Fundamentals of Environmental Pollution and Control
Prof. Jayanta Bhattacharya
Department of Mining Engineering
Indian Institute of Technology, Kharagpur
Lecture No. # 12
Ground Water and its Contamination

I mean we are going to begin a new area of study and that is you know ground water, ground water and its contamination right.

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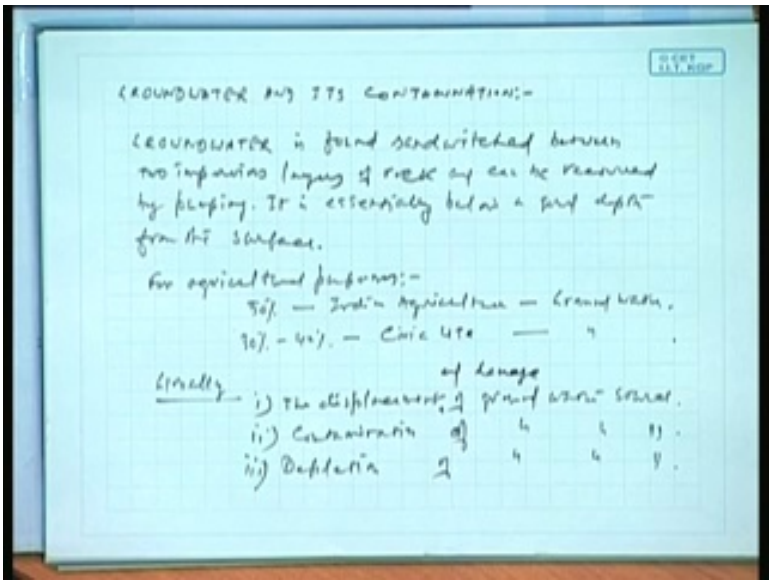

We have a popular belief that you know most of our water supplies are generally derived from surface water say ponds, rivers and you know the water reservoirs that we find in the surface. On the other hand you know the large part of the water for our supply actually essentially comes from ground water. The ground water you know how this can be defined is ground water is you know ground water is, ground water, ground water is found sandwiched, some sandwich between, between two impervious layers, impervious layers of rock, impervious layers of rock and can be recovered, recovered by, can be recovered by pumping, can be recovered by pumping. This is what you know we would explain this ground water and it is essentially it is, it is essentially below a good depth, below a good depth from, from the surface, since from the surface.

A ground water is about you know for agricultural purposes largely for agricultural purposes, purposes more than about, more than 50%, more than 50% of Indian total agriculture, Indian agriculture, agriculture depend on ground water, depend on ground water. So this, this 50% of this ground water and again about 30 to 30% to 40% of civic use, civic use, use, civic use is contributed, civic use is contributed by ground water, so ground water. Globally, globally, globally the ground water the, the displacement, the displacement, displacement of ground water source, displacement of ground water source, contamination, contamination of ground water

source, contamination of ground water source and thirdly the loss, the depletion of, depletion of ground water source are three major problems. You see huge problems to say, it's a basically you know a, of, it has now, it is of such a measure, it is of such a measure, you will be surprised to know that you know a large part of the world and a large section of the people are continuously without the supply of water and much of essentially due to lack of ground water sources. Ground water sources are getting depleted all throughout the world I mean the what is happening is you know over pumping is one key reason why the ground water sources are you know damaged, the ground water sources are damaged and displaced.

You can write displacement and damage and damage, I will explain this damage part, displacement and damage of ground water source, this is a worldwide phenomenon and in a much, much more is a greater phenomenon in countries like India you know where an agricultural uses, agriculture is more and more using ground water because of surface you know the surface water streams are not always available and also many of the Indian areas are not sufficient with surface water sources. So you know mostly they have to depend on ground water and since we do not have good canalling system in our, to support our agriculture much of the water has to be drawn from ground water and the farmers are forced to use ground water. And as a result of which what is happening is in all cases as the increase of ground water source has taken place, as the increase of ground water has taken place and urbanization and urbanization has taken place.

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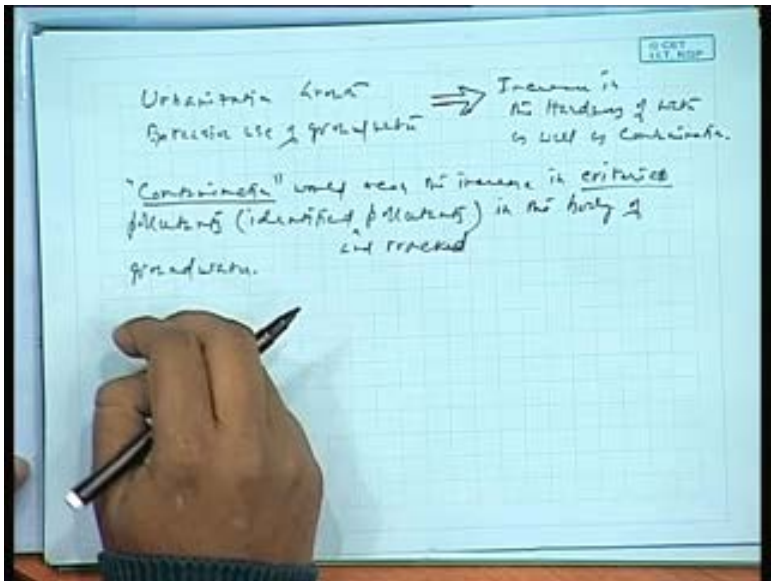

