Availability and Management of Groundwater Resources
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Lecture - 17
Confined and Unconfined Aquifer, and their Parameters (Continued)

Welcome you all in the fourth module confined and unconfined aquifer and their parameter once again. Today we will discuss the some specific conditions of aquifer in hard rock areas in part three.

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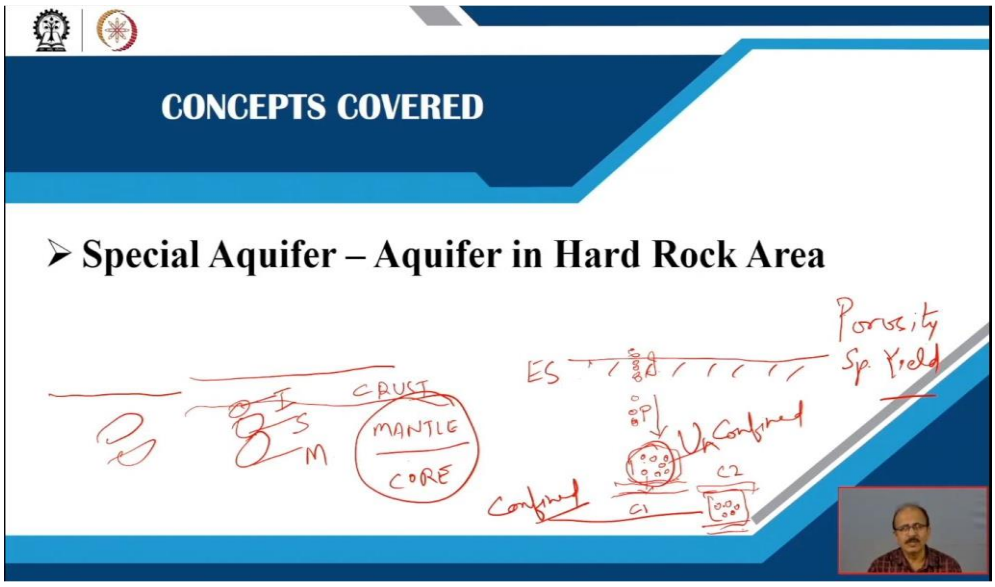

As we know that in the aquifer generally the groundwater remains underneath the earth surface. So, we have also seen how the water that is the rainwater or the sum of the water from the surface water just moves inside the earth surface by the different process of infiltration and percolation. This we have already discussed in greater detail. Now the point is that once the, water will enter inside the earth surface, so this is the surface inside water is entering just.

So, by the process of infiltration and by the process of percolation it reaches to the rock which is lying underneath the earth surface may be at shallower depth or at greater depth. So, these rocks are having some special characteristics that is why it is storing the water it is having some sort of restriction of the movement, downward movement in terms of the impermeable stratum. Sometimes, as we know in the previous slides, we have discussed also.

Sometimes this impervious stratum lies only just beneath the surface beneath the rock formations. And sometimes the impervious stratum remains at the top as well as at the bottom of the rock formations, so these rock formations are definitely holding the water. But the condition is that in case one the underneath impervious stratum is just down the rock formations whereas in the case two, the impervious the term is lying above as well as below.

Means it is only an underlying by impervious data it is overlying and underlying by impervious data. So, this is termed as the confined aquifer and this is termed as unconfined aquifer. So, this we have understood with the discussion based on the previous lectures. Now point is that this much we have become aware that this condition remains because the water will move towards gravity to ultimately the water just reaches to the formation which holds the water.

We call it as an aquifer on the basis of this condition. It has again been classified as unconfined and confined aquifer. Point is in the area today's discussion; it based on the characteristics of aquifer in the hard rock area. Because, we have discussed in the previous lectures that earth interior is composed of all the three important types of rocks; that is igneous rock, sedimentary rock and the metamorphic rock.

We have also discussed that these three important rocks remain primarily in the upper portion of the earth crust that is the called a crust. This is crust below it will come mental and then we are getting core. So, but we are not bothering for this area in the crusted areas generally we may find the aquifers at the saliva depth or add some greater depth. So, in these two conditions the point is that in some cases at on the surface.

In some cases, we are getting only the some unconsolidated formations or consolidated formations. So, generally, we are having consolidated and unconsolidated formations inside the surface. So, these formations will behave differently with the accumulation of the water body inside it. So, we have seen that in the case of unsaturated formations generally the water bodies remains in a greater volume.

