Availability and Management of Groundwater Resources
Prof. Prasoon Kumar Singh
Department of Civil Engineering
Indian Institute of Technology-Dhanbad

Lecture-44
Estimation of Total Annual Replenishable Natural Groundwater Recharge (Contd.)

Welcome you all in the part 5 of the module 9 that is estimation of total annual replenishable natural groundwater recharge. So far we have discussed the different areas hilly areas, command area, non-command areas as per the groundwater assessment unit and the different categories. That is the safe category, then the critical category, then the semi-critical category then the over exploited category.

So, through these categories generally the areas are being categorized and on the basis of these categories only your withdrawal from the area is just quantified whether the withdrawal is okay or not from the area. If not then what are the necessary conservation measures? So, for this we have already discussed in the last 4 different parts of the lecture.

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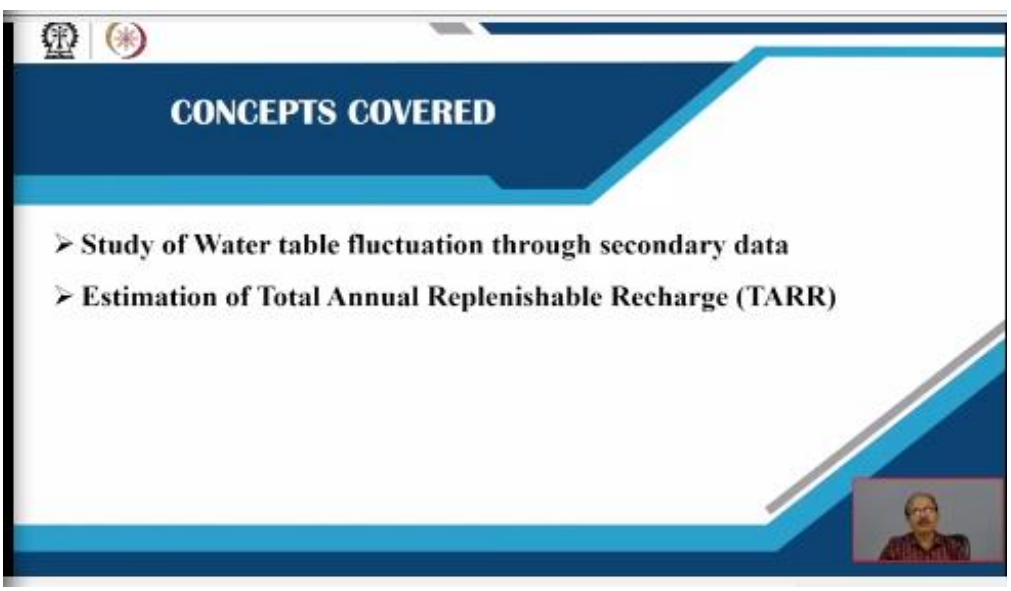

Now I will try to just discuss on the points of the water table fluctuations and the estimation of total annual replenishable recharge with some numerical.

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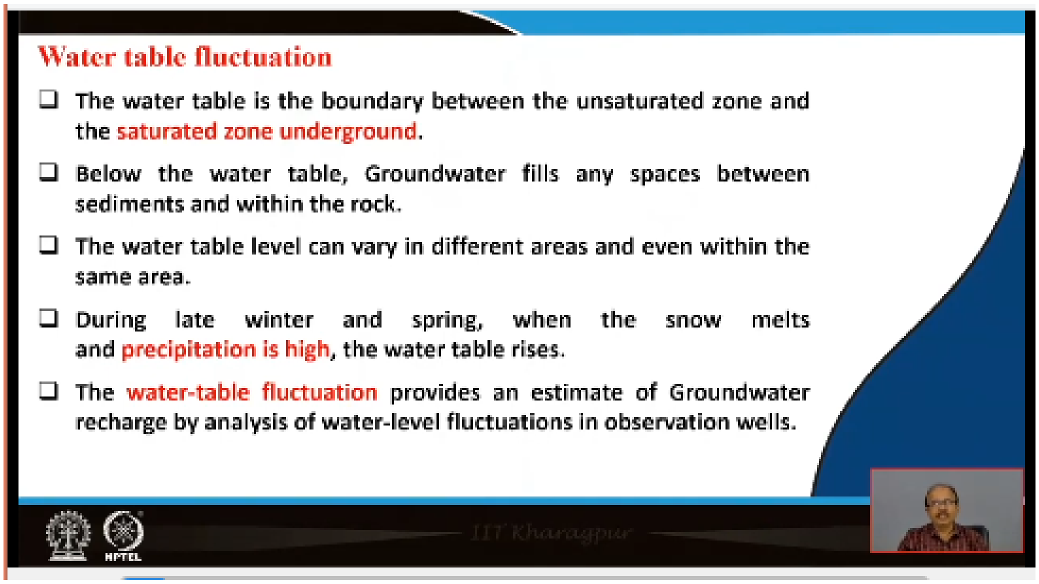

So, in this lecture I will start from the water table fluctuation; we have come across about the different facts also. That generally the water table remains at the depth during the pre-monsoon season, it just extends up that is near it is coming towards the ground surface in the monsoon season and then after the post-monsoon season against it fluctuates as per the movement of the groundwater inside the earth surface.

So, the water table is the boundary between the unsaturated zone what we have discussed during the earlier lectures are weather zone and the saturated zone that is the aquifer, that is the rock formations which is holding the water. So, this water table is just it is boundary, it is the upper part of the unconfined aquifer. Now below the water table generally groundwater fills any spaces between the sediments and within the rock.