So urbanization, urbanization, urbanization, urbanization growth, urbanization growth then extensive use of, extensive use of, extensive use of say ground water, extensive use of ground water, extensive use of ground water is leading is these things are leading, you know you can see this, these things are leading many, various other things as well the extensive use of in the essential use of urbanization, urbanization growth, extensive use of ground water then you know say is all leading you know is being led by, its leading to the contamination.

If one is you know increase, increase in the hardness, increase in the hardness of water as well as, as well as contamination okay contamination, as well as contamination. Say you know contamination here you know is all this cases where I have been explaining contamination, contamination, contamination would mean the increase in, increase in criteria pollutants, criteria pollutants, criteria pollutants, criteria pollutants are, this word criteria pollutants is says known as the identified, identified pollutants, identified pollutants, identified pollutants or identified and tracked pollutants and tracked, identified and tracked pollutants. What does it mean? Identified is you know there are many pollutants you know which are say you know there are, there in some cases there may be a causes of concern may be less you know but in a contamination when we are talking about contamination, the concern is high I mean in the sense that the water may be, there may not be significant growth in the, in the water about TSS and TDS, but there may be a sudden increase in a concentration of certain compound or chemicals that, that is beyond the threshold, beyond the threshold.

Let me explain you a little bit about this. You see it does not matter I mean if you are studying environmental science, you should also know this. It does not essentially matters you know if a unclassified TDS in water increases from say 5000 milligrams per liter to say 7000 or 8000 milligrams or even say 10000 milligrams per liter, it essentially does not cause a large chain of disturbance or you know effect on the population either animals, humans or what whosever. But it makes a tremendous sense you know it makes a, if a, it is a tremendous case if you just think about a water having say 0.001 milligram per liter of arsenic and the arsenic value getting increased by say 0.01. From 0.001 if it goes to 0.01 it is of huge concern.

So when you are talking of criteria pollutants, we are only discussing about those pollutants which are critical for our information that in the, that pollutants which need to be identified and which need to be tracked that means you know how their concentration and all other things are changing have to be identified and not only identified they have to be regularly monitored and checked that is what is meaning about tracking, right. So, this is you know the contamination of increase in criteria pollutants identified and tracked pollutants in the body of, in the body of ground water, in the body of ground water. So in a, is essentially ground water is having a serious consequence and mostly there are a larger you know is as you have said in one case that I have said, it is generally said that the future source should be fought on water not on, in many cases not on you know the petroleum or you know any other gases. That's the way it is being depleted throughout the world in this it's of major concern but all this thing is in a, as I have said you know it's basically much depends on the urbanization, the style, the people, standard of living, how the people are living of and all these things all taken together I mean is basically leading the great depletion of ground water and as well as contamination of ground water, okay.

Let me now briefly explain about what is this you know the mostly and as a result of which you know in this aquifers if you just see you know this the ground water, ground water source, next targeted is ground water source and characterization, ground water source and characterization, ground water source and characterization right where what are the sources of ground water and how do we characterize them. Characterizing mean, characterizing means you know what are the typical parameters or properties that will be important for us to know, to identify and characterize a particular ground water from the another, how one ground water would be considered different from the another is the characterization. We are talking about

characterization, we would like to know about the physical and also chemical features required of a ground water regime say required of a ground water regime, the ground water's you know where that they are stored, the ground water where they are stored inside the ground is known as the aquifers. I think you have, we have known of this aquifers as this as you have some idea about this aquifers and how does it look? See you know here if you just observe a ground water source and what we see is the soil through you know if it is, if you are just considering about the layers of the ground you know is it's like this.

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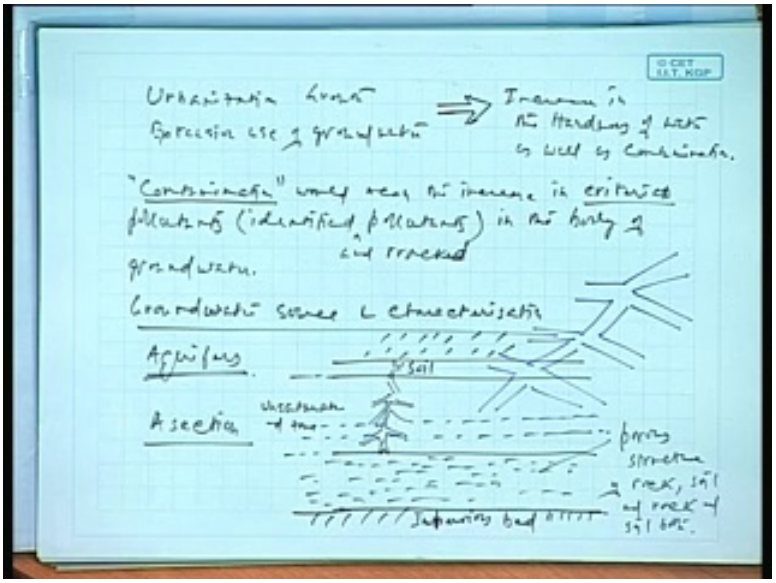

