Availability and Management of Groundwater Resources

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Lecture - 15
Confined and Unconfined Aquifer and their Parameters (Continued)

Welcome you all once again in the NPTEL course on the subject availability and management of groundwater resources. Today we will discuss the fourth module related to the subject entitled confined and unconfined aquifer and their parameters. So, from the very beginning we have started from the hydrological cycle important cycles which give us the availability of groundwater resources within the earth's surface.

There were several parameters of the hydrological cycles we have seen. The infiltration, the percolation, the evapotranspiration, then the runoff, then the precipitation and among all parameters the one recharge parameter is available in the nature that is the precipitations. So, within that we came across that the precipitated water infiltrates down to the soil layers and then the rock layers inside the earth surface percolates.

And then it moves towards the gravity store in certain rocks in rocks and within the rocks the generally groundwater remains inside the earth surface. So, this movement we have seen in the very first lecture. In the second lecture, we have seen some of the formations the important formations the geological formations, which generally hold the groundwater. And the third lecture we have seen that the some of the zones inside the or surface vadose zones, saturated zones live within the earth's surface.

Which are also very important for the movement of the groundwater inside the earth surface. So, now today we will concentrate on the confined and unconfined aquifers and their parameters.

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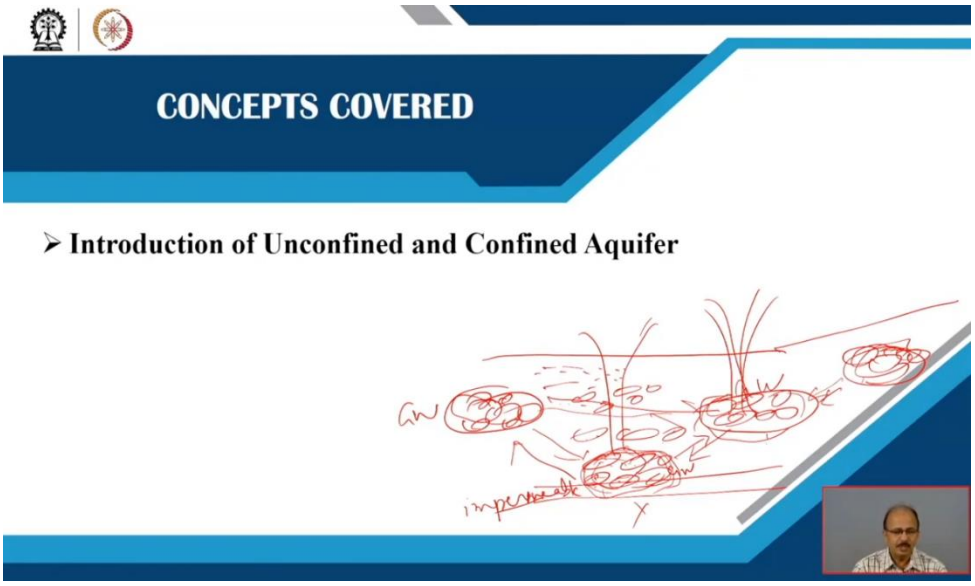

We have seen if we will just see we have seen that inside the earth surface we are having some for layers inside the earth surface we are having the different formations say at the just beneath the earth surface we are having the soil formation then small, small rock formations and in this way, we are getting we are having some bigger rocks and then our rocks which is holding the groundwater.

So, this is this one is impermeable rocks and here you above it just these rocks are having the behaviour to store some of the rainwater as a groundwater. So, this behaviour generally we have seen and we have termed these rocky formations as an aquifer. So, these aquifer today's we will just enter in the greater detail about these rocky formations because we have in the prior whatever we have discussed in the earlier lectures which we have discussed that the; different rock formations because the rock formation has come up with the different age during the different age. These rock formations have been created and the characteristic of the different formations inside the earth surface is also having different in nature. So, what is there that those rocks from the very beginning we have learned that those rocks which is having the ability to store the water.

It is very important that it the rocks should have the porous structure that is it is having some pore volume also. So, in the pores the rocks will be there a water will be there and this behaviour of the rocks formations which is just to storing the water in it is known as the porosity, we have

learned earlier porosity. It means that the rock which is holding the groundwater should have a very good porous behaviour.

