1. IRRIGATATION

Irrigation is artificial application of water for the purpose of crop production. Irrigation water is used supplied to supplement the water available.

1. Rainfall
2. Contribution of soil moisture from ground water

In many areas, the amount and timing of rainfall are not adequate to meet the moisture requirement of crops. Hence, irrigation is essential. Scientific management of irrigation water provides best insurance against weather induced fluctuations in total food production. Water is being a limited source; it should not only meet the requirement of crop production, but also meet the requirement of

1. Growing industry
2. Human and livestock consumption
3. Hydro-electric power generation
4. Recreation and
5. Navigation

Classification of Irrigation works:

Classified into three categories based on the irrigated are it generated in the scheme.

a)Major irrigation Projects - Irrigating area of >10,000 ha

b).Medium irrigation Projects - Irrigating area between 2,000 and 10,000 ha

c). Minor irrigation Projects - Irrigating < 2,000 ha

The minor irrigation schemes consists of irrigation tanks, canals, diversion works and almost all ground water schemes.

Main types of Irrigation

I. Direct irrigation or river – canal irrigation phases:

i) Diversion of water from river

ii) Conveyance of water to land

iii) Application of water on land.

II. Storage irrigation: phases: (same as above)

III. Sub-soil water irrigation: Phases: a) Lifting of water from wells

b) Application of water recycling.

Benefits of Irrigation:

1. Irrigation works are a paying concern to the Govt.
2. It assures proper and successful growth of crop because assured supply water.
3. Irrigation protects people from the occurrence of famines when rain in any year is severely deficient.
4. The owner of agricultural land is a gainer as the value of his land will increase if it is served by a near-by canal system.
5. Hydro-electric power can be generated from the fall on some canals or by the water stored in a storage reservoirs.
6. Some large canals can serve the dual purpose of irrigation and land navigation.

Disadvantages of Irrigation:

1. If excess water is applied, the land becomes saline and water logged, thus become infertile or barren.

2. Excess irrigation remains into pools on the surface of the ground. Will greed mosquitoes, cause malaria in the round about area.

Some other terms:

1. Flow irrigation:

   When irrigation water in canal is available at such all level that it can flow over the adjoining land by gravity is known as flow irrigation.

2. Lift irrigation:

   When water has to be lifted up before it could be applied on land by gravity is called lift irrigation.

WATER REQUIREMENT OF CROP

It is necessary to know about the cropping seasons (i.e crops grown in each season) and the amount of water required by each crop during its period of growth for proper water management. For successful growth of the crop, it requires:

1. Proper warmth
2. Proper moisture
3. Proper agriculture soil
4. Proper aretion and
5. Proper method of cultivation

There are two principles of cropping seasons in India

1. Kharif season (June - October) and
2. Rabi season (November – February)

Kharif crops require about twice to thrice the quantity of water require by rabi crop.

Duty and Delta:

Each crop requires certain amount of water after certain fixed interval of time throughout its period of growth. The time that a crop take from the instant of its sowing to that of its harvest is called the period of its growth.

The time between first watering of a crop at the time of sowing to its last watering before harvest is called the **base period** of the crop and is expressed in days.

Delta: The total depth of water in cms required by a crop to come to maturity is called its

Knowing the area under crop and its delta, we can find out the amount of water in cms that must have to be applied on the area to mature that crop.

Duty is the ratio between the irrigated area and the quantity of water used. It is expressed in liters per second per hectare and indicates the continuous flow requirement per hectare of cropped area.

The relation between the quantity of water availability and the crop area matured and the required to mature is known as duty of water.

Relationship between Duty, delta & Base period

Let there be a crop of base period 'B' days. Let l Cumec water be applied to this crop on the field for 'B' days is

$$= B \times 24 \times 60 \times 60 \text{ cubic meters}$$

Let it be equal to 'V'

$$V = B \times 24 \times 60 \times 60 \text{ cubic meters}$$

Let ‘V’ cubic meters of water mature D hectares of land

= D x 10,000 sq. meters

Let this quantity equal to A

$$\text{Delta} = \frac{V}{A} = \frac{B \times 24 \times 60 \times 60}{D\text{x}10,000} = 8.64 \frac{B}{D} \text{ meters}$$

$$= 864 \times B / D \text{ cms.}$$

Factors affecting duty:

1. Kind of crop
2. Season
3. Rainfall
4. Nature of soil and
5. Methods of cultivation

Duty is of two types:

1. The duty expressed as Lts/sec/ha is flow duty. It will usually be expressed in direct irrigation.
2. In storage irrigation, the duty is normally expressed a hectares/one million cubic meters of water this type of duty is known as quantity duty.

Importance of duty:

1. It helps in design of irrigation canals is proposed in an irrigation project.
2. It helps to check efficiency of working of a cannel system.

Problem:

A tank has a water spread area of 40 ha with an average depth of 3 cm water that can be irrigation of the duty is expressed as :

i). 160 Hectares per cubic meters/sec

ii). 110 Hectares Cm and

iii). 30 Hectares/million cum of water.

Solution:

Total water available = 40 x 3 x 100 hectare cms

Delta = 864 x E/D = 864 x 120/960 = 108 cms

i) Area that can be irrigated $= \frac{40 \times 3 \times 160}{100} = 111$ hectares

ii) Area that can be irrigated $= \frac{40 \times 3 \times 100}{110} = 100$ hectares

iii) Water available in million cum. M $= \frac{40 \times 3 \times 10{,}000}{10{,}000}$

Area that can be irrigated $= \frac{40 \times 3 \times 10{,}000 \times 20}{10{,}00{,}000} = 100$ ha

Problem: II

A water course has a culturable command area of 2600 hec out of which the intensities of irrigation for perennial sugarcane and rice crops are 20 and 40 respectively. The duty for these crops at the head of water course are 750 hec/cume and 1500 hec/cume respectively. Find the discharge at the head of the water course.

Solution:

Area under sugarcane = 2600 x 0.2 = 520 hectares

Area under rice = 2600 x 0.4 = 1040 hectares

Water required for sugarcane $= \frac{520}{750} = 0.694$

Since sugarcane is perennial crop, it will require water throughout the year. Hence the water course must carry a total discharge of

(0.694 + 0.577) = 1.271 Cumecs.

2. WATER LIFTING DEVICES

Lift irrigation requires that water is to be raised from its source to the field surface. Devices for lifting irrigation water range from age old indigenous water lifts to highly efficient pumps. Pumps operated by electric meters/oil engines have come into prominence in all large lift irrigation schemes becomes of high output and efficiencies. Selection of water lifting devices for a particular situation depends on.

1. The amount of water to be lifted
2. Depth from which water is to be lifted
3. Type and amount of power available
4. Acreage to be covered
5. Economic status of the farmer.

Water lifting devices may be classified into four groups based on the kind of power used for their operation.

1. Manual devices - Swing basket, picottah or counter poise, Archemedian screw
2. Animal powered devices
3. Wind powered
4. Mechanically operated.

MANUAL DEVICES:

1. Swing basket: This device consists of a basket or shovel like scoop to which for ropes are attached and two men facing each other swing the basket between them.
2. Piccotah:
3. Archiemedian screw or counter poise lift

Counter poise lift: Is known as picottah and is commonly used to lift water from shallow wells.

$$\text{Velocity ratio:} \quad \frac{\text{Motion of effort}}{\text{Motion of load}} = \frac{Z2}{Z1} = \frac{a}{b}$$

Now: (W + W2) Z = W3 Z2

$$\frac{W1=W2}{W3} \qquad \frac{Z2}{Z1} = \frac{a}{b} \quad 1.2m \text{ to } 3m$$

$$W3 = \frac{a}{b}(W1 + W2) = 2000 \text{ to } 2300 \text{ litres.}$$

ARCHEMEDIAN SCREW: The device consists of wooded drum with interior portion in the form of a screw or augur rotated by means of a handle fixed to a central spindle. When the handle is turned, water moves up through drown the filed channel and discharges. The screw will be 2.1 to 2.4 m long and the length of the spindle is 4.2 m. The discharge and the mecemical efficiency will be maximum which the lower end of the screw is only half submerged in water at an angle not more than 30. Height from which water can be lifted – 0.6 to 0.9 m.

