الكلية	**الهندسة**
القسم	**الهندسة المدنية \السدود والموارد المائية**
المادة باللغة الانجليزية	Hydrology
المادة باللغة العربية	**هايدرولوجي**
المرحلة الدراسية	**الرابع**
اسم التدريسي	**محمد مجيد حميد**
عنوان المحاضرة باللغة الانجليزية	Infiltration
عنوان المحاضرة باللغة العربية	**التسريب**
رقم المحاضرة	5
المصادر والمراجع	Subramanya, K. 2017. Engineering Hydrology. 4th ed. New Delhi: McGraw Hill Education**.**
	Chow, Ven Te, David R. Maidment, and Larry W. Mays. 2013. Applied Hydrology. 2nd ed. New York: McGraw Hill Education.
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Hydrology

RUNOFF

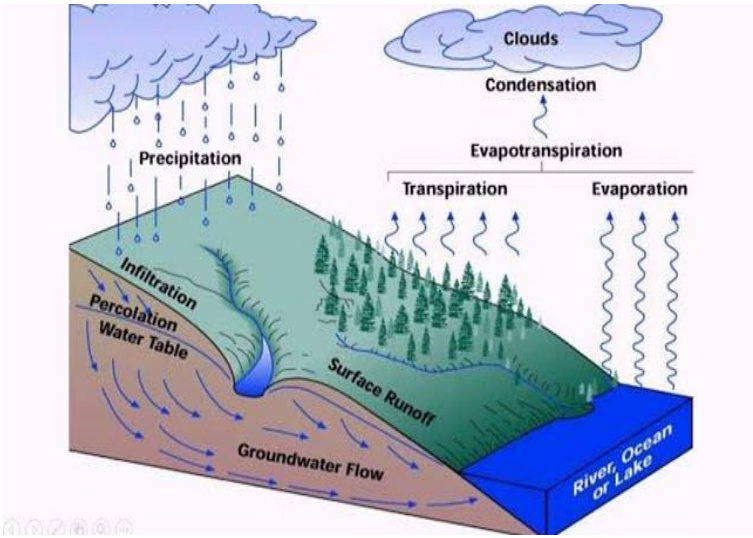
Runoff: Is that portion of ppt. that makes its way towards, lakes, streams, and oceans as surface and sub-surface flow .By using the water balance equation:

ppt. + Irr. – Evap. – Trans. =ΔS

$R = ppt. - E - \Delta S$

Ppt. : precipitation; Irr. : irrigation water Evap & Trans are evaporation and transpiration

After satisfying the requirements of evapotranspiration , interception, infiltration into the ground, and storage, the runoff flows into streams.



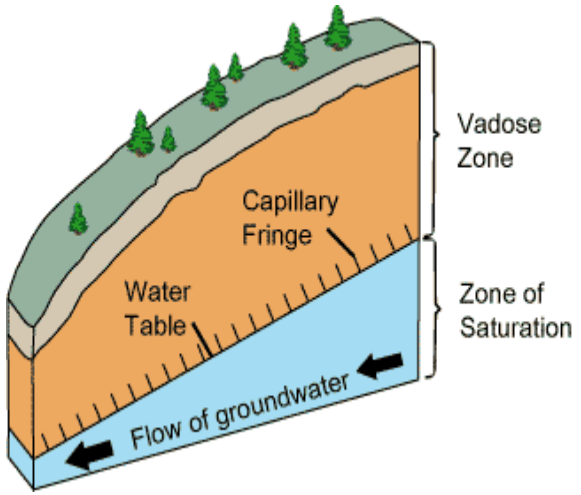
Infiltration

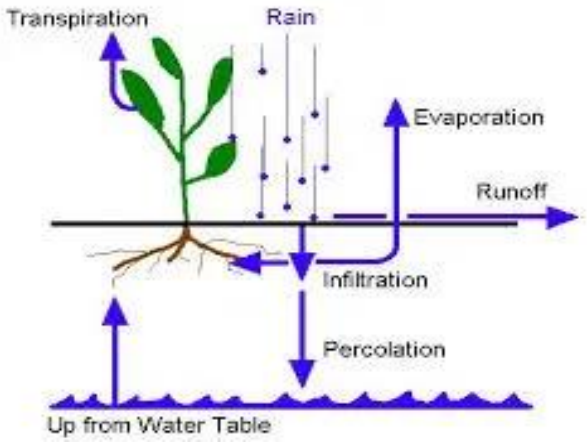
- Is the passage of water from the soil surface into the soil, and it's different from **percolation** which is the gravity flow of water within the soil.
- OR

