Availability and Management of Groundwater Resources

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Lecture - 07
Geological Formation as Aquifer (Continued)

Welcome you all in the second module entitled Geological Formation as Aquifer, in which we will discuss about the different characteristics of the rock which are just storing groundwater inside the earth's surface. So, prior to it we have already framed our mind regarding the availability of the groundwater resources that the only recharge source on the surface of the earth is the precipitation.

So, through the rain water it infiltrates down the earth through the soil layer it just percolates and then it reaches to the underlying rocks formations which are having certain specific characteristics which behave like an aquifer. So, in this part two lecture series we will see that which are the important groundwater potential zones in our Indian subcontinent as well as what is the ill characteristics of any rock. Because suppose the rock is storing water inside the earth's surface.

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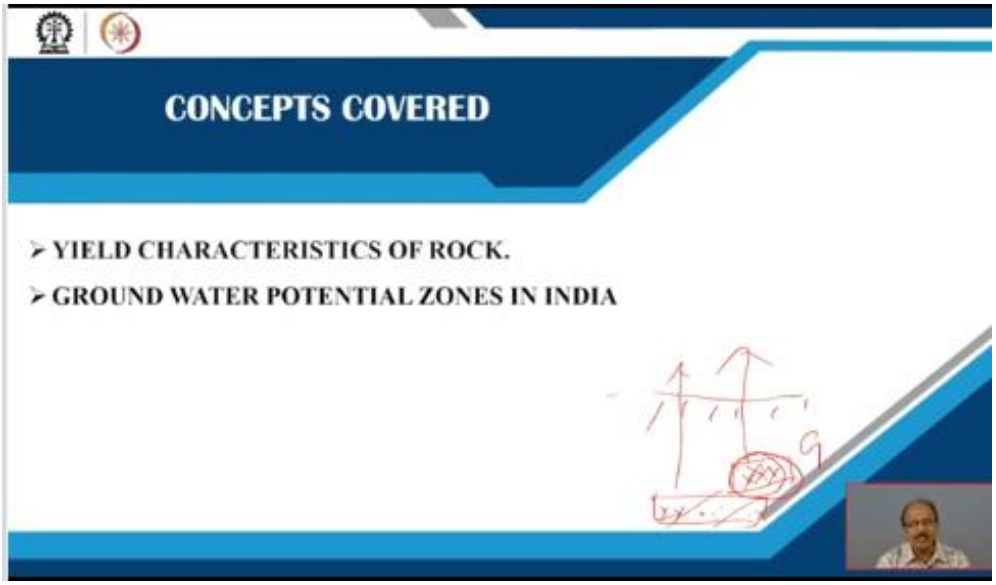

Suppose the rock say this is the earth's surface and within the earth surface, the rocks are lying different rocks are lying. So, every rock is having different behaviours, so every rocks are having

the different characteristics also. So, now suppose some rocks can assimilate or it can store greater volume of water so this is having the greater volume of water, whereas this is a big rock but it is not having the availability to store the water this is having very little volume of water within it groundwater within it.

So, what is happening if the rocks which is having good amount of water will give more water through the wells means if you will withdraw water from this rock, it will give more volume of water which is called as yield. It is just having a very good yield that is why whenever we are trying to withdraw the water from this rock it is giving us water quantity in a larger volume. Whereas, this is a very big log inside the surface it is also storing the water since it is big.

So, it may store a greater amount of water within it. But this rock is having not a such a characteristic which gives a better yield to the above the surface. So, the point is that yield is also very important. For any aquifer yield is also very important if the yield of the well or the aquifer is good then the chances for getting more groundwater from in the area is greater. So, that is the main point we will discuss today.