So, what this is one thing. Second thing this is the one setup of rock inside the earth surface this is the second set of the rocks which is also bearing. This is also holding the ground water, this is also holding the groundwater, this is also in the ground water. So, similarly this is another set of formations which is also having the grounwater. So, suppose this set of formation is having good amount of ground water.

Then what will happen, if it will be extracted then it will the volume of the water will reduce here. Then what will happen? Time will come then there will be no water in these formations. So, what should be the second property? First property that is to have the ability to store the water good, so what should be the second property that this aquifer should have ability also. What ability for what? Ability for receiving the water from another aquifer, as well as transferring the water from this aquifer to this aquifer this property should be there. This property should be there. Then what will happen? Suppose we are extracting the volume of water from this aquifer if it is having the ability to receive the water then what will happen from this aquifer the water will come here and it will fill up.

Otherwise, if not then what will happen then we will see that this aquifer is just it will remain dry because the water has been extracted already, so no amount of water is there. And since it is having no characteristic also it is having it is good it is having good porosity. But ability to transmit the water is very poor. So, it is not a good aquifer but here what we are seeing that this is also a very good formation which is holding the water inside the earth surface.

So, here what we are seeing this is an aquifer this is a rocky formation first, this rocky formation in from it also we are just drawing the water strapping the water. So, what is happening; the volume of water is reducing in this since reducing in this but what is happening? Just from this aquifer and this aquifer the remaining water whatever water has been extracted is again filling this aquifer.

So, it means that not only this aquifer is good but these two are aquifer also good because they are holding the water and when they were needed it also able to transmit the water to one aquifer to another aquifer. So, it means that underground formation underground geological formation should have ability to store the water as well as to transmit the water. And on that basis the two different types of aquifers have been classified known as unconfined aquifer and confined aquifer what we have discussed just now.

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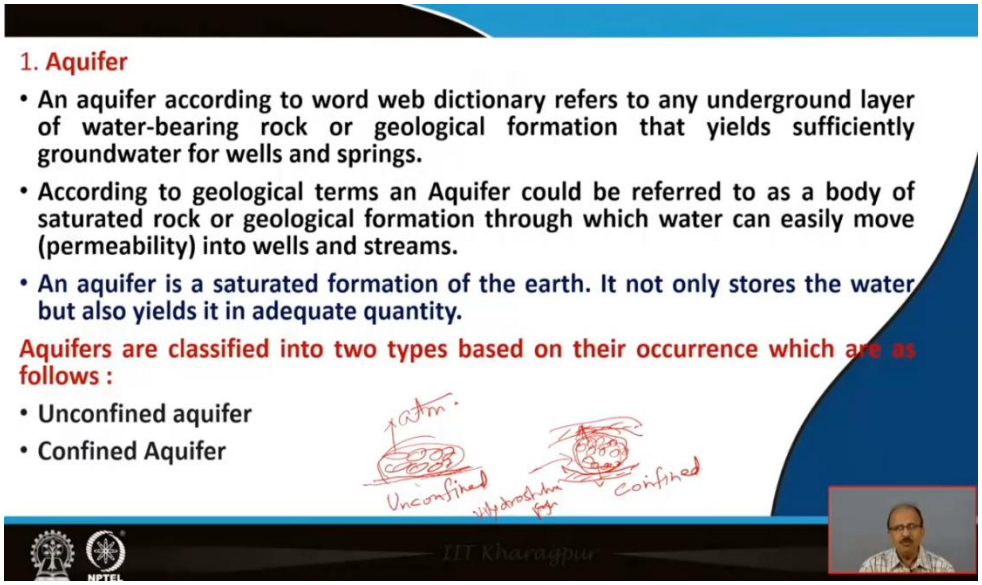

So, this is the two different types of aquifer one is the confined aquifer another is a unconfined aquifer. First of all, we should know aquifer is a rock formation, underground rock formations or water bearing rock formation or geological formation which yields sufficient amount of groundwater from for wells and springs. So, this is having sufficient amount of water. According to some geological meaning aquifer can be referred as a body of saturated rock.

