Availability and Management of Groundwater Resources
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Lecture-42
Estimation of Total Annual Replenishable Natural Groundwater Recharge (Contd.,)

So, welcome you all in the part 3 of the module 9 that is estimation of total annual replenishable natural groundwater recharge. So, in the last 2 part we have discussed about the different techniques and the different methods through which the recharge can take place in the underlying aquifer. Now we in this part 3 we will discuss about the methods.

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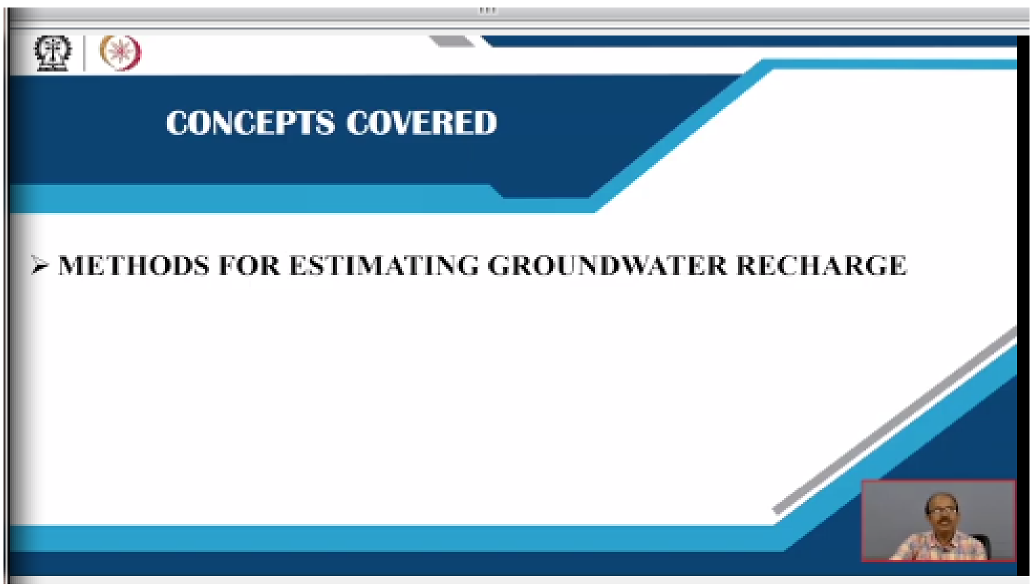

What are the different methods which are just estimating the groundwater recharge in the underlying aquifer? So, different methods will be discussed in this part 3 lecture in a systematic way.

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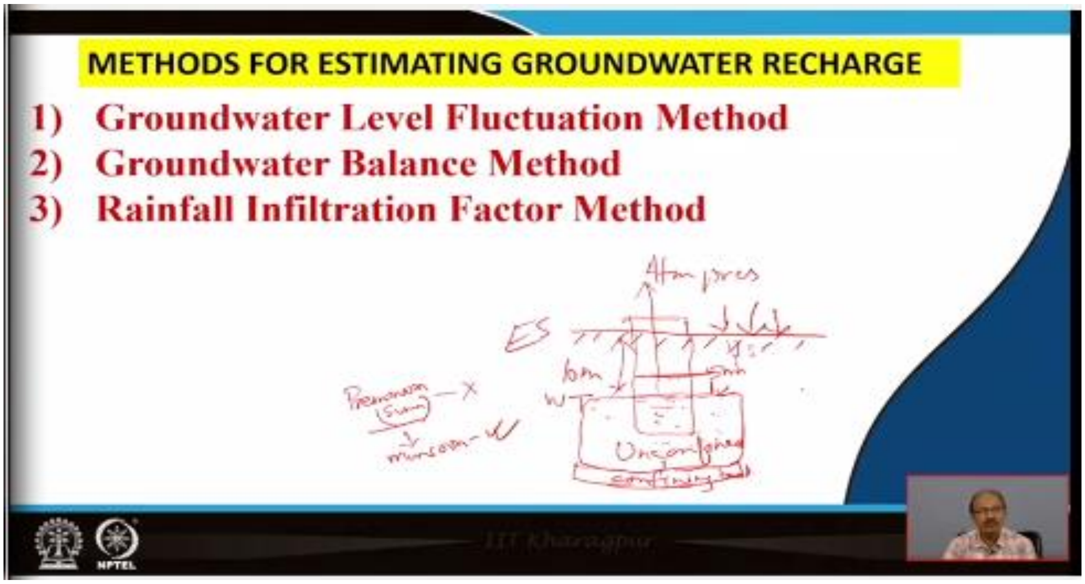

