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ADDITIONAL ANSWER SHEET

S.V.V.S.N. ENGINEERING COLLEGE, ONGOLE.

(Affiliated to Acharya Nagarjuna University)

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UNIT-II

Losses (or) Abstractions from Precipitation:-

(Pruthi 139 BC Punmia)

The precipitation will be falling on land surface. Whole amount of precipitation will not run off because losses that take place during (or) after the precipitation

(ఒక ఏరియాలో వర్షం పడినప్పుడు ఆ ఏరియాలో వర్షం నీరు మొత్తం run off అవ్వదు ఎందుకంటే వర్షం పడేటప్పుడు కానీ లేదా వర్షం పడిన తర్వాత కానీ water కొంత losses కి గురవుతుంది ఆ losses ఉంటాయి)

→ The Important losses consist of

(i) Interception

~~(ii) evaporation~~

(ii) Depression storage

(iii) watershed leakage

(iv) Evaporation

(v) Transpiration

(vi) Infiltration

Out of these, Evaporation, Transpiration and Infiltration are the major losses

Thus,

Precipitation − surface runoff = Total loss

where

Total loss = Interception + Depression storage + watershed leakage + Evaporation + Transpiration + Infiltration

(I) Interception :-

Interception may be defined as that amount of precipitation water which is intercepted by vegetation foliage, buildings and other objects laying over the land surface

(చెట్ల ఆకులు) (భవనాలు)

(Interception అంటే వర్షపు నీరు ఆకుల మీద బిల్డింగ్ల మీద పడి నేలను touch కాకుండా తిరిగి evaporate అవుతుంది)

→ Interception water does not reach the land surface, but is returned back to the atmosphere by evaporation.

→ The various factors will be affect interception are

(i) storm factor

(ii) Plant factor

(iii) season of the year and

(iv) prevailing wind

(ii) Depression storage:-

Ex:- గుంటల లో నిల్వ ఉన్న స్థితి (compact చేసిన soil)

This is one of the catchment area generally many depressions are shallow depths and of varying size and shape.

The precipitation (వర్షం) will be falling on land surface first water runs towards the depression storage and filling it.

The storage water in these depression storage partly evaporates and partly infiltrates into the ground.

The following relationship may be used for computing the depression storage

$$V_{ds} = K\left[1 - e^{-P_e/K}\right]$$

where

V_{ds} = volume of water stored in surface depression

P_e = Rain fall excess (volume of rainfall in excess of infiltration and interception)

K = Depression storage capacity of the basin

The following are the factors that affect depression storage

(i) land form (భూమి ఎలా ఉన్నదో ఎత్తు పల్లాలు తెలుసుకొని)

(ii) soil characteristics (భూమి స్వభావం)

(iii) Topography (భూమి పై ఉన్న ఎత్తు పల్లాలు)

(iv) Antecedent precipitation index and (ముందటి వర్షపాతం)

(v) Man made disturbance etc

Ex:- terrace farming (వరుసల వ్యవసాయం)

(iii) water shed leakage:-

Watershed leakage may be defined as flow of water from one basin to another basin, (or) from one basin to the sea through major faults, fissures (పగుళ్లు, నెర్రెల ద్వారా ప్రవహించటం)

ఒక place లో ఉన్న నీరు ఇంకో place లో ఉంటే ఒక place లో ఉన్న నీరు వేరొక ఇంకో నీరు లోకి చేరుతుంది ఎలా అంటే భూమిలో ఉన్న పగుళ్ళు ద్వారా ప్రవహిస్తుంది ఎలా ఉంటే ... ప్రవహిస్తుంది

These faults, fissures may be formed due to the catchment water will be moving down wards ~~reach the water table~~ that time will be formed fissures (పగుళ్లు)

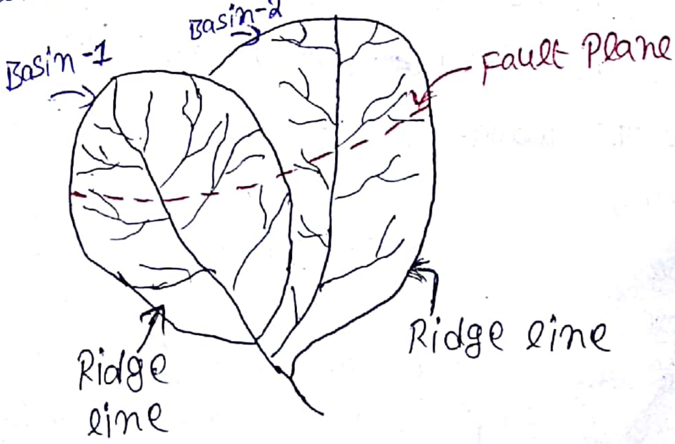

Fig 4.29 watershed Leakage

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UNIT-II

In this chapter u can study only 3 topics

Evaporation → Factors affecting evaporation → measurement of evaporation → Evaporation reduction

Evapotranspiration → Factors affecting evapotranspiration → measurement of evapotranspiration

Infiltration → Factors affecting infiltration → measurement of Infiltration

Evaporation:-

* Evaporation is the process in which liquid form of water changes to gaseous state at the free surface. Below the boiling point through the transfer of heat energy.
* It is a continuous and natural process by which a substance changes from liquid to gaseous state.
* The main source of evaporation is the solar radiation
* The loss of evaporation is high may be 90% of annual precipitation will be evaporated

Factors affecting evaporation:-

(1) Nature of evaporation surface.
(2) Area of water surface
(3) Depth of water in the water body.
(4) humidity. (5) wind velocity. (6) Temparature.
(7) Atmospheric pressure and (8) quality of water.

