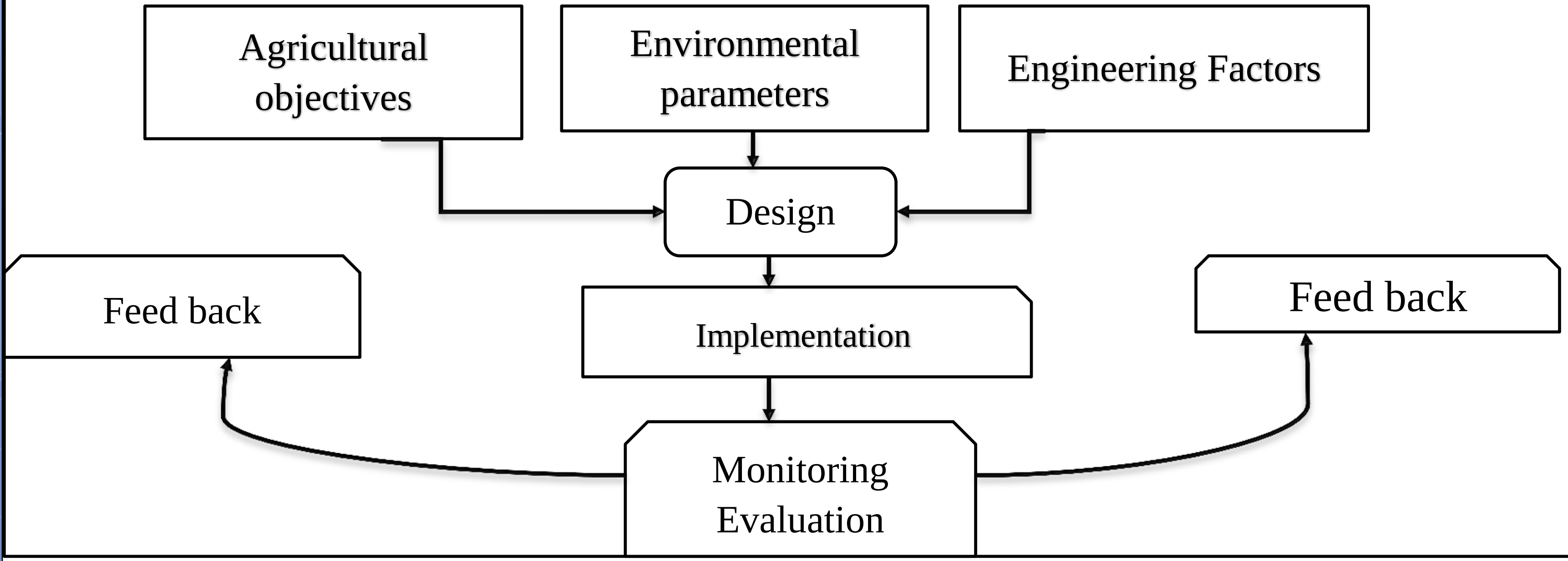
Factors Related to Drainage

- For the design of agricultural drainage systems we group all these disciplines together in three types of input factors:
  - The agricultural factors,
  - The environmental factors (parameters) and
  - The engineering factors



1. Agricultural factors of Drainage

1. Objectives And Effects

Main Objectives of Agricultural Drainage Are:

- Prevention or reduction of ponded or waterlogged condition,
- Salinity control and
- Making new land available for agriculture

Effects of Agricultural Drainage Are:

- Reduction of amount of water stored on or in the soil
- Discharge of water through the system

2. Field Drainage Systems and Crop Production

Land drainage directly increases yield of crops due to more favorable soil profile created as a result of drainage.

3. Water Table and Crop Production

- Optimum water table depth is required for best soil-water-air relationships
- It should be controlled within close limits of the root zone throughout the crop growing season
- If ground water is free from salts, maintain water table level up to root zone depth (as deep as required)
- If ground water is with salts, water table level should be deep enough to prevent capillary flow from bringing dissolved salts.