In the case of semi consolidated we may get water but little then the unconsolidated formation, but in the case of consolidated formations it is very difficult to have water. Yes, we may get water but those water will remain either in fractures or some fissures or in some

joints where the cracks are there in those very areas only we may get water in the consolidated formations.

So, three important types on nature of the formations are there consolidated very compact. No space but we may get water where in some fractures in some your joints in some small fissures etcetera. Semi concentrated also we may get water but in unconsolidated formations of gravels your sand so, we are getting a very good amount of groundwater inside the surface. So, the condition of the soft rock areas where generally the unconsolidated and semi consolidated rocks remain.

There is no problem the infiltration and your percolation generally helps the process and the water accumulates inside the aquifer. Even the formation is your of sedimentary rocks or the formations of your very soft rocks, where there are more spaces we have also learned in the previous lecture that porosity and specific is very important factor specifically very important factor for and depicting any aquifers are best aquifer.

Because porosity as we know is nothing but it is the volume of pore divided by total volume of a rock. So, this is porosity and is yield we have also studied we have studied in the previous lecture that porosity is nothing but it is equal to the specific yield plus a specific retention. While, pumping only this much water the amount we are getting water while we travel. So, yield is very important for any saturated formations any your saturated formation.

The yield is very important in saturated formation generally we are getting very good yield. So, we are getting very good amount of water also while we travel but, this is the case of your soft rock area where hard rock remains in a very little amount in the soft rock area, there is no problem the infiltration and percolation process helps and then we may get groundwater in the underlying aquifers.

Now, today's discussion is based on the hard rock area because, our surface is met up soft rock area, as well as the hard rock area. So, every places we are having amount of groundwater but, at some places we are getting more amount of groundwater at some places we are having a very less amount of groundwater. So, this more and less amount is dependent on the type of rocks underneath the earth surface.

So, this today's we will discuss we will see how much water we can get when we will consider the hard rock aquifer.

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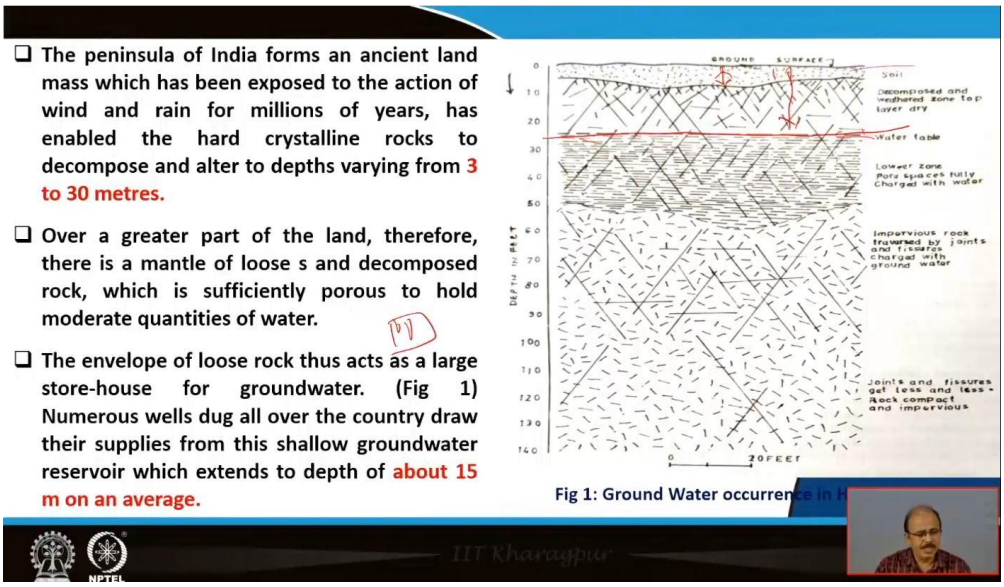

So, in the hard rock generally in peninsula India the southern India forms an ancient land mass, which has been exposed to the action of wind and rain for millions of years. So, what has happened it hard this line rocks decomposed there and decomposed to a depth 3 meters to 30 meters. So, in the peninsular India generally, which are the rock mass the hazard in exposed to the action of wind and rain, so weathering has taken place in a greater amount there.

