Irrigation and Drainage
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Lecture - 26
Irrigation Well

This is lecture number 26. In this lecture we are going to learn the Irrigation Wells. So, this week and the following week we will be concentrating on I mean some information from irrigation wells, as well as irrigation pumps ok. So, because these are important, when you are talking about extracting water or a (Refer Time: 00:43) I mean water to the field.

So, we have seen how to you know get water from canals? So now, in the local if you have some water sources like in irrigation wells. So still we need to understand; how to get the water from irrigation wells for the irrigation purpose.

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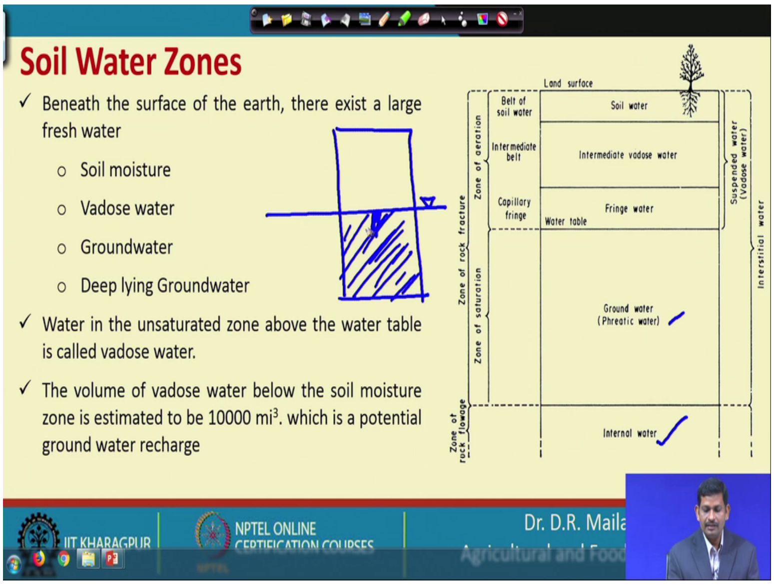

So here, in order to understand that we need to know the soil formations and what are the different soil water zones; just to understand, and what is an aquifer, what is not a good aquifer right and the aquifer properties. So, in this lecture we will be focusing on the aquifers and their properties ok.

So now, see here the soil water zones. So, if you start digging the soil from the surface right. So, you can observe different zones ok. So, the first zone here if you see. So, the first where the crops are grown so, this zone is called soil water zone right. So, this is as for as crop production is concerned this is important this zone. And then, so this is the soil water zone ok. So, then below that there is intermediate zone and then fringe water zone and the groundwater and internal water. So, if you take a profile like this ok; so here, generally, this groundwater where the soil is completely saturated. So, if you dig hole in this particular point right and definitely you get water ok.

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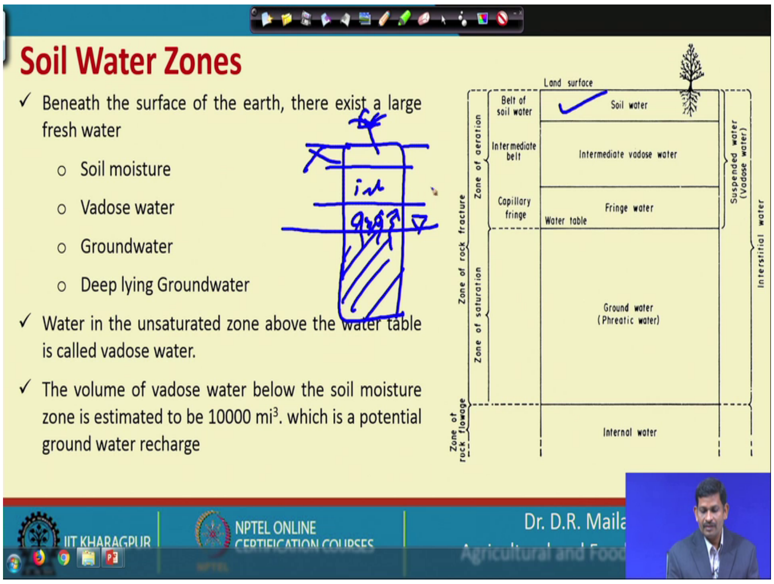

And if you make half of this for example so, this is the water groundwater and above this is the surface ok, this is the plant. And, the first zone here you see the soil water zone right, and the second is intermediate zone, and this is a capillary zone because the groundwater can move upwards due to the capillarity.

So, these are the main zones the first soil water zone, intermediate zone, capillary fringe zone, groundwater and this is the internal water. So, this is not accessible for usage ok. So then again, so this is called belt of soil water and this is intermediate belt and this is a capillary belt.

And so these whole thing from here to here so, since it is I mean the soil pores are not filled with water and I mean every time. So, that is called suspended water right, suspended water or zone of aeration. So, this is called zone of aeration, because the pores will have air in it both air and water in it. Whereas, there is a another zone it is called zone of saturation. So, where you see the pores are completely filled with water. So, that is the zone of saturation ok.

And from here to the zone of aeration, this is zone of aeration it is also called the Vadose zone ok. So, vadose zone is unsaturated zone. So, which start from you know land surface to the water table ok. So, that is the complete zone of aeration vadose zone water. So then, this is called the zone of rock fracture. So, where the water is available and the zone of rock flowing. So, this water will not be available for utility and ok. So, this way at least we understand what kind of water, which is present in the soil. So, the first is soil water, intermediate zone, and capillary fringe, and groundwater and then this is unavailable deep water deep groundwater zone ok.

So, here the top of the saturated zone or groundwater zone is called the water table. So, water table is the top of the groundwater zone. So, that is called water table. And, this water table is influenced by atmospheric pressure. So, directly you can have the influence of atmospheric pressure, because this soil is not completely filled with water. So, there is a atmosphere interaction to the zone. So, the pressure at the water table is equal to the atmospheric pressure ok.

So, again the groundwater if you see the volume of Vadose zone below the soil moisture zone is estimated to be around 10,000 mile cube. So, which is a potential groundwater recharge so, which is a potential groundwater recharge. So, here what we are expecting up to this whatever water, which is stored in the vadose zone will be contributed to the groundwater recharge and that will be estimated as 10,000 mile cube ok.

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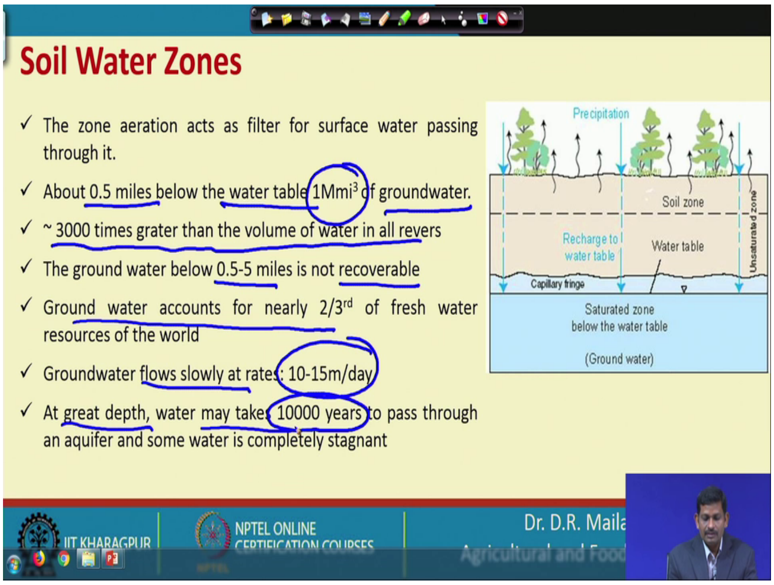

And then, the next if you see this Soil Water Zones further, the zone of aeration is acts like a filter. So, if you remember this we have like this is zone of aeration and zone of saturation. So, zone of aeration which acts like a filter for the rainfall, rainfall infiltrates down and this is a filter meter this is zone of aeration and recharge to the groundwater.