(1) Nature of evaporating surface:-

Different evaporating surfaces like soil, bushen land, forest area, houses and lakes
* Black cotton soil will absorb the heat so Black cotton soils helps to evaporate very faster so Black cotton soils helps to evaporate the soil water faster compositively then red soils

(2) Area of water surface:-

The evaporation loss directly depends upon the area of water surface
* The water surface area is more the evaporation of water will be more
* The water surface area is less the evaporation of water will be less.

(3) Depth of water in water body:-

* Deep water bodies the water will be evaporated slower. comparitively shallow water bodies.
* In shallow water bodies the water will be evaporated faster
in summer while in winter season

(4) Humidity:-

If the humidity in the atmosphere is more, evaporation will be less.
If the humidity in the atmosphere is less, evaporation will be high
Evaporation is inversely proportional to humidity

(5) wind velocity:- (speed)

wind removes over laying (top layer) vapour from a evaporating body.
* This heat vapour will effected behind the water body to absorb the vapour
* There by increasing the rate of evaporation

(6) Temperature of air:-

The air temperature will be increase due to the solar This air will meet cold objects the evaporation rate will be more.

The air temperature will be less the rate of evaporation will be less.

In summer season the air will be very heat, so evaporation will be high.

In winter season the air will be cold so evaporation will be less.

(7) Atmospheric pressure:-

Hot air don't have any weight so it will be flowing upper surface.

* In cold air having some weight so will be following in down stream of hot air is.

means above the ground surface.

* In heavy cyclone is comming that a time, high speed wind will came this wind, will be flowing faster and meet any obstacle and then rise upside meet hot air so

* After that This hot air become cool when because bottom side of cool air will meat upper side of hot air so become cool. so evaporation will be less.

* Some times the upper surface of hot air snow mountains that a time evaporation will be more.

(8) Quality of water:-

The water having any dissolved salts The type of water will be less evaporating

Ex:- Sea water is less evaporation
river water is more evaporating

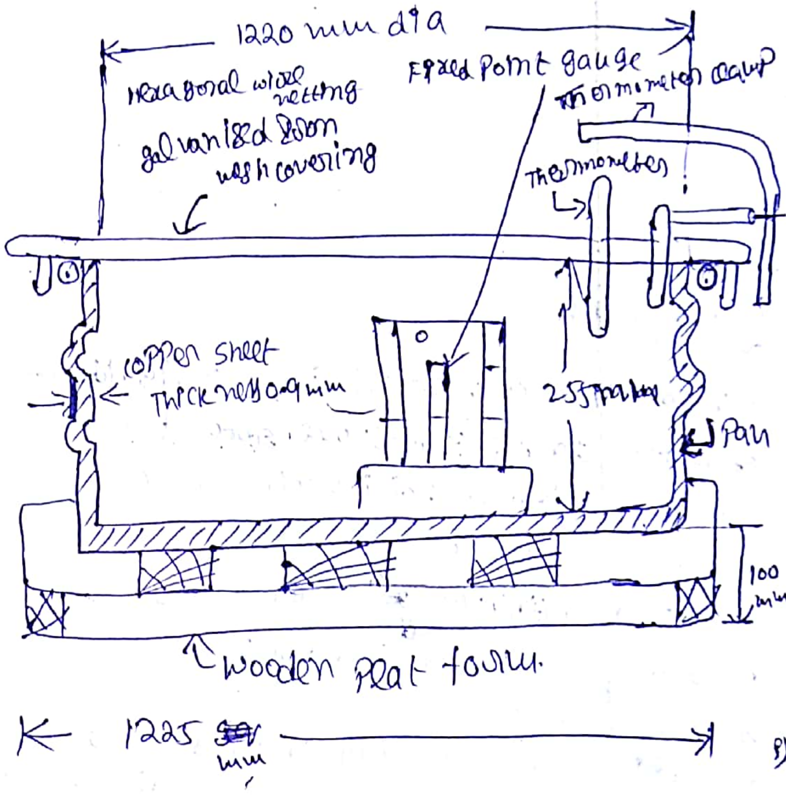
Measurement of evaporation

The following methods while useing the measurement of evaporation.

(1) Measurement using evaporation pans
(2) use of emperical equations
(3) water budget method
(4) Energy budget method.

(1) Measurement using evaporation pans

This is the most reliable method for the estimation of evaporation from large water bodies is that by measurement from evaporation pans.



* A pan of 1220 mm dia and 255 mm deep and Thickness of 0.9 mm with copper sheet and this equipment covered with hexagonal wire netting of galvanised Iron mesh covering

* ~~This water because of~~ to use of protecting birds.

* maintain the uniform temperature during day and night

* The pan is placed over a square wooden platform of 1225 mm width and 100 mm depth (or) height so that circulation of air is possible all around the pan.
* water level in the pan is recorded by a point gauge.
* measurement is taken at least once a day by adding water to the pan is calculated cylindrical glass jar to bring the water level in previous position.
* This gives directly how much of depth of water will be evaporated.
* The evaporation of pan, evaporation of lake and evaporation of reservoir will be difference due to the following reasons.

(i) Depth of exposure of pan above ground.
(ii) colour of the pan
(iii) Height of the rim
(iv) Heat storage and heat transfer capacity with respect to reservoir.
(v) pan diameter.
(vi) variation in vapour pressure, wind speed and water temperature.

Due to these reasons lake evaporation will be less than the pan evaporation.

The calculation of lake evaporation is

lake evaporation = pan coefficient x pan evaporation

* The pan coefficient for the Indian standard evaporimeter is around 0.8.

The values of Va (or) $V_{0.6}$ is computed the following equation

$$V_z = C.Z^{1/7}$$

where V_z = velocity at any height Z

$$\frac{V_{Z_1}}{V_{Z_2}} = \left[\frac{Z_1}{Z_2}\right]^{0.143}$$

(2) use of empirical equation:-

There are a large number of empirical equation for estimating the evaporation loss

we consider the following two popular formulas

(1) Meyer's formula (2) Rohwer's formula

(i) Meyer's formula:-

$$E = K_m (e_s - e_a)\left[1 + \frac{V_9}{16}\right]$$

where

E = evaporation

e_s = saturation vapour pressure at the water surface temperature

e_a = Actual vapour pressure

V_9 = monthly mean wind velocity in km/h at a height of 9 m above the ground.