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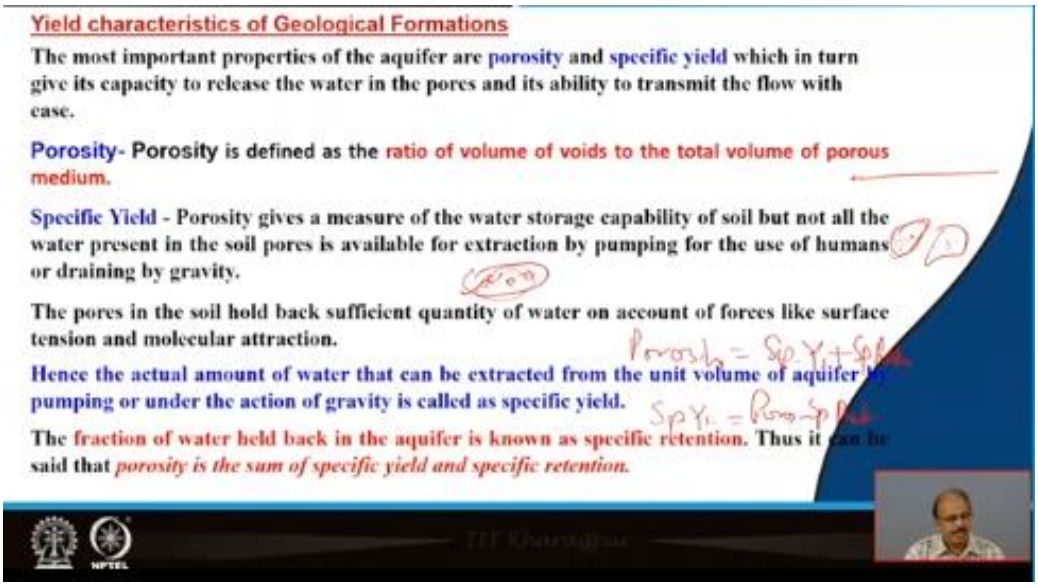

But prior to it we can also think over it that; what are the factors which are playing important role for making a good yield from any aquifer. So, the point is the important two important formation characteristics in general in every geological formation which is just behaving like an

aquifer the that is the first is the porosity, second is the specific yield. So, porosity as we have discussed earlier also porosity is the ratio of the volume of voids pore spaces to the total volume of whole spaces within the rocky formations so that is called as porosity.

So, definitely we can assume also that if and around the earth some rock is there and it is having large number of pores, so definitely this rock will have certainly more volume of water within it. Now the point is that water may remain in a greater amount, but what is the condition of its yield? Yield is also very important. So, for this generally the porosity which we have discussed just now gives a measurement of the water storage capability of soil.

But all the water present in the soil pores is available for extraction by pumping for the use of human or by draining by gravity. So, the point is that not all the water which is being stored in this rock sensitive porous it is having large number pores, so it may store more amount of water but the point is that it may not gives all the total water whenever somebody will if somebody wish to stack the from this soil or rock.

Then it may not give its full amount of water during the case of withdrawal. So, this factor is very important, because they are also in the rocks in the soil also some volume of water remains after withdrawing some volume of water remains there. It is remaining inside by if you are taking out the water pumping though some amount volume of water will remain within the soil or within the rock which behaves like an aquifer.

The pores in the soil or the rock hold sufficient quantity of water on account of forces some forces act there which is just holding the water within the soil or within the rock like surface tension and molecular attraction. Because of the surface tensile and the molecular attraction, these forces some volume of water retains as usual within the soil or rocky formations. While pumping volume of water may come out.

But few volumes of water will retain with the soil within rocks because of the molecular attraction or the surface tension forces. Now the point is the actual amount of water which can be extracted from unit volume of an aquifer during pumping or under the action of gravity is called

as specific yield. So, within the unit volume of an aquifer if the extraction is being done some volume of water is being pumped out then the actual amount of water which is just we are sending it out during the pumping from an immediate aquifer is termed as a specific yield. But the next important point is as we have discussed just now the fraction of water which will remain back held back in the aquifer because of the molecular forces, molecular attraction or the surface tension forces this volume of water within the soil or rock is called as specific retention.

This volume of water which remains within the soil or rock is called as a specific retention then we can also think like this that the porosity is equal to specific yield plus specific retention. We can also think of porosity is equal to specific yield as well as specific retention, means what? Means if the rock porous the rock which we are telling it as a porous definitely this rock will hold more volume of water within it.

Since it is having the space since it is having the capacity to store the water which is being in filtered and then it is just percolated down and there has reached to the formations, the formations are having a very good porous behaviour. So, large number of whites are present there. So, it will store the volume of water say groundwater will remain here, but next suppose we want to use this groundwater so definitely we will pump it out.

So, when we are pumping it out not all the total volume of water within this formation of the rock or the soil will move up it is not going out, all the total quantity of water which is being stored here are not going out. What is happening? Some volume of water is still remaining inside the soil or rock, because of the molecular forces molecular attraction and the surface tension forces.

These are the forces and because of these forces some volume of water still retain in this rock. This volume of water which is just retaining itself during the pumping activity is called as a specific retention. So, this is specific retention the volume of water which is left but the total volume of water which are being extracted during the pumping is called as specific yield. And I told you specific is a very good characteristics of any aquifer any good aquifer.

