Rural Water Resources Management
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Week 4
Lecture No. 4
Indian Aquifers

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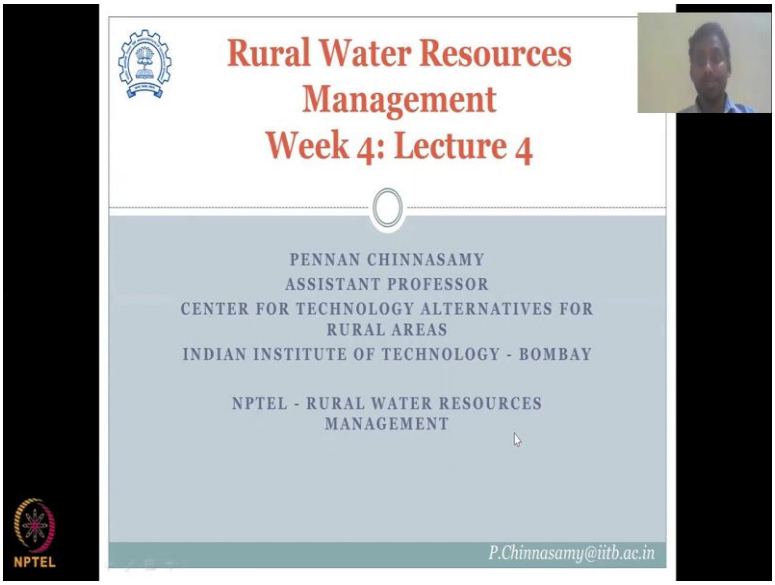

Hello everyone, welcome to NPTEL Rural Water Resource Management course, week 4, lecture 4. In this week, we have been focusing on groundwater hydrology. And you would have noticed that we are looking at mostly how the groundwater comes into the system, how it gets relocated to different compartments unconfined, confined etc. We looked at recharge and how delete recharge can happen. And we also discussed about farmers pumping and how that could actually take more water out then needed if you are not considerate about neighbouring farmers.

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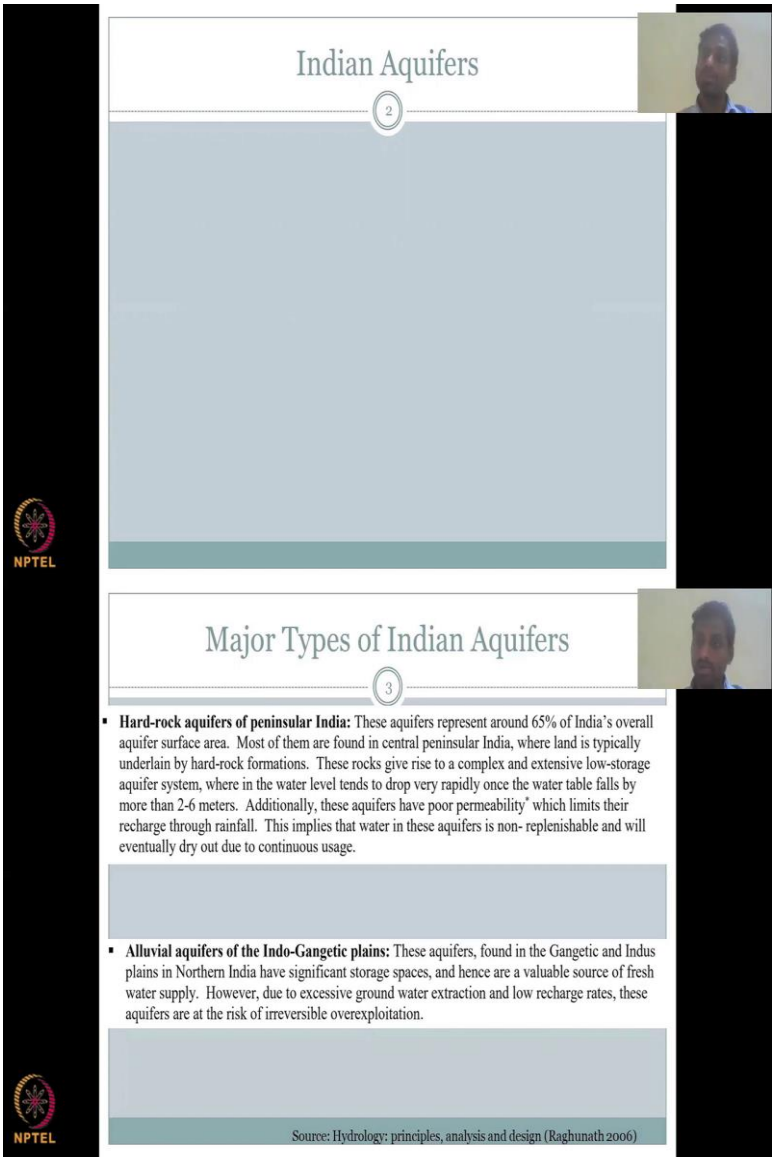