So, water table level can vary in different areas and even within the same area also it varies. So, during late winter that is the post-monsoon and spring when the monsoon snow melts and precipitation is high the water table generally rises. So, the water table fluctuation provides an estimate of groundwater recharge by analysis of water level fluctuations in observation wells. So, when the precipitation remains high and the snow melts the water table rises in the wells.

And this fluctuation provides an estimation of the groundwater recharge by analysis of water level fluctuation in the observation wells.

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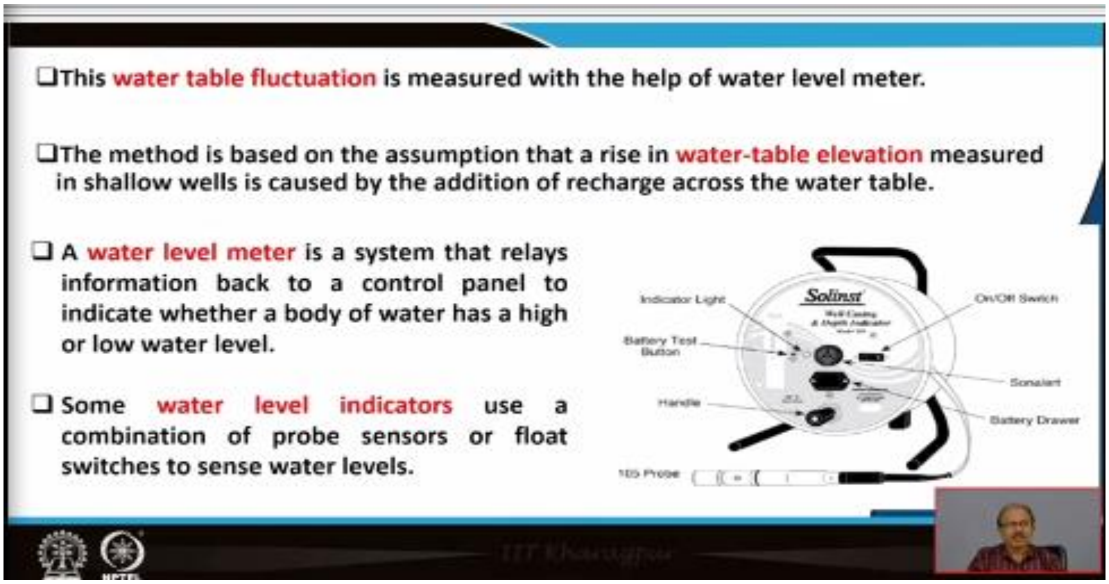

So, generally this water table fluctuation is measured with the help of one instrument which is called as water level meter. And the method is based on the assumption that a rise in water table elevation measured in shallow wells is caused by the addition of recharge across the water table. So, the recharge will take place and the water level meter is just a system you can see in the figure also just a system that relays information back to a control panel to indicate whether a body of water has a high or low water level.

So, these water level indicators use a combination of probe sensors or float switches to sense the water level because it will reach to the well inside and then as soon as it will touch the water level and some sort of sound will come out or some indication will be there with the probe sensors. So, in this way generally with the help of the water level meter the water level of the different wells are being recognized.

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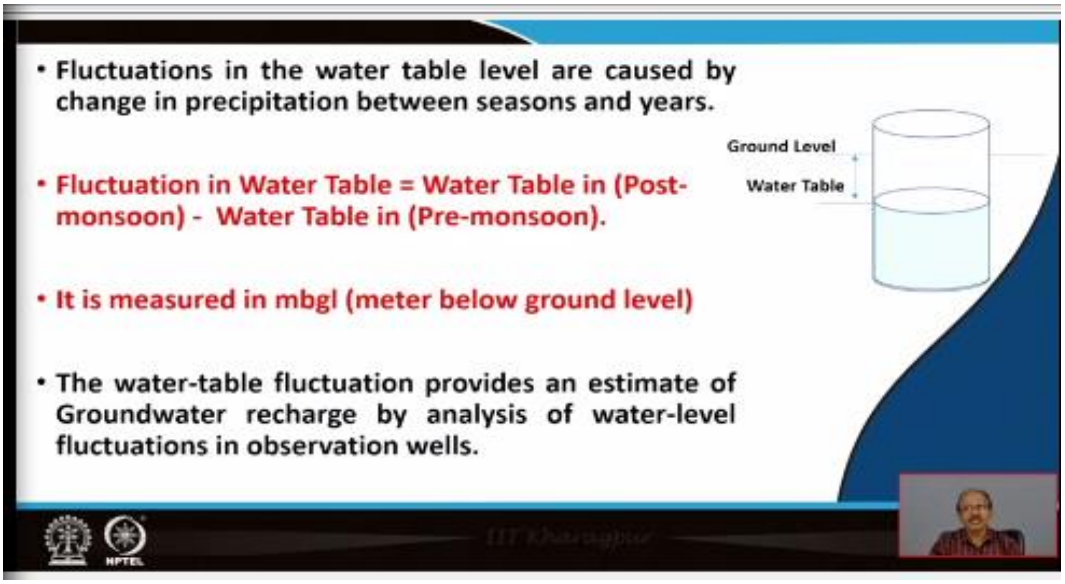

Now the fluctuation in water table are caused by the change in precipitation with between the seasons and years, so then only we are getting the fluctuations and fluctuations in water table generally means water table in post-monsoon and minus water table in pre-monsoon. If you will just post-monsoon water table subtract the water table of the pre-monsoon then it will give you the fluctuation which is generally measured in mbgl, mbgl means meter below ground level.

