GOVERNMENT POLYTECHNIC
KENDRAPARA

DEPARTMENT OF CIVIL ENGINEERING

LECTURE NOTES

Year & Semester: 2nd Year, 4th Semester

Sub- Hydraulics & Irrigation Engineering (Th-2)

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(HYDROLOGY)-

Definition :-

The science of studying the different forms of water available above the earth surface or below the earth surface is known as hydrology it includes the following points

1. The measurment of precipitation (i.e rainfall)
2. The study of water losess due to transpiration evaporation absorption and infiltration
3. Estimation of run-off and Peak flow
4. The procedure of river gauging
5. Pripairation of hydrograph to predict maximum flood discharge
6. The procedure of river training works
7. The procedure of flood barricading and flood control work
8. Availability of underground water

*** Importance of hydrology :-**

The knowledge of hydrology is very essential for the application

(a) Determination of the capacity of a reservoir from the rainfall Records and the yearly discharge observation of a river

(b) determination of Peak flow of a river

(c) Determination of suitable site for hydro-electric power generation

(d) Sources of water supply in a town or city

(e) methods to be adopted for the flood control

* Some Terms Related to Hydralagy :-

Catchment area :- the catchment area of a river means the area from where the surface run off flows to that river through the tributaries streams springs etc. the area is bounded by watershed line

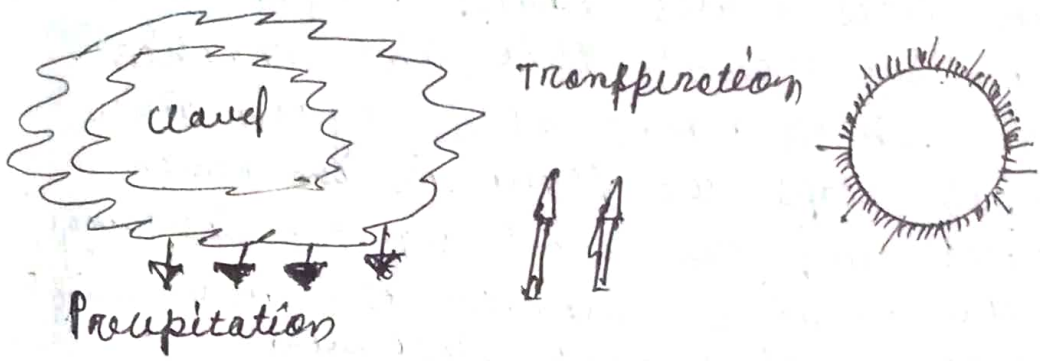
Run-off :- when it rains some portion of rain water infiltrated into the soil some is intercepted by vegetion some evaporates and the Remaining Portion flows over the ground surface to join the rivers, streams, lakes etc. This Portion of water which flows water flows over the ground surface is known as surface run-off or run-off

The surface run-off is also designated by rainfall excess or effective rainfall

* Hydralagy cycle :-

The water of the always changes from one state to other under the effect of the sun The water from the surface sources like lakes rivers ocean etc. converts to vapour by evaporation due to solar heat the vapor goes on accumulation continuously in the atmosphere, This vapour is again condensed due to the sudden fall of temprature and pressure Thus clouds are formed these clouds again cause causes the precipitation (i.e rainfall) some of the vapour is converted to ice at the peak of

* the mountains the sea ice again melts in summer and flows of rivers to meet the sea or ocean these processes of evaporation precipitation and melting of ice go on continuously like an endless chain and thus a balance is maintained in the atmosphere this phenomenon is known as Hydrological cycle



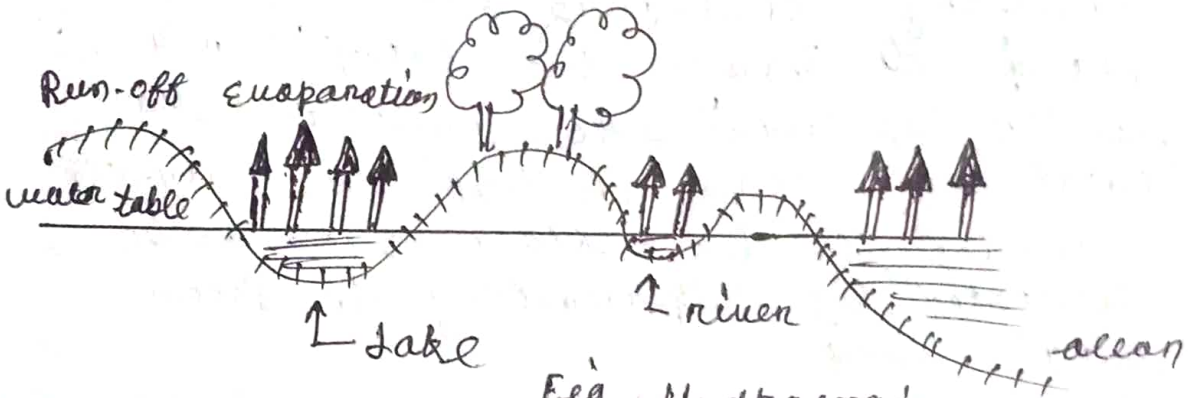
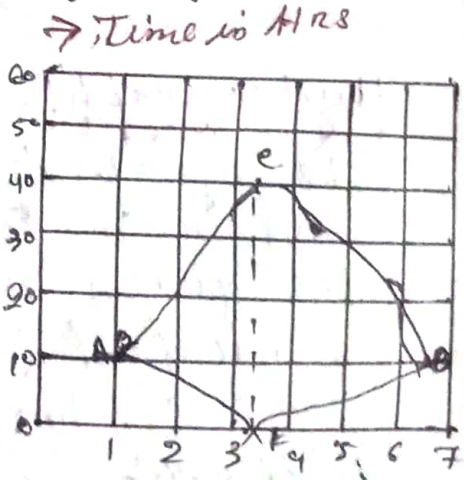


Fig. Hydrological cycle

* Hydrograph :-

The hydrograph is a graphical representation of the discharge of river (streamflow) against the time (in hr or days) The discharge is plotted as ordinate (Y-axis) and the time is plotted as abscissa (x-axis) fig



During the dry season there is only base flow (i.e ground water flow) but no surface run-off this may be shown by a line which is approximately straight nat shown in the figure)

Direct Run-off = □ Base flow = ■

in rainy season at the beggenning of the rainfall there is only base flow after some period when the initial losses (like interception, evaporation and infiltration) are fulfilled

⇒ The surface runoff starts and hence the discharge of the river goes on increasing hence the limb of the curve rises which caused rising limb (shown by the B) this line reaches to the speak value at 'C' again when the rain stops the flow in the river decreases and the line (CD) The discharge at the Point e indicate the maximum discharge (i.e) Peak discharge of flood discharge the total area under the curve ABCD indicates the total ~~area~~ run-off but this run-off includes the base flow is to ~~the~~ be deducted by separating it from total area