Since it is having the water so a saturated rock or geological formation through which water can easily move into wells and streams. So, again the point permeability is here it is having the ability to transmit the water. So, what is in actual sense aquifer is a saturated formation of the earth surface and it not only stores the water but also yields it in adequate quantity. So, only the storing is not the characteristics of any aquifer.

But whenever needed; it can yield a very good volume of water also, so this is called an aquifer. Generally, on the basis of their occurrence it is very important on the basis of their occurrence the aquifer is divided into two important types. First is called as unconfined aquifer and second is called a confined aquifer. So, as the word just describes unconfined means the formations the rocky formation is definitely remaining in unconfined mode.

Means it is not confined means it is not just in a closed manner. So, this is a set of formations the geological formations which is having the ability to store the water but this aquifer is having a permeable bed just for stopping the water on the this very area. So, if there will be no impermeable beds here, then what will happen the water will again move down and then it will hold the water not at this place but to some different place.

Whereas in the case of confined, confined means some rock formations are there, these rocks formation are porous in nature, so these are having the water but point is that it is tightly being enclosed from the top as well as the bottom. So, what is happening? In this case the water in the formations remains with the hydrostatic pressure it remains with the hydro static pressure. Whereas in this case, the water in the formations it remains with that contact to the atmosphere that is the atmospheric pressure.

So, here since it is confined and confined means just at the top as well as bottom of this formation which is having a very good porous behaviour having a very good volume of water is just being restricted to move the water up and down by some impermeable beds. So, these beds are impermeable means these beds are having the characteristics not to receive the water not to send the water. So, this is the case.

So, what will happen? The water in this area will remain in a very great pressure this is known as the hydrostatic pressure. Now since in this case this is also a formation geological formation this is also formation but, in this case, only the formation is covered by impermeable layer just beneath it or in the bottom, whereas here at the top as well as bottom we are having the layer geological formations which is just including the water body within the area.

So, here the water remains with great pressure that is hydrostatic pressure where there here in this case the water remains with the at most contact with the atmosphere that is with the atmospheric pressure. So, this type of rectifier is termed as unconfined this is not confined, so it is unconfined whereas this type of refer which is just overlain and underlain by confining beds or some formations or some rocks, which is not transmitting the water nor receiving the water.

So, this is called as confined aquifer. So, this is the basic difference between the confined aquifer and unconfined aquifer. The point is an aquifer is a rocky formation which is having the water storing ability as well as ability to transmit the water from one aquifer to another aquifer. Second is that this on the basis of occurrence the aquifer means the rocky formation inside the earth surface because we have to know about the ability of the groundwater resources.

Now we came aware that the water will remain inside the earth surface in certain rock formations. Now we have also understood that the rock formations should have the important characteristics in the form of porosity and permeability are greater details we have understood that the rock formation which is just holding the water it is having good porosity as well as good permeability.

So, now we have understood that the groundwater remains in rock formations and these rock formations may be either the unconfined type of rock formations or confined type of rock formations. So, these rock formations are termed as aquifer either in unconfined aquifer or in confined aquifer. The confined and unconfined aquifers have been divided on the basis of overlain and underlain by some confining beds.

If the aquifer is just underlain by any confining beds, confining beds means those beds which are having the porosity which are having the ability to store the water but not having the ability to store to transmit or move the water from one aquifer to another. So, this criterion has subdivided the aquifer the rocky formations into two different categories. What is we are knowing as a unconfined aquifer and confined aquifer? Now, we will understand some greater detail about these two.

