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ASAC 1101 : FUNDAMENTALS OF SOIL SCIENCE (2+1)

Level : B.Sc (Ag), I semester

Dr. PEDDA GHOUSE PEERA S.K.

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

**M.S.SWAMINATHAN SCHOOL OF AGRICULTURE,CUTM,
PARLAKHEMUNDI**

Topic

Movement of soil water

Water movement within the soil

1. **Saturated flow:** soil pores are completely filled
2. **Unsaturated flow:** larger pores in the soil are filled with air, leaving only the smaller pores to hold and transmit water.
3. **Vapor movement:** vapor pressure differences develop in relatively dry soils

Saturated flow

1. At least part of a soil profile may be completely saturated
2. All pores, large and small, are filled with water
3. The lower horizons of poorly drained soils are often saturated
4. Also, portions of well-drained soils above water restricting layers of clay are saturated

Saturated flow: Darcy's law

The quantity of water per unit of time Q/t that flows through a column of saturated soil can be expressed by Darcy's law:

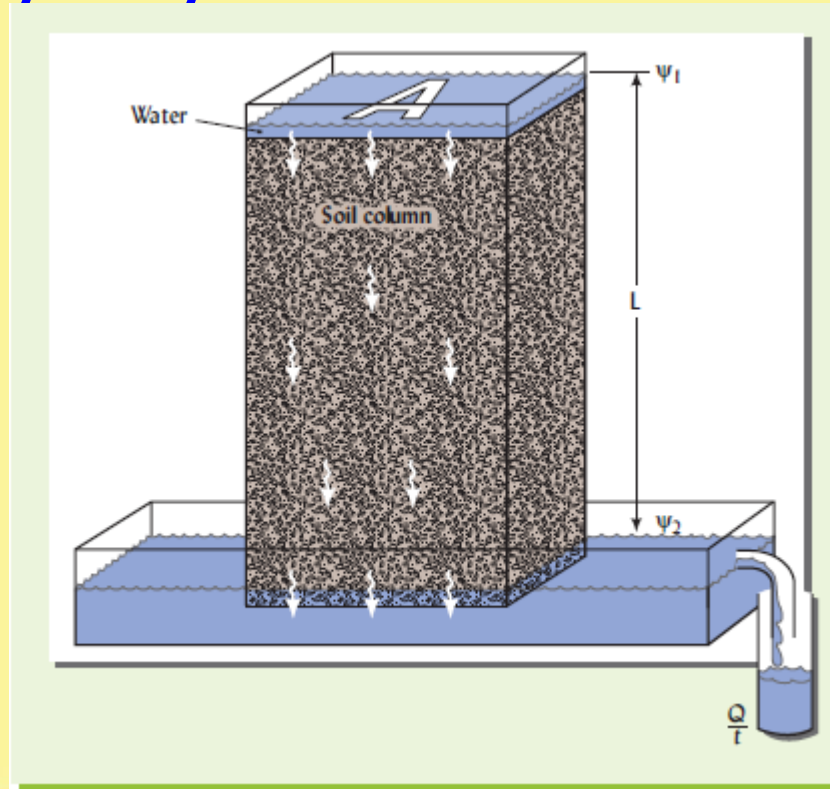
$$\frac{Q}{t} = AK_{\text{sat}} \frac{\Delta\psi}{L}$$

A is the cross-sectional area of the column through which the water flows

K_{sat} is the saturated hydraulic conductivity

$\Delta\psi$ is the change in water potential between the ends of the column (e.g., $\psi_1 - \psi_2$)