If the yield is good, it means the water from where it is coming is having a good repository of groundwater aquifer is good, that is why it is good. But we are on another way we are also knowing that the porosity is the summation of specific yield plus specific retention, what is happening or what we have seen here. So, this porosity is equal to specific yield plus specific retention we can also say it that specific yield is equal to porosity minus specific retention.

So, specifically nothing but the porosity minus specific retention. So, in this way also we can just think over it that few volumes of water while pumping it remains within the set formation that is maybe soil maybe rocks or any saturated formations in which the water remains inside the earth's surface.

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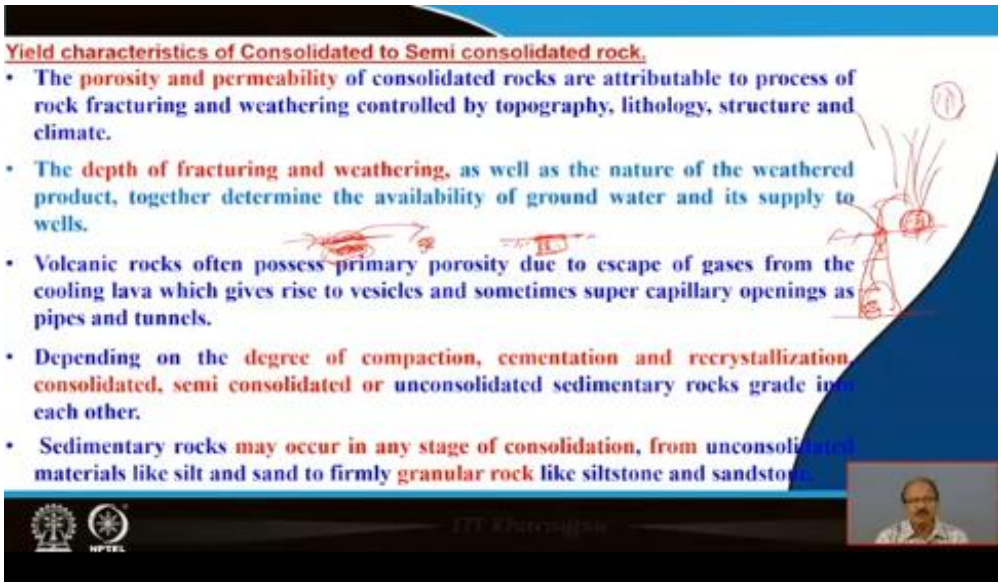

Now the point is that, this porosity yield permeability these are some of the characteristics on which the movement of the groundwater flows or the volume of the groundwater flows depends. The porosity and permeability of consolidated rocks we have already read about the rocks consolidated rocks, unconsolidated rocks we have seen that the porosity and permeability of consolidated rocks are attributable to process of rock fracturing and weathering then only it is possible.

In consolidated rocks the porous behaviour will always depend because of some sort of fracturing or weathering. What is weathering? Weathering is just the removal of the top upper

part of any exposed rock if it is lying on the ground surface and because of some natural legends. Natural legends mean your wind, river etcetera. Just loosening the top superficial part of the exposed rock and it these exposed rocks are moved to a certain distance and then it deposits.

So, what is happening? The rocks when it is weathered it become loose. So, if once it will become loose then what will happen some small voids will create there then only in any consolidated rocks there will be chances to have some volume of water within that very formation. Otherwise in consolidated rocks it is very difficult to have a good porosity as well as good permeability.

Porosity we have understood already the volume of voids divided by total number of voids, whereas permeability is the availability to transmit water from one formation or one rock to another rock or another formation. So, point is that in consolidated rocks since it is hard rocks it is not possible to have a very good porosity and permeability until unless there must be some weathered rock fractured activities has taken place.

Then only the rock will become looser it will develop some sort of cracks fisher etcetera. Then only it will store some amount of with water within it. So, this is very important in the case of the consolidated formations. The depth of fracturing and weathering and the nature of the weather product together determine the availability of groundwater and supply to wells. The depth up to which level suppose a rock which was exposed on the earth's surface this is the earth surface.

On the earth surface the rock was exposed the superficial part had disintegrated because of the weathering by whom, weathering by the natural agents. Natural agents are river, wind, glaciers etcetera. So, this consolidated rocks earlier it was consolidated rocks not having the chances to store the water or to transmit the water but anyhow because of the weathering phenomena or some sort of rock production phenomena.

There have some cracks have developed, which may store which can store some volume of water within it. Now the point is how much volume of water? It depends on the depth of fracturing how far it has the cracks and the depth of weathering also how far it has the weathered. This rock

may have weathered up to this part or this rock may have weathered up to this part. So, there will be a difference because earlier only this much portion were there.