So, from the water table if you go below 0.5 miles, so that accounts about 1 million mile cube of groundwater ok. And, that will be around 3000 times greater than the volume of water in all rivers. So, it is a huge amount of water, which is lying as groundwater ok, which is below 0.5 miles from the water table.

And, the groundwater below 0.5 to 5 miles is not recoverable. So, this is simply lying over there and it is not accessible or not recoverable. So, that is and the groundwater accounts nearly two-third of the fresh water, groundwater flows very slow. So, flows like 10 to 15 meter a day. That means, if you have 10 meter distance or 10 meter let us say room having 10 meter you know length. So, it takes you know a day to flow from one end to the other end.

And, the great depth the water may takes you know 1000 years. Suppose if you have a great if you go deep deeper see the 1000 years, it will take and that that passes through aquifer and sometimes completely stagnant ok.

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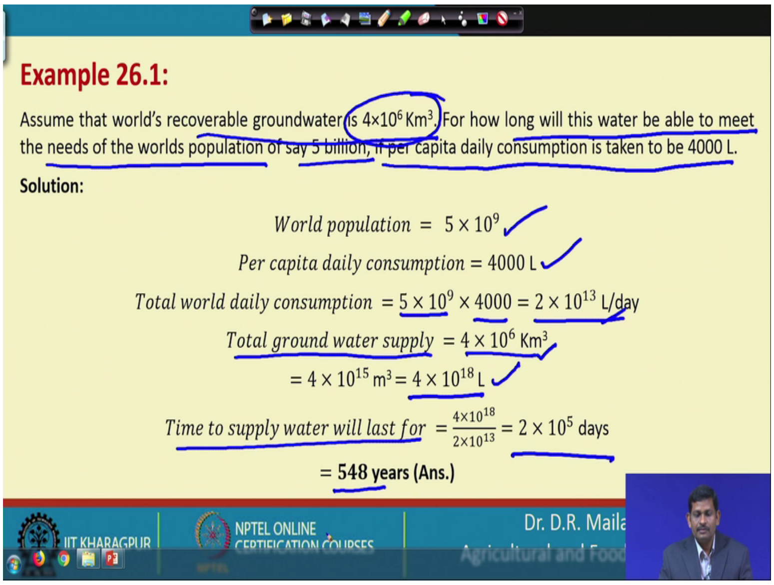

And next is, so this is a simple example to see how the water availability will be used for the existing population? So, assume that worlds the recoverable groundwater is this much ok. And, how long will this water be able to meet the needs of world's population say 5 billion, we have 5 billion population.

And so, how long, this amount will be useful for the 5 billion people. So, the 5 million if per capita daily consumption is taken as 4000 litre ok, per capita daily consumption is taken 4000 litre. So, let us world population is 5 into 10 power 9, that is the 5 billion and per capita daily consumption is 4000 litre and total world daily consumption is population and per head. So, to into 10 power 13 litre per day, say total world water consumption per day.

And total ground water supply is 4 into 10 power 6 kilometre cube you convert that into litres you get this ok. So now, you divide right divide this by this you get 2 into 10 power 5 days, you convert that it takes 548 years to deplete or utilise the entire water reserve for the 5 billion population ok.

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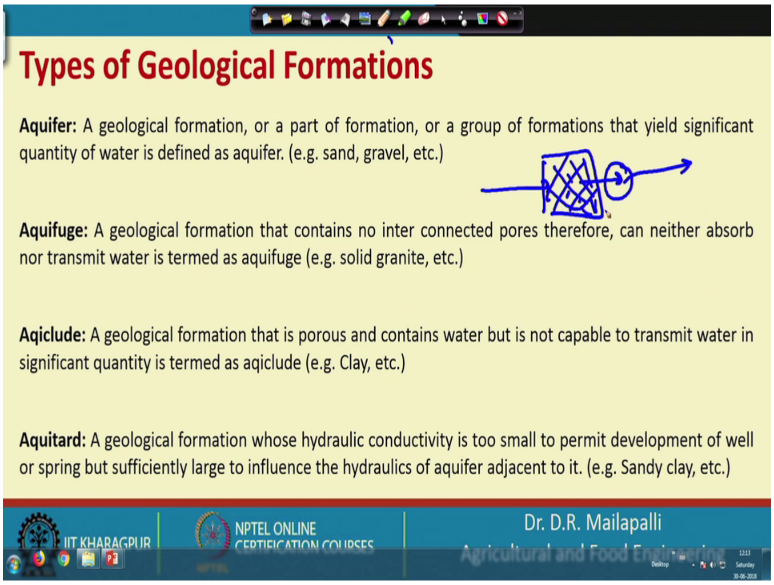

So, next is what are the type of geological formations? So, if you go down because water is there ok. So, the water is there does not mean that it is available always ok, it all depends on the media the porous media.

Suppose, if you have porous media in the sense this is soil type we are we are talking about. So, if you have sand, if you have clay, if you have silt loam. So, if you have rock fractions or if you have you know solid rocks. So, all this things based on the type of particular a geological formation with the water availability will be defined. So, for example, the types of geological formations are very important in order to understand, whether we able to get the water from the particular location ok.

So, here we have an aquifer. So, what is exactly the aquifer? So, each logical formation has a particular property like. So, it will. So for that, it is kind of a for example, assume that it is a sponge ok. Sponge is a porous material porous media. So, you add water what happens. So, it absorbs water at the same time if all pores are filled. So, the water is going to drain due to gravity ok; so that means, the sponge can absorb as well as transmits ok. So, that is the particular property.

The similarly, the soil or sands or other rock material; they will have a particular property. So, we are going to see whether that property can be I mean favourable for water availability or not. So, here aquifer; so that means, a geological formation, which absorbs water and transmits water. So, it has both characteristics ok. So, if you have a geological formation. So, it absorbs water and transmits water this is very important, (Refer Time: 12:58), because where you can extract water right. So, aquifer is very important in case of extracting water source or water reservoir.

Generally, the soils like sands or gravel. So, there you have a definite pore structure. So, that will be a good aquifer. So, if you observe like the drillers, who drills you know the tube I mean wells. So, they will be keep digging as long as. So, every time they will they started checking the material which is coming out from the whole ok.

So, then when the sea sand, when the sea sand is coming out from the whole then they think that there is the aquifer and they stop digging it and that is it there. So, because the sand is good aquifer material where, it can absorb or it can take water as well as transmit water.

