Draft Study Material

Irrigation Service Technician

(Qualification Pack: Ref. Id. AGR/Q1104)

Sector: Agriculture

(Grade XI)

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION
(a constituent unit of NCERT, under Ministry of Education, Government of India)
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Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives.

The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material.

Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material.

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Date: 20 June 2024

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Module 1	History and Introduction of Irrigation

Module Overview

Irrigation is a critical agricultural practice involving water's-controlled application to plants at specific intervals to support their growth and productivity. This module explores the significance of irrigation in agriculture, its methods, tools, and efficiency metrics. It highlights the importance of irrigation in addressing insufficient rainfall, improving soil fertility, enhancing crop yield, and ensuring sustainable farming practices. Furthermore, the module introduces modern and traditional irrigation techniques, agro-climatic zones, and methods for efficient water management.

Learning Outcomes

After completing this module, you will be able to:

- Define irrigation and explain its necessity in agriculture.
- Identify the various sources of irrigation water and understand their utilization.
- Describe traditional and modern irrigation methods, including their advantages and limitations.
- Understand the concept of irrigation efficiency and calculate different efficiency metrics.
- Explain land levelling methods and their importance in irrigation.
- Discuss the water requirements of different crops and factors affecting crop water needs.
- Differentiate between agro-climatic zones and their role in agricultural planning.

Module Structure

1.1. Introduction to Irrigation
1.2. History of Irrigation
1.3. Topography
1.4. Land Levelling
1.5. Equipment Used in Irrigation
1.6. Agro-Climatic Zones
1.7. Water Requirement of Different Crops
1.8. Traditional Irrigation Methods
1.9. Concepts of Irrigation Efficient

1. Introduction to Irrigation

"Irrigation means artificial application of water for plant growth which is required during their development stage".

Fig.1.1: Irrigation

Irrigation is the artificial application of controlled amounts of water to plants at required intervals. It also helps grow crops, maintains landscapes in dry areas and during periods of less than average rainfall, and makes the barren soils green. Irrigation has an important part in crop production, including frost protection, removal of weed growth in grain fields, and also stopping soil consolidation. In contrast, agriculture that depends only on direct rainfall is called rain-fed.

When required amounts of water are applied to the plant at particular intervals is known as Irrigation. It helps to grow the crops, to maintain the landscapes, and also maintain the moisture distribution or moisture requirements in the soil surface. It also has other uses in crop production, preventing soil consolidation, and also helps those areas which are prone or dry. This artificial application of water gives benefit chance to the farmers, that maintain their field moisture at a controlled amount of water.

"IRRIGATION IS THE APPLICATION OF WATER TO THE SOIL TO SUPPLY THE MOISTURE ESSENTIAL FOR PLANT GROWTH"

Source by - Agricultural Practices and Irrigation

1.1. **Need for Irrigation:** When rainfall is not sufficient for the plant, must receive the additional water/moisture from another source because plants required an adequate amount of water for their growth. In other words, in agriculture crops that require an adequate amount of water or moisture for their proper development, when the rainfall is insufficient then the artificial application of water is applied.

Irrigation: Irrigation means, watering the land to make it ready for agriculture. It is the process of application of water to crops through artificial channels to grow them. Water is vital for the growth of plants and trees. And, there can be no plants or crops if they do not have access to water in any form. It is, thus, crucial to supply water to crops and plants in time as per their need. The supply of water to plants comes from various water resources like:

- **i.** Wells
- **ii.** Ponds
- **iii.** Lakes
- **iv.** Canals
- **v.** Dams and Reservoirs

Importance of Irrigation: Irrigation is necessary for agriculture and farming.

1. Firstly, irrigation enables growth and photosynthesis in plants. Plants absorb minerals and nutrients from the soil via their roots. These minerals dissolve in the water present in the soil. Then the water transports these nutrients to all parts of the plant. In this way, it enables growth and photosynthesis.
2. Secondly, it provides the moisture that is crucial during the germination phase of the plant's life cycle.
3. Thirdly, it helps increase soil fertility by adding moisture to it. It also makes the land easier to plow.
4. Lastly, it increases the yield from the farm.

Purpose of Irrigation

- **i.** Providing insurance against short-duration droughts.
- **ii.** Reducing the hazard of frost (increase the temperature of the plant).
- **iii.** Reducing the temperature during hot spells.
- **iv.** Washing or diluting salts in the soil.
- **v.** Softening tillage pans and clods.
- **vi.** Delaying bud formation by evaporative cooling.
- **vii.** Promoting the function of some micro-organisms.

1.2 History of Irrigation

Irrigation is a very important part of agriculture, which gives the desired amount of water for particular crops. Here is a brief history of irrigation from the earliest days until modern times.

Table 1.1: History of Irrigation of the World

S. No.	Place	Method	Year
01	Egypt and Mesopotamia	Flood Method Dams and Canals	6,000 BC 3000 BC
02	China and India	Terrace irrigation method	4,000 BC
03	Sri Lanka	Underground canals	About 300 BC
04	North America	Chaco and Hohokam systems	900 AD
05	North Africa	Assyrian irrigation system	BC
06	Mexico	Dams and Canals	BC
07	Romans	Dams and Reservoirs	2,000 years

Irrigation has come a long way since it was first invented thousands of years ago. Localized irrigation is the name used to describe various types of irrigation methods used today. It involves water being distributed under pressure to an exact location, and it includes drip irrigation and sprinkler irrigation. This allows greater accuracy and control over the distribution of water, which is essential for many types of modern-day intensive farming. Modern irrigation systems are very advanced, and there are various systems in use around the world.

Surface systems are still in use today and involve the water being moved across the surface of a farming area to wet the soil. This is one of the oldest techniques used, and it is similar to irrigation through the flooding of rivers, which dates back thousands of years. In-ground systems are widely used in commercial settings. This is when the irrigation system is hidden in the ground so that the area looks cleaner and the pipes and other devices do not get in the way. Sub-irrigation is a more advanced form of irrigation that is widely used around the world. This involves artificially raising the level of the water table below the ground, which then moistens the soil from below rather than applying water onto the soil from above. It is a popular technique in many places around the world, and it is also used in greenhouses.

Irrigation demonstrates the ability of humans to control our world through the use of innovative techniques. It has been essential for the successful growing of crops right across the world for thousands of years, and it remains so to this day. Irrigation techniques may continue to develop, but the basic process of artificially directing water towards agricultural land has remained a mainstay of farming for thousands of years and has allowed humans to dominate their environment wherever they live.

1.2.1 History of Irrigation Development in India

- Irrigation is a very ancient science. Irrigation has been practiced in India from time immemorial and so has been the construction of canals.
- The Vedas are replete with references to wells, tanks, canals, and dams. Smritis too contain evidence of early irrigation works.
- The ancient rulers of India took a keen interest in the provision of irrigation facilities. The early irrigation works were not primitive but had a scientific basis. The most outstanding example of engineering talent in ancient times is manifest in the bold conception and construction of grand anicut across river Cauvery in the second century A.D.
- The British started irrigation development in the nineteenth century. They constructed dams such as Periyar and Mettur; the Nizams agar and Krishnarajasagar were constructed by the princes in their native states.
- Further, the British introduced a definite irrigation policy in 1854 with the setting up of the Public Works Department and instituting a separate fund for irrigation works.
- Two categories of irrigation work, namely Minor works and Major works came into existence. Minor works that were undertaken in principle more for the sake of protecting the existing cultivation and revenue from retrogression than as revenue-producing works continued to be financed out of the general revenues. Later minor irrigation works generally included private works (particularly their renovation) and private irrigation works formed a major constituent of the Grow More Food Campaign.
- Public tube wells were also included in the category of minor irrigation works when the department of agriculture was constituted in 1845. Major works were required to satisfy the productivity criterion.
- Later the Famine Commission (1880) and the First Irrigation Commission (1928) laid great stress on encouraging private works (wells, tanks, etc.,) to overcome recurrent famines.
- During the last 150 years, eight severe famines have occurred; the last one was in Bengal as late as 1943. In tropical and subtropical countries like India, famines occur due to drought conditions.

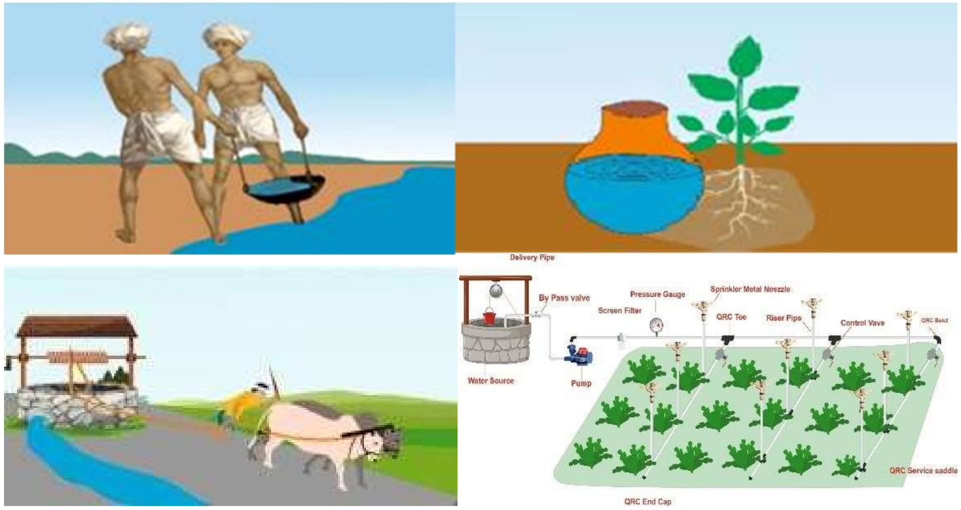


Fig.1.2: View of different Irrigation Methods

1.2.2 **Different types of soils and topography, land leveling concepts** As soil is one of the important aspects of irrigation, we must know the character/ property of the soil., it helps planning and application during irrigation.

Soil: Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. *Soil* is the material found on the surface of the earth that is composed of organic and inorganic material. Soils are complex mixtures of minerals, water, air, organic matter, and countless organisms that are the decaying remains of once-living things.

Types of soils: Soil is a natural resource that can be categorized into different soil types, each with distinct characteristics that provide growing benefits and limitations. Identifying the type of soil, you require for a project is paramount to support the healthy growth of plant life. Soil can be categorized into sand, clay, silt, peat, chalk, and loam types of soil based on the dominating size of the particles within a soil.

1. **Sandy soil:** Sandy Soil is light, warm, dry, and tends to be acidic and low in nutrients. Sandy soils are often known as light soils due to their high proportion of sand and little clay (clay weighs more than sand). These soils have quick water drainage and are easy to work with.

They are quicker to warm up in spring than clay soils but tend to dry out in summer and suffer from low nutrients that are washed away by rain. The addition of organic matter can help give plants an additional boost of nutrients by improving the nutrient and water holding capacity of the soil.

Fig.1.4: Clay Soil

2. **Clay Soil:** Clay Soil is a heavy soil type that benefits from high nutrients. Clay soils remain wet and cold in winter and dry out in summer. These soils are made of over 25 percent clay, and because of the spaces found between clay particles, clay soils hold a high amount of water. Because these soils drain slowly and take longer to warm up in summer, combined with drying out and cracking in summer, they can often test gardeners.

Fig.1.5: Silt Soil

3. **Silt Soil:** Silt Soil is a light and moisture-retentive soil type with a high fertility rating. As silt soils compromise medium-sized particles, they are well-drained and hold moisture well. As the particles are fine, they can be easily compacted and are prone to washing away with rain. By adding organic matter, the silt particles can be bound into more stable clumps.

Fig.1.6: Peat Soil

4. **Peat Soil:** Peat soil is high in organic matter and retains a large amount of moisture. This type of soil is very rarely found in a garden and often imported into a garden to provide an optimum soil base for planting.

Fig.1.7: Chalk Soil

5. **Chalk Soil:** Chalk soil can be either light or heavy but always highly alkaline due to the calcium carbonate or lime within its structure. As these soils are alkaline, they will not support the growth of ericaceous plants that

require acidic soils to grow. If chalky soil shows signs of visible white lumps then they can't be acidified and gardeners should be designed to only choose plants that prefer alkaline soil.

Fig.1.8: Loam Soil

6. **Loam Soil:** Loam soil is a mixture of sand, silt, and clay that are combined to avoid the negative effects of each type. These soils are fertile, easy to work with, and provide good drainage. Depending on their predominant composition they can be either sandy or clay loam. As the soils are a perfect balance of soil particles, they are considered to be a gardener's best friend, but still benefit from topping up with the additional organic matter.

1.3 **Topography**

Topography is the study of the land surface. It also gives information about water resources below the surface. For example, topography refers to mountains, valleys, rivers, or terrain on the surface.

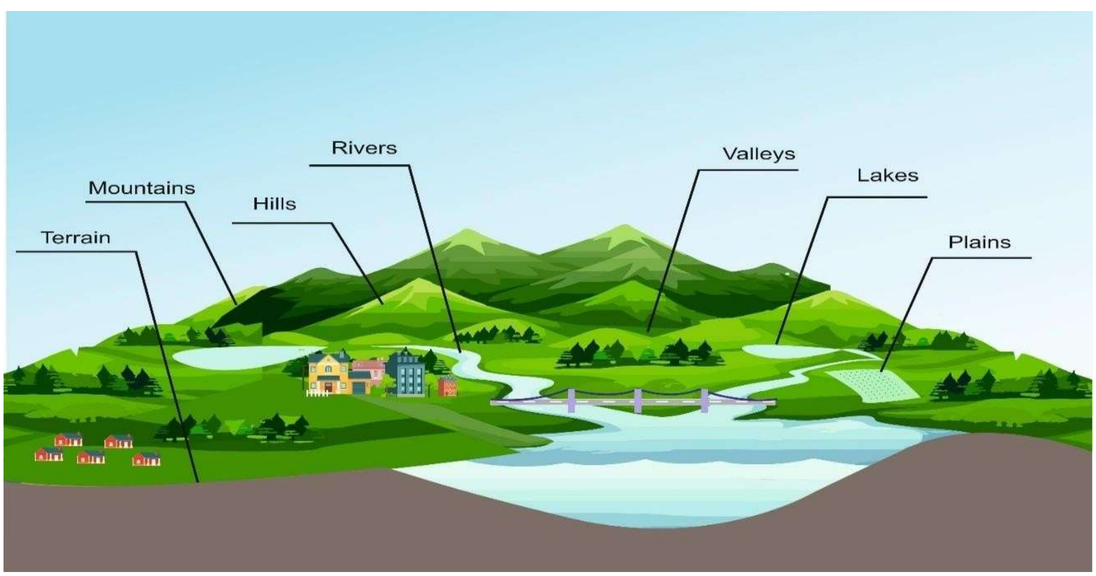


Fig.1.9: Topography

1.3.1 Topography Applications and Uses

Topographic maps show how rivers flow, how high mountains rise, and how steep valleys descend. They lay out the land such as in these examples:

- Geologists use topography to understand the tectonic activity, landforms, and where to dig a mine.
- Climate scientists tie topography into climate models to recognize air and water flow.
- Engineers use topographic maps to plan a road, construct a cell tower, or plan a hydroelectric dam.

1.4 **Land Levelling**

To bring uniformity in the land for avoiding the improper distribution of water on the surface, Land leveling is carried out. The irrigation plot is prepared in a way that no high and/or low spots disturb the uniform distribution of irrigation water on the field. It also ensures the optimal slope for water movement across a field when irrigated.

Importance of land leveling

Land leveling always improves the efficiency of water, labour, and energy resources utilization. The leveling operation, however, can be the most intensively disruptive cultural practice applied to the field and several factors should be considered before implementing a land leveling project. Major topographical changes will nearly always reduce crop production in the cut areas until fertility can be replaced. Similarly, equipment traffic can so compact or pulverize the soil that water penetration is a major problem for some time. The farmer has many activities that contribute to his productivity and therefore require his skill and labour. The irrigation system should be designed with him (or her) in mind. A field leveled too high standards is generally more easily irrigated than one where undulations require special attention.

Precise land leveling improves irrigation and energy efficiency. This also reduces the labour requirement for water applications. A properly leveled land can be properly irrigated and excess water can be drained out. However, major topographical changes in the process of land leveling may reduce crop production in the cut areas or additional soils may have to be added in cut areas for improving soil fertility. Further farm types of machinery movement compact soil and disturb soil pores and thereby reduces water movement through the side. Hence it is essential to estimate locations and volumes of cuts and fills, maintain proper cut-fill ratio by minimally affecting the crop production, and at the same time involving the less cost for land leveling. Hence land leveling design should be done properly.

Land leveling methods

There are several methods for land leveling such as – Plane method, the Profile method, the Plan inspection method, and the Contour adjustment method.

1. **Plane Method:** The plane method is the most commonly used method of land leveling design. This method is feasible whenever it is required to grade the field to a true plane. The procedure involves first determining the centroid of the field and then determining the average elevation of the field. This is obtained by adding the elevations of all grid points in the field and dividing the sum of elevations by the number of grid points. Any plane passing through the centroid at average elevation will produce an equal volume of cut and fill. Based on the longitudinal downfield grade and cross-field grade required for the field, the elevation of each grid point (It is a point at the intersection point of the two-line/ equal distant interlocking perpendicular, vertical and horizontal axes) is computed from the estimated centroid. The following example illustrates the method to estimate average elevation and elevation at different grid points for the desired slope.

Cut and Fill: Cutting and Filling is the process of moving earth from one place to another, to make ground more level. A 'cut' is made when the earth is cut from above the desired ground height and a 'fill' is when the earth is used to fill a hole to the desired ground level. Cutting and filling is a common technique used to create an even ground surface.

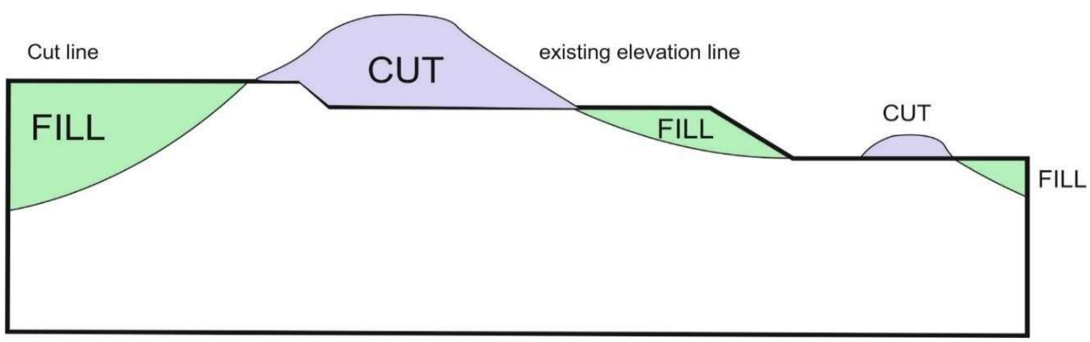


Fig.1.10: Cut and Fill

2. **Profile Method:** The profile method of land levelling design consists of plotting the profiles of the grid line and then laying the desired grade on the profiles. With this method, ground profiles are plotted and a grade is established that will provide an appropriate balance between cuts and fills as well as reduce haul distance to a reasonable limit. It is usually well-adapted to the levelling design of very flat land with undulating topography on which it is desired to develop a fairly uniform surface relief.

   Using the profile method, the designer works with profiles of the grid lines rather than with elevations. The profiles are normally plotted in one direction with the individual profiles located on the paper so that the datum line for each profile is in the correct position with adjacent profiles. Profiles may be plotted across the slope or down the slope. Trial grade lines are plotted on each profile based on the design criteria. The balance between cuts and fill is approximated by eye and compacting the areas between the plotted profiles and the trial grade line (A-line or slope of longitudinal in which any construction works built). Usually, several trials are necessary before a satisfactory set of grade lines are attained. The volume of cut and fill is computed and further adjustment of the grade lines is done to obtain the desired cut-fill ratio for the field.

3. **Plan Inspection Method:** The plan inspection is a rapid method. Although this method does not ensure minimum cuts and fills or the shortest length of haul, however, it gives a quick estimate. This method is adapted to moderate flat land slopes. A proposed ground surface map is overlaid on the original contour map. Hence it involves contour adjustment using the procedure. New contour lines are drawn using uniform slopes and spacing between them.

4. **Contour Adjustment Method:** A balance between the cut and fill can be approximated by maintaining the proposed contour, an average position concerning the original contour at the same elevation. Some of the design cut and fills from the stake points are compared with the total and then readjusted to obtain design levels. The contour adjustment method is adapted to smoothening of steep lands that are to be irrigated.

This method demands considerable judgment on the part of the designer to keep the earthwork and haul to a minimum. The design grade elevations are determined after a careful study of the topography. It involves trial and error methods considering downgrade and cross-slope limitations.

1.5 Equipment Used in Irrigation

1. Bulldozer
2. Scraper
3. Grader
4. Laser Land Leveler

- **Bulldozer:** A bulldozer is a large and powerful tractor fitted with a substantial metal plate used during building or conversion work, to drive large volumes of dirt, sand, snow, debris, or similar material and usually equipped with a claw-like system on the back to loosen heavily compacted materials.
- **Scraper:** A scraper is a device that has a small handle and a blade of metal or plastic that can be used to scrape a specific surface clean.
- **Grader:** A wheeled leveling machine for the land surface, particularly when making roads.
- **Laser Land Leveler:** It is a leveling machine used to smooth the ground surface with a certain degree of the desired slope from its average elevation using a directed laser beam in the field.

1.6 AGRO-CLIMATIC ZONES

Food and Agriculture Organization (FAO) defined an agro-climatic zone (ACZ) as a land unit represented accurately or precisely in terms of major climate and growing period, which is climatically suitable for a certain range of crops and cultivars. In other words, it is an extension of the climate classification keeping in view the suitability to agriculture.

Agro-Climatic Zone/Regions in India

In our country, there are fifteen broad agro-climatic zones based on physiography, soils, geological formation, climate, cropping patterns, and the development of irrigation and mineral resources for extensive agricultural planning and developing future strategies. It helps to integrate plans of the agro-climatic regions with the state and national plans to enable policy development based on techno-agro-climatic considerations. The agro-climatic zones with major crops in India are given below:

Table 1.2: Agro-Climatic Zone of India and their Major Crops

S.No.	Regions in India	Area	Crops
1.	Western Himalayan Region	Jammu and Kashmir, Himachal Pradesh, and the hill region of Uttarakhand.	Wheat, Maize, Barley, Oats, and Saffron; Peaches, Apricot, Pears, Cherry, Almond, Litchis, Walnut.
2.	Eastern Himalayan Region	Arunachal Pradesh, the hills of Assam, Sikkim, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and the Darjeeling district of West Bengal.	Maize, Rice, Potato, and Tea; Orchards of Pineapple, Litchi, Oranges, and Lime.
3.	Lower Gangetic Plain Region	West Bengal (except the hilly areas), eastern Bihar, and the Brahmaputra valley.	Rice, Pulses, Maize, Potato, and Jute.
4.	Middle Gangetic Plain Region	Parts of Uttar Pradesh and Bihar.	Wheat, Rice, Maize, Millets, Gram, Barley, Peas, Mustard, and Potato.
5.	Upper Gangetic Plains Region	Central and western parts of Uttar Pradesh and the Hardwar and Udham Nagar districts of Uttarakhand.	Rice, Wheat, Sugarcane, Millets, Maize, Gram, Barley, Oilseeds, Pulses, and Cotton.
6.	Trans-Ganga Plains Region	Punjab, Haryana, Chandigarh, Delhi, and the Ganganagar district of Rajasthan.	Sugarcane, Cotton, Wheat, Rice, Gram, Maize, Millets, Pulses, and Oilseeds.

7.	Eastern Plateau and Hills	Chhotanagpur Plateau, extending over Jharkhand, Orissa, Chhattisgarh, and Dandakaranya.	Rice, Maize, Oilseeds, Ragi, Gram, Millets,Potato, Tur, Groundnut, Soybean, Urad, Castor, and Groundnut.
8.	Central Plateau and Hills	Bundelkhand, Baghelkhand, Bhander Plateau, Malwa Plateau, and Vindhyachal Hills.	Millets, Wheat, Gram, Oilseeds, Cotton, and Sunflower.
9.	Western Plateau and Hills	The southern part of the Malwa plateau and Deccan plateau (Maharashtra).	Wheat, Gram, Millets, Cotton, Pulses, Groundnut, Oilseed, Sugarcane, Rice, Wheat, Oranges, Grapes, and Bananas.
10.	Southern Plateau and Hills	Interior Deccan includes parts of southern Maharashtra, the greater parts of Karnataka, Andhra Pradesh, and Tamil Nadu uplands from Adilabad District in the north to Madurai District in the south.	Millets, Oilseeds, Pulses, Coffee, Tea, Cardamom, and Spices.
11.	Eastern Coastal Plains and Hills	Coromandel and northern Circar coasts of Andhra Pradesh and Orissa.	Rice, Jute, Tobacco, Sugarcane, Maize, Millets, Groundnut, and Oilseeds.
12.	Western Coastal Plains and Ghats	Malabar and Konkan coastal plains and the Sahyadris.	Rice, Coconut, Oilseeds, Sugarcane, Millets, Pulses, and Cotton.
13.	Gujarat Plains And Hills	Hills and plains of Kathiawar, and the fertile valleys of Mahi and Sabarmati rivers.	Groundnut, Cotton, Millets, Wheat, Tobacco. Rice, and Oilseeds,
14.	Western Dry Region	West of Aravalli (Rajasthan).	Bajra, Jowar, Moth, Wheat, and Gram.
15.	Island Region	Andaman-Nicobar and Lakshadweep.	Rice, Millets, Areca Turmeric, Maize, Pulses, nut, and Cassava.