Recommended Depths of Water Table by FAO (1980)

For Irrigation Season

- ✓ Field crops and vegetables --- Depth between 1.0 & 1.2 m
- ✓ For fruit crops --- Depth between 1.2 & 1.6 m

- Lower range values (1 & 1.2 m) are best to coarse textured soils greater range depths (1.2 & 1.6 m) are best to fine textured soils)

4. Water Table and Soil Condition

A good soil structure favours both the soil aeration & storage of soil water.

2. Environmental Factors of Drainage

When we introduce drainage system into an area, we are manipulating the environment

I. Side Effects Inside the Project Area

- Loss of wetland
- Change of habitat
- Lower water table
- Subsidence
- Erosion
- Seepage
- Leaching of nutrients, pesticides and other elements

2. Side effects outside the project area

- Disposal of drainage effluent (liquid wastes)
- Seepage from drainage canals
- Lower upstream water table

3. Engineering Factors of Drainage

Table: examples of **Engineering Factors** by type of drainage system

Type of drainage system	Enigineering factor
Surface drainage system	Length and slope of the fields, dimensions of beds, terraces and open drains
Subsurface drainage system	Depth, spacing, and dimensions of open or pipe drains
Tubewell drainage system	Depth, spacing, and dimensions of wells, pump capacity
Main drainage system	Depth, width, cross-section, and slope of drains, spacing of the network

SOIL AND HYDROLOGICAL CONDITIONS

1. Drainage surplus

drainage surplus is based on:

1. The maximum duration and frequency of surface ponding
2. Maximum height of the water table
3. The minimum rate at which water table is lowered

2. Dissolved Salts in the Ground Water

Accumulation of salts in the soils leads to:

- Unfavorable soil-water-air relationships
- Decrease in crop production
- Chief causes for salt build-up
- Poor water management practices
- Land goes out of order unless remedial measures are taken up.

3. **Hydraulic Conductivity**

- It can be correlated with the soil texture or the pore size distribution.

Hydraulic conductivity of some soil types

Soil type (texture)	Hydraulic conductivity (m/d)
Dense clay (no cracks, pores)	< 0.002
Clay loam, clay (poorly structured)	0.002 - 0.2
Loam, clay loam, clay (well-structured)	0.5 - 2.0
Sandy loam, fine sand	1 - 3
Medium sand	1 - 5
Coarse sand	10 -50
Gravel	100 - 1000