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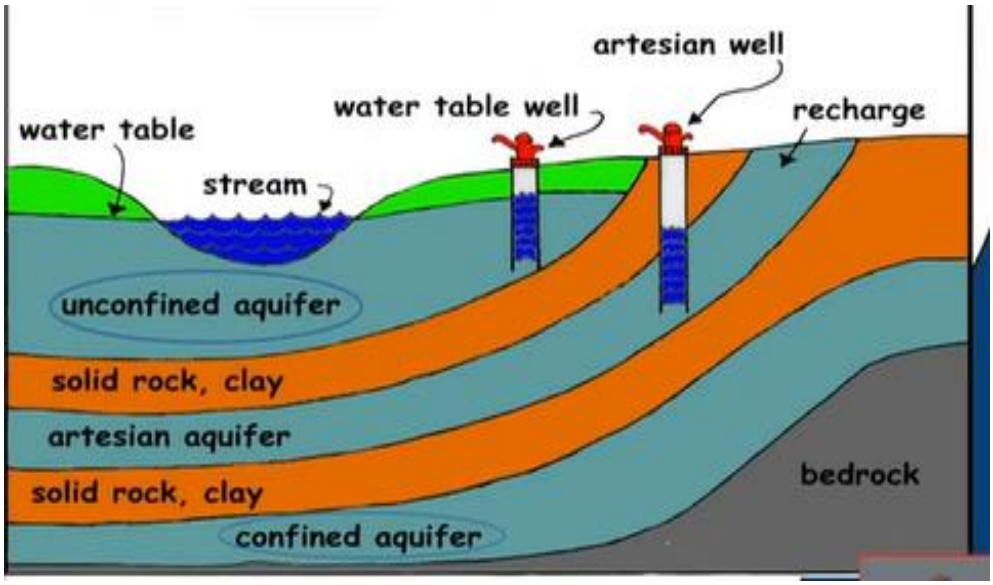

Here we can see, this is a very small sketch about the just showing you the different types of aquifers, here we can see that the unconfined aquifer. Why unconfined aquifer? Because here some rock is there lock is solid rock and this is clay solid rock means consolidated rock I have told you in the consolidated rock there are lesser chances of getting pores rather we are having the chances of getting fractures or lineaments.

Where this is clay, clay is also a type of confined beds. So, what is the; it is also restricting the movement of water it is the store water here the store groundwater here that is why this formation is termed as unconfined aquifer. But it is not allowing this layer of the rock formations inside the earth surface. They are not allowing to move the drop of water from unconfined aquifer to this aquifer.

So, what is happening? In the case of unconfined aquifer, we have seen that the top part of the unconfined aquifer called as the water table. So, here we are getting the water table. Now in the case of this one is the case of artesian aquifer; here we can see the valley is there because water level moves up to here. Now just beneath it we have having the aquifer known as confined aquifer, confined aquifer means we are having the bedrock her.

Bedrock or consolidated rock it is not having the ability to store the water, it is not having to ability to transmit the water. Above it also or the solid rock clay, which is a confining bed, so

these two beds just restricting the volume of water to remain here only. So, this is called as confined aquifer. In the case of confined aquifer, the water remains with greater pressure whereas in case of unconfined required the water remains just open to the atmosphere.

So, here we are getting in case of unconfined aquifer the water remains with the atmospheric pressure where here in the confined aquifer the water remains in the hydrostatic pressure. So, this we have seen.

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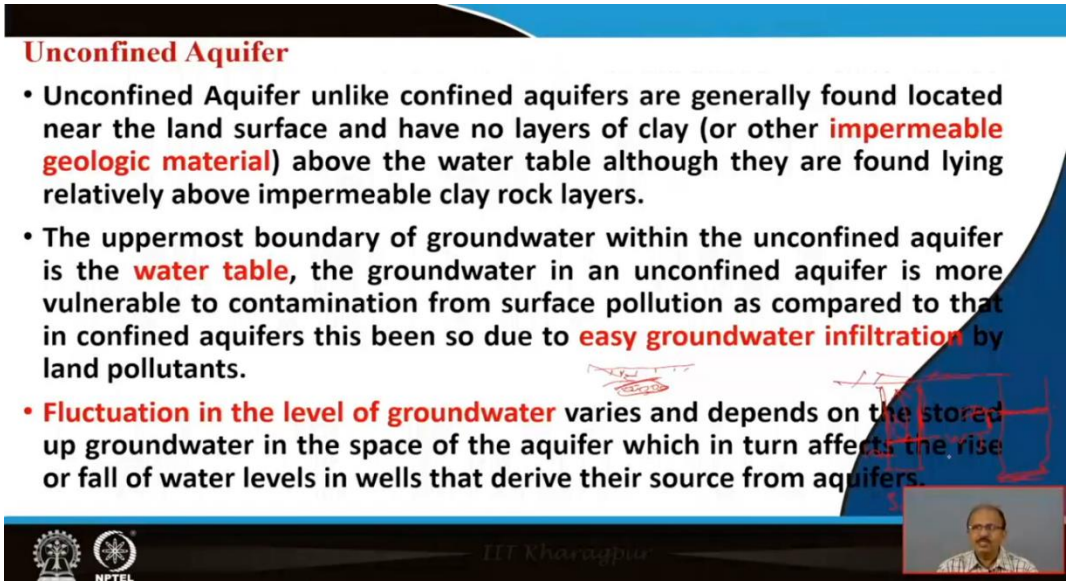