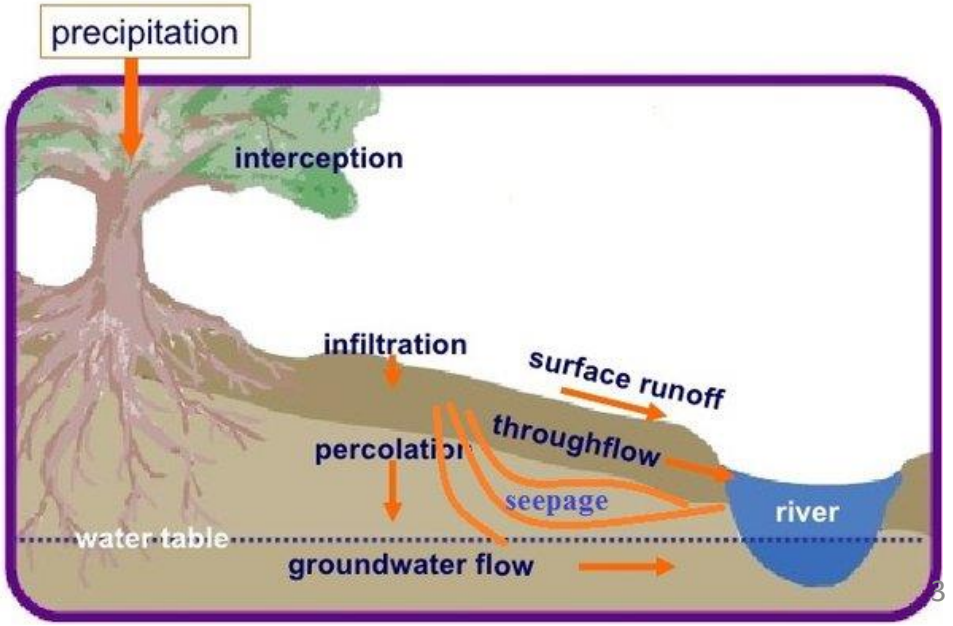
Is the process by which water enters the soil from the ground surface.

Infiltration provides the soil moisture deficiency the excess water moves downwards by the force of gravity. This is called (**percolation**).