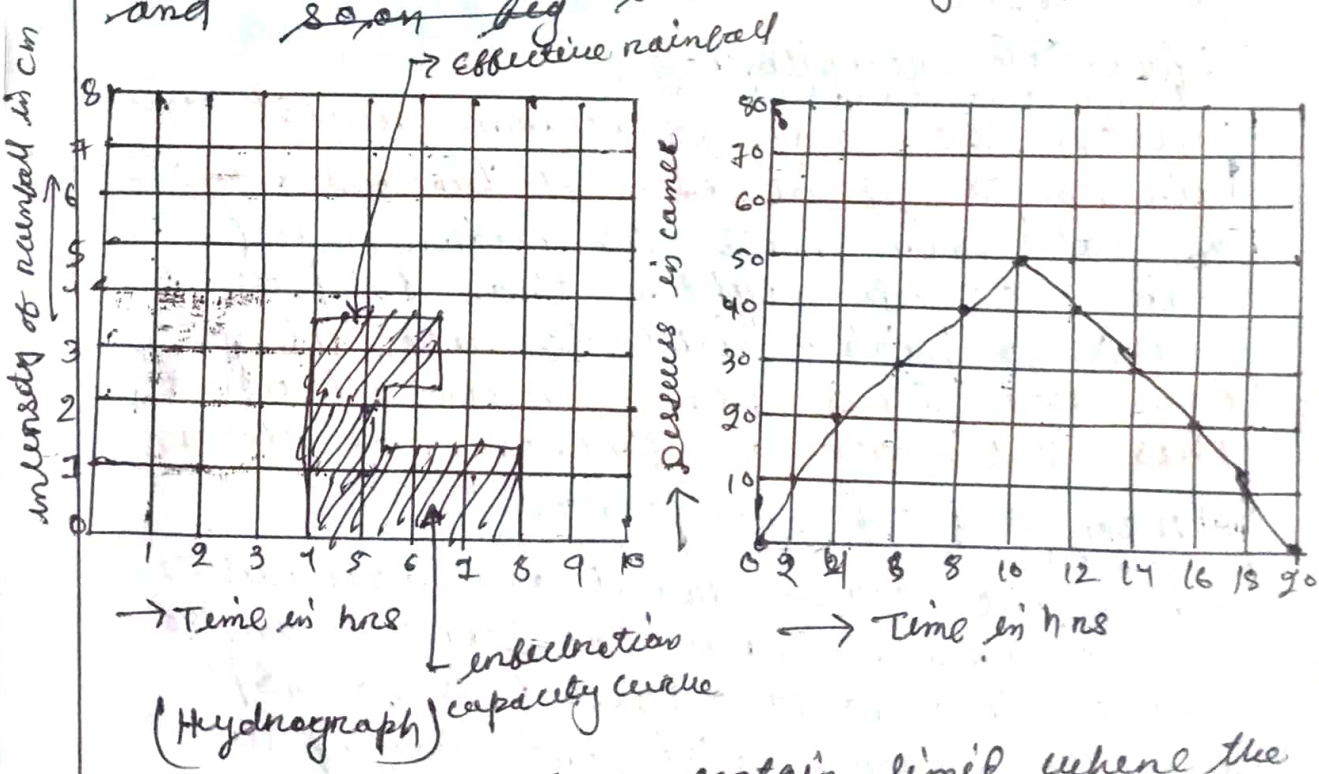
The method of separation of base flow is discussed in sec 3.8

Hydrograph:-

The graphical representation of rainfall and run-off is known as hydrograph The graph is prepared with intensity of rainfall (in (cm/hr) as ordinate and time (in hrs) as abscissa The ~~entire~~ infiltration loss (shown by dotted portion) the upper portion indicated the effective rain fall is as contained on the graph for the determination of total run-off at any specified period

* unit Hydrograph :-

A unit Hydrograph may be defined as hydrograph which is obtained from one cm of effective rainfall (i.e run-off) for unit duration here effective rainfall means the rainfall excess (i.e. run-off) which directly flows to the river or stream the unit duration is the period during which the effective rainfall is assumed to be uniformly distributed the unit duration may be considered as 1 hr. 2 hr. 3 hr. 4 hr etc. As for example if a hydrograph is prepared for an effective rainfall of one cm lasting 2 hrs. then it is known as 2 hr unit hydrograph for the duration of 3 hrs is it 3 hrs is is known as unit hydrograph and so on (Fig 3.4) show on



⇒ Atmosphere up to a certain limit where the limit exceed and the temperature and pressure fall to a certain value the water vapour will get condensed and thereby cloud earth in the form of precipitation rain. Known as hail etc this is known as precipitation

~~Forms~~

Types of Precipitation Rainfall :-

Depending upon the various atmospheric conditions the precipitation may be of the following types

① Cyclonic Precipitation :-

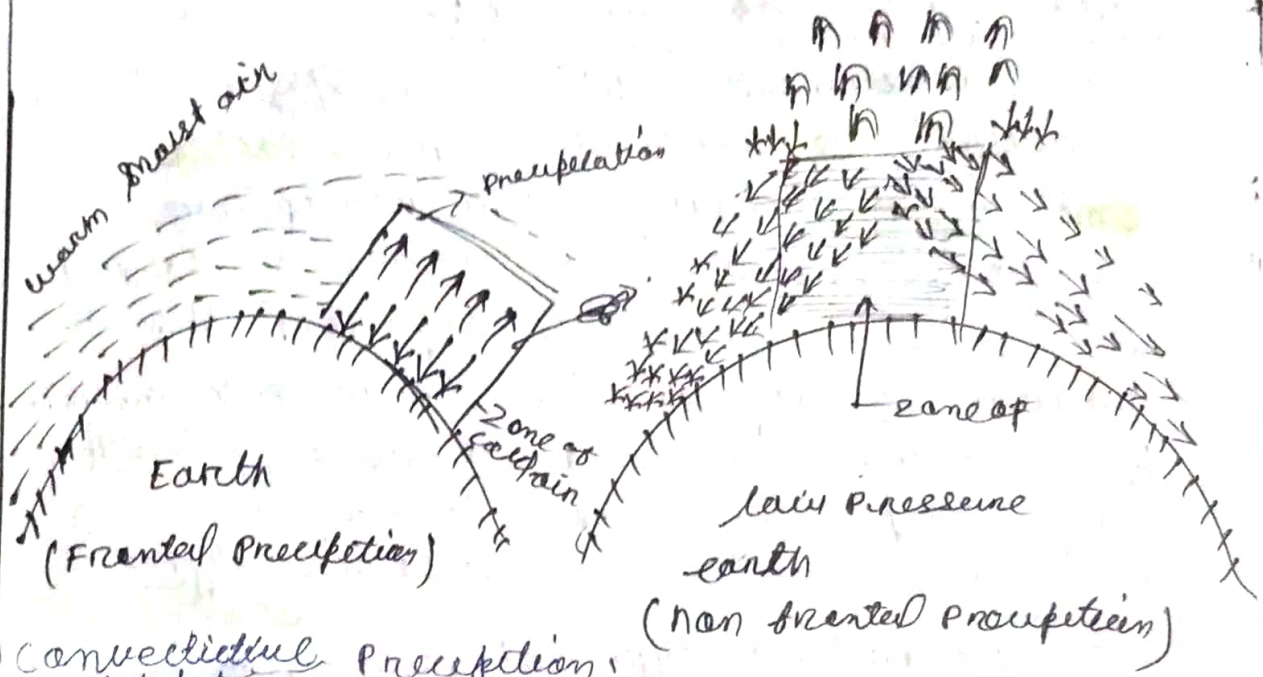
This Types of Precipitation is caused by the difference of pressure within the air mass on the surface of the earth If low Pressure is generated at some place the warm moist one from the surrounding area rushes to the zone of low pressure with violent force The warm moist air rises up with whirling motion and get considered at higher altitude and ultimately heavy rain fall occurs This may be of two types

(a) frontal Precipitation :-

⇒ when the moving warm moist ~~air~~ air mass is obstructed by the zone of cold air mass the warm moist air rise up lighter than cold air mass) to higher altitude when it gets condensed and heavy rainfall occurs This is known as frontal Precipitation

