Availability and Management of Groundwater Resources

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Lecture-40
Estimation of Total Annual Replenishable Natural Groundwater Recharge

Welcome you all in the part 1 lecture of the module 9 estimation of total annual replenishable natural groundwater recharge. So, from the starting of the lectures in the course ability and management of groundwater resources our objective was to know about the groundwater ability at any place on the surface of the earth and its proper management. So, just we will recap the previous lectures that we have started from the hydrological cycle.

Then thereafter we have seen that some of the formations which are very much good for different type of aquifer that is confined and unconfined aquifer. These formations are generally holding the groundwater resources within the earth's surface. Thereafter we have just discussed about the characteristics of these aquifers that is the porosity, permeability behaviour which are very, very important component for storage of the water as well as its movement underneath the earth's surface from one aquifer to another aquifer.

Now after this we have discussed the types of aquifer based on the confining beds, the two different types of aquifer we have discussed and thereafter we have discussed about the types of the wells, the infiltration, the different types of your recharge behaviour of the aquifer formations and from the very beginning we have become aware that only the charge force on surface of the earth is the precipitation.

So, we have discussed in detail about the precipitation, how the rainfall can be measured through rain gauge and the different places are having the different types of index of wetness which we have discussed in detail and thereafter we have discussed about the infiltration behaviour of the earth's surface, infiltrometer test we have seen, how we can find out that how much amount of water can be recharged at any place.

So, now after discussion of so much systematic step by step event of the groundwater because now groundwater we have seen that through the several chapters the groundwater has reached to the aquifer and from one aquifer to another aquifer it is having the characteristics in form of

transmissivity and storativity. That it is just moving from aquifer to aquifer means it is having some sort of loss of movement also, in the terms of groundwater we have followed the Darcy's law. So, now after so much of discussion about the ability of the groundwater resources now we have just reach to the estimation of replenishable natural groundwater recharge annually.

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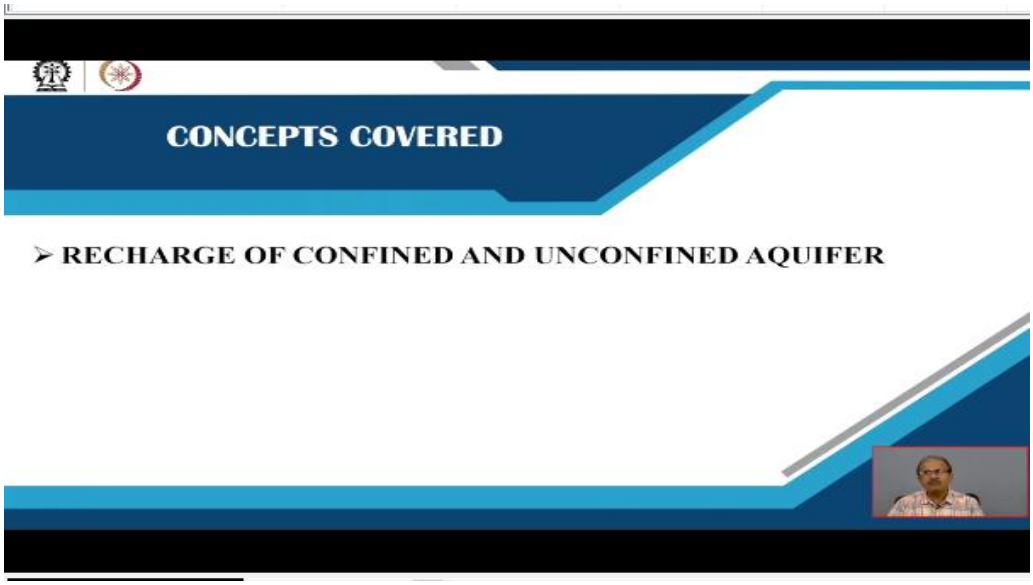

So, in this generally we will discuss the recharge of the confined and unconfined aquifer, because generally in the nature, in the earth's surface we are having the two different types of aquifer. These two at different types of aquifers are supplying groundwater resources to the earth's surface from the different technique, different mechanism. So, we will discuss in a systematic way about the recharge behaviour of the confined and unconfined aquifer.