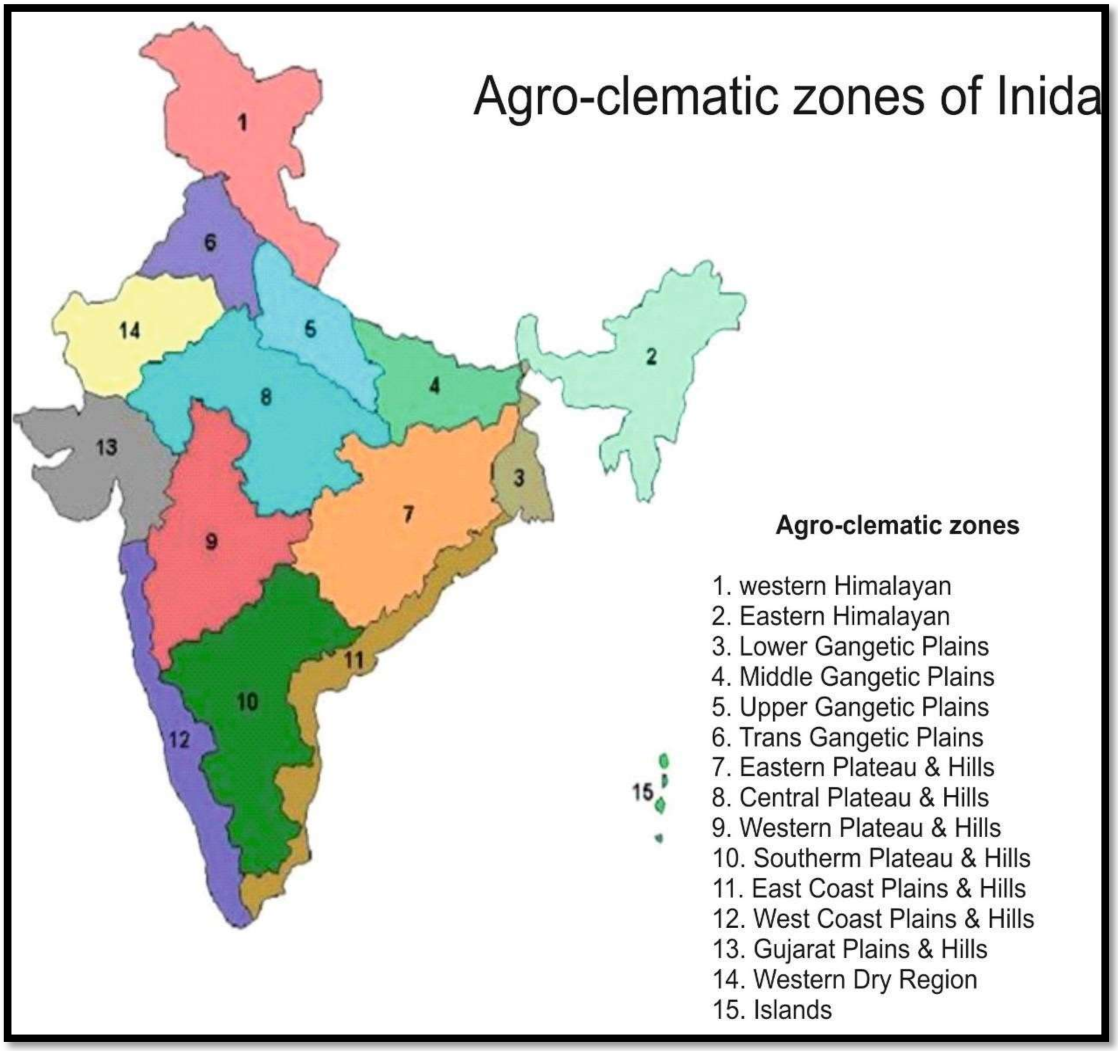


Fig.1.11: Agro-Climatic Zones in India

1.7 Water Requirement of Different Crops

The amount of water required by a crop in its whole production period (sowing to harvesting) is called a water requirement. The amount of water taken by crops varies as per soils and climate conditions.

Table 1.3: Water requirement of different crops

S.no.	Crop	Water Requirement (mm)
1.	Wheat	450-650
2.	Rice	900-2500
3.	Maize	500-800

4.	Sorghum	450-650
5.	Sugarcane	1500-2500
6.	Soybean	450-700
7.	Groundnut	500-700
8.	Cotton	700-1300
9.	Ragi	400-450
10.	Sunflower	350-500
11.	Castor	500
12.	Tobacco	400-600
13.	Tomato	600-800
14.	Potato	500-700
15.	Onion	350-550
16.	Chilies	500
17.	Bean	300-500
18.	Cabbage	380-500
19.	Pea	350-500
20.	Banana	1200-2200
21.	Citrus	900-1200
22.	Pineapple	700-1000
23.	Grape	500-1200

1.7.1 Component of crop water requirement

The amount of water required by various crops to develop optimally is known as crop water requirement (CWR).

1. Evaporation refers to the movement of water from the soil surface or water surface in field into the atmosphere.

2. Transpiration refers to the movement of water from the soil into a plant, up the plant body, and out the plant's leaves into the atmosphere. The crop water requirtemnet varies from place to place, crop to crop and depends on agro-ecological variation and crop characters.

The following features which mainly influence the crop water requirement are:

1. Crop factors - Variety, Growth stages, Duration, Plant population and Crop growing season.
2. Soil factors – Structure, Texture, Depth, Topography and Soil chemical composition.
3. Climatic factors – Temperature, Sunshine time, Relative humiodity, Rainfall and Wind velocity
4. Agronomic management factors – Irrigation method are used, Efficiency and frequency of irrigation, Tillage and other field operations.

1.7.2 Quantification of irrigation water

1. **Delta (Δ):** It is defined as the depth of water required by a crop during the crop season to meet its requirements. It does not have any revelance to the area of the cropped field. The depth of water required for a crop to fully grow in entire season is known as 'Delta'. It is expressed in 'mm or cm'.

$$\Delta = 864\ B/D$$

Where,

Δ in cm, B in days and D in ha/cumec

2. **Duty (D):** It is defined the total volume of irrigation water required for a particular type of crop to mature. It is expressed as acre/cusec or hectare/cumec.

3. **Base period:** The time on which crop is watered, the time from first watering to last watering of crop by which the crop grows. It is only watering period in which crop is irrigated. The base period is in days and denoted by 'B'.

4. **Net irrigation:** It is defined as the total amount of irrigation water required to bring the soil moisture content in the root zone depth of the crop to field capacity.

$$\sum NIR = n\frac{Mfci - Mbi}{100}.\rho bi.Di$$

Where,

NIR = net amount of water to be applied during an irrigation, cm.

Mfci = gravimetric moisture content at field capacity in the ith layer of the soil (%),

Mbi = gravimetric moisture content before capacity in the ith layer of the soil (%),

ρbi = bulk density of the soil in the ith layer, g/cm3

Di = depth of the ith soil layer, cm, within the root zone, cm. N = number of soil layers in the root zone D.

5. **Gross irrigation:** The gross water requirement is the total amount of water, inclusive of losses, applied through irrigation.

$$GIR = \frac{NIR}{\text{Over all irrigation efficiency}}$$

1.8 Irrigation Methods

Different irrigation methods are adopted as per the property of the soil and types of crops. Water is vital for the growth of plants and there can be no plants or crops if they do not have access to water in some form. Irrigation is carried out by traditional methods as well as modern methods.

1.8.1 Traditional Irrigation Methods

These irrigation systems were used in earlier years. However, even today some small farms in rural areas adopt these. Although they are cheaper than modern methods, they are not as efficient. Because they need human or animal labour to function. Some of these systems are,

1. **Moat:** It is also called the pulley system; it involves pulling up water from a well or other such source to irrigate the land. This is a time-consuming and labor-intensive process, but it is very cost-efficient. Also, using a moat avoids wastage of water. In it, water is drawn with the help of a pulley from a well to irrigate. It requires a lot of time and labour.

Fig.1.12: Moat / Pulley system

2. **Chain pump:** A chain pump consists of two large wheels connected by a chain. There are buckets attached to the chain. Further, one part of the chain dips into the water source. As the wheel turns, the bucket picks up water. The chain later lifts them to the upper wheel where the water gets deposited into a source. The empty bucket gets carried back down.

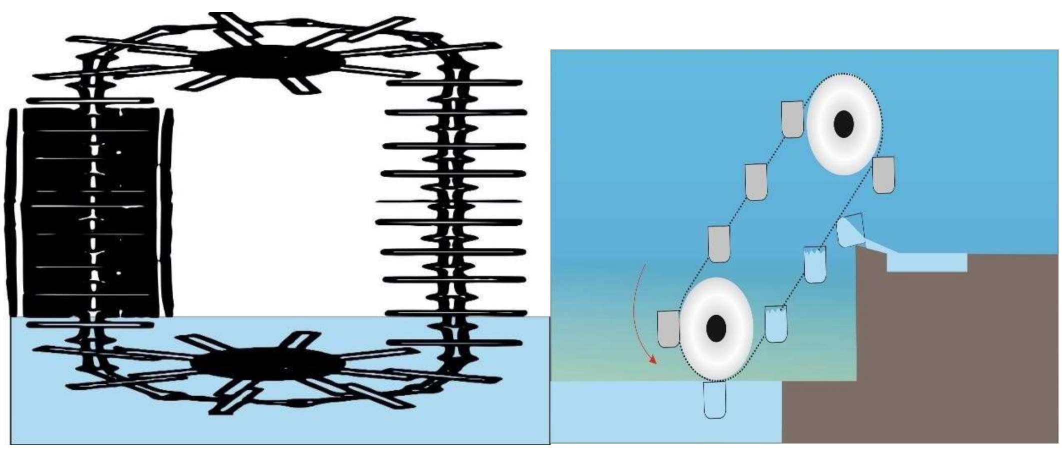


Fig.1.13: Chain pump

3. **Dhekli:** It is similar to a pulley system but instead of a pulley, a pole is used. At one end a bucket is tied and at the other some weight for counterbalance. It is a process of drawing water from a well or such a similar source. Here we tie a rope and bucket to a pole. At the other end, we tie a heavy stick or any other object as a counterbalance. And we use this pole to draw up water.

Fig.1.14: Dhekli Irrigation

4. **Rahat:** A large wheel is placed above the well which is turned with the help of an animal-like ox to draw water from the well. Rahat uses animal labour. Above the well, we tie a large wheel. An ox or cow would turn the wheel to draw the water from the well.

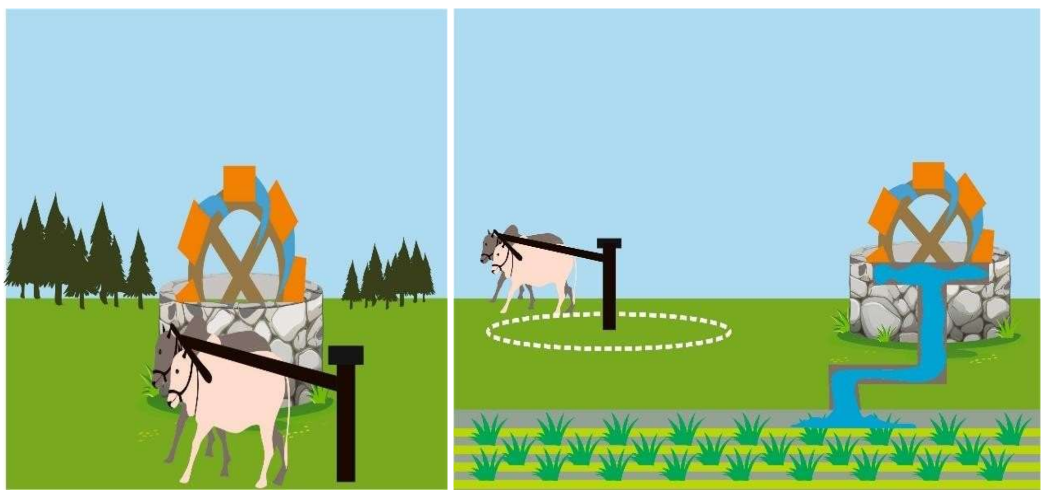


Fig.1.15: Rahat Irrigation

Modern Irrigation Methods

Agriculture or farming is a very ancient occupation for the human being, and so are methods of irrigation. We can see evidence of different irrigation techniques employed by ancient civilizations which include irrigation canals, dams, water storage facilities, structures like aqueducts, and the like.

The methods of irrigation can be divided into four main types such as - Surface irrigation, drip, sprinkler, and sub-surface:

1. **Surface Irrigation**: It is one of the most common methods of irrigation. Here water is applied to the soil with the help of gravity. Since the distribution of water is not regulated, surface irrigation is known as flood irrigation.

Fig.1.16: Surface Irrigation

This irrigation system is further classified into three other types of modern methods of irrigation. These are as follows-

A. **Furrow irrigation:** In this method, water is made to flow through shallow channels which are evenly spaced out and at a slope to the field. The water in these shallow channels is supplied through a variety of ways such as siphon, main ditch, gated pipe, etc.

Inflow rate, soil infiltration, slope, and shape of furrows, and surface roughness determine the speed of the water. It requires less capital investment, but it is one of the most labour intensive methods of irrigation.

Fig.1.17: Furrow Irrigation

B. **Basin and Border Irrigation:** Both of these techniques involve water running through the soil. However, in basin irrigation, water is supplied to a field which may result in ponding for a while. On the other hand, water is made to flow through ditches running through the ground with a drainage system at the end.

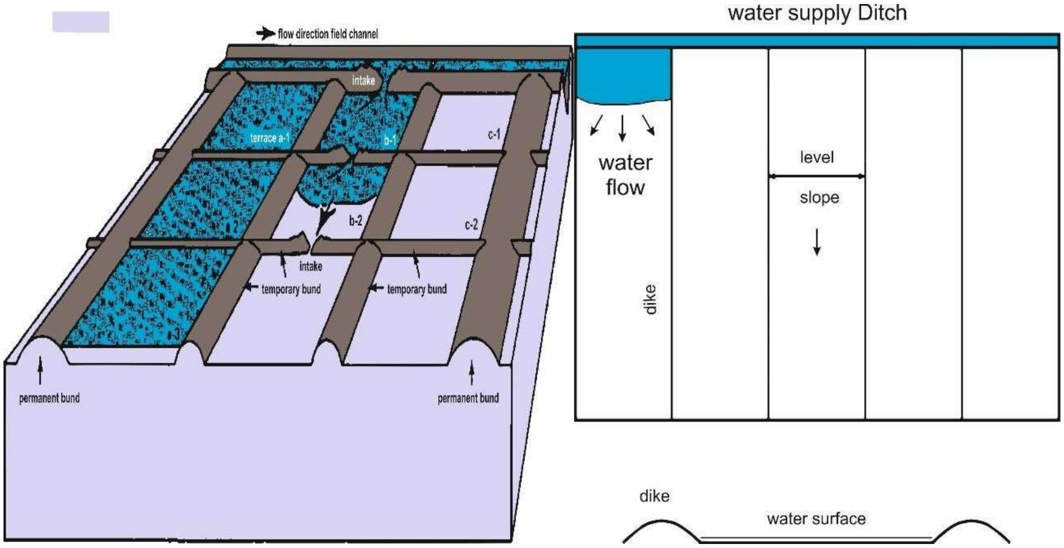


Fig.1.18: Basin Irrigation

2. **Drip Irrigation System:** Drip irrigation is sometimes referred to as trickle irrigation. It drips water into the soil at very low rates (2-20 liters/hour) using a system of small diameter plastic pipes equipped with outlets known as emitters or drippers. It is the most used irrigation system these days. In drip irrigation, we lay plastic pipes in rows near the crops or plants. These pipes have holes in them. The water seeps from these holes drop by drop, hence the name drip irrigation. Drip irrigation is one of the most efficient irrigation methods as it reduces water wastage in agriculture.

Fig.1.19: Drip Irrigation

Drip irrigation advantages

- It saves up to 70% more water than flood irrigation. With the water that is saved, more area may be watered.
- Crop matures quickly, expands steadily, and is healthier.
- Returns on investment are larger and faster when maturity is early.
- The effectiveness of fertiliser use increases by 30%.
- Reduced labour costs, interculturing costs, and fertiliser costs.
- Through the micro irrigation system itself, fertiliser and chemical treatment can be administered.
- It is also possible to cultivate productively on hilly, saline, waterlogged, sandy, and undulating terrains.

3. **Sprinkler System:** Sprinkler systems mimic the phenomenon of rain. In sprinkler systems, the pipes carry water to central locations on the farm. The sprinklers placed there, distribute the water across the fields. The sprinkler method is one of the most efficient irrigation methods to irrigate uneven land for agriculture. Besides, sprinkler systems provide the best coverage regardless of the size of the farm.

Fig No. 1.20: Sprinkler Irrigation

Sprinkler Irrigation system advantages

The following are some of the sprinkler irrigation system's main benefits:

- It is inexpensive and incredibly simple to put up. You won't need to spend a lot of money on manpower to set it up.
- There is no demand that you set up the sprinkler irrigation system in numerous places of your field.

- Setting up sprinkler irrigation has virtually little impact on crop growth. Thus, you won't suffer a significant loss.
- The plants can receive frequent applications of water without your assistance.
- Water will always be distributed equally.
- You may manage the amount of water delivered, allowing you to conserve water according to the needs and requirements of the plants.
- All sorts of soil can be used to set up sprinkler irrigation.
- Other uses for this technology include cooling during periods of high temperature.

1.9 Concepts of irrigation efficiency, conveyance, application, storage, distribution, field and crop water use efficiency.

Irrigation efficiency: It is a ratio of the amount of water used to meet the consumption use requirement of crop and necessary to maintain the salt balance in the root zone to the total amount of water diverted for irrigation.

It is a proportion of the total volume of water diverted for irrigation to the amount of water needed to meet the crop's consumption needs and to maintain the salt balance in the root zone.

$$Ei = 100 (S-P-R-O)/S$$

Where,

S = total amount of supplied water, P = total percolation

R = total runoff

O = operation losses in channels and pipelines

1. **Reservior Storage Efficiency:** It is the efficiency with which water is stored in the reservoir.

$$E_r = 100 \times \left(1 - \frac{V_e + V_s}{V_i}\right) = 100 \left(\frac{V_o + \Delta S}{V_i}\right)$$

Where,

Er = reservoir storage efficiency (%),
Ve = evaporation volume from the reservoir, Vs = seepage volume from the reservoir,
Vt = inflow to the reservoir,

Vo = volume of out flow from the reservoir,
ΔS = change in reservoir storage.

2. **Water Conveyance Efficiency:** It is the ratio between the water that delivered to the field or farm and that water divereted from the irrigation channel or water sourse. It is used to measure the efficiency of water conveyance systems associated with the canal network, water courses and field channels.It is represented as follows:

$$Ec = 100 (Wf/Wd)$$

Where,
Ec = conveyance efficiency (%),
Wf = the volume of water that delivered to the farm or field (m3)
Wd = the volume of water divereted (m3) from the source.

3. **Water Application Efficiency:** It is the ratio between the water stored in the root zone during irrigation and that water delivered to the field or farm.

$$Ea = 100 (Ws/Wf)$$

Where,
Ea = application efficiency (%),
Wf = the volume of water stored in root zone (m3)
Wd = the water delivered to the field or farm (m3).

4. **Water Storage Efficiency:** It is the ratio between the water stored in the root zone and that water needed in the root zone before irrigation.

$$Es = 100 (Ws/Wn)$$

Where,
Es = storage efficiency (%),
Ws = the volume of water stored in root zone (m3)
Wn = the water needed in the root zone prior to irrigation.

5. **Water Distribution Efficiency:** It is the ratio between the mean of numerical deviations from the average depth of water store during irrigation (Y) and the average depth stored during irrigation (d). Mathematically, it is expressed as:

$$Ed = (1 - (Y/d)) \times 100$$

Where,

Ed = distribution efficiency (%),

Y = Average numerical deviation in depth of water stored from average depth stored during irrigation

d = Average depth of water stored during irrigation.

6. **Water Use Efficiency:** It is defined as the weight of crop produce per unit depth of water over a unit area. It denotes the production of crops per unit water applied. It's unit kg/cm/ha.

A. **Crop Water Use Efficiency:** It is defined as the ratio of crop yield per amount of water depleted by the crop in the process of evapotranspiration (ET).

Crop water use efficiency = Y/ET

B. **Field Water Use Efficiency:** It is defined as the ratio of crop yield (Y) to the amount of water used in the field (WR).

Field water use efficiency = Y/WR

ACTIVITIES

Activity 01: Visit a different farm, where an irrigation system has been installed.

Material Required

1. Pen
2. Notebook

Procedure

1. First, visit the different farms.
2. Second, see the field which method was adopted by the farmer in their fields.
3. Write the name of the method adopted by the farmer.
4. Write their importance and application of methods.

Activity 02: Sketch drip irrigation system Material Required

1. Pen
2. Notebook

Procedure

1. First, visit the different farms.
2. Second, identify the drip irrigation system.
3. List out the component of the drip irrigation system
4. Sketch the drip irrigation system and label it.

CHECK YOUR PROGRESS

A. Short answer questions

1. What do you mean by Irrigation?
2. Briefly describe the land leveling and their methods?
3. Define the term soil and its types?
4. What do you mean by agro-climatic zones and list out their major crops?
5. Briefly describe the traditional and modern irrigation methods?
6. Explain the major factor that influencing the crop water requirement?
7. Describe the irrigation efficiency.

B. Fill in the blanks

1. Soil is the material found on the surface of the earth that is composed of ………… And material.
2. Geologists use ………….. to understand the tectonic activity, landforms, and where to dig a mine.
3. Cutting and filling in the process of ……………… from one place to another, to make ground more level.
4. A chain pump consists of two larges ___________ connected by a chain.
5. In sprinkler systems, the pipes carry water to ……………. locations on the farm.
6. The ……….. of water required for a crop to fully grow in entire season is known as 'Delta'.
7. ………………………. is defined as the weight of crop produce per unit depth of water over a unit area.

C. Multiple choice questions

1. The water requirement for a wheat crop is ……………..

A. 300-450 mm
B. 400-500 mm
C. 450-600 mm
D. 450-650 mm

2. In our country, there are …………….. broad agro-climatic zones based on physiography, soils, geological formation, climate, cropping patterns, and development of irrigation.

A. 10
B. 11
C. 13
D. 15

3. ____________ is the study of the land surface.

A. Leveling
B. Surveying
C. Topography
D. Geology

4. FAO full form is……………….

A. Field and Agriculture Organization
B. Food and Agriculture Organization
C. Fodder and Afforest Organization
D. Food and Animal husbandry Organization

5. It is the ratio between the water that delivered to the field or farm and that water diverted from the irrigation channel or water sourse.

A. Water Application Efficiency
B. Water Storage Efficiency
C. Water Distribution Efficiency
D. Water Conveyance Efficiency

6. It is the ratio between the water stored in the root zone and the water needed in the root zone prior to irrigation.

A. Water Application Efficiency
B. Water Storage Efficiency
C. Water Distribution Efficiency
D. Water Conveyance Efficiency

Module 2 Sprinkler Irrigation System

Module Overview

This module teaches the basics of designing, installing, and operating a sprinkler irrigation system. These systems are commonly used in farming and gardening to better use water and improve crop growth. The different types of sprinkler systems and the key factors that affect their operation, like water pressure. This module includes checking its parts and following the correct installation guidelines for effective use. Important topics include planning the layout, preparing trenches, fitting pipes, and installing components like valves, mainlines, sub-mains, laterals, and sprinkler heads. this module also covers how to operate and maintain the system and how to adapt it for different farming situations.