So, this water table fluctuation is very, very important which we have to conduct first for finding out the TARR value of any area. So, water double fluctuation provides an estimate of groundwater recharge by analysis of water level fluctuation in observed wells. So, if we will measure the water table first, first we have to measure the water table of the entire wells which you have chosen for finding out the total annual replenishment recharge just within the 2 different season.

One season will be your post-monsoon season, other season will be your pre-monsoon season. So, then you just take out the fluctuations in water table and this fluctuation in water table is generally indicating about that the type of recharge in the area also which area? Suppose any area is having a high water total fluctuation, means in this area the recharge is not so good but if the fluctuation is low then it means the recharge is good for that area.

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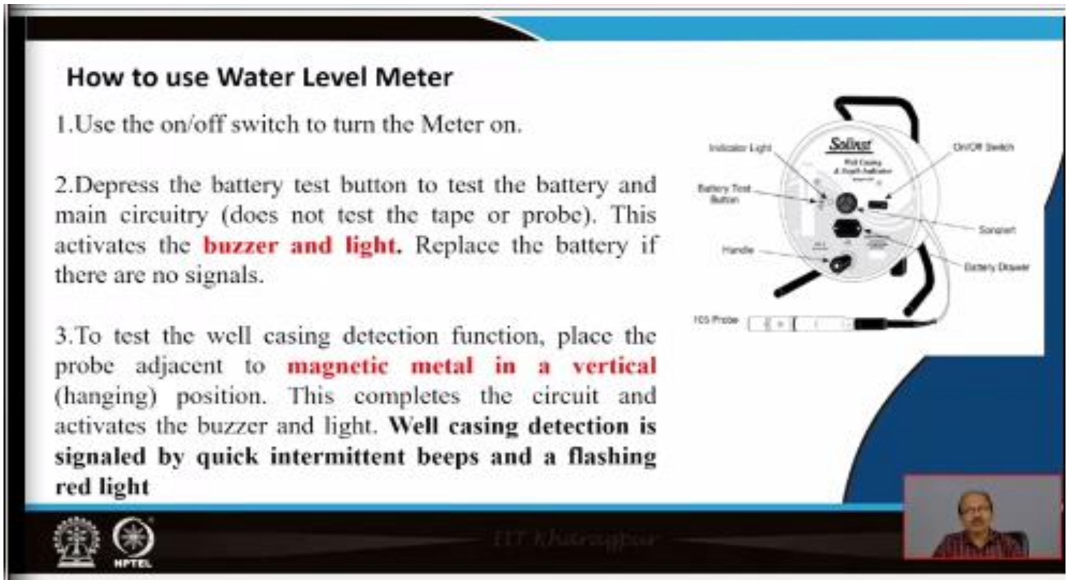

Now how to use any this water level meter because it is important first and foremost stocks is to find out the water table fluctuation. So, use the on/off switch to turn the meter and then the battery test button to test the battery and main circuitry. And generally this activates the buzzer and light, both will come from water level meter. If there are no signal just buzzer and light is not coming then you please just replace it.

And to test the well casing detection function places the probe adjacent to the magnetic metal in a vertical position because the probe will go down into the well. So, just you put it in the hanging vertical position, this completes the circle and activates the buzzer and light. So, well casing detection is signaled by a quick intermittent beep and a flashing red light. So, in this way this water level meter works.

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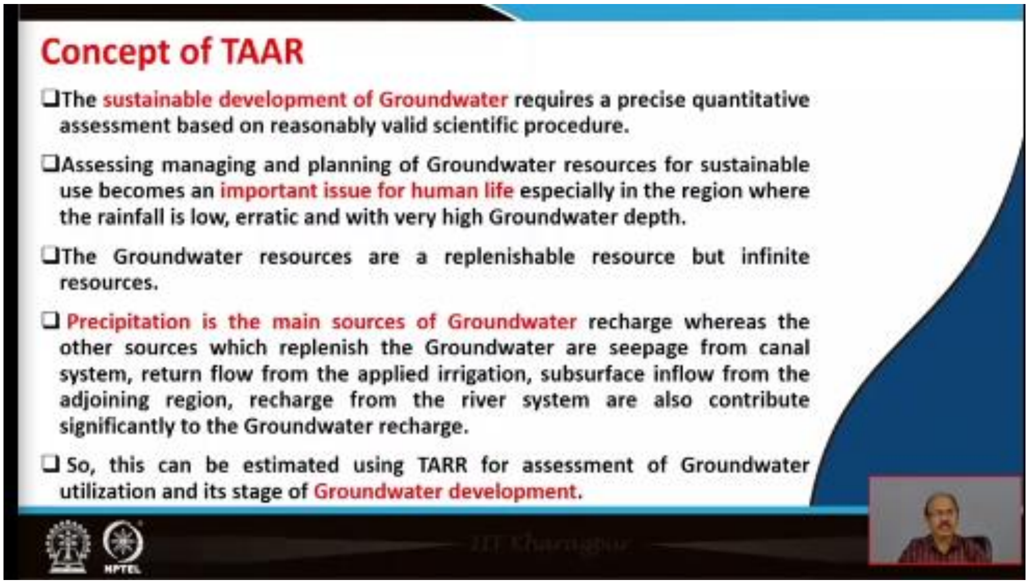

Now we have already now understood about the finding out the water table fluctuation in any area, just subtract the water table of the pre-monsoon from the water table of post-monsoon then you will get the fluctuation. Now the sustainable development of groundwater requires some assessments which are based reasonably on the valid scientific procedure. Assessing and managing and planning of groundwater resources for sustainable use it becomes an important issue for human life.

And especially in the region where the rainfall is low, where the rainfall is low erratic and with very high groundwater depth, so this area it is very important to assess the groundwater resources in a very systematic and valid very scientific ways. Because rainfall is low means what? If the rainfall will remain low definitely the recharge will be less, so you have to take precaution in the area where you are going to assess the water table ability in any region.