Discharge ----------- --------- 16000 litres/hour

ANIMAL POWERED DEVICES:

Rope and bucket lift: Is also popularly known as Monte or charsa charge and is the most common water lift in India to draw water from deep wells. This device consists of a bucket or a bag having a capacity of (180 to 225) liters and made of leather or galvanised iron frame work at the top. It is attached to one and of the long strong rope. The rope passes over a pulley and a pair of bullocks hitched to the other end of the rope and provide the power to lift the bucket.

It works up to 30 mts depth.

Discharge expected from 15m depth - 9000 liters/hr.

Self emptying bucket: It is also same as above in construction except that a leather spout is attached to the bottom of the bucket. A second lighter rope is fastened to the lower end of the spout. The second rope passes over a roller. On the lip of the receiving through. Both the ropes are tied together and then hitched to a bullock yak an their lengths are so adjusted that the spout doubles up along the side of the bucket is being raised from the well.

Device suitable to lifted no exceeding 9m

Discharge : 8000 lits/hours.

Two bucket lift: Two bucket: it is known as circular moths and is common in some parts of south India. Two buckets are used in this lift, which alternately raised, emptied lowered and filled. i.e. while on bucket is lifted full, the other is lowered empty into the well. A rope and pulley arrangement what a central rotating level permits reciprocating action while the bullocks move in a circular path. Each bucket is of about 70 litres capacity. This devices is suitable for lifts up to about 5m. It capacity is about 14000 litres/hr.

Person wheel: consists of a chain of buckets, a large open spoken drum and a suitable driving mechanism. Two parallel loops of rope or chain having carthen ware pots or metal containers attached to them at intervals, pass over the drum and loop into the water in the well. A horizontal shaft extends from the axle of a small vertical gear. The teeth of the vertical gear mesh with the teeth of a large horizontal wheel. The shaft of a large wheel have a pole extended from it horizontally and the animals are hitched to this pole.

The Persian wheel lifts water up to 10m. but its efficiency is considerably reduced when the lift exceeds 7.5.m. with the increase of height, the number of loaded buckets are increased and this nuts a heavy strain on the animals. Average discharge of a Parisian wheel is about 10000 lit.

Wind powered water lifting device

Wind Mill: The wind mill utilizes the natural power from wind. It consists of a large diameter vane wheel or when a strong wind blows, it rotates the vane wheel, which in turn works and water is lifted up, in average daily output of 1,36,000 litres is possible under prevailing wind. The minimum wind velocity required for operation is (16 Km/hr)

Classification of pumps:

On the basis of the depth of pumping water level with respect to the ground surface, the pumps are classified as SHALLOW WELL pumps and DEEP WELL PUMPS.

Shallow well pumps

As one which can lift water from pumping depth of 6 m or less when they are placed on the ground surface. This is the normal recommended depth from which the pump can lift the water efficiently. Reciprocating and Centrifugal pumps are the examples of shallow well pumps.

The most common types of pumps used for lifting water from shallow Wells and Deep wells are given below:

a) Centrifugal pump
b) Deep well turbine pumps
c) Submersible pumps

Reciprocating pumps are in limited use in irrigation because of their low efficiency.

Centrifugal pump

Among modern water lifting devices centrifugal pumps are the most widely used for irrigation purpose, they are (1) economic in cost (2) Easy to operate & (3) give steady discharge.

Centrifugal pump employs the centrifugal force in pumping liquids. This pump mainly consists of two parts. (1) Impeller or rotor: Which adds energy to the water in the form of increased velocity and pressure (2) Casing which guides the water to and form the impeller. The impeller is a wheel mounted on the device shaft and provided with a number of vances. The casing T called, the volute is in the form of a spiral with a cross – sectional area increasing towards the discharge opening. The impeller is rotated at very high speed by the motor or engine. Water coming at the centre eve of the impeller is picked up by the vanes and accelerated to high velocity by the rotation of the impeller and thrown out by the centrifugal force in to the volute a discharges.

Classification of Centrifugal Pumps:

1. Depending upon energy conversion
   (a) Volute (b) Diffuser
2. Plane of rotation of the impeller plane of rotation
   (a) Vertical (b) Horizontal
3. Type of impeller
   (a) Open (b) Semi-open (c) Closed
4. Number of stages.
   (a) Single stage (b) Multi stage
5. Suction
   (a) Single suction (b) Double suction
6. Method of drive:

(a) Direct driven
   i) Close coupled
   iii) Mono block

(b) Belt drive
   ii) Flat belt drive
   iv) 'V' Belt drive

BASED ON ENRGEY CONVERSION:

(a) Volute type

In the volute-type pump which is the most commonly used, the impeller discharges into a I progressively expanded spiral casing as shown in fig. The casing is proportioned to reduce gradually the velocity of the liquid as it flows from the impeller to the discharge, thus changing the velocity head into pressure head.

(b) Diffuser type: The impeller is surrounded by diffuser vanes pending passages formed by stationary guide vanes. In these expending passages the direction of flow is changed and the velocity head converted to pressure head before the water enters the volute. In this type, the velocity head leaving the impeller is more completely converted into pressure head than the volute type. Hence its efficiency is slightly higher.

II. Based on plane of rotation of impeller:

1. Horizontal centrifugal pump: In this type the pump shaft is horizontal and the impeller is mounted vertically on the shaft.

This most commonly used for irrigation purpose. It costs less. Easier to install and more accessible to inspection and repair.

2. Vertical Centrifugal Pump: In this type the shaft is vertical and the impeller is mounted horizontally on the shaft. For satisfactory operation the suction lift of the pump should not exceed 4.5 to 6.0 m.

Impeller: It is a rotor or circular disc provided with vanes. It is made of cast iron. The basic function of impeller is to add energy to the water and converts the velocity head into pressure head. Thus, it lifts the water through suction pipe, energy water and converts velocity head into pressure head by delivering water through delivery pipe.

Types of impellers: The design of impeller greatly influences the efficiency pump and operating characteristics of the pump.

There are four types of impellers. They are:

i. **Open type**: Open type impeller does not have the supporting plates to the vanes. The impeller vanes are just welded to the central hub of impeller. This type of impeller is generally used where water is contaminated with semi-solids and sand. The vanes are subjected to damage after prolonged use.

ii. **Semi-Open type:** In this, one side of vanes will be protected by having side plate or shroud and other side of vanes is exposed to water. It can be used to lift the water, having some amount of suspended sediments.

iii. **Enclosed or closed type:** In this, the vanes are enclosed between shrouds or side wall on either side. It is designed to pump clear water. They develop higher efficiencies, especially in high pressure pumps.

iv. **Non-clog type:** Non-clog impellers are specially designed for sewage lifting. They have vanes which are well rounded at their embrace ends and have large passage ways between the vanes. They can handle sewage water containing solid particles and other impurities. All the impellers are shown in figure.

Other important parts of the centrifugal pump:

1. **Stuffing box or gland**: Where the shaft leaves the casing, there is a gland and stuffing box to prevent leakage of air, to enter the casing and prevents water to come out from the causing.

2. **Bed plate:** For mounting the pumps and to fix properly on the foundation for avoiding vibrations.

3. **Foot valve:** The foot valve is an integral part of a centrifugal pump installed to lift water from open walls, rivers, canals and ponds. The valve is fixed at the end of suction pipe It avoids every time priming of centrifugal pump when it is operated. It is also restricts entry of foreign material, especially floating debris and acquatic plants etc., into the suction pipe. Hence, a strainer forms an essential part of foot vale. The valve is one-way flap piece made of leather or rubber and hinged to valve body. The flap rests on a well machined base plate when pump is not working and prevents return flow of water from suction pipe into well. Thus, water is retained in the pump casing and suction pipe, eliminating the need for priming of the pump every time when it is started. The foot valve is made of cast iron, however, due to more friction and energy loss in cast, iron foot valves, they are now replaced by energy efficient foot valves, made of RPVC. The main purpose to retain water in the pump and suction pipe and there by eliminate the need for priming each time the pump is operated.