In today's lecture, we will be looking at the types of aquifers based on geology in Indian, Indian aquifers. So, the Indian aquifers as per the government books on and reports on groundwater hydrology, you would notice that it is mostly based on geology. So, the major types of Indian aquifers are only two types the major ones hard-rock aquifers of Peninsular India, which represents about 65 percent of India's overall aquifer surface, if you take 100 percent as India's aquifer surface and you have the hard-rock aquifers as around 65 percent.

Most of them are found in central peninsular India, because that is where you have these hard-rock geology, hard-rock as the name suggests, it is a rock which has not been fully disintegrated into soil or unconsolidated materials and minerals, still there is a lot consolidated rocks and within the rocks there could be a lot of fractures and that is where the water is stored.

And as the clay say land is typically undermined by hard-rock formation. So, the geology, which is the formation drives the aquifer name and it gives rise to complex and extensive low storage aquifer systems is very, very low in storage. So, when you hit hard-rock aquifer storage and then you put a pump, hit means when you drill in and hit it, what happens is you actually tap into a water which has been there for millennia, or at least 100 years.

And your understanding is oh wow, I have taken groundwater now, I have access groundwater, let me take it all it will recharge, but it will not because of the complexity the hard-rock aquifers and it is very low in storage. So, the storage you see, the volume see, it might be the total volume, it may not recharge. So, when you pull all of it out within a year or two you have depleted your aquifer.

Wherein the water level tends to drop very rapidly, once the water table falls by 2 to 6 meters. So, studies have noted that if the water table is lower across the region by 2 to 6 meters, suddenly the water level fluctuates and comes down to very unsustainable levels. Think about the cone of depression.

So you have many cone of depressions now and so slowly it is lowering down 2 meters, 3 meters, but once it hits around 2 to 6 meters, suddenly the water level falls and additionally these aquifers have poor permeability, permeability of letting the water go through the substrate system and that is why it is limited recharge through rainfall you cannot achieve much rainfall through just rainfall. When the author says recharge through rainfall, which means natural recharge, you can augment it but still very, very less is going to happen.

So this implies the water in these aquifers is non-replenishable and eventually dry out due to continuous usage. So this is the water which is approximately 65 percent across India. And so it is very, very important to preserve this natural resource and if you do not understand on the availability of the water how the process is happening, people tend to just use it because if they do not use it the next farmer will use it that mentality is also there.

So, if you go to rural regions they will say Sir, if I do not use my groundwater someone else will use it. So that concern is also there and that is why we are pushing as a group to convert more into communal groundwater usage, wherein everyone is accountable for how much groundwater they use.

The second type of major Indian aquifers is alluvial aquifers or the Indo-Gangetic plains. The author claims that Indo-Gangetic plains is one of the aquifers, but it is overall an alluvial

aquifer, what is an alluvial aquifer? The geology is alluvium which is deposited by your rivers and moving water bodies in these aquifer, so tese aquifers formed in the Ganges and Indus plains in Northern India have significant storage space because every year you have sedimentations. So, once the sediment layer is going, thickening every year, water can get stored in it. And hence a valuable source of freshwater supply. How will you get access to groundwater extraction and low recharge rates, these aquifers are at risk of irreversible over exploitation.

So the recharge rates are still low, then that is the natural recharge rate, when compared to hard-rock aquifers, the recharge is much, much better. And because of the better hydraulic conductivity, permeability, etc. But the point here to be noticed is that these planes already have good water in terms of surface water on the Ganges, the Indus, these are one of the biggest rivers in the world.