Learning Outcomes

After completing this module, you will be able to:

1. Define sprinkler irrigation and explain its suitability for different soil types and crops.
2. Classify various types of sprinkler irrigation systems and describe their features and applications.
3. Identify the units of measurement used in micro-irrigation systems and their significance.
4. Describe the key components of a sprinkler irrigation system, including pumps, pipelines, and sprinklers.
5. Recognize tools and materials required for maintaining sprinkler irrigation systems.
6. Perform the step-by-step installation of sprinkler systems, including head control units, trenches, pipes, and valves.
7. Identify the specifications and requirements for mainlines, sub-mains, laterals, and sprinkler heads.
8. Perform routine maintenance and troubleshoot common issues in sprinkler irrigation systems.
9. Analyse the adaptability, advantages, and limitations of sprinkler irrigation systems for various crops and terrains

Module Structure
2.1 Introduction to Sprinkler Irrigation
2.2 Types of sprinkler irrigation system
2.3 Design of sprinkler irrigation system
2.4 Components of the sprinkler irrigation system
2.5 Principle components of sprinkler irrigation system
2.6 Tools and Material required for installation of sprinkler irrigation system
2.7 Installation of Sprinkler Irrigation System
2.8 Operation and Monitoring of Sprinkler Irrigation System
2.9 Adaptability of sprinkler irrigation systems

2 Introduction: "A set of pipe and sprinkler network is composed in one system is called sprinkler irrigation system".

Fig.2.1: Sprinkler Irrigation

2.1 Sprinkler irrigation is a method of applying water like rain (break into small droplets). It is suited for most row, field, and tree crops. Water can be sprayed over or under the crop canopy. If a site is known to be windy most of the time, sprinkler irrigation will not be suitable. The sprinkler breaks up the water into droplets sized 0.5-4 mm. The drop size is controlled by the pressure and nozzle size of the sprinklers. The average rate at which water is sprayed onto the crops is measured in mm/hour. The water application rate depends on the size of sprinkler nozzles, operating pressure, and also the distance between the sprinklers. The water application rate must not exceed, the maximum allowable infiltration rate for the soil type. The excess water application rate will result in water loss, soil erosion, and surface sealing. There may be inadequate moisture in the root zone of crops or plants after irrigation and they may get damaged.

The force with which the water flows out of the sprinkler is known as its 'water pressure'. Water pressure is measured in pounds per square inch (psi). Therefore, sprinklers are designed to work at certain pressure levels, which are recommended as their operating pressure. If the pressure is above or below then the recommended level of water distribution will be affected. When the pressure is low, the water drops become larger and they cannot irrigate the crops that are far from the system. If the pressure is high, then the droplets will be smaller and the crops will not be irrigated evenly. It can also damage the sprinkler heads. Although sprinklers are adaptable to most soils, they are best suited for sandy soil. These can be used for irrigating lawns, gardens, and agricultural fields.

2.1.1 Units of measurement in micro irrigation system

Measurement of any physical quantity involves comparison with a certain basic, arbitrarily chosen, internationally accepted reference standard called 'unit'. The standards of measurement are useful for minimizing errors. The units for fundamental or base quantities are called 'fundamental' or 'base' units. The units of all other physical quantities can be expressed as combinations of the base units. Such units obtained for the derived quantities are called 'derived units. A complete set of these units, both the base and derived units, is known as a system of units.

These units, which are adopted for international use under the System International Units, are now employed for all scientific and technical purposes. There are seven fundamental units - metre, kilogram, second, ampere, kelvin, candela, and mole, and two supplementary units - radian and steradian. All other units are derived by the multiplication or division of these units without the use of numerical factors.

Table 2.1: Units of measurement

Psi	Pound per square inch
kPa	Kilopascal
Gal	Gallon
Gpm	Gallon per minute
Gph	gph Gallon per hour
L	Litre
Lph	Litre per hour
Lps	Litre per second
Ml	Milliliter
ml/min	Millilitre per minute
mm/h	Millimetre per hour
cm	Centimetre
m	Millimetre
M	Metre
m/sec	Metre per second
A	Area
in/hr	Inches per hour
Ft	Feet
ft/sec	Feet per second

2.2 Types of sprinkler irrigation system: Classification of different types of irrigation systems based on operating pressure, volume, and point of application are as follows:

i. Centre pivot
ii. Towable pivot
iii. Rain gun

iv. Impact sprinkler
v. Pop up sprinkler
vi. Linear move sprinkler

i. Centre pivot: The centre pivot is capable of irrigating most field crops. It consists of a single sprinkler lateral supported by a series of towers. It is anchored at one end and rotates around a fixed central point called 'pivot point'. The control panel attached to the pivot point gives commands to the central pivot machine. A drive unit or drive tower touches the ground, which contains necessary components for the machine to move. It consists of a base beam, drive train, wheels, and other structural support equipment. The towers are self-propelled so that the lateral rotates around the pivot point installed in the centre of the irrigated area. The long pipes between the drive units are called 'spans'.

Spans consist of the main water line, sprinklers, and a supporting structure to hold the weight between the towers. A tower box controls the drive unit components, about the direction and duration.

Fig. 2.2: Centre pivot

ii. **Towable pivot:** Towable pivot is similar to the centre pivot. But here, the pivot is towed away by a tractor. There are 3-4 wheels in the centre of the pivot, which make it possible to move the pivot from one place to another by pulling it with the help of the tractor. It helps farmers to carry out mechanized irrigation in an economical manner. It can easily irrigate fields as the machine can be towed away from one field to another in minimum time.

iii. **Rain gun:** A rain gun is used as a water spray mist or fog beam. It discharges water at less than 175 lph. It is used to irrigate trees and other crops separated widely. Fruit tree crops like citric fruits, mango, guava, avocado, etc., can be irrigated with a rain gun. The passage diameter of the rain gun is small. Therefore, the release of filtered water is essential, amounting up to a requirement of 60-80 mesh (250 to 177 microns). The minimum operating pressure is 1.5-2 kg/cm2. The heads of rain guns are mounted on plastic wedges (or piles) 20-30 cm above the ground. Rain gun is suitable for field crops like groundnut, onion, potato, sugarcane, cotton, and plantation crops, such as coffee and tea.

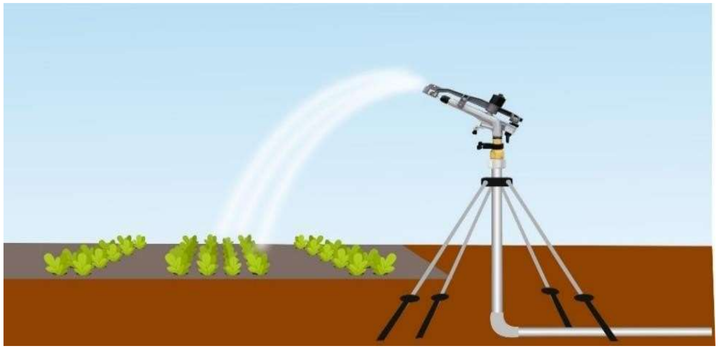


Fig. 2.3: Rain Gun

iv. **Impact sprinkler:** This sprinkler is driven in a circular motion by the force of outgoing water, and at least, one of its arms extends from the head. The sprinkler arm is repeatedly pushed back into the water stream by a spring. When the arm strikes the water stream, it scatters the stream and re-orients the flow, enabling a uniform watering area around the sprinkler. Impact sprinkler is recommended for closely spaced field crops like potato, leafy vegetables, cotton, oilseeds, pulses, cereals, fodder crops, etc.

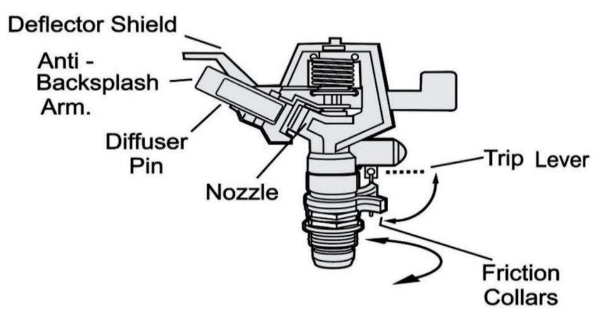


Fig. 2.4: Impact sprinkler

v. **Pop-up sprinkler:** A pop-up sprinkler consists of an inlet, body, cap, wiper seal, riser, nozzle, and radius adjustment screw. Such a sprinkler is portable and easy to install, thereby, making it ideal for irrigating lawns, seasonal flowers, and planting beds.

Fig. 2.5: Pop up sprinkler

vi. **Linear move sprinkler**: Linear move sprinkler irrigation system is similar to the centre pivot system in construction, except that neither end of the lateral pipeline is fixed. It is composed of a series of towers that are suspended and move laterally in the direction of rows. The whole line moves down the field perpendicular to the lateral. Water delivery to the continuously moving lateral is a flexible hose or open ditch pickup. Both the centre pivot and linear move systems are capable of high-efficiency water application. By 'water efficiency', it means reducing water wastage by measuring the amount of water required for a specific purpose and the amount of water delivered or used. Such a system requires high capital investment but is not labour intensive.

Fig. 2.6: Linear move sprinkler

2.3 Design of sprinkler irrigation system

The layout of a sprinkler irrigation system will include measuring the land and drawing its sketch to scale on graph paper. Mark the location of hedges, shrubs, trees, and also walls, and driveways on the sketch. Divide the area into zones for laying out the main lines and laterals. The next step is to determine the available water flow for the sprinkler system, to ascertain how many sprinkler heads can run at one time. Plan the pipe layout according to the placement of risers and sprinkler heads.

A sprinkler irrigation system consists of a pump unit, mainline, laterals, risers, and sprinkler heads along with filter screens, desilting devices, flow regulators, and fertilizer application system. It is mostly used to humidify the atmosphere, especially for young plants, sandy loam soils, greenhouses or poly-houses, and land having up and downslope. In sprinkler irrigation, water is conveyed under pressure through pipes to the area to be irrigated, where it is discharged through sprinklers.

2.4 Components of the sprinkler irrigation system are as follows:

1. **Pump unit:** A pump is used for developing the required pressure. It can be used under the following conditions. The land is undulating for levelling (the levelling work will be cost-intensive). The soil is porous, erodible, and impermeable (which makes it difficult to irrigate it by any other method). The flow rate is too less for employing the surface irrigation method.

2. **Filtration unit:** A filtration unit is required to remove the impurities present in the irrigation water. Hydro-cyclone, media, and screen are the different types of filters. The choice of filter depends on the quality of water. If the quality of water is poor, then a filter of higher mesh size is used.

3. **Pipeline:** The layout of mains, sub-mains, and laterals depends on local conditions like topography, soil characteristics, and source of water. The mainline must be laid along the slope and the laterals across the slope or nearly on the contours. In a portable system, the laterals need to be of the same size so that they can be changed easily.

4. **Sprinklers:** The selection of sprinkler depends on its nozzle size and the pressure with which it discharges water. It must also be ensured that the water discharged does not cause run-off or damage to the crops. Besides, it must supply water to the crops sown in a field uniformly under the prevailing wind conditions. It must meet the irrigation water requirement of a crop and the irrigation frequency.

The common symbols used when designing sprinkler irrigation plans are as follows.

a) Sprinkler – full: This nozzle will, generally, throw water all around it at 360° and a distance of 3.6–4.5 meters.

b) Sprinkler – half: This nozzle will, generally, throw water all around it at 180° and a distance of 3.6–4.5 meters.

c) Sprinkler – quarter: This nozzle will, generally, throw water all around it at 90° and a distance of 3.6–4.5 meters.

d) Sprinkler – one-third: This nozzle will, generally, throw water all around it at 120° and a distance of 3.6–4.5 meters.

e) Sprinkler - three quarter: This nozzle will, generally, throw water all around it at 270° and a distance of 3.6–4.5 meters.

f) Sprinkler - two-third: This nozzle will, generally, throw water all around it at 240° and a distance of 3.6 to 4.5 meters.

g) Sprinkler – variable arc nozzle: It represents a pop-up with a variable arc nozzle, which means it can be adjusted from 0 to 360 degrees. This nozzle will, generally, throw water at a distance of 3.6–4.5 meters.

2.5 Principle components of sprinkler irrigation system

The sprinkler system consists of:

1. Pumping set
2. Main line
3. Lateral lines
4. Risers and sprinkler heads

1. Pumping set: In pumping set, the pump usually lifts the water from source and pushes it through the distribution system and the sprinklers. In this volute centrifugal pump, deep well turbine pump and submersible pumps are mostly used to operate sprinkler systems. In this electric motors and internal combustion engines are used to drive the pumps of the sprinkler system.

2. Main line: In sprinkler irrigation system, the main line is generally made up - Rigid Poly Vinyl Chloride (PVC) and High-Density Polyethylene (HDPE) pipes are, normally, used. It helps to minimize corrosion and clogging in the pipe line. Pipes of 63 mm diameter and above with a pressure of 4 –10 kg/cm2 are recommended for main lines.

The pump provides the needed pressure to distribute the water through the sprinkler nozzles. The supply, main and lateral pipelines convey the water to the sprinklers.

3. Lateral line: The lateral lines usually are portable. Buried permanent laterals are used in- gardens, tree nurseries, and other sites. The lateral pipes are usually available in lengths of 5, 6, or 12 m.

4. Riser and sprinkler head: A riser is a long tube made of plastic or metal that is used to carry water or gas. The sprinkler head is the most important component in the sprinkler irrigation system, and it is available in a single nozzle and twin nozzle sprinkler head.

2.5.1 Fittings and other accessories

Some of the important fittings and other accessories used in the installation of mains, sub-mains, and sprinkler heads are as follows.

A. **Water meter:** It is used to measure the volume of water delivered. It is necessary to operate the system, to supply the required quantity of water.

Fig.2.7: Water meter

B. **Flange, coupler and nipple:** 'Flange' is used to connect pipes with the use of bolted connections and gaskets. A 'coupler' is a short pipe with a socket at one or both ends that allow two pipes to be joined together (Fig.2.8). 'Nipple' is a short pipe, usually, provided with a male pipe thread for connecting two other fittings on either end.

Fig.2.8: Coupler

C. Pressure gauge: It is used to measure the operating pressure of the sprinkler system (Fig.2.9). To ensure uniformity

Fig.2.9: Pressure Gauge

in the application of water, the sprinkler system is operated at the desired pressure.

D. Lateral cock, elbow, tee, reducing joiner, ring take-off and end cap: Bends and elbows are used for changing the direction of the water. The water takes a curve path while flowing through a pipe bend. Tees are T- shaped pipe fittings, having two outlets at 90 degrees connected to the mainline. A reducer is a component that is used to reduce the pipe size from a larger to a smaller bore. A butterfly valve is a quarter-turn rotary motion valve that is used to stop, regulate and start the flow of water. A 90-degree rotation of the handle can completely close or open the valve. An end cap is used to bend the pipe into the two holes for stopping the water flow. Goof plugs can be used to plug holes from where emitters have been removed.

Fig.2.10: (a) Lateral cock Fig.2.10: (b) Tee

Fig. 2.10: (c) Reducing joiner Fig. 2.10: (d) Elbow

Fig. 2.10: (e) Coupler ring take-off Fig. 2.10: (f) End-cap

2.6 Tools and Material required for installation of sprinkler irrigation system

A wide range of irrigation tools and equipment are available for use. Therefore, the selection of appropriate equipment or tool is essential for installing different components of a sprinkler irrigation system. The following tools, equipment, and material are required for the installation of the system.

1. **Pipe wrench:** It is a tool used for turning soft iron pipes and fittings with a round surface for assembly or disassembly (Fig. 2.11). Its adjustable jaws allow it to lock in the frame so that any forward pressure on the handle tends to pull the jaws together. It is available in 14″, 18″, 24″ and 36″.

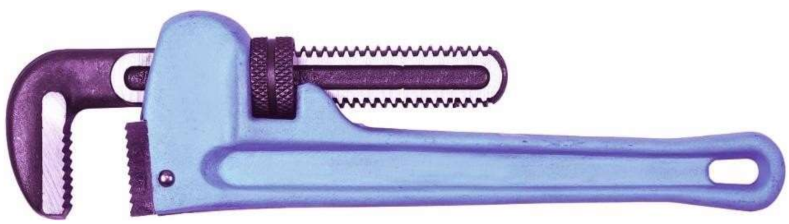


Fig. 2.11: Pipe wrench

2. **Spanner set (preferably adjusting sly wrench):** It is commonly known as 'combination wrench' (Fig. 2.12). A wrench (it is also known as a spanner) is a tool used to provide grip in applying torque to turn objects.

Fig. 2.12: Spanner set (preferably adjusting sly wrench)

3. **Drill machine:** A drill-machine is used for drilling holes in PVC pipes (Fig. 2.13). Drill bits of different sizes are used for drilling holes in PVC pipes.

Fig. 2.13: Drill machine

4. **Drill guide**: It is a tool that guides a drill to make a bore or hole in a PVC pipe (Fig. 2.14).

Fig. 2.14: Drill guide

5. **Screwdriver:** A screwdriver is a tool (manual or powered) used for turning (driving or removing from the material) screws (Fig. 2.15). A typical screwdriver has a handle and a shaft, and a tip that the user inserts into the screw head to turn it. The shaft is, usually, made of tough steel to resist bending or twisting.

Fig. 2.15: Screwdrivers

6. **Pliers**: It is a hand tool used to hold objects firmly with tongs (Fig. 2.16). It is also useful for bending and compressing a wide range of iron, aluminum, and steel material, such as wires and sheets.

Fig. 2.16: Pliers

7. **Hacksaw blade with frame:** A hacksaw blade is a fine-toothed saw, principally, used for cutting metals (Fig. 2.17). It can also be used to cut plastic and wood.

Fig. 2.17: Hacksaw blade

8. **Measuring tape:** It is a flexible ruler, consisting of a ribbon of cloth, plastic, or metal strip with linear measurement markings (Fig. 2.18). It is a common measuring tool used for land measurement.

Fig. 2.18: Measuring tape

9. **Hose punch:** It is a tool used to make a hole on polyethylene tubes or laterals to install different types of emitters or drippers. The punch size varies with the size of the connector (Fig. 2.19).

Fig. 2.19: Hose punch

10. **Take-off tool:** It is used for dismantling and disconnecting the emitter from the lateral or poly-tube.

11. **Solvent cement:** It is a substance that is used to bind thermoplastic pipes together by softening the surface of the material being bound.

12. **Teflon tape**: It is a polytetra fluoro ethylene (PTFE) film used for sealing pipe threads. The tape is sold with specific widths wound on a spool, making it easy to wind around pipe threads.

Fig. 2.20: Teflon tape

13. **Jute:** Jute is used to wrap around the threads of pipes to make them leak-proof.

14. **GI threaded joint synthetic compound:** It is an additive compound that prevents the rusting of pipe, gives a certain grip during the installation of pipes, and makes their joints leak-proof.

15. **Pencil or marker:** A pencil or marker is used to indicate a position and mark necessary details on the components or equipment for easy identification.

16. **Hot plate**: Hot plate welding also called 'fusion welding', is used to join plastic pipes (Fig. 2.21).

Fig. 2.21: Hot plate

2.7 Installation of Sprinkler Irrigation System

The components of the sprinkler irrigation system are tested before being installed. The entire system is tested once the installation is complete. The installation work must be carried out as per the installation guidelines. Guidelines to maintain the system and few precautions starting from the installation will ensure trouble-free operation.

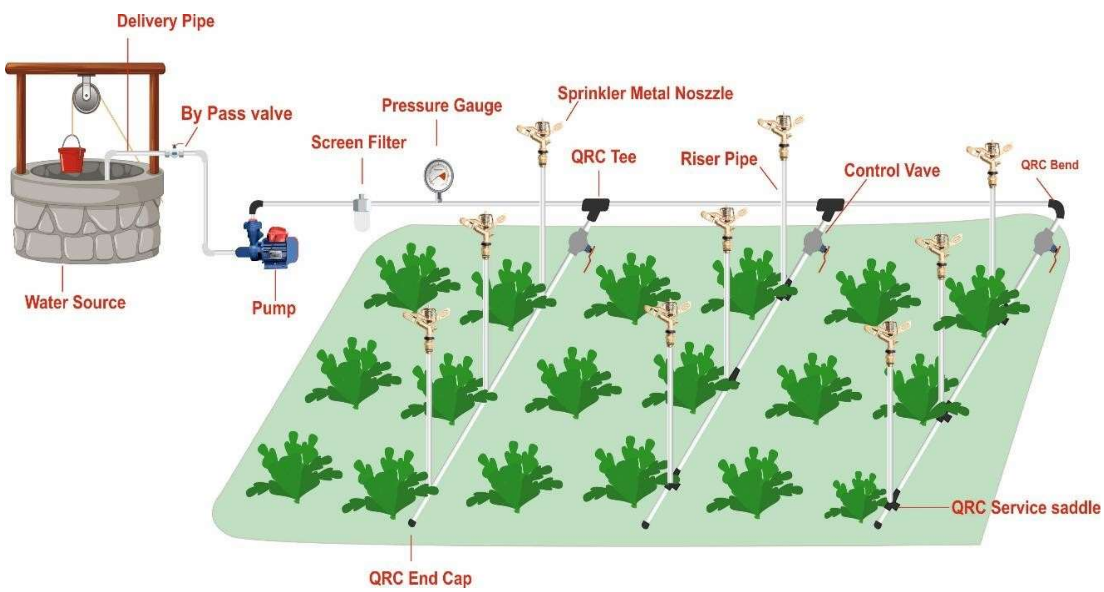
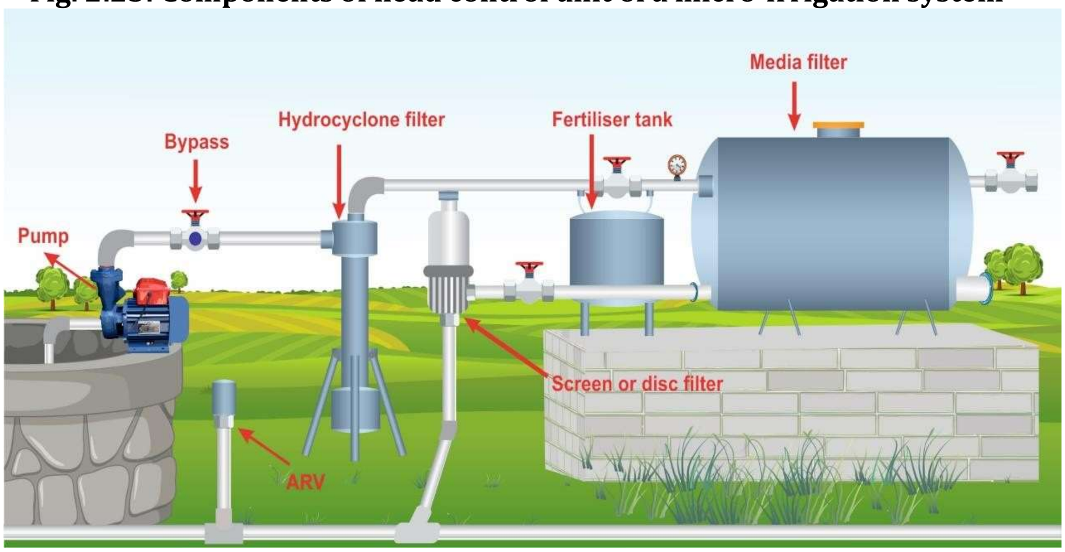


Fig. 2.22: Layout and components of sprinkler irrigation system

2.7.1 Installation of the Head Control Unit

The installation of the head control unit requires a cemented platform. The size of the platform depends on the various components to be installed, such as pump, bypass mechanism, non-return valve, hydro-cyclone filter, fertigation unit, media filter, screen or disc filter, and air release valve. A layer of paint on these fittings is used to avoid rusting. Pressure gauges are installed wherever needed to check pressure readings. Fig. 2.23 shows the various components of the head control unit.

Fig. 2.23: Components of head control unit of a micro-irrigation system



2.7.2 Preparation of trenches: Trenches must be wide enough to allow easy handling of pipes. They must be deep enough to allow a 60 cm cover over pipes. The bottom of the trenches must be smooth and free of sharp objects, such as stones. During excavation, all large stones, which can damage the pipes, must be removed from the brink of a trench. The width of the trench must be 45–70 cm and depth 75 cm. The trenches must be dug in a straight line.

2.7.3 Installation of pipes: PVC pipes must be laid according to the size and class as specified in the design. Care must be taken while laying the pipes during a hot day. Contractions due to a fall in temperature may loosen the pipes.

Before joining the PVC pipes, remove the burr from the edges. The outer and inner surfaces of the pipes must be cleaned with sandpaper before applying solvent cement. A clean cloth must be used to clean the joining surfaces of the joints. Solvent cement must be applied evenly around the spigot end of each pipe. The spigot end of the pipes must be pushed into the sockets to the depth of the entering mark. Always store the solvent cement in a cool and dry place away from the fire and reach of children. Use Teflon tape to avoid leakage through the threaded ends. Avoid over-tightening of these fittings by pipe wrench. Give support or fill in the trenches immediately after joining PVC pipes and fittings on curves and valves. Backfilling of trenches must be done only after the testing is over. All back-filling material must be free of stones as they can damage the pipes.

Fig. 2.24: PVC pipes

2.7.4 Installation of valves

Air valves on the mainline must always be installed at the highest point of the pipeline or a point of change in the slope. Control valves must be installed a minimum of one feet above the ground level and need to be straight, both vertically and horizontally. Use Teflon tape to wrap the threaded parts of adopters for fitting them into the valves to avoid leakage. Avoid over-tightening by pipe wrench.

2.7.5 Installation of main, sub-mains and laterals

A. **Mainline:** Rigid Poly Vinyl Chloride (PVC) and High-Density Polyethylene (HDPE) pipes are, normally, used as main lines to minimize corrosion and clogging. Pipes of 63 mm diameter and above with a pressure of 4-10 kg/cm2 are recommended for main lines. The mainline is the primary artery of a sprinkler irrigation system, usually, laid along the length of a field, which serves as a conveyance system for delivering the total amount of water to the sub-mains at the required pressure. The mainline is, normally, buried about 30 cm below the soil surface and supplies water to the sub-mains.

