MPSC 2023

Maharashtra Public Service Commission

Assistant Engineer Examination

Civil Engineering

Irrigation Engineering

Well Illustrated **Theory** *with*
Solved Examples and **Practice Questions**

MADE EASY Publications

Irrigation Engineering

Contents

Chapter 01

Irrigation Principles, Practices and Project

1.1 Definition of Irrigation

Irrigation may be defined as the process of artificial application of water to the soil or land for the growth of agricultural crops. In other words, it is a science of planning and designing a water supply system for the agricultural land to protect the crops from adverse effects of weather.

1.2 Historical back ground

Pandit Jawaharlal Nehru used to call Dams as the Temples of modern India. Due to successful efforts of Independent India the gross area, under irrigation has come up from 19% during 1947-48 to 50% during 2000-01.

Surface irrigation = 52%

(a) Canal = 37% (b) Tanks = 15%

Subsurface irrigation = 48%

Mainly Wells and Tubewells.

1.3 Benefits of Irrigation

(i) **Increase in crop yield**: Increase in crop yields occur on account of good irrigation systems leading to increase in food production

(ii) **Protection against famines:** Food production of a country can be increased by availing irrigation facilities. This helps preventing famine situations

(iii) **Revenue Generation:** Assumed supply of irrigation water leads to growing of superior crops by the farmers. Farmers become prosperous by selling the crops while governments revenue is generated by imposing taxes on irrigation water

(iv) **Avoidance of mixed cropping:** Mixed cropping means sowing of two or more crops together in the same field when weather conditions are not favorable for a particular type of crop. The need of mixed cropping is eliminated if we have good irrigation facility

(v) **Navigation:** Irrigation canals may be used for inland navigation. Inland navigation is useful for communication and transportation.

(vi) **Hydroelectric Power Generation:** Major river valley projects are planned to provide hydroelectric power together with irrigation. Thus, at the same time dual purpose is served

(vii) **Generation of employment opportunities:** During construction of irrigation works like canal headworks, weir/barrage, overhead irrigation works, employment opportunities are generated.

1.4 Ill Effect of Irrigation

(i) **Wastage of irrigation water:** Abundant supply of irrigation water tempts the cultivators to use more than the required amount of water.

(ii) **Formation of marshy land:** Excessive seepage of water from irrigation canals may lead to formation of marshy lands along the course of the canals.

(iii) **Dampness in weather:** Temperature of the commanded area of irrigation project gets lowered considerably and the area may become damp. Dampness in the area lead to occurrence of diseases originating from dampness.

(iv) **Loss in valuable lands:** In various cases, valuable lands get submerged when storage reservoirs are formed on account of construction of weirs, barrages or dams.

(v) **Water logging:** Due to over and intensive irrigation water logging occurs.

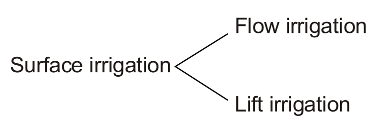
(vi) **Diseases:** Due to water logging various diseases occurs.

1.5 Types of Irrigation

Irrigation may be broadly classified into:

Surface Irrigation

- In this method, irrigation water is distributed to the agricultural land through small channels which flood the area upto a required depth.
- Water is applied and distributed either by gravity or pumping.
- This method is good for soils with low to moderate infiltration capacities and lands with uniform terrain.



(i) Flow irrigation

- Water available at higher level is supplied to a lower level by the action of gravity.

(ii) Lift irrigation

- Water available at lower level is lifted to a higher level by mechanical or manual means and then supplied for irrigation. (e.g. pumps etc.)
- Mostly tubewells are used for this purpose.

Flow irrigation can be further subdivided into:

(a) Perennial irrigation (b) Flood irrigation

Subsurface Irrigation

- In this method, water flows underground and nourishes plant roots by capillarity.
- Water is applied to the root zones of crops by underground network of pipes.
- The network consists of main pipe, sub main pipes and lateral perforated pipes.
- This method is suitable for soils which are highly permeable.