But now this much portions are with the rocks. So, the rocks are having larger area weathered area so it will store much volume of water within it. Now this is the case of the consolidated rocks in which there were lesser chances of having good porous and permeable behaviour. But point is in the unconsolidated there is no problem but the volcanic rocks are forming by the consolidation of the lava.

We have seen when the magma which remains in the core of the earth, this is the core and mental then crust. So, then it is a earth surface so they have the core here because of high temperature the rocks of this remains in the molten conditions. So, when this is called as magma but when this magma through some weaker zone through the mantle and the crust reaches out to the surface it erupts here so this is called as volcanism.

So, through the process of volcanism the same magma returns into the lava and when the lava will consolidate it is forming the volcanic rocks when the magma is consolidating it is forming the plutonic rocks. The difference is that one is forming inside the earth's surface where other is forming outside the earth's surface. One is forming from the consolation of magma that is a liquid rocky liquid, other is forming by the consolidated lava.

So, point is that lava volcanic rocks now this lava will accumulate work one place then cementation packing will every process will be here and then it will become a rock termed as volcanic rocks. The point is that in the volcanic rocks large number of gases remains because it is just erupting out all in a sudden to the surface, so large number of gases remains within this rock. So, these gases generally just escape to the atmosphere.

Then what is happening? These volcanic rocks which were having large number of gases the gases had erupted out then small recycles opening develops and within these openings the groundwater retains there it remains there within these openings only the groundwater remains.

So, in volcanic rocks often primary porosity due to escape of gases from the cooling lava which gives rise to vesicles and sometimes super capillary openings as pipes and tunnels develop.

So, here in this case primary porosity remains volcanic rocks often possess primary porosity due to escape of gases from the cooling lava, which gives rise to recycles and sometimes super capillary openings as pipes and tunnels. So, what is happening in this what we are seeing that the degree of compaction cementation and crystallization consolidated semi-consolidated and unconsolidated sedimentary rocks have been graded into the different types.

The summary is that the sedimentary rocks which is forming because of the weathered weathering processes of the pre-existing rocks, sedimentary rocks may occur in any stage of consolidation from unconsolidated materials like silt and sand to firmly granular material like silt stone and sandstone. So, this generally in the consolidated to semi consolidated formations we are getting not a good yield within the rock formations.

We are not getting a good yield compared to the unconsolidated formations. So, this is the brief about the yield characteristics of the different formations which behaves like an aquifer.

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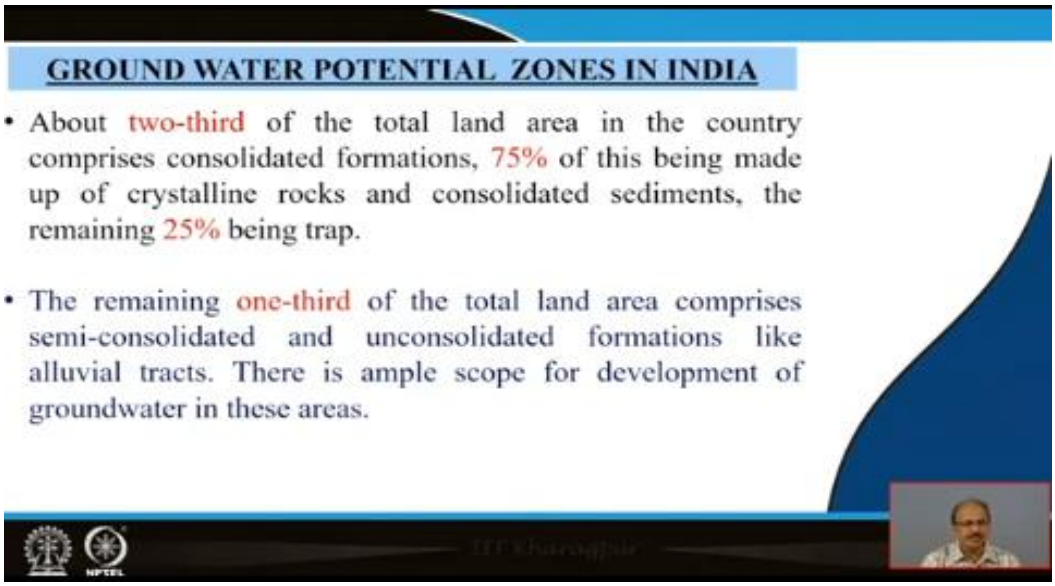

The point is that in the unconsolidated formations, generally a good yield remains a greater volume of water can be extracted during pumping from the unconsolidated formation and in semi

consolidated on your this type of formations generally concentrated formations generally are better yield is very less visible in the different type of formations. Now what are the formations in our India?