K_m = coefficient accounting for various other factors

= 0.36 for large deep waters

= 0.50 for small shallow waters

(ii) Rohwer's formula

$$E = 0.771 (1.465 - 0.00073 \, P_a)(0.44 + 0.0733 \, V_{0.6})(e_s - e_a)$$

$V_{0.6}$ = mean wind velocity in km/h at 0.6 m above ground level.

E, e_s and e_a have the same meaning as in Meyer's formula.

P_a = mean atmospheric pressure (i.e) barometric reading in mm of mercury

(3) water budget (or) water balance method:-

This method balances all the incoming, outgoing and stored water in a lake (or) reservoir over a period of time, using the following equation

Σ inflow $-$ Σ outflow = change in storage + evaporation loss

$$\Sigma I - \Sigma O = \Delta S + E$$

$$E = \Sigma I - \Sigma O \pm \Delta S$$

The above equation can be generalised (calculated) as under, taking all the factors of inflow and outflow

$$E = (P + I_{sf} + I_{gf}) - (O_{sf} + O_{gf} + T) \pm \Delta S$$

where P = precipitation

I_{sf} = surface water inflow

I_{gf} = ground water inflow

O_{sf} = surface water outflow

O_{gf} = ground water outflow

T = Transpiration loss, which may be neglected.

ΔS = change in storage

The above equation does not give accurate result because it is very difficult to measure I_{gf} and O_{gf} for a lake/reservoir.

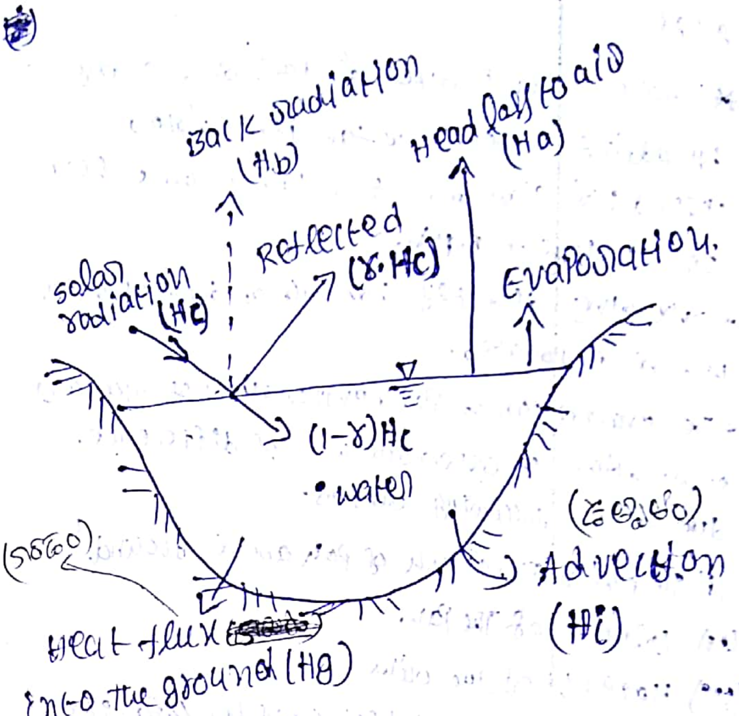
(page 334)

(4) Energy budget (or) energy balance method:- page

This method is based on the principle of conservation of heat energy by (utilization) evaporation

Thus, the energy available for evaporation is determined by considering the incoming energy, out-going energy and energy stored in the water body over a known time interval.

Let us consider a water body, as shown in fig. The energy balance at the evaporating surface in period of one day (say), is then given as



(i) Net heat energy received (or) Net incoming energy

$$H_n = H_c(1-\gamma) - H_b$$

$[\because H_c - (\gamma H_c) = H_c(1-\gamma)]$

where $H_c(1-\gamma)$ = The incoming solar radiation into a surface of reflection coefficient "γ" as shown in fig

The value of 'γ' for water surface approximately 0.05; and for newly laid snow = 0.90

H_b = back radiation (long wave) from water body

(ii) out-going energy = $H_a + H_g + H_i$

where H_a = heat lost to air.

H_g = heat lost to ground

H_i = net heat conducted out of the system by water flow (advected energy)

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(iii) Heat stored in the water body (H_s)

(iv) Heat used in evaporation

$(H_e) = \rho_w \cdot L_a \cdot E$

where

ρ_w = Density of water

L_a = Latent heat (quality of heat it is not visibul) of vaporisation of water.

E = Evaporation in mm

Using energy conservation law, we have.

Total incoming energy = out going energy + energy stored + energy used in evaporation

$H_n = (H_a + H_g + H_i) + (H_s) + (H_e) \rightarrow ①$

(or)

All the energy terms in the above eq'n are in calories/sq.mm/day.

More over, all the terms except Ha in above eq'n can be measured or evaluated indirectly.

Ha can be estimated by using Bowen's ratio (β), given by the eq'n.

β = Heat transferred water surface to the atmosphere (Ha) / Energy used in evaporation (He)

$= 6.1 \times 10^{-4} P_a \left[\frac{T_w - T_a}{e_s - e_a}\right] \rightarrow ②$

where P_a = Atmospheric pressure in mm of Hg

T_w = water temperature in °C

T_a = Air temperature in °C

e_s = saturation vapour pressure at T_w°C in mm of Hg.

e_a = air vapour pressure in mm of Hg.