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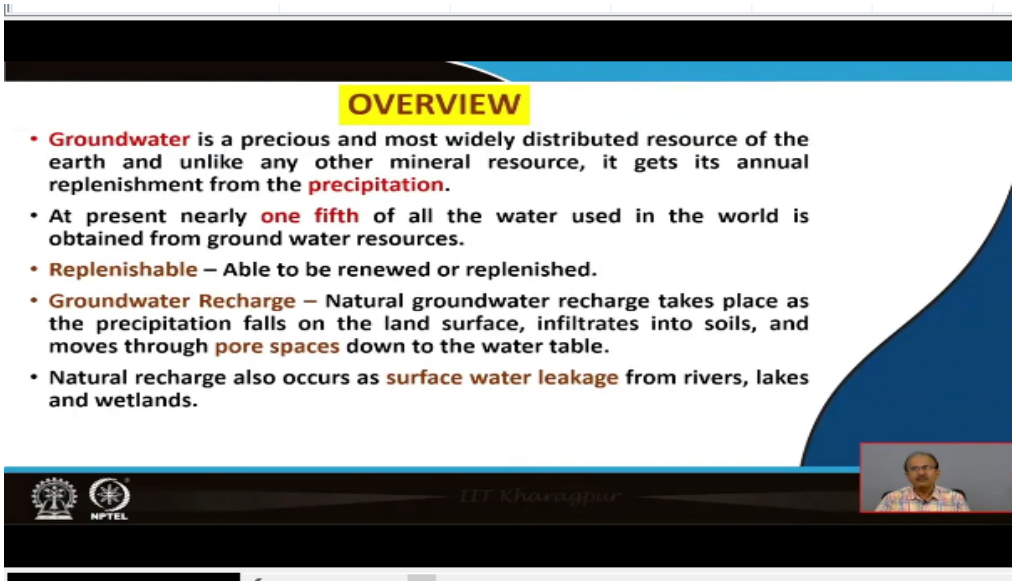

But prior to it we just we will see that groundwater is a precious and most widely distributed resource of the earth's surface; it gets annual replenishment from the precipitation. So, this precious resource is replenishing only from the source that is the precipitation. Presently nearly one fifth of all the water used in the world is obtained from groundwater resources. Replenishable term means able to be renewed or replenished.

Groundwater recharge means natural groundwater recharge which is taking place as the precipitation falls on the land surface then infiltrates into the soil and then moves through the pore spaces down to the water table. So, natural recharge occurs as surface water leakage from river, lakes and wetlands also. So, what we have seen?

We have seen that in case of the aquifer because just aquifer is lying just underneath the earth's surface. So, here the aquifer is lying, several aquifers are lying underneath the earth surface at different, different places. So, once the precipitated water will fall on the earth's surface, this is the earth surface. So, this will first infiltrate down if you will recall the previous lectures.

This will first infiltrate down, so this infiltration take place then percolates down through the soil layers, different soil layers are here inside the because these are the unsaturated media that is the weather zone if you recall the name weather zone is here unsaturated which meets this zone extends till the water table reach. So, this is the first aquifer, this is the second depth wise aquifer. This is the third depth wise aquifer.

So, first depth wise aquifer is this one, so this is the water table. So, here the precipitated water infiltrates into the soil then percolates through the soil and reaches to the aquifer. That is the rocky formation which is holding the water and this is the upper layer of the those rock aquifer. So, in this way generally the aquifers are being recharged inside the earth's surface.

This is very, very important. These are having the pore spaces, so through it, it remains stored there as well as from here from one pore to another pore through the ability of movement that is the permeable behaviour they transmit also from one aquifer to another aquifer inside. So, this type generally the replenishment of the groundwater resource takes place with the precipitation only.

Yes natural recharge of course is also taking place in terms of surface water leakage that is surface water sources we are knowing in these are the rivers, lakes and wetlands. So, from there also through some the same mechanism infiltration through leakage it is reaching to the underlying aquifer. That is the rocky formations.