L is the length of the column



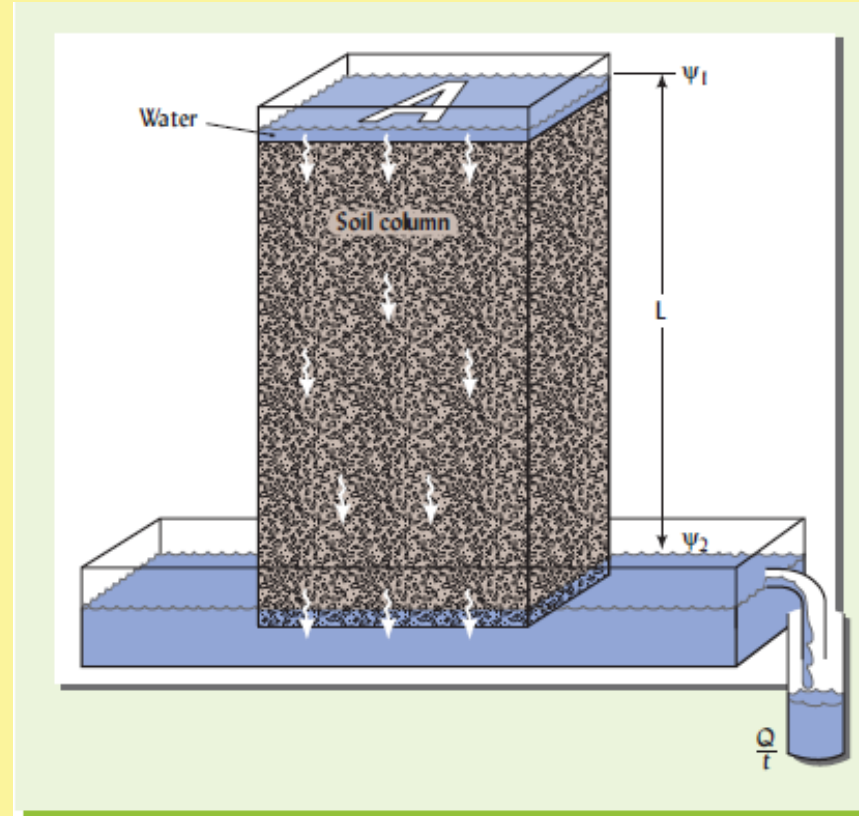
Saturated flow: Darcy's law

For a given column,

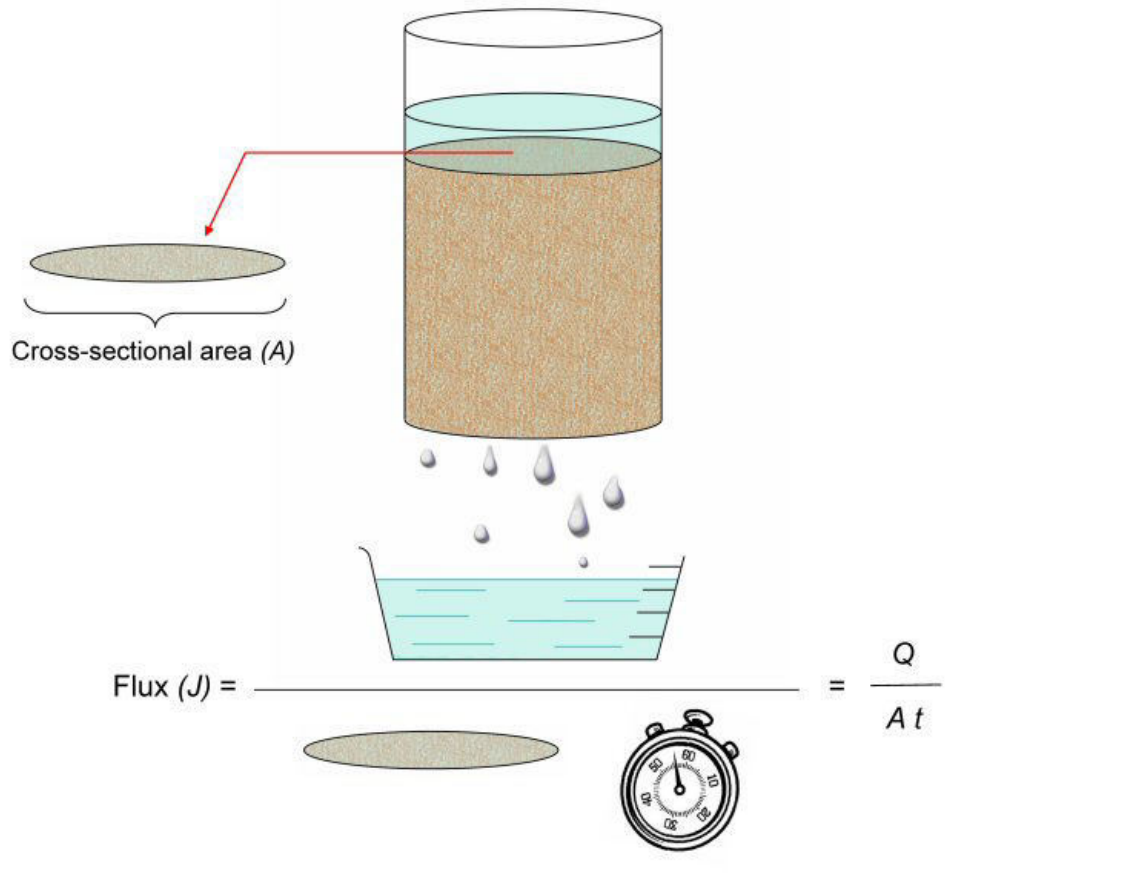
K_{sat} = saturated hydraulic conductivity (cm/s) = ease with which the soil transmits water

