

Availability and Management of Groundwater Resources
Prof. Prasoon Kumar Singh
Department of Civil Engineering
Indian Institute of Technology (ISM), Dhanbad

Lecture- 51

Rainwater Harvesting and Artificial Groundwater Recharge (Contd.)

Welcome you all in the part 2 of the module 11 rainwater harvesting and artificial groundwater recharge, so in the first part we have understood about the basic components of the your rainwater harvesting and artificial recharge structure.

(Refer Slide Time: 00:43)



CONCEPTS COVERED

- **Sources of water for recharge.**
- **Rainwater harvesting techniques**

Now in this part we will discuss about the sources of water for recharge and the rainwater harvesting techniques.

(Refer Slide Time: 00:50)

SOURCE OF WATER FOR RECHARGE

Rooftops:

- Buildings with impervious roofs provide effective free of charge water for various uses.

Paved and Unpaved Areas:

- Landscapes, open fields, parks, stormwater drains, roads and pavements and other open areas can be effectively used to harvest the runoff.
- The main advantage in using the ground as collecting surface is that water can be collected from a larger area.
- This is particularly advantageous in areas of low rainfall.

So generally, water is recharged in a pit means your the structure which will just store the rain water. So the point is in the storage space from where the water will come or will reach. So the sources of, the water for recharging at a specific pit is first is the roof tops. So buildings with impervious roofs will provide effective free space of charging water for various uses, so the roof should be impervious only then it will store the water, so this is the one of the source roof tops.

Now, paved and unpaved areas example landscapes, open fields, parks, storm water, drains roads, and pavements, and other open areas can be effectively used to harvest the run off. Runoff is the surplus rain water which is not infiltrating percolating and moving down towards the aquifer. So then what will happen this surplus rainwater which will move through the topography in the form of runoff.

So it will be harvested then it will it can be harvested in the space like open field, in some parks, in some drains, in some roads, and pavements and also in some open areas. Where it can be harvested and then when there will be use any need it can be utilized as well. So the main advantage in using the ground at collecting surface is that water can be collected from a larger area, in the ground we can collect huge volume of water but on the roof we cannot collect huge volume of water.

It the volume of water will be according to the size of the roof the area of the roof only. So this is particularly advantageous in areas where there is low rainfall, so if the low rainfall will be there you can think for harvesting the rain water on the paved and paved areas.

(Refer Slide Time: 03:23)

Waterbodies:

- Lakes, tanks and ponds are precious stores of rainwater.
- The harvested rainwater can not only be used to meet the water requirements of the city, but it also recharges groundwater aquifers.

Stormwater Drains:

- Those regions which have proper network of stormwater drains provide a simple and cost-effective means for harvesting rainwater.

Now water body lakes, tanks, and ponds are also precious storage space of rainwater. Lakes, tanks and ponds these are the naturally surface sources of water, so here also we can go for the storage of the rain water. The harvested rainwater can not only be used to meet the water requirements of the city, or of the town area, or of the area, but it is also recharging the groundwater aquifers.

So the amount of water which is being harvested will not only going to be used to meet the water requirements of the people who are living in the city or town or area but ultimately this water is also recharging the underlying groundwater aquifers. So now storm water drains those regions which have proper network of storm water drains provide a simple and cost effective means for water harvesting structure. So these areas storm water drains are if there is a proper network of strong water drains in area it will provide a simple and cost effective means for harvesting rain water.

(Refer Slide Time: 04:48)

Rainwater Harvesting (RWH) Techniques

1. Surface Runoff Harvesting:

- ❑ Rainwater is collected into natural reservoirs or tanks, or the infiltration of surface water into subsurface aquifers before it is lost as surface runoff.



2. Roof-top Rainwater Harvesting (RRH):

- ❑ Roof-top rainwater harvesting involves diverting and recharging (or) storing part of the rainwater that falls on the roof of a house.
- ❑ The harvested water is directly stored in a recharge pit, which collects and slowly recharges into the groundwater storage/aquifer in that area.



Now what are the techniques what are the techniques of the rainwater harvesting. The first is the surface runoff harvesting or at the present day it is called as your water harvesting, because here the rain water as well as surface water both are harvesting. So this rain water is collected into natural reservoirs or tanks or the infiltration of surface water into subsurface aquifers before it is lost as surface runoff.

So this thing we have understood when we were discussing about the runoff also, that rainwater which is collected into natural reservoirs or tanks after infiltration of the surface water into subsurface aquifers it is just losing as surface runoff. So this is the one technique second technique is roof top rainwater harvesting we have discussed. So here roof top rainwater harvesting involves diverting, and recharging, or storing all things diverting the rainwater recharging, or storing part of the rainwater that falls on the roof of a house.