Because at every place we are having the groundwater but which are the predominant formations which behave like an aquifer in our Indian subcontinent? We will just throw some light on this also. About two thirds of the total land area in the country comprises consolidated formations, 75% of this being made of crystalline rocks and consolidated sediments and remaining 25% being are trapped which is also type of consolidated rocks.

Now the remaining one third of the total land area comprises semi consolidated to unconstrained formations like alluvial tracts, but the best one is the unconsolidated formations for behaving like a good groundwater repository area inside the earth surface.

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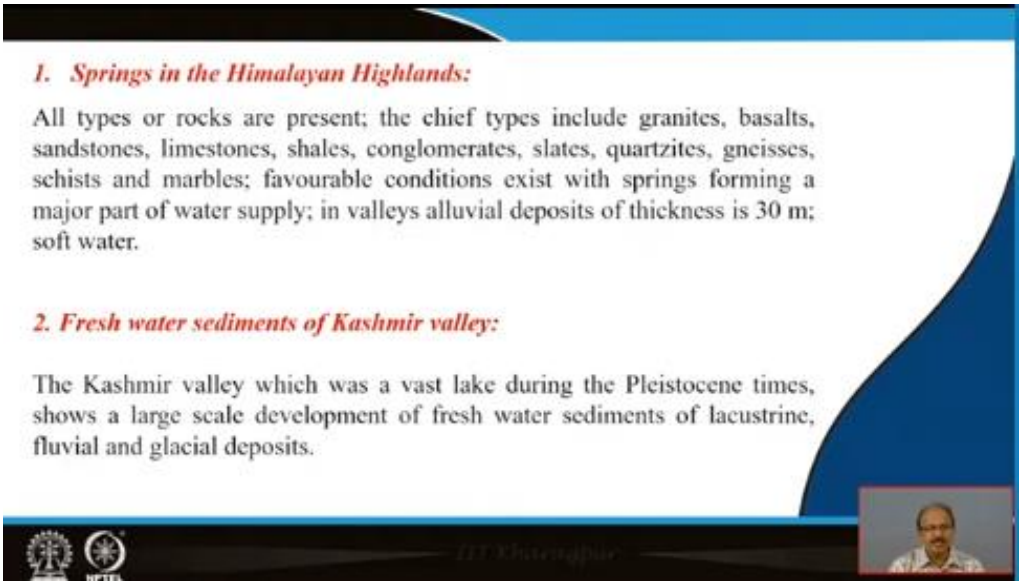

Now this is the case of the Himalayan Highlands. In the Himalayan Highlands generally, springs are very predominant. So, the rocks are generally present all the three important types that is the igneous granites, basalts are the example of igneous sedimentary that is the sandstone, limestone, shales, conglomerates. Then the metamorphic like slates, quartzites, gneisses, schists, marbles etcetera.

So, all the three important types of rocks generally are lying in the Himalayan Highlands and several springs have also been noticed. And these springs are mainly acting as a main major power part of the water supply in the areas, so this is the case of the Himalayan Highlands. Then fresh water sediments of Kashmir valley, if you will see in during the Pleistocene times, these are some of the geological period, geological time series where in which the different climate were there.

So, in the Kashmir valley generally lake vast lake is prevalent of the Pleistocene times, it shows a large scale development of freshwater sediments of lacustrine, fluvial and glacial deposits. So, these are some of the deposits because of the weathering and erosion phenomenon because of river glaciers etcetera. So, this is the case of the Kashmir valley.