So, the groundwater resources are a replenishable resource, no doubt, but infinite in nature also. And the precipitation is the main sources of groundwater recharge we came through the different lectures also. Whereas the other sources which replenish the groundwater are seepage from canal system, return flow from the applied irrigation, irrigated water also again going down. Subsurface inflow from the adjoining region then recharge from the reverse system are also these are contributing significantly to the groundwater recharge of any locations.

So, it can be estimated by using TARR for assessment of ground utilization and for finding out the groundwork development of any area. So, for this generally we are just finding the grounded development, we are just computing the TARR total annual replenishable recharge by different methods.

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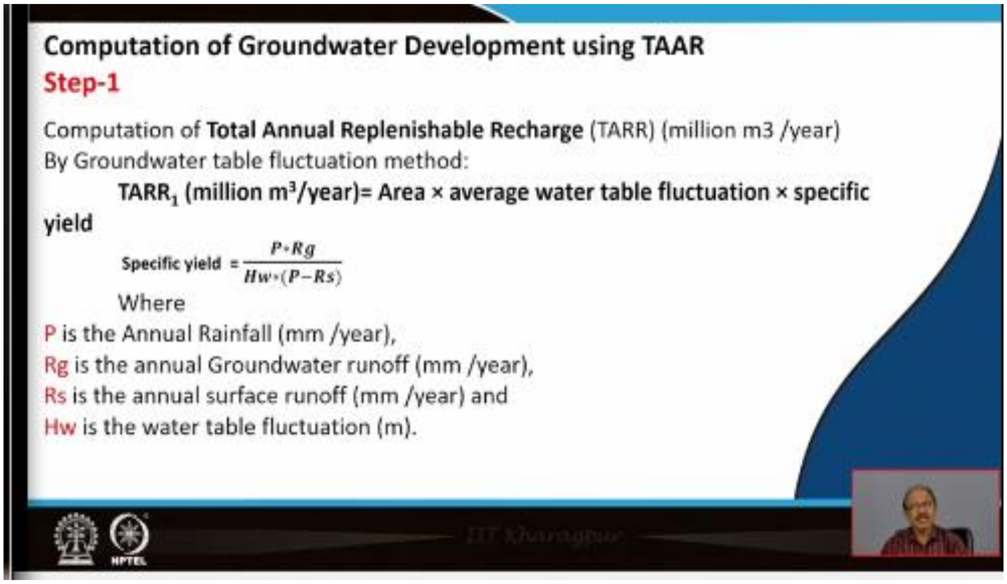

Now what are the different steps of computation of TARR? The step 1 is the computation of total annual replenishable recharge; this is a TARR in million cubic meter per year. By groundwater table fluctuation method we have read in the different parts of the in this lecture that the 3 important methods are water table fluctuation method, rainfall infiltration factor method and the water balance method for finding out the total annual replenishable recharge of any area.

So, this is by the method of a groundwater fluctuation method, you can see

$TARR_1$ (million m^3/year) = Area × average water table fluctuation × specific yield

So, we have already known about how to find out the water table fluctuation, so area is mentioned and the specific yield we know

$$\text{Specific yield} = \frac{P*Rg}{Hw*(P-Rs)}$$

Where,

P is the Annual Rainfall (mm /year),

Rg is the annual Groundwater runoff (mm /year),

Rs is the annual surface runoff (mm /year) and

Hw is the water table fluctuation (m).

So, by this method we can find out the specific yield, now water tool fluctuation data is with us and area we are also knowing. So, if we will put all the 3 data here we can get the TARR in million cubic meter per year by the groundwater table fluctuation method. Here water tool fluctuation is mentioned, so it is the method of groundwater table fluctuation method.

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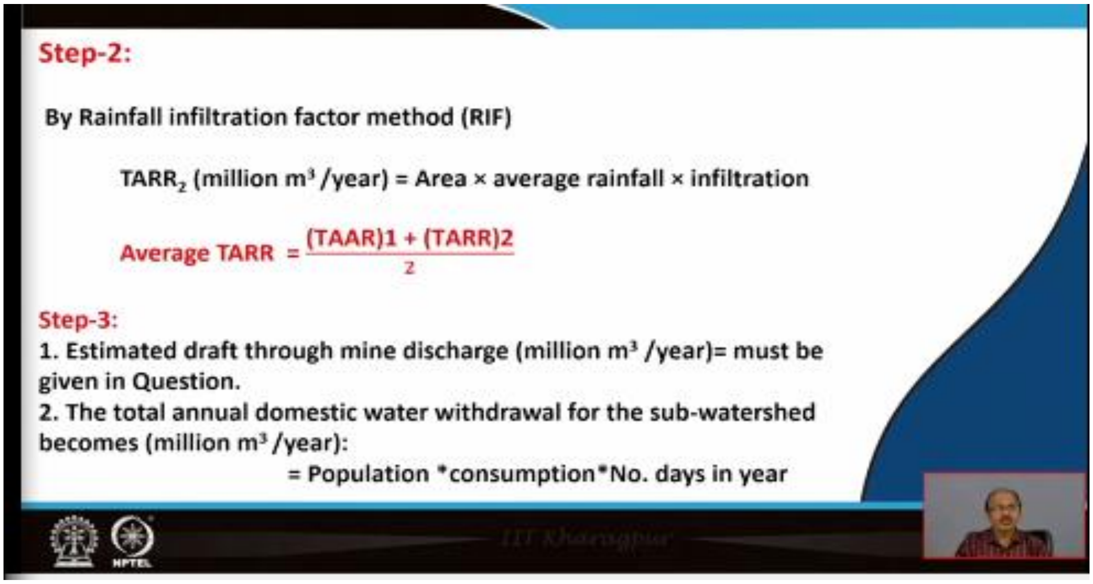