(b) non frontal Precipitation :-

when the warm moist air mass rushes to the zone of low Pressure from the surrounding area a cyclone is formed and the warm moist one rise up like chimney towards higher altitude at higher altitude this air mass gets condensed and heavy rain-fall occurs this is known as non-frontal Precipitation

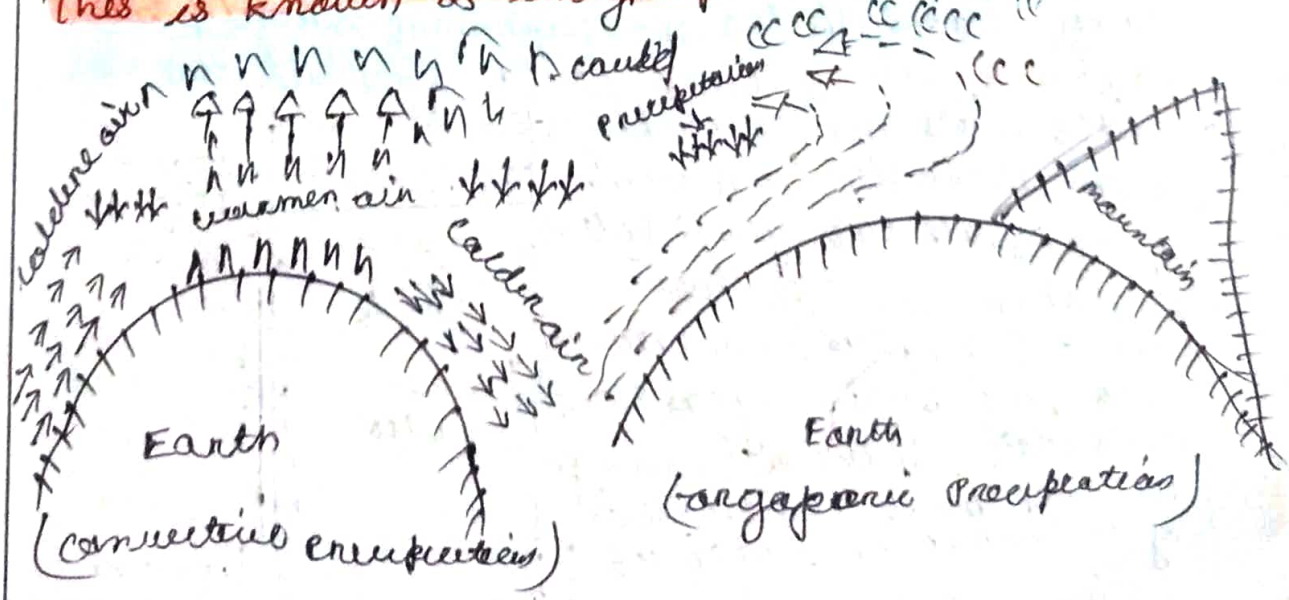


② Convectional Precipitation :-

in tropical countries when a particular hot dry the ground surface gets heated unequally the warm air lifted to high altitude and cooler air is taken is place with high velocity Thus the warm moist air mass is condensed at the high altitude causing heavy rainfall This is known as convitive precipitation

③ orographic Precipitation :-

⇒ The moving air moist air when obstructed by some mountain rises up to a high altitude left then gets condensed and precipitation occurs This is known as orographic precipitation



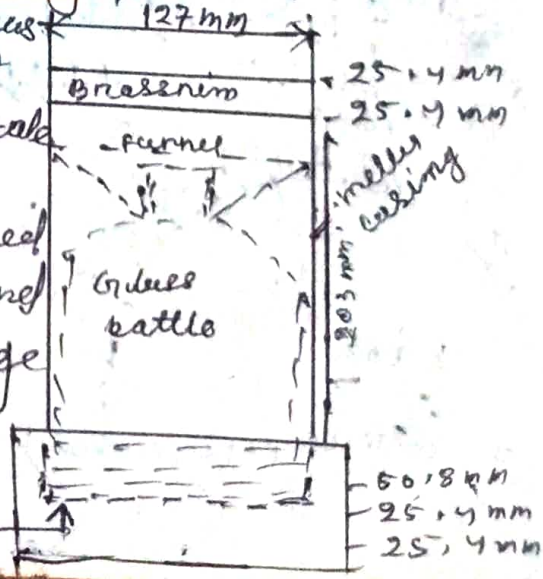
* measurement of rain fall :-

The instrument which is used to measure the amount of rain fall is known as raingauge the Principle of raingauge is that the amount of rainfall in a small area will Represent the amount of rainfall in a large area Provided the meteorological characteristics of both small and large area Similar the raingauges are of the following types

* Non-Recording type raingauge :-

Simon's raingauge is a non-Recording type of raingauge which is most commonly used it consist of metal casing of diameter 127 mm which is set on a concrete foundation A glass bottle of capacity about 100 mm of rainfall is Placed within the casing A funnel with brass rim is Placed on the top of the bottle the arrangement is shown the figure

The rain fall is Recorded at every 24 hours. Ordinarily the measurement is taken 8.30 AM every day in case of heavy rainfall the measurement should be taken 2 or 3 times daily so that the bottle does not overflows to measure the amount of rainfall the glass bottle is taken of and the collected water is measured in a measuring glass and recorded in the raingauge record book when the glass bottle is taken off



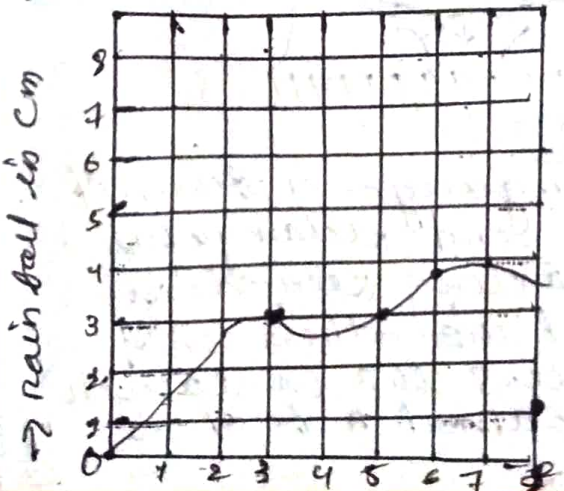
its immediately replaced is taken off its Recorf a new bottle same capacity

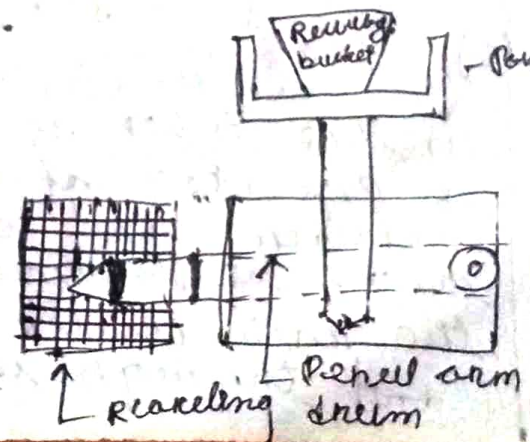
Recording type raingauge

⇒ This type of raingauge the amount of rain-fall is automatically recorded on a graph paper by some mechanical device Here no person is required for measuring the amount of rainfall from the container in which the rain water collected the Recording type raingauge may be of three types