So, generally there are 3 important methods through which the groundwater recharge estimation is being done. So, with the help of these 3 important recharge methods then scientifically also we can able to find out the total groundwater recharge in a specific area. So, first method is the groundwater level fluctuation method, so this is the first method through which we can estimate the groundwater recharge.

Second is the groundwater balance method and third is the rainfall infiltration factor method. If you will see the name of the 3 different methods if these all methods are very well related with the groundwater which is lying in a rocky formation underneath the earth surface that is an aquifer. So, in the first method the method is based on the groundwater level fluctuation, this method is based on the level fluctuation means groundwater level fluctuation.

Just in the case of unconfined aquifer we have seen this is the earth surface and a dug well is here, a dug is here, just a dug well here, so this is the dug well and this is the level of the water which generally we termed as a water table and this dug well is having some top here on the ground surface. So, this is a well and the water remains in with the atmospheric pressure. So, this is the dug well example of dug well and since it is a dug well.

So, this formation is a unconfined aquifer, this is a unconfined aquifer if it is unconfined aquifer definitely this is a confining beds. That is the impermeable beds, confining bed that it is a rock.

So, this rock is just restricting the movement of water which is stored here, it is a rock having a very good porosity and permeability means pores and permeable behaviour. So, this is having water but this water is stored here because a rock is just underlying it which is not able to receive the water from this area, so that is why this is the unconfined aquifer.

So, in this unconfined aquifer this is the water table at a period say X, say it is a period say X and X is nothing but it is the pre-monsoon, that is the summer time. During the summer say it is a depth, depth is about 10 meter but what happened after pre-monsoon that is summer then monsoon game. So, during monsoon lots of rain in there, so what has happened? The lots of rain falls on the earth's surface, so recharging become popular at this time because of the infiltration and percolation and the water is reaching here.

So, during the monsoon year, then what will happen? The same level which were only a 10 meter just it rises to here that is at 5 meter. So, this much fluctuation has taken place from the summer to monsoon that is the 5 meter. That is since after recharging what happened? The water level has moved up because of the recharging of the area, the volume of the water has increased, once it will increase the definitely the layer is going up.

So, the first method is based on the groundwater level fluctuation method. This method, groundwater level fluctuation this is just fluctuation of the groundwater level, so this is the first method. Second method is based on the groundwater balance method, this groundwater balance also we have discussed in the beginning of the lectures that the only recharge source on the earth's surface is your precipitation.

And we have also learned that precipitated water resisting to the earth's surface whereas evaporated water the transpirated water, these all water are again going back to the atmosphere. Surface runoff is definitely your flowing through the topography of the land surface and ultimately it is joining to the riverbeds at some distant places. So, we have also discussed that inflow is equal to outflow; in any area inflow is equal remains outflow.

And this inflow is equal to outflow is nothing but these are the groundwater balance. So, this counter balance method is also very important in the estimation of the groundwater recharge. And third is the rainfall infiltration factor method, so we know that once the rain will fall on the earth surface definitely the infiltration will take place. So, this infiltration will take place and it will vary from place to a place, suppose just the underlying soil cover is dry then what will happen?

The infiltration rate will be higher because the sub soil layer is dry, so definitely the rain water will enter fastly, so the infiltration rate will be more. But once the soil layer will become saturated with water definitely a time will come when the infiltration will stop. So, what has happened? This infiltration is playing very, very important role in the charging also because only the infiltrated and percolated water is reaching to the underlying aquifer.

So, that is why the third method is related with the rainfall once the rain will fall definitely the rain water will infiltrate and once the rain water and infiltration factor will play then this method will be very, very important for estimation of the groundwater recharge in any area.