Fig. 2.25: HDPE pipes

B. Sub-mains: Light PVC, HDPE, or Linear Low-Density Polyethylene (LLDPE) pipes are used as sub-mains. Pipes having an outer diameter of 32-75 mm with a pressure of 2.5-4.0kg/cm2 are, normally, used as sub- mains. The diameter of the main and sub-mains depends on the water requirement of a crop and the size of the field. Both main and sub-mains are provided with flush valves at the outlets to occasionally flush the pipes to remove sediments and clogging. A flow control valve (ball valve) is fitted at the beginning of each sub-main. The flush valve must not be fixed vertically but horizontally, after fixing an elbow so that the water does not spill over onto the person carrying out the work while flushing.

The sub-mains, which run perpendicular to the laterals, deliver water to the laterals. The sub-mains are connected with the mainline using fittings like a tee, elbow, etc., as per the installation sketch. Solvent cement must be used to ensure perfect binding at the joints.

C. Laterals: Laterals are tubes located between the shut-off valve and sprinkler heads. The laterals are, usually, made of LDPE, Linear Low- Density Polyethylene (LLDPE) or HDPE pipes of 10 to 20 mm in diameter and with a wall thickness of 1–3 mm with a pressure rating of 2.5 kg/ cm2. Lateral pipes are, usually, flexible, non-corrodible, resistive to radiation and the effects of temperature fluctuation. They are easy to install. Laterals are, usually, black. The laterals supply water to a field through sprinklers.

To install laterals, the following need to be done:

I. To connect the laterals (poly-tubes) to the sub-mains, holes are drilled on the PVC sub-main pipes using a drilling machine. The holes are drilled at a distance equal to the row spacing of the crop. The size of the holes depends on the size of the laterals and the grommet take-off (GTO).

II. Grommets are fixed in the holes and take-offs are fixed on the grommets. The laterals are then connected to the take-offs.

D. Sprinkler riser and head

Sprinkler risers connect the sprinkler heads to the lateral pipes or tubes. Sprinkler heads distribute water uniformly over the field without run-off or excessive loss due to deep percolation. The most commonly used sprinklers have two nozzles, one to cover a farther area and another to cover the area near the sprinkler. The sprinkler heads are installed on riser pipes. To avoid turbulence in riser pipes, the minimum height of the riser is 300 mm for 25 mm diameter and 150 mm for 15–20 mm diameter. In general, 900 mm long GI pipe of 25 mm diameter is used.

(a) **(b)**

Fig. 2.26: (a) Sprinkler head (b) Sprinkler riser

The characteristics that need to be considered for sprinkler selection are jet trajectory, operating pressure and sprinkler body design. The sprinkler operating conditions to be considered in sprinkler selection are soil infiltration characteristics, desired irrigation depth, desired or appropriate irrigation cycle, crop characteristics, wind conditions and plant spacing.

The uniformity of water distribution from sprinklers depends on the pressure of water, wind velocity, rotation of sprinklers, spacing and nozzle diameter. The spacing of sprinklers in a lateral, and lateral spacing are adjusted considering all these parameters.

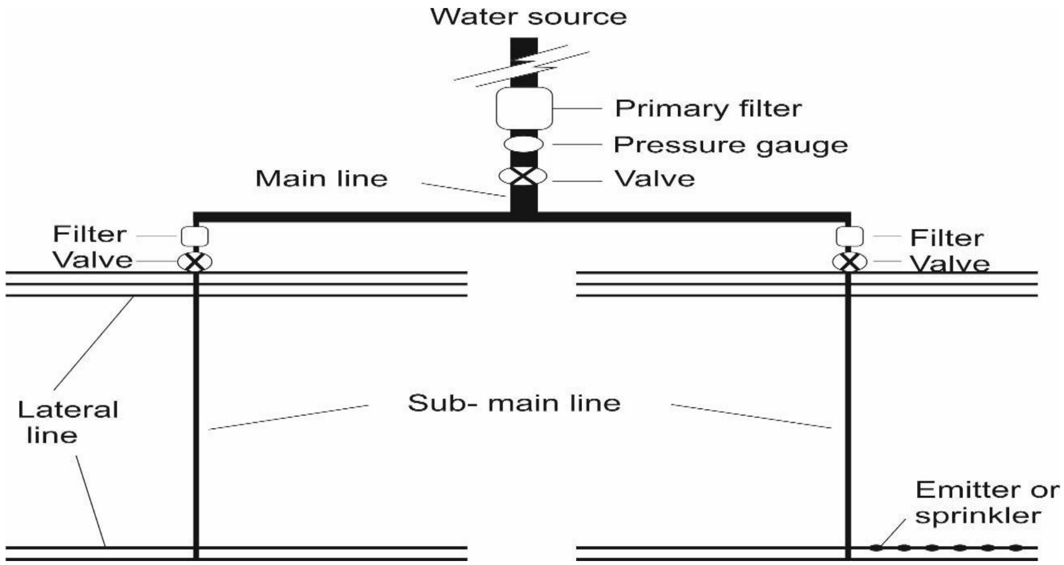


Fig. 2.27: Components of sprinkler irrigation system

2.8 Operation and Monitoring of Sprinkler Irrigation System

A sprinkler irrigation system must be operated keeping with the recommended irrigation practice. It must be ensured that the prime mover and pump are in alignment, particularly, in case of tractor-driven pumps. Service and installation procedures with respect to pump and power units must be observed. While starting the sprinkler system, the motor or engine is started with the valves closed. The pump must attain the pressure stated on the type- plate, else there is a fault in the suction line. After the pump reaches the regulation pressure, the delivery valve is opened slowly. Similarly, the delivery valve is closed after stopping the power unit. The pipes and sprinkler lines are shifted as required after stopping, in case of portable sprinkler system.

The following steps need to be followed for operating the sprinkler system:

i. Start the pump and open the valve to fill the pipes with water.

ii. Release all end caps and flush valves to clean the system of dirt and clogging. Before operating the system, the end caps installed at the end of the laterals and sub-mains are released so that dirt in the pipes is washed away and air is also driven out. Open the control valve and let the water flow freely through the pipes for some time. Then, close the end caps and ensure that water comes out from each sprinkler.

iii. Check the pressure and discharge of water, and ensure that all sprinklers are operational.

iv. Operate the system according to the recommended irrigation schedule.

2.8.1 Operation and efficiency of sprinklers

The two main types of spray head installation are risers and pop-ups. Both the types are available in different spray patterns, including full-circle, half-circle, quarter-circle and fully adjustable. These spray head nozzles are made to deliver matched precipitation rates, meaning that a quarter circle pattern will deliver one-fourth as much water as a full circle. Each sprinkler delivers a metered amount of water over a part of the entire zone. It is essential that each zone has the same type of sprinkler heads as each type has a specific rate of application. If different types of sprinkler head are placed on the same lateral, the distribution will be uneven, leading to the emergence of dry or wet spots.

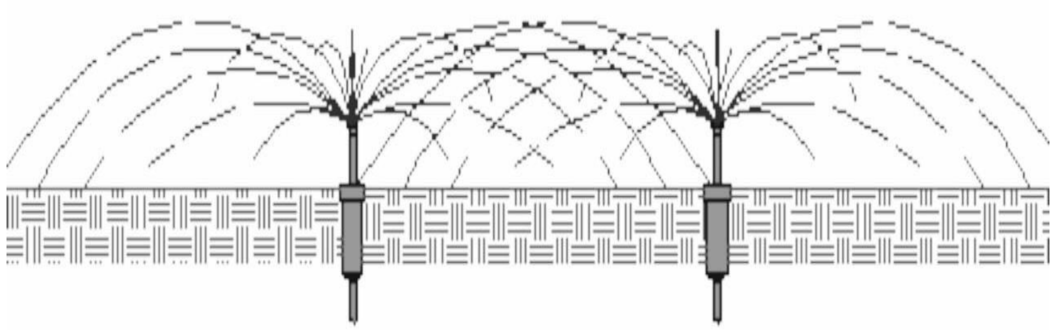


Fig. 2.28: Schematic sketch of overlapping sprinkler sprays

The operation and efficiency of sprinklers depend on the degree of uniformity of water application, which depends on the water spray distribution characteristics of sprinkler nozzles and sprinkler spacing. The sprinklers are installed in a manner that they overlap the watered area. This overlap may seem like a waste, but it is a necessity.

The spray distribution characteristics change with the nozzle size of a sprinkler and its operating pressure. At lower pressure, the drops are larger and water from the nozzle falls in a ring away from the sprinkler. For higher pressure, the water from the nozzle breaks into fine droplets, which fall close to the sprinkler. Almost all sprinklers have an in-built radius adjustment device in order to reduce the radius of the water throw.

Fig. 2.29: Overlapping sprinkler sprays in a farm

Operating a sprinkler at pressures above the design range results in excessive misting (small droplet size) and water is easily blown away or evaporated or may accumulate close to the sprinkler. The actual spacing, however, shall be guided by the size of pipes available in the market. Generally, pipes of 6 m (full size) and 3 m (half size) are available.

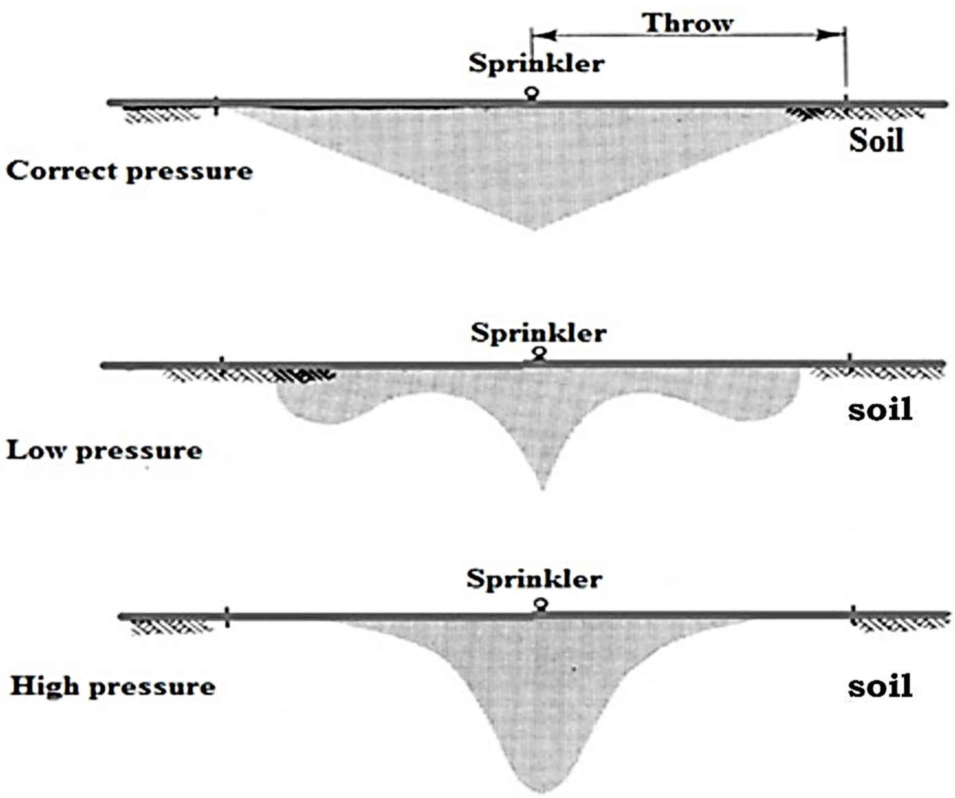


Fig. 2.30: Effect of variation in water pressure on sprinkler spray pattern

2.8.2 Maintenance of sprinklers

1. Do not apply oil, grease or any other lubricant on to the sprinklers. They are water lubricated and using oil, grease or any other lubricant may make them defunct.

2. Sprinklers, usually, have a sealed bearing and at the bottom of the bearing there are washers. Usually, it is the washers that get damaged and not the metal parts. The washers are to be checked for wear and tear. Replace the damaged washers.

3. After several operations, the swing arm spring of the sprinkler may need tightening. This is done by pulling out the spring end at the top and bending it again. This will increase the spring tension.

4. Check all equipment at the end of the season and make necessary repairs and replacements so that the equipment is ready for the next season.

2.8.3 Maintenance of Sprinkler Irrigation System

At the beginning of each growing season, check the irrigation line from the valve to the spray heads for leaks. Take a round of the entire field and check if there is leakage at joints or damage to any component of the system. Rectify the defects, if any, by replacing the spare parts. Remove folds or kinks on laterals or pipes, and make them straight.

Clean the irrigation system periodically to remove dirt and debris that have built up over time. There are few basic steps that one must take at least once in a year to ensure that water always gets through the system. Using a filter can prevent build-up of minerals and organic particles in pipes, risers and nozzles, and make it easy for cleaning. It is also important to follow these instructions in order to flush each zone in the system at least once a year.

i. Turn off water supply to one zone, and remove nozzles and sprinkler heads.
ii. Run water through the zone for few minutes until the filter is clean and a clear stream of water flows from each sprinkler.
iii. Take apart the nozzles (depending on the type, you can do this by hand or with a screwdriver or special key).
iv. Clean the nozzles to remove dirt or deposits.
v. Rinse the filter screen or basket.
vi. Reassemble the filter and replace the damaged or worn out parts.
vii. Turn on the zone again to check that everything is leak-proof and operational.

Table 2.2: Maintenance schedule for sprinkler irrigation system

Frequency	Check	Action
Daily	Pressures	Check that pump and block pressures are within the prescribed limits.
	Emitter operation	Check for clogged, broken or misplaced emitters. Repair, replace, unclog or reposition the emitters.
	Leaks	Check for water wastage and leaks in pipes and other equipment, and repair them immediately.
	Primary filter	Flush primary filters as prescribed.
	Fertigation application	Check that fertigation applications are within specification.
Weekly	Lateral lines	Flush the lateral lines as prescribed.
	Exposed joints	Check and repair them if needed, e.g., quick coupling rubbers.
	Secondary filters	Flush the secondary filters as prescribed.
	System pressure and flow	Check that the system pressure and flow are as per the irrigation design plan.
	Pump operation	Check that pump
		operation is within the prescribed parameters.
	Block pressures for automated valves	Check that the block pressures are within the prescribed limits where automated valves are used.
	Pump oil levels	Check pump oil levels as prescribed.

	Fertigation plant	Inspect the fertigation plant.
	Pipes	Check for leaks and repair them.
Monthly	Valves, water meters and gauges	Visually check the valves, water meter and gauges, and look for damage and vandalism.
	Filters	Open and inspect the filters as prescribed.
	Pump pipe work	Check for leaks at the pump station that causes water losses and airlocks.
	Pump motor	The pump motor must be greased as prescribed.
Annually	Valves	Check the service valves and replace them, if required.
	Filters	Clean the filters and replace them annually or in two years.
	Pump	Change oil in the pump.
	Water sampling	Take water sample at the end of lateral lines and send it for analysis.
	Emitter delivery tests	Test specific emitters for discharge and pressure.
	Sprinkler parts	Replace nozzles annually and the other parts when needed.
2-10 years	Pump	Replace the bearings and other worn out parts of the pump every five years.
	Hydraulic valves	Replace the diaphragms in hydraulic valves every three years.
	Poly pipe and emitters	Replace the poly pipe and emitters every 7–10 years.

2.8.4 Principles for maintenance of pipes, fittings and sprinkler heads

The general principles regarding the maintenance of pipes, fittings and sprinkler heads are as follows:

A. Maintenance of pipes and fittings

Pipes and fittings virtually require no maintenance but attention must be paid to the following:

i. Periodically, clean dirt or sand out of the groove in the coupler, in which the rubber sealing rings fit.
ii. Keep all nuts and bolts tight.
iii. Do not lay pipes on new damp concrete or on piles of fertilizer.
iv. Avoid trampling over the pipes.
v. Remove the end stop or end cap and flush the laterals or pipes for 1-2 minutes. Starting from the sub-main inlet, flush the first 4-5 laterals or pipes and proceed to the end. This will help in gaining higher velocity in the laterals and pipes for cleaning. Flush the sub- mains at the end of the irrigation process to remove debris.

B. Maintenance of sprinkler heads

i. When moving the sprinkler lines, make sure that the sprinklers are not damaged or pushed into the soil.
ii. Do not apply oil, grease or any other lubricant on the sprinklers. They are water lubricated and using oil, grease or any other lubricant may stop them from working.
iii. Sprinklers, usually, have a sealed bearing and at the bottom of the bearing, there are washers.

2.9 Adaptability of sprinkler irrigation systems:

a. It is suitable for most row, field and tree crops.
b. Water can be sprayed over and under the crop canopy.
c. Adaptable to any farmable slope whether uniform or undulating, which only subject to limitations imposed by land use capability and economics.
d. Periodic – move systems are well suited for irrigation in areas where crop- soil-climate situation doesn't require irrigations more often than every 5-6 days.

e. Soils with low water holding capacity and shallow rooted crops require light and frequent irrigation. For these fixed or continuously moving systems are suitable.
f. Fixed systems canal so be designed and operated for frost and freeze protection, blossom delay and crop cooling.
g. An application of sprinklers for frost control.

2.9.1 Advantages of sprinkler irrigation systems:

a. Land unsuitable or uneconomical for levelling.
b. Suitable for sandy soil having infiltration rate.
c. Ideally suited to steep slopes or irregular topography.
d. Rate of flow available is too small to distribute water efficiency by surface irrigation methods.
e. Used for irrigating high valued plantation crops like tea, coffee, orchards, etc.
f. Higher water application efficiency.
g. Frequent ad small application of water.
h. Application of fertilizers, pesticides and soil amendments.

2.9.2 Limitations of sprinkler irrigation systems:

a. Large initial investment and high annual depreciation.
b. Unsuitable for very fine textured soils having infiltration rate less than 4 mm/hr.
c. Requires well-organized service facilities.
d. Uneven water distribution caused due to high winds.
e. Evaporation losses when operating under high temperature.
f. Requires water free from silt and debris.

ACTIVITIES

Activity 01: Field visit near your school Material required

1. Notebook
2. Pencil

Procedure

1. Visit a farm, where a sprinkler irrigation system has been installed.
2. Discuss the following with the owner of the farm.
   a. What are the advantages of sprinkler irrigation system?
   b. In which crop(s), sprinkler irrigation system has been more useful?
   c. What are the common problems that you encounter in maintaining sprinkler irrigation system?
3. Note down the specification and their parts name.

CHECK YOUR PROGRESS

A) Answer the following question:

1. Define sprinkler irrigation systems and its types.
2. Briefly describe the principal component of the sprinkler irrigation system.
3. Write down the step-by-step procedure for the installation of the sprinkler irrigation system.
4. Write about the adaptability, advantages, and limitations of sprinkler irrigation systems.

B) Multiple choice question

1. ml/min stand for.
   a. microliter per minute
   b. milliliter per minute
   c. mass liter per minute
   d. million liter per minute

2. The minimum operating pressure of rain gun is …………
   a. 1–1.5 kg/cm2
   b. 1–2 kg/cm2
   c. 1.5–2 kg/cm2
   d. 1.5–2.5 kg/cm2

3. A tool used for turning soft iron pipes and fittings with a round surface for assembly or disassembly.
   a. Pipe wrench
   b. Spanner

c. Plier
d. Hacksaw

4. Full form of GTO.
a. Gun take off
b. Grove take off
c. Grommet take off
d. Grip take off

C) Match the following

Column A	Column B
1. Drill guide	**A.** 
2. Sprinkler head	**B.** 
3. Reducing joiner	**C.** 
4. Hose punch	**D.** 
5. HDPE pipe	**E.** 

Module 3	Drip Irrigation System

Module Overview

This module provides a comprehensive understanding of drip irrigation systems, a sustainable and efficient method of delivering water directly to the root zones of plants. It explores the types, components, and working principles of drip irrigation systems. Additionally, the module delves into design, installation, and maintenance practices to ensure optimal system performance and water conservation.

Learning Outcomes

After completing this module, you will be able to:

- Explain the concept and advantages of a drip irrigation system.
- Identify and describe various types of drip irrigation systems.
- Understand the components of a drip irrigation system and their functions.
- Design a basic drip irrigation system based on crop and soil requirements.
- Install and maintain a drip irrigation system effectively.
- Apply preventive and corrective measures to ensure the longevity and efficiency of the system.

Module Structure

3.1 Introduction: A drip irrigation system, also known as a 'trickle irrigation system', is a method of applying the required amount of water directly to the root zones of plants through drippers or emitters at frequent intervals. In this system, water is applied drop-by-drop or by a micro jet on the soil surface or sub-surface at a rate lower than the infiltration rate of the soil. The emitters dissipate pressure from the distribution system using orifices, vortexes, and tortuous or long flow paths, thus, allowing a limited volume of water to be discharged. Most emitters are placed on the ground but they can also be buried. The emitted water moves within the soil system largely by the unsaturated flow. The water moves into the soil and wets the root zones of plants vertically by gravity and laterally by capillary action. The lateral movement of water beneath the surface is greater in medium to heavy soil as compared to sandy soil. The wetted soil area for widely spaced emitters will, normally, be elliptical in shape. Drip irrigation can be used on windy days and during various land operations.

Fig. 3.1: Drip Irrigation System

3.2 Types of drip irrigation system

The drip irrigation system can be classified into the following:

1. Surface drip irrigation
2. Sub-surface drip irrigation
3. Family drip
4. Online drip
5. In-line drip

1. **Surface Drip Irrigation:** Surface drip irrigation is used to irrigate perennial crops (plants that live for more than two years) and annual crops (plants that germinate, produce seeds, flower, and die in one year).

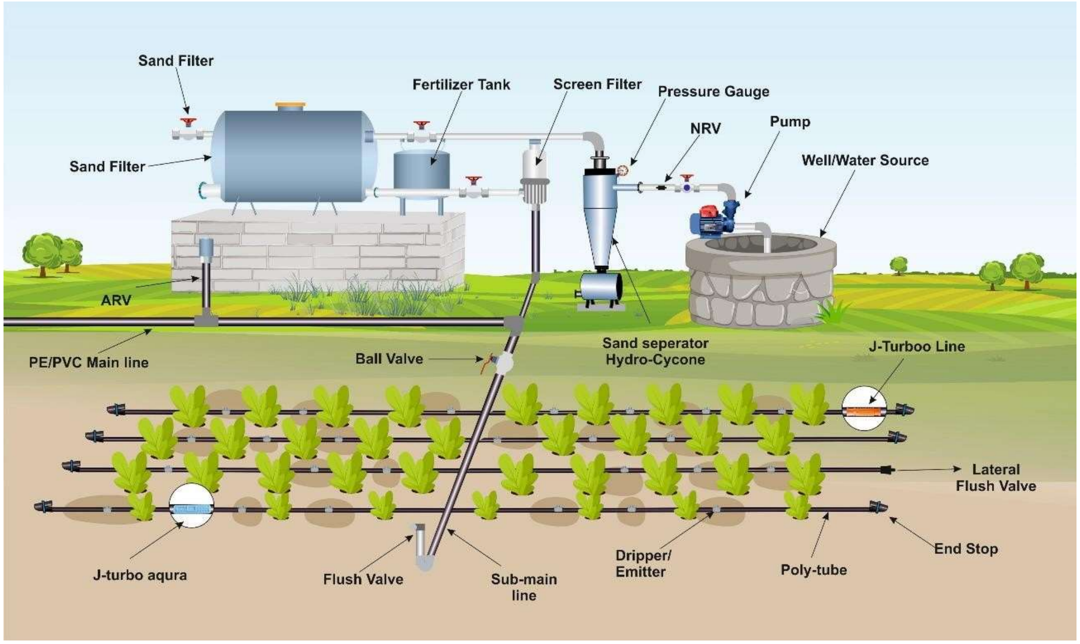


Fig. 3.2: Components of surface drip irrigation system

Typical surface drip irrigation system consists of the following:

- **Pump unit**: It comprises a pump and a power unit to supply electricity to the pump. The pump draws water from the source and provides the right pressure for its delivery into the pipe system.
- **Head control unit:** It consists of shut-off, air, and check (non-return) valves to control the discharge and pressure of water in the entire system. A pressure relief valve is installed after the pump unit to return excess water when the system is not operated at its full capacity. It may also have filters to clear the water. The filters remove sediment and debris, which can clog the system. Disc filters are commonly used to filter water from ponds, reservoirs, tanks, and other sources that contain algae. Some head control units contain a fertilizer or nutrient tank to supply fertilizer solution to plants.
- **Tubing:** It consists of mainline, sub-main lines or sub-mains, and laterals. The mainline conveys water from the source and distributes it to the sub- mains. The sub-mains convey water to the laterals, which in turn supply it to the emitters or drippers. The laterals are, usually, 13-32 mm in diameter and supply water into fields through the head control unit.
- **Emitters or drippers:** These devices are used to control the discharge of water from the laterals to plants. They are made of High-Density Polyethylene (HDPE) plastic. Water enters the drippers at approximately 1 kg/cm2 pressure and is delivered at zero pressure in the form of droplets at a low rate of 1-2.4 litre/hour. There are mainly two types of emitters.

a) **Online emitters:** These are small plastic devices, which convey small streams of water from polyethylene (PE) tubing to the soil. The water, then, moves through the soil via capillary flow and creates a wetted circle, the size of which depends on the soil type, flow rate, and irrigation schedule. Online emitters are attached to the PE tubing wall by inserting the emitters' barb-shaped base through a punched hole. These can be placed anywhere along the length of the pipe. Some emitters have self- piercing barbs. The diameter of pipes used for installing online emitters is usually, between 12 and 20 mm.

b) **In-line emitters or drip lines:** These consist of small plastic emission devices, which are pre-inserted into the PE tubing at specified intervals during the tubing extrusion process. Their rate of water flow depends on the inlet pressure. With lower inlet pressure, the water flow decreases, whereas, with high pressure, it increases. This emitter is available in 0.8 lph to 4 lph discharge rate.