So if you are looking at these rivers, and saying that people are still using groundwater, which means the demand side has to be managed, not the supply side. So if you are having a big river, but still you are saying it is not enough, and you are going to groundwater, so there is some concern of how you use a water, whereas is northern regions, you have these Ganges, Indus plains. But when you go to southern regions, there is not much big rivers, the Kaveri, Krishna all are much, much smaller compared to the Ganges.

So, what would people do in the south, if they do not have such a volume, so they are going into groundwater depletion. So that should not be happening in the north regions where you have these Ganges planes, but unfortunately, groundwater has been depleted. So there has to be a better understanding of why the water is used. Is it sustainable in the long term? Or are we just looking at short term benefits?

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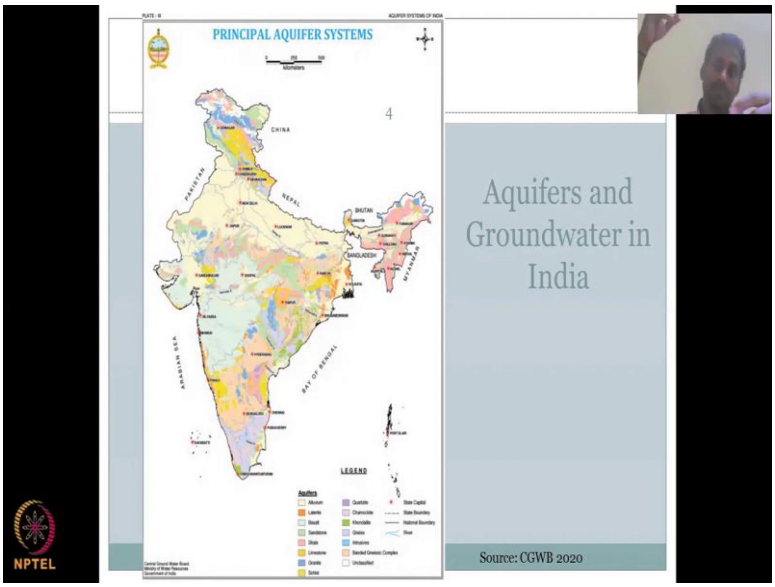

Let us look at the principal Aqua systems as given by central groundwater board, they have labeled many in terms of the aquifers and what you could see here is your aquifers are alluvial along the Indus-Ganges plain. Also, you would see aquifers, alluvial aquifers along the coast where the rivers drain, because when the rivers move and drain into the oceans, they have sediments, and the sediments become the alluvium material, alluvium aquifer.

So you see all these waterways depositing alluvium across, and then going into Bangladesh, etc. So this is the Brahmaputra bringing in a lot of alluvium, your Ganges, your Indus. So all these big, big rivers bring in a lot of alluvium and then you have your Krishna-Narmada all on the coastal sites, you would see Kaveri giving water on the coastal, like discharging water into the ocean along the coast. But also they would deposit the sediment informed deltas.

So those alluvium aquifers are highly rechargeable compared to hard-rock aquifers, and the central area, central regions where granite, mostly granite gneiss, we call a GNEISS. So gneiss granites are hard rocks formed from metaformic formations. And they do not give in that much ground water because the pore space is very, very limited. It is not the rock opposing, it is not hydrophobic, it is because the pore space is much limited. And these rocks are not as weathered as the Himalayan regions, so you would see rocks but it is not as weathered. So, what happens is only when weathering happens you have a space for the water to get in.