(a) weighing bucket raingauge :-

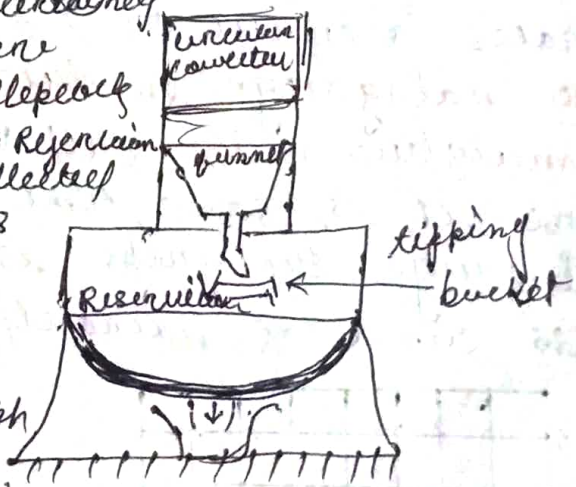
⇒ This types of raingauge consists of a Receiving bucket which is placed on Pan the Pan is again fitted with some weighting mechanism A Pencil arm is provided with the weighting mechanism is such a way that the movement of the bucket can be traced by a pencil on the moving Recording drum so when is transmitted through the pencil which traces a curve on the recording drum the raingauge produces a graph of cumulative rain fall versus time and hence it is some time called integrating raingauge the graph is known as the mass curve of rainfall





(b) Tipping bucket raingauge :-

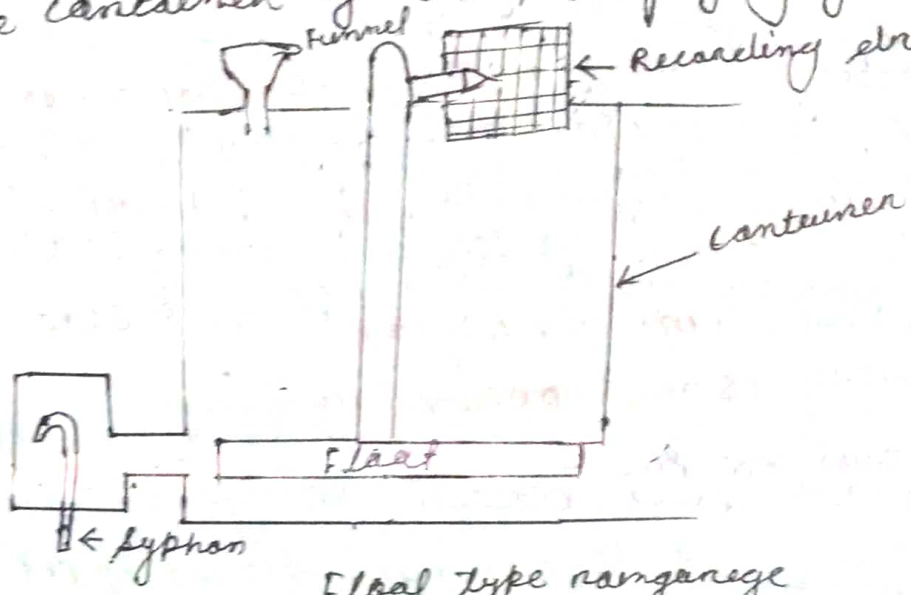
It consist a circular collector of diameter of 30cm in which the rain water is entirely collected. The rain water then passes through a funnel fitted to the circular collector and gets collected in two-compartment tipping buckets arranged below the buckets. At the same time the other bucket comes below the funnel when 0.25 mm rainfall water is collected in one buckets then the tips and discharges the water in a Reservoir kept below the buckets of the same time and other buckets comes below the funnel and the rain water goes on collecting in it when the water in the Reservoir in this way a circular motion is generated by the buckets this circular motion is transmitted to a Pen or Pencil which traces a wave like curve on the sheet mounted on a Rotating drum the total rainfall may be ascertained from the graph there is an opening with stopcock at the bottom of the Reservoir for discharging the collected rain water sometimes a measuring glass provided to verify the Results shown by the graph



(c) Float type raingauge :-

In this types of raingauge a funnel is provided at one end Rectangular container and a rotating Recording drum is provided at the other end the rain water enters the container and through the funnel A boat is

Provides within the container which rises up as the rain water gets collected there the float consist of a rod with which can lain a Pen arm bar Recording the amount of rainfall on the graph Paper wrapped on the Recording drum it consist of a syphon when the float rises to some ~~of~~ definite height and the container goes on emptying gradually



Float type rangeage

* Selection of site of raingauge stations:-

The following points should be considered while selecting a site for rain gauge station

(a) The site should be an level ground an open space should never be on slaping ground

(b) the site should be such that the distance between the gauge station and the objects should be at least twice the height of the objects

(c) in heavy area where absolutely level ground is not available the site should be so selected that the station may be well shaded from high wind

(d) The site should be easily accessible to be observer

(e) the site should be well protected from cattels by wire fencing

Network raingauge

⇒ The network of raingauge stations should be properly design to be cover whole area of the basin A guide line has been setup by the world meteorological (WMO) for the network raingauge station

(a) For Plain Region :- one station for every 600 - 900 Sq km

(b) For mountainous Region :- one station for every 100 - 250 Sq km

(c) For arid Region :- one station for every 1500 - 10000 Sq km

Forms of Precipitation :-

Rain :- It is common form of Precipitation size 0.5 mm to 6 mm

- Intensity of light rain < 2.5 mm/hr
- moderate rain 2.5 - 7.5 mm/hr
- heavy rain :- 7.5 m/hr

Snow :-

⇒ It consist of the flakes density 0.06 gm/cm³ 0.15 gm/cm³

Drizzle :-

⇒ A fine sprinkle of water droplet less than 0.5 mm

glaze :-

⇒ when rain or drizzle ~~of water dropped~~ comes in contact with cold ground at around 0°c the water droplet freeze to

Defination of Irrigation :-

The process of artificial application of water to the soil for the growth of agricultural crops is termed as IRRIGATION. It is practically a science of planning and designing a water supply system for the agricultural land to protect the crops from bad effect on drought of low rainfall. It includes the construction of weirs, dams, barrage and canal systems for the regular supply of water to the culturable lands.

Necessity of IRRIGATION :-

Throughout the crop period adequate of water is required near the root zone of the plants for their growth. At times during the crop period the rainfall ~~are~~ ~~to~~ ~~the plants~~ ~~for~~ may not be adequate to fulfil the water requirement. The intensity of rainfall is practically uncertain and beyond the control of human power and it may not be well distributed throughout the crop season on the culturable area. So irrigation becomes absolutely necessary to fulfil the water requirement of the crops. The following are the factors which govern the necessity of IRRIGATION.

(a) Insufficient Rainfall :-

When the seasonal rainfall is less than the minimum requirements for the satisfactory growth of crops the irrigation system is essential.

(b) Uneven Distribution of Rainfall :-
When the rainfall is not evenly distributed during the crop period on throughout the culturable area; the Irrigation is extremely necessary.

(c) Improvement of perenial crops :-
Some perennial crops like sugarcane, cotton etc, Require water throughout the major part of the year, But the rainfall may fulfil the water Requirement in Rainy Season only, so for the Remaining part of the year, IRRigation becomes neccessery.

(d) development of Agriculture in Desert area :-
⇒ In desert area where the rainfall is very scantly Irrigation is Required for the development of agriculture.

Benifits of Irrigation :-
The following are the important benfits of Irrigation.

(a) yield crops :-
In the period of low rainfall of drought, the yield of crop may be increased by the Irrigation system.