So, here the similarly aquifuge; aquifuge is a geological formation ok. So, it neither absorb neither transmit.

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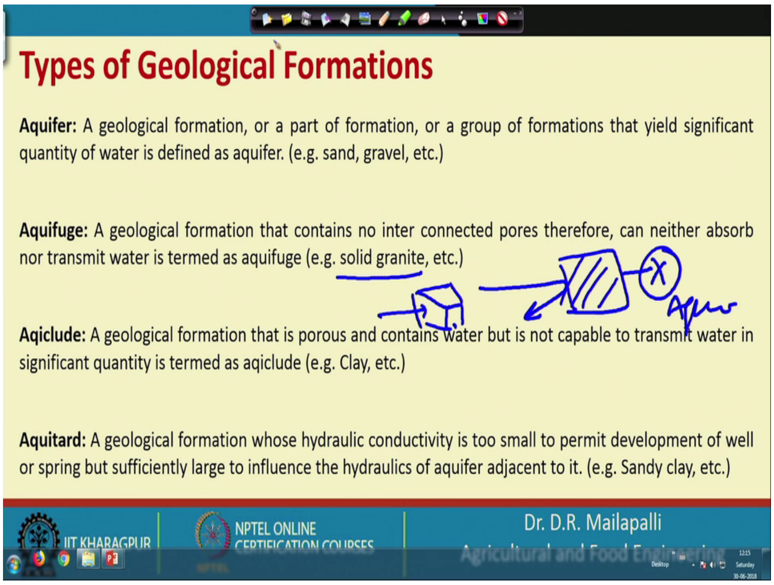

So, if you say suppose this is a material right. So, it cannot absorb as well as once it is not absorbing there is no question of getting water from this material. So, this is called aquifuge; aquifuge are solid granite. So, if you have a solid granite right. So, since there is no definite pores. So, water cannot penetrate in that means, it cannot absorb and it cannot transmit ok.

So, these are aquifuge bad aquifers you do not get any water in that formations ok. And, aquiclude the geological formation that it porous aquifuge sorry aquiclude aquiclude is a porous ok. So, it only can absorb, but it cannot transmit ok. So, contains water, but it is not capable to transmit water. So, that, that is aquicludes; for example clays. So, clays absorb right and it swells. So, once it has water it starts swelling hence very I mean a small quantity can lose out, but it is really not transmitting anything.

So, this is aquiclude and aquitard: aquitard the name indicates aquitard is kind of a retard. So, aquifer got retarded so; that means, a good aquifer after you know long period of time. So, the sand is good aquifer. So, having clay particles into a welcoming clay particles into the system. So, that can block the pores ok. So, that acts as aquitard ok. So, this aquitard what happen? So, it also absorbs water but the thing is, it is not going to transmit water, but it is definitely influencing the neighbour neighbouring aquifers ok.

So, this is important. So, geological hydraulic conductivity is too small ok. And, permit development of a well or spring, but sufficiently large to influence the hydraulics aquifer adjacent to it like sandy clay etcetera.

So these 4 are the important geological formations, we need to consider here.

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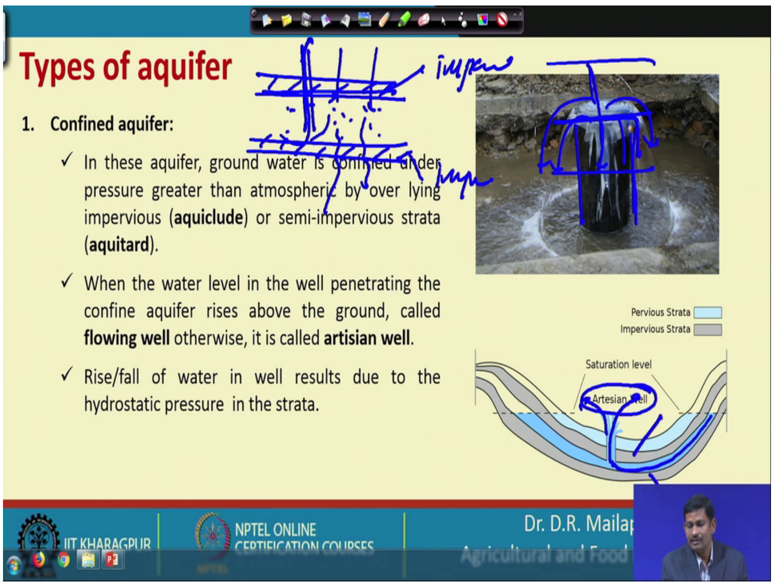

So the next is the confined aquifer. So, now, we are talking about aquifers aquifer that is a good which can absorb and transmit water ok. So, the confined aquifer, so in this case what happen if you see this picture? So, they are if the soil layer is present. So, this is a soil layer or reservoir which is present in between 2 confined layers. So, it is generally impervious layer. So, this is an impervious layer; that means water will not pass or water will not enter, water will not pass, water will not enter.

So; that means, it is confined between the 2 impervious layers ok. So, this is called a confined aquifer so; that means, the water or the saturated stratum is the under pressure basically. So, definitely if we drill hole into that, if you drill hole into that; that means, if you dig a hole or if you put a well into this. So, definitely water will enters through this right like a jet ok.

Similarly, if you see this so, this is one impervious surface this is another impervious layer right. So, this is geological formation. So, when you make hole it is going to come out ok. So, this kind of a wells are called artisian wells or flowing wells. So that that means, this continuously flows ok. So, they continuously flows, suppose if these head the pressure head, which is more than the level of you know the well the outlet at the well definitely it is going to flow. If, the pressure head which is less than the length of the well right so, this will be staying here constantly this will be staying constantly here. So, that is called these are in this case this is called flowing well whereas, in this case this will be artisian well ok.

All right so, here artisian well and flowing wells are there rise and fall of water in well results due to the hydrostatic pressure in the stratum. So, raising falling it all depends on the pressure, which is build up inside the aquifer this is confined aquifer ok.

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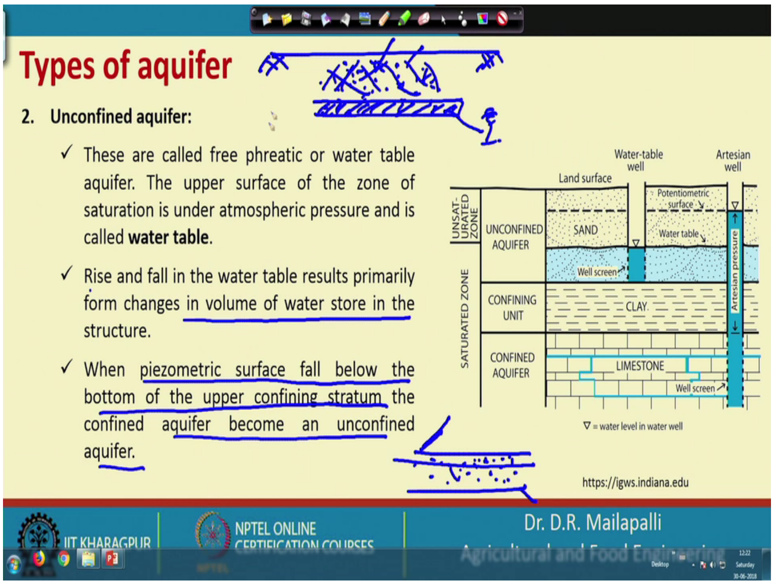

So, the next is unconfined aquifer. So, here if you see the unconfined aquifer case so, the one part is impervious surface then other part is the open to the atmosphere. So, suppose this is the ground level and there is a impervious layer and this is a soil stratum; that means, it is completely saturated right completely saturated.