Now if you will see in detail, this unconfined aquifer just are generally found located near the land surface. Generally, we can we are having the unconfined type of aquifer in the shallower depth or near to the land surface and having no layers of clay, clay we are knowing it is a permeable geologic material clay above the water table, although they are formed lying relatively above impermeable clay rock layers.

So, generally unconfined aquifers are found located at the shallower depth without any clay layers. Because clay having the property that it will store the water it will having the ability to store the water but it is not having the ability to transmit the water to move the water. So, that is why the unconfined aquifer generally lies at the near to the land surface just near to the earth surface and the uppermost boundary of the unconfined aquifer is termed as the water table.

So, uppermost boundary of the unconfined aquifer is termed as water table the ground water in a confined aquifer is more vulnerable to contamination from surface pollution as compared to in case of confined aquifers. Because in the case of confined aquifers it is a bit deeper and easy groundwater infiltration by land pollutants are generally seen noticed in the case of unconfined aquifer.

So, this is there in the case of unconfined aquifers the contaminants flow is more whereas in the case of confined aquifers generally we are getting less pollution in the water of the confined aquifers. Now fluctuation in the level of groundwater, this also is there in the case of unconfined aquifer because we have seen the case of unconfined poor just beneath the earth surface that shallower depth the aquifers which are remaining it was nothing rocky formations which are remaining.

This top part in known as the water table which just remain in open to the atmosphere. Pollutants we have seen that land pollutants are really available to mix with the shallower unconfined aquifer. So, in this aquifer the water table what we have seen, the upper part of the water groundwater level in the unconfined aquifer termed as water table. This generally fluctuate depends on the different times and of the different season.

It behaves just vary from one depth to another depth. So, this means that suppose in during the summer time generally the water table remains at a greater depth. So, if this is the earth surface so and if this is one of the shallow dug well is here and this dug well is of the unconfined in nature behaviour and this is the water table. So, during the summer season this water table remains at this place.

But what happens and this is the just the; your well what we have constructed here. So, this is the depth of the water in the well ‘H’. Now what has happened next during this is it is in the summer season, summer season the water table is here. After monsoon the same well the what we have seen that this water table just rises up, it rises up. Now the water table just arises this much. Why? Because of the infiltration percolation and more amount of water interest into the rocky formations, so level of water increases after monsoon.

So, this is during the summer, this is during the post month soon, so after monsoon. So, level of water increases, so what is happening, the water table comes at this place. It is just enhances the problem this level to this, say if it is 10 meter so it has just come to 7 meters. So, what is happen? This is meter below ground level MBGL. It is 10 MBGL and this is 7 MBGL. So, after monsoonal season, we have noticed that just the water table which remains open with the atmosphere it fluctuates with the up and down of the atmospheric pressure.

So, what has happened is it is just risen up after the monsoon seasons in during the post monsoon season the same water table has risen up which has grown deeper during the pre-monsoon or summer season. The concept is that this water level generally fluctuates and this fluctuation behaviour is very important in the case of your unconfined aquifer. So, this thing we have noticed in the case of unconfined aquifer.