$\Delta \Psi / L$ = the amount of force driving the water = the water potential gradient = hydraulic gradient (saturated flow)

the same principles apply where the water potential gradient moves the water in a horizontal direction

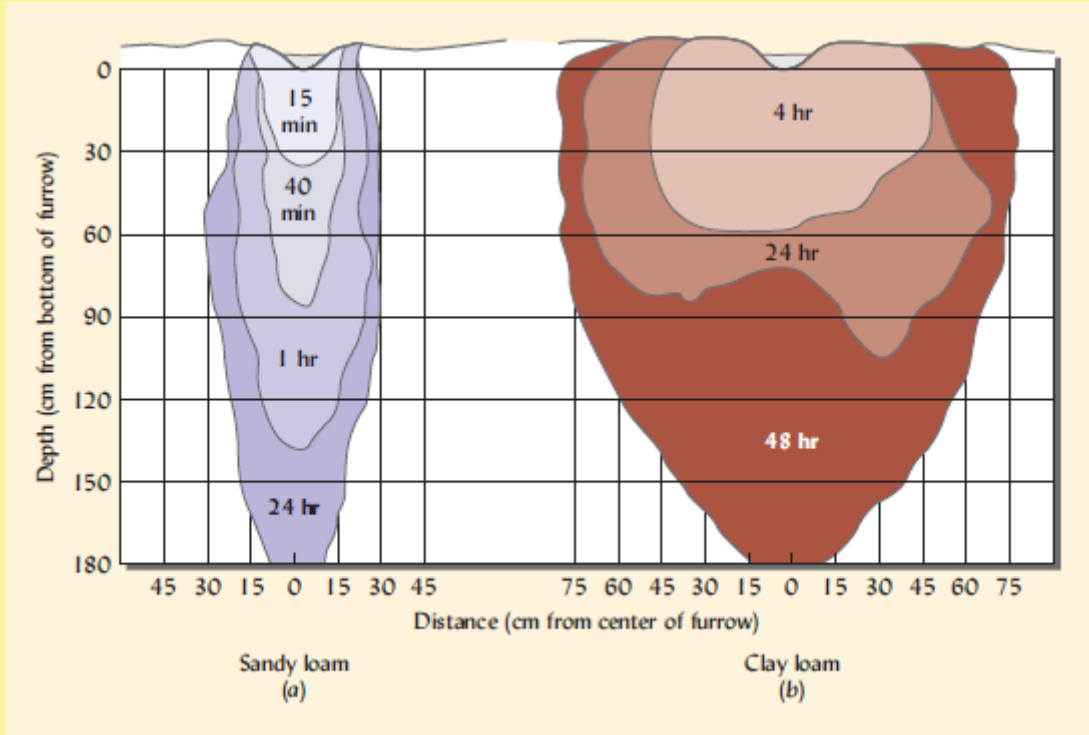


Saturated flow: Darcy's law



Flux can be thought of as water flowing from a hose. The flux is the rate of water discharged by the hose, divided by the cross-sectional area of the hose.