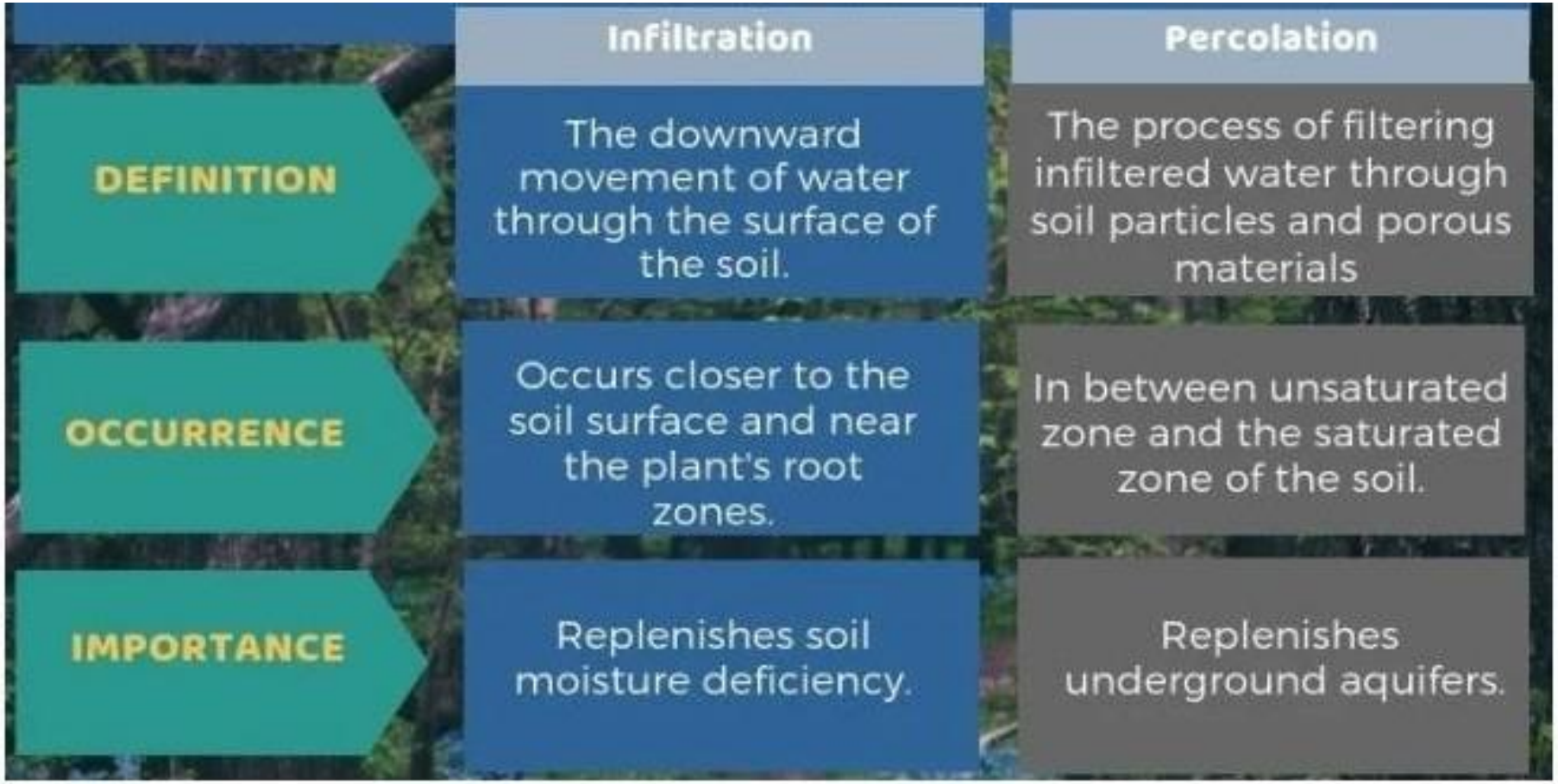
Percolation: Is the movement of water within the soil (the two phenomena of infiltration and percolation are interrelated).







Infiltration vs Percolation



The Infiltration capacity

- The max. the rate at which water can enter the soil in a given condition. The infiltration capacity (f) is high at the beginning of a storm when the soil is dry, it decreases as the soil becomes saturated until it reaches a constant value(fc).

- To find the infiltration capacity at time (t.) after the beginning of storm use the following eq. :

$f_t = f_c + (f_o - f_c)\, e^{-kt}$

Where:

fo: initial infiltration capacity.
fc: limiting constant value of infiltration capacity.
***Note*:** the values fc, fo, k depend upon the type and conditions of the soil.

Factors affecting infiltration rate

1- soil moisture: when soil is dry infiltration rate is high because there is strong capillary attraction for the moisture as the soil becomes saturated, the infiltration rate decreases.

2-Type of soil medium: The infiltration rate depends upon the type of soil, texture, amount of clay and colloids in the soil, and thickness and depth of the permeable layer.

Factors affecting infiltration rate

3-Permeability: Infiltration will continue only if the infiltrated water is transmitted by the soil.

4-Compaction of soil: Compaction reduces the infiltration rate.

5-Avilable storage in soil stratum: It depends on the thickness of the stratum, porosity, and water content of the soil. The infiltration is more if the available storage is large.

Factors affecting infiltration rate

6-Depth of surface detention: The rate of infiltration increases as the depth of surface detention increases.

7-Temperature of water: An increase in temperature causes a reduction in the viscosity of water leading to an increase infiltration rate.

8-Vegetal cover: The dense vegetal cover over the surface of the soil increases the infiltration rate. It provides protection of the soil surface against the impact of raindrops.