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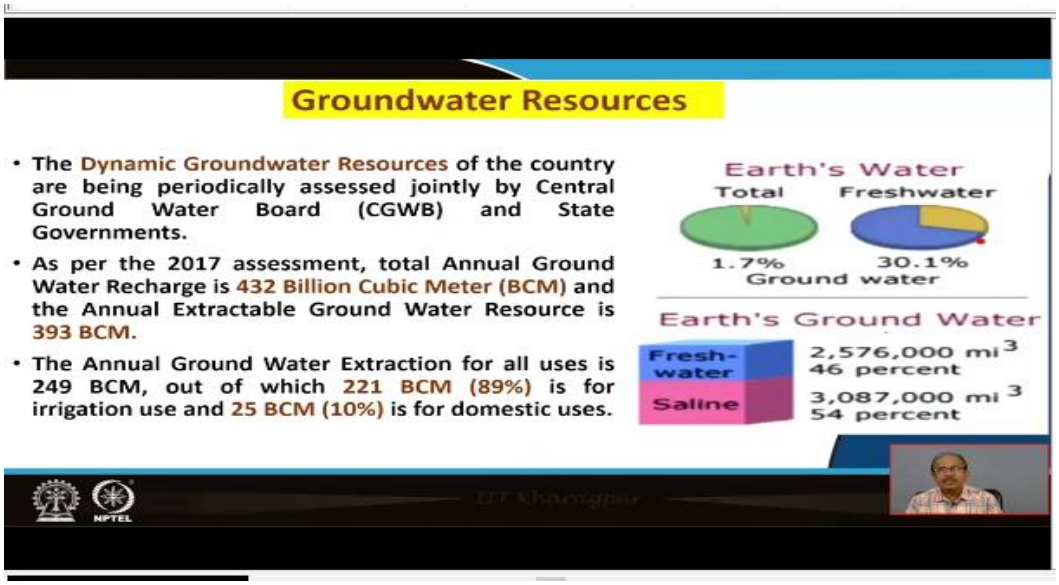

So, actually this dynamic this is not a static resource, this is a dynamic resource groundwater resource, dynamic resource and these are periodically assessed by one of the regulatory authority that is the central groundwater board and state groundwater board also in our country India. As per the 2017 assessment, the total annual groundwater recharge is 432 billion cubic meter.

And the annual extractable groundwater resource is 393 BCM billion cubic meter. So, here you can see that the recharge of the groundwater at further 2017 assessment by the CGWB central groundwater board. Now the name has changed just the ministry of Jal Shakti, it is coming under the ministry of Jal Shakti, ministry of water resources. So, this central groundwater board is giving the statistics of the details about the recharge volume as well as the extractable groundwater resource volume.

So, it is coming to 432 billion cubic meter in terms of annual groundwater recharge, whereas annual extractable groundwater resource is 393 BCM. So, we can see that the annual groundwater extraction for all uses is 249 BCM out of this to 21 BCM million cubic meter 89% is for irrigational purposes and remaining 25% that is the 25 BCM that is the 10% is for domestic uses and rest 1% is for other activities.

So, this figures clearly shows that the amount of groundwater resources are very, very less in terms of its recharge value, because extraction is too much for different uses and the resource recharge is completely dependent on your precipitation during the monsoonal season.

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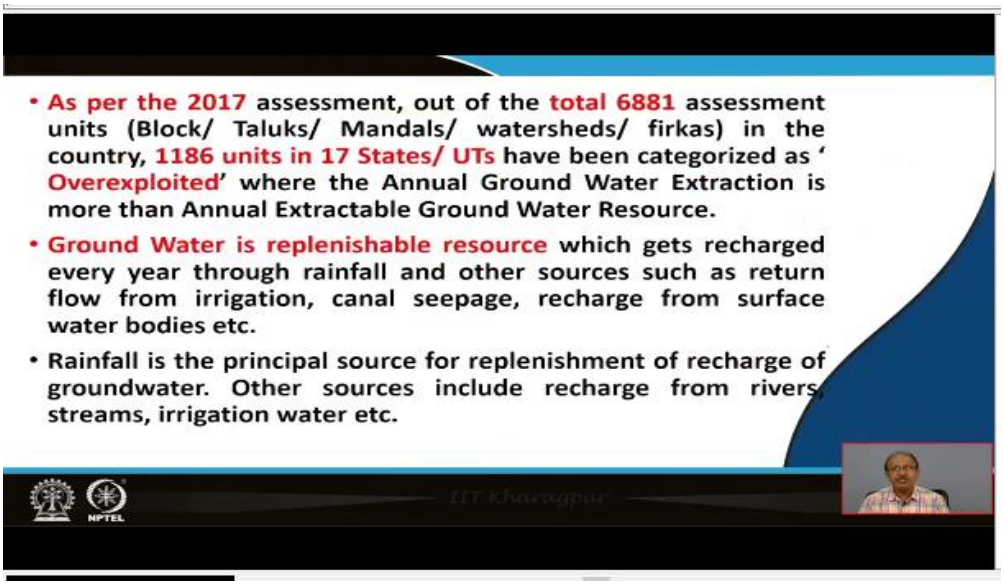