So whatever falling on the roofs of the house only those quantity of water can be just diverted can be just recharged or stored at a specific place. The harvested water is directly stored in recharge pit, whatever amount of the harvested water is there it can be directly stored in a recharge pit which collects and slowly recharges into the groundwater storage or aquifer in that area. So it is just going down and it is recharging ultimately the groundwater which remains within an storage or aquifer area.

So in the diagram also we can just see the surface runner of rainwater harvesting is generally used when there is a water crisis it is also a solution to submergence problem. Drainage problems and the reduction in flood level that time also not only the roof top rainwater harvesting but surface runoff harvesting is also used; for the different applications, for the different works of the human beings, and the industrial operations. Now second technique through which the rainwater harvesting can be done is next technique to which the rain water harvesting can be done is the through the dams.

(Refer Slide Time: 07:29)

3. Dams

- Dams are barriers that are designed to trap water. Rainwater can accumulate directly in them, or drainage systems can be created to direct water into them.
- This technique is mostly used for irrigation purposes or treated and then distributed for domestic use.
- Unlike ponds, measures are applied to reduce the amount of water draining into the ground.



So dams or barriers that are designed to trap water, it is just you can see the slice gates are here which is just these gates are not allowing water to move in this side. So this is stored in there this because of this these gates the water remains stored in the catchment area, this is the main application of dams also. So if these are the barriers which are designed for trapping of water. If rain water can accumulate here directly no problem our drainage system can be created to direct water into them or some drainage system can be diverted to this dam area.


So the rain water whatever is falling on the land surface it all will reach to the place of the dam and it will collect in the, their attachment of it. So this technique is mostly used for irrigation purposes or treated and then distributed for domestic features. So generally the dam water are used for the irrigation purposes, in some agricultural field or in some specific cases it can be treated and then can be utilized for domestic usage as well.

So unlike ponds measures are applied to reduce the amount of water draining into the ground. So in the case of pond there are certain measures which is just reducing the amount of water draining into the ground. But in the dam it is just you can see that it is collecting and can be utilized while there will be viscosity of water or it can be their water are mostly used in the irrigation purposes but can be used after treatment for domestic users also.

(Refer Slide Time: 09:35)

4. Underground Tanks:

- ❑ These are constructed by **digging into the ground and creating a space which is then cemented to reduce water infiltration.**
- ❑ The top is also **sealed, and water is obtained through pipes directed into the tank.**
- ❑ Pumps are used to get **water out.**
- ❑ Underground tanks are wonderful for harvesting rainwater because since they are **located underground where sunlight does not really penetrate, the rate of evaporation is reduced.**



Now underground tanks through this method also we can store a collector and store the water. So underground tanks in the diagram also you can see some of the underground tanks recharge tanks are here. So this is your technique through which in the rain water is collecting, then storing and then it remains within a tank and which can be utilized at the time of its need. So these are constructed by digging into the ground and creating a space which is then cemented to reduce water infiltration.

So in the side just a digging a place into the ground and creating some space some area and then cementing it the border is cementing to reduce water infiltration the top is also sealed and water is obtained through pipes directed into the tank. So this top is sealed properly and water is obtained through pipes and directed into the tanks. Pumps are used to get water out different pumps will be there which will get the water out.

So underground tanks are wonderful for harvesting rainwater because since they are located underground where sunlight does not really penetrate the rate of evaporation is reduced. So rate of infiltration is reducing so these are good for the harvesting of rain water.

(Refer Slide Time: 11:18)

5. Rain Saucer:

- ❑ In this technique, rainwater is directly collected as it falls from the sky by using a rain-saucer.
- ❑ These look like **upside-down umbrellas** or big funnels and are usually attached to a pipe so that the collected water is directed elsewhere.
- ❑ Sometimes the collecting container is placed underground with only the rain-saucer above the ground. **It is a simple yet effective method.**



Now the next is the rain saucer then so in this technique rainwater is directly collected as it falls from the sky by using a rain saucer. So here what is happening directly it is falling and from the sky and collecting in a structure these look like upside down umbrellas or big funnels. And are usually attached to a pipe so, that the collected water is directed elsewhere. So you can see this, these are just looking the upside down umbrellas through pipe the rain water is coming and it is storing in this tank.

So collected water is stored and directed to a somewhere as per the use, sometimes the collecting container is placed underground with only the rail saucer above the ground. Sometimes this hole will remain under underground only this thing will remain at the top, so it is a simple yet effective method.