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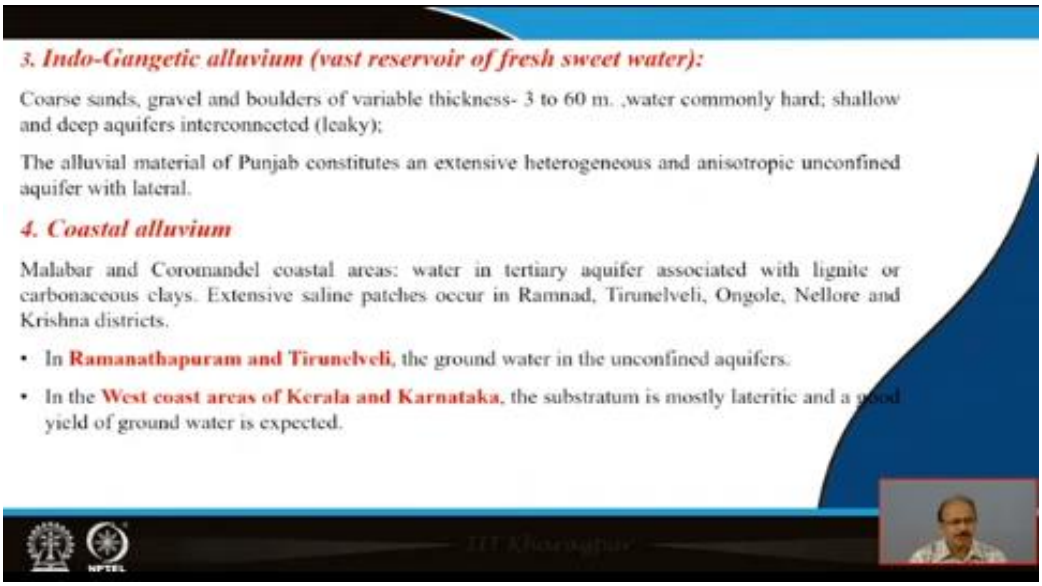

Now Indo-Gangetic alluvium it is also a very good repository of groundwater resources here the coarse sand, gravel and boulders of variable thickness are remaining present. Water commonly hard in nature sallow and deep aquifers are generally interconnected. So, the point is that the shallow means, you are unconfined as well as deep means the confined aquifers are generally remain present some of the leaky aquifers are also been noticed this leaky of course we will discuss in the later class.

The alluvial material of Punjab consists an extensive heterogeneous and an isotropic unconfined aquifer. So, in Punjab generally we are getting heterogeneous and an isotropic unconfined aquifer. Now coastal alluvium in the Malabar and Coromandel we can see the coastal areas water in tertiary aquifer. So, here the water remains present in the formations rock formation of tertiary age associated with lignite and carbonaceous clays.

Extensive saline patches occur in a Ramnad, Tirunelveli, Ongole, Nellore and Krishna districts. So, here we are getting some of the extensive tertiary aquifer. In Ramanathapuram, Tirunelveli the groundwater is remaining in the unconfined aquifers unconfined type of aquifers. In the western coast of Kerala and Karnataka the mostly the aquifers are of the lateritic in nature and yield of the water is very good yield of the groundwater in this area.

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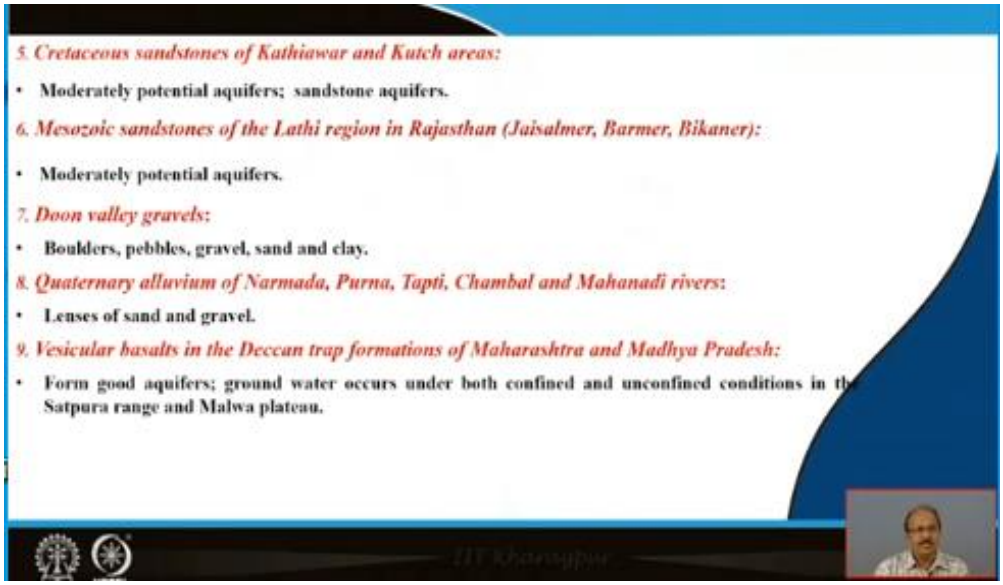

Now in the cretaceous sandstone of Kathiawar and Kutch areas in Gujarat areas you can see moderately potential aquifers we have not it has been noticed and the sandstone aquifers are a bit dominant in there. So, in sandstone aquifers are remaining present in the Kathiawar and Kutch areas. Mesozoic sandstones of the Lathi region in Rajasthan, Jaisalmer, Barmer and Bikaner if you will see the moderately potential aquifer not such a good deal compared to some other aquifers.