So, as per this 2017 assessment it is clear that total 6881 assessment units, assessment unit may remains in blocks, taluks, mandals, watersheds, firkas in the country 1186 units in 17 states in an Union territories have been categorized as overexploited. So, this is a very dangerous term. Over exploited means the exploitation is too much with respect to the recharge in the specific area.

So, you can see out of 6881 assessment units, 1186 units I have been categorized as overexploited where the annual groundwater extraction is more than the annual extractable groundwater resource. So, this is a very important figure in terms of the groundwater level deterioration throughout the earth's surface. Groundwater is replenishable resource; no doubt it is a replenishable resource which gets recharged every year through rainfall.

And other sources such as return flow from irrigation, canal seepage then recharge from surface water bodies etcetera. Therefore, rainfall is the principal source for replenishment of recharge of groundwater. Other sources also are there that is the recharge from river, streams, irrigation water etcetera. The point is that the groundwater can only be replenished by the rainfall which is generally occurring in our monsoonal season.

Few rainfalls also take place in our country during the winter season also. So, post monsoonal season also we are having some amount of rainfall, but the rainfall is the only factor which is recharging the underlying aquifer. So, this is very, very important if the rainfall will be good, we can find out with that in terms of index of wetness also, whether it is a good year, good year means rainfall is above than the average rainfall.

Bad year means rainfall is below the average annual rainfall and normal year is the it is equal to, so if it is rainfall is above the average annual rainfall definitely the recharge in that very specific year will be more in the underlying aquifers. So, the groundwater resource will remain in plenty at that duration.

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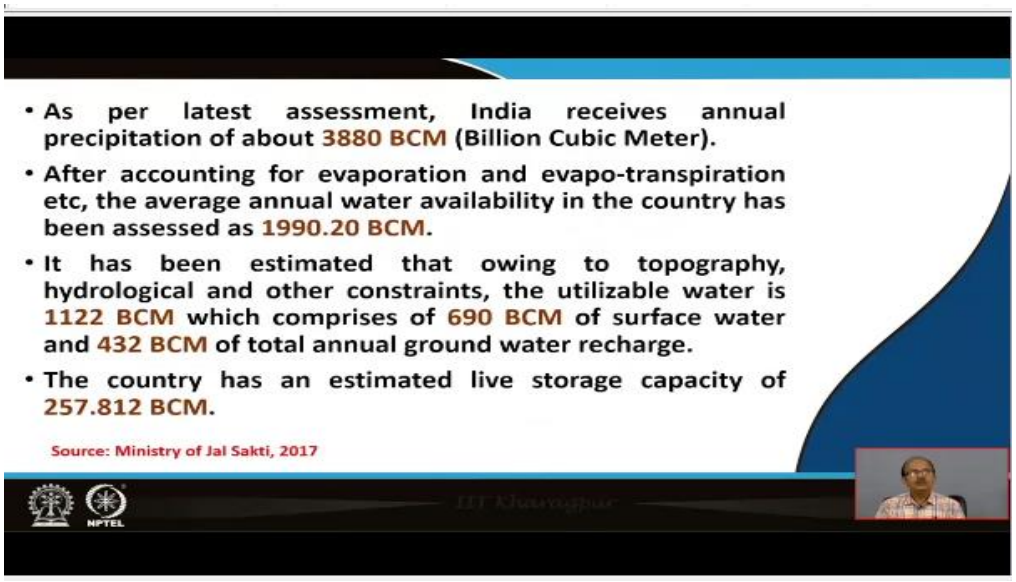

So, as per the latest assessment India receives annual precipitation of about 3880 BCM billion cubic meter in our country. After accounting for evaporation and evapotranspiration I told you these two are the different components of the water losses from the earth's surface. Evaporation generally takes place from the open surface of the surface water sources that is the rivers, that the lakes, that is the ponds.