(b) Protection from famine :-
The food production of a country can be Improve by ensuring the growth of crops availing the Irrigation facilities, this helps a country to prevent famine situation

(c) Improvement of cash crops :-
⇒ Irrigation helps to improve the cultivation of cash crops like vegetables, fruits, tobacco etc.

(d) Prosperity of farmers :-
when the scepply of Irrigation water is assured the farmers can grow two or more crops in a year on the same land, Thus the farmers may earn more money and improve their living standard.

(e) Source Revenue :-
when Irrigation water is supplied to the cultivation in lieu of some taxes, it helps to earn revenue which may be spent on other developement schemes.

(f) Navigation :-
The Irrigation canal may be utilised for inland, multi purpose ~~Reservoirs~~ ~~are~~ ~~formed by~~ which is further useful for communication and transportation of agricultural goods.

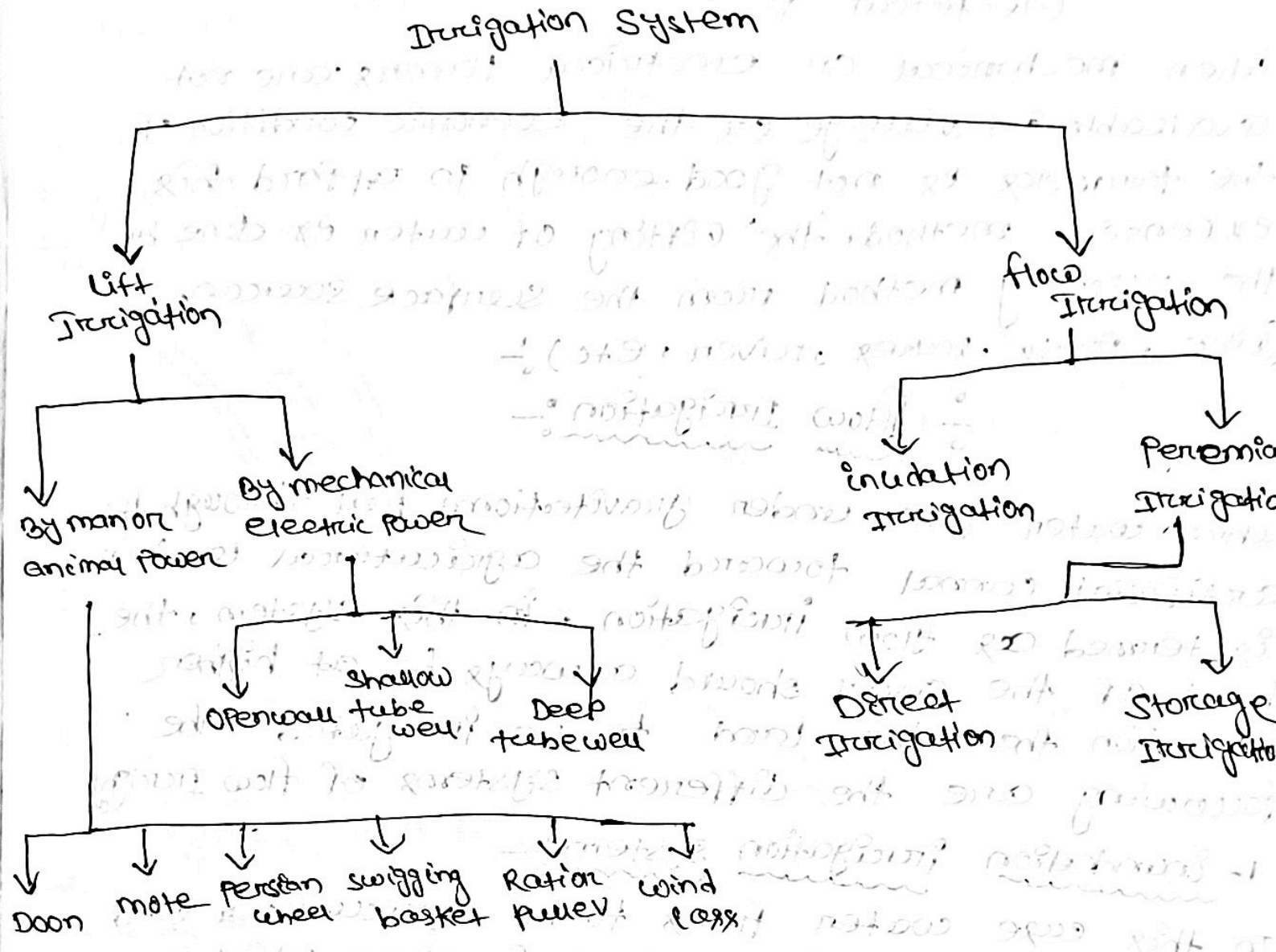
(g) Hydroelectic Power Generation :-
In some river valley projects multi purpose Reservoirs are formed by constructing high dams where hydroelectric Power may be generated along with the Irrigation system.

(h) water scepply :-
The Irrigation canal's may be source of water scepply for domestic and industrial purpose.

(i) General communication :-
The Inspection road along the canal banks may serve as communication link with the otherwise Remote villages.

(k) Developement of fishery :-
They Reservoir and the canals can be utilised for the developement of fisher projects.

Systems of Irrigation :-



A. Lift Irrigation :-

When water is lifted from surface sources or underground source by man or animal power, mechanical or electrical power and directly supplied to the agricultural land, then it is known as lift-Irrigation. In this method isolated small areas can be irrigated. The vast areas cannot be included in this system. Lift Irrigation can be divided into two groups.

Uncontrolled flooding :-

This method is applicable in inundation irrigation system. Here the land is flooded with water by inundation canal. As there is no controlling system in inundation canal, this type of distribution of water is known as uncontrolling flooding. This method results in wastage of water and over irrigation.

Controlled flooding :-

This method is applicable in permnial irrigation system. In this method, the agricultural area is flooded with water through the canals, which are provided with Regulators. It is again sub-divided in to following types.

(a) free flooding.
(b) Basin flooding.
(c) check flooding.
(d) Border flooding
(e) zig-zag method.

(i) free flooding :-

In this method, the agricultural land is divided in to small strips of by a series of field channals which are connected to the supply channal. the strips of land are flooded with water by opening the field

Regulator (f.R)
waste water
the river or d
Basin method
This method
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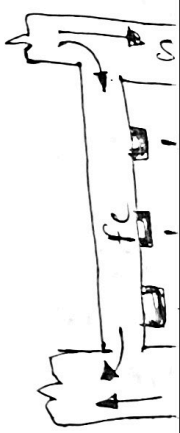

f.c
f.R

check
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basin

Again, the flow of water through the canal stops automatically when the water level of the river falls, below the canal bed.

So, this system of Irrigation depends completely on the water level of the river As there is no Regulator at the head of the canal, over Irrigation is possible Resulting in damaging the crops.