So; that means, in this case the pressure which is acting on the stratum is atmospheric pressure right. This is not confined between 2 2 impervious layers, but since this is open to the atmosphere now right. So, the pressure which is acting on this, this is atmospheric pressure. So, in case of unconfined aquifer; so the soil stratum a geological formation will be sitting on the impervious layer is sitting on impervious layer only one side.

And, the top of the geological formation is known as the water table here. And whereas, the top of geological formation in case of confined aquifer it is called a piezometric surface or a potentiometric surface ok. So, here also the rise and fall of the water table results primarily form the changes in the volume of storage in the structure. So, when the piezometric surface fall below the bottom of the upper confined stratum the confined aquifer becomes unconfined aquifer ok.

So, in case of confined aquifer, so this is the pressure right. So, this is the pervious impervious layer. And, this is a soil stratum in case of confined aquifer. Suppose, if this pressure falls below the stratum; so that means, this is not right now it is a full and that there is hydro enough hydrostatic pressure. And, then it is definitely influenced by the atmospheric pressure. So, then the pressure equipotential line if you join that will be equal to the water table not the not the piezometric surface in case of confined aquifer.

So, when the confined aquifer can act as unconfined aquifer. So, that is because when there you are not getting enough pressure in the unconfined confined geological formation. So, that becomes unconfined even if it is sitting between 2 impervious surfaces.

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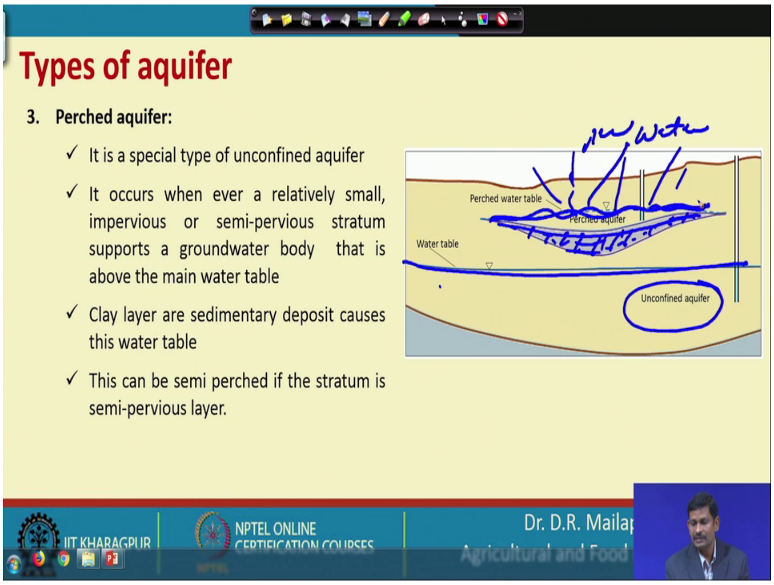

Next is the perched water table, this is a localized condition if you see. So, for there are there are clay you know layers, which are formed in locally. So, since it is a clay layer for example, this is a clay layer. And so, the water which will be stored here just like your unconfined aquifer just like unconfined aquifer. So, since it is a locally you know formed. So, this is called perched water the perched aquifer and this is called perched water table, this is perched water table because the water table is influenced by atmospheric pressure here ok.

So, the here if you see. So, this is unconfined aquifer, this is the unconfined aquifer and this is water table whereas, this one is the local unconfined aquifer or perched water perched aquifer and it has also have water table. So, if you drill hole here. So, water will be available up to this if you drill hole here. So, this is connected to the unconfined aquifer and since it is a water table. So, water will be seen at this point ok. So, this is basically formed due to clay or any sediment deposits.

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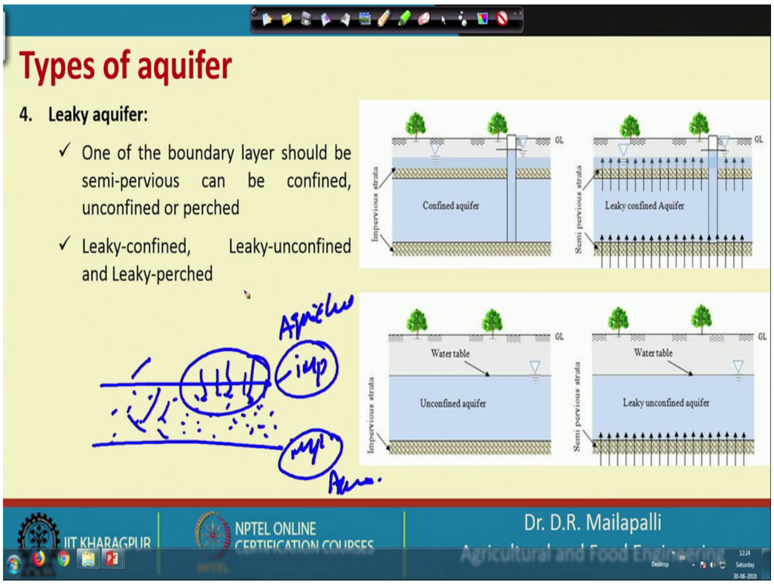

So, the next is leaky aquifer ok. So, the other one is leaky aquifer. So, here in case of confined aquifer, if you see there is a impervious surface this is also impervious surface. So, in between this is a soil stratum. So, sometimes what happen; so here impervious I mean layer could be this is aquiclude this is called aquiclude where it cannot transmit or absorb water, this is also aquiclude or to be aquifuge right if you (Refer Time: 24:20) aquiclude ok.

Sometimes, you have aquitards right. So, aquitards are kind of a semi ok. So, in that case what happens. So, if there is leakage say simply there is a leakage; so that means, it is not perfectly impervious layer and so this kind of aquifer is called the leaky aquifer ok.

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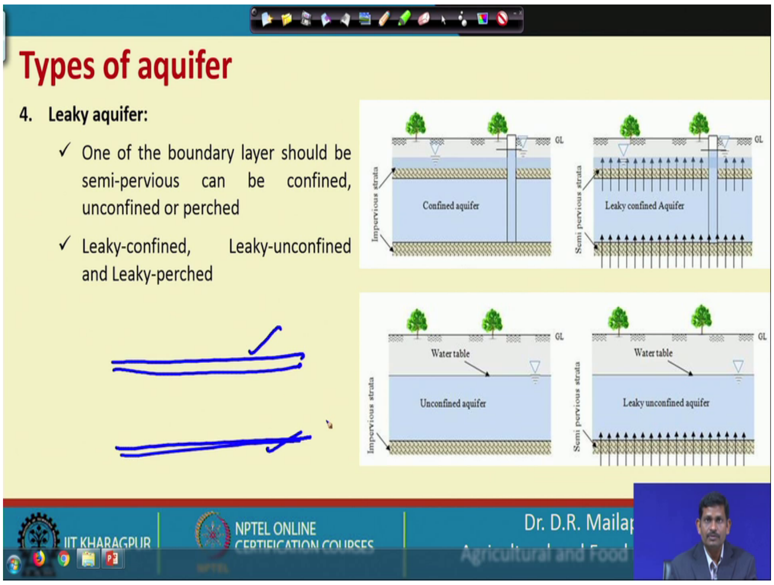

So, leaky aquifer case with your leaky like a pervious could be on top or it could be on bottom ok. The pervious surface could be bottom or top in both cases, it will be leaky aquifer.