A surface drip irrigation system is, generally, used to irrigate high- value vegetable crops, such as tomato, broccoli, celery, cauliflower, spinach, kohlrabi, leaf lettuce, etc.

2. Sub-surface Drip Irrigation: Sub-surface drip irrigation is a method of irrigating crops through buried plastic tubes, containing embedded emitters located at regular spacings. A sub-surface drip irrigation system has a similar design as a surface drip irrigation system. But in this case, the drip tubes are typically located 38-84″ (97-213 cm) apart and 6-10″ (15-25 cm) below the soil surface. In sub-surface drip irrigation, evaporation is minimized and water is used more efficiently as compared to surface irrigation.

Fig. 3.3: Sub-surface drip irrigation

In sub-surface irrigation, the effects of surface infiltration like crusting, water losses via evaporation and surface run-off are eliminated. Water is applied directly to the root zone of a crop as opposed to surface irrigation, in which most weed seeds hibernate. Water application is efficient and uniform in this system. Sub-surface drip irrigation helps in water conservation in open field agriculture, often resulting in saving up to 25-50 per cent water as compared to the flood irrigation system.

3. Family drip or gravity fed drip irrigation

Family drip or 'gravity fed drip irrigation' system is a low-cost system developed for small family plots. It is suitable for house gardening and peri- urban agriculture. It can also be used to demonstrate the working of drip irrigation system. Family drip system is designed for areas measuring 500- 1000 m2. It consists of five components — elevated tank, shut-off valve, filter, main line and drip line.

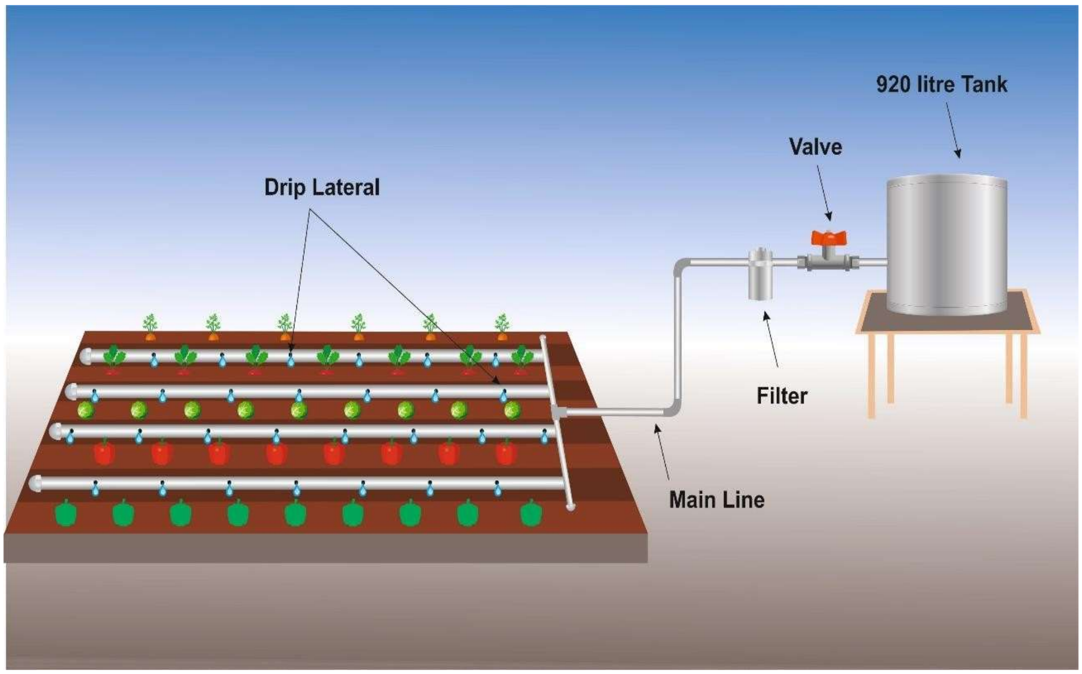


Fig. 3.4: Family drip or gravity fed drip irrigation

Generally, a family drip irrigation system comprises a drum, control or shut- off valve, filter (small disc or screen filter), mainline, and drip laterals. The drip outlets are spaced at 30 cm. No central pressurized water system or power source is required in this system. Therefore, it is cheap, easy to install and operate.

4. **Online drip irrigation:** In this system, emitters or drippers are fixed externally on the laterals at designed spacings. Thus, the drippers can be checked and cleaned easily in case of clogging. The dripper spacing can be changed at any time to cover the increased root zone of a plant. Online dripper system is used in orchards, vineyards, artificial landscapes, and nurseries. It is, generally, used for irrigating horticultural plants like mango,

coconut, orange, lemon, banana, grapes, pomegranate, papaya, sapota, guava, teakwood, bamboo, amla (Indian gooseberry), etc.

Fig. 3.5: Online drip irrigation

5. **In-line drip irrigation**: In this system, drippers are fixed in the lateral tube at designed spacings at the time of manufacturing to meet the requirement of various crops. It is effective for row crops like cotton, sugarcane, groundnut, vegetables, and flowering crops. Dripper spacing depends on the water requirement of a crop and the water-holding capacity of the soil. Once installed, the dripper spacing cannot be changed.

Fig. 3.6: In-line drip irrigation

3.2.1 Design of drip irrigation system

Drip irrigation, also known as 'trickle irrigation, is a planned irrigation system, in which water is applied directly to the root zones of plants using applicators (orifices, emitters, porous tubing, perforated pipes, etc.) operated under low pressure. The applicators are placed either on or below the surface of the ground. Drip irrigation system consists of pump unit, head control unit, mainline, sub-main lines or sub-mains, laterals, and emitters or drippers.

The design of the surface drip irrigation system must describe the pump requirements. There is a range of options for the type of filter. There are filters with mesh, disc, and media types. A major consideration in the design of a surface drip irrigation system is drip tubing lateral spacing. In normal irrigation design, the pipe size must be specified based on economic and friction loss, and water hammer considerations. Dripline depth will depend on soil characteristics, rooting depth, and cultivation practice being followed in a field. Soil having more sand content requires closer spacing of drip tubing laterals, which increases the cost of the drip irrigation system. Wider spacings are possible with heavy soil, which contains more clay (e.g., black soil), as lateral movement of water is greater in such soil.

The typical spacing of 4 lph (1.06 gph) emitters

1. Coarse soil (sand): 60 cm (24″)
2. Medium soil: 1m (39″)
3. Fine soil (clay): 1.3 m (48″)

Typical spacing of 2 1ph (0.53 gph) emitters

1. Coarse soil (sand): 30 cm (12″)
2. Medium soil: 60 cm (24″)
3. Fine soil (clay): 1 m (39″)

3.3 Components and symbols of drip irrigation system:

a) **Pump unit:** The pump unit lifts water and produces the desired pressure for distributing water through emitters. Electric motor-driven pumps can be activated using a pump start relay that is activated by a computer.
b) **Head control unit:** It consists of valves to control the discharge and pressure of water in the entire system. It may also have filters to clean the water. The head control unit turns the automatic valves on or off through control signals. These valves then run water to the required sections. The symbol given in Fig.3.7 represents the head control unit.

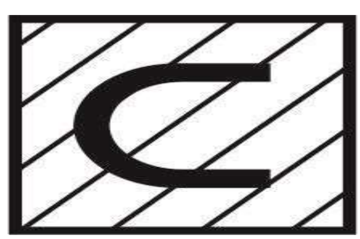


Fig. 3.7: Symbol for the head control unit

c) Automatic control valve: Valves allow to turn different sections on and off automatically. The symbol used to represent an automatic control valve, also known as ‘solenoid’, is given in Fig.3.8.

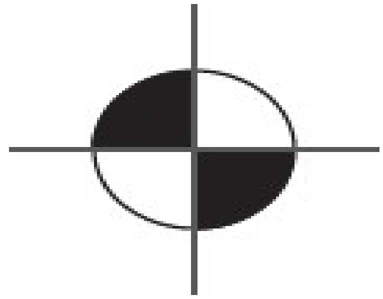


Fig. 3.8: Symbol for automatic control valve

d) Gate valve: Gate valves may be used in place of electric valves to turn different sections on or off. They are manually operated isolation valves. The symbol used to represent a gate valve, also known as a 'hand-operated valve', is given in Fig.3.9.

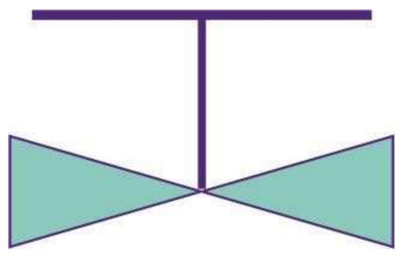


Fig. 3.9: Symbol for gate valve

e) Flush valve: It is a self-opening valve that allows lines to be flushed when the pipe pressure is low. It shuts when the pressure builds up. The symbol used to represent a flush valve is given in Fig.3.10.

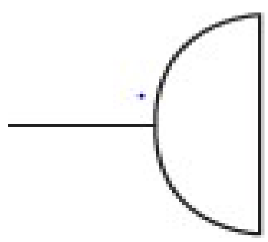


Fig. 3.10: Symbol for flush valve

f) Automatic air release valve: Automatic air release valves (ARV) are used to displace air contained within an irrigation system, which can adversely affect its performance. The symbol used to represent an automatic air release valve is given in Fig.3.11.

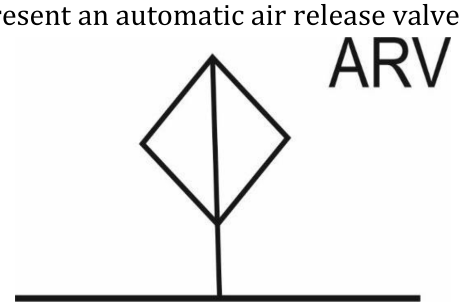


Fig. 3.11: Symbol for an automatic air release valve

g) Check valve: A check valve, also called a 'non-return valve', is a mechanical device in a pipe that permits the flow of water in one direction only. It prevents the backward flow of water. The symbol used to represent a flush valve is given in Fig.3.12.

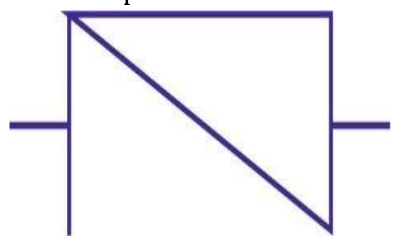


Fig. 3.12: Symbol for a check valve

h) Pressure reducing valve: It is commonly used when installing a drip irrigation system or where high pressures can pose a problem. The symbol used to represent a pressure reducing valve is given in Fig.3.13.

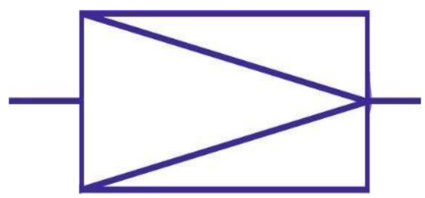


Fig. 3.13: Symbol for pressure reducing valve

i) Filter: Common types of filters include the screen and graded sand filters, which remove fine material suspended in water. Filters come in different volume capacities and mesh sizes (filtration particle exclusion capacities). The symbol used to represent a filter is given in Fig.3.14.

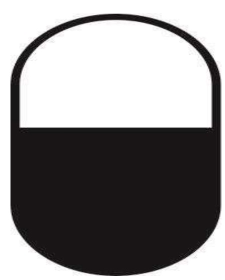


Fig.3.14: Symbol for filter

j) Screen filter: It uses a fine mesh formed into a column to filter out undesirable elements from water. The symbol used to represent a screen filter is given in Fig.3.15.

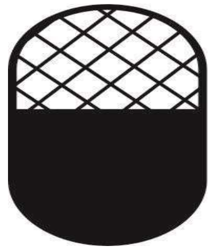


Fig.3.15: Symbol for a screen filter

k) Mains, sub-mains, and laterals: Mainlines, sub-mains, and laterals supply water from the control head into the fields. They are, normally, made of flexible material, such as PVC pipes. Laterals or drip lines are small diameter (1-1.25 cm) flexible lines made of Low-Density Polyethylene Pipes (LDPE). Generally, the main and sub-mains are laid across the slopes, while laterals are placed along the slopes. If a field is divided into sub-blocks, each block is provided with one sub-main and a control valve. Based on the available data of water capacity, the water requirement of a plant, and pressure required at the lateral layout designs for the micro- irrigation system are made.

Fig. 3.16: Sub-mains and laterals

The symbol that represents the mainline, which carries water to different sections of the irrigation system are given in Fig.3.17.

Fig. 3.17: Symbol for mainline

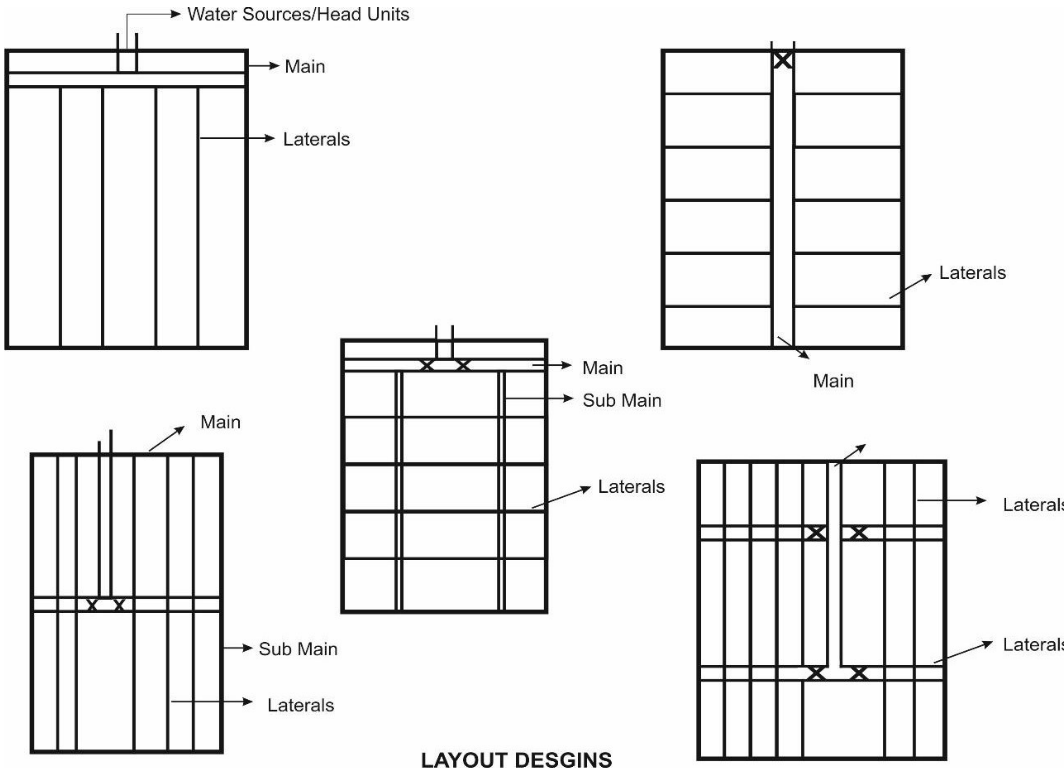


Fig. 3.18: Layout of drip irrigation system based on water source location

Laterals are, normally, laid parallel to each other. There is, usually, one lateral line for each crop row. The symbol used to represent lateral lines is given in Fig.3.19.

Fig. 319: Symbol for lateral line

l) Emitters or drippers: These are fixed at regular intervals in the laterals. They are usually, spaced more than 1 m apart. For row crops, more closely spaced emitters may be used to wet a strip of soil. They supply a specified quantity of water to plants in a field. Water is delivered at or near the root zones of plants, drop-by-drop. The PVC valves allow water to flow at a slow rate (2–16 litre per hour) and in various shapes and designs. Emitters are selected based on soil texture and crop root zone system.


Fig. 3.20 (a): Online dripper Fig. 3.20 (b): Inline dripper

To measure the anticipated variations in the discharge of water in emitters, a pressure gauge is used. The symbol for the pressure gauge is shown in Fig.3.21.

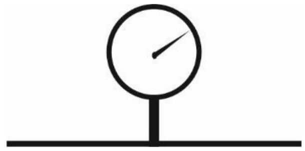


Fig. 3.21: Symbol for pressure gauge

3.4 Installation procedure of Drip irrigation system

3.4.1 Maintenance of Drip Irrigation System

An irrigation system requires minimal maintenance if it is planned and designed as recommended. The components must be checked as per the guidelines for the installation of specific products. A maintenance plan and regular monitoring of the system ensure that minor problems do not turn into major ones.

Fig. 3.22: Drip irrigation system

The quality of water differs from its source. Higher rainfall in summer means that water sources are muddy due to the increased content of silt and sand. Algae are more prevalent during warmer months, which increases the biomass that has to be filtered. The quality of water, usually, becomes poor because of lower water levels as pumps tend to suck more dirt and there is little time for the silt and sand to settle out of the water. When the water quality is poor, filters must be flushed at regular intervals. It is essential to keep a record of lateral flushing, filter flushing, and water quality.

In preventive maintenance, we use specific steps to stop drippers from getting blocked or clogged. On the other hand, corrective maintenance deals with getting rid of any obstructions that are messing up the system.

Maintenance of the distribution network

A drip irrigation system requires more attention and maintenance as compared to other irrigation systems. A drip irrigation system is vulnerable to over-pressurization and clogging, both of which can drastically reduce the system's durability and performance.

For drip irrigation, turn on the system 20–30 minutes before the inspection to allow enough time for emitter-wetting patterns to show up. Check for leaks or clogged emitters from the valve to the end of the irrigation line. Check the placement of emitters near plants.

System flushing

System flushing is the process of opening flush valves on the mainline, sub- mains, or laterals while under pressure. Flushing increases the water velocity inside the pipeline or dripper line, which scours and removes contaminants off the walls or from individual emitters. The pressure of the regulating valve is increased to achieve enhanced velocities, nevertheless, care must be taken not to exceed the burst pressure of the emitter line and take-off adapters.

Recommended flushing velocities are as follows.

i. Main line: 1 metre per second.
ii. Sub-mains: 1 metre per second.
iii. Laterals: 0.5 metre per second.

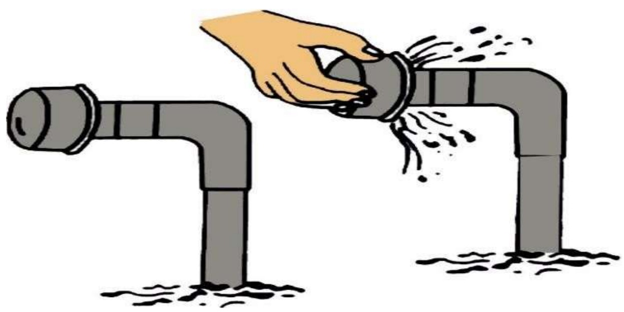


Fig. 3.23: Main or sub-main flushing

System flushing needs to be carried out at regular intervals. The frequency of flushing depends mainly on the water quality and weather. Table 3.1 indicates the starting point for flushing. However, individual site conditions influence the increase or decrease of flushing intervals.

Table no. 3.1: Flushing intervals

Quality	Water source	Flushing interval
Good	• Bore water with no presence of iron or magnesium.	06 months

Average	• Rivers, dams, or lagoons that are slow-flowing. • Wastewater discharged from industries after treatment.	04 months
Poor	• Rivers, creeks, or canals are found in hot climates with increased biological growth and no chemical treatment. • Faulty placement of the pumping point in the direction of the wind with little or no sedimentation. • Untreated effluent water after sedimentation.	Monthly
Very poor	• Bore water having high iron or magnesium content.	Fortnightly

3.4.2 Types of filters and their maintenance

A. **Hydro-cyclone filter**: In a hydro-cyclone filter, water enters the hydro-cyclone via a tangential inlet, which creates a spiral flow along the walls of the filter. The centrifugal force separates the waste and sand particles and pushes them towards the walls of the sand separator. Particles gravitate downwards into the sedimentation tank, while clean water moves upwards and exits through the top outlet. A hydro-cyclone filter requires the least maintenance as regards cleaning. For cleaning, flush the chamber by opening the flush valve or cap or opening the main valve. The filter becomes ineffective once the dirt collection chamber is full.
B. **Sand filter:** Sand filter helps remove heavy organic and inorganic pollutes. Over a period, contaminants present in the water accumulate and clog the pore space of the sand bed, thereby, reducing filter efficiency. Backwashing is a process, in which the water flow direction is reversed and the sand bed is lifted and expanded, allowing it to release the collected dirt mainly from the top. Daily backwashing of a sand filter is desired. The dirt is carried away through the valve opening. The backwash flow needs to be adjusted with care as excess flow may lead to the removal of sand from the filter, while insufficient flow will not clean the sand.

The steps of the backwash operation are as follows:

a. Open the backwash valve.
b. Close the outlet valve.
c. Open the bypass valve.
d. Close the inlet valve.

Few installations come with semi-automatic and automatic backwash options, where the opening and closing of the valve are done at the same time. The sand filters must also be cleaned regularly in the following manner:

a. Open the lid of the sand filter.
b. Start the backflush operation.
c. Put one hand inside the sand filter and stir the sand thoroughly.
d. Allow all water along with dirt to flow through the main hole of the sand filter.
e. Close the lid for normal operation.

Fig. 3.24: Backwashing

C. Screen filter: Screen filters remove sand from water. Flushing at scheduled intervals is necessary for the maintenance of screen filters. It is recommended to flush the screen filter when the pressure drops more than 0.5 kg/cm2 (5 m at water head). The pressure difference can be observed by checking the inlet and outlet pressure by using a single three-way control valve at regular intervals. The process of cleaning the screen filter is simple.

Flushing of a screen filter is done in the following manner:

a. Open the drain valve, thereby, allowing the water force to flush out dirt through the valve.

b. Open the screen filter lid. Remove the screen and clean it under running water by rubbing it with a cloth or soft nylon brush.
c. Protect the metal parts of the filter from scratches, acid, chlorine, or fertilizer spillage, and apply oil paint immediately on the scratch to avoid corrosion.

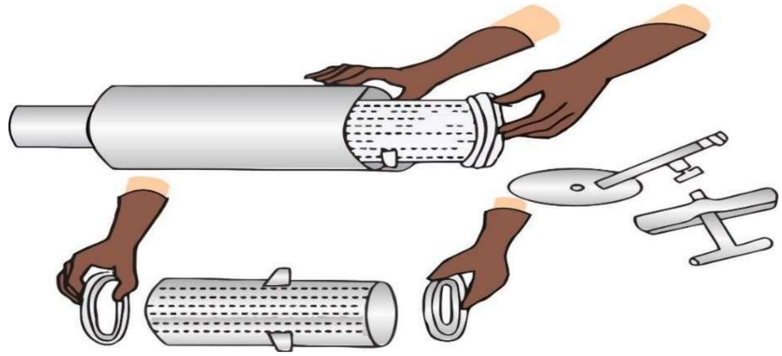


Fig. 3.25: Dismantling of the screen filter

D. Disc filter: A disc filter serves as a primary or secondary filter for water, which contains a high amount of organic or inorganic matter. It consists of a stack of discs, each with a series of microscopic grooves. The dimension of the grooves determines the effective mesh size of the filter, which generally, ranges from 40 to 600 mesh. Disc filter requires less maintenance. Flushing of the disc filter is done either by opening the drain valve or by backflushing.

The steps followed for cleaning the disc filter are as follows.
Step 1: Remove the filter element and loosen the disc set by extending the spine element.
Step 2: Now, remove the screen and clean it with pressurized clean water.
Step 3: Replace the worn-out discs with clean ones.
Step 4: If the disc filter is to be cleaned with an acid or a chlorine solution, use the recommended concentration.
Step 5: Assemble the filter after cleaning.

Fig. 3.26: Cleaning of disc filter

Advantages of drip irrigation systems:

i. Uniform and controlled water distribution close to plant roots along plant rows.
ii. Application of water and fertilizer at the optimum rate to the root system.
iii. iii Minimizes loss of water by deep percolation below the root zone.
iv. iv Eliminates land leveling and irrigation on steeper slopes.
v. v Efficient water application to orchards.
vi. Restricts weed growth to wetted areas.
vii. Permits use of poor-quality water and frequent irrigation.

Limitations of drip irrigation systems:

I. The higher initial cost of installation.
II. Clogging of opening in the emitters.
III. Presence of dissolved salt left in the soil

ACTIVITIES

Activity 01: Field visit near your school

Material required

1. Notebook
2. Pencil

Procedure

1. Visit a farm, where a drip irrigation system has been installed.
2. Discuss the following with the owner of the farm.
   a. What are the advantages of a drip irrigation system?
   b. In which crop(s), the drip irrigation system has been more useful?
   c. What are the common problems that you encounter in maintaining a drip irrigation system?
3. Note down the specifications and their part's name.