It may be divided into following two types:

(i) Natural Sub-irrigation

Leakage water from channels during its passage through sub soil irrigates crops sown on lower lands.

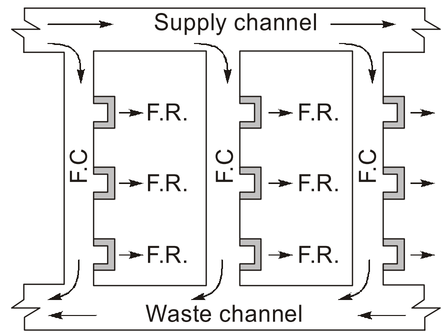
(ii) Artificial Sub-irrigation

- In this method, a system of open jointed drain is artificially laid below the soil.
- This is costly process, so recommended in areas where crops provide high returns.

1.6 Methods of Irrigation

1. Free flooding
2. Border flooding
3. Check flooding
4. Basin flooding
5. Furrow irrigation method
6. Sprinkler irrigation method
7. Drip irrigation method

Free Flooding or Ordinary Flooding

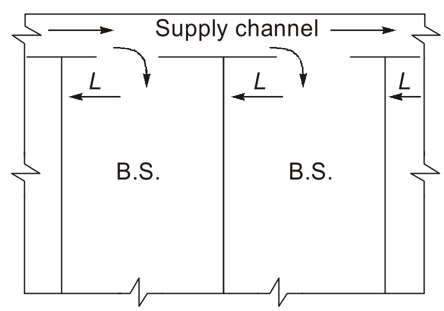


F.C. = Field Channel
F.R. = Field Regulator

- Since the movement of water is not restricted, it is some times called wild flooding.
- In this method contour-ditches called subsidiary ditches are made and are generally spaced at about 20 to 50 meters apart.
- This technique is suitable for sloppy land and crops like pastures etc.
- The water application efficiency in this technique is low.

NOTE: This method may be used on rolling land (topography irregular) where borders, checks, basins and furrows are not feasible.

Border flooding



B.S. = Border Strips
L = Leeves

- In this method land is divided in to a number of strips, separated by low levees called borders. The land area is confined between 10 to 20 m width and 100 to 400 m length of the each strip.
- Land is prepared perpendicular to the direction of flow in ditch.
- Let the discharge through supply ditch = Q
  The depth of water flowing over the strip = y
  Rate of infiltration of the soil = f
  Area of the land irrigation = A
  The Approximate time required to cover the given area is given by

$$T = 2.3\frac{y}{f}\log_{10}\left(\frac{Q}{Q - f\cdot A}\right)$$

- The maximum area that can be irrigated with a supply ditch of discharge Q, and the soil having infiltration capacity f is given by

$$A_{max} = \frac{Q}{f}$$

- This method is very common in India. The shorter and narrower strips are found to be more efficient.

NOTE: To prevent water from concentrating on either side of the border, the land should be levelled perpendicular to the flow.

Example-1.1 Determine the time required to irrigate a strip of land of 0.04 hectares in area from a tubewell with Q = 0.02 cumecs; f = 5 cm/hr and y_{avg} = 10 cm

where, Q = discharge through the supply ditch
y_{avg} = average depth of water flowing over the strip
f = infiltration rate of the soil

Also, determine the maximum area that can be irrigated from the tubewell.

Solution: Given, $A = 0.04 \text{ ha} = 0.04 \times 10^4 \text{ m}^2 = 400 \text{ m}^2$

$$Q = 0.02 \text{ m}^3/\text{s}$$

$$f = 5 \text{ cm/hr} = \frac{0.05}{3600} \text{ m/s}$$

$$y = y_{avg} = 10 \text{ cm} = 0.1 \text{ m}$$

$$t = 2.303 \frac{y}{f} \log_{10}\left(\frac{Q}{Q - fA}\right)$$

$$= 2.303 \frac{0.10}{0.05/3600} \times \log_{10}\left(\frac{0.02}{0.02 - \frac{0.05}{3600} \times 400}\right)$$