9-Other factors: A large number of other factors, attract the rate of infiltration such as **water quality**, **turbidity**, **salt content**, **entrapped air in soil pores.**

Measurements of infiltration capacity

1-Flooding-type infiltrometer: it consist of metal cylinder open at both ends(22.5 cm) diameter , (60 cm) long . The cylinder is put in the ground by a plate and hammer about (10 cm) length of the cylinder above the soil surface is (55 cm) filled with water gradually water infiltration occurs, water is added to the cylinder to keep the water level steady, reading is taken at regular intervals to determine the rate and amount of infiltration.

Measurements of infiltration capacity

2-Rainfall simulator type infiltrometer: water applied in the form of spray, water is applied on a plot of (2 x 4)m in the form of artificial rain at a uniform rate various intensities of rainfall can be simulated:

Infiltration = rainfall – surface runoff


Natural Resources Conservation Service
Helping People Help the Land
TRAY 1
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Cropland
HIGH-TILL + NO COVER CROP
TRAY 2
unlock the SECRETS of SOIL
Cropland
NO-TILL + COVER CROP
TRAY 3
unlock the SECRETS of SOIL
Urban
PAVED
TRAY 4
unlock the SECRETS of SOIL
Grassland
OVER-GRAZED & COMPACTED
TRAY 5
unlock the SECRETS of SOIL
Grassland


Crop
Range


Iowa NRCS
Rainfall Simulator
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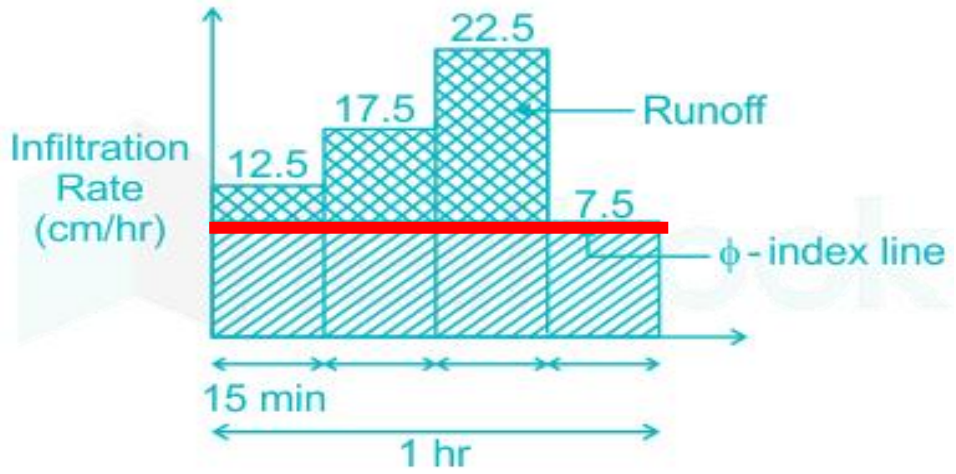
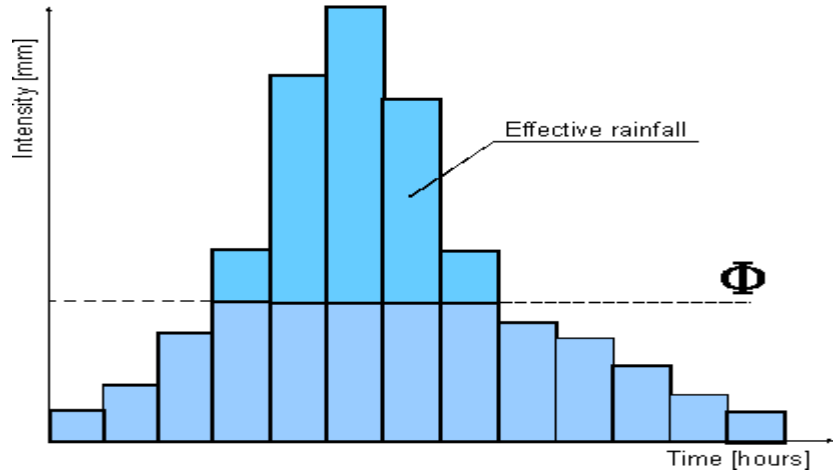
Infiltration indices