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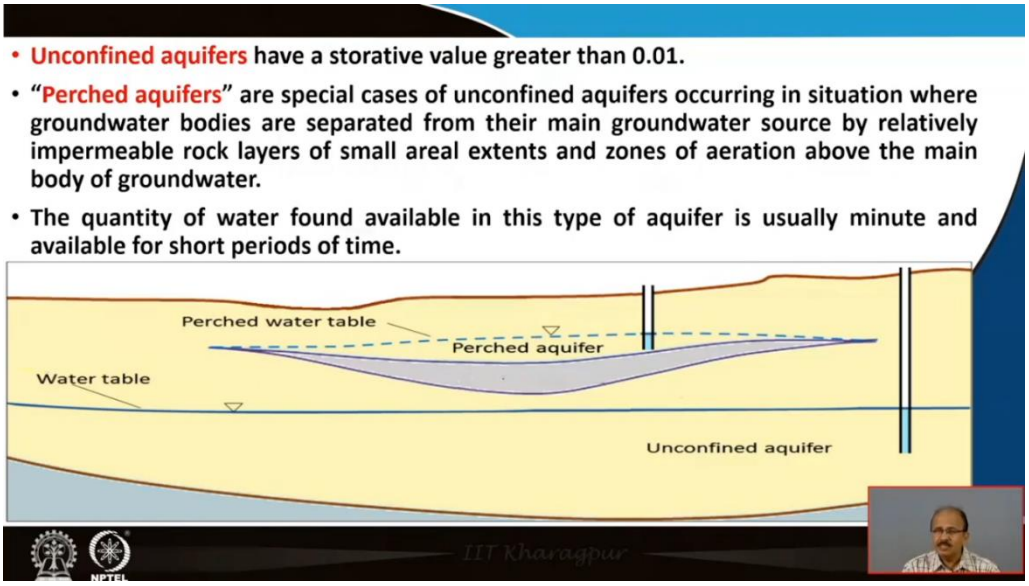

Now in the case of unconfined aquifer one important characteristic is that it has the storative value greater than 0.01. So, now one special case of unconfined aquifer is termed as the perched aquifer. This also we have we are noticing at some places on the earth surface that in the unconfined aquifer, in the case of unconfined aquifer means in the case of unconfined aquifers will exist when some confining beds will remain underlain inside the aquifer or just at the bottom of the aquifer.

So, aquifer has become unconfined in nature, but in between or at certain specific place within the unconfined aquifer all of sudden some impermeable beds come or impermeable rock layer exist which will restrict the moment of water down. We can see here this is a confined aquifer, this is unconfined because this is the confining beds just underlain at the bottom and this is just the layer of the water in the unconfined water table you have seeing here.

But what we are noticing one small impermeable rock layers of aerial extent came here. And just it separated the water, this water table from to this water table means what is happening here the quantity of water found available in this type of aquifer is usually minor very small in amounts and for very short period of time also because it is just separated from the main groundwater source by relatively impermeable rock layers or small aerial extents.

So, above the main source of groundwater this is the ground water, this is unconfined layer, in between if sometimes we are getting some of the impermeable rock layers, then it is forming some another water table and those water table is known as the perched water table and this just is the special case of unconfined aquifer not the confined aquifer.

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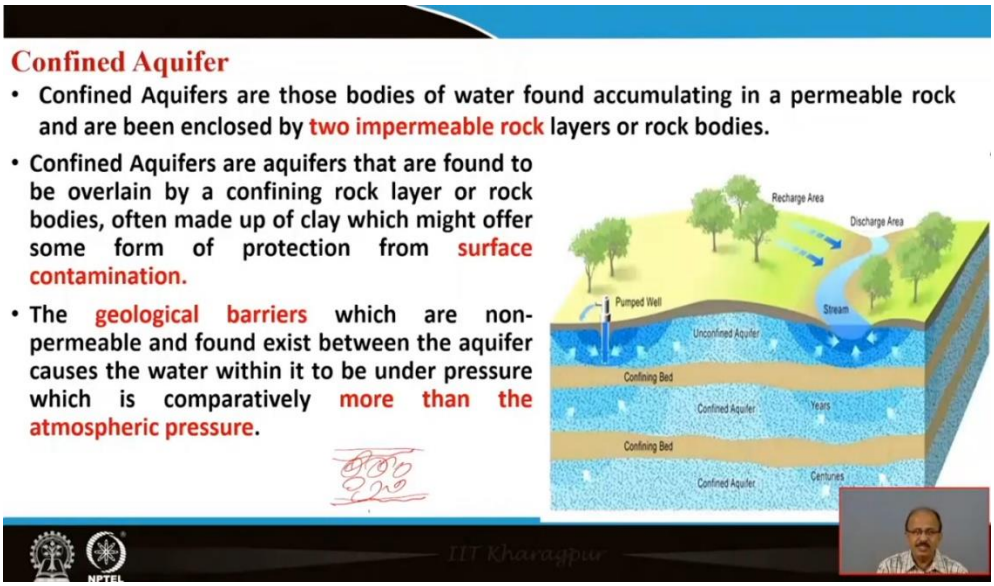