Saturated flow



Points to remember:

Saturated flow occurs

1. Downward
2. Horizontally
3. Upward

The rate of horizontal and upward flow is usually not rapid, since the force of gravity does not assist horizontal flow and hinders upward flow

Factors affecting Ksat

Macropores ($r > 0.08$ mm):

1. Account for nearly all water movement in saturated soils
2. Sandy soils generally have higher saturated conductivities than finer-textured soils
3. Air trapped in rapidly wetted soils can block pores and thereby reduce hydraulic conductivity

NUMBER OF MACROPORES IN THREE SIZE CLASSES, THEIR PROPORTION OF THE SOIL POROSITY AND THEIR CONTRIBUTION TO TOTAL WATER FLOW IN AN IRRIGATED MAIZE FIELD^a

Most of the flow took place through the largest class of pores even though the smaller pores were far greater in number and in percent of the total soil porosity. Note that only 5.5% of the total soil porosity is considered here, the other 94.5% being comprised of pores smaller than 0.1 mm.

	Effective pore radius, ^b mm		
	>0.5	0.5–0.25	0.25–0.1
	Large macropores	Small macropores ^c	
Number of pores, m ²	235	167	2200
% of effective porosity	3.1	----- 2.4 -----	
% of flow	88	9	3

Factors affecting Ksat

Biopores (>1 mm):

1. Root channels and earthworm burrows
2. Perennial grass → network of stable biopores → Ksat much higher than annual crop plant cultivated fields → Ksat higher in no-till than conventional tillage