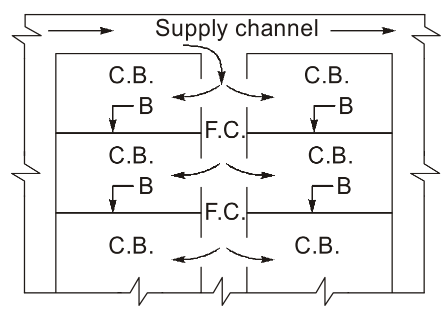
$$= 16581.6 \times 0.14 = 2343.46 \text{ s} = 39.06 \text{ min}$$

Maximum area that can be irrigated,

$$A_{max} = \frac{Q}{f} = \frac{0.02}{0.05} \times 3600 = 1440 \text{ m}^2$$

Check Flooding

- This is similar to ordinary flooding except that water is controlled by surrounding the check area with low and flat levees.
- The confined plot area generally is kept between 0.2 to 0.8 hectares.

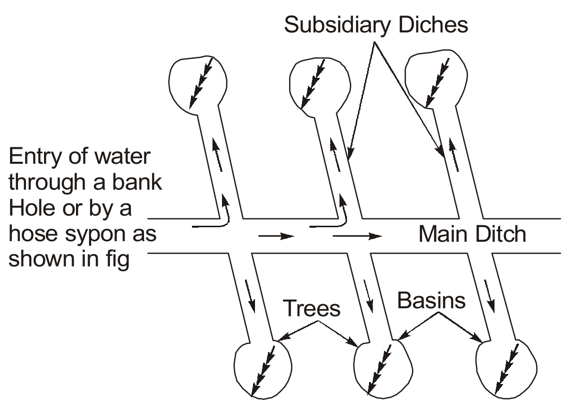


F.C. = Field Channel
B = Bunds
C.B. = Check Basin

NOTE: This method is suitable for more permeable soils as well as for less permeable soils.

Basin flooding

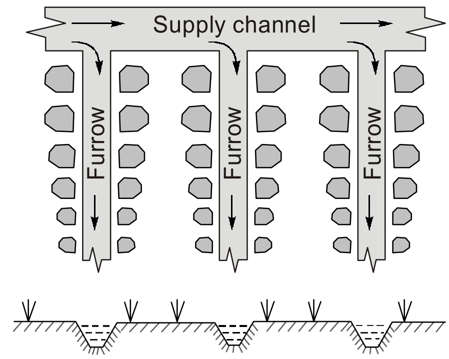
This method is a special type of check flooding.



(a) Plan view

NOTE: This method is adopted specially for orchard trees.

Furrow Irrigation



- In furrow irrigation method only 1/5 to 1/2 of the land area is wetted by water.
- In this method evaporation losses are less and less pudding of soil is required.

NOTE: Furrows vary from 8 to 30 cm deep, and may be as much as 400 meters long.

Sprinkler Irrigation

- Water is sprayed through a network of pipes and pumps. This method gives uniform distribution of water.
- This method is suitable when
  1. Topography is irregular.
  2. When soil is excessive permeable or highly impermeable.
  3. When water table is high.
  4. When water is scarce.
- Advantages of this method are
  1. Seepage losses are less.
  2. Leveling of land is not required.
  3. Fertilizers and insecticides can be mixed with the water.
  4. This prevents salinity and water logging.
  5. Less labour work is required.
- Disadvantages of this method are:
  1. Evaporation losses are high.
  2. Initial cost and operating cost are high.
  3. Not suitable for heavy irrigation (e.g. for rice).
  4. Technical persons are required to look after.
  5. Larger energy power is required.