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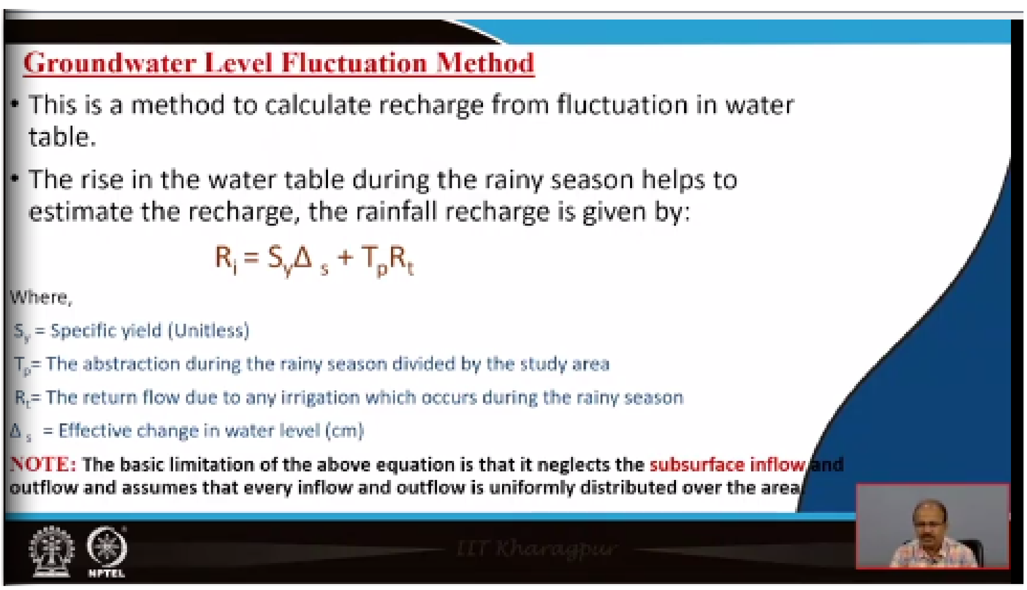

So, now one by one we will discuss. The groundwater level fluctuation method, a method to calculate recharge from fluctuation in water table, the rise in the water table during the rainy season as I have discussed in the previous slides that the water table will rise in rainy season helps to estimate the recharge. That is the rainfall recharge is given by

$$Ri = Sy\ \Delta s + Tp\ Rt,$$

where Sy is the specific yield and we know it is a ratio, so it is a unit less, the

Tp the abstraction during the rainy season divided by the study area.

So, in the study area what are the abstractions? Now Rt the return flow during any irrigation which occurs during the rainy season, so this is the Rt the return flow. Because after irrigation also some of the water is just returning and it is recharging the area. So, this return flow is can be also counted. Now delta s is the effective change in water level, so what is the change in water level? So, point is the basic limitation of the above equation is that it neglects the subsurface inflow and outflow and assumes that every inflow and outflow is informally distributed over the area.

So, this is the general consideration or limitation with this method, groundwater level method where Ri is the return flow due to any irrigation, Sy is the specific yield, delta s is the effective change in water level, Tp is the abstraction during the rainy season divided by your study area and Rt is the return flow due to any irrigation. So, in this way the rainfall recharge can be estimated.

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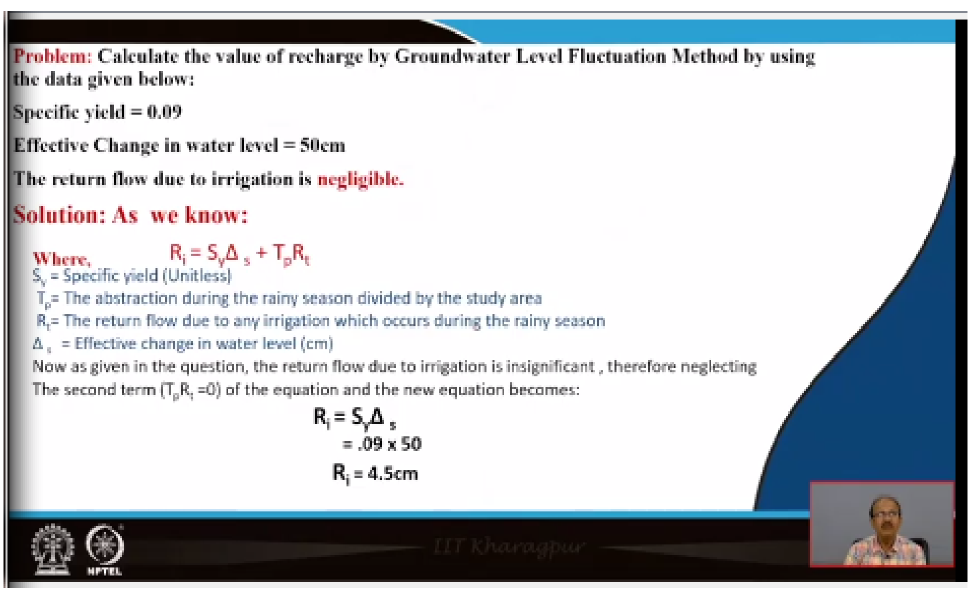