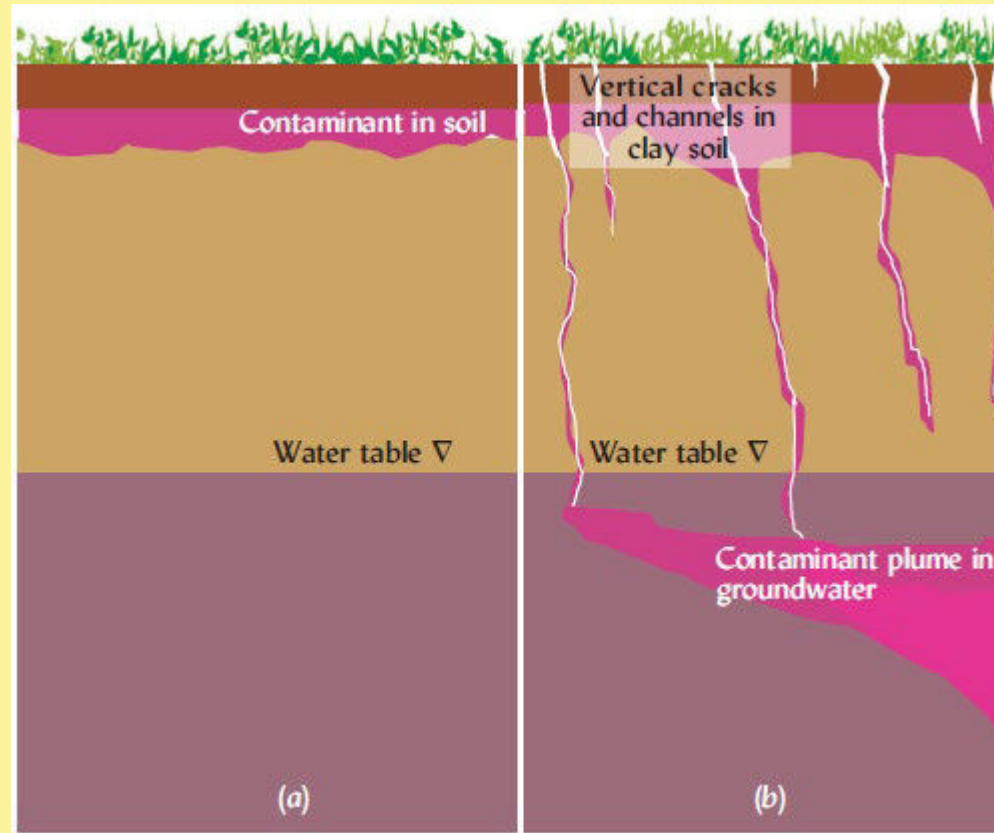


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Factors affecting Ksat

Preferential Flow

Macropores with continuity from the soil surface down through the profile encourage preferential flow



Factors affecting Ksat

Finger Flow

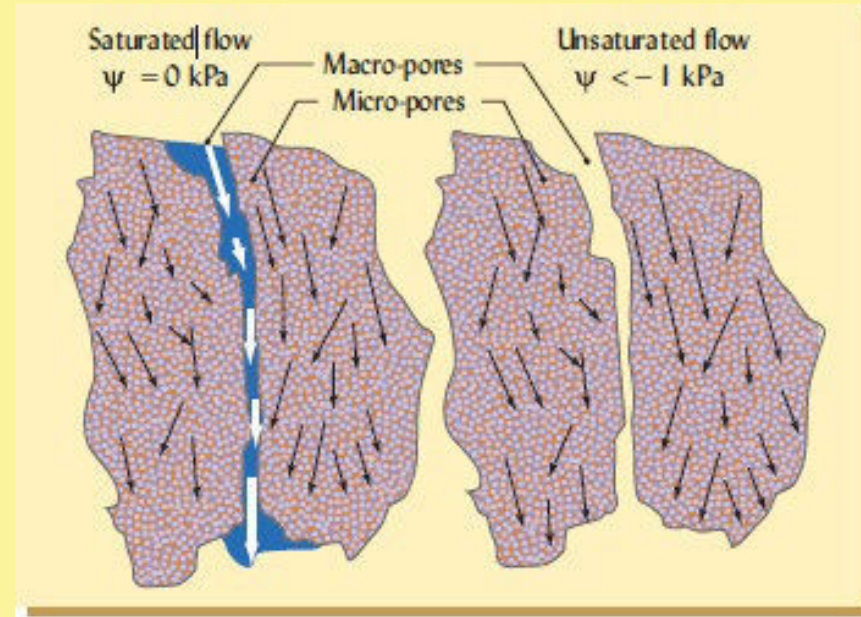
In very sandy soils, hydrophobic organic coatings on sand grains repel water, preventing it from soaking in uniformly. Where these coatings are absent or wear off, water rapidly enters and produces “fingers” of rapid wetting



P.C Stefan Doerr

Unsaturated flow

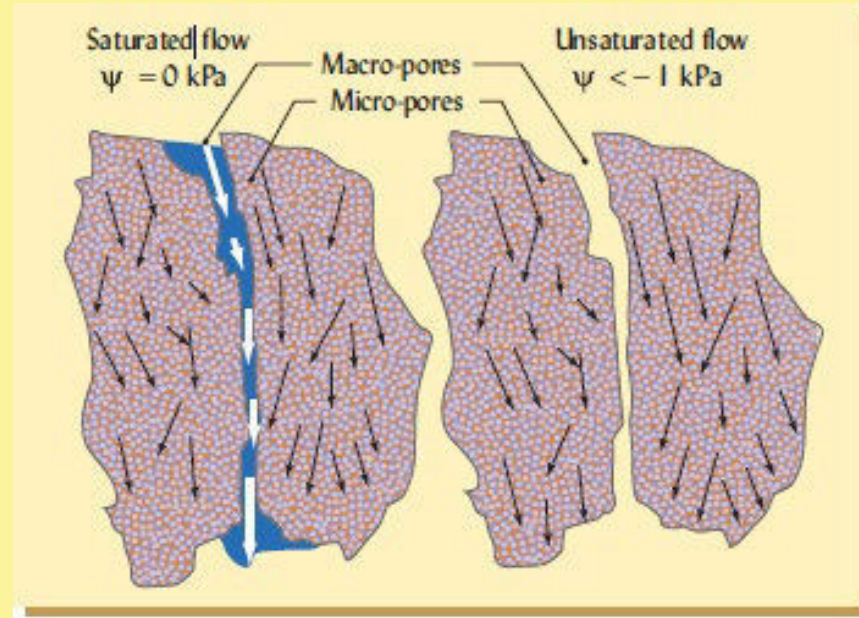
1. More common
2. Complicated than saturated flow
3. Saturated flow: both macro and micropores are filled with water
4. Unsaturated flow: macropores are filled with air and micropores helps in water movement
5. Water content and potential variable