CHECK YOUR PROGRESS

A. Answer the following question:

1. Define drip irrigation system and their types?
2. Briefly describe the principle component of the drip irrigation system.
3. Write down step by step procedure for installation of the drip irrigation system.
4. Write adaptability, advantage, and limitation of drip irrigation system.

B. Multiple choice question

1. The diameter of pipes used for installing online emitter's is usually, between _____ and ______mm.
   a. 10 and 15

b. 12 and 15
c. 12 and 15
d. 12 and 20

2. It is a device that has a fine mesh formed into a column to filter out undesirable elements from water.
a. Valve
b. Pump
c. Screen filter
d. Air filter

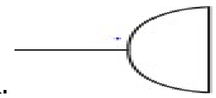
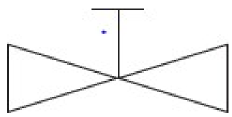
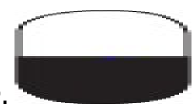
3. Dripper spacing depends on the water requirement of a __________ and the water- holding capacity of the soil.
a. Crop
b. Soil
c. Field
d. Water

4. Full form of HDPE.
a. High-Density Polyethylene
b. Height-Density Polyethylene
c. Hi-Density Polyethylene
d. Haul-Density Polyethylene

5. Backwash operation is
a. Open the backwash valve
b. Close the outlet valve
c. Open the bypass valve
d. Close the inlet valve
e. All of the above

6. Recommended flushing velocities of mainline is _________.
a. 0.5 metre per second
b. 0.75 metre per second
c. 01 metre per second
d. 02 metre per second

C) Match the following

Column A	**Column B**
1. Inline dripper	A. 
2. Symbol for filter	B. 
3. Symbol for flush valve	C. 
4. Online dripper	D. 
5. Symbol for gate valve	E. 

Module 4	Irrigation Pumps

Module Overview

This module provides an in-depth understanding of irrigation pumps, focusing on their types, working principles, components, and applications in agriculture. Pumps play a critical role in lifting water for irrigation, contributing significantly to the agricultural economy by enabling efficient water usage. The module covers various pump types, including centrifugal, axial flow, mixed flow, and turbine pumps, as well as the principles of operation, selection criteria, and key factors for efficient pump performance. Practical considerations such as pump installation, priming, and suction pipe design are also discussed, ensuring a comprehensive grasp of the topic.

Learning Outcomes

After completing this module, you will be able to:

- Explain the importance of irrigation pumps in agriculture.
- Classify different types of pumps and understand their specific uses.
- Describe the working principle and components of centrifugal pumps.
- Evaluate factors influencing the selection and efficiency of irrigation pumps.
- Understand the importance of proper pump installation and maintenance practices.
- Design suitable suction pipes and assess pump performance using characteristic curves

Module Structure

4.1 Introduction: Water is lifted by various devices for irrigating the agriculture field. In the agriculture field, the irrigation pump is the most common device used for water lifting. A pump is a mechanical device that is used to increase the pressure energy of water, so that water is lifted from a lower level to a higher level. This is usually achieved by creating low pressure at the inlet and high pressure at the outlet of the pipe.

Pumps are operated by humans and animals, in our country. The simplest form of a manual lifting device is the water bucket or scoop used to lift water from shallow wells, reservoirs, or canals. The use of a bucket, rope, and roller or pulley helps to lift the water from the source point to the desired place. Lifter uses his/her weight for pulling the water. Labor costs of human-powered irrigation are high. Mechanically powered pumps are very important for the agricultural economy of the country as large volumes of water can be lifted for irrigation purposes at a low cost. This chapter deals with irrigation pumps as it is used for irrigation in agriculture field.

4.2 Classification of pumps

Pumps are powered by mechanical means other than man or animal can be classified as positive displacement pumps or variable displacement pumps. Pumps are classified by design, speed, horsepower.

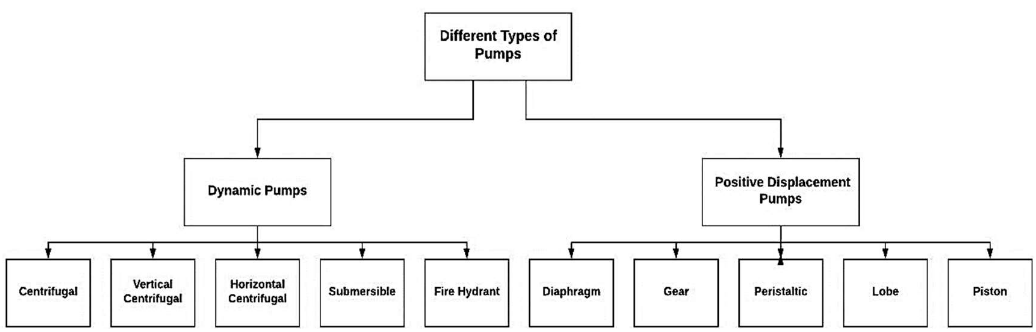


Fig.4.1: Flow chart of pumps

1. **Dynamic pumps:** Dynamic pumps are used for water.

2. **Positive Displacement Pumps:** Positive displacement pumps are further classified as piston pumps, diaphragm pumps, gear pumps, screw pumps which are not used for irrigation purposes.

Variable Displacement Pumps: These pumps are classified into the centrifugal pump, axial flow pump, radial flow pump, horizontal centrifugal pumps, vertical centrifugal pumps, and submersible pumps are commonly used for irrigation.

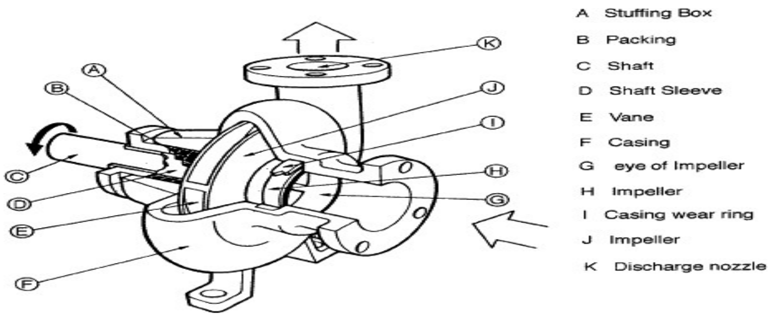


Fig.4.2: Components of a centrifugal pump

4.2.1 Centrifugal pumps

Centrifugal pumps are available in a wide range of sizes and flow rates and can be used for both low and high head or pressure applications. Centrifugal pumps are recommended for pumping from rivers, lakes, canals, and wells. Usually, but not always, the pump is located above the water source.

In centrifugal pumps, water enters the centre of the impeller and it is picked up by the vanes, which is accelerated to a high velocity by rotation of the impeller, Fig.4.3. The water is forced to discharge into the casing, where much of the velocity energy is converted to pressure. When water is forced away from the center, or the "eye" of the impeller, a vacuum is created and atmospheric pressure pushes more water in.

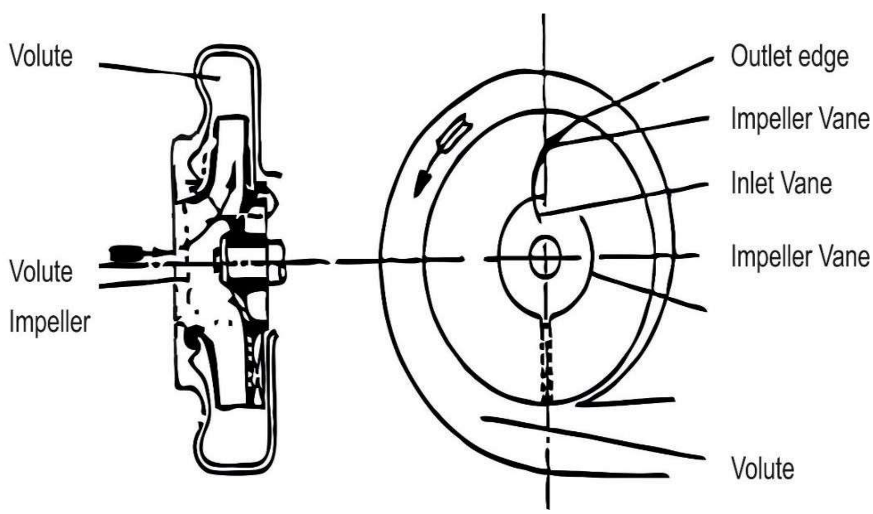


Fig.4.3: Working principle of centrifugal pump

This pump works on the principle of centrifugal force. Centrifugal forces that pushes the liquid away from the center (in tangential direction) which converting prime mover energy into mechanical energy through shaft. Then mechanical energy is converted into fluid energy through impeller. It also converts kinetic energy into pressure energy through the volute casing.

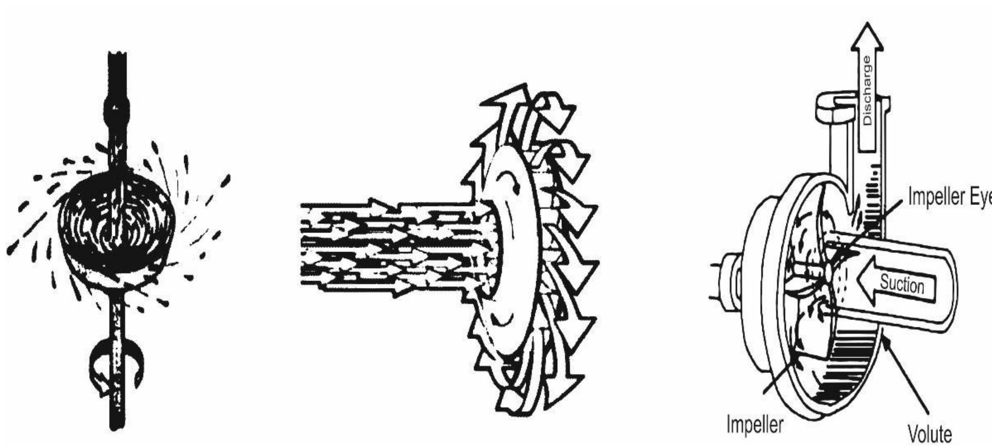


Fig.4.4: Diagram of working principle of centrifugal pump

Major parts of centrifugal pump: All important parts like impeller, eye, vanes, volute casing and shaft etc are shown in the Fig 4.5. The two basic parts of a centrifugal pump is a rotary element or impeller and the stationary element or casing Fig 4.5. The impeller is a wheel or mounted on a shaft and provided with a number of vanes or usually curved. The vanes are arranged in a circular array around an inlet opening at the centre. The impeller is secured on a shaft mounted on suitable bearings.

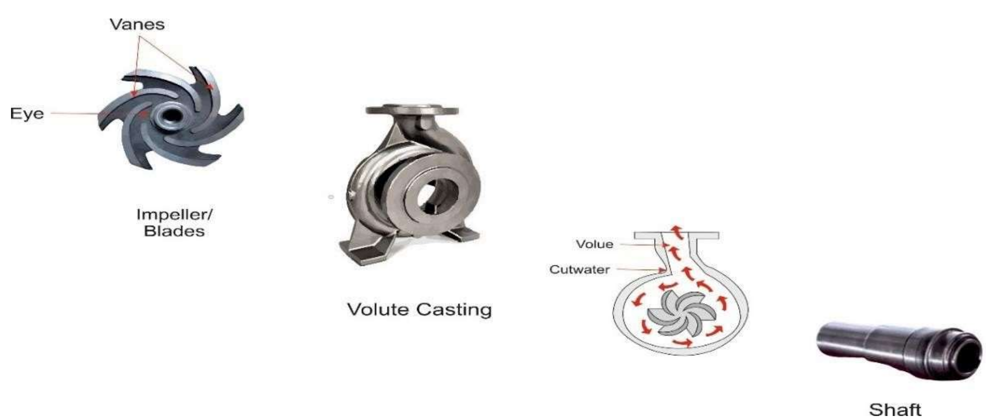


Fig. 4.5: Major parts of centrifugal pump

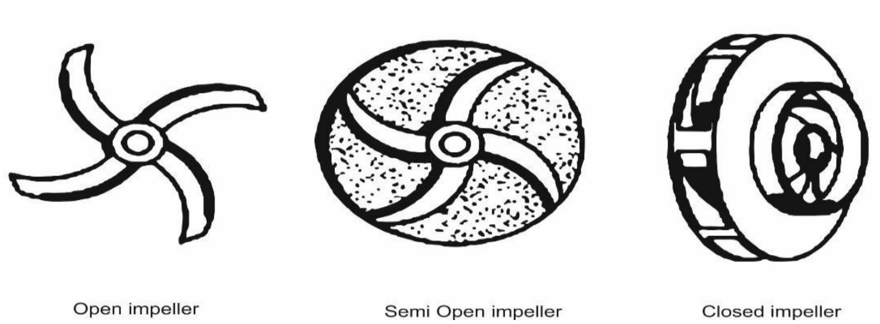


Fig.4.6: Different types of impeller

Electric motors

Pumps are operated with the help of electricity. Electricity has often been considered the ideal source of energy, and electric motors are suitable for all sizes of installation, from very small to very large. The size of electric motor varies from a fraction of horsepower to many thousands of horsepower. Sizes of electric motor may be single phase to three phases. Costs of operation and maintenance electric motor are low and more life.

4.2.2 Principle of operation of centrifugal pump

In a centrifugal pump, an impeller rotating inside a close-fitting case which draws the liquid at the center and by virtue of centrifugal force throws out the liquid through an opening or openings at the side of the casing.

In the design of an impeller, production of high velocity and partial transformation of the velocity into pressure head is created due to hydraulic principle. During the operation the pump is filled with water and the impeller is rotated. The blades cause the liquid to rotate with the impeller and in turn impart a high velocity to the water.

Centrifugal force makes water to be thrown outward from the impeller into the volute casing. The outward flow through the impeller reduces pressure at the inlet, allowing more water to be drawn in through suction pipe by atmospheric pressure or an external pressure. The liquid passes into the casing where the high velocity is reduced and converted into pressure and water is pumped out through the discharge pipe. This conversion of velocity energy into pressure energy is accomplished either in a volute casing or in a diffuser casing.

The number of vanes used in an impeller varies with the service characteristics of pump. In general, higher the head, the more the vanes used and greater the rate of pumping. Too few vanes provide poor guidance for the flow of water and it causes excessive frictional resistance. The minimum number of vanes is usually three and the maximum about twelve.

Importance of priming in pump

Centrifugal pumps does not start, if impeller is not filled with water, and suction is not created while starting the pump. To start pump, water is filled in the impeller so that air is not trapped in the casing of pump. The filling of water and air trap removal is known as priming. Priming is a important step prior to start pump.

We can say ‘Priming is the process in which the impeller of a centrifugal pump will get fully sub merged in liquid without any air trap inside’. It is advisable to start the pump only after priming.

A. Axial flow pumps

Axial flow pumps is also known as propeller pump. These pumps are usually selected for pumping large volumes of water against relatively low (lifts) heads. Capacities range from 40 to 6,000 L/s (liters per second). Total dynamic head (TDH), which is pump lift plus friction losses, is usually from 1 to 2 meters but not more than 10 meters under certain design conditions. As the term "axial flow'' implies, the impellers lift the water and push it forward perpendicular to the plane of rotation, or parallel to the axis.

B. Mixed flow pumps

Mixed flow pumps are used for intermediate lifts over a wide range of flow rates. Most mixed flow pumps are installed where head requirements do not exceed 15 m, although they are available for heads ranging from 6 to 25 m. Capacities vary from 40 to 6,000 L/s. Mixed flow pump, lift the water and also accelerate it.

C. Turbine pumps

In turbine pump, the impeller is surrounded by diffuser vanes which have small openings near the impeller, where the liquid flows into the chamber and around pump discharge. In this velocity should be changed into pressure, which take place between the diffuser vanes. For water turbine practice, diffuser vane casing was initiated, where diffusion vanes are necessary. Turbine pumps are used to lift the water in shallow to deep well. But it is more popular in deep tube wells because of its design or structure.

Turbine pumps can be designed for discharges of less than one liter per second to more than 600 L/s. It is generally used for high head situation, A summary of pump types is given in Table 4.1

Table 4.1: Type of pumps for various pumping conditions

Condition	Pump Type
a) Low to high lift, suction not exceeding 4 to 4.5 m, and low to moderate capacity.	• Centrifugal (end suction)
b) Low lift and large capacity.	• Propeller or axial flow
c) Low to moderate lifts and moderate to high capacities.	• Mixed flow
d) Deep well with high lift over wide range of capacities (usually low to moderate).	• Deep well turbine (semi-enclosed or enclosed multiple-stage impellers)

centrifugal pumps in end section and deep well turbine configurations are illustrated in Fig. 4.6.

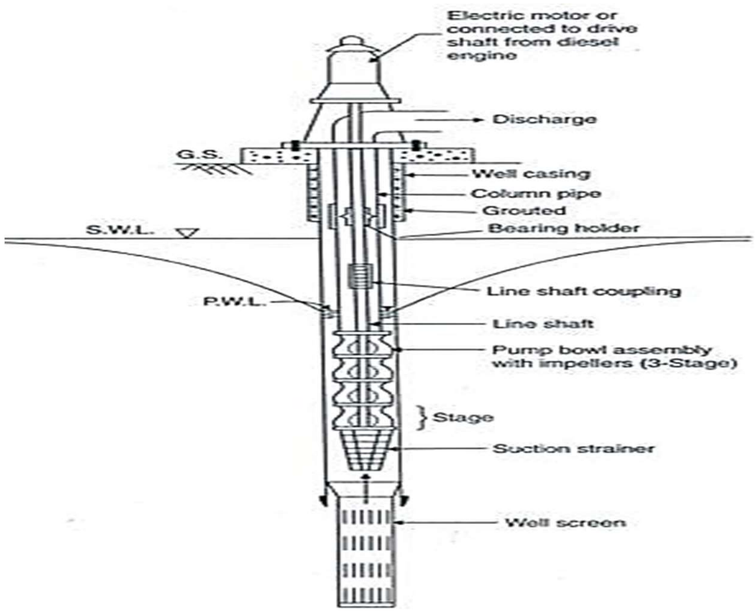


Fig. 4.6: Vertical Turbine Pump

Multistage Centrifugal Pump: This pump is used to achieve a higher discharge pressure multiple impeller are used within a single pump. Depending upon the requirement.

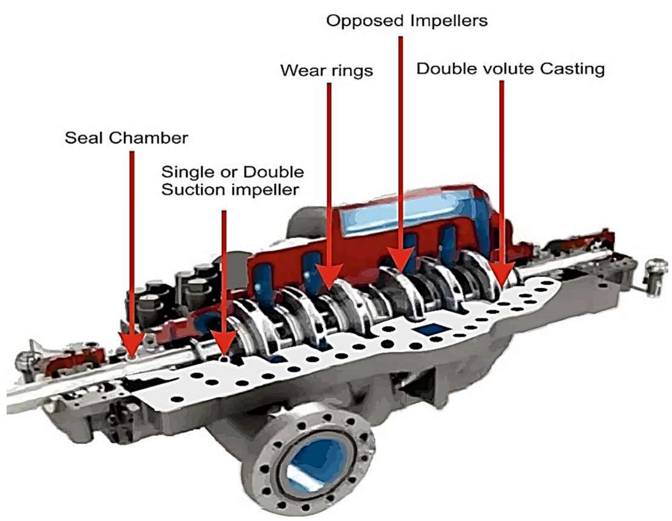


Fig.4.7: Multistage Centrifugal

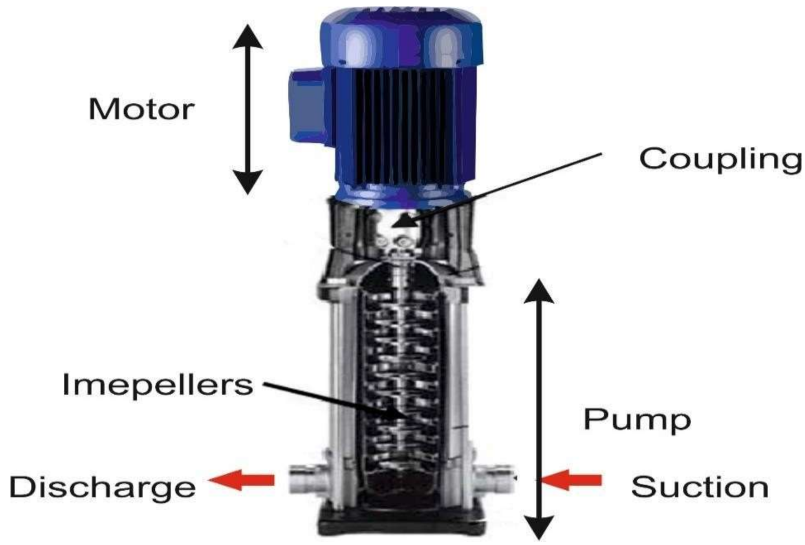


Fig. 4.8: Vertical Multistage Centrifugal Pump

4.2.6 Selection of pumps and power units

The selection of pump and power units depends upon several factors, including:

- Amount of water to be pumped;
- The operating efficiencies (this includes the efficiencies of individual components such as impellers, and gearheads);
- The pumping head (lift and/or pressure requirements);
- Horsepower requirements;
- Available energy (e.g. electricity, diesel);
- Cost and returns on investment; and
- The size of farm, type of irrigation, and the available labor supply.
- Pumps are usually designed for a specific set of operating conditions. The pump must be operated at or near the design values and constant pump operating conditions.

4.2.6.1 Amount of water to be pumped

The amount of water to be pumped depends upon crop water requirements, the area to be irrigated and irrigation efficiency. The size of the pumping plant needed depends upon the amount of water required and the time that will be devoted to pumping.

In irrigated agriculture, however, pumps are usually designed and operated continuously only during peak crop water requirements. During other growing stages, the pump is operated at different intervals to meet different crop water uses. Some irrigators prefer to irrigate their field during daytime hours only. To economize both labour and pumping plant costs, the proper design of a system is required.

For example; A first approximation of the size of the pumping plant can be made by assuming that, for maximum crop growth, the plants will require an application equivalent to one litre per second per hectare (1 L/sec/ha) of continuous pumping. This assumes that rainfall is negligible. Another rough estimate is that crop water requirements during the growing season are seldom less than 3 mm per day and usually will not exceed 8 mm per day. The amount of water a pump must deliver can be calculated from the continuity equation:

Qt = 28ad (metric)

Where,
Q = required pump discharge in liters/second
t = time in hours
a = area in hectares
d = desired irrigation depth in centimeters

Note: In the metric system, a pump discharge of 1 liter per second will cover one hectare to a depth of 8.64 mm in 24 hours, or 0.36 mm per hour.

4.2.6.2 Pumping Lift or Head

The total pumping lift or amount of pressure that a pump must develop to force the water through pipes, sprinklers, etc., to the desired elevation is referred to as "head" or total dynamic head (TDH). The relationship, if water were standing-in a vertical pipe, is-

Metric system	Head	Pressure
	100 meters	10 kg/cm2

The total dynamic head (TDH) is a measure of the energy per unit weight added to the pumped water by the pump, and is the sum of the changes in pressure, elevation, and velocity heads between the pumping water level in the well and the point of discharge, along with any friction losses between the two points. Figure 4.9 shows a typical pump installation for a centrifugal pump drawing water from a canal or pond and discharging through a sprinkler system.

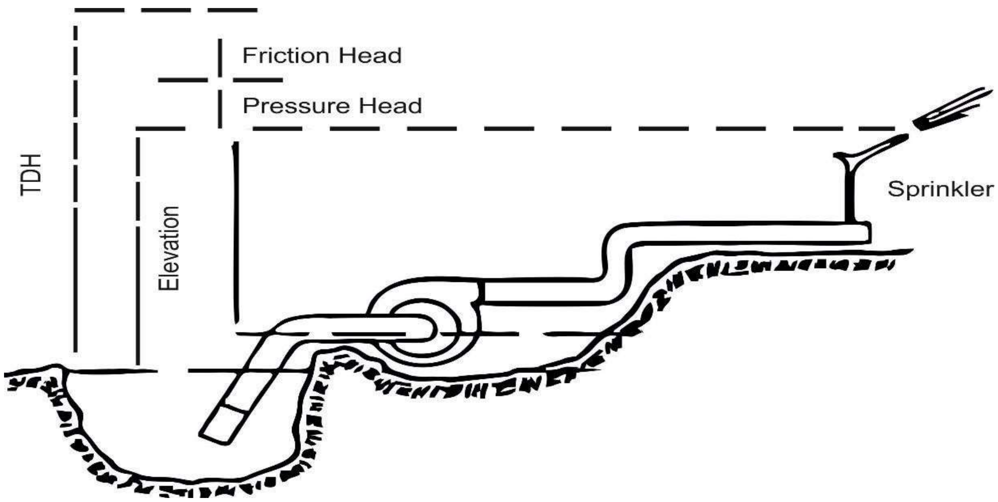


Fig.4.9: Diagram of a centrifugal pump installation showing head and lift

The total dynamic head must be determined as accurately as possible to design a pump. The TDH in Fig.4.9. can be determined as follows:

TDH = hp + hz + hv + hf

Where,
hp = pressure head. This is usually the pressure required at the discharge point, eg., to force water out through sprinklers.
hz = elevation head. This is the difference in elevation between the pumping water level and the point of discharge or the point at which hp is measured.
hv = velocity head. This can be visualized as the vertical distance water would flow out of the end of the pipe as a result of its velocity. It is given by the equation:

$$hv = \frac{v^2}{2g}$$

Where, g is the acceleration of gravity (9.8 m/sec2 in metric system).