Pump accessories: They include couplings, bends, flanges, gland and base plate etc., Coupling and flanges are used for joining pipes. Flanges are generally used at both suction and delivery points of pump. 90ºC bends are used at both suction and delivery of pump. Gland is a packing material used in stuffing box at the entry of shaft into pump casing so that there is no water leakage. Pump base plate is fixed to the concrete foundation by bolts and nuts so that there are minimum vibrations when pump is in operation.

Priming

The process of remover air from pump casing and suction pipe. It can be done by following methods.

1. By installing foot valve at the bottom of the suction pipe and pouring water through delivery side till the pump casing and suction pipe are filled.
2. By using auxiliary exhaust pump.
3. By giving water connection into the suction pipe from a tank located at a higher elevation.
4. By providing self priming pump.

Installation of a Centrifugal pump on foundation:

For a centrifugal pump to continue to operate at its designed efficiency and also to prolong the life of the equipment the pump should be correctly located the following points should be kept in view while installing the pump set.

ii. Easily accessible for inspection and maintenance.

iii. Cover to protect the unit

iv. Safeguard against flood conditions

v. The alignment of pump and motor must be correct

vi. The proper foundation should be provided to avoid vibrations.

vii. Suction and discharge pipe lines should be supported independently of the pump, so that strain on pump casing can be avoided.

Pump troubles: When the centrifugal pump fails to operate or the discharge or pressure drops, the case of troubles should be investigated immediately and steps may be taken the calumniate it.

1. Pump fails to prime:

a) Air leak in the suction line or in the pump in the threaded connect on coat with white lead.

b) Foot value may have debris lodged between rubber flap and valve seat

c) Gaskets may shrink-tighten the bolts.

d) Rotary shaft seals may load.

1. Pump fails to develop sufficient pressure or capacity

   a) Check pump speed since capacity varies directly with speed
   b) Check the suction line for air leaks and foot value
   c) Check function lift-too high reduce the pressure
   d) Check for the worn-out parts
   e) Check for the impeller clogging causes reduction in capacity and pressure.

2. Pump takes too much power:

   a) Check the speed which may be high
   b) Head may be lower than the pump rotating, there by pumping much water
   c) Check mechanical defects like bent shaft, misalignment find box etc.,

Characteristic curves:

The inter relationship of capacity head, power and efficiency and best shown by graphically and these are curves are called characteristic curves of the pump. These curves serves as a basis for (1) selecting a pump to provide the required head and (2) the capacity for the range of expected operating conditions at or near the maximum efficiency. These curves vary in shape and magnitude depending on the size of the pump, type of impeller and overall deign.

Characteristics of the centrifugal pump:

i) Smooth and even flow

ii) Adapted to high speed operation

iii) Capacity and head depend upon RPM and impeller diameter and width.

iv) R.P. is function of capacity, head and pump efficiency.

v) When the speed is kept constant "Capacity decreases"

vi) When the speed is changed constant "Capacity decreases" as head increases and power is reduced. Like wise when the head is reduced power applied goes up and capacity increases.

vii) Whom the operating speed in changed, capacity will head change square of the change in speed while H.P. change it cube of the charge the speed.

viii) When the capacity various directly with the diameter of the impeller directly, head take with the square of the diameter and H.P. varies as the cube of the diameter.

Installation:

Direct connected pumping sets are always mounted in a horizontal position on a level foundation. Concentrate foundation with-foundation bolts imbedded in the concentrate are in general and satisfactory arrangement.

Suction Pumping:

It should be direct and short as possible. The submergence of the foot value should be sub out 60 cm below the pumping water level. It is necessary that the streamer is kept at least 1 m. Above the bottom of the well. Sharp bends fitting should be avoided and it should be air, tight, of the section pipe should be equal to or larger than the suction opening of the pump.

Deliver opening:

U bends, elbows, tees and other fittings should be minimum. When pumping to distant places or under height head and reflux valve or non return valve near the pump will help the pump from water hammering. "Sluice valve" is provided to have smooth flow.

SUBMERSIBLE PUMP:

A vertical turbine pump close coupled to a small diameter submersible electric motor is termed as a submersible pump. The pump element and motor operate entirely submerged. Such an installation elements the long vertical shaft in the column pipe. Efficiency is increased by the direct coupling of the motor and its effective cooling by submerge in water. The principle advantage of the submersible pump is that it can be used in a very deep tube wells.

Where a long shaft would not be practical. Submersible pump has no working part above the ground.

The submersible pump consists of

1. **Pump element:** Is similar to the vertical turbine pump.
2. **Electric motor:** Submersible electric motor has the same diameter as the pump bowl but it is much longer the ordinary one. The electric cables, leads from the motor to starting box on the ground surface are water proofed. Submersible pumps are adapted to tube wells of 10 cm. Diameter or larger.

Common troubles and remedies:

1. Pump fails to start — 1. Fuse blow
2. Pump starts and discharge is steady But reduced amount of water — 2. Over lead trip flies short circuit

   1. Motor running in reverse
   2. Pump operating against a head greater than
   3. Pump is air locked
   4. Voltage low

When discharge is below normal:

i. Faulty in power supply
ii. Mechanical friction in pump
iii. Pump is worn out by sand

Limitations:

1. Pump and motor required to be pulled out from the well for repairs
2. Life of the pump is effected due to abrasion and encrustation by sand
3. No. oil engine can be used here

Estimating the pump capacity:

The required pump capacity for the irrigation can be computed by the formula

$$Q = \frac{28 \quad A.D}{EH}$$

Where Q = Discharge in liters /sec.

A = Area in hectares

D = Gross depth of irrigation in centimeters

E = No of days permitted for irrigation

H = No of hours of operation.

In crop rotation system, the capacity of the pump designed for the maximum requirement of water in a particular month. The following example for an area of 20 hectares with crop area shown below.

1. 8 ha maize (irrigated)

   Irrigation interval 5 days in sandy loam and 15 days In heavy soils — 5 cm irrigation

2 6 ha groundnut (Irrigated)

Irrigation interval 8 days in sandy loam and 5 cm irrigation

10-12 days in heavy soils.

3. 4 ha of paddy (Irrigated)

Irrigation interval 10 days in heavy soils 10 cm irritation

The following may be assumed for all three crops mentioned above:

Irrigation period (Interval = 10 days

No. of working hours/day = 16 hours

So, water requirement for

$$\text{Maize} = C = 28 \times \frac{AD}{EH} = \frac{28 \times 8 \times 5}{10 \times 16} = 7 \text{ LPS}$$

$$\text{Ground nut} = Q = \frac{28 \times 6 \times 5}{10 \times 16} = 3.25\text{LPS}$$

$$\text{Paddy} = Q = \frac{28 \times 4 \times 10}{10X16} = 7 \text{ LPS}$$

Total capacity required = 7 + 3.25 + 7 = 19.25 LPS.

Power requirements and efficiency:

A pump operates most satisfactorily under a head and at a speed for which it was designed.

Terms and definitions:

Static head is the vertical distance between the water surface at the source and at the out let.

Static suction head, is the vertical distance between the water level and the counter line of the pump.

Static discharge head: is the vertical distances between the centre line of the pump and the point of free delivery of water. Static head = static suction head = static discharge head.

Friction Head: is the head required to over come the resistance of the pipeline and fittings (including strainer elbows, bends, reducing sockets, tees, valves etc.,) in the pump system.

$$hf = \frac{4\ f1\ v^2}{2\ g\ d}$$

Where f = Coefficient of friction of pipe

L = Length of pipe in m.

R = Hydraulic radius in m.

V = Velocity m/s

D = Diameter of pipe.