So this is just a section of the ground water, section is section right, we are just dealing with a section you know it's both say somewhat infinite on all ends, let I'll also explain this. What has happened is here it is the soil, it's the soil, this after this soil you know it's we find a large unsaturated zone. Here what is the characterization of this unsaturated zone is that is, this is known as the unsaturated zone that means unsaturated zone, unsaturated zone and this is you know you say basically here is this is say impervious, impervious, impervious bed, impervious bed so where the water cannot go out I mean just for, just for an understanding. It's not necessary that the ground water cannot exist below this level also, ground water can very well exists but then again when it is existing, it must exist between two impervious layers, supposedly impervious layers.

Now here this is, this is the ground water zone if you just see this, this is the unsaturated. What happens is try to understand this, this is in case of rain, in case of a rain, in case of a rain, in case of a rain the water essentially you know through this pores through different micropores, micropores you know it would try to go from you know different sources like this and it would, it would carry on, this is micropores and different fishers and things like that you know and mostly it would come and come and collect into the impervious bed. This is what is the, this is what is a combination of you know here a porous structure. Remember this, this is not water only this is all ground water sources you will find a sudden say a porous structure of rock, soil or and rock and soil both. Porous structure you know where this water would essentially come and

reside the water would come and reside this is what is from where the water is coming and going to be collected.

Here, if in under normal circumstances what is happening is so as you can see this, this particularly during rainy season try to understand this during rainy season, during rainy season this level, this level can rise, this level can rise okay. This level can rise you know in a during rainy season you will find that this, the porous structure is the water we locked in would rise right and at the same time when this you know during, during the, after the rainy season when the summer season sets say about this time say about this time, this level would generally go down, this level would generally go down because you know this there will be no recharging, there will be no recharging and very likely all this ground water, all this ground water bodies are, all these ground water bodies are essentially continuous in nature.

So, here all we can see is a ground water source, a ground water source being connected with another ground water source and that is how it is continuing. No case a ground water can be, in no case a ground water can be a single, a single definite I mean a definite source of water in the sense what I want to mean here is that they are not, they are always continuous in nature. So, one ground water linking with the another that ground water source is getting linked with the another, so you have find that finite infinite chain or streams of ground water all converging and then moving away and you know being connected in a throughout structural manner. So, the ground water here regime in Kharagpur, ground water regime of Kharagpur would be largely connected with the ground water regime of Purulia, would be connected with the largely with the ground water regime of dhanwad or say Bihar areas but they are connected but not necessarily completely sharing the water, they are connected by all means.

So, you know what you see is a ground water is essentially a, the, a sources of water, a number of sources of water connected with each other in a continuous fashion. So, in a ground water is you know even if I make a drawing of a small ground water source, remember this is just only a section of the ground water. We are not talking about is we are just mainly in all cases the ground waters are in all cases, this is a continuous stream connected from one to another okay. Now, here it is, this is the porous structure, in this porous structure here now let me go into another drawing here I mean this is of the ground water source here.

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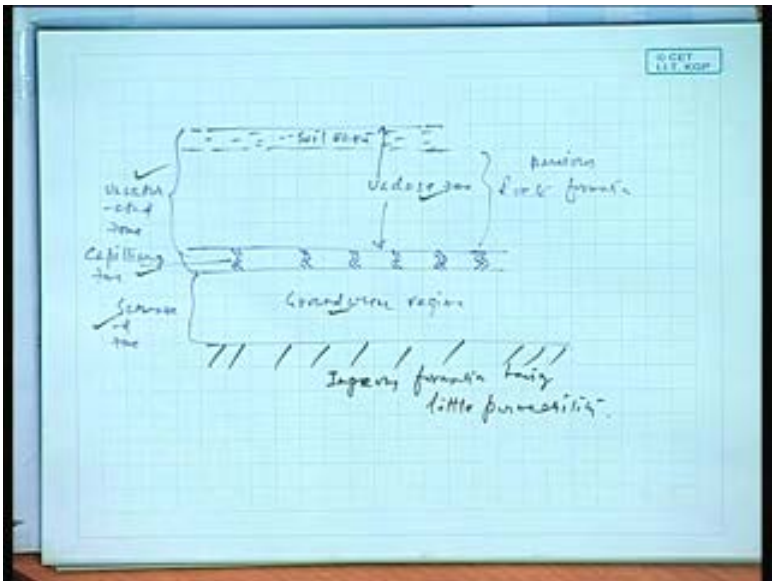

You see, you see if you just observe this you know the one we have said this is there would be a certain weight of soil water that is soil water and this one is, this one is, this as I have said unsaturated zone mostly this unsaturated zone, this unsaturated zone, the unsaturated zone. What is happening here is you know it's of interest is you know if you just what you mean by soil being unsaturated? That means you know the soil will have water less than its capacity, the capacity. When the soil becomes saturated? During rainy season, when you find after a large great shower you find the water being collected on top of the soil for quite some time, at that point of time the soil is saturated. The saturated will be with water, so you know it cannot no longer hold the water, so it would just keep the water on top of it or it would allow it to pass through okay. So, that is where you can find you know water getting collected you know during rainy season. So, this is what is this water in nonetheless in a soil, in a soil structure you'll get to know more.