Because of friction losses, possible water hammer and other structural damages may occur, and the velocity in most irrigation pipes should be kept below 2 m/sec. Therefore, the velocity head is minimal. It is usually negligible when estimating TDH and thus is not even accounted for.

hf = friction head. This is the pressure or head that the pump must produce to overcome friction, i.e., the loss that occurs as water "rubs" against pipe walls and fittings.

4.2.6.3 Horsepower and efficiency

Horsepower is the power of unit measurement or the rate at which work is done. The power of the engine was measured in terms of horsepower. Water horsepower (WHP) is the theoretical horsepower required for pumping. It is defined as the power output energy per unit time of a pump or energy that the pump provides to the water in the form of discharge and head, this quantity is called water horsepower (WHP). With discharge, Q and TDH, the equation is:

$$\mathbf{WHP = \frac{Q * TDH}{76}}$$

Where, Q(discharge) is in L/sec, and TDH (total dynamic head) is in meters (m)

$$\mathbf{WHP = \frac{Q * TDH}{273}}$$

Where, Q(discharge) is in cubic meters per hour, and TDH (total dynamic head) is in meters (m).

The power required at the pump shaft is called shaft horsepower (SHP) and determined by the water horsepower (WHP) and pump efficiency (Ep).

For 'Ep' expressed as a decimal fraction, the equation is:

$$\text{SHP} = \frac{\text{Water horse power}}{\text{Pump efficiency}}$$

Efficiency is the ratio power output to power input.

$$\text{Pump efficiency} = \frac{\text{Water horse power}}{\text{Shaft horse power}}$$

Brake horse power is actual horse power required to be supplied by the engine or electric motor for driving the pump.

$$\text{BHP} = \frac{\text{Water horsepower}}{\text{Pump efficiency X drive efficiency}}$$

4.2.6.4 Pump characteristic curves

The pump characteristic curve is also known as performance curves, which shows the interrelationship between head, capacity, efficiency and power of pump. Knowledge of pump characteristic is very important at the time of pump selection, which is best to particular conditions of operation and thus obtain a relatively high value of efficiency with low operating cost.

An example of a typical characteristic curve is shown in Figure 8 for a centrifugal pump. A pump that operates near the flattest portion of the efficiency curve should be selected so that a small change in conditions will not significantly change the pump efficiency.

The total head (TDH) that a pump will develop is plotted on the graph versus the pump discharge. Often more than one curve is shown. Each curve is for a different sized impeller or rotation speed.

After the required discharge (Q) and TDH are determined, a search is made through a manufacturer's pump curves to find the pump with a high operating efficiency that meets these conditions.

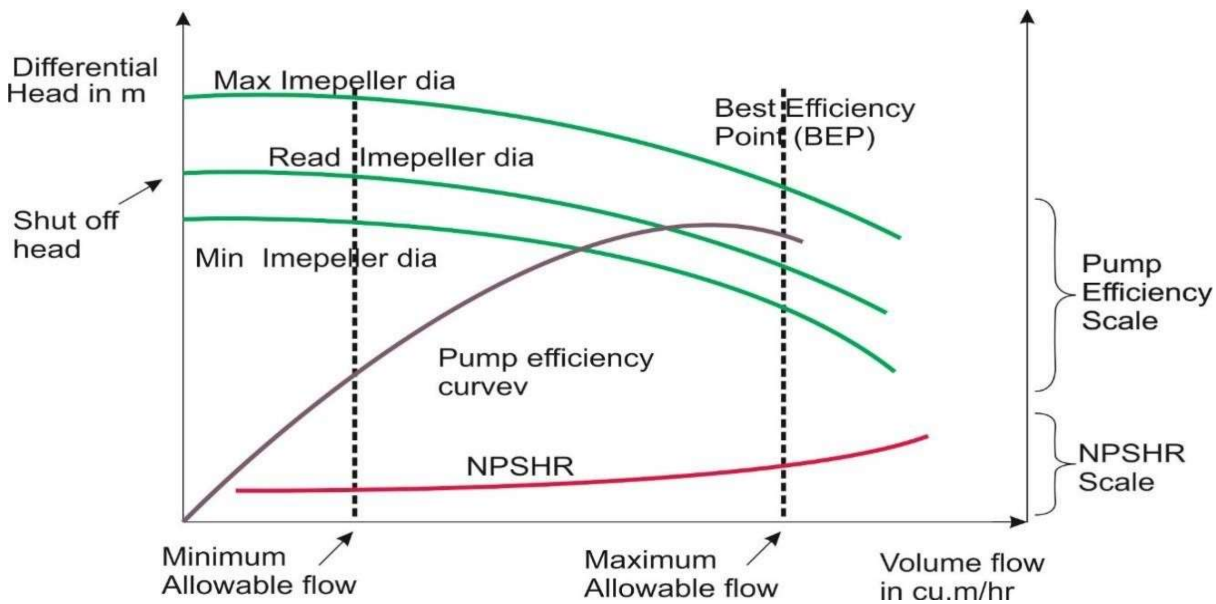


Fig.4.10: Pump Characteristics Curve

4.2.6.5 Pump location

The physical location of the pump in relation to the water level in the sump (well, reservoir, pond) from which water is being pumped should be ideal. If the location of pump is too high than cavitation may occur. The pump may operate very inefficiently. If the pump is too high above the water surface, it may also lose its prime.

The height or distance that a pump can be located above a water surface varies with elevation above sea level, properties of the water, friction loss in the suction pipe, and the net positive suction head requirements of the pump.

Before installation of pump the know about the Net positive suction head (NPSH), which is defined as the head that causes water to flow through the suction pipe into the pump.

NPSH required is the suction head (pressure) required at the inlet of the impeller to ensure that the liquid will not boil or form vapor pockets that result in cavitation. NPSH required is a function of the pump design and supplied by the manufacturer. NPSH available represents the pressure head. It determines how high a pump can be located above a water surface and can be calculated for any installation. To operate successfully, any pump installation must have an available NPSH equal to or greater than the required NPSH at the desired pump condition. Therefore, to assure good pump operation and prevent cavitation, the pump may need to be placed as much as 0.6 m to 0.9 m (2 to 3 feet) lower than the NPSH would indicate at normal atmospheric conditions.

Thus:

NPSH available ≥ NPSH required

Example: To calculate how high above or below the pumping water level the impellers may be located, consider the following-

PL = atmospheric pressure – NPSH required - friction losses in suction - vapour pressure. If PL is positive, the pump may be set above the pumping water level a distance PL. If PL is negative, the pump must be set a distance PL below the pumping water level.

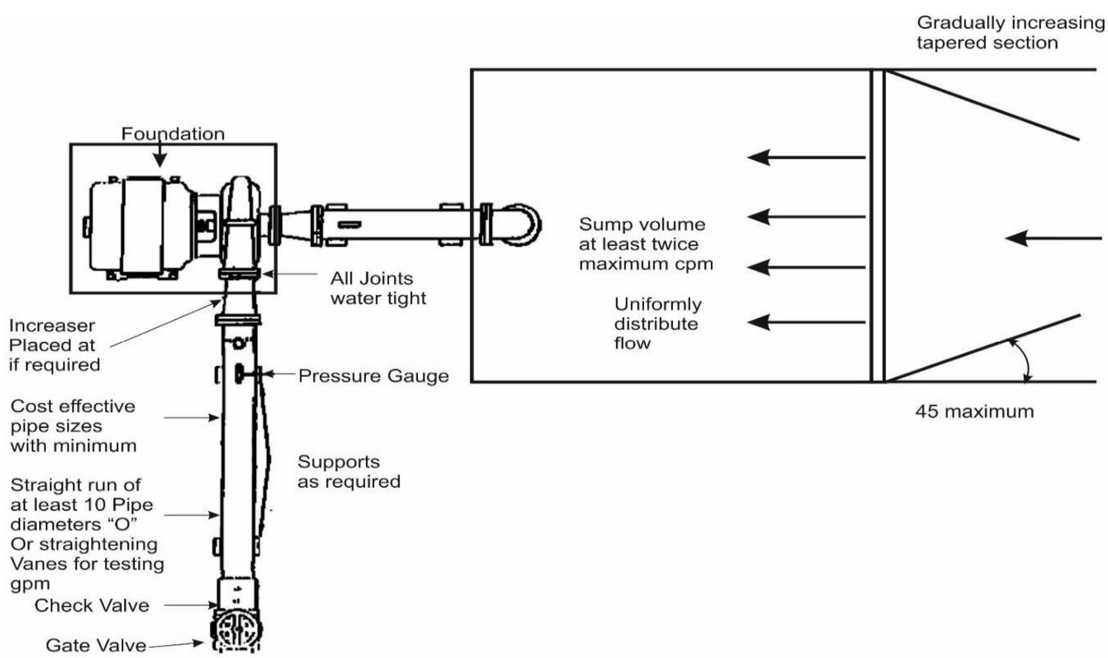


Fig.4.11: Recommended Pump Installation

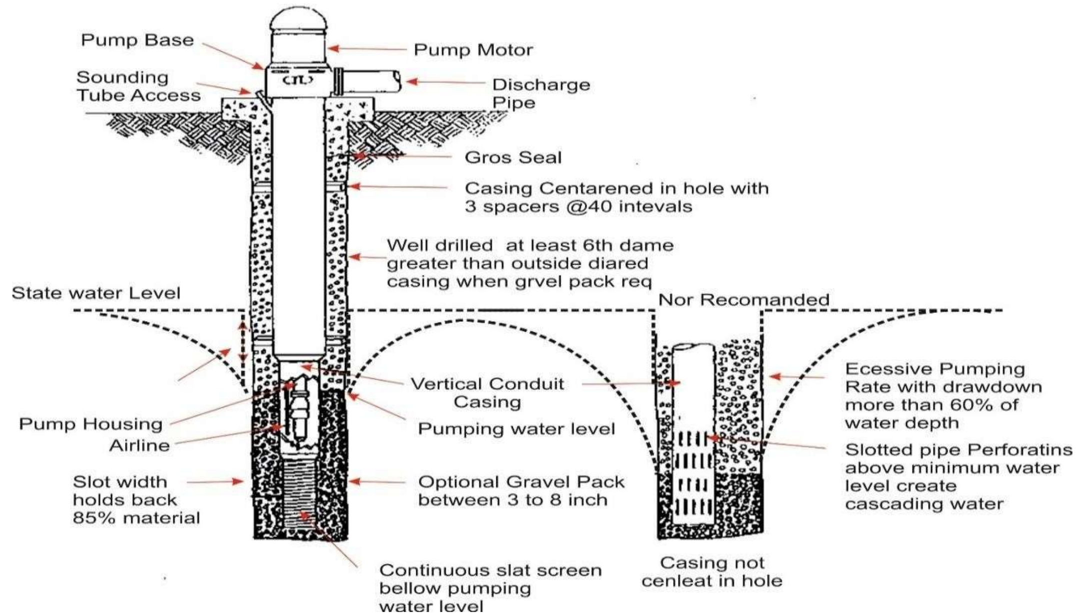


Fig. 4.12: Recommended Pump Installation (Turbine)Design of Suction Pipe

When pumping water from a sump, the proper design of the suction pipe is essential to good for pump performance. If suction pipe is too long or with too many bends, or too small a diameter, cavitation and poor pump performance may result. This may be case also, if the pump is located at very height above the water surface.

Another critical factor in the suction pipe design is the potential for entrapped air in the pipe. The pump may lose its prime, not operate at expected efficiency, or give somewhat erratic discharge and pressure increases. The guidelines for suction pipes are designed with potential problems in installation and operation.

The following guidelines should be followed for suction pipe design:

1. Keep velocity as low as possible. This is accomplished with a larger diameter suction pipe.
2. Avoid bends in the suction pipe but, if bends are necessary, use long radius bends.
3. Keep the suction pipe horizontal or continually sloping upward towards the pump. Avoid high spots in the line.
4. If the suction pipe is to be reduced in diameter as it enters the pump, use a reducer of a length at least twice the diameter of the small pipe.
5. If the reducer is in a horizontal portion of the pipe, an eccentric reducer, placed with the flat side up, should be used. If a conventional reducer is used, the pipe must be inclined sufficiently to prevent air entrapment.
6. Make sure the joints in the suction pipe are well sealed, otherwise difficulty in pumping will be experienced and air will continually be sucked into the system.

7. Ideally, a straight pipe eight diameters in length just upstream from the pump suction inlet should be used to provide uniform, non-spiralling flow.
8. The suction pipe should be of equal or greater diameter than the pump suction connection.
9. Do not use screens on the suction pipe inlet, as they may clog and reduce flow and pressure at the impeller inlet. Screens should be placed at some distance from the suction pipe.
10. Use a streamlined suction bell at the inlet of the suction pipe if possible. If not possible, use an inlet that minimizes friction loss.

4.2.6.6 Pump Installation

1. First select the pump required at that site.
2. Read and understand the instruction manual of the pump.
3. Make the proper foundation.
4. Install the pump and other material like (turbine, motor, engine etc.) at the base of foundation.
5. Check the proper alignment of the pump.
6. Grout the base of foundation.
7. Install the piping.
8. Check the second alignment and readjust the piping according to alignment.

4.3 Turbine and Propeller Pumps

In general, turbine and propeller pumps are used in situations where no suction piping is required. They are usually placed in a pumping pit with the pumps submerged, so no suction pipe is necessary. As a result, they are generally supplied with a suction bell attached to the bottom of the pump. No suction pipe design is required.

If these types of pumps are to be installed in a situation that would require suction pipe, the same guidelines for design as were advised for centrifugal pumps would be used.

4.4 PUMPING FROM A STREAM OR POND

Irrigation can be carried out by pumping water from ponds and streams if the lift is not too great. A small horizontal centrifugal pump set not higher than 10 feet above the water. These types of pumps are made in different sizes for delivering water from low to high capacity (30 to 1,000 gallons or more per minute).

4.5 PUMPING FROM SHALLOW IRRIGATION WELLS

When the bottom of the river, where the ground-water level is permanently within 10 feet or 05 from the surface, small irrigation wells may be successfully used for the irrigation of farmland. Casings for such wells are ordinarily made from sheet metal slotted to permit water to enter. In some instances old range boilers with the ends cut out are welded together and slotted with a welding torch Small centrifugal pumps set at the ground surface are quite satisfactory.

4.6 Centrifugal Pump Troubles and Remedies

Troubles in centrifugal pumps can be grouped into two classes: mechanical troubles and hydraulic troubles. Mechanical troubles include breakage of the pump coupling or shaft. These troubles are easily traceable and can be attended to promptly. However, hydraulic troubles such as failure to deliver water, reduction in discharge and overloading of the prime mover are more difficult to rectify. The major troubles encountered in a centrifugal pump and their remedial measures are discussed below, which can serve as guidelines for the pump users.

Table 4.2: Trouble encountered in centrifugal pumps and their remedies

SYMPTOM	PROBABLE FAULT	REMEDY
1. Pump does not deliver water	The impeller rotating in the wrong direction.	Reverse direction of rotation.
	The pump not properly primed with ¾ air or vapor lock in the suction line.	Stop the pump and reprime.
	The inlet of the suction pipe was insufficiently submerged.	Ensure an adequate supply of liquid.
	Air leaks in the suction line or gland arrangement.	Make good of any leaks or repack the gland.
	The pump is not up to the rated speed.	Increase speed.
2. Pump does not deliver rated quantity	Air or vapor lock in the suction line.	Stop pump and reprime.
	Inlet of suction pipe insufficiently submerged.	Ensure adequate supply of liquid.
	Pump not up to rated speed.	Increase speed.
	Air leaks in the suction line or gland arrangement.	Make good any leaks or repack gland.
	Foot valve or suction strainer choked.	Clean foot valve or strainer.

	Restriction in delivery pipework or pipework is incorrect.	Clear obstruction or rectify error in the pipework.
	Head underestimated.	Check head losses in delivery pipes, bends and valves, and reduce losses as required.
	Unobserved leak in delivery.	Examine pipework and repair leak.
	Blockage in impeller or casing.	Remove half casing and clear the obstruction.
	Excessive wear at neck rings or wearing plates.	Dismantle pump and restore clearances to original dimensions.
	Impeller damaged.	Dismantle pump and renew impeller.
	Pump gaskets leaking.	Renew defective gaskets.
3. Pump does not generate its rated delivery pressure	Impeller rotating in wrong direction.	Reverse direction of rotation.
	Pump not up to rated speed.	Increase speed.
	Impeller neck rings worn excessively.	Dismantle pump and restore clearances to original dimensions.
	Impeller damaged or choked.	Dismantle pump and renew impeller or clear blockage.
	Pump gaskets leaking.	Renew defective gaskets
4. The pump loses liquid after starting	Suction line not fully primed ¾ air or vapor lock in the suction line.	Stop pump and reprime.
	The inlet of suction pipe insufficiently submerged.	Ensure adequate supply of liquid at the suction pipe inlet.
	Air leaks in suction line or gland arrangement.	Make good any leaks or renew gland packing.
	Liquid seal to gland arrangement logging ring (if fitted) choked.	Clean out liquid seal supply.
	Logging ring not properly located.	Unpack gland and relocate logging ring under supply orifice.
5. Pump overloads driving unit	Pump gaskets leaking.	Renew defective gaskets.
	Serious leak in the delivery line, pump delivering more than its rated quantity.	Repair leakage.
	Speed is too high.	Reduce speed.

	Impeller neck rings worn excessively.	Dismantle the pump and restore clearance to the original dimensions.
	Gland packing too tight.	Stop pump, close delivery valve to relieve internal pressure on packing, slacken back the gland nuts and retighten to finger tightness.
	Impeller damaged.	Dismantle pump and renew impeller.
	Mechanical tightness at pump internal components.	Dismantle the pump check internal clearance and adjust as necessary.
	Pipework exerting strain on the pump.	Disconnect pipework and realign to pump.
6. Excessive vibration	Air or vapor lock in suction.	Stop pump and reprime.
	Inlet of suction pipe insufficiently submerged.	Ensure adequate supply of liquid at suction pipe inlet.
	Pump and driving unit incorrectly aligned.	Disconnect coupling and realign pump and driving unit.
	Worn or loose bearings.	Dismantle and renew bearings.
	Impeller choked or damaged.	Dismantle the pump and clear or renew the impeller.
	Rotating element shaft bent.	Dismantle pump and straighten or renew shaft.
	Foundation not rigid.	Remove pump, strengthen the foundation and reinstall pump.
	Coupling damaged.	Renew coupling.
	Pipework exerting strain on pump.	Disconnect pipework and realign to pump.
7. Bearing overhauling	Pump and driving unit out of alignment.	Disconnect coupling and realign pump and driving unit.
	Oil level too low or too high.	Replenish with the correct grade of oil or drain down to correct level.
	Wrong grade of oil.	Drain out bearing, flush through bearings; refill with the correct grade of oil.

	Dirt in bearings.	Dismantle, clean out and flush through bearings; refill with the correct grade of oil.
	Moisture in oil.	Drain out bearing, flush through and refill with correct grade of oil. Determine cause of contamination and rectify.
	Bearings too tight.	Ensure that Bearings are correctly bedded to their journals with the correct amount of oil clearance. Renew bearings if necessary.
	Too much grease in bearing.	Clean out old grease and repack with correct grade and amount of grease.
	Pipework exerting strain on pump.	Disconnect pipework and realign to pump.
8. Bearing wear	Pump and driving unit out of alignment.	Disconnect coupling and realign pump and driving unit. Renew bearings if necessary.
	Rotating element shaft bent.	Dismantle pump, straighten or renew shaft. Renew bearings if necessary.
	Dirt in bearing.	Ensure that only clean oil is used to lubricate bearings. Renew bearings if necessary. Refill with clean oil.
	Lack of lubrication.	Ensure that oil is maintained at its correct level or that the oil system is functioning correctly. Renew bearings if necessary
	Bearing badly installed.	Ensure that bearings are correctly bedded to their journals with the correct amount of oil clearance. Renew bearings if necessary.
	Pipework exerting strain on the pump.	Ensure that pipework is correctly aligned to the pump. Renew bearings if necessary.
	Excessive Vibration.	Refer to symptom 6.
9. Irregular delivery	Air or vapour lock in the suction line.	Stop pump and reprime.

	Fault in driving unit.	Examine driving unit and make good any defect.
	Air leaks in suction line or gland arrangement.	Make good any leaks or repack gland.
	Inlet of suction pipe insufficiently immersed in liquid.	Ensure adequate supply of liquid at suction pipe inlet.
10. Excessive noise level	Air or vapor lock in suction line.	Stop pump and reprime.
	Inlet of suction pipe insufficiently submerged.	Ensure adequate supply of liquid at suction pipe inlet.
	Air leaks in suction line or gland arrangement.	Make good any leaks or repack gland.
	Pump and driving unit out of alignment.	Disconnect coupling and realign pump and driving unit.
	Worn or loose bearings.	Dismantle and renew bearings.
	Rotating element shaft bent.	Dismantle pump, straighten or renew shaft.
	Foundation not rigid.	Remove the pump and driving unit, and strengthen the foundation.

ACTIVITIES

Activity 01: Visit the water pump shop

Material required:

1. Pen
2. Notebook
3. Pencil

Procedure:

1. First take permission from owner of water pump shop
2. Visit their shop and assess the different types of pumps are available in their shops
3. Ask the specification of pump available in the shop
4. Note down their specification and draw the rough sketch of pump
5. Note down the cost of pump.

Activity 02: Visit the field site where centrifugal pump is fitted

Material required:

1. Pen
2. Notebook
3. Pencil

Procedure:

1. Identify the pump fitted in the field site
2. Note the type of pump
3. Measure the suction head, discharge, capacity and horsepower.
4. Draw the sketch diagram of pump

Activity 03: Joining of pump with the pipe Material required:

1. Pen
2. Notebook

Procedure:

1. Collect the all material like tools, pipe, pump, etc. for joining the pump.
2. Draw the image for joining
3. Join the pipe step by step with pump

CHECK YOUR PROGRESS

A. Short answer questions

1. What are the factors that determine the amount of water to be pumped?
2. How is cavitation in pumps caused? How does it affect the functioning of pumps?
3. Explain briefly the functioning of centrifugal pump and the important parts.
4. Why centrifugal pumps have to be primed? what is priming of pumps?
5. What are the points to be considered while suction pipe of a pump is installed?
6. Explain under which conditions where turbine and propeller pumps are used.
7. Explain pumps characteristics curve, how is it used when a new pump has to be installed.

B. Fill in the blanks

1. A pump is a ________________ device that is used to increase the pressure energy of water so that water is lifted from a lower level to a higher level.
2. Centrifugal force makes water to be thrown outward from the _____________ into the volute casing.
3. Turbine pumps can be designed for discharges of less than one liter per second to more than ____________.
4. Horsepower is the ____________ of unit measurement or the rate at which work is done.

C. Match the following:

Column A	**Column B**
Type of pump required	**Field Requirement**
1. Mixed flow.	a) Low to high lift suction not exceeding 4 to 4.5 m, and low to moderate capacity
2. Centrifugal (end suction).	b) Low lift and large capacity.
3. Propeller or axial flow.	c) Low to moderate lifts and moderate to high capacities.

Module 5	Maintain Health and Safety at the Workplace

Module Overview

This module provides an in-depth understanding of irrigation pumps, focusing on their types, working principles, components, and applications in agriculture. Pumps play a critical role in lifting water for irrigation, contributing significantly to the agricultural economy by enabling efficient water usage. The module covers various pump types, including centrifugal, axial flow, mixed flow, and turbine pumps, as well as the principles of operation, selection criteria, and key factors for efficient pump performance. Practical considerations such as pump installation, priming, and suction pipe design are also discussed, ensuring a comprehensive grasp of the topic.

Learning Outcomes

After completing this module, you will be able to:

1. Explain the importance of irrigation pumps in agriculture.
2. Classify different types of pumps and understand their specific uses.
3. Describe the working principle and components of centrifugal pumps.
4. Evaluate factors influencing the selection and efficiency of irrigation pumps.
5. Understand the importance of proper pump installation and maintenance practices.
6. Design suitable suction pipes and assess pump performance using characteristic curves

Module Structure

5.1 Introduction

There is a lot of work performed by the different types of machines and machinery in the agriculture sector. During work / field conditions, how to use equipment and other accessories is very important. There are also many other risks in the field scenario, such as environmental, chemical and physical, etc. Therefore, it is very important to be cautious in the field of agriculture during work, as well as to focus on health and safety.