- ϕ-Index: the average rate of rainfall where the volume of excess rainfall of that rate is equal to the volume of surface runoff, the value of ϕ-index can be derived from rainfall hyetograph by trial and error.
- To determine the value of ϕ-index a horizontal line is drawn on the hyetograph. So that the shaded area above the line is equal to the volume of surface runoff.
- **Hyetograph** is the graph that demonstrates the relation between time and intensity of rainfall.
- The area below the horizontal line represents all kinds of losses including interception, depression, storage, and infiltration.
- If the shaded area ≠ volume of measured surface runoff, then the horizontal line must be shifted upward or downward till the condition is satisfied.





w-index

w-index average rate of infiltration during the period when rainfall intensity exceeds the infiltration rate.

$$w - Index = \frac{P - R - S}{tf}$$

w-Index = average rate of infiltration(cm/hr)

p = total storm ppt. (cm)

R = total surface runoff (cm)

S = depression and interception (cm)

t_f = time period when the rainfall intensity exceeds infiltration rate (rainfall period)(hr).

The min. value of w-Index is called (w- min. index), it is obtained when the soil is very wet . the losses are very little they are neglected , then

$$w\text{- index} = \phi - index$$

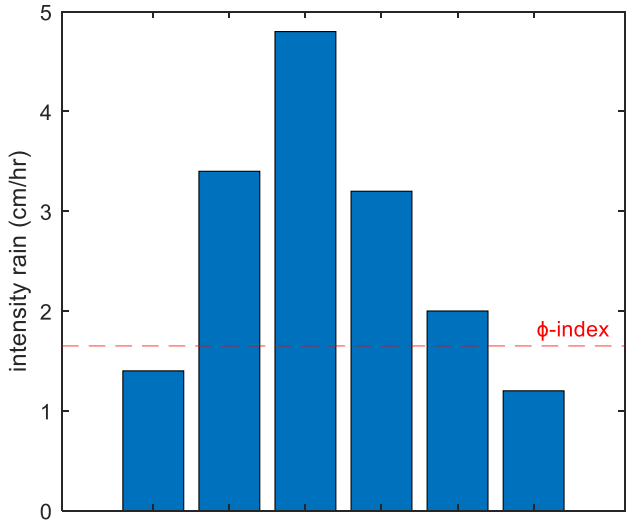
ϕ-Index vs w-Index

- The ϕ-Index determines the rainfall rate at which the volume of excess rainfall matches the volume of surface runoff. It focuses on the overall balance between rainfall and runoff.
- The w-Index, on the other hand, specifically looks at the infiltration rate during intense rainfall events when the rainfall intensity exceeds the soil's ability to absorb water. It provides insight into the capacity of the soil to handle high-intensity rainfall.

EXAMPLE 1; for a storm of 3 hr duration , the rainfall rates are :

time period(min)	Rainfall rate(cm/hr)
30	1.4
30	3.4
30	4.8
30	3.2
30	2
30	1.2

Determine ϕ-index and w-index if surface runoff is 3.4 cm ?



Time : 30 min

Solution:

1-Assume ϕ-index is more than 1.4 cm/hr

$R = ((3.4-\phi)+(4.8-\phi)+(3.2-\phi)+(2-\phi))^{x}\ 30/60$

$3.4=6.7-2\phi$

$\Phi=1.65$ cm/hr >1.4 cm/hr ok

2-total precipitation:

$P=(1.4+3.4+4.8+3.2+2+1.2)^{x}\ 30/60 = 8$ cm

$$w-index = \frac{p-R-S}{t_f}$$

$$= \frac{8-3.4-0}{3} = 1.53\frac{cm}{hr}$$

Homework

The rate of rainfall for the successive 30 min periods of a 3-hour storm are: 1.6, 3.6, 5.0, 2.8, 2.2 and 1.0 cm/hour. The corresponding surface runoff is estimated to be 3.2 cm. Then, the ø index

Ans = 1.8 cm/hr

MOHAMMED


Thanks for your attention!
Any questions?