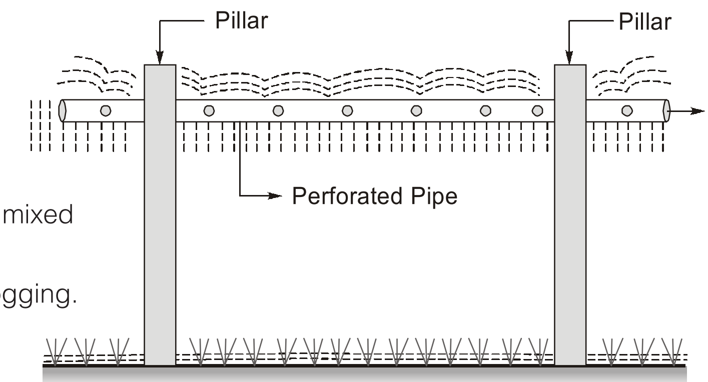


Fig. Perforated lateral pipes

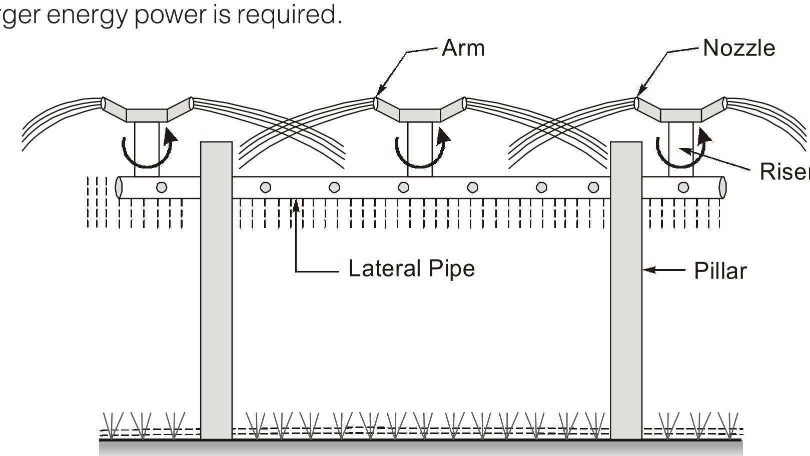


Fig. Rotary sprinklers

NOTE: It is a costly process and widely used in USA.

Example-1.2 Which of the following statement is correct for sprinkler irrigation method?

(a) It is used for rise and jute.
(b) It is used for soil having low infiltration rate.
(c) It is best suitable for very light soil
(d) It is requires borders and field channel

[SSC-JE : 2017]

Answer: (c)

Drip irrigation: (Trickling Irrigation)

- In this method water is directly applied to the root zone of the plants through drip nozzles.
- Evaporation and percolation losses are least.

NOTE: The drip nozzles, also called emitters, or valves, are fixed on laterals, at regular intervals of about 0.5 to 1 m or so, discharging water at very small rates of the order of 2 to 10 litres per hour.

1.7 Important Irrigation Projects in India

1. Bhakra Nangal Project
2. Damodar Valley Project
3. Farraka Barrage Project
4. Gandak Project
5. Godawari Barrage Project
6. Hirakud Project
7. Mahanadi Delta Project
8. Mayurakshi Project
9. Kosi Project
10. Tungabhadra Project

Types of irrigation projects

Projects	Irrigation Potential (CCA)	Cost of Project
Major Irrigation Projects	> 10,000 ha	> 5 crore
Medium Irrigation Projects	2000 – 10000 ha	0.25-5 crore
Small Irrigation Projects	< 2000 ha	0.25 – 0.5 crore

1.8 Quality of Irrigation Water

The quality of the irrigation water very much depends on the constituents of the soil which is to be irrigated. The various types of impurities, which make the water unfit for irrigation are classified as:

Sediment concentration in water

- When the fine sediment from water is deposited on sandy soils, the fertility is improved. On the other hand if sediments have been derived from the eroded areas, it may reduce the fertility or decrease soil permeability.
- Sedimented water creates troubles in irrigation canals and increases the maintenance cost.

Concentration of soluble salts

- Salts of Na, K, Ca. & Mg may be injurious, however the effect of the salts on the plant growth depends upon the total amount of salt in the soil solution.
- If salt concentration > 700 ppm then it is harmful to some plants. But if salt concentration exceeds 2000 ppm then irrigation water is injurious to all crops.
- The salinity concentration of the soil solution (C_s) after the consumptive water (C_u) has been extracted is given by

$$C_s = \frac{C.Q}{Q-(C_u - p_{eff})}$$

Where, Q = The quantity of water applied ; C_u = Consumptive use of water

p_{eff} = Useful rainfall ; C = Concentration of salt in irrigation water.