4. **Drainable Porosity**

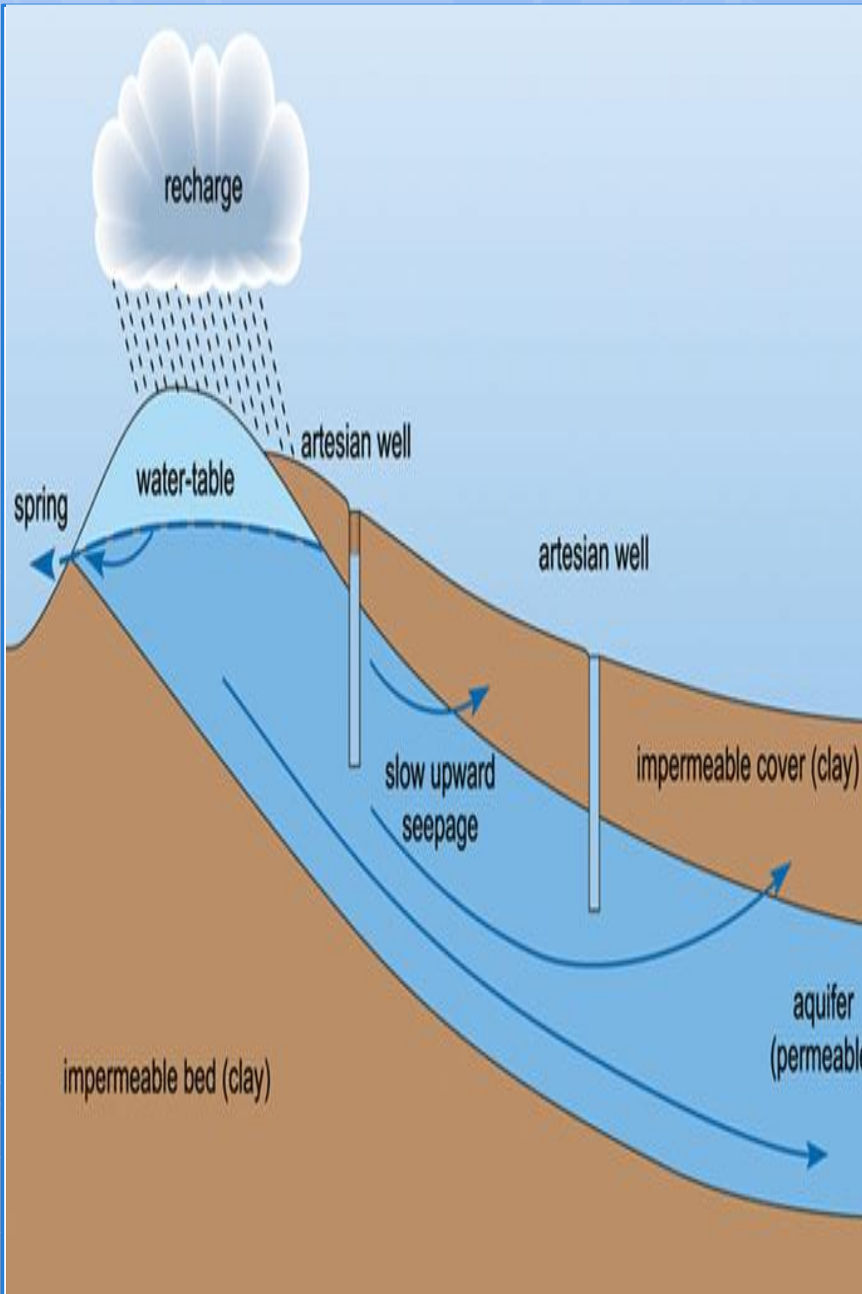
- Called as effective porosity
- It is the volume of water drained (or taken up) by unit volume of soil when water table drops (or rises) over a unit distance
- It is related to rate of fall of water table
- The quantity of water released by an incremental fall of water table is equal to the volume of voids are emptied
- In general two types of pores exist
    - capillary or small pores: induce greater holding capacity (poor drainage in clay soils) .
    - No-capillary or large pores-induce drainage and aeration.

Concept of Impermeable Layer

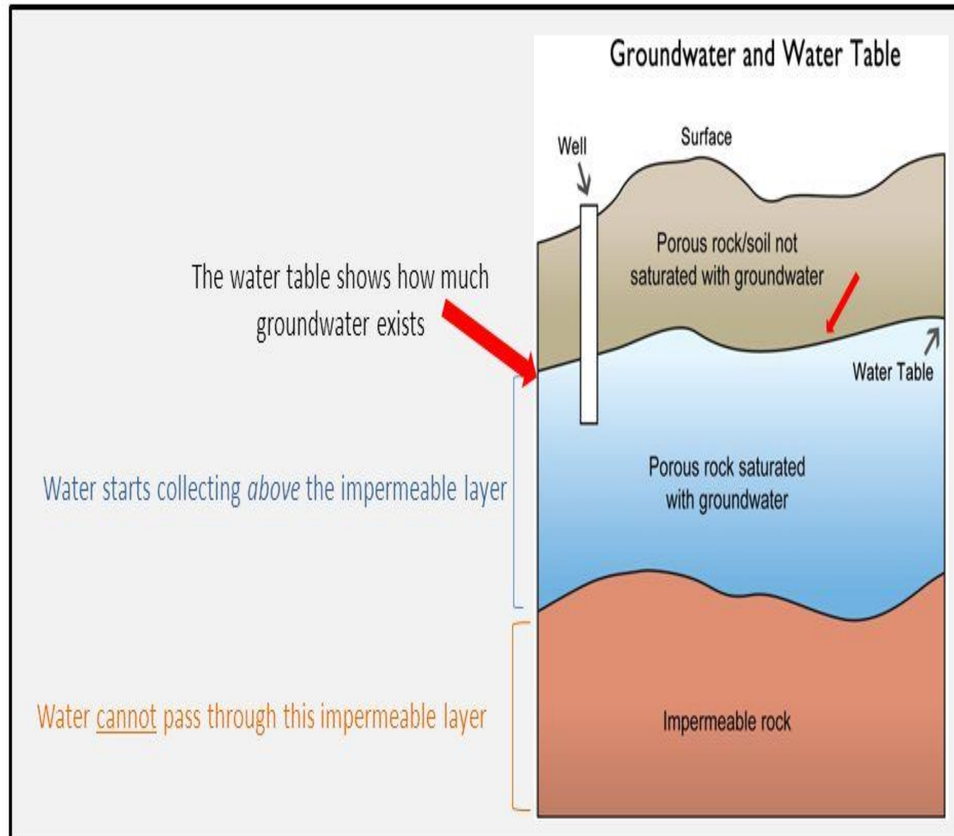
- It is a layer of material (such as clay) in an aquifer through which water does not pass or passes extremely slowly.