Now step 2 is by the rainfall infiltration factor method. So, here the area will remain same average rainfall will be here and the infiltration will be here. So, in this way also by putting the data we can find out TARR by the rainfall infiltration factor method. Now just average both the TARR by water table fluctuation and by the rainfall infiltration factor method and by dividing by 2 we are getting the average TARR of any.

$$\text{Average TARR} = \frac{(\text{TAAR})1 + (\text{TARR})2}{2}$$

So, now step 3 is the estimation of the draft, that is draft through the mine discharge of industrial discharge in million cubic meter per year and generally it is mentioned in the your industrial discharge fact sheet also or mine discharge fact sheet also, so it will be in question? And the total annual domestic water withdrawal for the sub-watershed becomes (million m^3 /year):

= Population *consumption*No. days in year

So, number of days in year this can be computed and, in this way, generally we are finding out the total discharge from those that area, population we are knowing, consumption we can put and the number of days in year is also mentioned.

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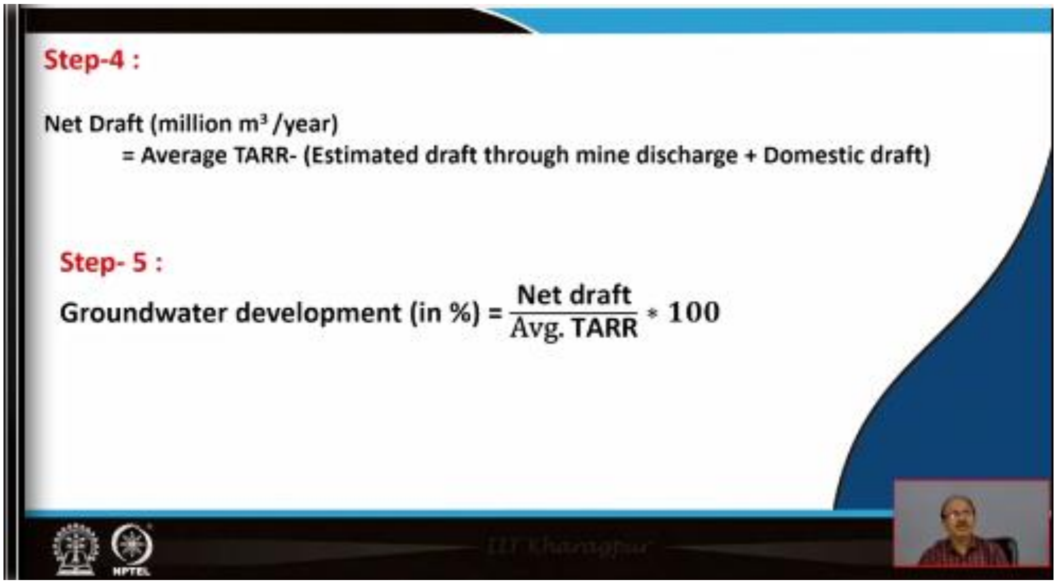

Now step 4 is finding out the net draft. So,

Net Draft (million m^3 /year)

= Average TARR- (Estimated draft through mine discharge + Domestic draft). And the last step is

Groundwater development (in %) = $\frac{\text{Net draft}}{\text{Avg. TARR}} * 100$

So, in this way we are generally finding out the groundwater development in any area.

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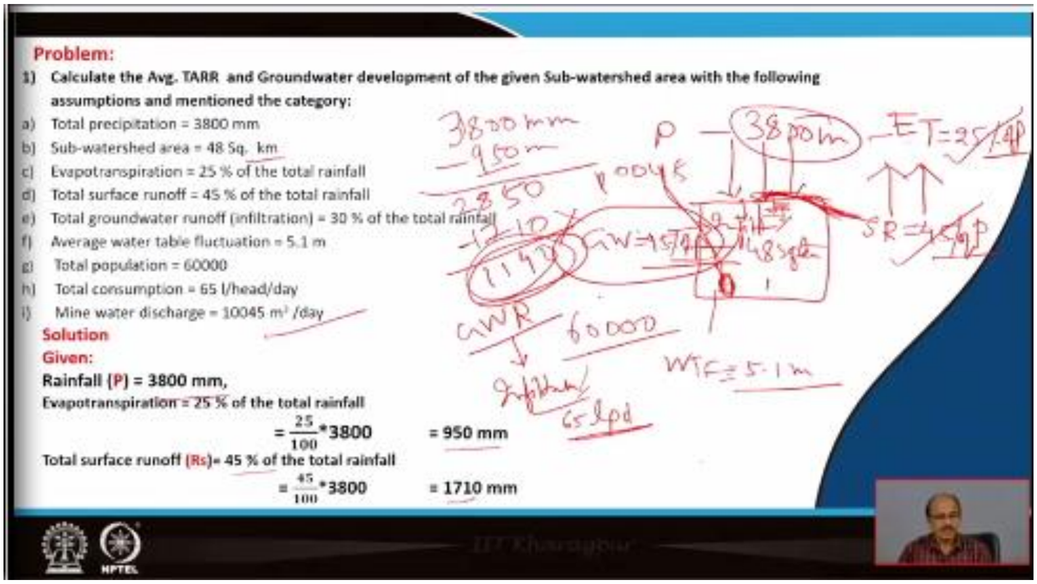

So, now we will discuss 1 problem related to the category which we have defined earlier safe, critical, semi critical and over exploited category.

