Abstractions from precipitation

1-***Evaporation***

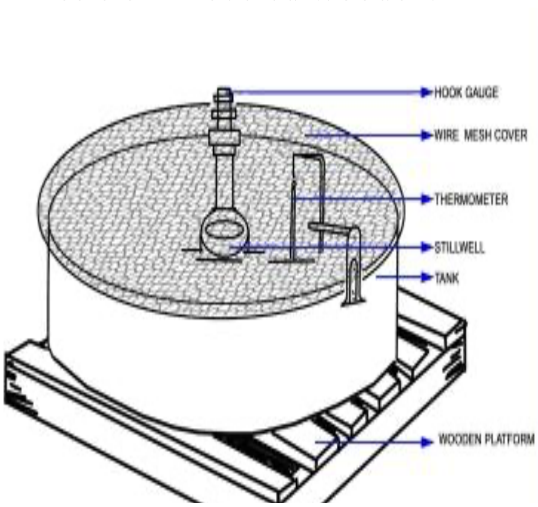
Evaporation is when a liquid changes to a gaseous state at the free surface, below the boiling point through the surface of heat energy. Evaporation is understood to be a cooling process because the heat is removed from the surface where evaporation has taken place. Energy must be available for the evaporation process, chiefly solar vapor pressure and wind.

1.1-Factors affecting evaporation:
Temperature, humidity, radiation, and wind speed.

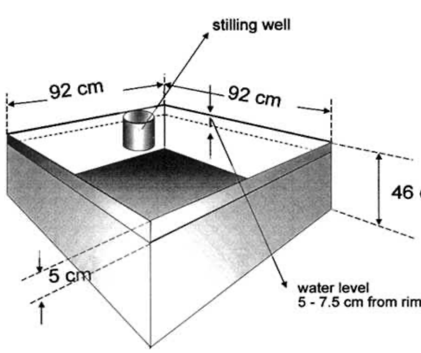
1.2- Evaporation measurement
There are three general methods commonly in use for measuring evaporation which are mainly indirect:

A-Measurement from evaporation pan. (floating, sunken and surface type)
B-Water budget.
C-.Energy budget method.
D-Correlation with climatic data.

A- Evaporation pans: the class A pan is the most widely used(fig.)it is a cylinder made of galvanized iron with 122 cm dia. &25 cm depth, and the pan rests on a leveled wooden.



Class A pan is usually filled to a depth of 20 cm and refilled when the depth has fallen to ≤18cm. the water surface is measured daily with a hook gauge. Also, there are other types of pans like the Indian standard pan(the same as class A) and Colorado sunken pan (is square,1 m on a side and 0.5 m deep buried in the ground to within 5 cm so it looks like a lake or water surfaces.



Colorado pan

Pan evaporation is used to calculate lake evaporation. (E) by using a pan coef.(C_p)and it is necessary because evaporation from a pan exceeds that from either an open body of water.

$E=C_p\ Ep$

B-Water budget:

Another estimate depends on an accurate water budget in which evaporation is the only unknown variable $Q_{in} - Q_{out} = \Delta S$

C-Energy budget method:

This method is an application of the law of conservation of energy . the incoming and outgoing energy stored in the water body over a known time , so the energy balance to the evaporating surface in a period of one day is given by:

$H_n=H_a+He+Hg+Hs+Hi$

H_n=net heat energy received by the water surface.

H_a=sensible heat transfer from water surface to air.

He=heat energy used in evaporation.

H_g=heat flux to the ground.

H_s=heat stored in the water body.

H_i=net heat conducted out of the system by water flow.

D-Correlation to climatic data

Empirical formulas have been developed to rate either pan or actual evaporation to atmospheric measures. The form of the equations are similar and in general are related to vapor pressure and wind speed.

$E=f\ (\Delta e,U)$ (mass transfer eq.)

Where

Δe=change in vapor pressure from the water to the air.

U=wind speed.

The atypical equation developed by Hefner:

$E=0.0024(e_o-e_a)U$

E=evaporation(in/d)

e_o=saturation vapor(in)

e_a=vapor pressure(inches of Ag)

U=wind speed (miles/d)

Also the correlation was further as follows (by Kohler, et al.)