This in the soil structure, this, this is you know mostly in under all cases when if you just observe after the rainy, after the rain after sometime the water goes away even if you do not have a connection you know if you just keep the water just like that and arrange for the water at some places without the water being flown, without the water been flown, the water would generally go away from that place or you know it would be again the old condition that it will return back return to. So, here that is what is that when it returns to its old condition, at that point also it retains some moisture and water as well.

Essentially in a, in a soil, in a soil we can have say at about this time, at about this time we will have about 1 to 2 % of soil moisture unless you know that is why you know you need requiring, you require watering during this, during this, during this seasons for the plants to grow. Isn't it? So, this is the soil water remains, this one is an unsaturated zone that is you know identify you know this is conceptually, conceptually this is the saturated zone, saturated zone. Conceptually it is said that there is a zone between there is what is the difference, how this, is there any line daily meeting unsaturated zone and saturated zone. There is no, in fact this one is basically is a run by

a capillary zone, this called the capillary zone, capillary zone where the water from the saturated zone would continuously move in a capillary towards the unsaturated zone, towards the unsaturated zone.

So, you know in case this one is, this one will have their due to capillary pressure, the water would move generally upwards from the saturated zone, towards the unsaturated zone. So, this is what you know this is, this particularly this zone, this saturated, complete this zone is known as one typical term we generally call it as a the vadose zone, the vadose zone, the vadose zone and this one is the ground water, this is the ground water, ground water regime, the ground water regime. Here, in this vadose zone is completely unsaturated, so it's completely unsaturated, so it's completely unsaturated this is the vadose zone, this is these are basically the rock formations, rock formations suddenly a permeable or pervious, pervious rock formation, pervious rock formation where this is the rock generally is pervious, so allows the water to go in. And here in most cases you will find you say as most cases ideally it should be an igneous formation having little porosity, igneous formation having.

Sir, as the surface water is going inside and in the aquifer and we are drinking water that gives from aquifer. Aquifer? Yes. Okay I'll, I'll explain you that, I'll just explain you, I'll having, igneous formation having a little permeability. It is not, it is not precise or prudent enough to say that the water is, the rock is completely impervious, rock is never completely impervious. In all there, all circumstances, all natural substances that we see mostly they are pervious but you know the permeability may be very low so that is what we would talk about. So, here in situation like this you know will find that is so this is the ground water essentially remains in this area. So, there are two few areas of important unsaturated zone, saturated zone, capillary zone, vadose zone and ground water regime. These are the 5 things you know which you should have an understanding of right.

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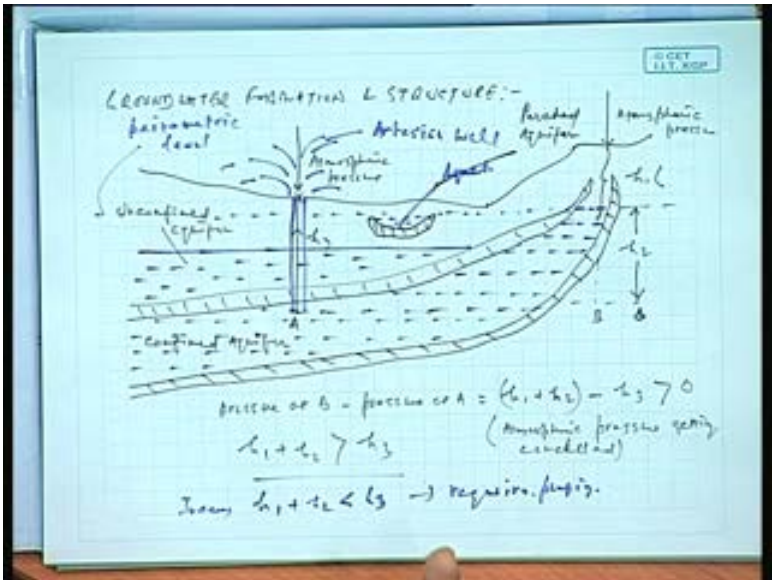

Having said this, having said this you know you would go into a say having said this, we say the ground water, ground water formation and structure, ground water formation and structure to make this you know to see this, now will just have a drawing you know here you see this, this is what is, this is what is generally, this generally a surface topography, say this is a surface topography. And inside this surface topography we just have a, we just have a ground water source which is, which is locked in an, which is locked. These are two impervious layers of rock, these are two impervious layers of rock and here this is, this is the another impervious layer of rock. Now, you see this you know here, here if you can just expand it to further expand it little further here okay. What is happening here is this, at this point of time say you know at this point you know just let us say this is a, this is what is known as the unconfined aquifer, we will call this as unconfined aquifer. There is no confinement actually, the water is freely, water can move freely, water can move freely you know wherever the water getting connected they are getting moved freely, so it's called unconfined aquifer, unconfined aquifer right and this is a confined aquifer, aquifer.