So, now just based on this one numerical is there calculate the value of recharge by groundwater level fluctuation method by using the data given below. specific yield = 0.09, effective change in water level = 50 cm and the return flow due to irrigation is negligible. So, now as per the equation what we have seen in the previous slide

$$Ri = Sy\ \Delta s + Tp\ Rt.$$

Where Sy is the specific yield, Tp is that abstraction during the rainy season divided by the study area, Ri the return flow due to the any irrigation which occurs during the rainy season and Δs the effective change in water level. So, now as given in the question the return flow due to irrigation is insignificant therefore neglecting the second term Tp * R t = 0 because return flow is 0 then total will become 0 of the equation.

Then the new equation becomes Ri = Sy * Δs and Sy

$$Ri = 0.09*50 = 4.5 \text{ cm},$$

so this is the value of recharge by groundwater level fluctuation method.

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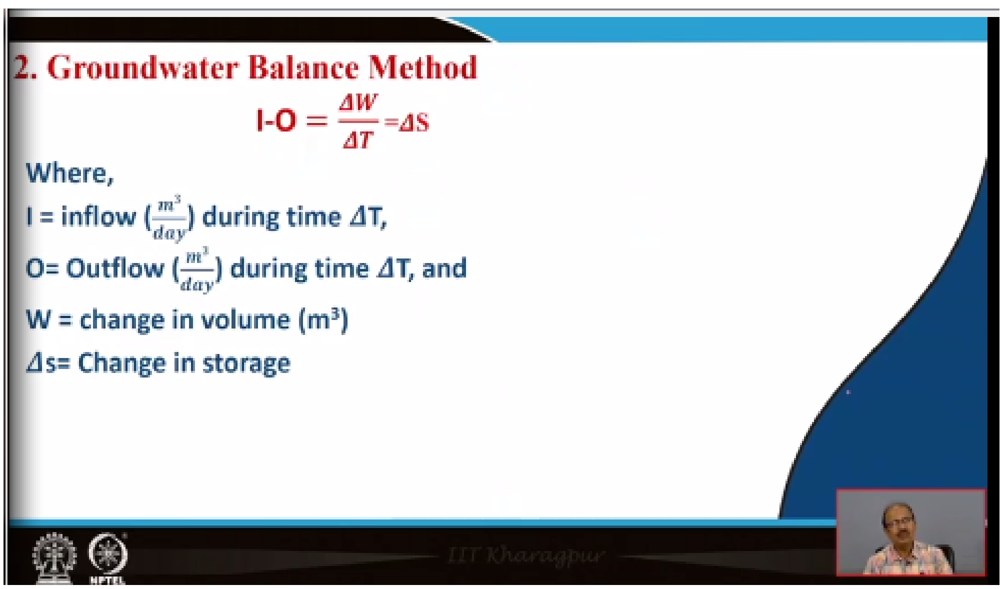

Now next is the groundwater balance method, in which we have discussed that the inflow is remains equal to the outflow. So, what is happening in this case? In the groundwater balance method

$I\text{-}O = \frac{\Delta W}{\Delta T}$

Where,

I = inflow $(\frac{m^3}{day})$ during time ΔT,

O= Outflow $(\frac{m^3}{day})$ during time ΔT, and

W = change in volume (m^3)