Now confined aquifer, just see confined aquifers are those as I have discussed confined aquifers are those body of water found accumulating in a permeable rock and have been closed by two

impermeable rock layers of bodies. So, I have discussed in the previous slide also, if suppose any formation are there and if these formations are overlain as well as underlain by some impermeable rock's formations, rock of formations.

Then this type of groundwater which remains being enclosed within these in impermeable rock layers; unknown as the confined aquifer. So, confined aquifers are aquifers which are just overlain by some confining rock layer or rock body, generally made of clay or some form of protection from surface contaminations. So, this is having lesser contamination compared to the unconfined aquifer.

The geological barriers which have generally non-permeable and found exist between the aquifer causes the water within it to be under pressure. This causes the water to remain under great pressure and this is compared to more than the atmospheric pressure. So, in the case of a confined aquifer the water remains in a greater pressure compared to the unconfined aquifer.

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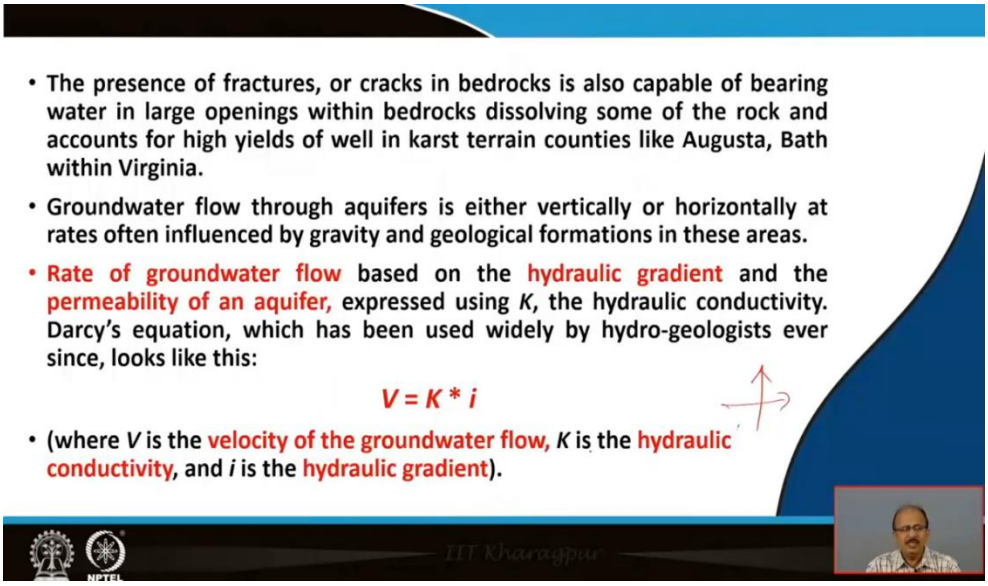

Now the presence of fractures of cracks in bed rocks because every water body is having some bedrock. And if the rocks are having some sort of fractures of cracks then what is happening is capable of bearing water in large openings within bedrocks dissolving some of the rock. So, some of the rocks are having some large openings because of the dissolving nature and account for high yields of well also, it gives the high yields of well also.

And therefore, the groundwater flow through aquifer is either vertically or horizontally at rates often influenced by gravity as well as geological formations in these areas. So, these two decides about the rate of the groundwater flow because very important is inside the earth surface the rate of the groundwater flow is very important and it is been influenced by the gravity as well as the geographical formation of the areas.

So, what we have seen that rate of groundwater flow is based on the hydraulic gradient and the permeability of an aquifer. So, these two very important parameters, generally expressed by K, the hydraulic conductivity is expressed by K Darcy's equation. Darcy is one of the scientists who has just given us an equation in the form of

$$V = K * i,$$

where V is the velocity of groundwater flow,

K is the hydraulic conductivity and

i is the hydraulic gradient.

