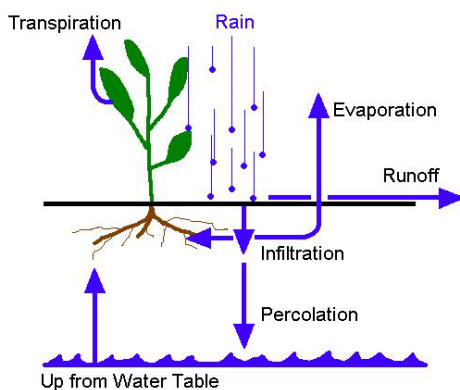


## Hydrologic Cycle

Hydrologic cycle is the circulation of water between the atmosphere and the earth. It is driven by solar energy.

Components of the field hydrologic cycle

Precipitation  
Infiltration  
Runoff  
Evaporation  
Transpiration  
Percolation  
Capillary rise

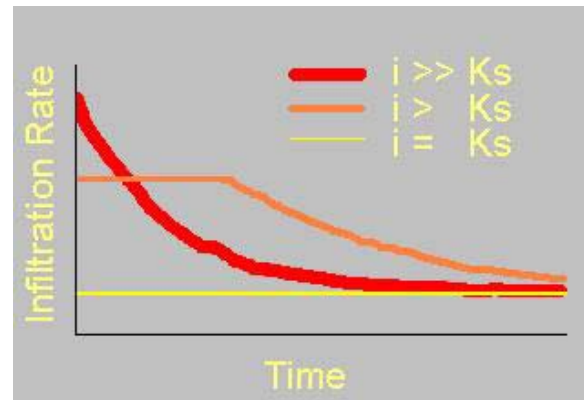


## Infiltration

A portion of precipitation is intercepted by vegetation and evaporates without reaching the soil. But once at the soil surface water may infiltrate or runoff.

If the soil surface is stable and does not form a crust, rainfall at an intensity less than or equal to the saturated hydraulic conductivity of the soil will all infiltrate the surface. Even rainfall at an intensity greater than the saturated hydraulic conductivity may all infiltrate the surface provided that the water potential gradient at the soil surface is large due to relatively dry soil (very negative matric potential) below the soil surface. With continued infiltration, however, the upper part of the profile tends to become uniformly wet so that the matric potential component of the water potential

gradient goes to zero. Under these conditions, gravity is solely responsible for infiltration and infiltration decreases to a limiting value equal to the saturated hydraulic conductivity. Ponding and runoff occur once infiltration becomes less than rainfall intensity.



Infiltration rate as a function of time for different rainfall intensities.

Factors other than the rainfall intensity and soil hydraulic properties affect infiltration.

Soil moisture at onset of infiltration.

Surface deterioration and crust formation. Raindrop impact may destroy surface aggregates. The detached particles clog pores and reduce hydraulic conductivity at the surface.

Vegetative cover and crop residue protect the surface soil from raindrop impact.

Slope --a greater proportion of precipitation subject to runoff as slope increases.

## Soil-Plant-Atmosphere Continuum

Via transpiration, soil water passes through the plant to the atmosphere down a potential gradient: soil to root to stem to leaves to atmosphere. Water evaporates in the intercellular air spaces of leaves and diffuses out the stomata into the atmosphere. Potential drop is greatest from leaves to atmosphere.

## Evapotranspiration (ET)

Combined water losses by evaporation (E) and transpiration (T). Meteorological and soil factors affect E and T.

Radiant energy ↑	ET ↑
Water vapor pressure ↑	ET ↑
Temperature ↑	ET ↑
Wind speed ↑	ET ↑
Soil water content ↑	ET ↑

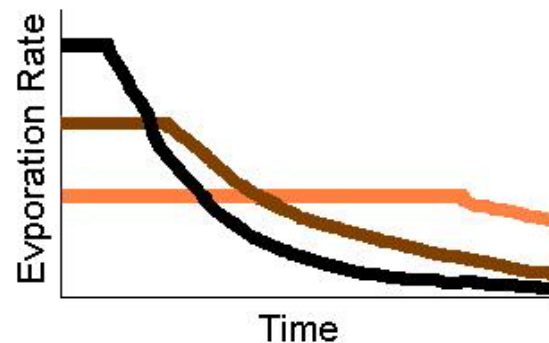
Relative contribution of E and T to ET varies with climate and vegetation.