Eq'n ① and ② can further solved as ③

$H_n - H_g - H_i - H_s = H_a + H_e \rightarrow ③$

$\frac{H_a}{H_e} = \beta$ we know that

Adding 1 both sides

$1 + \beta = 1 + \frac{H_a}{H_e}$

$1 + \beta = \frac{H_a + H_e}{H_e}$

$H_a + H_e = (1+\beta) H_e$

$= (1+\beta) \rho_w L_a E$

substituting this value in eq'n ③ we get.

$H_n - H_g - H_i - H_s = (1+\beta) \rho_w L_a E$

$$E = \frac{H_n - H_g - H_i - H_s}{\rho_w L_a (1+\beta)}$$

E can be measure calculating all the above H terms and calculating β in eq'n ②. For short periods of less than a week Hi and Hs can be neglected as negligibly small. The above eq'n can be written as

$$E = \frac{H_n - H_g}{\rho_w \cdot L_a (1+\beta)}$$ (for small periods)

Estimation of evaporation from a lake by the above method gives satisfactory result, with errors of the order of 5%.

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There are other methods, like mass-transfer method etc., to determine evaporation losses; but the most important widely used first method pan measurement method.

Evaporation Reduction:-

The different methods for reducing the evaporation from water surface are
(1) Reduction in surface area
(2) mechanical covers
(3) suppression (reducing) of evaporation by surface films

(1) Reduction in surface area:-

The evaporation is reduces with the reduction (dicreasing) in surface area. Evaporation is a exposed water spread area. Evaporation is directly proportional to the exposed water spread area.

The different techniques for reducing the evaporation are as follows.

(i) By selecting a conventional reservoir site.
(ii) By constructing reservoirs on minimum area which are maximum storage.
(iii) The water is stored below the ground evaporation can be reduced.
(iv) stream channels (ధారలు) are straight end the evaporation is less.
(v) By storing water in one large reservoir rather than (బదులుగా) storing it in a number of small reservoirs, the evaporation can be reduced.

(2) Mechanical covers:-

(i) The mechanical covers is highly recommended in the case of small reservoirs.
(ii) The mechanical covers while using reducing of evaporation.
(iii) various types of mechanical covers are roofs, floating rafts, wind breaks, floating light weight concrete block etc.
(iv) The loss of water due to transpiration can be reduced by the removal of aquatic plants near the water surfaces.

(3) Suppression (reducing) of evaporation by surface films

The molecules attach the water at one end and other end will not attached.

* These chemicals acts as evaporation suppressor (reduce evaporation)
* It is forming a layer on water surface

This monolayer thickness less than 1 micro cm is formed on water surface which suppresses (reduces) the evaporation.

* This layer is invisible (కనిపించదు)
* The mono layer formed, penetrate due to rain fall but it's formulated again after it's breakdown.

Therefore it is a flexible and moves with the water surface.

The factors effecting the mono layer failure layers:
(a) Action of wind
(b) oxidation
(c) Application methods (Hill area, oceans)

The mono layer reduces the evaporation but do not reduce the amount of solar energy pg No 332 (SK. Garg)

(1) A reservoir with a surface area of 300 hectares has the following average meteorological values during a given week

water temperature = 30°c

Relative humidity = 50 %

wind velocity at 1m above ground = 12 km/h.

Mean barometer reading = 750 mm of Hg.

Estimate the average daily evaporation from the lake reservoir and the volume of water evaporated from the lake during this week make use Mayer's formula as well as Rohwer's formula. Take saturation of vapour pressure at 30°c as 31.82 mm of Hg ?.

Sol :-

[∵ barometer is a instrument measuring of atmospheric pressure

Mayer's formula :-

$$E = K_m \left[e_s - e_a \right] \left[1 + \frac{V_9}{16} \right]$$

1 mm of Hg = a unit of pressure = 0.001316 atmosphere

Pressure units force/unit area

Given data

e_s = saturation of vapour pressure @ 30°c

= 31.82 mm of Hg.

K_m = 0.36 for large deep water → [∵ From standard table. 7.23 SK. Garg]

e_a = ?

$\frac{e_a}{e_s}$ = 50 % (relative humidity) (R_H) [∵ $\frac{e_a}{e_s} = R_H$]

e_a = 50 % e_s

= 0.5 × 31.82.

= 15.91 mm of Hg

$V_9 = ?$

$V_1 = 12\ km/h$

$$\frac{V_9}{V_1} = \left[\frac{9}{1}\right]^{1/7}$$ → [∵ wind velocity at 1m above ground] Given in Problem

$$V_9 = V_1\ [9]^{1/7}$$

$$\therefore V_9 = 12 \times [9]^{0.143}$$

$$= 16.43\ km/h$$

[∵ The values of V_9 (or) $V_{0.6}$ is computed The following eq'n

$$V_Z = C \cdot Z^{1/7}$$

$$\therefore \frac{V_{Z_1}}{V_{Z_2}} = \left[\frac{Z_1}{Z_2}\right]^{1/7}$$

where V_Z = velocity at any height Z]

substituting values we get

~~E = 0.36~~ [3

$$E = K_m\ [e_s - e_a]\ \left[1 + \frac{V_9}{16}\right]$$

$$= 0.36\ [31.82 - 15.91]\ \left[1 + \frac{16.43}{16}\right]$$

$$= 11.61\ mm/day$$

Total evaporation volume in 7days (1 week) from 300 hectares of surface area.