And we may get some decomposition in the rocks to a depth of 3 meters to 30 meters. Greater part of the land mass, you can see loose and decomposed rock is sufficiently porous to hold moderate quantity of water. I have told you in the case of consolidated formations, it is a very difficult to have a greater amount of groundwater within it because there are no space. But because of the decomposition because of the weathering phenomena due to the natural legend that is wind and water, rain.

For these what happens some decompositions take place in the hard rock if it is a hard rock. So, it was exposed there in high rock areas, it will suppose, so some decompositions take place and some depths form within it some spaces forms within it. So, what will happen greater part of the land is having decomposed and then it makes mass more pores inside and if these pores generally hold moderate quantity not very high quality is a water.

But moderate quantity of water, we may get in the hard rock area also. The loose rock acts as a large storehouse for groundwater, so because of these weathering phenomena what will happen the loose materials the material which materials developed because of the weathering phenomena that acts as a good storehouse for the groundwater. Numerous wells all over the country draw their supply from this shallow groundwater to a depth of about 15 meters on an average.

And in the side figure we can see it is a very clear figure we can see here in the ground surface this is the ground surface. And ground surface we are just below the ground surface we are getting the different, different soil layer. So, again, soil is having different layers inside the surface the top soil is having some different typical behaviour chemical behaviour. Just the bottom soil which is just below the top soil will have different texture compositions and chemical composition.

So, anyway this in the hard rock area generally we get just beneath the earth surface the soil cover. And then we can get some decomposed and weather zone top layer drying the decomposed and weather zone. So, this zone has weather decomposed and they are dry also, these are dry also. So, in this way then after this since this layer is the decomposed so and whether. So, in this area just below in to this area we are getting the water table.

Means now we are getting the water table generally, in the hard rock areas, we may get the water table just blow the weather part weather and loaded part. So, now just below the water table you can see we are having a zone which pore spaces fully charged with water whatever zone we are getting pore spaces are fully charged with water. But it just below to this zone the impervious rocks traversed by the joints these are the joints.

And the impervious rocks have just filled up and fissures charged with groundwater. So, what has happened because of the impervious rock is impervious, so it is just traversing by joints and fissures. So, then these joints and fissures are charged with groundwater, these are charged with groundwater and at the just below it we can see joint and fissure get less and less because here, you can see much more quantity of joints and fissures we are getting.

But below it has reduced and here rock is compacted and totally impervious. So, what will happen the just the point is that in the hard rock areas generally we are having the chances of

getting water. We are having the chances of getting groundwater, but not to the extent what we are getting in the case of the soft rock areas where we are getting the unconsolidated formations, that is the saturated formations we are getting in a greater amount.

But here, saturated formation we can see, it is remaining there in the hard rock period remaining, so it particularly remaining at some bit depth. So, in the soft rock area, we may get aquifer in the shallower depth but in hard rock area generally we are getting the aquifer at the deeper depth. This is the important points in the hard rock area compared to the soft rock area. So, the volume by also we are getting more volume in the case of soft rock area.

We are getting less volume in the case of your hard rock area, why? It is also very clear that the top most layers after the soil layer is rather than decomposed. So, because of the weathering and decompositions of fissures and cracks develops in which groundwater may remain there, it. That is why since it is remaining groundwater is just filling the fissures and pores of the fissures and joints so we are getting the groundwater at this step.

We are getting this is the depth of the groundwater from the ground surface, this is the ground surface. So, here only does this is the soil layer only, so point is that in the hard rock area as we are going down, we are seeing also the fissures and joints are gradually decreasing and lastly, we are the rock becomes totally compact, impervious. So, it does not allow amount of groundwater remaining inside the rocks.

So, in this way generally groundwater occurs in the case of our hard rock conditions, hard rock condition means is what generally, the igneous rock and the metamorphic rocks like hard rock areas. Also, we have discussed already in the previous lectures that rocks igneous rocks and sedimentary rocks are generally we metamorphosing just by the action of temperature pressure and chemical agent just the mineral assemblages in the rocks are transforming changing.

And that is why the metamorphic rocks are just considered, those metamorphic rocks, which is whose parent is sedimentary they are very good repository of groundwater resources which parent is sedimentary but those it metamorphic rocks, which parent is igneous we may get very lesser amount of groundwater in that because, in the case of igneous we are knowing it

is a hard and compact rock, igneous rock is forming because of the consolidation of the molten magma.