And evapotranspiration and transpiration are the activity which takes place through the stomatal opening of the leaf surfaces of the plants. So, these two activities generally the water losses take place, water moves against to the atmosphere and the average annual water availability in the country is assessed and that is 1990.20 BCM as per the report of the ministry of Jal Sakthi.

It has been estimated that going to topography, hydrological and other constraints, the utilizable water is 1122 BCM which comprises of 690 BCM of surface water and 432 BCM of total annual groundwater recharge. So, actually you can see here the 432 BCM is available groundwater resource which is generally used as a utilizable water resource. The country has an estimated life storage capacity of the water resource is about 257.812 BCM billion cubic meter. So, this is all about our statistics of the water resources in our Indian scenario.

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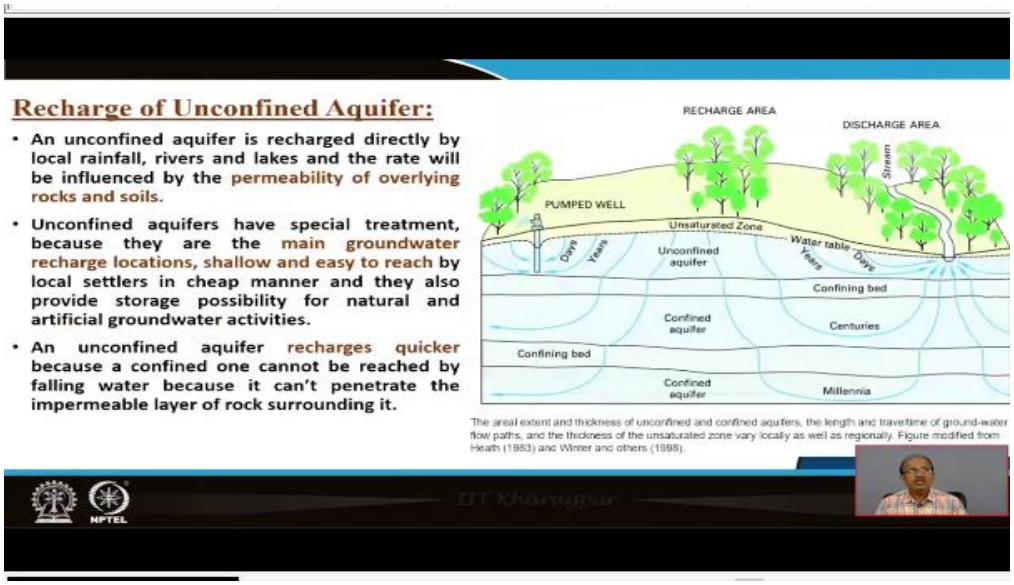

Now recharge of unconfined aquifer; we have discussed the two different types of aquifer, while discussing the types of aquifer we have discussed that an aquifer which is having on an unconfined bed under lane not at the top only at the bottom. Then such type of aquifer is termed as unconfined aquifer because top portion will remain open with the atmosphere and the upper layer of the water in this very rocky formation.

And when a confining bed is just lying underneath it is called as water table. So, this is the recharge of unconfined aquifer generally it is charged directly by local rainfall, then the rivers, then the lakes and the rate will be influenced by the permeability of overlying rocks and soils.

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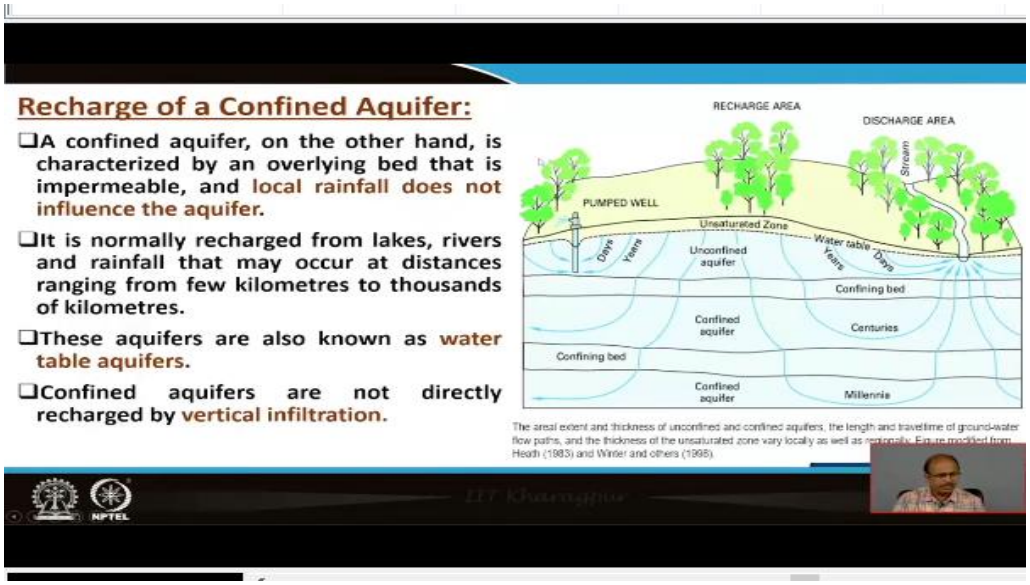