$$= \frac{11.61}{1000} \times 7 \times (300 \times 10^4)\ m^3$$

$$= 2,43,810\ m^3$$

(b) Rohwer's formula:-

$$E = 0.771\ (1.465 - 0.000732\ P_a)\ (0.44 + 0.0733\ V_{0.6})\ (e_s - e_a)$$

where

$e_s = 31.82$ mm of Hg

$e_a = 15.91$ mm of Hg

$P_a = 750$ mm of Hg

$$\frac{V_{0.6}}{V_1} = \left[\frac{0.6}{1}\right]^{1/7} \rightarrow [\because \text{wind velocity at } 1m$$

$$V_{0.6} = V_1 [0.6]^{1/7}$$

$$= 12 [0.6]^{0.143}$$

$$= 11.15 \text{ km/h.}$$

$$E = 0.771 (1.465 - 0.000732 \, Pa) (0.44 + 0.0733 \, V_{0.6}) (e_s - e_a)$$

$$= 0.771 (1.465 - 0.000732 \times 750) (0.44 + 0.0733 \times 11.15) (31.82 - 15.91)$$

$$= 14.13 \text{ mm/day}$$

$$\text{Total evaporation} = \frac{14.13}{1000} \times 7 \times (300 \times 10^4 \, m^2)$$

$$= \frac{14.13}{100} \frac{m}{day} \times 7 \, day \, (300 \times 10^4 \, m^2)$$

$$= 2,96,730 \, m^3$$

Conclusion:-

The evaporation loss as computed by Rohwer's formula is about 20 % higher than that calculated by Meyer's formula Hence, such formulas give only rough approximate values.

However Rohwer's formula is generally preferred to all others.

UNIT-II Problems

(1) A reservoir with average surface spread of 4.8 km^2 in the first week of November has water surface temperature of 30°c and relative humidity of 40%. wind velocity measured at 3.0m above the ground is 18 km/h. The mean barometer reading is 760mm of Hg. Calculate the average evaporation loss from the reservoir in mm/day and the total depth and volume of evaporation loss in the first week of November. Use both meyer's equation as well as Rohwer's equation. take saturation vapour pressure at 30°c as 31.81 mm of Hg.

Sol (a) using meyer's formula.

$$E = K_m (e_s - e_a)\left[1 + \frac{V_9}{16}\right]$$

Given that

$e_s = 31.81$ mm Hg

Relative humidity $R_H = 40\%$
$= 0.4$

We know that
$\left[\because \frac{e_a}{e_s} = R_H\right]$
$e_a = e_s R_H$

$e_a = e_s \times R_H$
$= 31.81 \times 0.4$
$= 12.724$ mm Hg.

$V_9 = V_2 \left[\frac{9}{3}\right]^{1/7}$
$= 18 \left[\frac{9}{3}\right]^{1/7}$ [∵ velocity is measured at 3.0m]
$= 18 \times 1.1699$
$= 21.06$ km/h.

$K_m = 0.36$ for large deep waters ~~bod~~

$E = 0.36 (0.4 - 12.724)\left[1 + \frac{21.06}{16}\right]$
$= 15.91$ mm/day.

Total ~~mean~~ depth of evaporation in one week

$= 7 \times 15.91$

$= 111.4$ mm.

Total volume of water evaporated $= (111.4 \times 4.8 \times 10^6) 10^{-3}$

$= 0.5347 \times 10^6$ m^3

$= 53.47$ hectare-m.

(b) using Rohwer's formula:-

$E = 0.771 (1.465 - 0.000732 P_a)(0.44 + 0.0733 V_{0.6})(e_s - e_a)$

Given that

$e_s = 31.81$ mm Hg. ~~and ea=~~

$e_a = 12.724$ mm Hg.

$P_a = 760$ mm Hg.

$V_{0.6} = \left[\frac{0.6}{2}\right]^{1/7} \times 18$

$= 15.16$ km/h.

$E = 0.771 (1.465 - 0.000732 \times 760)(0.44 + 0.0733 \times 15.16)$
$\times (31.81 - 12.724)$

$= 20.74$ mm/day

$\therefore$ Total evaporation for one week $= 20.74 \times 7$

$= 145.2$ mm.

$\therefore$ Total volume of water evaporated $= (145.2 \times 4.8 \times 10^6) \times 10^{-3}$

$= 0.697 \times 10^6$ m^3

$= 69.7$ hectare-m.

Thus, we find that Rohwer's formula gives about more higher result the Mayer's formula.

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Evapo-transpiration

* Evapo-transpiration is a combined term of evaporation and transpiration.
* It is defined as the total loss of water through evaporation and transpiration from the plants.
* Transpiration is the process which water is lost through the living plants during the respiration process and back to the atmosphere.
* Evapotranspiration is more during summer season as greater amount of solar energy is received on the earth surface.
* The evapotranspiration rate falls down with increase in relative humidity which is most observed in rainy days.

Factors affecting evapotranspiration:-

The different factors which affects the evapotranspiration are as follows.

(1) climatic factors
(2) crop characteristics
(3) meteorological factor
(4) soil characteristics
(5) surface of leaves.
(6) Temperature
(7) Atmospheric conditions
(8) Parameters of rain fall
(9) surface area.

(1) climatic factors:-

* The evapotranspiration is more during the month of summer. more amount of solar energy received in this period
* The solar radiation supplies energy for evapotranspiration process. There fore increases length of the day increases the rate of evaporation

(2) crop characteristics:-

The evapotranspiration is high at seeding stage. but decrease after the opening of seeds
Hence higher the crop density, higher is the evaporation.

(3) meteorological factors:-

The free surface ~~evaporation~~ evapotranspiration is influenced by meteorological parameters (ప్రభావితం) The parameters are The increase in temperature, sunlight and attractive forces, increases the evapotranspiration. but decreases the humidity.

(4) soil characteristics:-

Hydraulic Conductivity and water holding capacity of soil effect evapotranspiration. The dry density of soil was decreases, evapotranspiration also decreases.

(5) surface of leaves:-

Dark colour leaves (or) more greenish coloured leaves will extract the solar radiation, so evapotranspiration increase ~~light~~ light coloured surface of leaves reflect the more radiation. so evapotranspiration decreases.

(6) Temperature:-

(ఎ[illegible])

The rate of evaporation more influenced by the temperature than any other factor.