1) Calculate the Avg. TARR of the given Sub-watershed area with the following assumption:
   a) Total precipitation = 3800 mm
   b) Sub-watershed area = 48 Sq. km
   c) Evapotranspiration = 25 % of the total rainfall
   d) Total surface runoff = 45 % of the total rainfall
   e) Total groundwater runoff (infiltration) = 30 % of the total rainfall
   f) Average water table fluctuation = 5.1 m
   g) Total population = 60000
   h) Total consumption = 65 l/day/head
   i) Mini water discharge = 10045 m^3 /day

Solution

Given:

Rainfall (P) = 3850 mm,

Evapotranspiration = 25 % of the total rainfall

$$= \frac{25}{100}*3800 \qquad = 950 \text{ mm}$$

Total surface runoff (Rs)= 45 % of the total rainfall

$= \frac{45}{100}*3800 \quad = 1710$ mm

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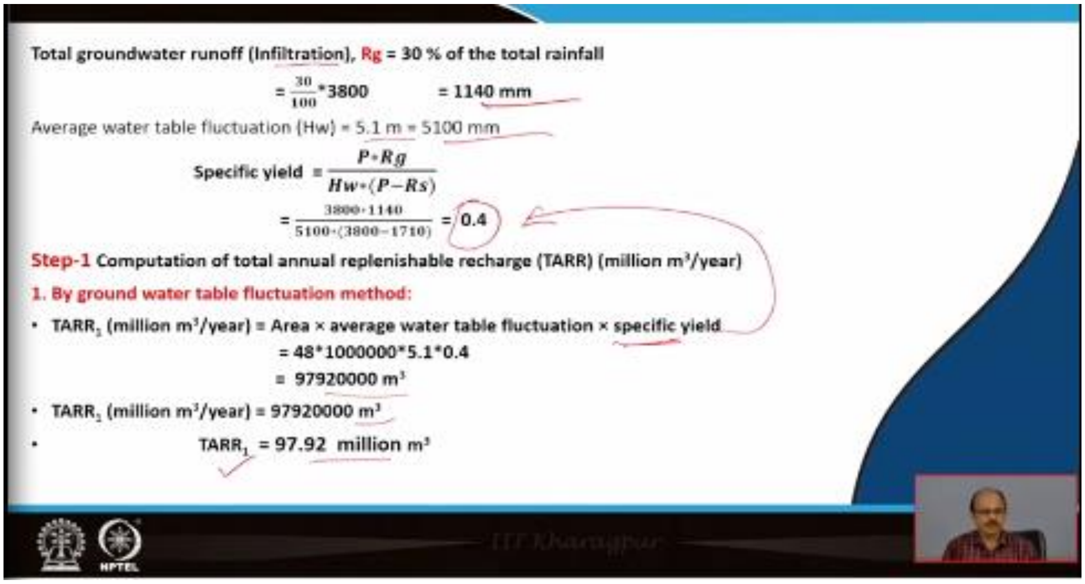

Total groundwater runoff (infiltration), Rg = 30 % of the total rainfall

$= \frac{30}{100}*3800 \quad = 1140$ mm

Average water table fluctuation (Hw) = 5.1 m = 5100 mm

Specific yield $= \frac{P*Rg}{Hw*(P-Rs)}$

$= \frac{3800*1140}{5100*(3800-1710)} = 0.4$

Step-1 Computation of total annual replenishable recharge (TARR) (million m^3/year)

1. By ground water table fluctuation method:

$TARR_1$ (million m^3/year) = Area × average water table fluctuation × specific yield

= 48*1000000*5.1*0.4

= 97920000 m^3

$TARR_1$ (million m^3/year) = 97920000 m^3

$TARR_1$ = 97.92 million m^3

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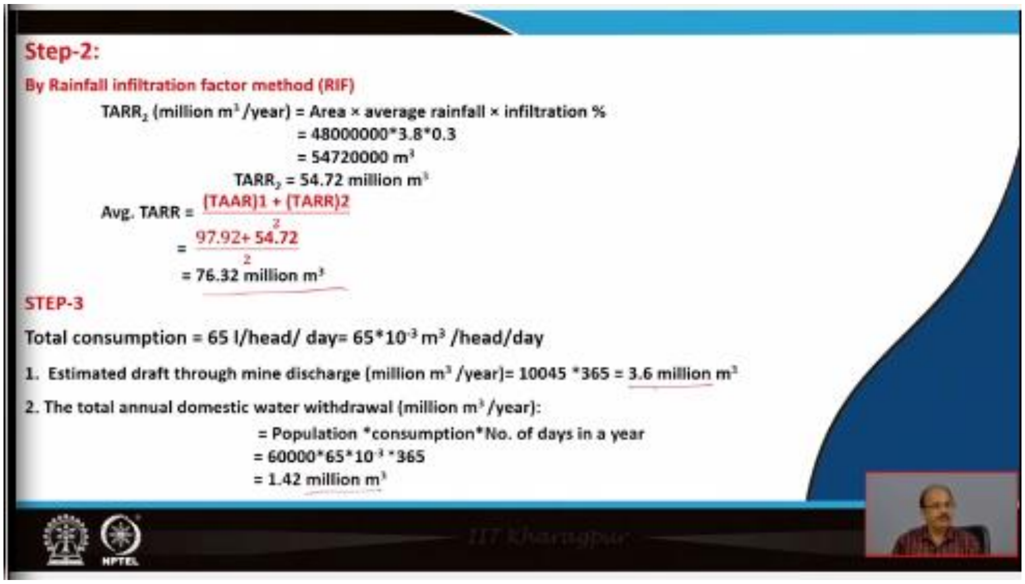