So, if you observe this. So, here and also the leaky aquifer could be a confined leaky or a unconfined leaky. So, in this case leaky confined aquifer. So, impervious and impervious, but still you see the leakage from the bottom to top. So, here unconfined aquifer you can still see the leakiness here. So, this is leaky unconfined aquifer.

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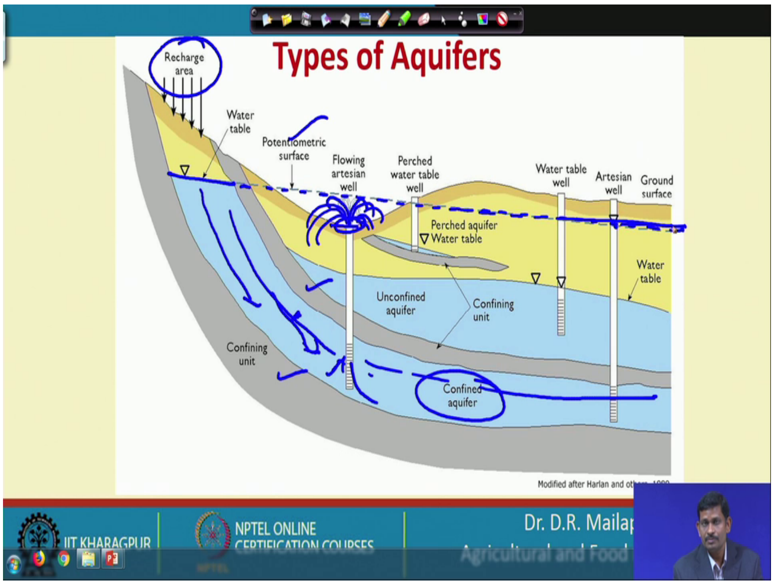

So, the next is if you over all see the all aquifers sp this is the picture. So, let us say at this point there is a recharge is taking place. Since, this is open to the atmosphere. So, here this level is called water table.

Then from there the entire water will be flowing through the 2 impervious layers. So, then this is a confined aquifer, and if you drill hole at this point right, the water which is under hydrostatic pressure is going to flow right. So, here also if you drill hole to this and you get a water level here right. So, whatever this line we are showing. So, that will give the pressure head at this point and pressure. So, the pressure present in this confined aquifer right. So that is, this is also called the piezometric surface or potentiometric surface ok.

So, since this piezometric surface is above the top of the well. So, it starts flowing continuously ok. So here since the top of the well is more than the piezometric surface the water level will be staying in the in the well ok. So, that is one thing and above that since these 2 are impervious surfaces this is a confined aquifer.

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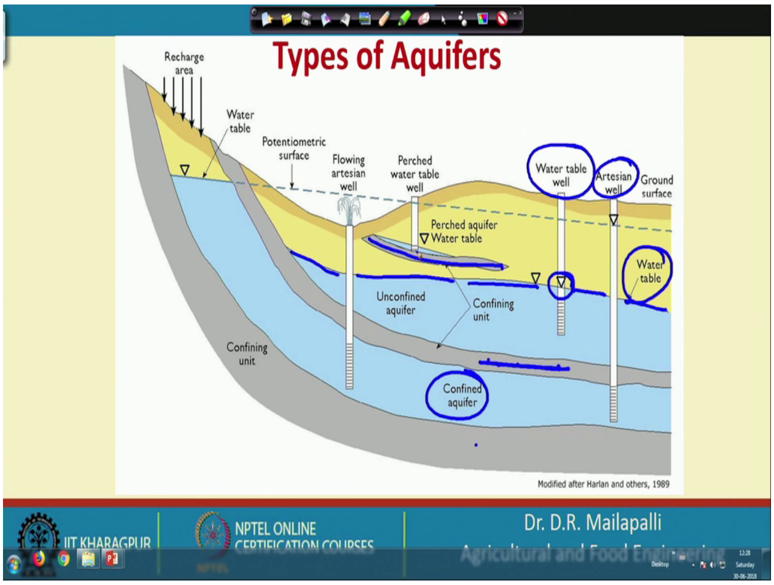

But, above that there is again geological formation which has this, is impervious surface bottom and the top there is no impervious surface this is open to the atmosphere. And you can see the top of this geological formation called water table, because this is atmosphere intervention.

So, if you drill hole at this point. So, water level which is seen in this water is called water table well, this is water table well or phreatic well, this is also called phreatic well, this is the artesian well; since it is connected to the confined aquifer, this is phreatic well ok. Since, it is connected to the unconfined aquifer ok. So, there is also you can also see the local locally formed you know aquifer that is the perched aquifer and if you have connected to the (Refer Time: 28:01) connected to this perched aquifer is perched water table value right. So, this will show the aquifers and the wells and then 2 surfaces water table and piezometric surfaces.

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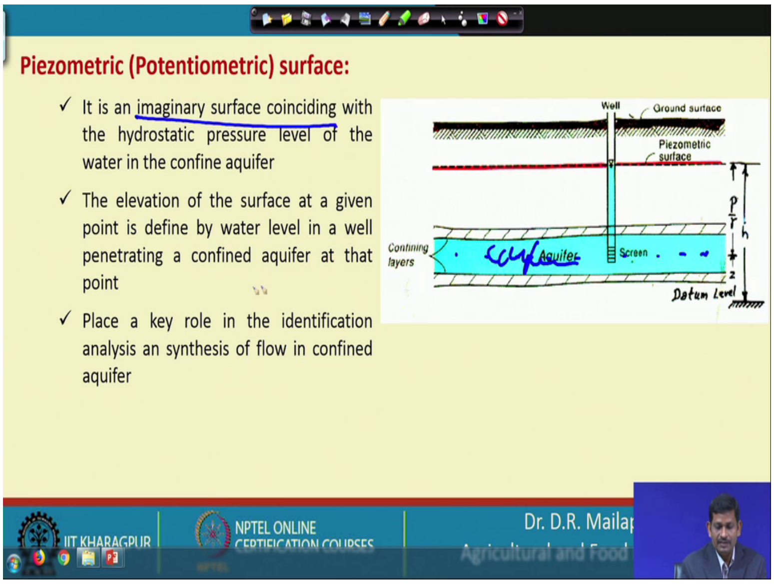

So the next is the same the piezometric surface is already explained. So, this is an imaginary surface, which connects the all points the pressure in the aquifer confined aquifer this is the confined aquifer. And, the elevation of surface at a given point defined by water level is a penetrating confined aquifer ok.

