Availability and Management of Groundwater Resources

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Lecture - 14
Vadose and Saturated Zone (Continued)

Welcome you all in the part 5th that is the last part of the lecture module 3 vadose and saturated zone. So, what we have understood that inside the earth's surface for finding the resource groundwater resource in the earth's surface there are some rocky formations which are holding the water, general term is the aquifer. So, this concept has already built up and just from the earth's surface if we are moving inside, we are seeing that few meters, kilometres depth remains of the vadose zone and then the water table comes.

Because it is not certain that you will get the water table at such and such depth. So, first point is that as we move down the first layer which is coming that is the vadose zone, zone of unsaturation that is the zone of aeration. Then the water table layer comes means water table layer decides that the below layer is the zone of saturation. So, zone of saturation means now the groundwater is available at this place from this place the groundwater inside the earth.

So, the concept of the vadose zone, the water table, the zone of saturation we have clearly understood.

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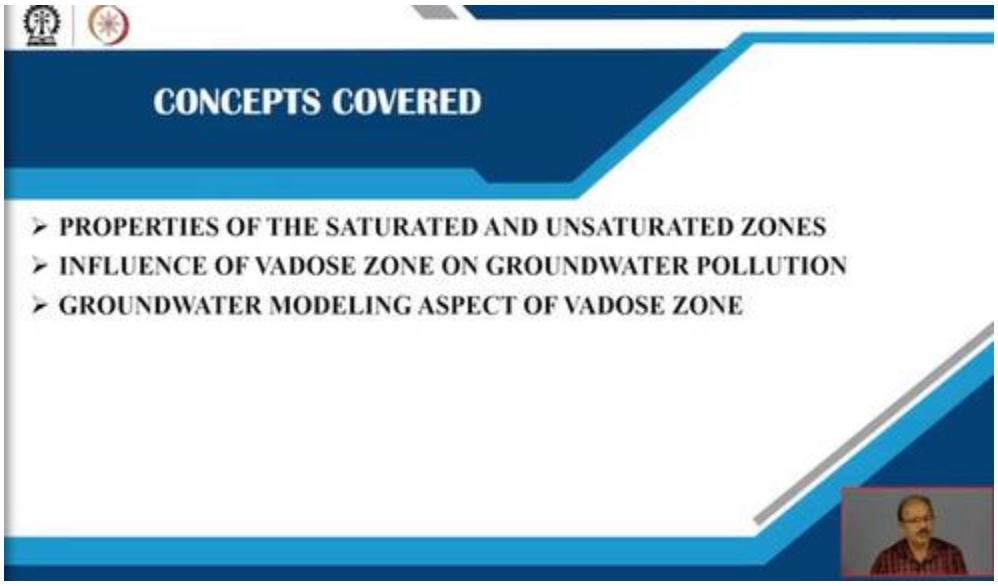

Now, few concepts are still left which I have tried to give you here, the properties of the saturated unsaturated zones, the influence of vadose zone on groundwater pollution and the groundwater modelling aspects of vadose zone. Because nowadays at the present day lots of research works are going on with respect to the groundwater contaminant, transport, modelling, contamination in the groundwater pollution etcetera.

And if we will see the role of the water zone is very, very important for making groundwater polluted. So, these brief concepts we will also keep in our mind.

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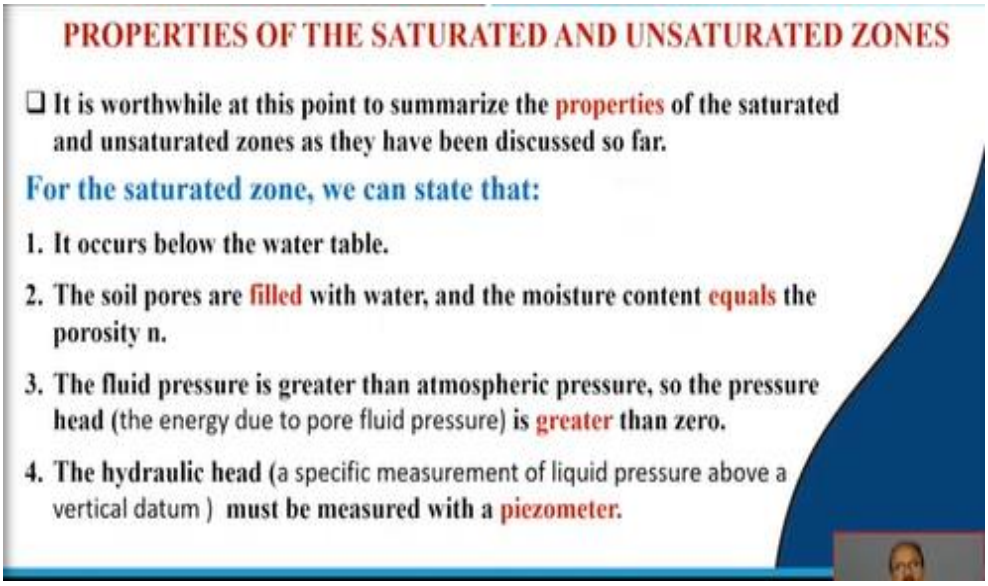

First the properties of the saturated and unsaturated zones, so unsaturated zone and saturated zone we have understood. At this point just summarizing the properties; that first thing is that the saturated zone this is the saturated zone it is remaining just below the water table this is the first concept that the saturated zone will remain just below the water table. Here the soil pores, the different pores soil pores because this is the zone of saturation.