Let me explain the difference here when, why you would have a very practical significance of confined and unconfined aquifer. Here what is happening here is like this, you know if you see this at this point of just you know at this about say think about two points here, this one is here. And okay see this is open to atmosphere, so we will say is atmospheric pressure okay, here also the same atmospheric pressure is essentially applying, atmospheric pressure okay. There would be a certain atmospheric pressure, we would just say you know we would know is that you know by say about h_1 equivalent, h_1 equivalent of the hydraulic head you say this is a pressure of the rock which can be considered as h_1 equivalent of hydraulic head. So, you know it's you just can see it is basically a mass pressure that mass pressure is being converted into a hydraulic pressure okay, thinking of a water column instead of a mass just having a water column.

See here in this case interestingly if you just observe, so you can find say you know here this is another, another height that we can generally talk about, so you know here it is, here remember it's not free and open you know it's basically the rock mass working on that, rock mass working on that and you know there is a pressure which is, which can be directly transferred from the atmospheric pressure here. And if you just observe here say you know you can see this as atmospheric pressure and this one is h say h_3 okay. So, if you just see you know if you make a difference here, so you can find out say now the point of difference at this point you know this is the pressure, the pressure that would be generated, the pressure is see if you can just the pressure at this point. So, here you can see say point A say this is point A, point B okay at this point say here this point B, point B. What we are seeing is if you are just comparing the pressure here, say we are just trying to make a difference of this pressure here, so you can see this pressure at, at point B at B minus pressure at point A, pressure at point A just observe here that you know the difference is basically h_1 plus h_2, h_1 plus h_2 minus h_3. This is this atmospheric pressure, atmospheric pressure getting cancelled. Isn't it? Atmospheric pressure getting cancelled okay, right atmospheric pressure getting, getting cancelled. So, in cases of whenever the situation is like this, whenever h_1 plus h_2 in a situation like this is more than h_3 or you can find a positive value here more than 0, you can find a value more than 0. What we expect here is the water to flow, water to flow from upward and if there is a hole connecting, if there is a hole connected the water would automatically, the water would automatically go out of this.

If we can just think of a hole being connected so this water would begin to flow out. This is what is famously known as the artesian well. Okay, I think you should not have an, this is, this is an artesian well. So, in all pilgrimage site wherever you have found that the water coming out from, from this from the ground water is basically an artesian well in the condition of this and you'll also observe you know if you just say you know sometimes in many places you would see that this condition changes seasonally as well, conditions seasonally changes. So, in some cases you will find the water coming out, in some cases you would not find water not coming out. So, essentially all those situations where you have seen that water coming out is not by any divine help, it's merely because of this special condition. So, this is what is this artesian well so, where it would require no pumping is required for the water to come out. In all other cases, in all other cases to overcome the difference in pressure, to overcome this is the pressure to, to, to resists the pressure, to overcome and resists the pressure one has to do some pumping.

In many cases that is where, wherever in other cases when, when in a condition like this, when h_3 is more than h and h and h_1 plus h_2, so when cases, in cases when this is negative or below 0 it requires pumping, so as the water to bring out. Isn't it? So this one is h_1 h_2 whenever it is less than h_3 so in a request pumping, so request pumping, in all, in all situation request pumping. This is how this water basically gets out of the artesian well. This is what is, this is particularly, this is what is you know there is one name to that particular level where you can get either this is the place, this is the place very likely that you can during, during drilling, during drilling you will first find strike water, this level. You see this the top most level here is likely to be the level where at the time of drilling, at the time of drilling, you will find first strike water, first strike water in the sense that first strike water not in the form of moisture but in the form of water dispersed into the rock structure, water dispersed into rock structure.

On top of that also there would be water but the water will be mostly moisture right, water will be found in the form of, in the, found in the form of vapour. But here only on this thing is, this is what is famously known as piezo, piezometric level. This is what is famously known as the piezometric level and as well and as well there are you know in some structure you know there are some structures, you know you will find that you know in many cases in a village also, in a village area you will find the in some cases you know even if the village is generally dry on the all other areas, in all other areas but there are some places there is water. You know in a well you people generally talk of whenever all well gets dry but that well does not get dry. What is that reason will discuss? You see in many cases, in many cases if they are not specific, special type of ground water what it essentially you say this is an aquitard which is a local, this is this is, this is called a, this is called a, this is called a perched aquifer, right perched aquifer. This is, this should be called a perched aquifer, perched, perched aquifer, perched aquifer. This would be known as the perched aquifer.

This one is where the water is collected in an impervious structure, in an impervious structure within a pervious structure where water getting pervious otherwise but there is an impervious structure say you know some kind of igneous intrusion. The intrusion, the nature of the igneous intrusion in a metamorphic rock or a sedimentary rock would make that particular area to be impervious, the water would not go out.