So, it is very important to understand that and unconfined aquifer. Generally, an unconfined aquifer remains open, the water table remains open with your this is the unconfined aquifer underlying this is the confining beds. Confining beds means impermeable beds which are not allowing water to move downward. So, these are not allowed lying. So, this is the confining beds the top portion even open with the atmosphere.

This is remain open. So, here in case of this type of aquifer, when this type of aquifer will be there then the recharging will take place either by the falling of the rainfall, direct rainfall will fall on the surface, then it will infiltrate, then it will percolate and then the water will move downward and it will just recharge the rocky formation through which generally the water is being extracted also.

So, it is just replenishing this type of aquifer. Now second mode is from the surface water sources through the leakage, through the seepage of the water from the bedrocks of the rivers, the leaks, the waters are just coming and it is just storing in the rocky formations. But it is very well depend on the influence, very well depend on the permeability behaviour of the underlying rocks.

Because suppose this is the riverbed, river and the rock beds of the rivers it will just having the leakage in the direction then what will happen if the permeability will be good only then the water will come to the aquifer formation. Otherwise it would not be recharged through the surface water sources. So, this is very important in case of the unconfined aquifer because permeability of overlying rocks and soils are very, very important which is generally influencing the rate of recharge of the unconfined aquifer.

Now unconfined aquifers have special treatment, because they are the main groundwater recharge locations. These are remaining at shallow depth and also very easy to reach by local people in cheap manner and they also provide storage possibility for natural and artificial groundwater activities. So, generally the dug well is a very good example of an unconfined aquifers which is generally remaining in all the villages, all the places and the depth of the well remains shallower.

So, very easy to reach to the water table and collect water for different purposes. So, such type of aquifer unconfined grouper recharges quicker because a confined one cannot be reached by the falling water because it cannot penetrate the impermeable layer of rock surrounding it. This is very important. With respect to the confined aquifer unconfined aquifer recharging is taking very quickly.

Why because there is a possibility of just infiltrating and percolating and coming down the water volume is reaching down to the aquifer. So, unconfined aquifer there is no problem, but in case of confined aquifer definitely the problem is there because confined beds are remaining at the top as well as at the bottom. So, through the falling of rain it is very difficult to have the recharge in such type of aquifer.

Because that cannot be reached quickly to the aquifer and because it is just surrounded by the confining beds at the top as well as at the bottom.

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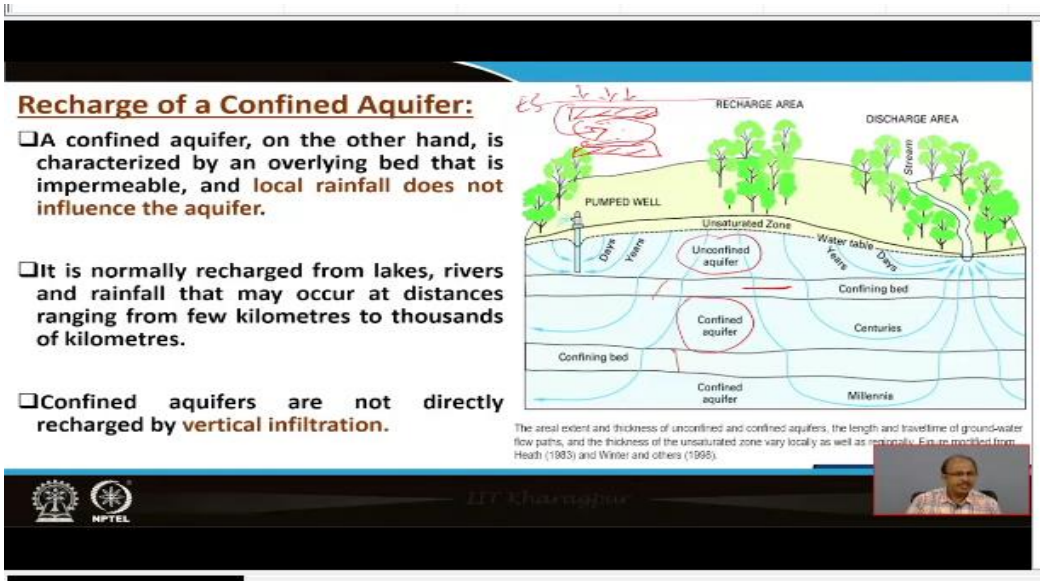

