times 4\ hrs \times 3600 s/hr = 144{,}000\ m^3$
  Total tail water $= 0.27 \times 4 \times 3600 = 3888\ m^3$
  Total water in root zone $= 0.3\ m \times 32\ ha \times 10{,}000\ m^2/ha = 96{,}000\ m^3$

Solution to Example Contd.

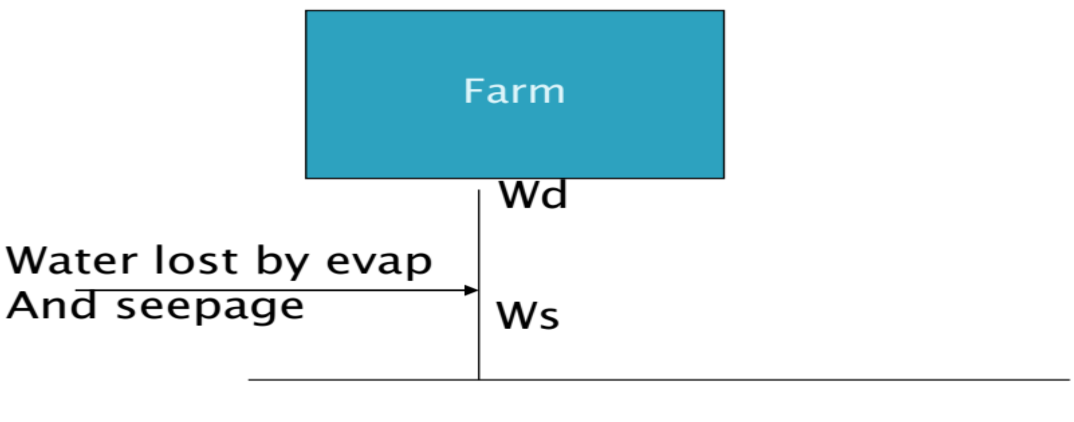
$$E_a = \frac{\textit{Water in root zone after irrigation}}{\textit{Total volume of water applied}}$$

$= 96{,}000/144{,}000$

$=$ <u>**66.7%.**</u>

Water Conveyance Efficiency

$$E_c = \frac{Water\ delivered\ to\ the\ Farm\ (W_d)}{Water\ of\ \ water\ diverted\ \ from\ a\ stream,\ reservoir\ or\ well\ (W_s)}$$



Example

- 45 m³ of water was pumped into a farm distribution system. 38 m³ of water is delivered to a turn out (at head ditch) which is 2 km from the well. Compute the Conveyance Efficiency.

Solution:

$$E_c = \frac{Water\ delivered\ to\ the\ Farm\ (W_d)}{Water\ of\ \ water\ diverted\ \ from\ a\ stream,\ reservoir\ or\ well\ (W_s)}$$

= 38/45 = ***84%***

Water Storage Efficiency (E_s)

$$E_s = \frac{Volume\ of\ water\ in\ the\ root\ zone\ after\ irrigation}{Volume\ of\ water\ needed\ in\ root\ zone\ to\ avoid\ total\ water\ moisture\ depletion}$$

► **Distribution Efficiency:**

$$\text{Distribution efficiency } \eta_d = \left(1 - \frac{y}{D}\right) ж\ 100$$

► **Water use Efficiency:**

$$\text{Water use efficiency} = \frac{\text{Economic yield}}{\text{C.W.R}}$$

Project Efficiency

- $$\text{Project efficiency} = \eta_p = \frac{W_s}{W_d} \times 100$$

Ws = amount of water stored in crop root zone
Wd = amount of water diverted from source

Operational Efficiency

$$\text{Operational efficiency} = \frac{\text{Actual project efficiency}}{\text{Project efficiency of ideal system}}$$

Determination of Irrigation Requirement of Crops

- Effective Rainfall (R_e)
- Consumptive Irrigation Requirement (CIR)
- Net Irrigation Requirement (NIR)
- Field Irrigation Requirement (FIR)
- Gross Irrigation Requirement (GIR)

Effective Rainfall (Re)

- It is the part of precipitation falling during the growing period of a crop that is available to meet the evapo transpiration needs of the crop.

Consumptive Irrigation Requirement (CIR)

It is defined as the amount of irrigation water that is required to meet the evapo transpiration needs of the crop.

Net Irrigation Requirement (NIR)

Amount of irrigation water required at the plot to meet the evapo transpiration needs of water as well as other needs such as leaching etc.,

NIR= Cu –Re+ water lost in deep percolation for the purpose of leaching.

Field irrigation Requirement (FIR):

- Amount of water required to meet NIR + water lost in percolation in water courses, field channels and in field application of water.

$$FIR = (NIR)/\eta_a$$

Gross irrigation requirement (GIR)

- Sum of water required to satisfy the field irrigation requirement and the water lost as conveyance losses in distributaries upto the field.

$$GIR = (FIR)/\eta_c$$

Reuse of waste water for agriculture

- In rural and peri urban areas of most developing countries, the use of waste water for irrigation is a common practice.
- Wastewater is often the only source of water for irrigation in these areas
- Farmers often prefer waste water because its high nutrient content reduces or even eliminates the need for expensive chemical fertilizers.

Advantages

- This technology reduces the demands on portable sources of fresh water.
- It may reduce the need for large wastewater treatment systems, if significant portions of the waste stream are recycled or reused.
- The technology may diminish the volume of waste water discharged, resulting in a beneficial impact on the aquatic environment.