$Ep=(e_o-e_a)^n(m+Bu)$ where:
Ep=daily evaporation(in/d)
e_o=saturation vapor(in of Hg)
e_a=atm. Vapor pressure(in of Hg)
U=wind speed (mpd)-6in.above pan rim.
n, m& b constants.
The other important climate variables are mean daily air and water temperature, wind movement, and solar radiation.
To estimate lake evaporation a general formula can be used with different temperatures, mean daily airspeed, and elevation above sea level

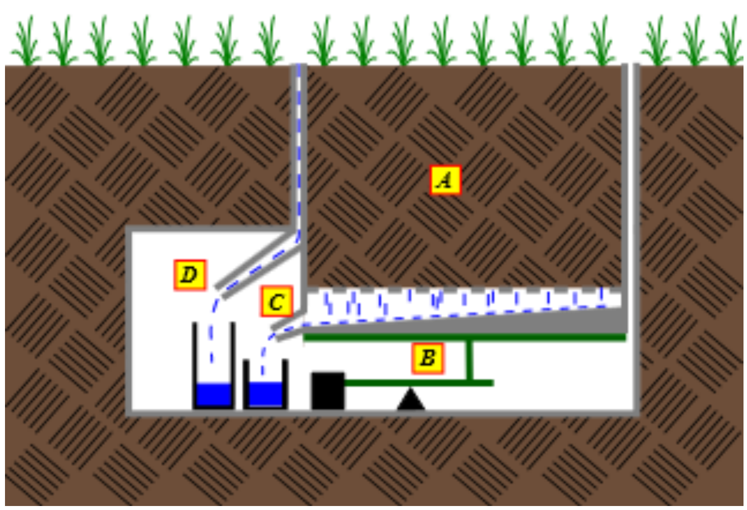
2-Evapotranspiration

Transpiration is the process by which water leaves living plants' bodies and reaches the atmosphere as water vapor. While transpiration takes place the area in which plants stand also loses moisture, so, evaporation and transpiration processes can be considered as evapotranspiration.

2.1 Measurement of Evapotranspiration**:**

A- Lysimeters

It is a special watertight tank containing a block of soil and plants. Evapotranspiration is estimated in terms of the amount of water required to maintain constant moisture condition



B- Field plots:

The calculations by the following relation

Evapotranspiration =precipitation+ + irrigation input+runoff+increase in soil storage- groundwater loss.

C-Equations:

Penman's eq.

PET= $AH_n+E_a\ \gamma/A+\gamma$

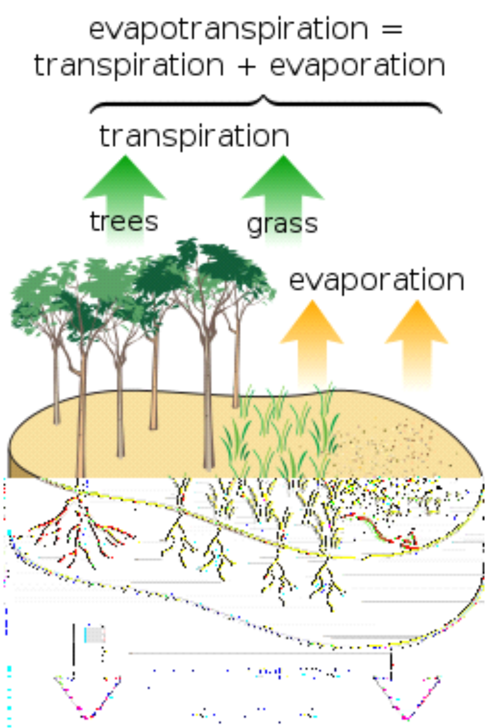
PET=daily evapotranspiration(mm)

Slope of the saturated vapor pressure.

H_n=net radiation in mm.

E_a=parameter including wind velocity

γ =constant=0.49 mm of mercury/°C



3- Infiltration (f)

When water is applied to the surface of the soil , a part of it seeps into the soil . This movement of water through the soil is known as infiltration and play a significant role in the runoff process by affecting the timing , distribution and magnitude of surface runoff. The rate of infiltration depends on rainfall intensity, soil type, soil moisture, surface condition, and vegetal cover.