(7) Atmospheric conditions:-

The evapotranspiration varies inversely with atmospheric humidity.
∴ Atmospheric pressure increases evapotranspiration will be decreases.
It means humidity will be more evapotranspiration will be decreases.

(8) Parameters of rain fall :-

The rate of evapotranspiration increases with increase in frequency and amount of rain fall

(9) surface area :-

In Irrigated area which are surrounded by large arid (very dry) (or) semi-arid (some dry) condition. The rate of evapo transpiration is more.

Measurement of evapo-transpiration.

Measurement of evapotranspiration can be measured in two ways

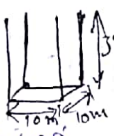
(1) Direct measurement
(2) Measurement by use of eqations

(1) Direct measurement :-

The direct measurement of evapotranspiration can be measured by five principal methods

(a) Tank lysimeter methods
(b) Field experimental plots
(c) soil moisture studies
(d) Integration methods
(e) Inflow and out flow studies for large area

(a) tank lysimeter methods :-



* Tank container with ground level having an area of $10m^2$ and 3m deep
* large size of tank is useful to the greatest root development.
* A tank is filled with soil of the field and crop is grown in it
* To measure the required quantity of water and to maintain the constant moisture conditions of the crop with the tank proper growth

(b) field experimental plots :-

* In this method Irrigation water is appled to the selected fields in such a way that there is neither run off nor deep percolation.
* It is seen from observations the more amount of water will be used the yield of the will be increases rapidly but in certain point ~~a~~ and than decreases with further increases in water
* That is break down in the curve and That is consumptive use of water in the field

(c) soil moisture studies :-

The soil moisture is measured before and after the each irrigation.
* The quantity of water ~~ex~~ extracted (observed) per day from soil is computed for each period.
* A curve is drawn by ploting the rate of use of water against time ~~and this curve~~

(d) Integration method :-

The Integration method is summation of the Products

~~(i) on unit~~
(i) ~~constant~~ unit consumptive use for each crop times it's area.
(ii) ~~unit~~ consumptive use of native vegetation times it's area.
(iii) ~~water surface~~ evaporation ~~time on water surface area~~
(iv) evaporation from bare land times it's area.

→ u take a some area will be irrigated. area in that area crop is grown the period of 6 months that crop after that land will not use so soil will effect evaporation so in that time crop the another seed ~~soil~~ means soil will be no loss of moisture

(e) Inflow – out flow studies for large Areas

In this method, annual consumptive use is found for large areas.

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

where
U = valley consumptive use.
I = Total inflow during 12 months (1 year)
P = yearly precipitation
Gs = Ground storage at the beginning of the year
Ge = Ground storage at the end of the year
R = yearly out flow.

(2) Measurement by use of equations:-

(a) Penmans equation.
(b) Blaney - criddle formula.
(c) Hargreaves class A pan evaporation method.

(a) The Penmans equations:-

The Penman's equation is used to calculate the potential evapotranspiration by combining the energy balance and mass - transfer methods.

* According to Penman the potential evapotranspiration PET is given by

$$PET = \frac{AH + Ea\gamma}{A+\gamma}$$

where A = slope.

γ = psychrometric constant (0.49 mm of mercury/°C)

H = Net radiation
$= Ha(1-r)\left[a + \frac{bn}{N}\right] - \sigma (T)^4 (0.56 - 0.092 \sqrt{e}) \left[0.10 + 0.9 \frac{n}{N}\right]$

Ea = mass transfer.
$= 0.35\left[1 + \frac{U_2}{160}\right](e_s - e_a)$

(b) Blaney - criddle formula:-

Blaney - criddle has given the accurate empirical formula which daily potential evapotranspiration [PET] can measure.

$$PET = 2.54\,KF$$

where K = Empirical coefficient

$$F = \frac{PT'}{100}$$

P = mean daily percentage
T' = mean daily temperature (t)

$$T' = \frac{T_{maximum} + T_{minimum}}{2}$$

(c) Hargreaves class A pan evaporation method.

This method is very much used in India, apart from it's use in Israel, Philippines and U.S.A, According to this method the consumptive use (Cu) (or) Evapo-transpiration (Et) is given by

$$E_t \text{ (or) } C_u = K\,E_p$$

where K = consumptive use coefficient on different crop

Ep = class A pan evaporation

$E = 0.456\, R_A \cdot C_t \cdot C_w \cdot C_h \cdot C_s \cdot C_e$ (cm)

where
R_A = Extra-terrestrial radiation (cm
Ct = coefficient of temperature.
Cw = coefficient of wind velocity
Cs = " " percent possible sunshine
Ch = " " relative humidity
Ce = " " elevation

$C_t = 0.393 + 0.02796\,T_c + 0.0001189\,T_c^2$

$C_w = 0.708 + 0.0034\,W - 0.0000038\,W^2$

$C_s = 0.542 + 0.008\,S - 0.78\times10^{-4} S^2 + 0.62\times10^{-6} S^3$

$h = 1.250 + 0.0087H + 0.75 \times 10^{4} H^2 - 0.83 \times 10^{-8} H^4$

$Ce = 0.97 + 0.00984E$

(E being elevation in 100 metres)

Infiltration:-

Infiltration may be defined as the down ward moment of water from soil surface into the soil mass through the pores of the soil.

In simple terms infiltration is the entry (or) passage of water into the soil through the soil surface. once water enter into the soil, the process of transmission of water in the soil known as percalation.

Infiltration and percalation are directly inter-related when percalation stops, infiltration stops.

(write here) this topic

Factors affecting infiltration:-

(1) condition of entry surface :- (vegetation covers, versus bare land)

(2) Permeability)

(3) Antecedent moisture conditions in soil.

(4) Temperature.

(5) Intensity and duration of rainfall.