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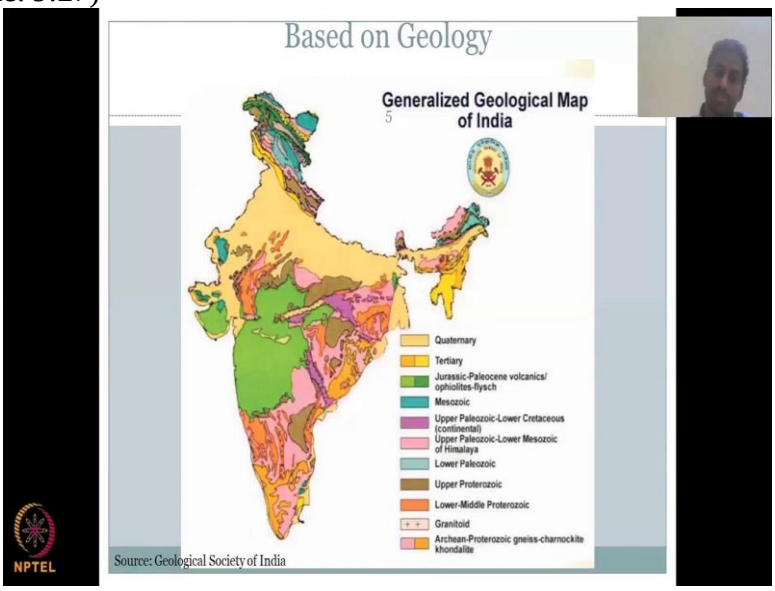

So, these are also based on the geological survey maps from the Geological Survey of India. And we can see a generalized geological map here. So quaternary are much, much younger geology and those are the sediment driven alluvium, colloquium driven deposits. So you could see a lot of these materials along the river valleys, the big, big river valleys.

Whereas the central India is Jurassic Palaeocene volcanic rocks and all the pink color, you would see Upper Palaeocene, Lower Cretaceous continental rocks. So all these are stills from the Himalayan regions you could see of the Himalayas. And they are not that much weathered in terms of becoming porous sediments porous soil, it is still a hard rock. And the hard rock is characterized by fractures, the fractures first a rock is there, fractures form, and then the fractures, water and sunlight act upon and then it disintegrates into soil materials. So still, there is a lot of hard-rock aquifers here, which also is a concern that water cannot be stored in pore spaces.

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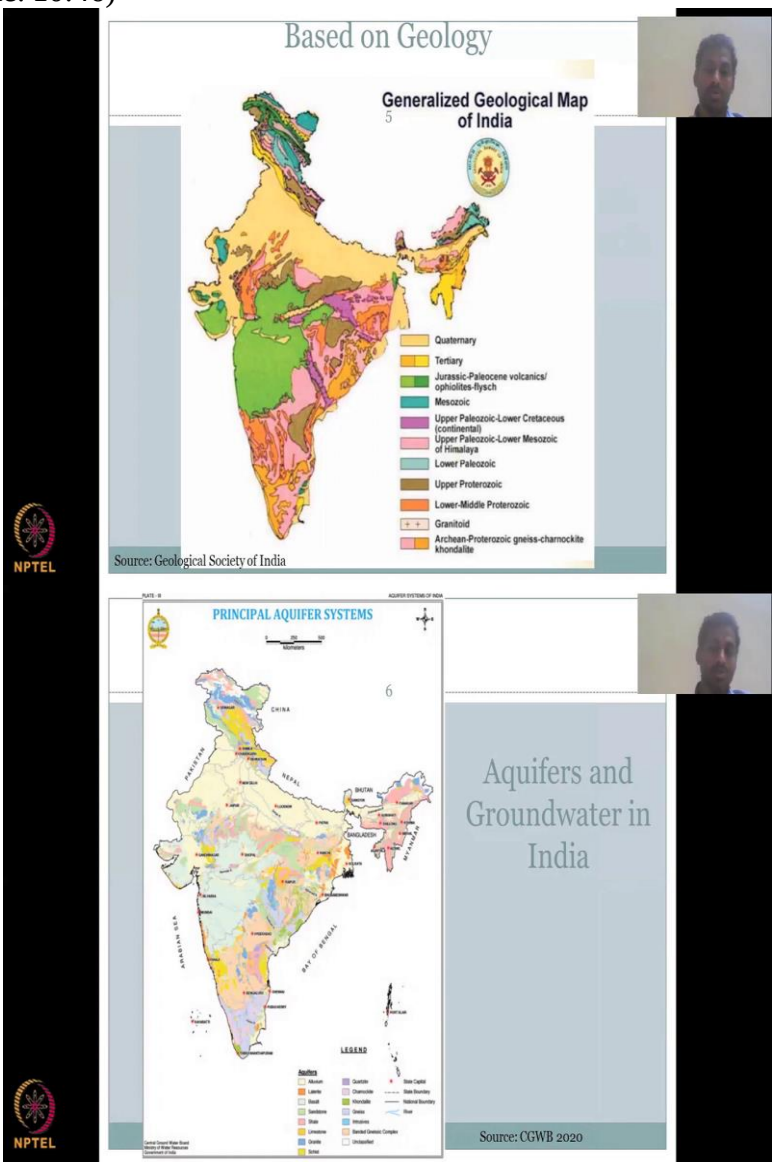