So, if you are drilling a well or if you are making a, if you are making a well or a drill hole in those cases you'll certainly use you are going to get water, this is called a perched water table. So, in the most cases whenever you find that you know in a place like a, in a place where there are, there are no many not many sources or recognize sources of ground water yet you find that in some places the water is available, generally available. This is the perched water table where the water does not get dissipated, the water does not get displaced because of the, the igneous nature of the rock that holds it, igneous nature of the rock that holds it, right. So, this is what is, this is what has to be understood, this is what has to be understood about this ground water formation and structure. And as you can see here what would happen you know this is, this artesian well cannot be, artesian cannot take place in an unconfined aquifer, remember this.

At any point of time an artificial unconfined aquifer cannot give raise to a artesian well, it has to be a confined aquifer. Only when the water is under a pressurized condition by normal means, by natural, in a natural setting only then the artesian well is possible otherwise we find an unconfined aquifer. Unconfined aquifer whatever water we may have that water cannot be derived without pumping okay. So, that is that makes a difference between a confined aquifer and unconfined aquifer. So, it is here in a confined aquifer, we generally obtain that you know a certain kind of, all certain kind of you know pressurize condition of water which generally allows it to come out whenever required or things like that. I think it's clear, right.

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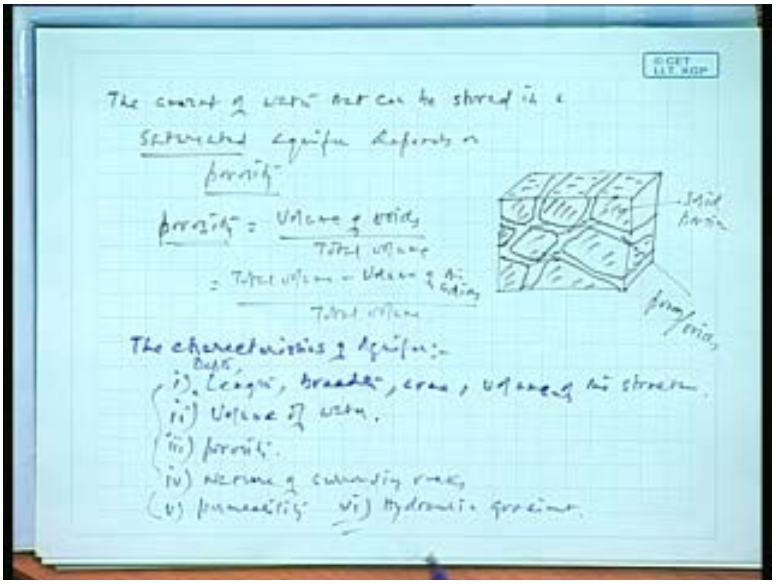

So, here from this case you know this is, this is what you would know more about as you have found out soon there are some cases the amount of water, the amount of, the amount of water that can be, that can be stored in a, in a saturated aquifer the water, the amount of water that can be stored in a saturated aquifer remember this saturated aquifer depends on porosity, depends on porosity. The porosity is known as, porosity would be, porosity is the volume of, volume of voids divided by the total volume. So, if you are just trying to think of a structure, if you are just trying to think of a structure either rock or soil or whatever I mean it can be rock, it can be soil

also in such a situation if there would be you know there would be the structures like this where there will be voids, there will be voids like this.

So you can just see in a, this may be a grain of sand, these are all grain of sand, between the grain of sand you find some spaces always. In the rock structure also, in any kind of rock structure you'll also find some voids. So, this one is this, this is the field portion that is this, that is this, the total volume would mean, a total volume would mean you know here if you just observe it like this, if you just consider it to be in a volume this would be, how it is. Say at least you know you make one drawing because you know I'll not go into this again say here if you can just observe this say you know this is what is the structure you can see you know in a three dimension that how this, the structure would be okay. Between these structures, between these two structures there will be, there will be always some porous, there will be some pores, these are known as the pores, these are known as the pores or say the voids, these are known as the voids.

You have learnt that I think you know just for your case you know you just refresh your memory here that you can see here this is what is the, this is the pores, this is the total, this is the solid portion, this is the solid, this is the solid portion. So, the total volume of the voids, the volume of the voids divided by the total volume or it can be total volume minus volume of the solids divided by total volume. This is voids plus solids, total volume is the volume of voids plus solids, okay. So, is, this is what is the porosity. This is one thing one characterize, it character that is important for all this aquifer you know generally this is other, other characteristics of, the other characteristics of the, the characteristics of an aquifer how the, how aquifer, the characteristics of aquifer you know this is length, breadth, area and volume I mean measured some kind of idea about this length, breadth, area and volume so you know this is one characteristic. Then you know volume of, volume of water, volume of volume of water yeah right volume of water then we have volume of water we have say here in such cases the length, breadth, area and volume of the aquifer total structure of the, total structure of the structure.