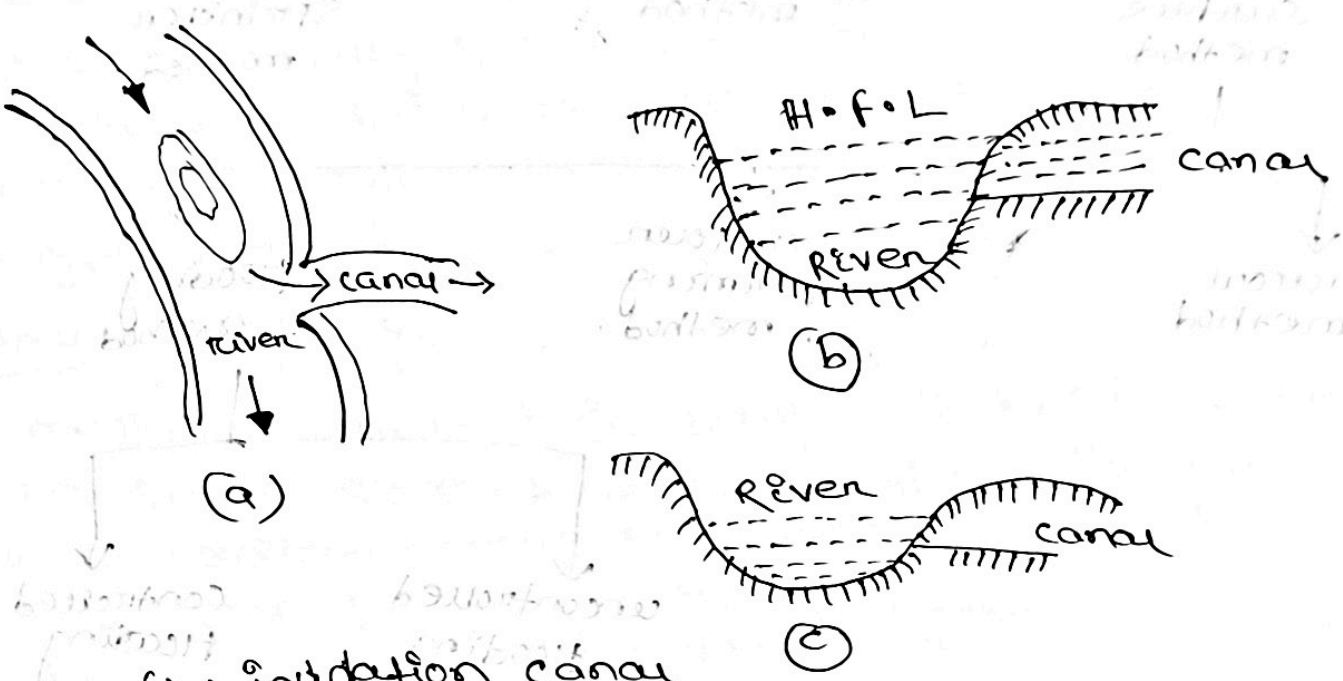


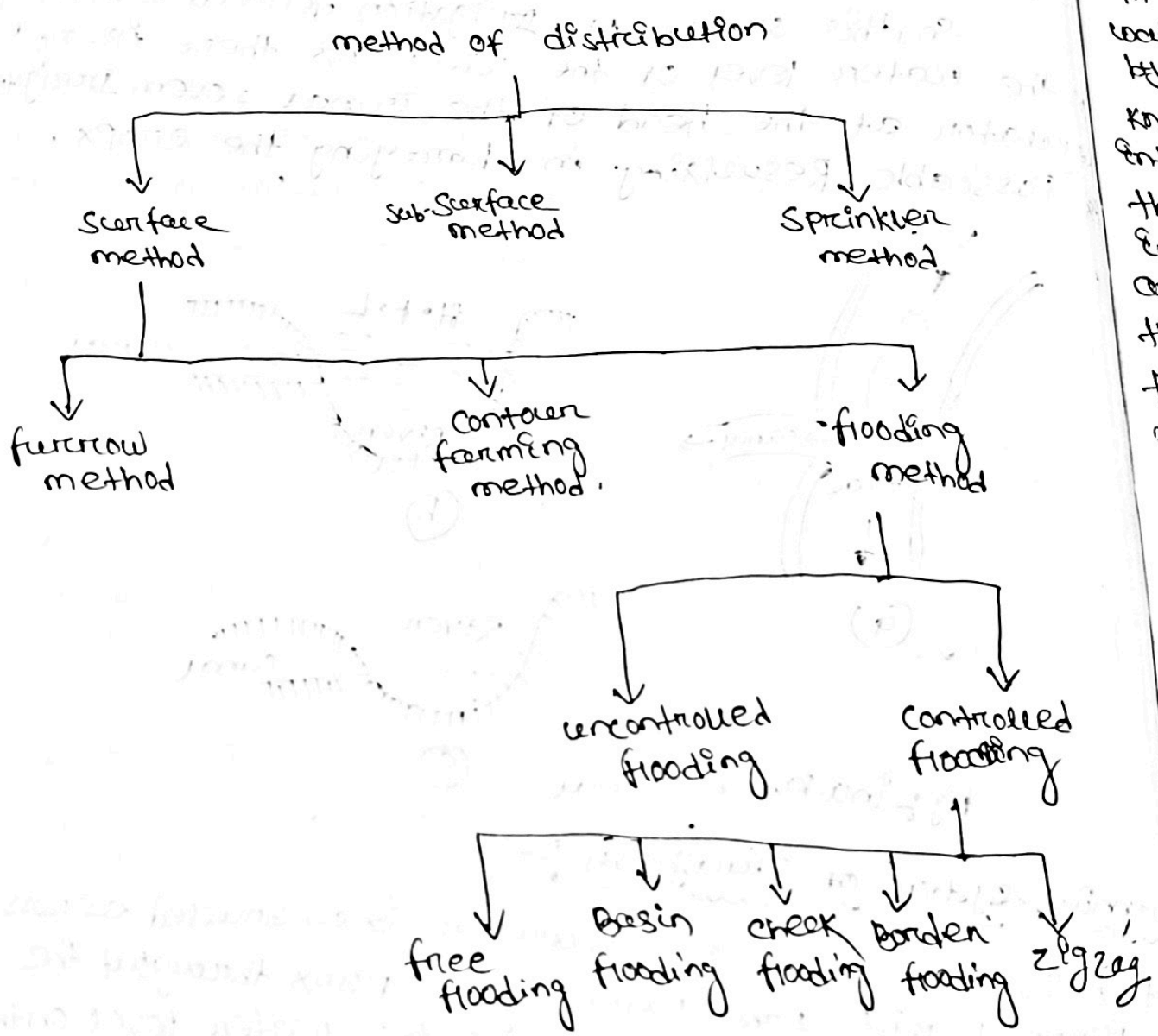
fig:- Inundation canal

Perennial System of Irrigation :-

In this system, a weir or a barrage is constructed across the Perennial river, the river which flows throughout the year in its full capacity. to raise the water level on the up stream side or a dam is constructed to form a storage Reservior. Then main canal is constructed on either or both the banks of the river. Regulator is constructed at the head of the canal to control the flow of water through the canal. toward the agriculture and land, This system is reliable as water is available throughout the year. The Perennial system of Irrigation

may be of the following types,

Method of Distribution of water :-

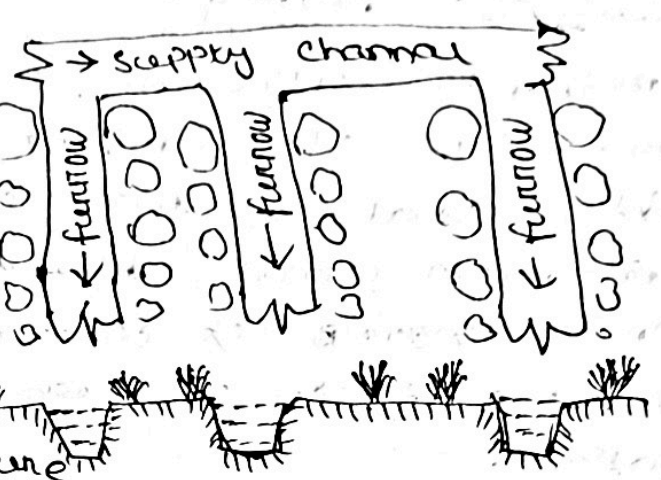


Surface method :-

In this method, the Irrigation water is distributed to the agricultural land through the small channels which flood the area up to the Required depth. The surface method is again sub-divided into three categories.