Friction coefficient ‘f’ is assumed to be between 0.01 for old pipes and 0.005 for new pipes.

$$\text{Velocity head:} = \frac{V^2}{2g}$$

Velocity head is the distance through which the liquid must fall to acquire a given velocity and is calculated from the formula: h = v2/2g : Where h = Velocity head in meters, V = velocity of the water in m/sec., g = 9.81 m/sec.

Total head = Static head + Friction head + Velocity head.

$$\text{WHP (Water Horse Power)} = \frac{\text{Discharge in liters per second X Total head in meters}}{75}$$

$$\text{SHP (Shaft horse power)} = \frac{\text{WHP}}{\text{Pump efficiency}}$$

Power to be supplied by engine or electric motor (Brake HP)

With direct drive (drive efficiency100%) Then BHP = SHP

$$BHP = \frac{WHP}{\text{Pump efficiency} \times \text{Drive efficiency}}$$

In case of electric motors, the input horse power is calculated by

$$IHP = \frac{WHP}{\text{Motor efficiency}}$$

Overall efficiency = Pump efficiency X drive efficiency X Motor efficiency

Energy consumption in Kilowatt hours per hour is = (Input HP) X 0.746

3. Water conveyance system

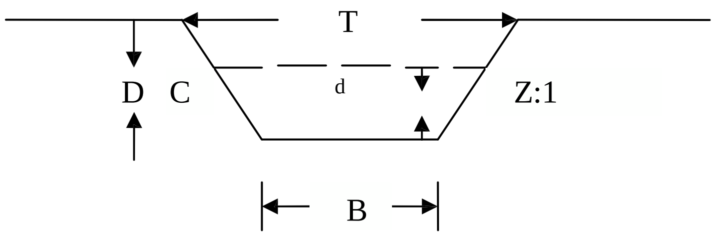

Fig :Open channel

Open channels: It is defined as any conduit in which water flows with a free water surface. Rivers canals and un-covered flumes are open channels.

Design of open channel: The design of open channel consists of deciding the following parameters.

a) Shape of the channel
b) Dimensions or the channel
c) Longitudinal slope of the channel

The elements of open channel are shown in the figure:

T = Top width of channel

D = Depth of channel after free board is added

d = Depth of flow in the channel

B = Bottom width

C = Wetted sides of the channel

Angle between the sloping side and horizontal (angle of report of the soil)

Definitions:

1. Wetted perimeter (p): Sum of the lengths of the sides of channel which are in contact with water.

$$P = C + B + C = 2C + B$$

2. Area of cross section (A)

$$A = \frac{(B + T)}{2} \times D = \frac{1}{2} (B + T) \times D$$

3. Hydraulic radius (R) : Is the ratio between cross sectional area of the stream and the wetted perimeter.

$$\text{Hydraulic Radius} \quad R = \frac{A}{P}$$

4. Hydraulic slope: Is the ratio of its vertical drop 'h' for a length of 'i' of the channel and is given by

$$S = \frac{H}{L}$$

5. **Free board:** Is the expected vertical distance between highest water level anticipated in the design and the top of the retaining banks. It is provided to prevent "Over topping of structures" because of " Wave action". Generally 20% of the designed depth is taken as Free-board.

Estimating the velocity:

The design is based on mean velocity of flow which is obtained by standard formula:

$$V = \frac{R^{2/3} \times S^{1/2}}{n} \quad \text{(Mannings formula)}$$

Where V = Mean velocity of flow in m/sec.

S = Hydraulic slope = H/L

R = Hydraulic radius in meters = $\frac{A}{P}$

n = Roughness co-efficient – 0.03 to 0.04

Meanings formula is commonly used in the design of water courses and field channels. Values of 'n' changes according to condition of the channel such sides and bottom.

Discharge capacity of the channel: Discharge capacity of the channel is obtained by the following formula.

$$Q = A \times V$$

where Q = discharge capacity in gum/sec.

A = Cross – Sectional area in sq.m

V = Velocity of water in mts/sec.

Advantages of earthen channels:

1. They are easily understood and accepted by farmers.
2. Low initial cost
3. They can be built and maintained by unskilled persons.

Side slopes: Normally, a channel should have slope about 0.1%. Where earthen channels is a semi-circle, as the wetted perimeter would the be a minimum and its hydraulic radius is max the best section i.e. when depth is $d = b/2$

The best hydraulic section of a trapezoidal channel under favorable structural conditions is:

$$B = 2d \tan \theta/2$$

In which b = bed width

D = depth of flow of the water

ɵ = the angle between the side and the horizontal.

Channel location: The channels must be located high enough above the land so that water can be readily diverted to the fields.

Lined channels:

Earth channels are lined with impervious materials to prevent:

1. Excessive seepages
2. Growth of weeds on the channel. Length of the water course. The seepage ranges from 20 to 40% of the water delivered to the channel. One of the main problem in the use of earthen channels is the control of weeds. Weeds obstruct the flow and also weed seed flows through irrigation water to the fields. That is why, certain channels needs continuous maintenance to control mass and weed growth and to repair damage by livestock, rodents and erosion.

Lining of channels provide:

1. Equal distribution water among farmers
2. Reduce the labor cost in maintaining the water course
3. Eliminate water lagging caused by seepage
4. More land will be available for cultivation since the cross-sectional area is less.

Materials for lining water courses: The most common material for channel lining include:

1. Concrete 2. Stone or brick masonry 3. Natural clays of low permeability 4. Clay tiles 5. Various rubber, plastic and asphaultic compounds 6. LDPE sheets.

Well mixed and well made cement concrete lining and also single layer bricks or stones laid in cement or lime mortar (1:3:5) provide virtually water proof channel lining. The other lining materials are susceptible to damage by trampling by livestock, insect, weed growth and erosion by high velocity flows. Their short life often makes them un-economical unless special protection is provided.

Pre cast concrete channel section:

Pre cast concrete is a term applied to concrete units that are manufactured at a central place and hauled to the job site. These may be made in semicircular. U-sections and in one meter lengths. The area of the land occupied by this channel is greatly reduced when pre cast concrete sections are used since side embankments are un-necessary. They can be joined with cement mortar. (1 cement : 2 sand)

UNDER GROUND PIPE LINE SYSTEM

An under ground pipe line water distribution system consists of buried pipes for conveying water to different points on the farm and allied structures required for the efficient functioning of the system. The system offers many advantages over open channels in water conveyance and distribution.

Advantages over open channels:

1. Entire area can be brought under cultivation, where as in open channels 2 to 4 % of land being wasted.
2. No culverts or other structures are required
3. Pipes do not interfere with farming operation
4. When properly installed, they have long life and low maintenance costs.
5. Eliminates water losses by evaporation and prevents damage to the pipes since they are placed below the ground.

Disadvantages:

With this under – ground pipe line system is that it requires higher initial cost. Since the under-ground pipe lines operate under pressure, they can be laid up hill or down hill, thus permitting delivery of irrigation water to areas not accessible by open channels. With an under ground pipe line system, wells need not be located at the high points of the farm but may at a location that provides the best water supply. The pipe lines do not clogged by vegetation and with blow material. They are ideally suited to undulated topography to reach water to fragmented and isolated. Locations on the farm and in the areas where land is costly.

Pipes for under-ground water distribution system:

Under-ground pipe lines are usually constructed with factory made reinforced concrete pipes, verified clay pipes asbestos cement pipes, and plastic or PVC pipes, where high pressures are involved RCC – p1,p2,p3 pipes are to be used.

P1 pipe - Up 8m. head

P2 pipe - Up to 8 to 20 meters head

P3 pipe - above 20m head.

The choice of the material for the pipes depends on the conditions under which the pipes is to operate and the relatives costs. Under most field conditions, concrete pipes are the most economical. Where soils contain salts in quality a chemical analysis should be made to find out what salts are predominate. If sulphates are high, concrete should be avoided. Asbestos pipes are most costly than concrete pipes. They give long service and adopted to wide range of water pressures. Plastic pipes are specially suitable in the smaller diameter for high pressure under ground pipe lines used for sprinkler irrigation.