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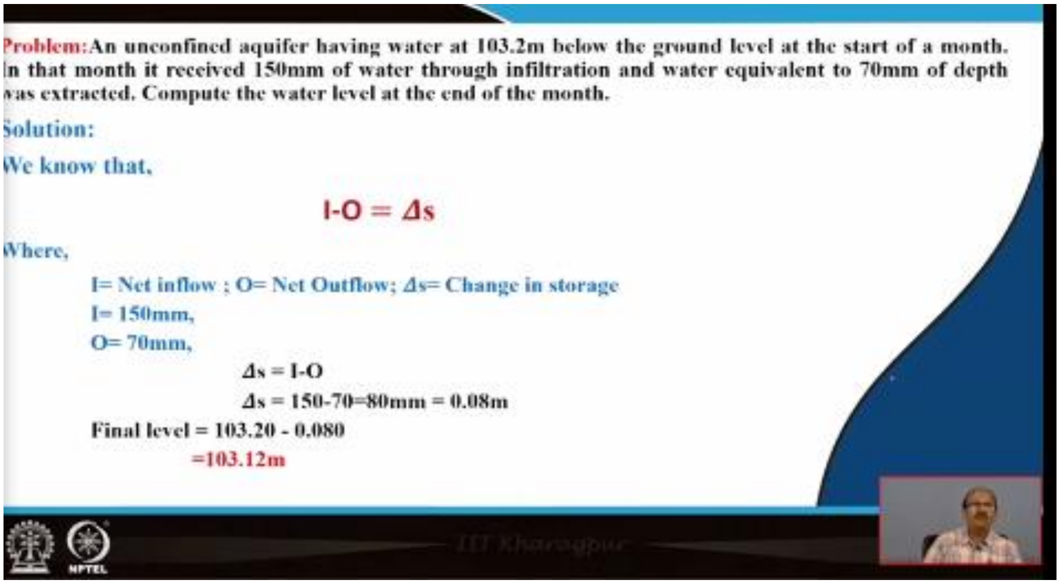

So, based on this equation also we can solve a numerical. An unconfined aquifer having water at 103.2m below the ground level at the start of a month. In that month it received 150mm of water through infiltration and water equivalent to 70mm of depth was extracted. Compute the water level at the end of the month.

Solution:

We know that,

$$I-O = \Delta s$$

Where,

I= Net inflow ; O= Net Outflow; Δs= Change in storage

I= 150mm,

O= 70mm,

$$\Delta s = I-O$$

$$\Delta s = 150-70=80mm = 0.08m$$

Final level = 103.20 - 0.080

=103.12m

so the final level will be 103.12. So, this is the water level at the end of the month. So, this type of water level is at the end of the month it is coming to 103.12 meter. So, this is another type of the problem with the help of groundwater balance method also we can compute the total recharge of any area.

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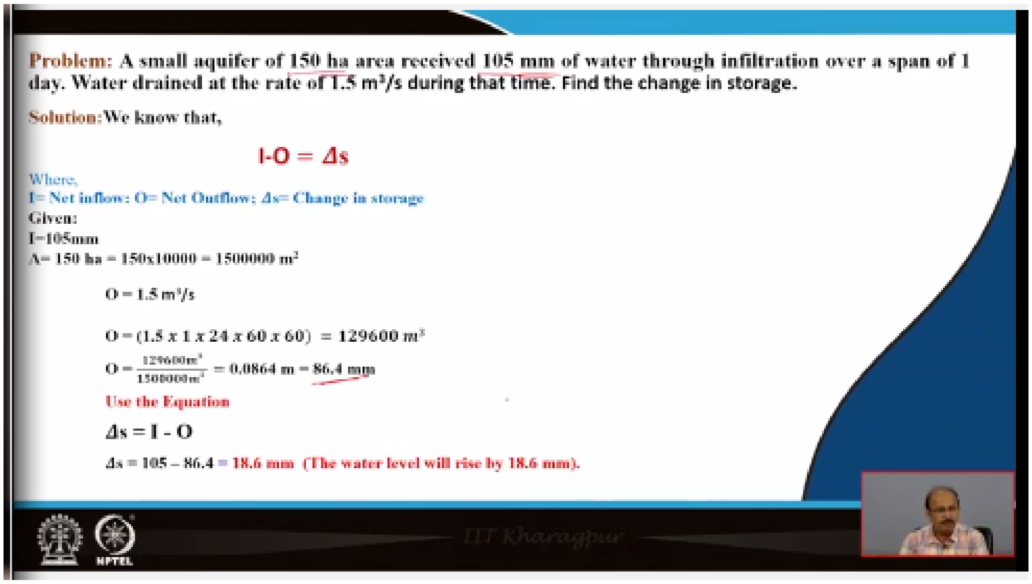