furrow method :-

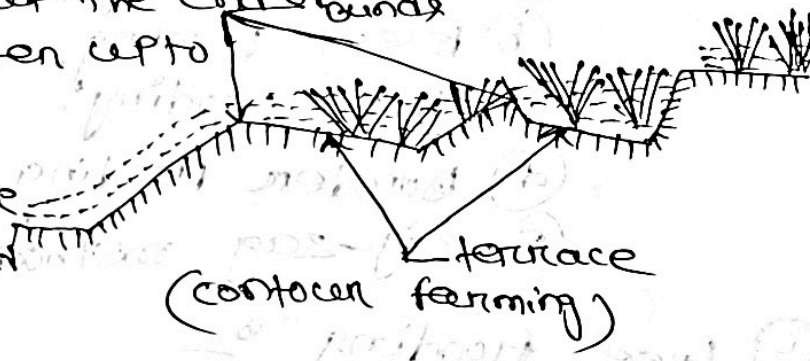
In this method, the irrigation water is supplied to the land by digging narrow channales known as furrow at Regular intervals. The water flows through the furrows and infiltrates into the soil and spread laterally to saturate the root zone of the crops. This method is suitable for the crops which are sown in rows. The crops are potato, ground nut, tobacco, sugarcane etc.



contour farming :-

This method is adopted in hilly areas, where the land has steep slope, here the land is divided into series of horizontal strips which are known as terraces small bunds are provided at the end of bunds each terrace to hold water upto the required depth.

This method serves also the purpose of flood control and soil erosion.



(contour farming)

flooding method :-

This method is suitable for the agricultural land which exists in flat topography in this method, the field is flooded with water with the help of field channa flooding method may be two types.

uncontrolled flooding :-

This method is applicable in inundation irrigation system. Here the land is flooded with water by inundation canal. As there is no controlling system in inundation canal, this type of distribution of water is known as uncontrolling flooding. This method results in wastage of water and over irrigation.

controlled flooding :-

This method is applicable in permial irrigation system. In this method, the agricultural area is flooded with water through the canals, which are provided with Regulators. It is again sub-divided in to following types.

(a) free flooding.
(b) Basin flooding.
(c) check flooding.
(d) Border flooding
(e) zig-zag method.

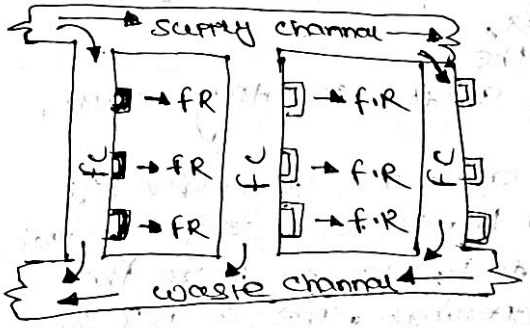
(a) free flooding :-

In this method, the agricultural land is divided in to small strips of by a series of field channals which are connected to the supply channal. the strips of land are flooded with water by opening the field

Regulator (f.R) the surplus water flows through the waste water channal and land is discharged into the river or drainage.

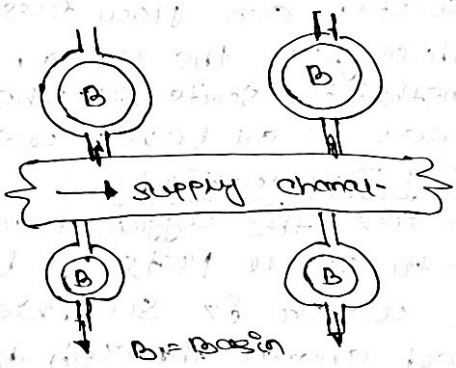
Basin method :—

This method is employed for watering orchards, in this method, each tree or a group of trees are enclosed by circular channal through which water flows. The circular channal is known as basin, each basin is connected to field channal. The field channal is again connected to the supply channal, when all the basins are filled with water, the supply of water stopped.



f.c = field channal
f.R = field Regulator

(free flooding)



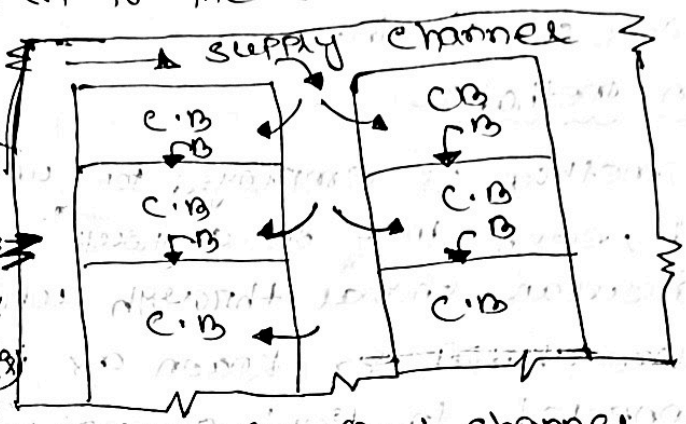
(Basin method)

Check flooding :—

In this method, the agricultural area is divided into small plots (known as check basin) by check bunds. The water is supplied to the channal, each basin is flooded with water to the desired depth

the water is retained for some hours so that it can infiltrate into the soil.

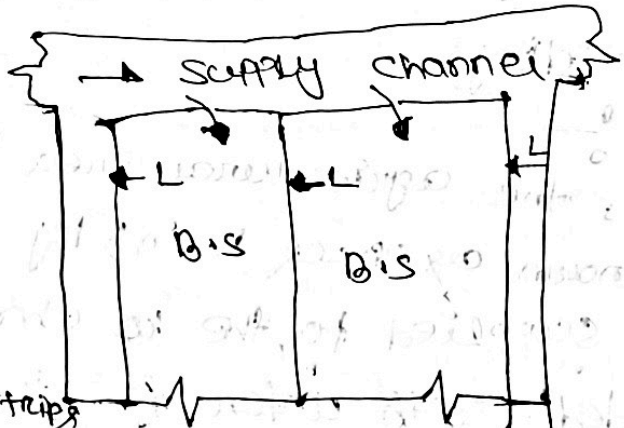
Border strips :-



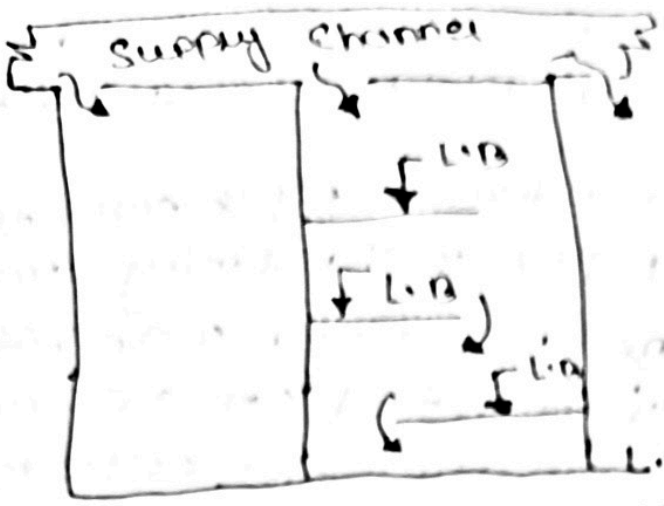
In this method the agricultural area is divided into series or long narrow strips (known as border strips) by levees ; i.e small bunds, fc = field channel B = Bunds C·B = Check Basin The strips are aligned along the country slope so that the water can flow easily (Check flooding) throughout the area. this method is suitable when the area is at level with gentle country slope.