The R.C.C. pipes used in India are manufactures according to I.S.I. (I.S. 458). They are usually available in sizes. 15 cm, 22.5, 30, 37.5, 45 cms. The length varies from 2 to 2.5 meters. The concrete mixture 1: 1 ½ : 3

Testing of irrigation pipe:

Irrigation pipes are tested (1) for water absorption (ii) for strength.

To test the water absorption, samples of the pipe are boiled for about 5 hrs. and gain in weight by moisture absorption is noted. The standard irrigation pipe should not exceed 8% of the originally dry weight. For strength, it should be tested on standard testing machines.

Discharge through irrigation pipe line:

The discharge through a pipe line can be determined by applying the Darcy's equation:

$$V = \sqrt{(h\, d\, g / 2fl)}$$

Where V= Velocity of flow through the pipes: cm/sec

h = available head causing the flow-cms.

d = Diameter of the pipe cms.

g = acceleration due to gravity cm/sec

l = Length of the pipe in cms

f = Darcy's roughness coefficient

$$Q = A \times V \text{ litres/sec.}$$

Example: Determine the discharge capacity of an under-ground concrete pipe line from the following data.

Dia. Of pipe = 15cm, length of pipe = 150m. f = 0.009 difference in elevation between water level at pump stand and discharge point = 2.6m.

$$V = \sqrt{(hdg / 2fl)} = \frac{260 \times 15 \times 981}{2 \times 0.009 \times 15000} = 100 \text{ cm/sec.} = 1.0 \text{ m/sec.}$$

Gross sectional area of the pipe = TD2/4 = 22/7 x (0.15)2 x 22/28

Discharge capacity = A x V = 0.0176 x 1.0176 x 1.0 = 0.0176 cum/sec = 17.6 lit/sec

Spacing of the pipes: When the prevailing land slope is in one direction only, the spacing between pipes varies from 100m. to 200 m. closer spacing are suitable for sandy soils and farther spacing for heavy clay soils.

Installation of concrete pipe: The process of laying the pipe line involves the following steps.

1. Selection of depth and grade of laying
2. Lowering the pipe and squeezing
3. Sealing the joint
4. Back filling the trench

To prevent damage of pipe lines, they must be kept at least 45 cm. below the ground. The width of the trench should be 70 cm for working convenience.

Structures for under ground pipe line:

Specialized structure are used with under ground pipe lines system to control the water and protect the pipe line from damage. Structures include (i) Inlet structures, (ii) Diversion structures, (iii) Air release vents (iv) End plugs and (v) Out lets.

PUMP STAND is an inlet structure required to be constructed to develop full low capacity of the pipe line, to maintain water surface elevations sufficient to distribute water to the different points on the farm. The minimum diameter of the pump stand should the kept not less than 60 cm.

GATE STAND:

It is a diversion structure and they are provided to control the flow into laterals when pipe lines branch off into water different directions.

AIR Vents: Are vertical pipe structures to release air entrapped in the pipe line and to prevent vacuum. Entrapped air must be removed to avoid water hammer and even flow. They are normally installed at the following points (1) about 80 to 100 cms downstream from the pump stand, (2) at all high points in the line, at sharp turns, (3) at any abrupt change in grade (4) at the end of the pipe line.

END PLUG: The end plug is provided where the line terminates, the function of the plug is to close a line and (to absorb the pressure developed at the end of the lines on account of water hammer.

Riser valves: Riser valves are installed at regular intervals on the pipe line to provide controlled delivery of water on to the fields at any desired location. Alfalafa valves are widely used as riser valves in under ground water distributions system.

Hydrants: Hydrants are devices placed over riser valve out lets as a means of connecting portable gate pipes to the pipe lines.

4. MEASUREMENT OF IRRIGATION WATER

It is essential to measured the quantity of water to (i) apply correct quantity of water when needed; at the rates based on intake rates. (ii) and to prevent land damage by applying more quantity.

Units: The commonly used units of water is of two kinds.

1. Units of volume: refers to water at rest. Ex. Litres, cum, har cm. etc (kg). Cft. Gallon, acre - inch.
2. Units of flow: Refers to water in motion. Litres/sec. cu-m/sec (MKS). Cft/sec. gallons/min (FPS).

Methods of measuring water: There are three methods used for measuring water (1) volumetric measurements (2) velocity for measuring water/area method, (3) Direct discharge method with measuring devices.

I. Water Measuring Devices:

They play an important role in applying required quantity of irrigation water during the distribution to different field crops. Water measuring devices can be grouped into four types.

A. Volumetric measurements

It is the simplest method and involves collection of flowing water from stream into a known volume of container (preferably bucket) over a period of time. The time may be measured with stop watch or wrist watch. The rate of flow can be calculated by using the formula.

$$\text{Discharge rate} = \frac{\text{Volume of water collected (Litres)}}{\text{Time of filling container, (seconds)}}$$

This method can be used to determine the discharge rate of pumps and other water lifts like Persian wheel and leather bucket lift. It is frequently used to caliberate other devices and instruments for measuring flow in hydraulic laboratories.

B. Velocity – area method

The flow rate passing a point in a pipe or open channel is determined by multiplying the cross sectional area of the flow at right angles to the direction of flow by average velocity of flow.

$$Q = a \times v \qquad \text{------------} \qquad (14.2)$$

Where, Q = discharge rate, m^3/s

A = cross-sectional area, m^2

V = average velocity of flow, m/s

The cross sectional area is determined by measuring the size of conduct and the average velocity is determined by using current meter for accuracy and by float method for approximate values of discharge.

C. Float method

This method requires a straight section of channel which is uniform and free from surface disturbances and cross currents. Float measurements should be carried on windless days to avoid wind induced float deflections. For accuracy, a string or tape should be stretched across the beginning, mid point and end of channel section.

These locations in channel must be far enough apart to allow accurate travel time measurements. The float should be released at a sufficient distance up stream for it to attain stream velocity before it enters the actual test section. The times when the float passes each station should be noted and recorded. Wide channels are often divided into segments and a float used to determine the velocity of each segment. The average velocity of the stream is computed with the following equation.

$$V = (CF)\ Vf$$

Where V = average velocity of the stream, m/s

CF = velocity correction factor from Table (14.2)

Vf = float velocity, m/s

Table 14.2 : Correction Factor (CF) for float method

Average depth (m)	0.3	0.6	0.9	1.2	1.5	1.8	2.7	3.7	4.6	› 6.1
C.F	0.66	0.68	0.70	0.72	0.74	0.76	0.77	0.78	0.79	0.80

D. Current meter

It is a small instrument containing a revolving wheel or vane that is turned by the movement of water (Fig.14.4). It may be suspended by a cable for measurements in deep streams of attached to a rod in shallow streams. The number revolutions of the wheel or vane in a given time interval is obtained and the corresponding velocity is obtained from caliberation table or chart of instrument. Standard procedure is to divide the cross section into segments and use the current meter to measure the average velocity in each segment from, two depth measurements. In the two depth method, the velocity is determined at 0.2 m and 0.8 m of the depth in each segment. The average of these two values gives the average velocity of flow for ordinary conditions.

D. Water meter

Water meters utilize a multi blade propeller made of metal or plastic or rubber, rotating in a vertical plane and geared to a totalize (counter) such that a numerical counter can totalize the flow in any desired volumetric units. Water meter are available for a range of suitable sizes of pipes, commonly used on the farm. There are two basic requirements for accurate operation of water meter.

a) The pipe must flow full at all times and
b) The rate of flow must exceed the minimum for the rated range.