- The salt concentration is generally measured by determining the electrical conductivity of water. It has been found that salt concentration is directly proportional to electrical conductivity (EC). The EC is expressed in micro mhos/cm.

S.No.	Types of water	Electrical conductivity (mmhos/cm)	Use in Irrigation
1.	Low salinity (C_1)	100 to 250	Can be used for irrigation
2.	Medium salinity (C_2)	250 to 750	Can be used after leaching
3.	High salinity (C_3)	750 to 2250	Cannot be used for normal soils
4.	Very high	> 2250	Not suitable for irrigation

NOTE: The injurious effects of salts on the plant growth depend upon the concentration of salts left in the soil.

Proportion of sodium ions to other cations:

- The proportion of sodium ions with respect to Ca & Mg ions is less and generally it is less than 5% of the total exchangeable cations.
- The proportion of sodium ions present in the soils, is generally measured by a factor called Sodium Absorption Ratio (SAR) and represents the sodium hazards of water.

  Sodium hazards of water.

$$\text{SAR} = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

The concentration of the ions is expressed in equivalent per million (epm).

$$\text{epm} = \frac{\text{Concentration(in mg/L)}}{\text{Combining weight}}$$

where, $$\text{Combining weight} = \frac{\text{Atomic weight}}{\text{Valence}}$$

- The SAR Value can be reduced by adding gypsum ($CaSO_4$) to the water or to the soil.

S.No.	Types of value	SAR Irrigation	Use in
1.	Low sodium water (S_1)	0 to 10	Can be used for all crops
2.	Medium sodium water (S_2)	10 to 18	Appreciably hazardous in fine textured soils
3.	High sodium water (S_3)	18 to 26	Harmful for most of the soils. High leaching and gypsum is required if water is used for irrigation
4.	Very high sodium water (S_4)	Above 26	Generally not suitable for irrigation

NOTE: High sodium soils are, therefore, plastic, sticky when wet, and are prone to form clods, and they crust on drying.

Concentration of Toxic Elements

Boron and Selenium may be toxic to plants. Traces of Boron are essential to growth of plants but if its concentration exceeds 0.3 ppm, it may be proved to be toxic.

Selenium even at low concentration is toxic.

NOTE: The concentration above 0.5 ppm in dangerous to nuts, citrus fruits and deciduous fruits.

Bacterial Concentration

Though it is not a serious problem but for food crops and vegetables it may be disastrous.

Example-1.3 What is classification of irrigation water having following characteristics: Concentrations of Na, Ca and Mg are 22, 3 and 1.5 mill-equivalents per litre respectively, and the electrical conductivity is 200 micro mhos per cm at 25°C?

Solution:

$$\text{SAR} = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} = \frac{22}{\sqrt{\frac{3+1.5}{2}}} = \frac{22}{\sqrt{2.25}} = \frac{22}{1.5}$$

$$\text{SAR} = 14.67$$

If SAR is between 10 to 18, then it is classified as medium sodium water and is represented by S2.

For electrical conductivity between 100 to 250 micro mhos per cm at 25°c, then irrigation water is classified as C1 water.

Hence, the given water is classified as C1-S2 water.

■■■■

STUDENT'S ASSIGNMENTS

Q.1 Irrigation is basically required in
(a) humid regions (b) arid regions
(c) semi arid regions (d) all of the above

Q.2 Pinpoint the correct statements:
(a) Irrigation helps in adopting mix cropping.
(b) 'Mixed cropping' means sowing of a different crop.
(c) Over irrigation may lead to saving in fertilizers.
(d) Irrigation helps in avoiding mixed cropping.