Shading of soil ↑	E ↓
Transpiration ↑	E ↓
Growing season lengthens	E ↓

## Evaporation and Its Control

External conditions set the evaporativity and evaporation from a wet soil is sufficiently fast to meet this external demand. This happens despite decreasing unsaturated hydraulic conductivity near the soil surface to decreasing water content because the matric potential gradient (wet soil below the surface to relatively dry soil at the surface) becomes increasingly steep. However, as the soil becomes progressively drier, not only does the hydraulic conductivity continue to decrease, but the matric potential gradient passes through a maximum and begins to decrease. Therefore, the soil can no longer supply water to the surface for evaporation as rapidly as demanded by the evaporativity

and the rate of evaporation steadily decreases.



Evaporation rate as a function of time for different evaporativities.

Control of evaporative water loss is important in arid regions or during drought in humid regions. Means of control include mulches and conservation tillage practices. These reduce

Exposure to solar radiation  
Surface temperature  
Vapor pressure drop  
Exposure to air currents

## Control of Transpiration

Seeks to increase soil water available to crop. Means include

Weed control by cultivation or herbicides  
Fallow cropping in semiarid areas

## Liquid Losses of Water

Percolation  
Runoff

Runoff occurs when rainfall rate exceeds infiltration. Percolation or drainage is greatest when infiltration greatly exceeds evapotranspiration.

## Percolation and Groundwater

Below the soil surface is (usually) unsaturated soil. This is called the **vadose zone**. It extends to a saturated zone just above the water table. This saturated zone is called the **capillary fringe**. It is a less than atmospheric pressure and its height depends on the largest pore size.

Upward movement of water from a shallow water table replenishes soil water lost by evapotranspiration. Shallow groundwater replenished by percolation.

Groundwater environmental issues and problems include

Water mining -rate of deep groundwater removal > rate of recharge  
Saltwater intrusion due to water table draw down in coastal areas  
Contamination due to migration of dissolved substances

The latter may also affect surface water due to lateral subsurface flow to surface bodies of water. There is a wide range of potential contaminants including agrichemical nutrients such as  $\text{NO}_3^-$  which may pose human and animal health problems and, along with P may lead to accelerated eutrophication of surface waters, and pesticides.

Movement of chemicals in drainage water is enhanced by macropores which contribute to preferential water flow.

## Land Drainage

Either surface or subsurface drainage is intended to improve aeration in root zone.

### Surface

Expedite runoff of ponded water. Land forming to eliminate local depressional areas coupled with system of drainage ditches.

## Subsurface

Design is influenced by several factors. For example, spacing is affected by the saturated hydraulic conductivity of the soil.

Soil type	$K$ (cm/d)	Spacing (m)
Clay	0.2	10 - 20
Loam	2.0	20 - 40
Sandy loam	12.0	30 - 70

The drains may be temporary subsurface tunnels (mole drain) or permanent (perforated pipe).

Better aeration promotes greater rooting vigor and depth, increased activity of aerobic microorganisms responsible for release of plant nutrients from organic matter and decreased activity of anaerobic microorganisms that reduce Fe or Mn and may create toxic levels of  $\text{Fe}^{2+}$  or  $\text{Mn}^{2+}$ . In addition to better aeration, drainage allows soil to warm faster and improves access for field operations.

Drainage is also important with irrigation. A shallow water table will sustain evaporative flux at the soil surface. This may present a salinization hazard if ground water is salty and evaporativity is high.

## Irrigation

It's an ancient water management practice. But care taken to prevent build-up of salts in soil and depletion of deep ground water.

### Types

<u>Surface</u>	Inexpensive but uniformity of distribution and use efficiency are poor.
<u>Sprinkler</u>	Expensive but offers uniform application and better use efficiency.
<u>Trickle</u>	Expensive and difficult to maintain but offers high use efficiency.