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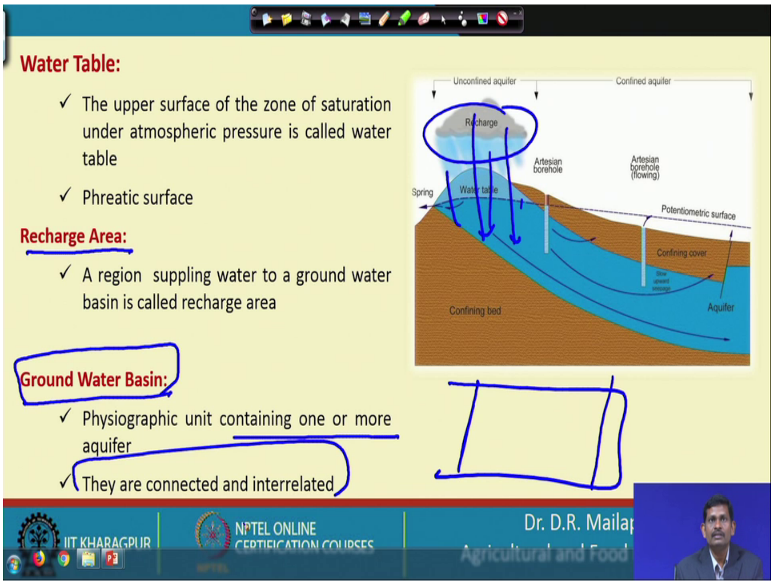

So, similarly if you see the water table I already explained. So, the water table basically connects the unconfined aquifer and the water table the pressure at the water table is equal to the atmospheric pressure.

So, recharge area here if you see which is the way the region which supplying water to the ground water; for example, here now this is the recharge point where it supplies the water to the ground water. So, this is a research area and ground water basin. So, this is a physiographic unit containing one or more aquifers. So, aquifers the whole that means, topography can have you know one aquifer or more than one aquifers. So, that is called as a ground water basin and the aquifers can be connected or interrelated they can be interrelated ok.

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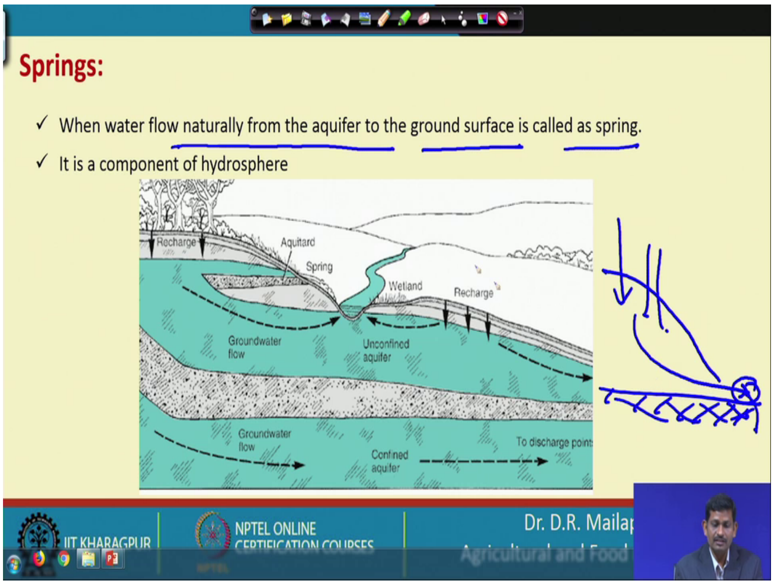

So, the next is the springs ok. So, the springs when water flow naturally from the aquifer to ground surface is called a spring suppose so, there is this kind of things. So, there is a water which is infiltrating down, but you have a impervious surface here. So, definitely that is going to pass through these and this forms the spring you can see so, this forms a springs.

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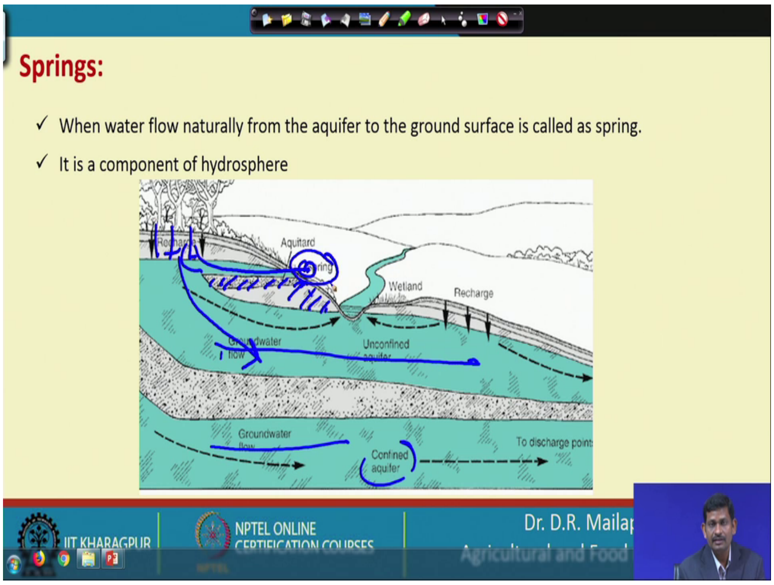

So, there are different kinds of springs the component of hydrosphere, if you see this is groundwater flow right in confined aquifer and this is unconfined aquifer.

So, the recharge which is going here right this is impervious surface due to impervious surface. So, the water some of water will flow through this and some water will flow through this and there. So this, since it is a impervious surface you can see continuously the water flowing right this called a spring.

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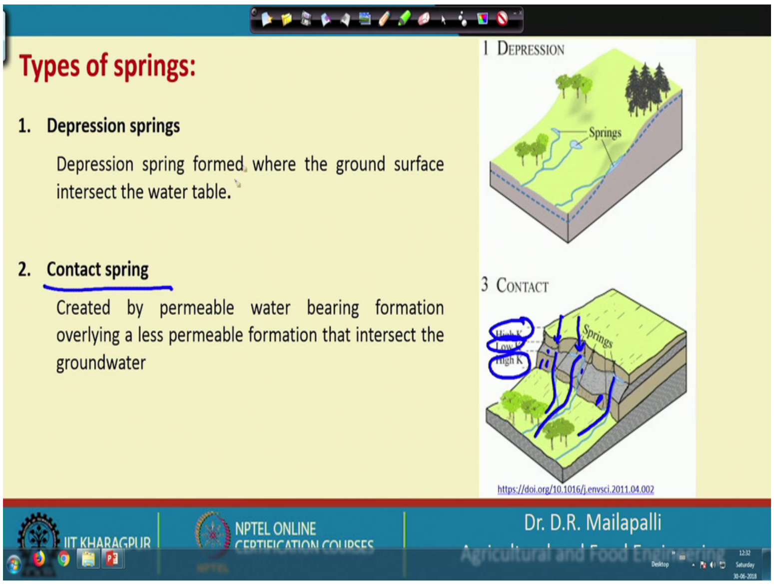

So, the next the types of springs could be like a depression spring. So, the depression spring where here the water which is infiltrating down will be this is a depression here right. So, the depression is connected to the water table right. So, the local water table since there is a water connected to water table and it is going to flow automatically right because there is a depression right.