So, in the case of confined aquifer generally the recharging is taking place not because of the local rainfall. Generally, the local rainfall is generally helping in the recharging of the unconfined equipment not the confined aquifer, because you have seen that a confined aquifer is an aquifer in which impermeable beds are remaining at the top as well as at the bottom so when the confining beds remain at the top and at the bottom.

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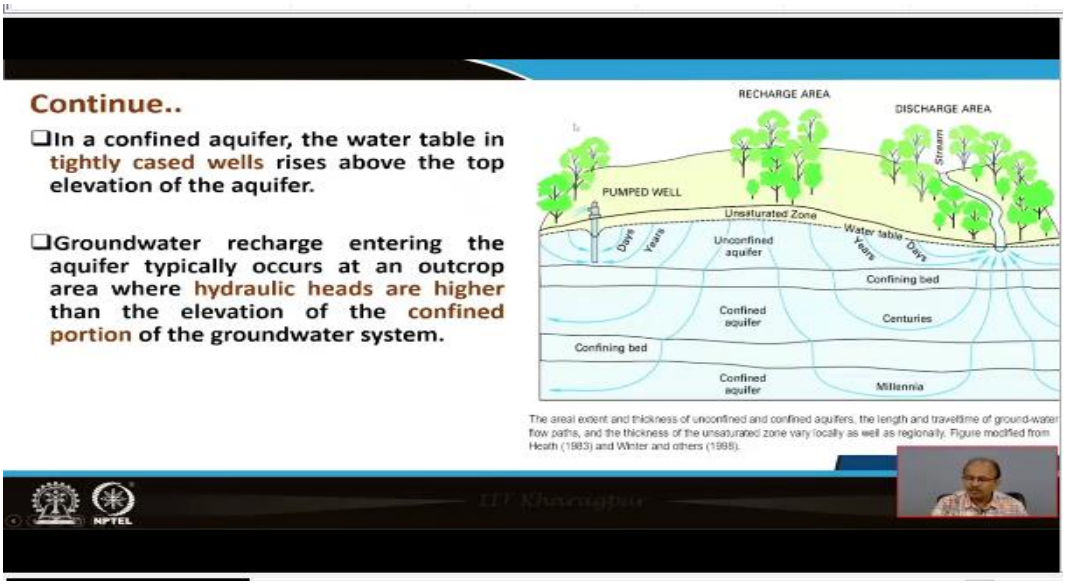

So, it is very difficult because suppose this is an aquifer and this aquifer is having one confining bed impermeable here, one impermeable here and this is the aquifer. So, this is the confined aquifer, why because these are impermeable these are also impermeable. So, what will happen if from the earth's surface if it is from the earth's surface if the rain will fall it may infiltrate it may percolate but this infiltrated and percolated water will not reach to this aquifer.

So, yes, it is reaching in the case of unconfined aquifer but in the case of confined aquifer it is not directly reaching it is not replenishing the water resource of this very area. This is where you can find aquifer. So, why because it is having the unsaturated confining bed at the top as well as at the bottom you can see here it is remaining. So, here you can see that in the case of unconfined aquifer few days will take to reach the water resource in the unconfined aquifer.

But in the case of just you see confined several in terms of years also centuries are taking place and millennium is taking place, so many times is taking place then only the water will be. So, what is happening? The best thing is that in the case of confined aquifer generally these types of aquifer are being recharged from your surface water sources that is from the rivers, streams,

lakes, ponds etcetera which may remain or which may occur at distances that is ranging from kilometers to thousands of kilometers.