The following should be addressed in the workplace in order to ensure health and safety precautions:

5.2 TYPES OF HAZARDS

The words ‘risk’ and ‘hazard’ are also used in exactly the same way. However, if you are responsible for overseeing your workplace's health and safety, it's important that you know the difference between them. The remainder of this chapter focuses on dangers, including where they could be found in various workplaces. To make the risk management process as seamless as possible, we also provide you with a number of additional tools. The six main categories of hazards are:

- **Biological:** This involves such threats that can cause adverse health effects, such as viruses, bacteria, insects, livestock, etc.

For example: Moulds, blood and other bodily fluids, toxic plants, waste and dust.

- **Chemical:** Such hazards are toxic substances that can cause harm. And both health and physical effects, such as skin irritation, irritation of the respiratory system, blindness, corrosion and explosions, can result.

- **Physical:** Certain hazards, including heights, noise, radiation and strain, are environmental factors that can affect an employee without actually touching them.

- **Ergonomic:** These hazards are a result of physical conditions that can lead to musculoskeleton injuries.

For example: A bad workstation setup in an office, poor posture and manual handling.

- **Psychosocial:** Covers those who may have an unfavorable impact on the mental health or well-being of an employee.

For example: Stress, physical harassment, and workplace violence.

- **Safety:** These are hazards which create unsafe working environments.

For example: A tripping hazard may result in exposed wires or a damaged carpet. These are also included in the physical hazards group.

5.3 Common hazards at agriculture farm

In agricultural farming, during field and environmental conditions, too many hazards occur. This is due to the amount of variables that exist in day-to-day activities:

- **Animal related injuries** - This covers all animal-related injuries, such as bites, punches, smashing and transmission of certain diseases such as bird flu, salmonella, ringworm and leptospirosis etc.
- **Hazardous equipment and machinery -** this covers all moving parts that are used by various types of farm machinery.
- **Heat** - this can potentially cause sunburn, heat stroke and dehydration.
- **Ladders and high places** - falls from these can cause serious major injuries.
- **Noise pollution -** this can affect the person's hearing, some of this are the noise created by machines and animals.
- **Pesticides and other farm related chemicals** - this will possess high hazard that can cause respiratory illness or poisoning.
- **Unsanitary conditions** - a lot of diseases can be caught with unsanitary practices and areas.
- **Vehicle hazards** - this will include potential accidents from vehicles like crashing and falling that can cause serious injuries.

Perhaps more than any other occupational group, agricultural workers are exposed to a tremendous variety of environmental hazards that are potentially harmful to their health and well-being. Farmers and farm workers suffer from increased rates of respiratory diseases, noise-induced hearing loss, skin disorders, certain cancers, chemical toxicity, and heat-related illnesses. There are precautions that can be taken to minimize or eliminate these potential hazards.

A. **RESPIRATORY HAZARDS**: Farming situations present several respiratory hazards to farm workers. Exposure to these hazards has been linked to excessive coughing and congestion in 20 to 90 percent of farm workers and families. Symptoms of chronic bronchitis were observed in as many as 50 percent of swine confinement workers and grain handlers.

Organic Dust Toxic Syndrome (ODTS) is a common respiratory illness manifested by temporary influenza-like illness with fever, headache, and muscle aches and pains. Although much less common than ODTS, Farmer's Lung is an allergic reaction caused by inhaling dust from moldy hay, straw, and grain. Dairy and grain farmers are the most common victims. The months when moldy crops are handled indoors are the most dangerous. For those who are susceptible, repeated exposure damages lung tissue, ca sing shortness of breath and a growing inability to perform strenuous work. Victims eventually may find it a struggle even to get out of a chair.

Dust from moldy hay, grain, and silage can also cause ODTS, which has symptoms resembling 'Farmer's Lung'. However, ODTS does not produce long-term illness or cause permanent lung damage. Nuisance dusts and gases also are hazards. Suspended dust particles not containing spores from moldy organic matter are considered nuisance dusts. Repeated exposure can turn portions of the lung into hardened, nonfunctioning tissue and cause chronic bronchitis and occupational asthma.

A variety of disabling gases, including nitrogen dioxide (NO2), hydrogen sulfide (H2S), ammonia (NH3), Carbon dioxide (CO2), and methane (CH4), are produced during many routine operations. Exposure to low levels of NO2, H2S, or NH3 will produce lung and eye irritations, dizziness, drowsiness, and headaches. High levels of H2S, particularly, and NO2, secondarily, will quickly render a worker unconscious and death will follow.

The best prevention of respiratory disease is to wear a respirator approved by the National Institute of Occupational Safety and Health (NIOSH). Air-purifying respirators remove contaminants from the air, but can only be used in environments with enough oxygen to sustain life. Supplied-air respirators must be used in oxygen-limited environments, or in environments with acute toxic gas levels.

B. **NOISE:** Agricultural noise is another common health hazard on the farm or agriculture field. The noise pollution generated by tractor and other agriculture machinery, which is used for different agriculture operation at the field site. Due to these noise farmers and labour has facing some disturbance during their field work. It is estimated that 10 percent of U.S. farm workers are exposed to average daily noise levels above 85 decibels, which is the "action" level at which hearing conservation program are required for industrial workers.

Prolonged exposure to excessive noise, such as that produced by tractors, combines, choppers, grain dryers, and chainsaws, can cause permanent hearing loss unless noise-control measures are taken.

Ears provide two warning signs for overexposure: temporary threshold shift (TTS) and ringing in the ears (tinnitus). The two types of hearing protection available are ear muffs and ear plugs. Ear muffs are more effective, but the level of protection varies due to differences in size, shape, seal material, shell mass, and type of suspension. Ear plugs may be custom fined or preformed rubber, plastic, or foam inserts. Preformed inserts are cheaper, but ear plugs properly inserted into the ear and custom-fitted by trained personnel are more effective because the ear canal shape may vary.

If you are continually exposed to loud noises, you should have periodic hearing tests. This test, called an audiogram, will reveal signs of hearing loss. If a hearing loss is noted, take steps to reduce exposure, thereby eliminating further damage to your ears.

C. SKIN DISORDERS: In the agriculture sector, the workers do their job/work in the open field. And the farmers and labour are direct contact with solar radiation which comes from sun rays, which is very create harmful effect to the skin of the farmers. Contact dermatitis is a skin disorder that occurs among agricultural workers.

There are two general categories: irritant and allergic. Irritants act directly on the skin at the place of contact. Allergic sensitizers, however, cause changes in the immune system so that subsequent contact produces a reaction. Phototoxic or photoallergic reactions occur when light, in combination with certain substances, causes skin disease. Other types of agricultural dermatitis include heat rash, origin infections, and insect and plant irritants.

A number of factors predispose an individual to dermatitis, such as age, sex, race, temperature and humidity, previous skin disorders, skin damage, and personal hygiene. Work-related skin diseases are often easy to detect, but difficult to diagnose. It is important for the physician to know chemicals and other agents to which an individual has been exposed. Wearing proper protective clothing, and washing frequently are the most effective means of prevention.

D. CANCERS: Skin cancer is a concern on the farm due to the long hour's farmers spend in the sun. Skin cancer is the most common form of cancer, with about 450,000 newly diagnosed cases in America each year. People at high risk include those with fair skin, blue eyes, and red or blond hair. Ninety percent of all skin cancers occur on parts of the body not usually covered by clothing. A place of particular concern for farmers is the back of the neck. Avoid overexposure, especially between 11 am. and 2 p.m.; use sunblock's that absorb or deflect ultraviolet rays; wear protective clothing, such as long-sleeved shirts, pants, and wide-brimmed hats; and conduct regular self-examinations for early detection.

There are three major types of skin cancer: basal cell carcinoma, squamous cell carcinoma, and malignant melanoma. Basal cell carcinoma is the most common form. It rarely spreads, but if left untreated, can spread to underlying tissues and destroy them. It usually occurs as a small, shiny, pearly nodule that may ulcerate and crust. Squamous cell carcinoma, although rarely life- threatening, is more dangerous than basal cell carcinoma because it spreads more rapidly. It may begin as a nodule or as a red, scaly, sharply outlined patch. Malignant melanoma is the least common, but deadliest, type of skin cancer. It starts as a small, mole-like growth that increases in size and forms irregular borders. It may change color, ulcerate, or bleed from a slight injury. Melanoma is completely curable in its early stages, but if left untreated, spreads rapidly through the lymph system

E. CHEMICAL HAZARDS: Many agricultural workers are exposed to chemicals on a daily basis. If they do not observe proper precautions, illness or even death may ensue. The Environmental Protection Agency estimates that there are close to 10,000 poisonings each year in America. Only about 28 percent of these occur on the job. The majority are the result of home-related poisonings.

Pesticides can enter the body through many routes, but the most common ways are through the skin and by inhaling. To prevent dermal (skin) contact and inhalation of pesticides, applicators should wear personal protective clothing and equipment.

When using diluted pesticides, the applicator should wear chemical-resistant coveralls or an apron. When handling concentrates during mixing and loading, a face shield, unlined rubber gloves and boots, and a lightweight rubber apron should be worn. Boots and aprons should be washed daily with soap and water and dried thoroughly, inside and out, to remove pesticide residues. All clothing worn while handling pesticides should be washed daily, separately from other clothing.

Wear a NIOSH (National Institute for occupational safety and health) approved respirator when the chemical label calls for it, and be sure to choose the type that protects specifically against the pesticide you are using. Respirators must fit the face well to ensure a good seal. Long sideburns, beards, or glasses may prevent a good seal

F. HEAT STRESS: Heat stress occurs when the body builds up more heat than it can handle. High temperatures, high humidity, sunlight, and heavy workloads increase the likelihood of heat stress. Use fans, ventilation systems, and shade whenever possible. A work area sometimes can be shaded by a tarp or canopy. Drink plenty of water before, during, and after work, and consider wearing cooling vests, which are garments with ice or frozen gel inserts.

Allow time to adjust to the heat and workload. People who are used to working in the heat are less likely to suffer heat stress. To become adjusted, do about 2 hours of light work per day in the heat for several days in a row; then, gradually increase the work period and workload for the next several days. An adjustment period of at least 7 days is recommended. If the warm weather occurs gradually, workers may adjust naturally.

Good health has long been acknowledged as one of the most critical elements to quality of life. The health of farm workers is a vital resource to protect. Following recommended precautionary measures to protect your health can go a long way to enhancing your quality of life.

5.4 Agriculture machinery and equipment safety

There are many different types of machinery and equipment used in agriculture. Some of the most common ones include tractors, cultivators, harrows, seeding equipment, sprayers, harvesters, mowers, balers, augers, trailers, all-terrain vehicles, etc. A wide range of tools are also used for agricultural production and maintenance tasks. The versatility of use for both male and female workers should be given first attention when choosing tools and equipment.

Before using such equipment, it is important to follow the safety regulations established by the relevant authorities with regard to the design, manufacture, installation, and use of agricultural machinery and equipment, as well as any necessary market surveillance.

5.4.1 Tractors and all-terrain vechicles

Farm tractors are the most significant piece of power equipment used in agriculture and are responsible for a significant share of accidents and fatalities in the upkeep and production of agricultural systems. Overturns, run-overs, and PTO entanglement are the three most dangerous risks related to tractor operations.

All-terrain vehicles (ATVs) are used as transport vehicles in many nations, partly because they offer the first step away from draught animals in some enterprises and partly because they are able to perform many tractor-like tasks in confined spaces, such as inside agricultural structures, other enclosures, and in livestock operations.

5.4.2 Ergonomics and the handling of materials

Agricultural workers' health outcomes are impacted by ergonomic factors. These factors include:

- The physical characteristics of the workplace (noise, heat, lighting, thermal comfort), the agricultural tasks to be carried out;
- The technology used to carry out the tasks (including workplace design, facility design, and agricultural material handling);
- The way the tasks are organised (including the use of shift work); and
- The characteristics of the workers (including demographics, physiology, human error, and identification and treatment of injured workers).

5.5 Agriculture-related illnesses and injuries

Agriculture is a dangerous profession. Farmers and farm workers frequently work at heights, close to pits and silos, with potentially hazardous machinery, vehicles, chemicals, and livestock. They are subjected to adverse weather, noise, and dust conditions. Family members working on the farm and kids living there are additional concerns.

The repetitious nature of agricultural work makes it physically taxing and can lead to a variety of health issues, including excruciating back pain.

The most dangerous industry sector is agriculture, forestry, and fishing due to the high numbers and rates of fatal injuries.

The most frequent causes of death are:

- transport – being struck by moving vehicles;
- being struck by a moving or falling object, such as bales, trees, etc.;
- falls from heights; asphyxiation or drowning;
- contact with machinery; injury by an animal;
- being trapped by something collapsing or overturning; and
- contact with electricity, with overhead power lines accounting for nearly two-thirds of these incidents (OHPLs).

The most frequent causes of non-fatal injuries are:

- slipping,
- falling, or falling on the same level;
- being struck by moving items, such as those that are flying or falling;
- falling from a height;
- coming into touch with machinery; and
- being bitten by an animal.

5.6 Procedure for providing first aid in case of medical emergency – cut, burns, bites, grazes, bruises, electric shock, external bleeding, etc.

There is basic medical emergency is required during work time;

Cut: If cuts are observed in your body than you have to follow some rules like; first clean that area with clean cloth or cotton, after that you can paste the powder or antiseptic gel, if cut is deep or long than you have to do stiches and a tetanus shot.

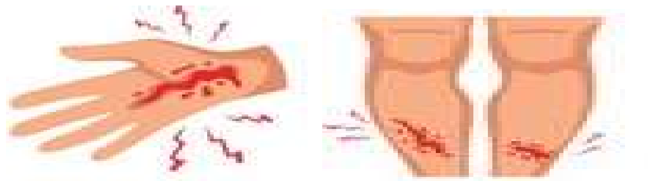


Fig.5.1: Cut

Burns: It is generally occurred due to sunlight, fire. To treat minor burns, follow these steps:

1. Cool the burn
2. Apply lotion
3. Bandage the burn
4. Take a pain reliever and if requires than also take tetanus shot.

Fig.5.2: Burns

Bites: If any bites occur during the workplace than you can check first, thereafter you can treat an insect bite or sting:

1. Remove the sting, hairs if still in the skin.
2. Wash the affected area with soap and water.

3. Apply a cold compress (such as a cooled cloth) or an ice pack to any swelling for at least 10 minutes.

4. Apply the antiseptic and take tetanus shot.

Fig.5.3: Bites

Scrapes or Bruises: To treat the scrapers or bruises, follow these steps:

1. Use direct pressure to stop any bleeding
2. Wash the wound with soap and water for 5 minutes
3. Gently scrub out any dirt with a washcloth
4. Use an antibiotic ointment (such as Polysporin).

External bleeding: To treat the external bleeding, follow these steps:

1. Apply direct pressure to the bleeding wound.
2. Raise the injured area.
3. DO NOT remove the foreign object, but apply padding on either side.
4. If blood leaks through the pressure pad and bandage.
5. Control any bleeding.
6. Recover the severed part.
7. Apply firm pressure, elevation and rest.

Electric shock: To treat the electric shock, follow these steps:

1. Begin Cardiopulmonary resuscitation (CPR) if the person shows no signs of circulation, such as breathing, coughing or movement.

2. Try to prevent the injured person from becoming chilled.
3. Apply a bandage.
4. Cover any burned areas with a sterile gauze bandage, if available, or a clean cloth.

Fig. 5.4: Electric Shock Sign

5.7 My first aid kit

It is necessary to have the following items in a first-aid kit. These items help patient immediate relief from pain or injury.

First Aid Kit Items	
• Adhesive tape	• Bandages in different sizes
• Antibiotic ointment	• Cold packs
• Allergy medicine	• Hand sanitizer
• Scissors	• Latex-free gloves
• Dettol	• Pain relievers medicine (like acetaminophen and ibuprofen)
• Cotton	• Calamine lotion
• Waterproof bandages	• Hydrocortisone cream

5.6.1 First aid assessment should take into account:

- The nature of the work.
- The history and consequences of injuries.
- The nature and distribution of the workforce.

- The remoteness of the site from the emergency services, including location, terrain and weather conditions.
- Working on shared or multi-occupied sites.
- Holidays and other absences of first aiders.
- The presence of trainers and the public.
- The possibility of medical conditions or allergies

5.8 Render appropriate emergency procedures

One of the most dangerous occupations is farming. There are some of the following steps that should be followed during any field or workplace emergency:

- Raise the alarm.
- Let everyone know about the emergency.
- Utilize emergency response options available on-site, such as fire extinguishers, etc.
- Get the emergency services involved (i.e., call 999 or 112).
- Controlling crowds, including evacuation as necessary.
- Evacuate people with disabilities.
- Farmers and workers are knowledgeable about using basic first aid in an emergency.
- Farmer/Labor is utilised.

ACTIVITIES

Activity 1: Activity 01: Make a list of hazards. Material Required

1. Pen
2. Notebook

Procedure

1. First, visit the disaster management office.
2. Second, identify the different types of hazards.
3. write the name of different types of hazards.
4. Write their application and precaution.

CHECK YOUR PROGRESS

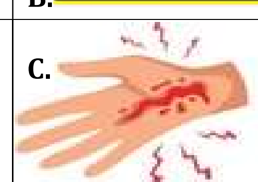
A. Answer the following

1. What do you mean by hazards and its types?
2. Briefly describe common hazards at agriculture farm?
3. Define the term chemical hazards?
4. What is the importance of First Aid Kit?

B. Fill in the blank

1. ______________ occurs when the body builds up more heat than it can handle.
2. Agricultural noise is another common ___________ on the farm or agriculture field.
3. Symptoms of chronic bronchitis were observed in as many as____________ of swine confinement workers and grain handlers.
4. _____________ hazard may result in exposed wires or a damaged carpet.

C. Match the following

Column A	Column B
1. Electric shock sign	A. 
2. Cut	B. 
3. Bites	C. 

ANSWER KEY

S.No.	Fill in the blank	Match the following
Unit 01	**1.** organic and inorganic **2.** topography **3.** moving earth **4.** wheel **5.** central **6.** depth **7.** Water use efficiency	**1.** A **2.** D **3.** C **4.** B **5.** D **6.** B
Unit 02	1. milliliter per minute 2. 1.5–2 kg/cm2 **3.** Pipe wrench **4.** Grommet take off	**1.** D **2.** A **3.** B **4.** E **5.** C
Unit 03	1. 12 and 20 **2.** Screen filter **3.** Crop **4.** High-Density Polyethylene **5.** All of the above **6.** Meter per second	**1.** B **2.** D **3.** A **4.** E **5.** C
Unit 04	**1.** Mechanical **2.** Impeller **3.** 3. 600 L/s 4. power	**1.** C **2.** A **3.** B **4.** D
Unit 05	**1.** Heat stress **2.** health hazard **3.** 50 percent **4.** tripping	**1.** B **2.** C **3.** A

GLOSSARY

Agriculture	**The art and science of cultivating crops and rearing domestic animals.**
Aquifer	It is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated material.
Back flush	The process of flowing pressurized water backwards through a filter to remove trapped debris and restore the filtration system for ongoing use.
Back pressure	An increase of pressure in the downstream piping system above the supply pressure at a point of consideration, which can cause a reversal of the normal direction of flow.
Backwash	A process in which the direction of the flow is reversed so that the water flows upwards through the sand bed.
Cavitation	It is the formation of bubbles or cavities in a liquid, developed in areas of relatively low pressure around an impeller. The imploding of these bubbles triggers intense shockwaves inside the pump, causing significant damage to the impeller or pump housing.
Centre pivot	An automated irrigation system, consisting of a sprinkler line, rotating about a pivot point at one end and supported by a number of self- propelled towers.
Clogging	It is the blocking of drip emitters by silt or other suspended solid matter.
Coarse grained soil	Soil containing more than 50 per cent minerals by weight and the size of soil particles is more than 75 micron.
Contour lines	A contour line is an imaginary line that is obtained by joining the points of constant elevation on the surface of the ground.
Controller	It is an automatic timing device that sends an electric signal for automatic valves to open or close, according

	to a set irrigation schedule.
Drip lateral	A water delivery pipeline or Low Linear Density Polyethylene (LLDPE) pipe that supplies water to the emitters from the main lines or sub- mains.
Elbow	An electro-mechanical device, in which the solenoid uses electric current to generate a magnetic field, thereby, operating a mechanism that regulates the opening of water in a valve.
Emitter	An irrigation device moulded from plastic and designed to deliver precise amounts of water to particular areas.
Fertigation	The application of fertilizers, plant nutrients or amendments through an irrigation system.
Fertilizer	An organic or inorganic material, either natural or synthetic, used to supply elements, such as nitrogen, phosphate, potash, etc., which is essential for plant growth.
Field capacity	The depth of water retained in the soil after draining the gravitational water. This stage is, normally, reached after 1–3 days after irrigation or rain. It is expressed as the depth of water in inch or foot. It is also called ‘field moisture capacity’.
Flow rate	The rate of flow or volume per unit period of time.
Flushing	It involves opening the ends of a pipe system and using an appropriate velocity to flush sediment and algae built up in sub-mains or tubes. Friction loss. It is a drop-in pressure as water moves through tubing due to friction in a pipeline.
Gravity flow	A flow of water drawn through a conduit under the force of gravity.
Gravity irrigation	An irrigation method, in which water pressure is generated by elevation.
Groundwater	It is the water below the Earth’s surface. Water stored in an aquifer is also called groundwater.

Hazard	The danger that an injury will occur with the use of an equipment, chemical or pesticide, etc.
Horsepower	The power of an engine is measured in terms of horsepower (about 745.7 watts).
Impeller	A rotating component equipped with vanes or blades used in turbo machinery, such as centrifugal pump.
Infiltration	The process of water movement through the soil surface into the soil matrix.
Infiltration rate	The velocity or speed at which water permeates into the soil. It is, usually, measured by the depth (in mm) of water layer that enters the soil in one hour.
Irrigation frequency	It is the measure of the number of irrigations applied per unit time.
Irrigation interval	The average interval between the commencement of successive irrigations in a field or an area.
Irrigation schedule	The schedule that decides when to irrigate a land and how much water to apply as per the measurement or estimate of soil moisture or crop water used by a plant.
Irrigation system	It includes the water source, water distribution network, control components and irrigation equipment.
Laterals or lateral pipes	Pipes used for conveying water from sub-main lines in case of drip irrigation, while in sprinkler irrigation, sprinklers are mounted on these pipes.
Leaching	Loss of water-soluble plant nutrients from the soil.
Mesh filtration	A process that uses mesh filters or mesh screens to filter water. Micro irrigation An irrigation system with small, closely spaced outlets used to apply small amounts of water at low pressure.
Mist irrigation	An irrigation method, in which water is applied in the form of small droplets.
Mister	An emitter designed to ‘atomize’ water into fog or

	heavy mist.
Net Positive Suction Head	It is defined as the difference between the suction head and liquid vapour head.
Orifices	A submerged opening with a closed perimeter through which water flows.
Perennial crops	Plants having a life cycle of more than two years.
pH	Negative logarithms of H+ ion concentration of a given solution.
Pitting corrosion	A type of corrosion that occurs in material having protective films.
Pre-plant irrigation	Pre-plant irrigation supplies moisture to the root zone of a plant prior to planting.
Pressure gauge	A device used for measuring the pressure of water.
Pressure regulator	A device used to reduce the incoming water pressure, which can be high for a drip irrigation system.
Pressurized irrigation	An irrigation system, in which water is conveyed to and distributed over a farmland through a network of pressurized pipes.
Priming	A process in which the impeller of a centrifugal pump is fully submerged in liquid without any air trapped inside.
Pump	A device that discharges a fluid by increasing the pressure.
Root zone	The depth of soil up to which the plant roots readily penetrate, and in which predominant root activity takes place.
Run-off	It is the downward movement of rainwater or surface water under gravity in channels ranging from small rills to large rivers.
Screen filter	A filter utilizing fine mesh screens to remove particles

	from flowing water.
Sediment	Solid fragments of inorganic or organic material that come from the weathering of rocks and are carried and deposited by wind, water or ice.
Shim	A thin packing strip or washer often used with a number of similar washers or strips to adjust a clearance for gear.
Shut-off valve	A device used to shut off the water supply.
Soil texture	The percentage share of sand, silt and clay in soil.
Solenoid	Coil of wire used as an electromagnet.
Solenoid valve	An electro-mechanical device, in which the solenoid uses electric current to generate a magnetic field and operate a mechanism that regulates liquid flow in a valve.
Surface irrigation	The application of water on land by surface flow.
Surface soil	The upper part of the soil mass about 10–20 cm in thickness.
Surface water	It refers to an open water body like river, stream or lake.
Sustainable agriculture	A systematic approach to agriculture that focuses on ensuring long-term productivity through the use of natural resources for meeting food and fiber needs.
Timer	An automatic timing device that sends an electric signal to open or close valves by a set irrigation schedule.
Topography	The study of the shape and features of land surfaces. It refers to the slope of the ground and how much uneven or levelled it is.
Topographic map	A map that contains information about the topography of an area.
Tortuous	It means full of twists and turns.

Transplanting	The process of shifting a plant from one place to another.
Vane	A broad blade of a machine or device attached to a rotating axis or wheel which pushes wind or water.
Vortexes	A circular, spiral, or helical motion in a fluid.
Water hammer	It is a pressure surge caused when water in motion is forced to stop or change direction.