(6) movement of man and animals

(7) change due to human activity

(8) quality of water

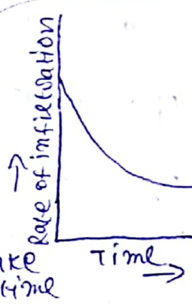
(9) presence of ground water table.

(10) size and characteristics of soil particles:-

(11) catchment parameters.

Infiltration capacity curve:-

Any soil to absorb the water from rain fall once the soil absorb the minimum amount of water after that soil absorb the maximum water slowly take more time



(1) Condition of entry surface:-

If the area covered with grass, vegetation and bushy plants, infiltration capacity will be more

The rain drops falling on the surface will cause in-washing of fines particles of the soil and will clog (మూసివేయు) the surface Thus resulting in the retardation (reduction) of infiltration.

The vegitation covers removes soil moisture through the transpiration. The rate will be more. and the infiltration rate will be more

(2) permeability:-

permeability means permit the water inside the soil mass.

ex:- Black cotton soils has less permit and red soils some more permit. silty soils are more permit.

The permit (or) percolation of water inside the soil depends upon the several factors such as type of particle size, presence of organic matter (dead plants) present in the soil.

(3) Antecedent moisture condition in soil.

The moisture condition present in the soil (it means) it the soil is wet soil infiltration rate will be less

The soil is dry soil infiltration rate will be high.

why because the heat will be more in soil it means temperature will be more the soil will be expention temperature will be less the soil will be contraction

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Signature of Invigilator

(4) Temperature:-

The viscosity (చిక్కదనం) of water changes with temperature.
In summer therefore infiltration will be higher due to the less viscous water and also particle to particle size of earth particle is elongated so infiltrated will be more.
In winter therefore infiltration will be lower due to the viscous is less and also particle to particle size of earth particle is compression stage so there is no gaps of earth particles so infiltration rate will be lower.

(5) Intensity and duration of rainfall:-

When the intensity of rainfall will be more will be falling in less area. This water will be compacted to the earth surface and in-wash of fine particles, so gaps of the soil particles will be filled with soil resulting in faster decreases in the rate of infiltration.
So less intensity of rain fall will be given more infiltration rate, higher intensity of rain fall will be given less infiltration

(6)

(6) Moment of man and animals:-

When the heavy moment of man (or) animals on soil surface, the soil will be compacted resulting gaps of soil particle to particle will be decreases so reduce the infiltration rate

(7) Change due to human activities:-

Cultivation of barren land (బంజరు), by growing crops and grass cover, resulting increased rate of infiltration.
On the other hand, construction of roads, houses, factories, play grounds, over-grazing (eating) of pastures (animals feed) result in reduction in infiltration capacity.

(8) Quality of water:-

Silts and other impurities are present in incoming water result reduction of infiltration rate, due to lock (or) closing of soil particle gaps.
The salts are present in water. viscosity (చిక్కదనం) will be less and this water react with soil to form complexes. That reduce the infiltration rate

(9) Presence of ground water table:-

-> The ground water table will be shallow reach in the top soil surface in this case infiltration rate will be less
-> The ground water table will be in deep depth of ground in this case infiltration rate will be more

(10) Size and characteristics of soil particles:-

The size of soil particles is bigger size result gaps of particle to particle will be more result more infiltration
The size will be less of particle to particle result gaps will be less result less infiltration
Infiltration rate is directly proportional to the grain size/diameter of granular soils.

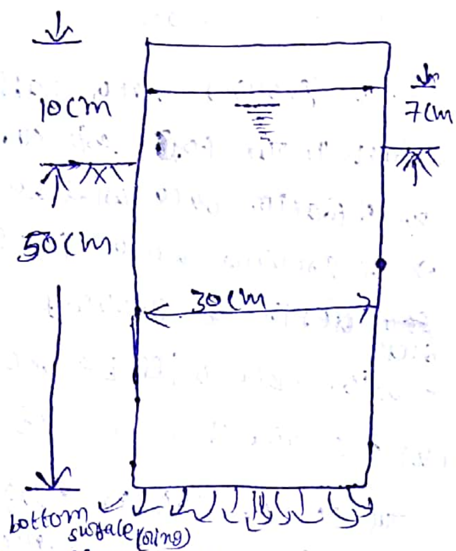
In other words the soil has swelling minerals like illite and montmorillonite.
The infiltration rate will be reduce

(M) Catchment parameters:-
Catchment area will be increase.
The water runoff will be increase. water will be moving one place to another place and stored in one place so the water will be runoff. so infiltration rate will be less.
catchment area will be decrease the running of water will be decrease so infiltration rate will be increase.

Filed measurement of infiltration rate:-

Infiltration is to be measured in the field in two ways.
(a) single tube infiltrometer.
(b) Double tube (or double ring) infiltrometer

(a) single tube infiltrometer:-



→ It consist of hallow meter cylinder of 30cm diameter and 60 cm length and both ends open.