Now one more problem with this A small aquifer of 150 ha area received 105 mm of water through infiltration over a span of 1 day. Water drained at the rate of 1.5 m^3/s during that time. Find the change in storage.

Solution:

We know that,

$$I\text{-}O = \Delta s$$

Where,

I= Net inflow: O= Net Outflow; Δs= Change in storage

Given:

I=105mm

A= 150 ha = 150x10000 = 1500000 m^2

$O = 1.5\ m^3/s$

$O = (1.5\ x\ 1\ x\ 24\ x\ 60\ x\ 60)\ = 129600\ m3$

$O = \frac{129600 m3}{1500000 m2} = 0.0864$ m = 86.4 mm

Use the Equation

$\Delta s = I - O$

$\Delta s = 105 – 86.4 = 18.6$ mm (The water level will rise by 18.6 mm).

So, the water level will rise by 18.6 mm, this water level will raise here, how much amount? The change in storage is the 18.6 mm.

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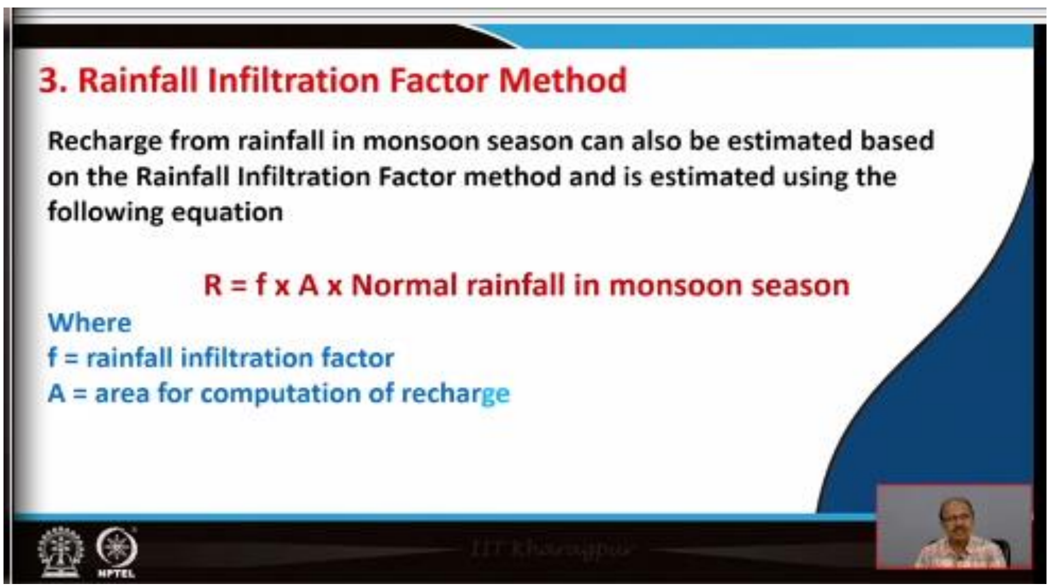

Now the third method is the rainfall infiltration factor method, this is the third method. So, recharge from rainfall in monsoon season can also be estimated based on the rainfall infiltration factor method and is estimated using the following equation also.

R = f x A x Normal rainfall in monsoon season

Where

f = rainfall infiltration factor

A = area for computation of recharge

So, this is there. Now this f is the rainfall infiltration factor and A is the area for computation of recharge.