But from there the water will just reach to the underlying soil layers. If the soil layer is having a good porous and permeable behaviour definitely through these very layers the water will reach to the underlying confined aquifer. So, generally the confined aquifers are recharged from lakes, rivers and rainfall which may occur at certain distance that is ranging from few kilometers from the place of its occurrence.

And then only the confined aquifer can be recharged. Otherwise, confined equippers are not directly recharged by vertical infiltration. As I have told you that by vertical infiltration it is not possible to have recharging in the confined aquifers, yes in the case of unconfined aquifers it is possible no problem, because unconfined equippers the top portion remain open with the atmosphere.

We have discussed several times that in the case of unconfined equipment the top portion is having the water table and water table is nothing but it is the upper part of any unconfined aquifer. So, unconfined aquifer means rocky formations having the water table from the earth's surface also you can see the level of the water; it means that is the water table. So, in this case through the rainfall it is possible to have some sort of recharging of the groundwater resources.

But in the case of unconfined aquifer it is not possible that if the rain will fall at the place the confined aquifer will become rich and having good recharge no, why at certain distance if the rain will fall definitely from that place it will just comes through the soil to through the different porous rocks and then it will just recharge the area. So, this is the point of understanding that recharging behaviour of confined aquifer and unconfined aquifer is completely different.

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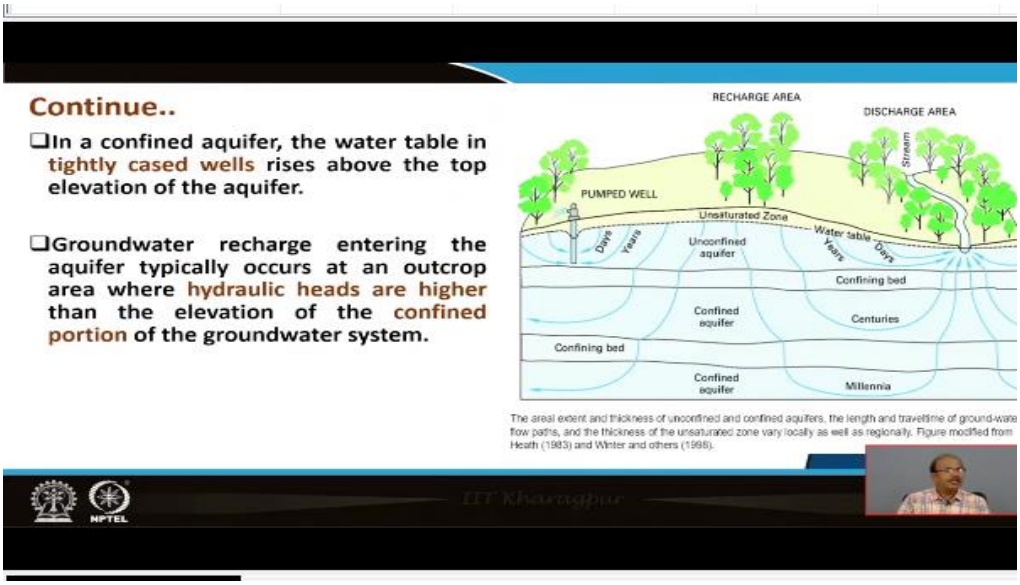

Now in a confined aquifer, the water table in tightly cased wells rises above the top elevation of the aquifer. So, generally in case of confined equipment the water table means the level of the water is tightly cased wells means having the closed wells rises above the top elevation of the aquifer. That is and then the water layer will rise at the top of the existing aquifer.

o, groundwater recharge entering the aquifer typically occurs at an outcrop area where hydraulic heads are higher. Generally, if the hydraulic heads will remain higher than the elevation of the confined portion of the groundwater system. So, in this way the groundwater recharge generally takes place. So, for the recharging of the groundwater which is just entering through the aquifer.

The outcrop area outlook area means those areas which has come out from the earth's surface where hydraulic heads are remaining higher than the elevation of the confined portion of the groundwater system, then only the groundwater recharge can be best suited. So, these are some of the concepts of the recharging of the confined aquifer and unconfined aquifer and with this thank you all.