So, if you look both of these maps together, you would see that the aquifer map, aquifer system mapped by the central groundwater board also follows the geology system. So the Geology is the key along with that your Indus river and other river basins, Ganges etc, together form these principal aquifer systems of India, and it is mostly divided based on the yield, water can be yielded from these aquifers.

Now, if you see this, you do have a rainfall variable also, it is not only groundwater, it is not only the rivers, but also good (())(11:28). So you have your Western Ghats area, Ganges regions, you have good rainfall, good storm water in terms of runoff, all these are there, so not much dependency you could see to groundwater.

But what happens in the central and southern regions where there is much, much lesser rainfall and also not big rivers flowing, you would have to see that most farmers go into

groundwater irrigation, because they have to do livelihood options for agriculture, domestic urban cities, everyone uses groundwater in the central and southern regions.

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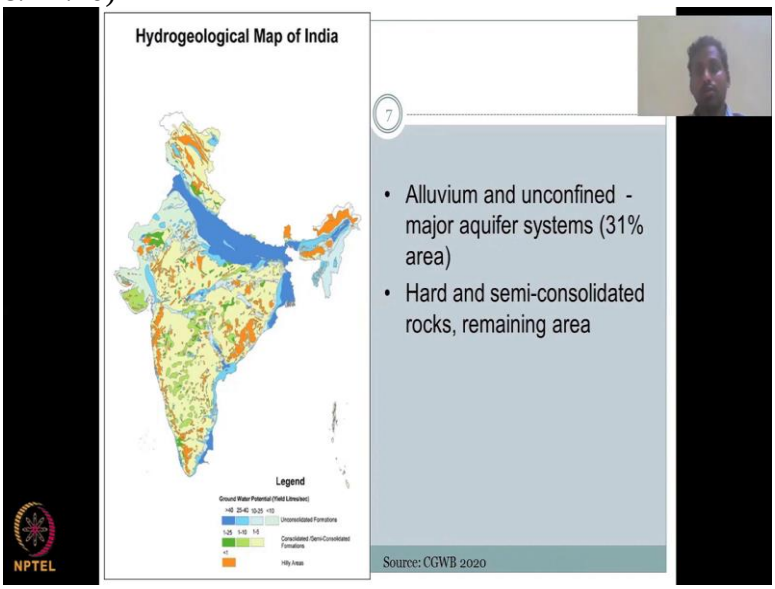

You saw the geology map, which is purely based on the rock material, the rock formations that were much, much deeper formations. So, when you say Quaternary, Jurassic period, it is not on the top, but on the very, very high depth. So that is where also you have some aquifer formations.

But when you look at hydrogeological map, it is the hydrology plus the geology map, which is made by central groundwater board, you could see alluvium and confined aquifers, hard-rock aquifers along with this Indian subcontinent and out of which alluvium and unconfined major aquifer systems contributed 31 percent of the area.

So, the alluvium is here your blue color and your unconfined which is your top aquifers, where unconfined and it is unconsolidated, which is mean it is broken formations. Those do occupy the light blue and blue colors and it is along the river basins, along the deltas where the rivers discharged.

And it is seen mostly across India in the northern regions right that is close to 31 percent but the major, major part is your hard-rock and semi-consolidated and unconsolidated rocks. So the rock area which is present in the central southern regions are the dominant aquifer type in India.

So, if you want to map it by yield, the high yielding aquifers around the alluvium aquifers and on the northern side. Whereas your central India, southern India is characterized by low yielding formations. You could leave Kashmir and other hilly regions out because most of

those regions you do not see much agricultural activities. But I am talking about the central basin and all the other smaller river basins in India, where you have so much agricultural activity, but very, very less groundwater potential.