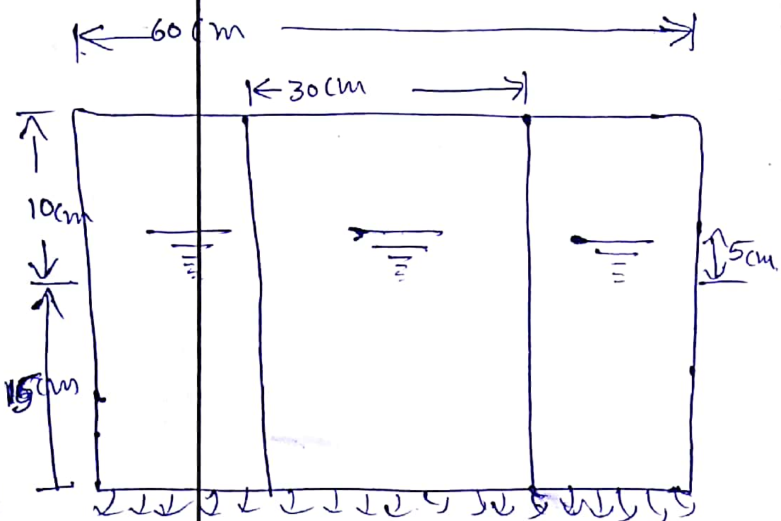
→ The cylinder is driven into the ground such that 10cm of it projects above the ground.
→ The cylinder is filled with water upto a head of 7cm (It means 57 cm filled with water)
→ The infiltrometer is maintained above the ground level.
→ Due to the infiltration of water, slowly the water level in the cylinder will be decreasy
→ The decreasing of water will be added to the cylinder will be maintained the constant level the added water will be measuring by Jar or burette
→ The observations are taken about 3 to 6 hours depending upon the type of soil.
→ The major draw back of single tube infiltrometer is that the infiltrated water percolates laterally at the bottom of the ring as shown in fig.
→ Hence, the bottom of the soil surface is saturated having some moisture content to absorbing the water content.
This moisture content will be absorb the soil in the tube
The both sides of the soil is dried soil so. the tube below soil is more.
so infiltration rate will be more.
→ Hence it does not truly represents the area how much area is saturated in the bottom surface.

(b) Double tube infiltrometer:-

* The previous defect of single tube infiltrometer while rectifing of these problem ~~two tubes~~ double tube infiltrometer will be introduced

* In double tube infiltrometer consist of two concentric hollow rings (or cylinders) driven into the soil uniformly without any tilt and disturbing the soil to the least depth of 15 cm

* The diameter of the ring may vary from 25 to 60 cm



* The water is applied in both inner and outer rings to maintain a constant depth of about 5 cm

* The water is slowly will be infiltrated absorb the ground, the 1 cm of water will be decreasing onto the tube after that the 1 cm of water will be added the added water will be measure by using of measuring jar (or) burret

* The water depth in the inner and outer rings should be kept the same during the observation period.

* The purpose of outer ring. into prevent the lateral percolation of water & soil is applied to the prevent on the soil

* The soil will be saturated and will not absorb the moisture content on middle tube of soil moisture

* The observations are continued till constant infiltration rate is observed (It means in ~~first~~ 1 hour 5 cm of water infiltrated and next 1 hour also 5 cm of water is infiltrated that is constant infiltration)

UNIT-II : Problems

P-332 (SK. Garg)

(1) A reservoir with a surface area of 300 hectares has the following avg. meteorological values during a given week.

- water temperature = 30°C
- relative humidity = 50%
- wind velocity at 1m above ground = 12 km/h
- Mean barometer reading = 750 mm of Hg

Estimate the avg daily evaporation from the lake reservoir and the volume of water evaporated from the lake during this week. make use of meyer's formula as well as Rohwer's formula to compare the results.

sol:- Meyer's formula.

[∵ barometer is a instrument measuring of atmospheric pressure]

$$E = K_m [e_s - e_a] \left[1 + \frac{V_9}{16}\right]$$

Given. e_s = saturation vapour pressure @ 30°C

= 31.82 mm of Hg → (from std table 7.23) SK. Garg

$K_m = 0.36$ for large deep water →

$e_a = ?$

$\frac{e_a}{e_s} = 50\%$ (relative humidity)

~~$e_a = 0.5$~~ $e_a = 50\% \cdot e_s$

$= 0.5 \times 31.82$

$= 15.91$ mm of Hg

$V_9 = ?$

$V_1 = 12$ km/h

$\frac{V_9}{V_1} = \left[\frac{9}{1}\right]^{1/7}$ [∵ wind velocity = 1]

$V_9 = V_1 \cdot [9]^{1/7}$

$\therefore V_9 = [9]^{0.143} \times 12 \text{ km/h}$

$= 16.43 \text{ km/h}$

substituting values, we get

$E = 0.36[31.82 - 15.91]\left[1 + \frac{16.43}{16}\right]$

$= 11.61 \text{ mm/day}$

Total evaporation value in 7 days (1 week) from 300 hectares of surface area

$= \frac{11.61}{1000} \times 7 \times (300 \times 10^4) \text{ m}^3$

$= 2,43,810 \text{ m}^3$

(b) Rohwer's formula

$E = 0.771(1.465 - 0.000732\, P_a)(0.44 + 0.0733\, V_{0.6})(e_s - e_a)$

where

$e_s = 31.82$ mm of Hg

$e_a = 15.91$ mm of Hg

$P_a = 750$ mm of Hg

$\frac{V_{0.6}}{V_1} = \left[\frac{0.6}{1}\right]^{1/7}$ → [∵ wind velocity = 1]

$V_{0.6} = [0.6]^{0.143} \times 12 \text{ km/h}$

$= 11.15 \text{ km/h}$

$E = 0.771(1.465 - 0.000732 \times 750)(0.44 + 0.0733\, V_{0.6})(31.82 - 15.91)$

$= 14.13 \text{ mm/day}$

Total evaporation $= \frac{14.13}{1000} \times 7 \times (300 \times 10^4\ m^2)$

$= \frac{14.13}{100}\ \frac{m}{day} \times 7\ days\ (300 \times 10^4\ m^2)$

$= 2,96,730\ m^3$

Conclusion:-

The evaporation loss as computed by Rohwer's formula is about 20% higher than that calculated by Meyer's formula. Hence, such formulas give only rough approximate values. However Rohwer's formula is generally preferred to all others.

Pg No 384 (SK2018)

2) A storm with a 15.0 cm precipitation produced a direct runoff of 8.7 cm the time distribution of the storm is as follows

Time from start in hr	1	2	3	4	5	6	7	8
Incremental rainfall in each hour in cm	0.6	1.35	2.25	3.45	2.7	2.4	1.5	0.75

Estimate the ϕ index of the storm.

Sol:-