Step-2:

By Rainfall infiltration factor method (RIF)

$TARR_2$ (million m^3 /year) = Area × average rainfall × infiltration %

= 48000000*3.8*0.3

= 54720000

$TARR_2$ = 54.72 million m^3

Avg. TARR = $\frac{(TAAR)1 + (TARR)2}{2}$

= $\frac{97.92+ 54.72}{2}$

= 76.32 million m^3

STEP-3

Total consumption = 65 l/day/head = $65*10^{-3}$ m^3 /day/head

1. Estimated draft through mine discharge (million m^3 /year)= 10045 *365 = 3.6 million m^3

2. The total annual domestic water withdrawal (million m^3 /year):

= Population *consumption*No. days in year

= $60000*65*10^{-3}*365$

$$= 1.42 \text{ million } m^3$$

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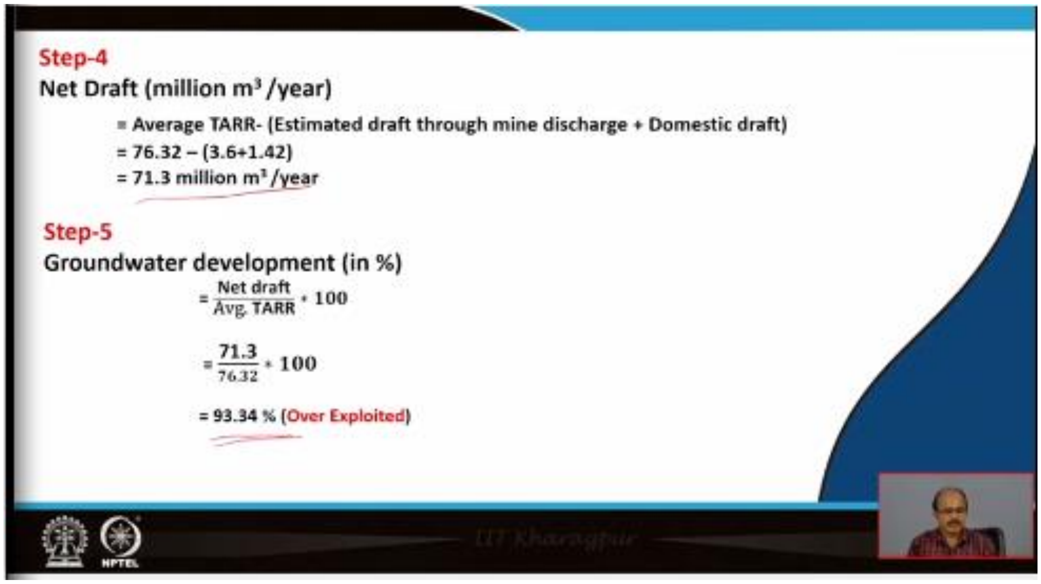

Step-4

Net Draft (million m^3 /year)

= Average TARR- (Estimated draft through mine discharge + Domestic draft)

$= 76.32 – (3.6+1.42)$

$= 71.3$ million m^3 /year

Step-5

Groundwater development (in %)

$$= \frac{\text{Net draft}}{\text{Avg. TARR}} * 100$$

$$= \frac{71.3}{76.32} * 100$$

$$= 93.34 \%$$

That is why in this way we can able to at least find out the estimate of the area with respect to the safe, critical, semi-critical and over exploited.

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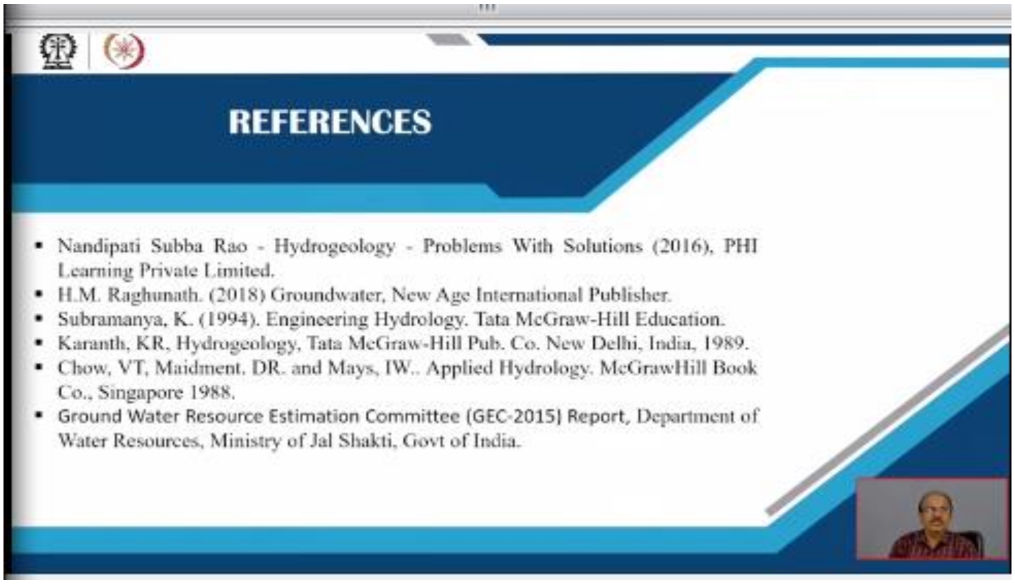

Now these we have mentioned some of the references also I have mentioned, you please go through it. And the references just I am mentioning here which I have taken use and you also go through it, these references are very useful for your further enhancement of the knowledge.