So, this equation, Darcy's equation is widely being used for the rate of groundwater moment. So, this we will discuss in the later class also related to the Darcy's law. Now, what is happening in the case of confined aquifer the presence of fractures of cracks in bedrocks is capable of bearing water in large openings within the bedrock. Dissolving some of the rock, here the generally the water we are seeing in the case of confined aquifers.

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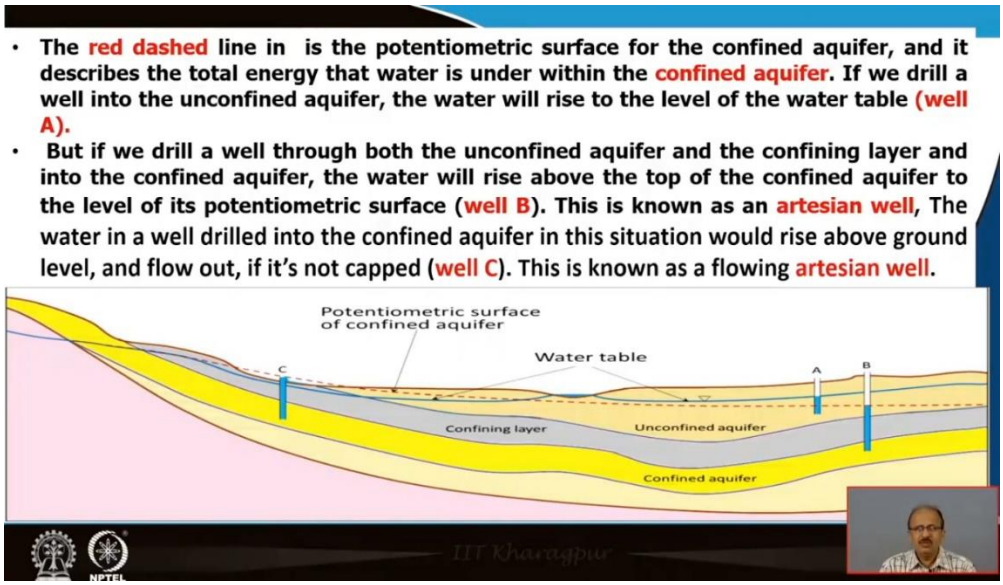

Now if you will see the diagram just below a potentiometric surface generally, we are getting in the case of confined aquifer, we are not getting in the case of unconfined aquifer. If described the total energy potentiometric surface in nothing but it describes the total energy that water is under within the confined aquifer. So, just if you will drill a well into the confined aquifer the water will rise to the level of the water table.

So, if thus we will confine with the water is rising just to the water table. But if we drill a well through both the unconfined as well as confined, this is unconfined this is confined. Then what will happen? The water will rise above the top of the confined aquifer to the level of its potentiometric surface well B, you can see here in the case of well B this is the potentiometric surface up to here.

If you can drill the; confined and unconfined the water level will rise up to the potentiometric surface, well B example. This is known as, this type of well is known as the artesian well. And the water in a well drilled into the confined aquifer in this situation will rise above the groundwater level and flow out, this will flow out here you can see then, it is not capped. So, this is known as the artesian well.

So, this potentiometric surface plays very important in making the different types of artesian well conditions and the generally confined conditions we are getting we are seeing, this is playing

very important role. So, the conclusion is that the; rocks which are the geological formation that has been made in different time period is having the properties of porosity and permeability. These are having the pores ability to store the water as well as to transmit the water.

And these rock formations if meeting with some type of impermeable rocks overlain or underlain, then this decides the formation of the two important type of aquifers. The former which is underlain only underlain by any confining beds is known as the unconfined aquifer. The latter which is when the underlain and overlain by any confining beds then such type of known as confined aquifer.

We are getting water table in the case of unconfined effort, whereas we are getting potentiometric surface in the case of confined aquifer. In the case of unconfined aquifer with the water remains with the atmospheric pressure whereas in the case of confined aquifer the water remains with the hydrostatic pressure. So, with this background now we will we can conclude that groundwater resource remain inside under certain aquifers may be unconfined aquifer or in confined aquifers. Thank you very much to all.