So, since the formation so it is compact no time to have the making the space inside it. So, pore spaces are not remaining there, so cracks and fissures are not there yes, cracks and fissures may be maybe there it may develop there, but because of this crack and fissures will come while the weathering and erosion phenomena. If the rock mass will just exposed, then the natural agents like wind air water etcetera.

They may erode the superficial part of the exposed rock. Then what will happen because of this weathering and erosion and phenomena what the small cracks features will develop joints will develop and these clarifications joints will have some pore spaces within it and within it the groundwater remains inside the earth surface. So, this is the basic difference between the soft rock areas as well as the hard rock areas.

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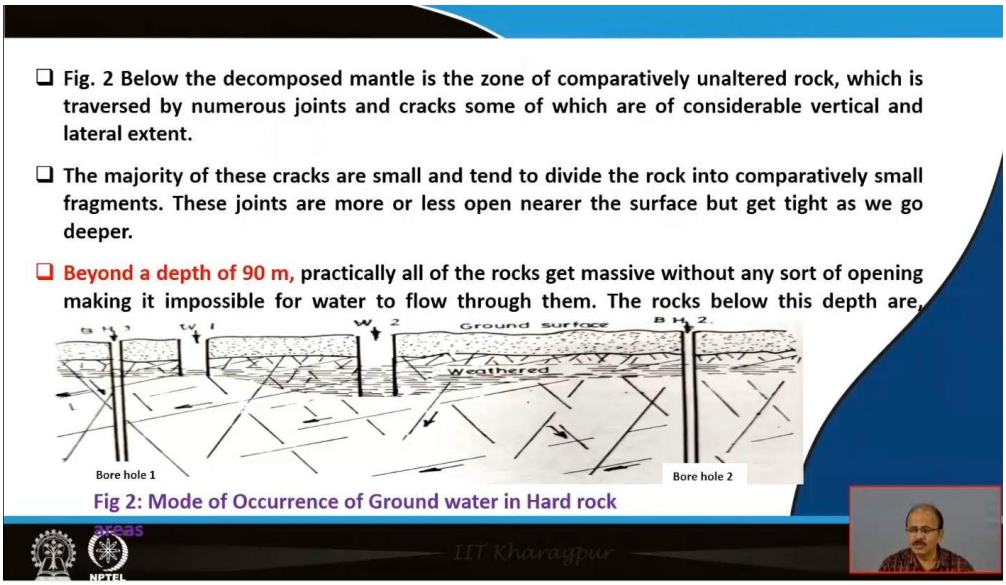

We can see some more discussion that, in this figure if you will see there is two well, well 1 and well 2 here two well is there well 1 and well 2 and the well 1 and well 2 is there and bore well is also there, bore well 1 and bore well 2. So, here we can see the in the case of this the cracks are majority developed, in the small cracks are developed and this is just dividing the rock into comparatively smaller fragments.

So, these joints are more or less open near the surface you can see they are open near to the surface but get tight as we go deeper because, in this place as it is the deeper side, we are

getting very less number of cracks here. So, what is happening beyond a depth of 90 meter practically all the rocks get massive beyond the rock 90 meter all the rocks get massive without any sort of opening and making it impossible for water to flow through them.

No water will remain inside it. So, rocks below this depth are very, very compact and they will not hold single drop of water within it.

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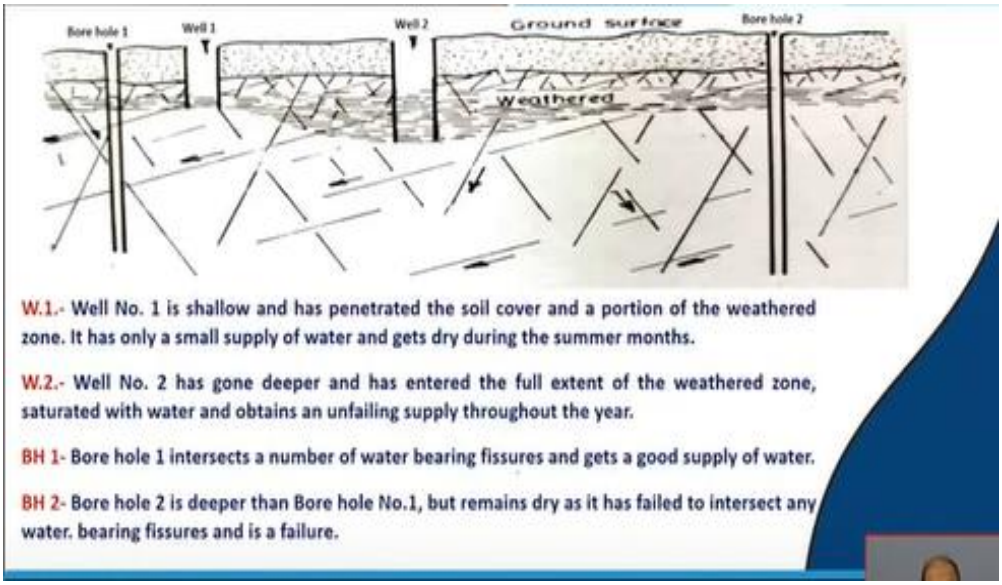