3.1 Infiltration capacity I.C.

The maximum rate at which a given soil at a given time can absorb water . It is designted as f_c and its unit in cm/hr

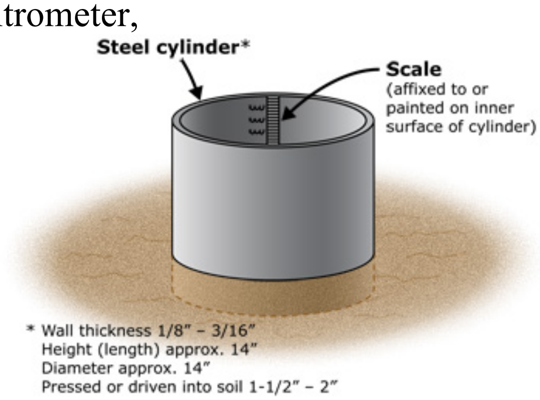
.$f = f_c$ when $i \geq f_c$

.$f = i$ when $i < f_c$

3.2 Infiltration measurement:

A-Flooding type infiltrometer.

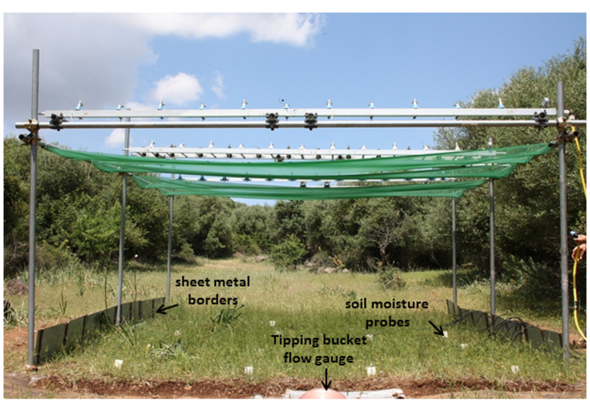
It is measured by infiltrometer a device used to measure the rate of water infiltration into soil or other porous media. Commonly used infiltrometers are single ring or double ring infiltrometer,



Single ring infiltrometer

The single ring involves driving a ring into the soil and supplying water in the ring either at constant head or falling head condition. Constant head refers to conditions where the amount of water in the ring is always held constant. Because infiltration capacity is the maximum infiltration rate, and if the infiltration rate exceeds the infiltration capacity, runoff will be the consequence, therefore maintaining constant head means the rate of water supplied corresponds to the infiltration capacity. The supplying of water is done with a Mariotte's bottle Falling head refers to conditions where water is supplied in the ring, and the water is allowed to drop with time. The operator records how much water goes into the soil for a given time period. The rate at which water goes into the soil is related to the soil's hydraulic

B- Rainfall simulator: it i a small land (2m*4m), and is provided with a series of nozzles on the longer side with an arrangement to collect and measure the surface runoff rate. The nozzles produce raindrops, so, surface runoff is measured, then the infiltration is measured.



3.3 Infiltration capacite values:

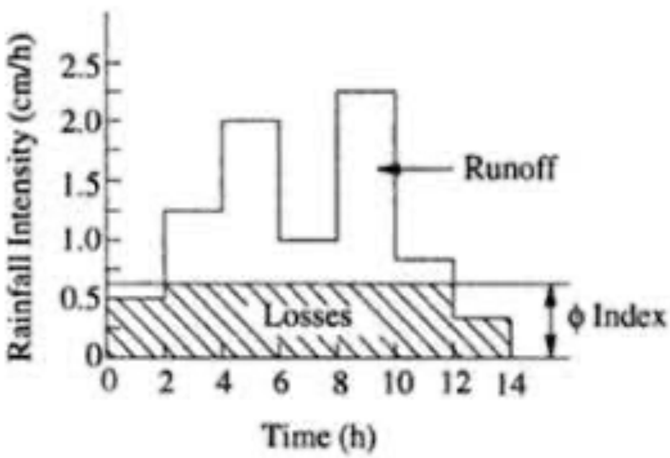
A-Green –Ampt model
Is based on Darcy's law
$F=K_s S_w(\theta_s-\theta_i)/i-K_s$
F=infiltration (L/T)
K_s=hydraulic conductivity of the soil (L/T)
S_w=capillary suction of the soil at the wetting front(L)
θ_i =initial water content.
θ_s=saturated water content.
I=intensity(L/T)