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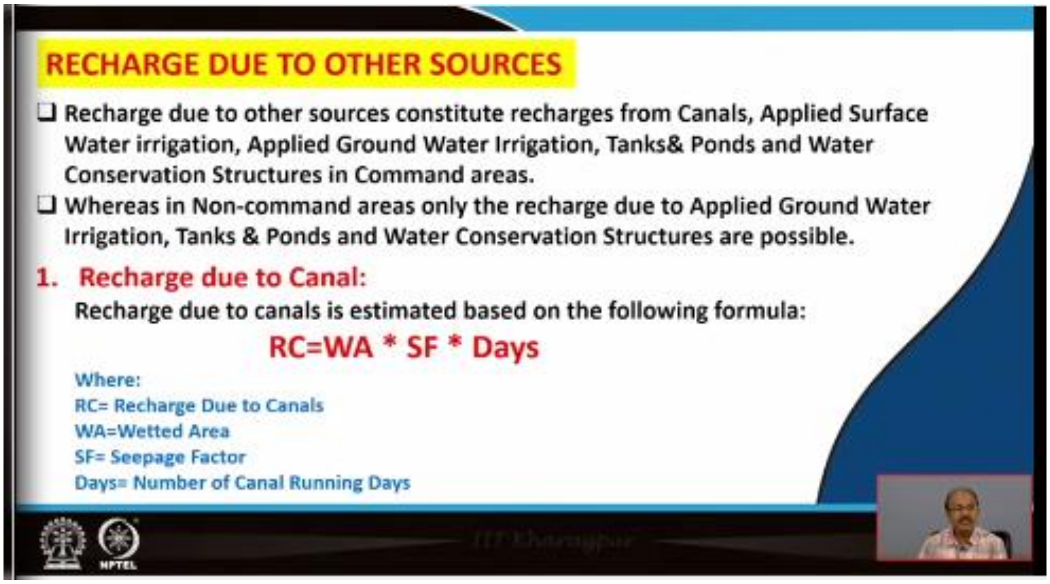

Now these are the methods through which the recharge can take place in the underlying aquifer. Now due to other sources also the recharge is taking place in the underlying aquifer. The recharge due to the other sources constitute recharges from canals, applied surface water irrigation, applied groundwater irrigation tanks and ponds and water conservation structure in command areas.

Whereas in non-command areas only the; recharge due to applied groundwater irrigation tanks and ponds and water conservation structures are possible. So, recharge due to canal, we can see that the recharge due to canal is estimated based on the following formula

$$RC=WA * SF * Days$$

Where:

RC= Recharge Due to Canals

WA=Wetted Area

SF= Seepage Factor

Days= Number of Canal Running Days

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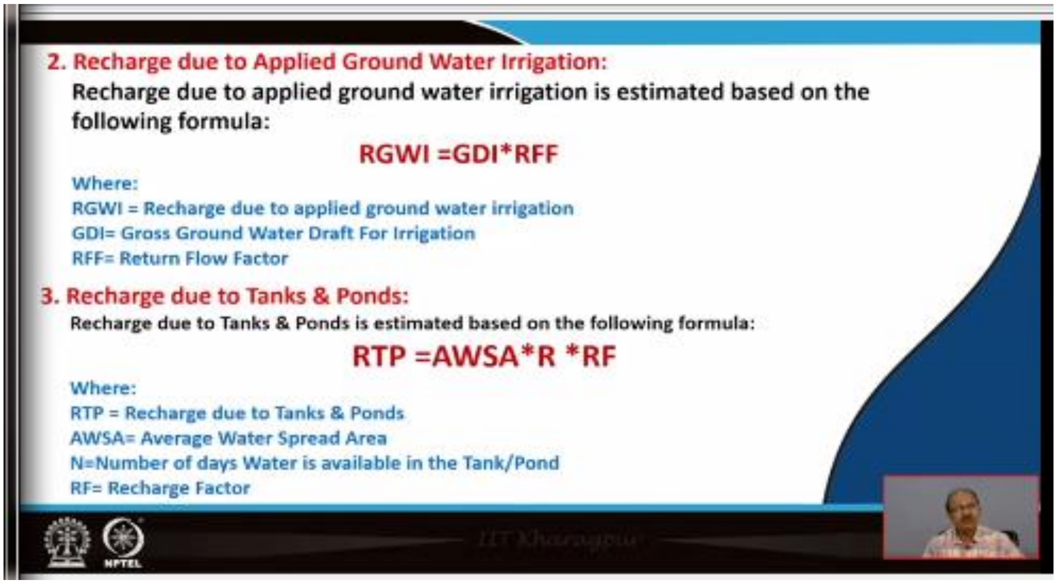