We generally do not say it from yeah they say depth is you know another important thing depth, you can write depth you know that suffices. So this volume of water as I have said this porosity is one important thing. Nature of surrounding rocks, nature of surrounding rocks, yes I think in the nature of surrounding rocks so one very important think nature of surrounding rocks is yeah, permeability, permeability is one important thing. permeability then you know is a permeability constant or hydraulic constant will say this hydraulic, hydraulic gradient, hydraulic gradient then say permeability constant as we have said hydraulic gradient. All these things you know there are few more, there may be few more which should be important for the characteristics of the ground water and has to be maintained has to be recorded properly. So, will take up this again in the next class, we will continue with this ground water for quite some time and till that time I think you know we, we come to the end of the class today and the next class I will still continue with this ground water contamination right, okay, thank you.

Preview of Next Lecture:

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Okay, we will start today's lecture with this you know the, with the continuation of what we began in the last class, what we started in the last class. We are actually discussing about ground water contamination and there in fact you know I have discussed about the characteristic of ground water sources, the characteristics, characteristics of ground water sources or that we know as aquifer, that we know as aquifers.

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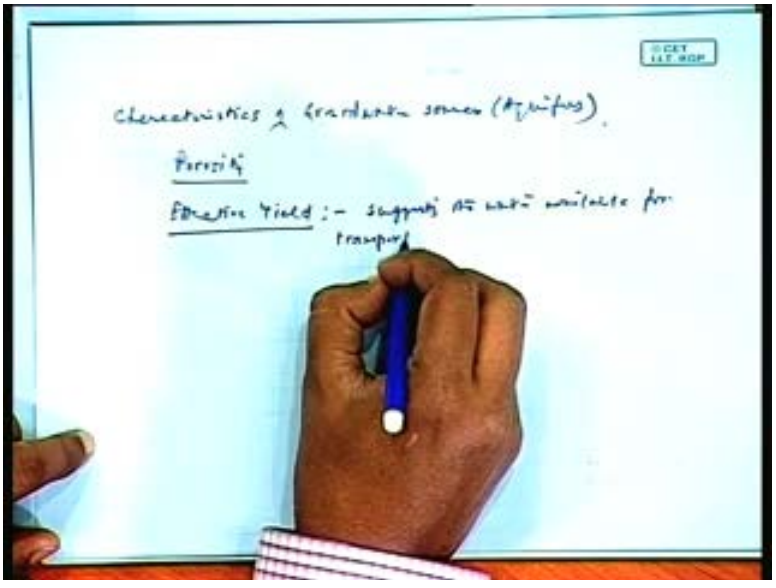

Having said that you know I have also discussed about porosity, porosity and we have, I have explained you know the porosity would mean that the total say that the void volume divided by the total volume. Isn't it? So, this what if we just try to understand little bit about this, you know there are another important thing is related to porosity is this effective, effective yield. The concept of effective yield is like this, I mean you know you see even if in many cases if you see you know it's like suppose you have a, you have wetted your cloths, you have wetted your clothes, how so well you rinse I mean you just turn it and all that. There would be certain quantity of water that would be essentially coming out, not all the water can come out. Isn't it? So, that you know when it cannot come out, so in it takes about the specific yield even if the water content may be say, say 20% or 30% of the, of the volume but you know only the available water that would be, that can be drained out would be about 20% of, 20% or so. So, you know you find a specific yield that is about a structure depending on a particular kind of structure that is what is you know in a, in addition to porosity we will also have another parameter which is known as effective yield. The effective yields suggest the water available, available for transportation, considering the three points and there the distance from the equipotential line, perpendicular distance from that point to the equipotential line and divided by the distance okay.

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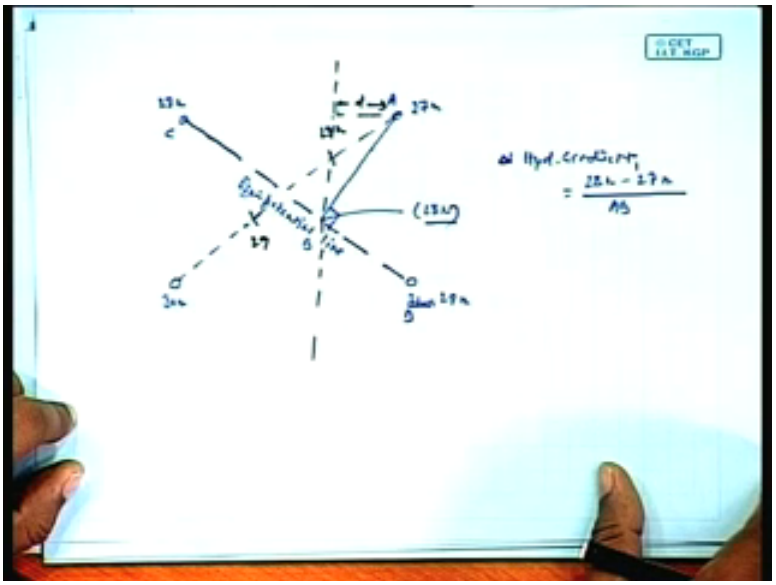

So, let me, let me take you another example in this case generally what we generally try to do is like this.