Now, here also we can see this is also here also the same figure is here well 1 will 2 is there ground surface is this one and the borehole 2 is here borehole 1 is here. In well number 1is shallower depth you can see well number 1 is adjust up to here it is shallower depth where as well number 2 is at a greater depth. So, well number 1 has been penetrated is dug with and it is just at the shallower depth it is well number one is a shallower depth.

And had penetrated the soil cover and a portion of the weather zone there, we have seen first there will be in earlier side we have seen that this is the land earth surface then this is the soil layer and then we will be getting the sum of the weathered zone inside it. So, suppose the thickness of the weather zone is up to this much and this weather zone is having the chances to have the water in some cracks and fissures whatever developed here.

But in the well numbered 1 is only up to the soil cover and just into the weathered zone, this is the weathered zone this zone is the weathered zone and this is the soil zone. So, well number 1 had just penetrated but it has penetrated the soil cover and a little portion of the

weather portion of the area. So, here only small supply of water remains here because it has not gone down small supply of water will remain here.

And so, what we as noticing that during the summer months this well become dry. Because, it is not having source of getting water from some other places. But what is happening in the case of well number two, it is going deeper you can see it has grown deeper it this way up to this much means just trust the without zone but here it has moved inside the weather zone. It has entered into the full extent of the weather zone.

Since it has entered to the full extent of whether zone, I have told you that in the fissures and cracks generally the water remains. So, what is happening this well 2 is getting sufficient amount of water and even throughout the year also in this well the water will remain there. Why? Because it has bore down a bit more deeper than the well number one in the weathered zone and in the very hard rock area.

If you will just recall the previous slide in the hard rock area the chances of getting water generally remains in the weather zone where the joints fissures your cracks etcetera will be there because these will only have some spaces and in this spaces only the water will means groundwater will remains. So, this is the condition of two different well 1 and well 2. Well 1 has been placed in a very shallower region that is just touching the soil cover.

And then the small portion of the weather zone whereas with well 2 has been penetrated from the soil cover to update more deeper in the weather zone. If you will penetrate more in the weather zone, what will happen more joints and fissure will be here? So, more amount of water, you may get in the zone where the well has been placed to a deeper zone in a weather zone. So, in the case of bore hole 1 also you can see bore hole 1 intersects a number of water bearing fissures, number of fissures it is just and get us a good supply water.

One fissure is up to this much then this much then this much. So, large number of fissures, it is traversing and getting this borehole one is getting good amount of water, but here what is happening the borehole is going down more deeper. Then, what is happening? It is remains dry and it has failed to intersect any water bearing fissures and then it is to keep failure. So, this usually happens in the case of hard rock areas.

In the case of hard rock areas generally, if you wish to have a good amount of water, you should take a bit deeper borehole in the area then only you may get some deeper aquifers in the hard rock areas because hard rock areas you are having only chances of getting water in some cracks, fissures, linear etcetera nothing else are there just like soft rock we will not get good amount of porous formations in which the plenty of water will remains.

In the hard rock area generally, the weather part is the part where the ground water remains in a greater amount. So, these weather part generally lie near to the surface more than at a deeper depth. So, that is why whenever you wish to have the groundwater supply generally, we should or you should take the shallower dug well to into a consideration compared to the deeper dug well.

Because, deeper dug well will be not there deeper bore well will be there and through deeper bore well may get water. In India also we are having certain state in which we are having hard rock terrain where you can see shallow deep tube well and deep tube well remains. A good example is our NCR areas Noida area you can rigid you can see large amount of wells are there, but those wells not the shallower wells those are remaining shallow deep tube well deep tube well.