E. Co-ordinate method

It is used to determine the velocity of water jet from pumping plants discharging horizontally. For pipes discharging horizontally, it is necessary to measure both horizontal (x) and vertical (y) distances. These distances are called x y Co-ordinates are measured form the centre of the end of the pipe to the centre of jet as shown in Fig 14.5. The formula used for estimating velocity of jet is:

$$V = \frac{x\sqrt{g}}{\sqrt{2y}} \quad \text{and}$$

$$Q = c \times a \times V$$

Where

Q = discharge rate, m^3/s
C = co – efficient of contraction, dimensionless (c = 1.0)
A = cross – sectional area of pipe, m^2
X = x-co-ordinate, m
Y = y-co-ordinate, m
G = acceleration due to gravity 9.81 m/s^2

II. Measuring Structures

These include weirs, flumes and orifices. These hydraulic devices are used in situations where natural control is not available and they provide a stable stage – discharge relationship.

1. Weirs

There are two types one is sharp crested and the other is broad crested weirs. Sharp crested weirs will have minimum surface contact with flowing water over the crest. Board crested weirs will have width of crest which maintains contact with overflowing sheet of water. The flow characteristics of these two are different. Generally, Sharp crested weirs are widely used in farm irrigation installations.

Terminology

Weir : A weir is a notch or opening of a regular form through which the irrigation stream is made flow.

Wire pond : It is the portion of the channel immediately up stream from the weir.

Wire crest: It is the bottom of the weir notch.

Head: The depth of water flowing over the weir crest measured at some point (4H) in the weir pond.

End contraction: The horizontal distance from the end of the weir crest to the sides of weir pond.

Weir scale on gauge: The scale fixed in the weir pond to measure depth of flow (H)

Nappe: The sheet of water which overflows a weir.

Bottom contraction: It is vertical distance from the weir crest to the bottom of the channel.

Weirs consist of a smooth, vertical and flat plate installed across the channel and [perpendicular to flow. The plate obstructs flow causing water to back up behind the weir plate and to flow over the weir crest as show in Fig 14.6. Thin plate weirs are most accurate when the nappe completely springs free of the upstream edge of the weir crest and air is able to pass freely around the nappe. A head of at last 6 cm and a crest thickness of not more than 1 or 2 mm are required for water to spring free of weir crest (James, 1988). The crest of thin plate weirs may extend across the full width of channel or be contracted. The most common notch shapes are rectangular, triangular and trapezoidal (Cipoletti wier).

i. Rectangular weirs

Full width weirs: Full width weirs are called suppressed rectangular weirs, because their sides are coincident with the sides of the approach channel and no end contractions of nappe are possible. The discharge rate of suppressed weir can be calculated from the equation.

$$Q = 0.0184\ LH^{3}/2$$

Where

Q = discharge rate, l/s. (Litres/second)

L = crest length, cm

H = head over the crest, cm

Contracted weirs: When the length of crest is less than the width of approaching channel, then end contractions are produced to the nappe. This requires that the distance from the sides of the weir to the sides of approaching channel be at least twice the head, but not less than 0.3 m (James, 1988), as shown in Fig., 14.7

The following equation is used to calculate the discharge rate.

$$Q = 0.0184\ (L - 0.1\ n H)\ H^{3}/2$$

Where

Q = discharge rate, l/s

L = crest length, cm

N = number of end contractions

H = head over the crest, cm.

ii. **V-notch (Triangular weir)**

It is accurate flow measuring device for flows ranging from 30 l/s to 300 l/s. A full contracted V – notch is given in Fig. 14.8. The head discharge relationship for V-notch is :

$$Q = 0.0138\ H\ ^{5}/_{8}$$

Where,

Q = discharge rate, l/s

H = head over crest, cm.

ii. Cipolletti weir

It is a trapezoidal fully contracted weir inclines outward at a slope of l horizontal to 4 vertical as shown in figure (14.9). Cipolletti weirs should not be used for heads less than 6 cm nor for heads greater than 1/3 the crest length (V.S. Bureau of Reclamation, 1975). The Head-discharge relationship for the Cipolletti weir is:

$$Q = 0.0186 \ LH3/2$$

Where

Q = discharge rate, l/s

L = crest length, cm

H = head over the crest, cm

Standard conditions for installation of weirs:

1. The weir should be set at lower end of the long pool. Sufficiently wide the given even and smooth velocity.
2. The weir must be vertical
3. The centre line of weir must be parallel to the direction of flow
4. The crest of the weir should be perfectly level
5. The distance of the crest above the bottom of the pool should be about two times the depth of flow and the sides of the pool should be twice the depth of the flow.
6. The depth of flow over the crest should not be less than 5 cms.
7. The weir gauge or scale may be placed on the upstream side of the weir structure at a distance of about 4 times the approximate head.

iv. Flumes

A flume is a specially shaped channel section that is constructed or installed in open channels to obtain a stable stage-discharge relationship for flow measurement. The principal advantages of flumers and that they cause small friction losses and not sensitive to velocity of approcach. In addition, most flumes are not subject to deposition of silt and debris because of relatively high velocities through tem. Among the different flumes, parshall flume is widely used for measuring irrigation water at farm level.

.**Parashal flume:**

It is having three principals sections.

1. Converting or contracting sections
2. Constricted or throat section
3. Diverging or expanding section

a. The floor or converging section is level and threat section includes downward and the floor of diverging section slopes upward. The parshall flume can abe constructed in a wide range of sizes to measure the discharge from a very small fraction of cum. To more than 100 cu.m/sec.

Discharge through the flume can occur either under two different conditions of flow i.e. (1) free flow condition and (ii) submerged condition. To determine the rate of discharge two depth gauges at converging section (HA) and threat section (HB) are provided. Only HA needs to be measured under free flow condition. Free flow conditions can be satisfied if the ratio of HA/HB are within the following limits.

With of throat	HA/HB (Free flow limit)
2.5 cm to 7.5 cm	0.5
15 cm to 22.5 cm	0.6
30 cm to 240 cm	0.7
3m to 15 m	0.8

After deciding the flow conditions the discharge can be obtained from calibration charts. The size of the flume is expressed on by the width of the threat.

Advantage of parshall flume over other measuring devices.

1. There is no need to provide weir pond in the upstream side
2. The flume does not clog easily with floating trash and it keeps itself clean of sand and silt
3. It can be used even in relatively shallow channels like irrigation furrows with flat grades.

III. Orifice: Orifice in open channels are usually circular or rectangular openings in a vertical bulk head through which water flows. The head causing flow through the orifice is determined by measuring the actual difference in elevation between the water level on the upstream side of the orifice and on its down stream side.

$Q = 0.61 \times 10^{-3} A\sqrt{2}\ gH$ (MKS units)

Were: Q = Discharge in LPS

A = Cross sectional area of orifice in sq.cm.

H = Head causing flow in cm.

G = Acc. Due to gravity 981 cm/sec²

Orifice can be used to measure water in comparatively small streams like the flow into borders, furrows and check basins

D. Tracer method:

They are independent of stream cross-section and can be used without fixing any structures. The discharge rate is calculated by balancing the concentrations of tracer at both upstream and downstream ends of flowing water.

5. Micro irrigation systems - Sprinkler irrigation

In the sprinkler method of irrigation, water is sprayed into the air and allowed to fall on the ground surface some what resembling rainfall. The spray is developed by the flow of water under pressure through small orificies or nozzles. The pressure is usually obtained by pumping. With careful selection of nozzle sizes, operating pressures and sprinkler spacing, the amount of irrigation water required to refill the crop root zone can be applied nearly uniformly at a rate suit to the infiltration rate of the soil, thereby obtaining efficient irrigation.

Adaptability of Sprinkler Irrigation:

1. It is not suitable in very fine textured soils where the infiltration rate is less than 4 mm/hr.
2. Particularly suitable to sandy soils that have a high infiltration rate.
3. Shallow soils unfit for land leveling, can be irrigated by this method.
4. Specially suitable to steep slopes or irregular topography.
5. If soil erosionis is a hazard. This method can be used.
6. Flexibility of sprinkler equipment adapted to most topographic conditons.
7. Well designed sprinklers distribute water better than any other method.
8. Soluble fertilizers, herbicides and fungicides and fungicides can be applied through irrigation water with little extra equipment.
9. Labor costs are usually less than other methods
10. This method of irrigation doesn't interferes with the movement of farm machine.