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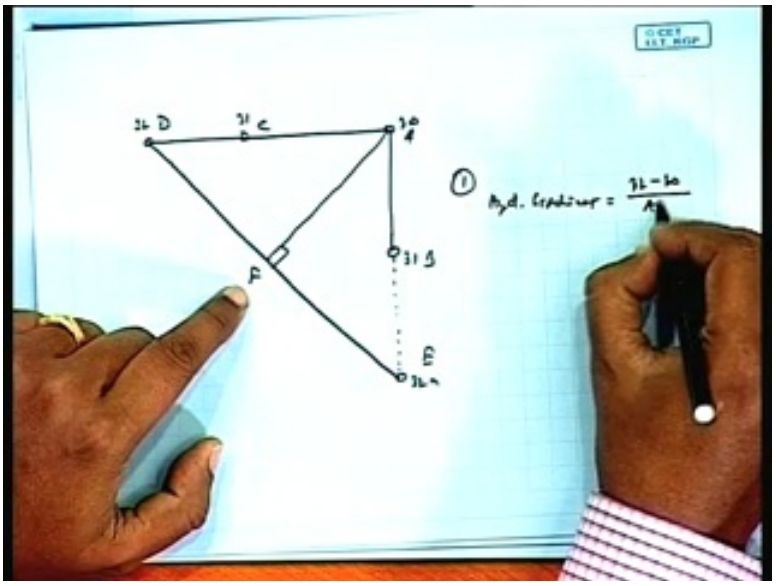

Say there are, there is an example like this. You know we have a plot. In cases when the plots are you know quite in a perpendicular fashion it is much more easier, it is much more easier to find out the equipotential line mostly in a, in a generally done in a Greek pattern. So, you know the, you can always find out the values like this say here for the same case say you know for here this one is say 32, this one is 31, this one is 31, this one is 31 and this one is 30 okay. There are two ways to do. The procedure one, one is you know you can extrapolate this, you can extrapolate this to. So, almost the same distance at the 30th, so this is 32 and then you can connect this to, this becomes the equipotential line here and then from here you can find out the perpendicular and can find out the hydraulic gradient. Isn't it? So, you can find out here say ABCDE, it is F so you can find out is, hydraulic gradient is, hydraulic gradient is 32, 30 minus 32 minus 30 divided by F meter cube per day and the time coefficient because in many cases the, the, the speed is very slow in aquifer, so we generally need not have to represented in terms of minute or in terms of second things like that.

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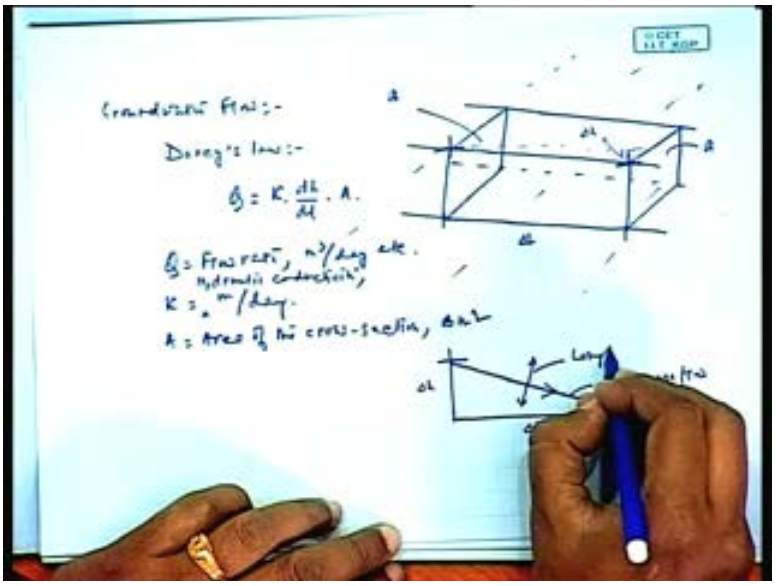

Mostly if you are representing in terms of days fair enough because the, the velocity is very low, velocity is very low. So, you know you can see here this is, this is the, this is known as the Darcy's law but this Darcy's law's provides to be you know somewhat quite simplistic in the, in the sense that there are few things you know it generally understands here, there is no, there are... If you are just observing this flow, if you are just observing this flow right here you can see this, if this is the direction you just see if this is if you can see you know in terms of a, if the change in the hydraulic head if you just consider this change in the hydraulic head here and the change here, the change here you see this, this one is del h, this one is del L. Isn't it? So, this is the two points in the, in the aquifer, this is the two points in the aquifer, this is del h, this is del L okay. Is it clear? So having said this, this is, this is, this particularly is one flow direction, is not necessary that you know the flow would be only in this direction. There would be, there would be a flow in the, in the normal to this direction of flow as well, normal, this spread of dispersion would be in the case of normal to the, to, normal to the direction of this flow. So, here you can see this is, these are known as, this is known as a transverse flow, this is known as the longitudinal flow.