And, here there is a contact spring the contact springs are like the High K. So, more water will infiltrate and at the bottom there is a Low K right and again High K. So, what happen here the water which is I mean infiltrating down cannot infiltrate in further layer. And that will be formed as a spring ok. Because, the and again there is a another layer which is High K ok. So, when the Low K is you know sandwiched with 2 High K s. So, then you can have this contact spring.

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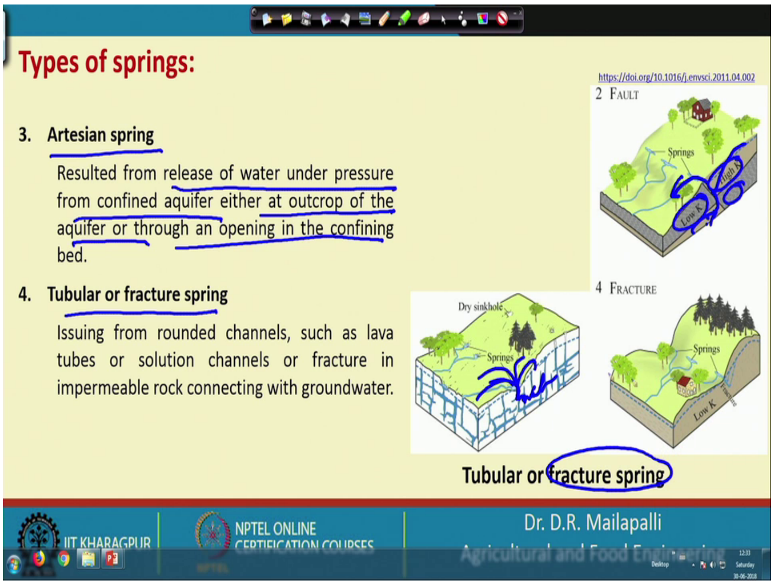

So, in the fourth one is the artesian spring, the similar to the artesian spring is suppose here it is a High K right, and here also this is a Low K the Low K and High K. So, water which due to High K is a water is going to pass, because if the Low K it cannot penetrate down ok. And then here from here this is High K. So, water from here and here will be oozed out here from here, because it cannot enter through this right. So, this is the water I mean here the resulted from the water under pressure from confined aquifer either at the outcrop of the aquifer or through the opening of the confining bed ok.

And, the tabular of fracture spring so, sometimes what I am there is a fractures if you see right. So, the water or factures are connected interlinked, the water from this fracture this facture this facture. And finally, if there is a way out right all fracture water will be oozed out as spring ok. So, this is called a fracture spring the same thing here.

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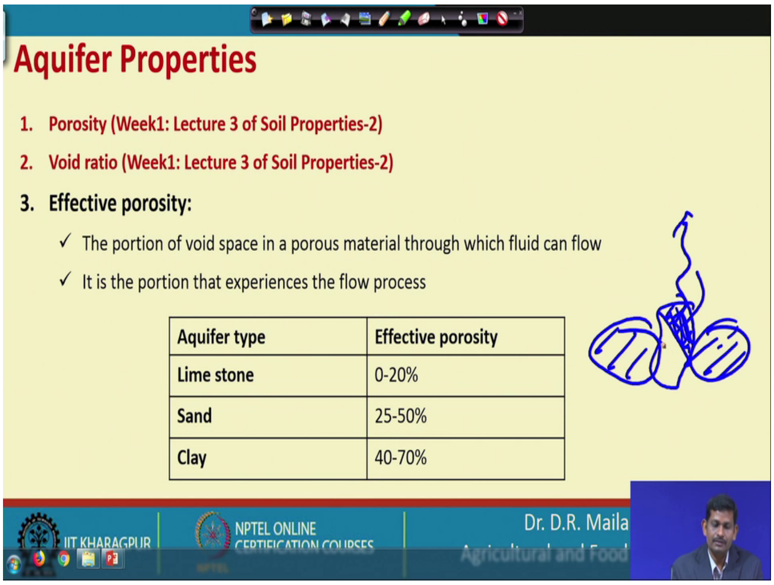

So, the other these are the aquifer properties if you see.

The porosity is one of the properties, because the soil media and void ratio another property. So, these properties are already explained in lecture number 3 of week number 1. So, you can go through that and other was an effective porosity. So, the effective porosity is the out of 100 percent of porosity. So, how much is really participated in the flow process groundwater flow process so, or what is the percentage of porosity, which is which is effectively you know used in groundwater flow? Ok.

So, the portion of void space in the porous material through which fluid can flow so, that is the thing and if the portion that experiences the flow process. So, that will experience the flow process. The other process may not be may not be experience the flow process. So, for example, if you have a pore here right this is a pore and soil particle sorry. So, this is the soil particle and this is another soil particle and you have pore right. So, some portion of the some portion of the pore will have fluid that will be you know flowing the other you know stagnant. So, in that case the porosity is not 100 percent and effective porosity is 100 percent, but effective porosity is not 100 percent ok.

So, aquifer type if you see lime stone the effective porosity will be 0 to 20 percent and sand 25 to 50 percent clays 40 to 70 percent right.

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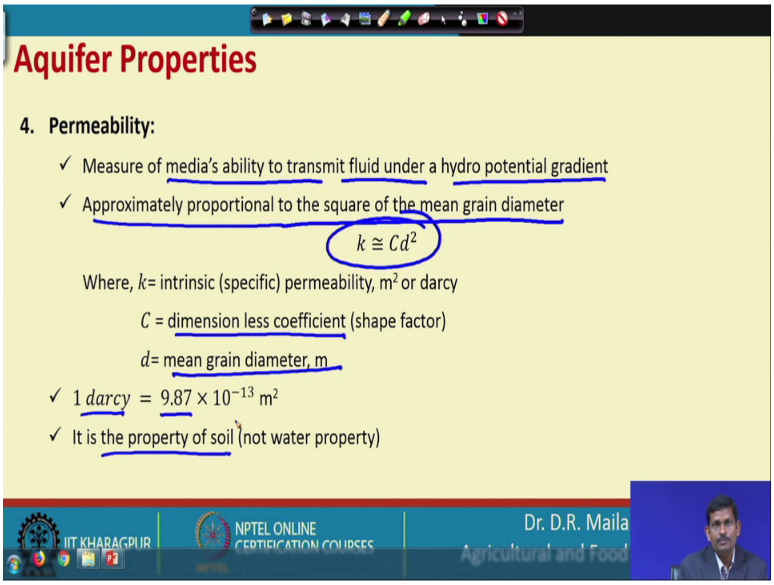

And so, next property is permeability. So, the permeability is basically the media property the sand property whatever it may be so, not the fluid property. So, a permeability is the measure of medias ability to transmit fluid under hydro potential gradient. So, if you have some gradient of flow right. So, the fluid will flow from one place to another place. And then that is due to the property of a material a property of the material ok. So, that is called the permeability.

So, the approximately the proportional to the square of the mean grain diameter suppose the permeability is expressed is equals C d square. So, C is the dimension less coefficient and the mean diameter d. So, it is expressed in Darcy. So, 1 Darcy is equal to 9.87 into 10 power minus 13 meter square and it is the property of the of course, soil or not the water property ok.