Limitations:

1. Wind distracts sprinkler patterns and causes uneven distribution of water.
2. Ripening soft fruit must be protected from spray
3. The water must be clean and free from and debris
4. Requires highest initial investment
5. Power requirements are usually high since sprinklers operate at 0.5 to 10 kg/cm.
6. Fine texture soils with low infiltration rate, cannot be irrigated properly in winds
7. If water is applied at low rate, evaporation losses and wind drift increases.

Types of Sprinkler Systems:

1. Rotating head system: Nozzles placed on riser pipes and fixed at uniform interval. The most common device to rotate the sprinkler heads is with a small hammer activated by the thrust of water striking against the vane. These may be high pressure (2 kg per cm) or low pressure system (1.4 hg per cm) or less.
2. Perforated pipe system: Consists of holes perforated in the lateral irrigation pipes in a specially designed pattern to distribute water fairly uniform. This is designed for low pressure of 0.5 to 2.5 kg/cm. It covers a strip if 6 to 15 metres. Suited for irrigation of laws of gardens and vegetable fields.

Sprinkler irrigation systems are generally classified into 1. Permanent 2. Semi-permanent 3. Portable.

Permanent systems: Are those having the pipes permanently located. Usually they are build and not interfere with tillage operations. Installation costs are much higher, but labour and maintenance costs are less.

Semi-permanent: Usually have the main lines buried and the laterals portable. The water supply is from fixed point. Installation costs are some what less than the permanent system, but lab our and maintenance costs are more.

Portable system: Have both main lines and laterals portable Installation costs are less, but lab our and maintenance costs are higher. These systems are designed to be moved around the farm from field or even from farm to farm.

Components of Sprinkler System

The components of sprinkler irrigation system include:

A. Pumping unit

The pumping unit is required to lift the water from the water source drawn from either open wells or bore wells and distribute the water through the network of pipe line. Pumps may also be used to boost up the pressure within distribution lines where there is insufficient pressure developed by the pump at source. The capacity of pump can be calculated based on the water requirement of crop, area to be irrigated, irrigation interval, hours of pump operation and system efficiency.

Both centrifugal and deep well turbine pumps can be used for operating sprinkler system depending upon the depth of water in the wells. Electric motors and Diesel engines can be used to drive the pump. Electric motors are used for fixed installations of sprinkler system, where as diesel engines are useful for portable type of sprinkler systems.

B. Main pipe line

Main pipe line may be permanent or portable. Permanent pipeline are used on the farms where boundaries are fixed and crops require full-season irrigation. However, portable pipe line is more economical when sprinkler system is to be used on number of fields. Generally, PVC pipes can be used for permanent type and HDPE or Aluminum pipes can be used for portable pipe line.

C. Lateral pipe lines

The lateral pipe lines are usually portable. A quick coupled aluminum pipe is the Best for most portable laterals. The lateral pipes are available in lengths of 5,6 0r 12 m.

D. Risers

Risers are small GI pipes fixed to the lateral pipes at sprinkler spacing. On top of the riser, the sprinkler heads are fixed. The size and length of riser will be decided based on pressure consideration and discharge.

E. Sprinkler head

Sprinkler head is the critical component of a sprinkler irrigation system. The suitability and efficiency of sprinkler system depends on the operating characteristics of sprinkler head. The operating characteristics of sprinkler head are affected by varying pressure and wind velocities.

The spray of water can be developed by two ways. One is by using revolving head sprinkles with one, two or more nozzles depending upon the diameter of wetted circle. The other is pipe with perforations which is not in practical use. Sprinkler heads may range from small single nozzle sprinkler to gaint multiple nozzle sprinkler that operate at high pressure.

Single nozzle sprinkles are used for low water application rates. Two nozzle sprinkler heads can apply water at higher rate and results in more uniformity than single nozzle sprinkler head. Revolving head sprinkles are classified according to pressure range and their position in relation to irrigat6ed crops. Table 15.4 presents the range of sprinkler operating pressure, sprinkler characteristics and their adaptability.

F .Debris screens and Desilting basins

Debris screens are required when the source of irrigation is surface water. The function of screens is to keep the system free of trash (Stics, plant straw, weed, seeds etc.,) which may plug the sprinkler nozzle. Desilting basins may be required to tap sand or suspended silts when the water is drawn from streams, open ditches or well water with silt.

A. Booster pumps

Booster pumps are used when a sprinkler irrigation system works with existing pumping unit installed in a well and there is insufficient pressure development to force water through sprinkles. This situation may arise when the area at higher elevations is to be irrigated by sprinklers.

B. Flow control valves and take off valves

Flow control valves are fixed in the system to regulate pressure and discharge of individual sprinkles along the laterals. They are seldom used on leveled land and even ground surface.

Take off valves are needed to control ;pressures in the lateral lines. They are required when there are significant differences in the main line pressure at different lateral take off points.

C. FERTILIZER APPLICATOR

Soluble fertilizers as in the case of drip system can be injected through sprinkler system to the crops. The fertilizer can be applied at the desired depth to the crop in soluble and readily available form.

The equipment used for injecting into sprinkler system is similar to as that of drip system. When applying fertilizer through sprinkler system, it is desirable to operate the system long enough to wet soil and plant foliage. Then, the fertilizer solution is injectged through the system for 30 minutes. After this, the system is operated for another 20 minutes to flush it from sprinkler pipe lines.

The quantity of fertilizer to be injected into the sprinkler system can be quantified by using the formula.

$$W_s = \frac{D_s \times D_l \times N_s \times W_f}{10{,}000} \qquad (15.2)$$

Where,

Ws = amount of fertilizer per setting, kg

Ds = distances between sprinklers, m

Dl = distance between laterals, m

Ns = number of sprinkler and

Wf = recommended fertilizer dose, kg/ha

Sprinkler selection and spacing: The actual selection of the sprinkler is based largely upon design information furnished by the manufactures of the equipment. The choice mainly depends on: (1) Diametre of coverage required (2) Pressure available (3) Sprinkler discharge.

The required discharge of a individual sprinkler is a function of the water application rate and the two way spacing of the sprinklers. It may be determined by the following formulation.

$$w = \frac{Sl \times Sm \times I}{360}$$

Were: w = Discharge capacity of each sprinkler in liter/sec

Sl = Spacing of sprinkler along the lateral in metres

Sm = Spacing of laterals long the main in metres.

I = Optimum application rate in cm/hr

High of sprinkler raiser pipe: Sprinklers are located just above the crops to be irrigated and therefore, the height of risers depends on the maximum height of the crop.

Capacity of the sprinkler system: It depends upon the area to the irrigated, the gross depth of water applied at each irrigation and the next operating time allowed to apply water to this depth. The capacity of the system may be calculated by the formula.

$$Q = 2780 \times \frac{A \times D}{f \times h \times e}$$

Were: Q = Discharge capacity of the pump litres/sec

A = Area to be irrigated - (Hectares)

D = net depth of water application - cms.

F = No. of days allowed for the completion of one irrigation

H = No. of actual operative hours/days

E = Water application efficiency in percent.

6. DRIP IRRIGATION

Drip or trickle irrigation is one of the latest methods of irrigation which is becoming increasingly popular in areas with water scarcity and salt problem. It is a method of watering plants with a volume of water approaching the consumptive use of the plants, there by minimizing conventional losses such:

i. Deep percolation
ii. Run-off
iii. Water evaporation

This method of irrigation is accomplished by using small or 'Drippers' at selected spacings to deliver water to the water slowly to keep the soil moist within the desired for plant growth.

The initial cost of the drip irrigation equipment is considered to be its limitation for large scale adoption crops like grapes, sugarcane, banana, guava and papaya and most other types of fruit trees and vegetables have been found to respond well to drip irrigation.