So, by because the hard rock terrain is there only the way in the weather part there are chances of having the water and then they are just distracting the water withdrawing the water from the locality and sending it to the nearby areas. So, this is the condition of the hard rock areas.

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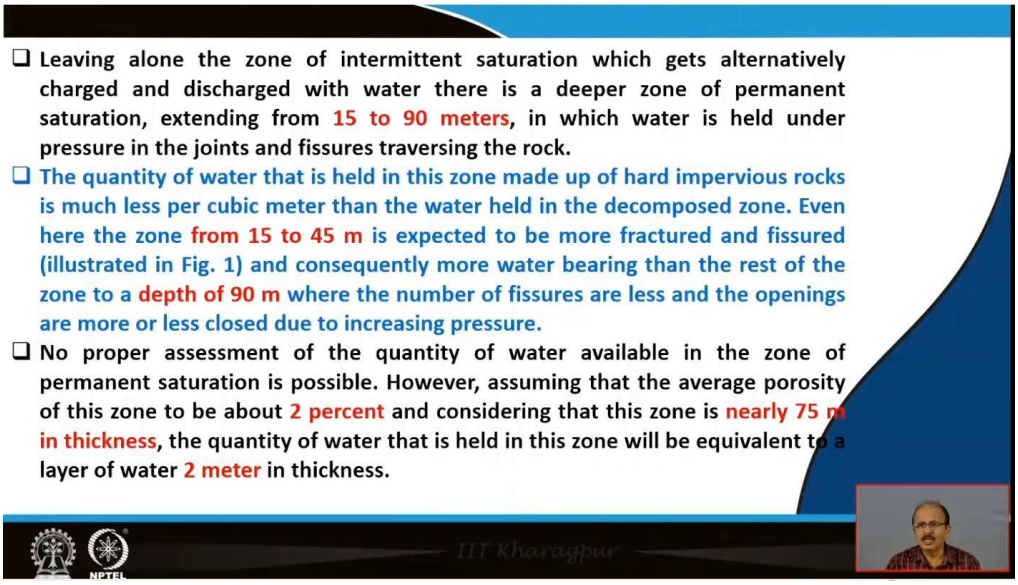

Now living alone, the zone of intermittent saturation which gets alternatively charged and discharged with water there is a deeper zone of permanent saturation. In which water is held under pressure in the joints and fissures traverse in the rock, this is also very important consideration. So, alone in the zone of intermediate saturations, you get alternatively charged and discharged with water.

It is very important at some depth say from 15 to 90 meters depth water remains. But it remains under pressure where in the joints and fissures travers in the rock. The quantity of water is held in this zone and which made up of hard impervious rock is much less per cubic meter than the water held in the decomposed zone. So, this is the important factor here the even here the zone from 15 to 45 meter is expected to be more fractured and fissures.

And consequently, more water bearing than the rest of the zone to a depth of 90 meter where the number of fissures are less and the openings are more or less closed due to the increasing pressure. So, this generally happens in the case of the hard rock areas, the quantity of water is held there. I mean the hard-impervious rock that will be there but the point is that at a greater depth you may not get the good amount of water.

Why? Because, the; number of fissures are less and the openings which remains earlier has been closed and due to the increasing pressure. So, what is happening the quantity of water generally in this zone in the hard rock zone is becoming less and less as the different time periods continues in the summer periods you may get ground water. But compared to the pre

monsoon in post monsoon season you may get a bit greater depth doing the pre monsoon season.

So, the time you also place very important role the season plays very important role. No doubt in the hard rock areas, there are chances of getting water but though you water will remain in cracks and fissures only and those cracks and fissures are developing by because of your weathering and erosion phenomenon.