(**Flow of water from the land surface into the subsurface**)

- It has great bearing on the **spacing of field drains.**
- For fine textured soils, the layer cannot always be considered as impervious layer, because, sometimes, its permeability differs only little from permeable layer, hence contributes to the discharge of drainage water. *Hence the layer is semi-permeable*.
- Generally, riverbed deposits, show impermeable layer b/n 2 to 4 m.



There is a layer of impermeable (does **not** allow passage of liquids) rock below ground at the base of an aquifer which stops the flow of water.



Drainage Coefficient

- Is the design capacity of the drainage system.
- Is typically expressed as a depth of water removed in 24 hours (one day)
- The concept of drainage coefficient is used for the design of drainage systems for agricultural lands.
- In agriculture lands, open ditches or drains are the most commonly used surface drainage structures.
- The rate at which the open drains should remove water from a drainage area depends on:

Con’d…

- Rainfall and Size of the drainage area
- Characteristics of the drainage area and
- Nature of the crops grown and the degree of protection required for them from waterlogging.

Con’d…

Drainage coefficient can be calculated:

Discharge rate; $Q = D_c \times A$

Where,

A = Area in ha ,

D_c = Drainage coefficient

Q = Discharge from the field

Methods for Estimation Drainage coefficient

1. Empirical methods:

- 1% MAR (mean annual Rainfall in mm)
- Hudson’s (1983) method
- Mazumdar’s (1983) method

2. Frequency Analysis method
3. USSCS (1972) method
4. Actual measurement of out flow from the surrounding area

❖ **The empirical methods are explained with the help of the following solved example:**

Examples: Determine the Drainage coefficient and the discharge for the following data by using the three empirical methods:

Arba Minch & Mean Annual Rainfall(MAR)=790 mm & Area =110 ha.

Determine:

a). Dc and b). Q

Solution:

(i) 1% of MAR method:

1% of MAR = 0.01 * 790 = 8 mm/day

DC = 8 mm/day ……. ***Ans***

Q = discharge of the drain = Area of the watershed * DC

$\therefore$ Q = 110 ha * 8 mm/day

$$= \frac{110 * 100 * 100 * 8}{24 * 60 * 60\ 1000} m^3/sec$$

$= 0.102\ m^3/sec$ or

= 102 ℓ/sec **…….Ans**

(ii) Hudson (1983)'s method:

if MAR $\leq$ 1000 mm , DC = 10 mm/day

if MAR $\geq$ 1000 mm , DC = $\frac{MAR}{100}$ mm/day

$\therefore$ In this case: MAR = 790 mm $\angle$ 1000 mm

Therefore; ***DC = 10 mm/day ……Ans***

Note : If MAR =1500 mm which is greater than 1000 mm

Therefore ;DC = $\frac{1500}{100}$ =***15 mm/day***

Since Area = 110 ha

$$\therefore Q = \left(\frac{10}{1000} * \frac{110 * 10^4}{86400} \right) * 1000\ \ell/sec$$

= 127ℓ/sec ….**Ans.**

($1m^3$ = 1000 Litters)

(iii) **Mazumdar's method (Class Activity)**:
Determined drainage coefficient by using the following table

MAR (mm)	< 750	750 - 1000	1000-1250	1250-1500	> 1500
DC(mm/day)	5-7.5	7.5-9	9-12	12-25	>25