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Unsaturated flow

1. Flow occurs due to potential difference
2. **Driving force** : matric potential instead of gravitational potential
3. **Matric potential gradient** is the difference in the matric potential of the moist soil areas and nearby drier areas into which the water is moving
4. Movement will be from a **zone of thick moisture films** (high matric potential, e.g., -1 kPa) to one of **thin films** (lower matric potential, e.g., -100 kPa)

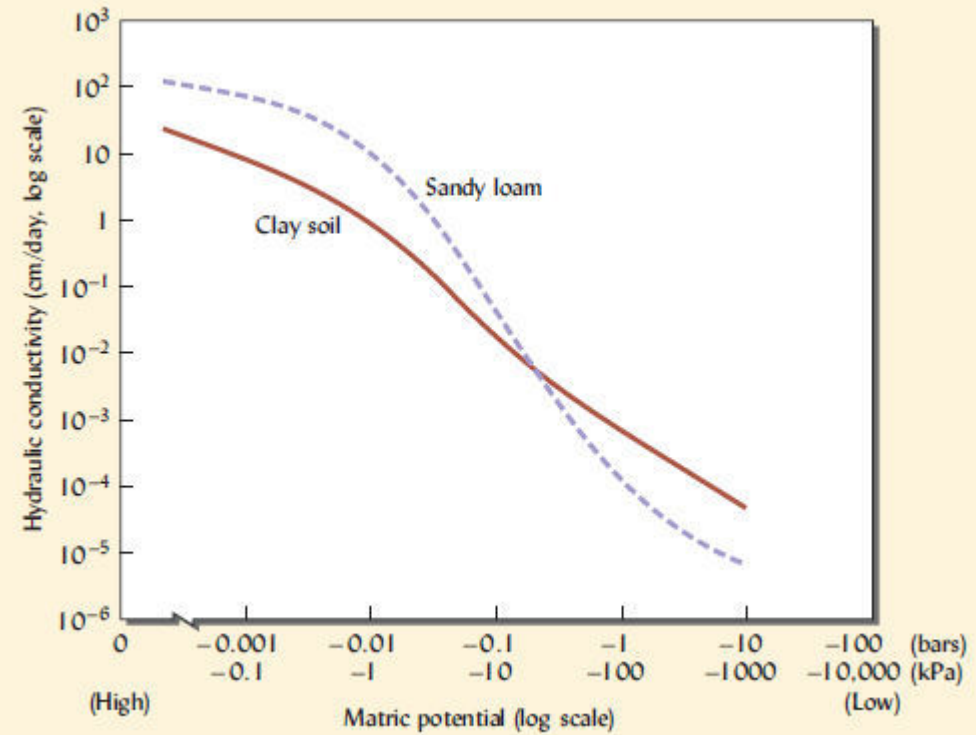


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Unsaturated flow

Influence of Texture

This relationship is to be expected because the sandy soil contains many large pores that are water-filled when the soil water potential is high (and the soil is quite wet), but most of these have been emptied by the time the soil water potential becomes lower than about -10 kPa. The clay soil has many more micropores that are still water-filled at lower soil water potentials (drier soil conditions) and can participate in unsaturated flow