Doon valley gravels here you can see boulders, pebbles, gravel, sand and clay these they all are having some of the characteristics for storing the groundwater. So, these types of formations remain in Doon valley. Now in Narmada, Purna, Tapti, Chambal and Mahanadi rivers you can see the quaternary alluvium presence and in the form of sand and gravel remains present there. Vesicular basalts in the Deccan trap formations of Maharashtra and Madhya Pradesh here if the forms very good aquifers groundwater occurs under both the conditions that is confined and unconfined conditions. So, in these regions generally there is a very good formations having a very good yield also, so in this region Maharashtra and Madhya Pradesh generally we are getting a good amount of water in groundwater in general.

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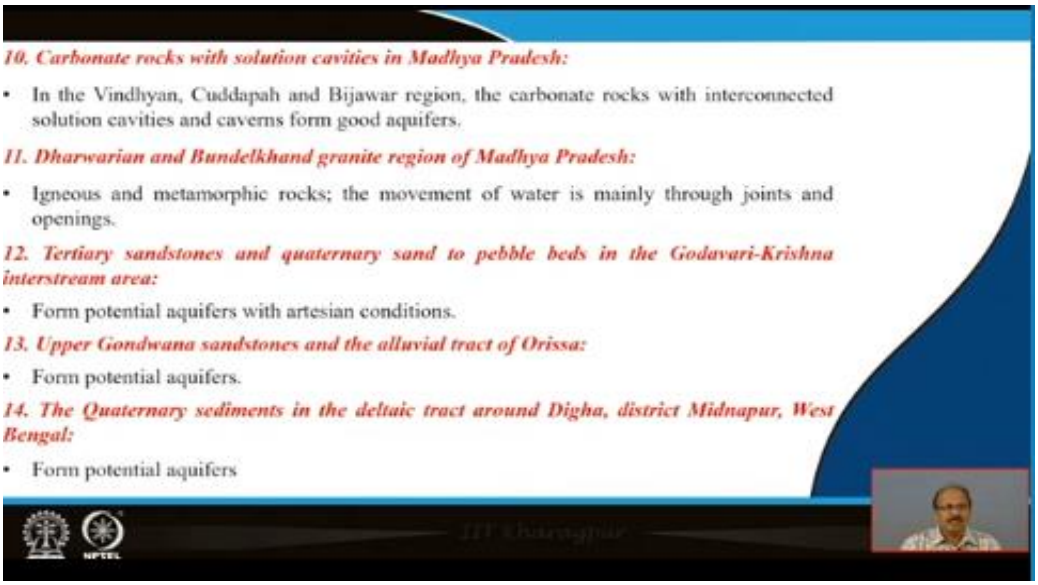

Now in Madhya Pradesh also the groundwater remains present in some of the carbonate rocks of Vindhyan, Cuddapah and Bijawar region. These are the region in which the carbonate rocks with interconnected solution cavities and caverns from could form a good aquifer. So, some of the carbonate rocks which forms the solution cavities within it and these later on forming the very good aquifers by interconnecting among or between the different types of the carbonaceous rock present in Vindhyan, Cuddapah and Bijawar region.

Now igneous and metamorphic rocks are generally present in the Madhya Pradesh region, Bundelkhand granite, Dharwarian granite. These are the important region in Madhya Pradesh geologically, they are the movement of water is mainly through joints and openings. So, where

there will be joints the movement of water is really through it only, so in the Dharwarian and the Bundelkhand granite region of Madhya Pradesh.

In the Godavari Krishna interstream area here the groundwater formations remain of the tertiary sandstones and quaternary sand behaves a very good amplifier in these regions. And they are having some potential aquifer also with artesian conditions, means the dominance of the confined aquifer are much more in this region. Upper Gondwana sandstone and the alluvial tract of Orissa have been noticed.

They are forming very good potential aquifers in Jharkhand, Odisha etcetera. Here upper Gondwana are playing important role for the formations having the good amount of groundwater. Now the quaternary remains in the deltaic tract around the Digha, district Midnapur, West Bengal. Here it also forms a very good potential aquifers in the region so, the sediments remain in the age of quaternary area.