This knowledge has to be imparted to the farmers because they, when they put up well they think that oh there is unlimited supply of water. But they do not understand that the yield would suddenly stop because everyone starts pumping and as the yield is increasing the recharge if it does not increase, the water will fall down drastically the water table.

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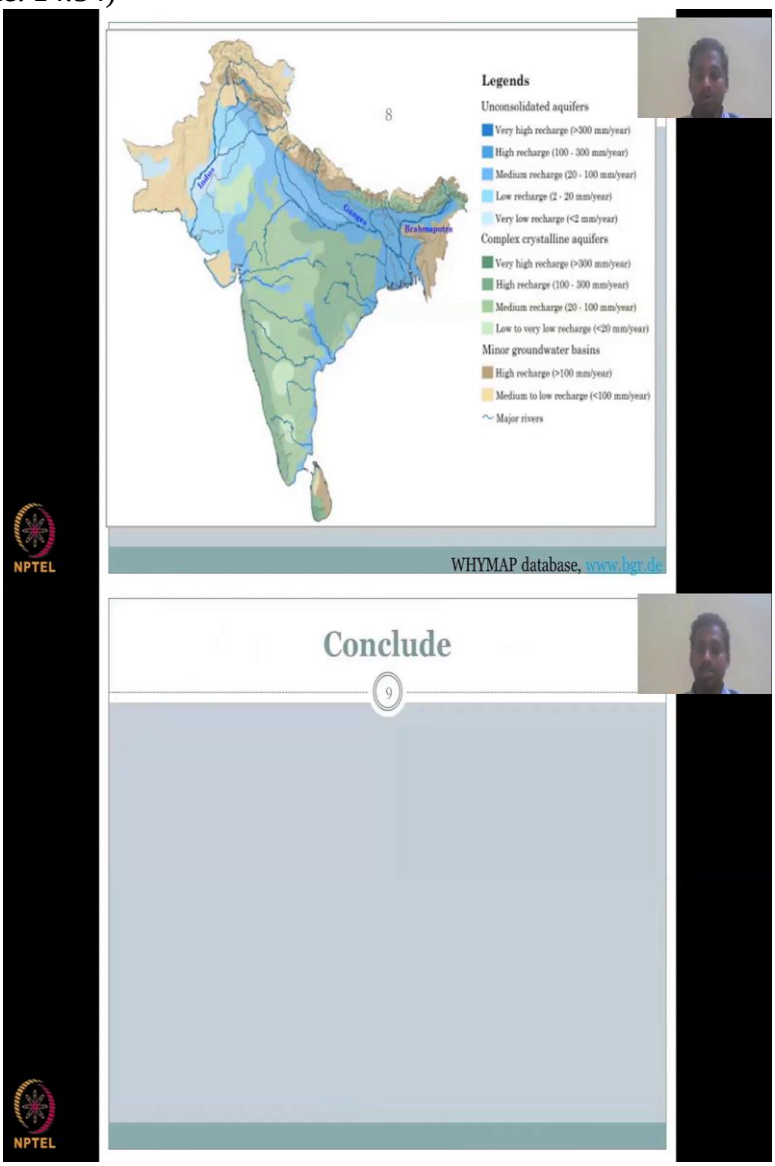

So there are multiple studies that have been done on this to see how these basins, how they recharge (())(15:06) water. And one particular study from Europe showcases that the unconsolidated aquifers, where you have a little bit more weathered formation, you could very high recharge, very highly recharge along the Ganges and you could see, if you visualize

further into this figure, you could see that high recharge is happening along the river channels, along the major tributaries. And that clearly shows that when the Ganges is flowing, it also can recharge and which also relates to the Ganges water machine that we discussed earlier.

So there is high recharge approximately greater than 300 million meters per year, just think about this number 300 millimetres, whereas the rainfall here is only around 600 millimetres, 600-700 millimetres. So, that is a big number just because of groundwater you are getting 300 millimetres of recharge, and then you have your high recharge areas. So, you have a very high along the Ganges, along the tributaries, along the Krishna-Kaveri tributary. And also you have high recharge, medium recharge, all still in the river basins, which is the alluvial aquifers.