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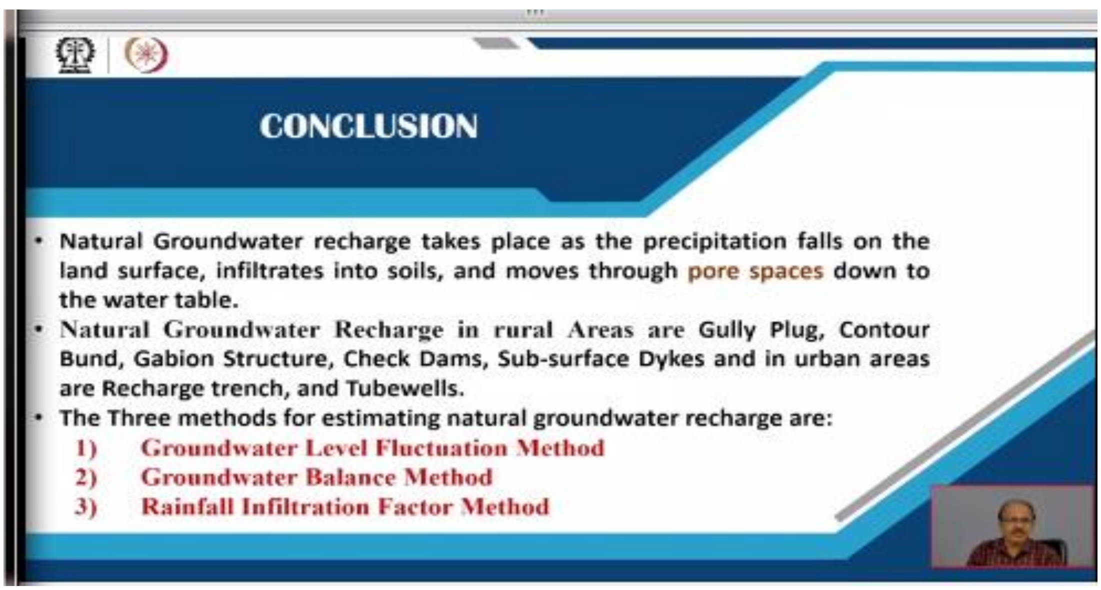

And the conclusion of this module 9 is the natural groundwater recharge takes place as the precipitation falls on the land surface, infiltrates into the soils and moves through pore spaces down to the water table. So, just we are knowing with the different lectures it has become clear. Now natural groundwater recharge in rural areas are generally by the methods of gully plugging, then contour bundling, then Gabion structure, check dams, subsurface dykes.

And in urban areas generally recharge trench and tube wells, recharging these are the few of the methods. Important 3 methods for estimation of natural groundwater recharge are the groundwater level fluctuation method, groundwater balance method and groundwater infiltration factor method. So, these are the 3 important methods through which we can just estimate the natural groundwater recharge of any area.

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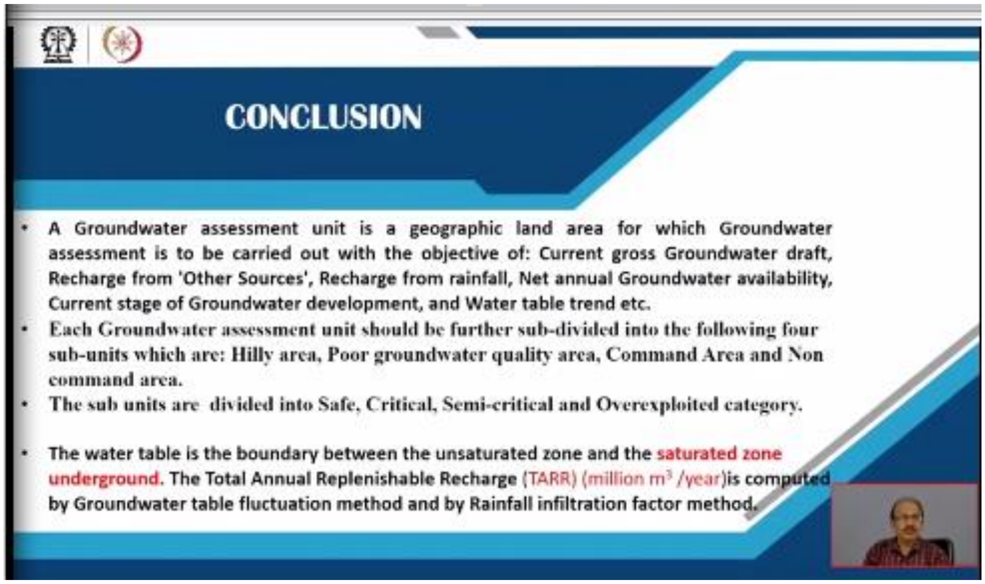

A groundwater assessment unit is a very important unit, it is a geographical land area for which the groundwater assessment is to be carried out with the objectives of what are the current gross groundwater draft, recharge from the other sources, recharge from rainfall, net annual groundwater ability, current stage of groundwater development and water table trend. So, in this way we can just assess the groundwater assessment of any geographical land area.

Each groundwater assessment unit is further divided into some units, 4 subunits say hilly area, poor groundwater quality area, command area and non-command area. And then the subunits are divided into safe, critical, semi-critical and over exploited category. So, these are some of the briefs of the just the conclusion part of these lectures. The water table is nothing but it is the boundary between the unsaturated zone and the saturated zone remaining inside the surface.

The total annual replenishable recharge TARR generally calculated in million cubic meter per year is computed by groundwater table fluctuation method as well as by the rainfall infiltration factor method. So, these all thing we have discussed in greater detail about the finding of the groundwater sources inside the area. Now we will learn some more chapter in the coming parts, thank you very much to all.