Drip System Components

D. Water source

It may be open well or bore well from which water is drawn for irrigation. Before using the water from any source, its suitability for irrigation must be checked. Any major contamination in the water source will lead to frequent clogging of emitters and requires frequent washing of emitters and laterals either by acid or chlorination. Bucks et.al (1979) classified the water into different classes based on physical, chemical and biological parameters .

E. Control head

It includes centrifugal pumping system, filtration unit and fertilizer applicator. The pump size can be determined by knowing the water requirement of crop under drip irrigation and the total head available for pumping water from water source. For gravity operated system, over head storage tank is required for supplying water through drip system.

Water soluble fertilizers can be effectively and efficiently applied along with irrigation water through trickle system. This process is known as fertigation.

Reduction in labour energy and equipment costs when compared to conventional methods of fertilizer application are the direct benefits available from fertigation.
Plant nutrient levels can be maintained at required level through out the season. However, materials such as inorganic forms of phosphorous that form chemical precipitates and cause clogging should not be injected into trickle irrigation system.

Soluble fertilizers which can be administered through drip system are given in the Table (15.3).
However, fertilizers compounds like aqueous ammonia, calcium nitrate, calcium ammonia nitrate, potassium sulphate, zinc nitrate and ferric sulphate should not be applied through drip system. The fertilizer applicators like venture injection system and pressure – differential injection system can be used for injecting fertilized into drip system. These units must be attached in the system before sand filters as shown in Fig:15.2.
Filtering unit consists of primary fitter (Gravel or Sand fitter) and secondary filter (screen filler) as its components. A typical ravel filter is given in Fig. 15.3 indicating different layers of gravel pack with varying sizes. It is more effective against light suspended material such as algae, non corrosive metal or plastic material. They are specified by the size of the holes in the screens (in mm. micron or mesh i.e. no of holes per inch^2). The most common mesh selected for drip irrigation is 100-200 mesh (0.15-0.08 mm dia).
B Main and Sub main pipes:

Main pipe conveys water from the source to the main control points in the field and supplies the required discharge to each sub main/lateral. The size of pipe varies from 25 mm to 75 mm depending upon the area, crop and discharge of the well. Both HDPE and RPVC pipes can be used for main pipes with wall thickness of 2.5 to 3 mm with rated pressure of 4 kg/cm^2. These are buried beneath the ground surface at 30 to 45 cm deep to avoid exposure to UN-rays from the su, which will give more life to the pipe.

Submain provide a means of grouping laterals into zones, the number of which depend on the area, shape of the field, topography etc. on small areas, a single sub main may suffice or may be omitted if the main line can substitute for the sub main. For the sake of minimizing pipe sizes, both sub mains and laterals can be arranged to split the flow of water into two directions to minimize the friction losses. The diameter of pipes very from 25 to 50 mm depending upon the length of laterals, crops and emitter discharge rate. These pipes are made of HDPE or PVC which are buried in the ground at 30 to 45 cm depth.

F. Lateral pipe

The lateral pipes are very flexible in nature and made of low density polyethylene (LDPE0 or Linear low density polyethylene (LLDPE). The size of the lateral varies from 12 mm to 16 mm based upon the discharge requirement of the emitters. The laterals are connected to sub mains using various techniques including undersized drilled holes into PVC sub mains, saddle connections, various adapters and pipe tee joints. The emitters are connected to the laterals at crop spacing intervals. The lateral down stream end is closed with an end plug or simply crimped over. The entire pipe system can be lied on surface or sub-surface.

G. Emitters

Emitters or drippers are the devices which allow water flow from lateral pipe to the soil in the form of drops at atmospheric pressure. This is very crucial part in drip systems. They are made of injected hard plastic material. Basically, there re two types of emitters namely pressure compensating and non-pressure compensating. The functional pressure discharge relationship of emitter devices is given by.

$$Q = Kh\times \qquad \text{----------------} \qquad (15.1)$$

Where,

Q = discharge rate of emitter, l/hr

K= Proportionality constant

H = Pressure head, m and

X = emitter discharge exponent whose value ranges from 0 to 1

When x value approaches to 0, the emitters are classified into pressure compensating, other wise wmitters are non-pressure compensating. Pressure compensating emitters deliver constant discharge for any pressure range applied. Emitters are again grouped into two as in line and online emitters based on the arrangement. Inline emitters are fixed within the lateral pipe while manufacturing the lateral pipes or by cutting the lateral line. Online emitters are fixed by punching a hole on the lateral and by thumb pressing of emitter into the lateral. Besides these, microtubes, diameter ranging from 0.5 to 3 mm can also be used as on line emitters. The discharge rate of emitters varies from 2 to 10 lit/hr at rayed operating pressure.

Biwall is a twin chamber tube with one chamber of larger diameter than the other . There are orifices at spacing of 0.45 to 1.8 m apart between chambers. There will be 3 to 6 outer orifices for each inner orifice. A part from these, another group of emitters include spitters, foggers etc., which are used in most of the green houses for increasing relative humidity in the growth chambers. These resemble mini sprinklers.

H. Other control and monitoring equipment

The control and monitoring equipment include fixing of pressure gauges before, after and within the frame work of control head to study pressure variation within the fitters and fertilizer applicator etc., and by pass valve to regulate discharge into the system and water meter for knowing the total volume of water pumped into the system. They also include various control valves within the pipe network to regulate discharge rate. The drip system can be operated in the pressure range of 0.25 to 2 kg/cm^2.

Field layout of drip irrigation for row spacing of 1.0 meter components of the system: Drip irrigation system essentially consists of 1. Main line 2..Sub-mains 3. Laterals 4. Emitters or drippers.

The PVC material is preferred for drip system as it can with stand irrigation water and is also not effected by chemical fertilizers.

The laterals may be designed to operate under pressures as lowers 0.15 to 0.2 kg/cm and as high as 1.0 to 1.75 kg /cm.

RUN OFF

Run-off is that portion of the precipitation that makes its way towards stream channel, lakes etc., as surface flow: or sub-surface flow. Before run-off and occur, the precipitation must satisfy the demands of 1. Evaporation 2.Interception 3. Infiltration and 4. Surface storage.

Run-off will occur only when the rate of prescription exceeds the rate at which water may infiltrate into the soil. The water after satisfying initial detention or depression storage starts moving towards streams on the surface of the land. Such type of run – off is known as surface run-off.

Sub-surface run-off is that portion of infiltrated water which penetrates shallows depths, travels laterally and is intercepted by channels or emerges on the surface. Appreciable amounts of sub-surface relative to the total storm run-off or likely to occur where permeable surface soils lie over slowly permeably or impervious horizons at shallow depths.

Factors effecting run-off. The factors effecting run-off may be divided in these factors associated with the precipitation and those of factores associated with water shed.

Rainfall duration, intensity and aerial distribution influences the rate and volume of run-off. Total run-off where as a storm of the same intensity but of long duration will result in run-off. The intense storm may actually decrease the infiltration rate because of its destructive action on the structure of the soil surface.

Watershed factors:

The factors which effecting run-off are (1) size (2) shape and topography, nature and extent of vegetative cover over the surface. Both run off volume and rate increases as water shed size increases. Long and narrow water sheds are likely to have lower run-off rates than more compact watersheds of the same size. Watersheds having extensive flat areas or depressed areas without surface outlets have lower run-off than areas with steep, well defined drainage patterns.

Estimation of the design run-off

To design soil conservation structures with the proper capacity to meet the needs of their respective conditions it is necessary to estimate peak run-off rates. The rational method is commonly used in predicting peak run-off rate of small water sheds.

$$Q = 0.0276 \quad CIA$$

Where: Q = Design peak run-off rate in cum/sec

C = Run-off coefficient

The values of C per different soils under different slopes can be had from a table.

I = Rainfall intensity in centimeters/hr for a duration equal to time of concentration

A = Watershed area in hectares

The rational method is based on the following assumptions:

1. Rainfall occur at uniform intensity for a duration at least equal to time of concentration of watershed.
2. Rainfall occurs at a uniform intensity over the entire area of watershed.
3. This method is applicable to watersheds of less than 1300 hectares.