Q.3 In flood irrigation preferred method of applying irrigation water to the comparatively steeper rolling land is
(a) check flooding (b) Border flooding
(c) wild flooding (d) basin flooding

Q.4 In a field under furrow irrigation, 'furrows' are referred to represent
(a) ridges on which crops are grown
(b) narrow ditches which carry irrigation water
(c) both (a) and (b)
(d) neither (a) or (b)

Q.5 In a mildly scarce area, the drip irrigation could be preferred for growing
(a) Wheat (b) Fodder
(c) Rice (d) Fruits and Vegetables

Q.6 Addition of gypsum to irrigation water is recommended to overcome difficulties posed by
(a) highly saline irrigation supplies
(b) irrigation supplies containing high quantities of sodium
(c) irrigation supplies containing heavy sediment
(d) all of the above

Q.7 High sodium content in irrigation water is
(a) generally good
(b) generally bad
(c) generally good, but bad for a few crops
(d) generally bad, but good for few crops

Q.8 Salinity in irrigation water is measured by
(a) SAR value
(b) electrical conductivity value
(c) pH-value
(d) none of the above
[KPSC-2015]

Q.9 The Sodium Absorption Ratio (SAR) of an irrigation water is 8. This water will be called
(a) low sodium water
(b) medium sodium water
(c) high sodium water
(d) none of the above

Q.10 Most suitable water for irrigation is
(a) C1-S1 (b) C2-S2
(c) C4-S1 (d) C1-S4

Q.11 On rolling land method of applying water is
(a) Check flooding (b) Free flooding
(c) Border flooding (d) Furrow flooding
[SSC-JE : 2017]

Q.12 Select the incorrect statement:
(a) Intensive irrigation should be avoided in areas susceptible to water logging.
(b) Extensive irrigation should be adopted in areas susceptible to water logging.
(c) Lift irrigation increase water logging.
(d) All of these
[MPPSC-2017]

Q.13 Which one is the best method of the reclamation of the acidic soils
(a) leaching
(b) provision of good drainage
(c) using gypsum as a soil amendment
(d) use limestone as soil amendment
[ESE-2002, SSC-JE : 2018]

Q.14 Sprinkler irrigation system is suitable when
(a) the land gradient is steep and the soil is easily erodible
(b) the soil is having low permeability
(c) the water table is low
(d) the crop to be grown have deep roots

Q.15 A soil sample has an exchangeable sodium percentage of 16%, it's electrical conductivity is 3.2 mill-mhos/cm and pH of 9.5. How is the soil classified?
(a) Saline soil (b) Saline-alkaline soil
(c) Alkaline soil (d) None of the above

Q.16 An identified source of irrigation water has ion concentration of Na^+, Ca^{2+} and Mg^{2+} as 20, 10 and 8 milli-equivalent per litre, respectively. The SAR of this water is approximately
(a) 2.06 (b) 6.67
(c) 2.67 (d) zero

Q.17 The time required to irrigate a strip of area 0.203 hectare by a stream discharge of 0.043 cumec, to provide an average depth of 6.35 cm to the field is (assume average rate of infiltration to be 5 cm/h)
(a) 2.75 hour (b) 1.35 hour
(c) 1.5 hour (d) 1.90 hour

Q.18 Identify the correct statements:
In the drip irrigation method
1. Deep percolation and run-off are eliminated.
2. Water application efficiency is very high.
3. Evapotranspiration is completely eliminated.
4. Fertilizer's can be applied economically along with water.

(a) 1 and 3 (b) 2, 3 and 4
(c) 1, 2 and 4 (d) 1, 2 and 3

ANSWER KEY / STUDENT'S ASSIGNMENTS

1. (d)	**2.** (d)	**3.** (c)	**4.** (b)	**5.** (d)
6. (b)	**7.** (b)	**8.** (b)	**9.** (a)	**10.** (a)
11. (b)	**12.** (c)	**13.** (d)	**14.** (a)	**15.** (c)
16. (b)	**17.** (b)	**18.** (c)		

HINTS & SOLUTIONS / STUDENT'S ASSIGNMENTS

9. (a)

For SAR value 0 to 10 irrigation water is classified as Low Sodium Water (S_1)