Zig-zag method :-

In this the agricultural area is sub-divided into small plots by low bunds in a zigzag manner the water is supplied to the plants from the field channel through the openings. The water flows in a zigzag way to cover the entire area. when the desired depth is attained, the opening are closed.



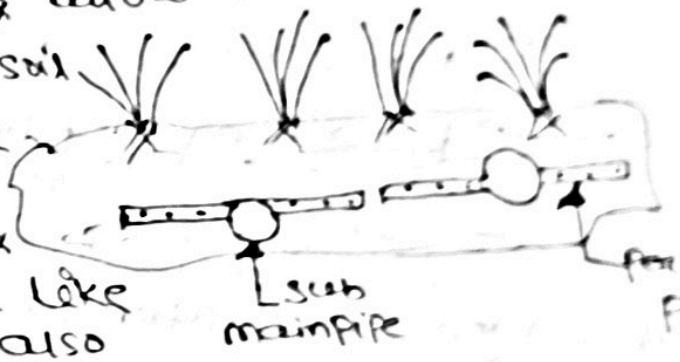
B·S = Border strips
L = levees. (Border Strips)



(zig-zag method)

Sub-Surface method :-

In this method, the water to the root zone of the crop by underground network of pipes, the network consists of main pipe, sub main pipes, and lateral pipes. The perforated pipes allow the water to drip out slowly and thus the soil below the root zone of the crops absorbs water continiously. This method is suitable for permeable soil like sandy soil. This method is also known as drip method or trickle (sub-surface method) method of irrigation.



Sprinkle method :-

In this method, the water is applied to the land in the form of spray like rain. The spraying of water is acheived by the network of main pipe, sub main pipes and lateral pipes.

The lateral pipes may be perforated at the top and side through which the water comes out in the form of spray and sparkles over the crop in

a particular area. Again the lateral pipes may contain series of nozzle through which the water comes out as a formula and sprinkles over in particular area.

Now-a days the lateral pipes consists of the water of riser pipes with rotating arms at the top. the arms are fitted with nozzle so, the water gets distributed on a circular with belt and pulley system. the network of pipe lines are supported on pillars and the water is forced through the line pipe lines by pumping unit. the following are different forms of sprinklers.

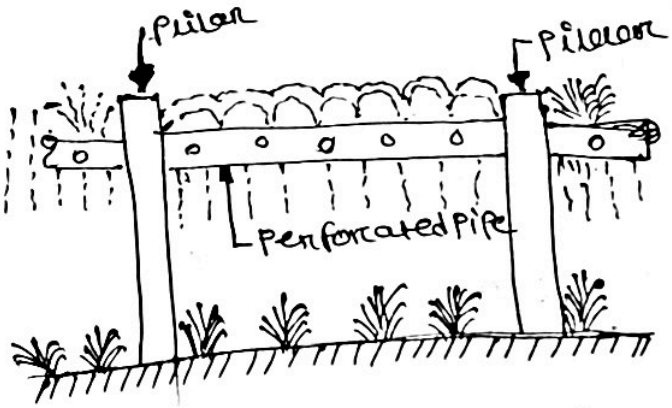
(a) perforation on lateral pipes.
(b) fixed nozzle on lateral pipes.
(c) Rotaining sprinklers.

Perforation on lateral pipes :-

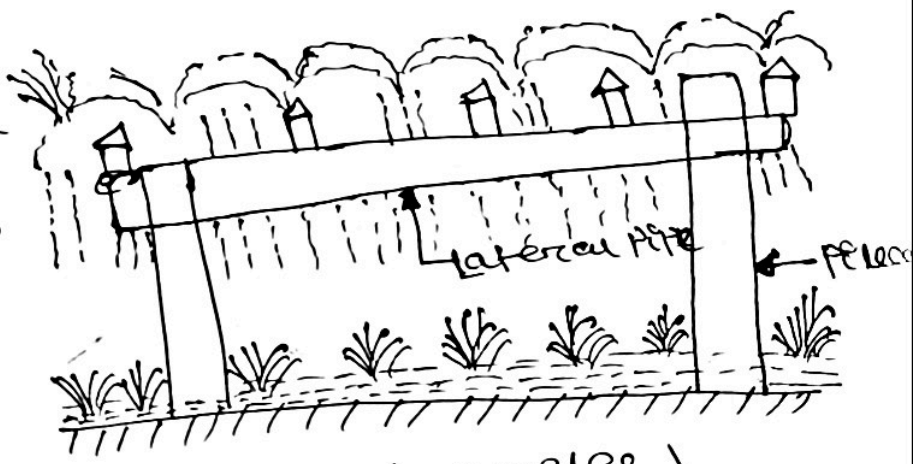
In this type, the lateral pipes are perforated along the top and sides. the water is sent under pressure by a pumping unit through the main pipe, sub-main pipes and lateral pipes. the water comes out through the perforations in all directions in the form of spray. the spacing of lateral pipes should be such that the whole area may be evenly sprayed with water. the lateral pipes are supported on pillars.

fixed Nozzales on lateral pipes :-

In this type, a series of nozzales are fixed alon the lateral pipes. The spacing of the nozzale are such that the water may cover the whole are evenly. the lateral pipes are supported on pillars when the water is forced under pressure throug the network of pipes, it comes out as fountain through the nozzles and spreads over the land.

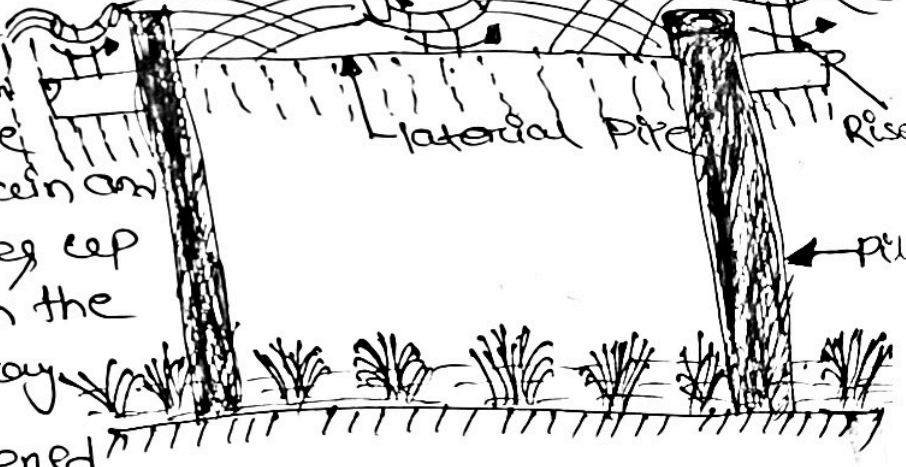


(Perforated lateral pipes)



(fixed nozzles)

Rotating Sprinklers :- In this type, the riser pipes are fixed on the lateral pipes at a regular intervals. On the top of the riser pipe are two arms which can rotate about a vertical axis. the upper ends of the arms consists of nozzles. when the water is forced under -pressure through the main sub-main or lateral pipes, it rises up and comes out through the nozzale in form of spray. As the arm rotate, a circular area is covered by each riser.



(Rotary sprinklers)