(Refer Slide Time: 12:28)


6. Water Collection Reservoirs:

- In this case, rainwater is harvested from roads and pavements.
- Water collected through this method is not really clean and may be contaminated.
- However, it can still be used for crop irrigation.

7. Barrage:

- A barrage is a dam that has several openings which can be closed or opened to control the quantity of water that passes through it.
- It is usually large and can be used to collect a lot of water.

8. Slopes:

- Rainwater is collected at the bottom of slopes when it flows on the ground.
 - This is a simple and natural way to harvest rainwater.
- 

Now water collection reservoir, this is also one of the techniques of collecting the rain water in this case rain water is harvested from roads and pavements. From roads and pavements, you can see after rain lots of surface water is flowing through the roads and pavement so it can be also harvested. As water collected through this method is not really clean and may be contaminated, definitely it will be contaminated however it can still be used for crop irrigation. So this, water collection reservoirs are also very good for storing of rain water.

Now barrage; barrage also dam that has several openings which can be closed or open to control the quantity of water that passes through it. So this is the, this is also just like a dam and it has remaining several openings and it is being closed or open as per the quantity of water inside the catchment area. So the quantity of water can be just made, more or less by the usage of the openings. It is really large and can be used to collect a lot of water whereas are generally remaining in large structure, and it is using for collection of lots of volume of water.

Now slopes rainwater is collected at the bottom of slopes when it flows on the ground. So this is also water flows from your top to bottom, so the rain water is also can be also collected at the bottom of the slopes in any land area when it flows on the ground. So at the bottom if any structure is there, then in this structure the rain water can be stored, because generally rainwater stored or moves to the bottom of the slopes of the area. This is simple and natural way to harvest rain water this is also a technique for harvesting of rainwater it is simple and natural also natural as well.

(Refer Slide Time: 14:48)

9. Trenches:

- This is another traditional method to harvest rainwater for irrigation that is still very much in use today.
- When it rains, the water is directed to the farm using trenches.



10. Rain Barrels:

- These are specifically designed for this purpose and can be purchased from retail stores.
- Rain barrels are used for harvesting rainwater that falls on roof-tops.



Now next is the trenches this is also a traditional no doubt it is a traditional method to harvest rain water for irrigation. That is still very much used in today's life also you can see when rain falls the water is directed to the form using trenches. Through this, trenches the water moves and through this with the help of these trenches it is a traditional method to harvest that in water. So this, trenches the surrounding areas can be irrigated with the help of the water which is stored.

This is the rain water which is stored during the falling of the rain and it can be utilized as well, so it is also one of the good methods for water harvesting. Next is the rain barrels rain barrels these are specially designs for this purpose and can be purchased from the retail stores as well. Rain balers are used for harvesting rainwater that falls on the roof tops. So it is just this is the rain barrels which can be purchased from the some retail stores also and these can be used where the just see, you can see the rain water is collecting on top.

It is coming to a pipe and through this pipe it can be stored in this run barrel, so this is also one of the important structures for your harvesting the rain water rain barrels.

(Refer Slide Time: 16:17)

Uses of Rainwater Harvesting System

- Drinking
- Cooking
- Washing vegetables
- Agricultural purposes
- Toilets (Bathing and Flushing Toilets)
- Gardens, House plants and Outdoor plants
- Lawns
- Water for pets, wildlife, livestock
- Pools and other water bodies
- Washing vehicles and equipment
- Fire protection

Next is the usage of rainwater harvesting system, so if the rain water can be harvested definitely it will be used in different form also. Say for domestic purposes drinking, cooking, then washing vegetables, agriculture purposes, bathing and flushing toilets, gardening, housing, house plants, and outdoor plants, lawns, then lawn watering, then water for pets, wildlife, livestock, pools and other water bodies, washing vehicles and equipment, and fire production. So for all the purposes this surplus rainwater which is harvested in a specific area can be utilized for the different applications different processes.

(Refer Slide Time: 17:17)

DESIGN OF STORAGE/ SETTLEMENT TANKS

- The quantity of water stored in a water harvesting system depends on size of the catchment area and the size of the storage tanks.
- The storage tanks has to be designed according to the water requirements, rain fall, and catchment availability.

Basic Data

- (i) Avg annual rainfall
- (ii) Size of catchment
- (iii) Drinking water requirements

Now we you can see that the how to design the storage of settlement tanks, because this is very important in certain place generally the storage and settlement tanks are being constructed also.

So the quantity of water stored in a water harvesting system generally depends on the size of the catchment area, and the size of the storage tanks. So what we have seen we have seen that if this is the roof top area.