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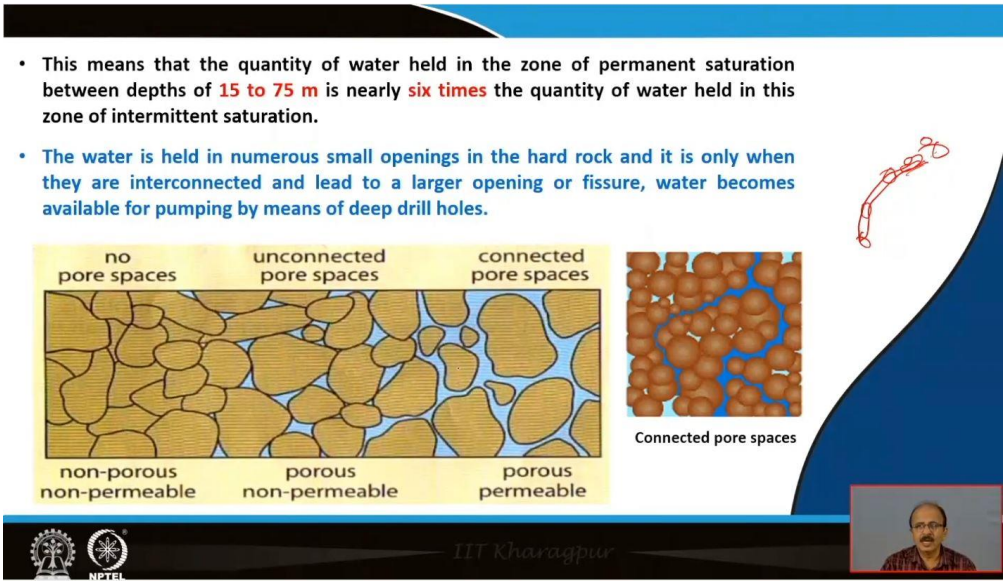

Now, we can see that the quantity of water held in the zone of permanent saturation between depths of 15 to 75 meter. Generally, in the hard rock areas if you will see the quantity of water remains near to the 15 to 75 meter depth, which is nearly 6 times the quantity of water held in the zone of intermittent saturations. So, this is generally studied as the, lots of studies has supported this point.

That the quantity of water will remain in the permanent saturation conditions only which, usually lies at the depth of 15 to 75 meter below the earth surface. Now this water is held in numerous small openings in the hard rock and it is only when they are interconnected and lead to a large opening of fissures. So, small opening supposes, this is small opening small openings are there.

So, these small, opening will interconnect because of the some of the geological phenomenon it will interconnect. So, then it will have some chances you can see small openings are there and then in the pores these openings have connected fissures this in the form of just like

fissures it is connected and through it the water just moves inside the earth surface. So, here you can see this formation is having no pore spaces what we are getting in the case of compact rock no pore spaces.

But in the case of some of the soft rock is conditions, we are getting good amount of pore spaces here also we are getting porous spaces but the porous spaces are not connected with each other or among each other. So, it is not connected among each other but here the pore spaces are connected with each other. So, this is now more porous and permeable formations in which there are chances of getting good groundwater in quantity inside the surface.

But in this case and in this case, you will see in this case there are no porous spaces. So, no need to have water in this because there are no chances of having groundwater in this where the ground water element there are no pore pressure. So, in these impermeable conditions because these are not nonporous and non-permeable. So, here we are not getting the groundwater inside the surface.

But in this case, it is porous but non-permeable however, it is varying water it is porous but it is not having the ability to move the water. So, what is happening this is because of the unconnected porous process the formation is porous although but not permeable. But this is having the pore spaces as well as the ability to transmit also because they are interconnected. So, generally what is happening the water is held in numerous small openings in the hard rock.

And it is only when they are interconnected lead to a larger opening or fissure water becomes available for pumping by means of deep boreholes. So, this is the criteria for getting water in the hard rock. In the soft rock there is no problem in the soft rock areas we can get groundwater in greater amount. But in the hard rock it is having problem because this water we are getting at a greater depth. So, this is the problem with the hard rock and the soft rock area.

In both the conditions we are getting the water but, in the case of soft rock conditions, there are chances of getting more water compared to the hard rock theorem, the point is that in the soft rock we are having good amount of pore spaces. So, these pore spaces are interconnected

also, so these rocks are porous as well as permeable because they are able to transmit or receive the water.

But in the case of hard rock areas, we are having the chances of getting water only in the weather part of the rock. So, weather part after the soil layers generally the weather part remains and in the weather part what we happening because of weathering phenomena small fissures, joints, cracks etcetera developing and these small fissures are cracks are having some spaces into which generally the groundwater stores there and it remains there.

But as we come down as we interest into depth greater depth you will never notice good amount of your cracks and fissures. So, we are not getting a very good amount of groundwater. In general, at the depth of 50 into 75 meters generally, in hard rock areas, there are chances of getting good volume of water because of their permanent saturations at these depths. So, with this just I am finishing the concept of the groundwater storage in the hard rock areas. Thank you very much to all.