Now recharge due to the applied groundwater irrigation. This recharge is also taking place with the groundwater irrigation and which is estimated on the basis of the following formula

RGWI = GDI * RFF,

Where:

RGWI = Recharge due to applied ground water irrigation

GDI= Gross Ground Water Draft For Irrigation

RFF= Return Flow Factor

So, by multiplying GDI and RFF we can get the recharge due to apply groundwater irrigation. Now recharge due to the tanks and ponds, so recharge due to tanks and pond is estimated based on the following formula, the formula is

RTP = AWSA* R * RF.

So, this is the RTP that is the recharge due to tanks and ponds, just multiply it with the average water spread areas,

N = number of days water level in the winter and in the tank and pond and

RF is the recharge factor, this is the recharge factor.

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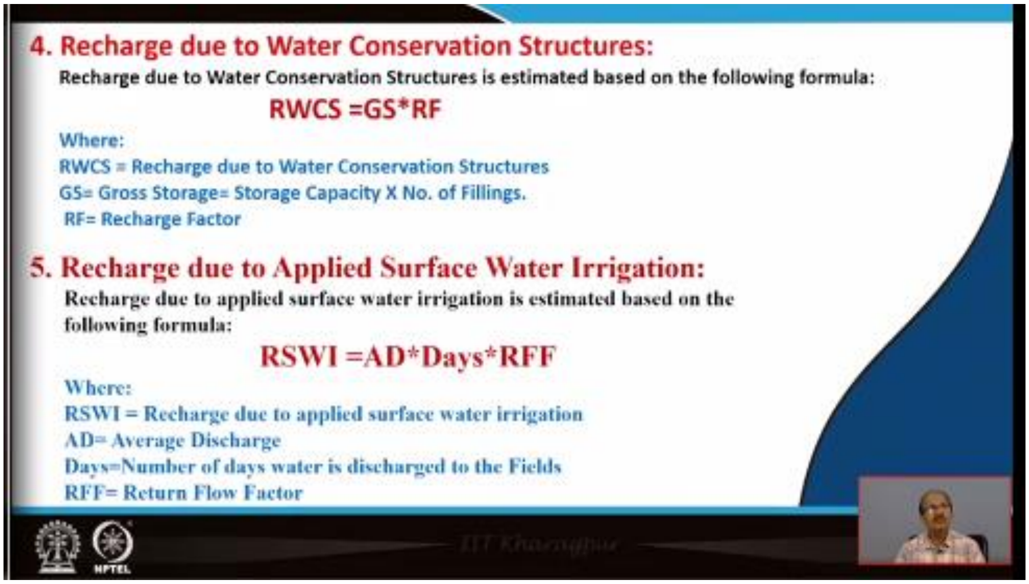

So, now just seeing some more techniques through which the recharge can take place. Recharge due to water conservation structures, so recharge is also taking place with the help of the water conservation structure on the basis of the following formula we can estimate also.

RWCS =GS*RF

Where:

RWCS = Recharge due to Water Conservation Structures

GS= Gross Storage= Storage Capacity X No. of Fillings.

RF= Recharge Factor

So, through this method also we can find out the recharge of any area. Now recharge due to applied surface water irrigation, it is also very important method. Through this method also the recharge can be found out, the recharge due to applied surface water irrigation is estimated by the formula

RSWI =AD*Days*RFF

So,

Where:

RSWI = Recharge due to applied surface water irrigation

AD= Average Discharge

Days=Number of days water is discharged to the Fields RFF= Return Flow Factor

So, what we have seen that few of the recharge techniques which these are very, very important for finding out the recharge of any area. And this recharge is very, very dependent on the underlying soil characteristics. The porosity porous behaviour of the rock or the soil layer and the permeability and the permeable behaviour of the rock on the underlying layer. So, with all such type of different methods the recharges are possible in any areas which are having a good porous and porosity, with this thank you very much to all.