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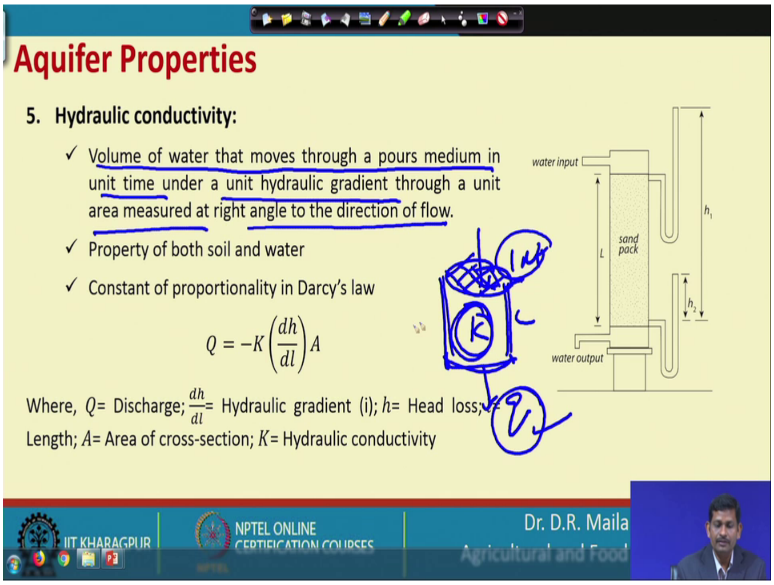

And the next is the hydraulic conductivity. So, here the hydraulic conductivity it is again fluid as well it is the property of soil as well as the water ok. So, it contains both fluid and soil property. So, let it is defined as the volume of water that moves through a porous medium in unit time under a unit hydraulic gradient, through a unit area measured at right angle to the direction of flow, if you have the flow measured here right q. So, the k the hydraulic conductivity which is equal to the q right, when it is measured through a 1 meter square or 1 1 unit area of cross section and then 1 unit area of cross section ok.

So, then and the unit gradient, suppose here the pressure and pressure the difference the pressure gradient is unit then the flow is equal to the hydraulic conductivity.

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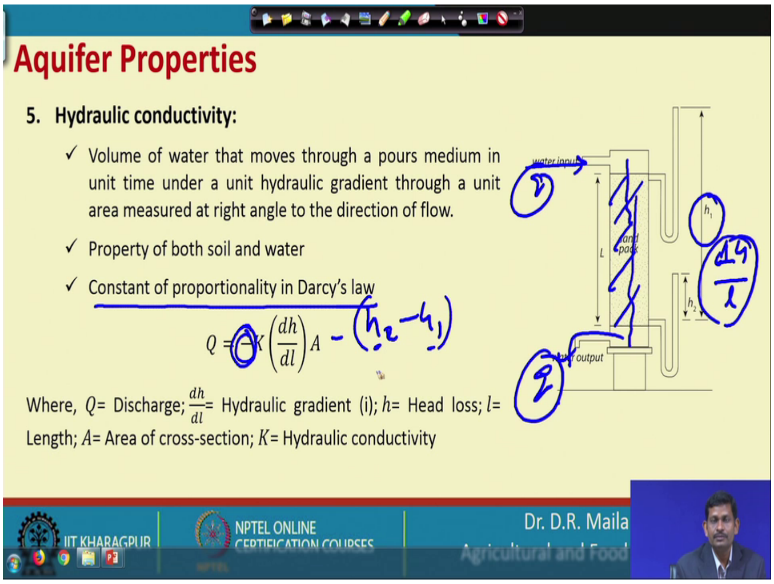

And so, this is first given the equation is given by Darcy. So, Q is equal to minus K dh by dl into A. So, here the negative sign indicates the pressure gradient, which is the gradient of pressure I mean pressure is decreasing towards the flow direction if you see here the pressure. So, this is the setup the Darcy setup let us say the soil sand column. So, input what is input in here. So, water is initially this is completely saturated.

So, water pass through this and collected here. So, this is q. So, since it is equilibrium. So, the q which is going in will be same as q coming here, but the pressures are different here. So, that pressure h 1 here and h 2 here the difference in pressure. So, that is delta h and the gradient is l delta h by l that is the gradient. So, since the pressure the flow rate, so this is h 2 minus h 1. So, h 2 is less h 1 is more. So, that is why this negative sign is required in order to get the positive q ok.

So, that way this equation will be used to estimate and knowing the q and knowing the area of cross section and the gradient you can estimate what is K? Ok.

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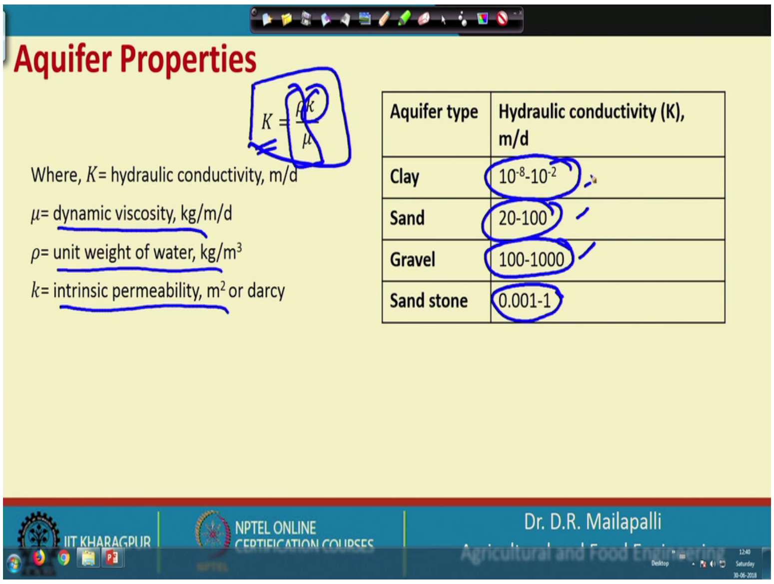

And then the K value here if you observe clearly. So, the K value; so as I said it has both the fluid as well as solid property. So, K this is permeability and rho by mu. So, these are the fluid properties ok. So, K has both fluid as solid properties.

So, mu dynamic viscosity and unit weight of water k is intrinsic permeability. So, for hydraulic conductivity K is clay for Clays 10 power minus 8 to 10 power minus 2. So, it is a big range right. So, sand 20 to 100, Gravel 100 to 1000 Sand stone 0.001 to 1 ok. So, hydraulic conductivity will be more in case of gravel and sand and less very less in case of clay right. So, that water is very difficult to transfer or transmit in case of clay soils.

So, in this lecture we mainly focused on some basic stuff on you know groundwater. So, what is geological formation? What is an aquifer? What is a aquifuse, aquitard right and aquiclude? So, these are different kinds of geological formations which are present underneath. And, also the different soil waters and then the properties of aquifers and we also studied, what is the aquifer types like confined aquifer, unconfined aquifer, perched aquifer and then leaky aquifer ok.

And, then we also studied the water table and (Refer Time: 40:55) I mean water table and peizometric surface and also different wells based on their connection to the different you know aquifers. So, the valleys connecting to confined aquifers is called artesian well, if the valleys connecting to your confined unconfined aquifer it is called phreatic well or water table well, if the valleys connecting to the perched aquifer that is called perched water well.

Thank you.