Infiltration and Percolation

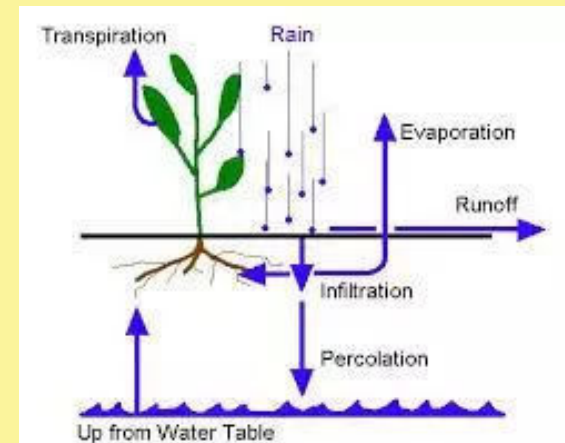
The process by which water enters the soil pore spaces and becomes soil water is termed infiltration, and the rate at which water can enter the soil is termed the infiltrability i (m/s):

$$i = \frac{Q}{A \times t}$$

Q =volume quantity of water (m³) infiltrating

A = Area of the soil surface (m²) exposed to infiltration

t = time (s)



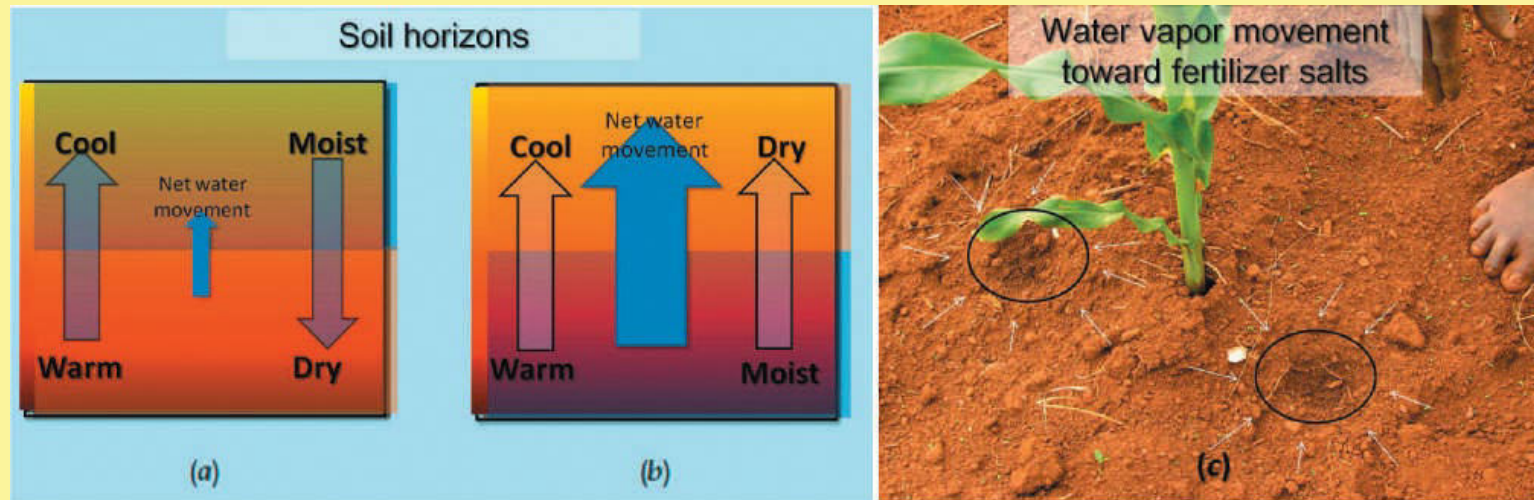
Forestrypedia

Infiltration is a transitional phenomenon that takes place at the soil surface. Once the water has infiltrated the soil, the water moves downward into the profile by the process termed **percolation**.

Water vapor movement

Two types:

1. Internal: within the soil
2. External: occurs at the land surface (surface evaporation)



Occurs due to:

1. Vapor pressure gradient (high moisture to low moisture zone)
2. Low salt to high salt (fertilizer) content
3. Temperature gradient