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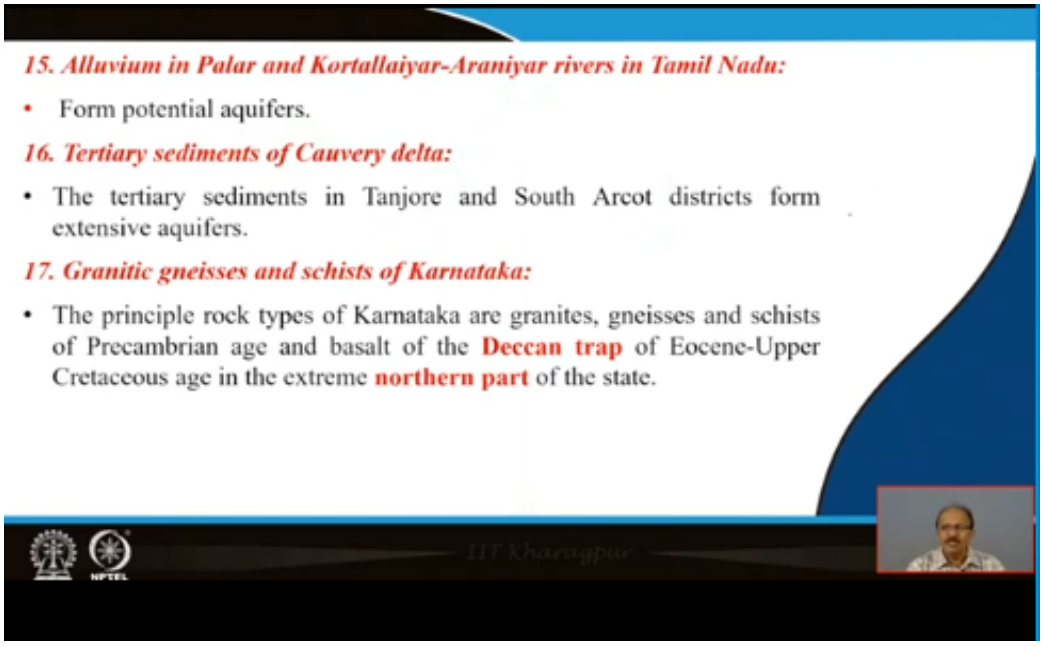

Now in this way we can also see that the alluvium in Palar and Kortallaiyar rivers in Tamil Nadu the it is also alluvium which is of the recent period in the geological time scale it behaves a very good potential aquifer in the area. Tertiary sediments of Cauvery delta here, the sediments of

Cauvery delta remains of the tertiary period so the tertiary sediments in Tanjore and south Arcot district these forms were extensive aquifers in the area;

And then the granite, gneisses and schists of Karnataka these granitic gneisses and schists a metamorphic rock are remaining present there, granite and schists both are here. So, the dominance of the metamorphic rock but the point is these metamorphic rocks are of the Precambrian age and the basalt of the Deccan trap of Eocene-Upper Cretaceous age and in this the northern part of the state is very much potential areas with respect to the groundwater availability.

So, the point is that throughout the Indian subcontinent as we know the upper part of the Indian subcontinent is the extra peninsular region, the lower part of the Indian subcontinent is the peninsular region and in between the Indian subcontinent alluvium remains. So, point is where we are getting the consolidated formations? It is a very tough to say which type of formations with respect to groundwater rigidity.

Now when we are getting unconsolidated formations then there will be chances for having the storing of the groundwater also, as well as the availability to remove the water from one aquifer to another. So, the different rock formation within an area behaves like an aquifer and these rocks are having some geological age during the different geological age, the different types of the rocks have been constituted.

And within the rocks the properties have developed, but in unconsolidated formations there is no problem there are poor species within it. So, the chances of storing water is very easily there are no problem at all, but wherever the consolidated formation of semi-consolidated formations are coming the point is where the groundwater will remain stored? So, it if it is having some fracturing or some sort of weathering then what is happening some species have developed, because of your fracture within the rock.

And the weathering activity within the rock some of the spaces have developed and within this space the groundwater remains stores inside it and whenever we wish to withdraw the water, we

are just pumping it. The point is when we are pumping, we must see whether the formations are having a very good specific yield or not. So, yield is very important if the formation is having very good yield definitely, those very groundwater potential formations are good in the earth's surface.

Otherwise, and in those areas the there will be much more volume of groundwater also within the earth's surface. Whereas the areas which are having poor water potential with respect to the groundwater in those areas some sort of artificial recharge or other techniques are being followed for the conservation of the water resources within the area. So, this in total the about the geological formations this behaves like an aquifer. Thank you very much.