And from the roof top area generally the water through some PVC pipe it comes to a tank known as storage tank. So this is the storage tank and in which the rain water will be accumulated here and this is the roof top area where the water rain water we are getting the rain water in this area the roof top area, so this water we are just trying to conserve. So the storage tanks are also designed according to the water requirements this tank, how much water is required, what is the amount of rainfall in the area, and the catchment ability also, whether the roof top area is small, big.

So these factors are very important for designing of any storage or settlement tanks. Basic data generally required for this is the average annual rainfall data we have read of the every area is having average annual rainfall data. The size of the catchment; the size of the catch material and the drinking water requirements what is the amount of water required for any specific purpose. So these are the generally the basic data which generally required for designing of any storage and settlement tanks.

(Refer Slide Time: 19:17)


Example: Suppose the system has to be designed for meeting drinking water requirement of a 5 member family living in a building with a rooftop area of 100 Sqm, Avg. annual rainfall is 600 mm, Daily drinking & cooking water requirement per person is 10 litres. (Take Runoff coeff = 0.85 & constant coeff. evaporation, spillage and first flush etc=0.8).

Solution:
We shall first calculate the maximum amount of rainfall that can be harvested from roof top.

Area of Roof top	-100 Sqm
Average annual rain fall	- 600 mm = 0.6 m
Runoff co-efficient for tiles surface (typical case)	- 0.85
Co-efficient for evaporation, spillage and first flush etc	- 0.80

Volume of water for 100 Sqm roof top
 = (Area of rooftop) x (Annual rainfalls in meter) x (Runoff coefficient) x (Constant co-efficient evaporation, spillage and first flush etc)
 = 100 x 0.60 x 0.85 x 0.80
 = 40.8 cum
 = 40,800 litres

Handwritten notes on slide:
 100 Sqm (circled)
 RTA
 40,800 litres



So with this just for knowing the details about this now we can see problem and through the problem we will try to design the storage tank, the water harvesting system. So, the problem is Suppose the system has to be designed for meeting drinking water requirement of a 5-member

family living in a building with a rooftop area of 100 Sqm, Avg. annual rainfall is 600 mm, Daily drinking & cooking water requirement per person is 10 litres. (Take Runoff coeff. = 0.85 & constant coeff. evaporation, spillage and first flush etc = 0.8).

We shall first calculate the maximum amount of rainfall that can be harvested from roof top.

Area of Roof top - 100 Sqm

Average annual rain fall - 600 mm = 0.6 m

Runoff co-efficient for tiles surface (typical case) - 0.85

Co-efficient for evaporation, spillage and first flush etc - 0.80

Volume of water for 100 Sqm roof top

= (Area of rooftop) x (Annual rainfalls in meter) x (Runoff coefficient) x (Constant co-efficient evaporation, spillage and first flush etc.)

= 100 x 0.60 x 0.85 x 0.80

= 40.8 cum

= 40,800 litres

This roof top area is receiving 40,800 liters of water this much amount of volume of water is being received by the roof top area.

(Refer Slide Time: 23:06)

Now,

The tank capacity has to be designed for dry period i.e. the period between two consecutive rainy season.

- With monsoon extending over 4 months the dry season is of 245 days has been considered.

- Drinking water requirement for family for dry season

= 245 x 5 x 10

= 12,250 litres as a safety factor, the tank should be built 20% larger than required.

= (1.2 x 12250 litres) = 14700 litres.

- Since Water storage is 40,800 litres, so this tank can meet the basic drinking & cooking water requirement of a 5 member family for the dry period.

Now the tank capacity has to be designed for dry period that is the period between 2 consecutive rainy seasons because dry period then monsoon is coming again what is happening after the winter

again dry period is coming. So the tank capacity should be designed taking into consideration for dry period that is the period between 2 conjugative rainy seasons. With monsoon extending over 4 months, monsoon extending over four months the dry season is up to 45 days has been considered here.

Here it has been considered monsoon is of 4 months and the remaining season is the dry season of 245 days. So what is happening drinking water requirement for family for dry season because 5 members of the family were there so

$$= 245 \times 5 \times 10$$

$$= 12,250 \text{ litres as a safety factor,}$$

The tank should be built 20% larger than required, so if we will put the value

$$= (1.2 \times 12250 \text{ litres}) = 14700 \text{ litres.}$$

So, what is happening since the water storage structure is having the capacity to store the 40,800 liters so this tank can meet the basic drinking and cooking water requirement of five-member family for the during the dry period. So, this way we can approach for the design of the any water storage structure thank you very much to all.