B-Horton equations
Infiltration can be written by Horton's equation ,this method gives an expression for varying infiltration :
$F(t)=fc + (f_o-fc)\, e^{-kt}$
Where f (t) =infiltration rate as a function of time cm/hr.
Fc=final or ultimate infiltration rate
f_o=initial infiltration rate.F(t)
K=constant(hr^{-1}) , depending on the soil characteristics and vegetation cover.
T=time.(duration of rainfall).

C-*Water budget*
If infiltration is the only unknown in the water budget (and the other variables can be measured, then the water budget would produce accurate results.

D-*Infiltration indices*
- ф index.
-w index.
- ф index: It is the average rainfall above which the volume of rainfall equals the volume of runoff, its derived from the rainfall hyetograph with the edge of runoff volume, the initial losses are also considered as infiltration. The -i ф index value is found by treating it as a constant infiltration capacity. If the rainfall intensity is less than ф the infiltration rate is equal to the rainfall

intensity. However, if the rainfall intensity is larger than the difference between rainfall and infiltration in an interval of time represents the runoff volume. It depends on the soil, vegetation cover, moisture, duration, intensity,



P=the whole area, I=lower part , R=upper part

W-index:In an attempt to refine ϕ- index the initial loose is separated from the total abstraction and an average value of infiltration rate is called the W index is defined as

$W= P-R-I_a / t_e$

P= rainfall(cm)

R=runoff(cm)

I_a=initial losses(cm)

T_e= duration of rainfall excess(when rainfall intensity is greater than W)

W=average rate of infiltration(cm/hr)

Φ=1 in/hr

Examples:

Ex.1

The table below shows the data on several storms observed on a river, compute the w-index for all storms and its average.

7	6	5	4	3	2	1	No.
8.1	3.91	2.87	14.2	4.55	2.98	2.82	Av.P
1.93	0.48	0.43	7.42	2.46	1.02	1.32	Av.R
36	24	18	72	24	48	12	T
0.172	0.143	0.136	0.094	0.087	0.041	0.125	P-R/t

W=P-R/t

$\sum$ W=0.798

W av. =0.798/7= 0.114 cm/hr.

.Ex.2

Drive the infiltration curve with time if F0=1.5 ,Fc=0.2? (use Horton's eq.)

$F=fc +(f_o-fc)\ e^{-kt}$

Solving for each value of t gives the results

T(hr)	1/6	1/2	1	2	6
F(in/hr)	1.43	1.29	1.12	0.85	0.36

$F= 0.2 +(1.5-0.2)\ (e^{-0.35\ t})$

Integrating over the boundary t=0, 6 hr.

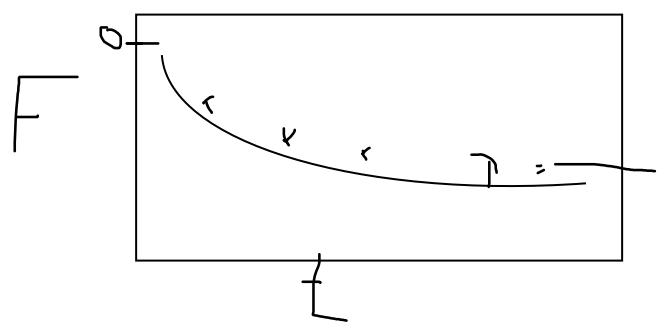
Vol=$\int$ f dt

$=\int(0.2 + 1.3\ e^{-0.35\ t})dt$

$(0.2\ t+(1.3/-0.35)e^{-0.35\ t})0,6$

$=(1.2 -(1.3/0.35)e^{-2.1})-(0-(1.3/0.35)e^{0})$

Vol=4.46 in.



H.W: given the data for rainfall intensities, 1-find Ø-index?if R= 6.6 cm.

T(HR.)	2	4	6	8	10	12	14
I(cm/hr.)	0.5	0.75	2	1	2.25	1	0.8

2-If Ø-index = 0.75 mm/hr. find R and F?