Then when you come to the complex crystalline aquifers, which is mostly found in the central regions, you have very high recharge in some regions where there is good forest cover, good networks of rivers tributaries, and also a lot of rainfall. So, do think that recharge can happen only when you have a good material, but also you need the rainfall, you cannot have recharge without rainfall. So that is what this is actually bringing in the hydrological concept also.

Then you have the medium recharge in central India and southern India and very low to very, very, very low recharge lesser than 20 millimetres per year among pockets. And these are the pockets where you have the shadow region of the Western Ghats. And you see that the Western Ghats is dark green in color which is very, very high charged, because there is a lot of rainfall. The Western Ghats comes along this angle, there is a lot of rainfall and then it deposits among the residents Ghats Kerala, Maharashtra, Konkan, region, etc.

On the other side of the Western Ghats, Vidarbha, and if you come to Tamil Nadu, you would see that there is very, very less rainfall and due to that there is less recharge. And then there is minor groundwater basins, which are also found in Gujarat and these are small groundwater basins formed by unique differences in the geological material.

So, this image actually clarifies more that you need to understand the geology, you need to understand the hydrology where does the rivers flow, where are the tributaries, where is the deposition happening to understand geological formations and aquifer potential and also the rainfall regions.

So, the aquifers yield is based on your geology, because that is the first one where you can create a pore space. The second is the availability of water either through rainfall, which is your hydro climate, your rainfall occurring regions, high rainfall occurring regions would have more rainfall to infiltrate. And then the third is your hydrology based aquifers wherein along the tributaries, along the tributaries and channels, you have a higher yielding aquifers.

So also, if you have a higher yielding aquifers, which means more recharge is happening, but are they getting into the aquifer too fast. If they do get too fast, then there is more interactions between the geological material and that is what you find along the Ganges that there is a lot of natural pollutants in the groundwater because there is a lot of arsenic, which is a natural pollutant and along the Ganges, if you have polluted water coming in and the Yamuna etc, because of the high recharge, it is not always good because the high recharge rate is there, you have to protect the water that goes into these aquifers.

If you do not maintain the quality, it is not only quantity that is important in groundwater also quality. If you do not maintain the quality, then the groundwater will be easily polluted in these regions. So now that is a concern for a high recharge area, high recharge is good, but also if you do not maintain the quality of the water that is going in, you are actually polluting the aquifer faster.

For example, let us take a case study, if you have political agents here, let us say industry, tannery, dyeing industry for clothes in Southern parts, and the water was put in the streets recharge is very low, only 20 to 100 millimetres per year, so only some pollutants are getting in, but if the same goes in the Ganges, then think about how much water is recharging the groundwater and all this groundwater has the potential to bring down the quality of your groundwater.

So, when we do groundwater hydrology, when we talk about groundwater use for rural environments, it is as important to talk about the quality as we talk about the quantity because black arsenic dead end or pollutant water cannot be used for agriculture, you do not use salt water in agriculture. So the same way, if your groundwater is polluted, you cannot use, so it is as important to maintain the recharge and maintain good quality recharge among these areas.

And whenever there is a flood, these tributaries do have a backlog of all the flooded water and the flood can actually infiltrate and pollute your aquifers. So in Kerala where there is annual level floods every year in Maharashtra, Mumbai for example, if you do not maintain

the flood water, and you are sitting in a zone, where high recharge is there, the flood water wants polluted, can enter into the groundwater aquifer and pollute the entire system.

Unlike your surface hydrology, where it is easier to clean the river if it is polluted, because for example, if a river is polluted, people will just let it dry, or a big flood can push all the pollutants away but in groundwater, it is not the case. Once a groundwater recharge occurs, it stays there, you cannot pull all the pollutants out because the polluting agents might be stuck with the soil and it stays there forever.

So it is as important to understand the recharge areas and also maintain the water that goes into the recharge areas, high recharge areas to get good groundwater availability. And this is very thinking about the long term sustainable, this is a very, very important goal that we should attain to preserve groundwater. With this, I will stop today's lecture. Let us get into the next lecture for the wrap up of groundwater hydrology, see you soon. Thank you.