So, all the soil pores will be filled up with water. And the here the fluid pressure is greater than the atmospheric pressure so the pressure head is greater than zero, the hydraulic head which is just a specific measurement of liquid pressure above a vertical datum how much is the liquid pressure generally we are measuring the hydraulic head. So, hydraulic head must be measured by an instrument and the name of the instrument is piezometer is known as piezometer.

So, what we are seeing that the saturated zone generally occurs below the water table. Then the soil pores are filled with water and the fluid pressure remaining greater than the atmospheric pressure and the hydraulic head must be measured with a piezometer it is measured with the piezometer.

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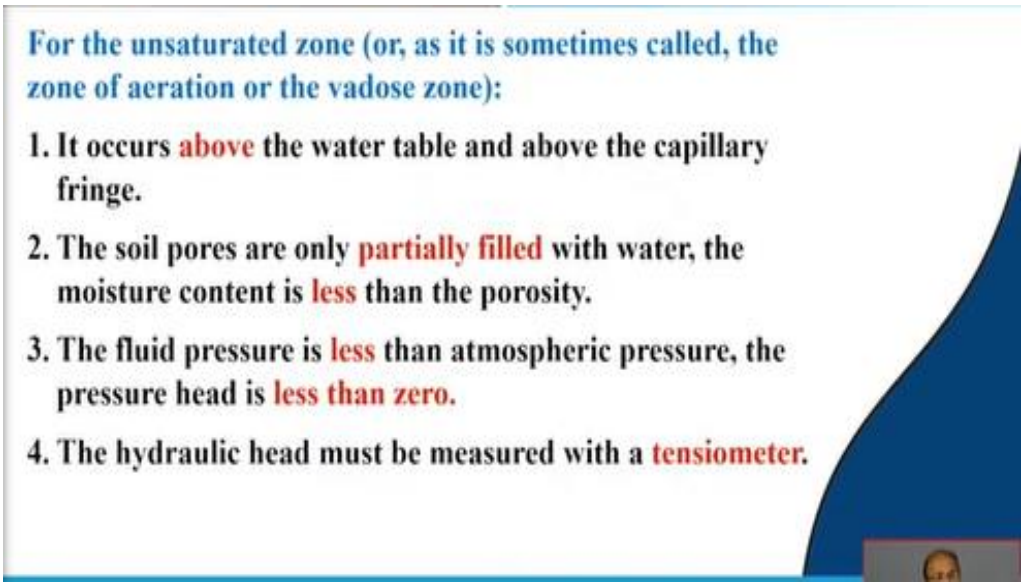

So, piezometer the concept is coming because suppose I have discussed already in the previous lecture that confined aquifer, confined aquifer or unconfined aquifer both are in the of the zone of saturation. So, the difference is that in confined aquifer is having top as well as bottom some

confining beds, confining beds means some impermeable beds, impermeable beds means we have already learned in the previous lecture about the aquiclude, aquifuge, aquitard, the types of the rock granite.

So, these are the rocks which are having no ability to transmit the water, so it is just blocking the water, it is just supposed through seepage the water is coming down so it is just blocking the water. Here also it is blocking the water to move up but this is confined aquifer but this one is unconfined aquifer because here at the bottom only it has been blocked top remains open with the atmosphere, this is atmosphere.

So, what is happening it remains at several depth this remains greater depth. So, what is happening, in this case if some instrument like piezometer will be fixed then what will happen because just upon here the pressures are remaining hydrostatic pressures. So, what is happening because of the puncturing in this because this is just closed all in a sudden if you will puncture then what will happen the water level will move up.

So, hydraulic head will be much higher than the earlier one when you will start the operation. So, that is why it is measured by different for different purposes it is measured. That was for the this what we have discussed this is for the saturated zone condition but for the unsaturated zone which is also called as vadose zone or zone of aeration what is happening. It occurs above the water table zone of saturation was occurring below the water table.

But zone of unsaturation is occurring above the water table, above the water table or sometimes you can see above the capillary fringe. Here the soil pores are partially filled with water because air is also filled up here, in the zone of saturation we were not getting any pore spaces filled with air. There the pore spaces were filled up with water only but in the case of zone of unsaturation generally the pore spaces are partially filled with water, then it is filled up with air also.

So, the fluid pressure is less than atmospheric pressure here and the pressure head is less than zero also, here the hydraulic head must be measured with a tensiometer. There the hydraulic

head were measured by the piezometer but here the hydraulic head is measured with the tensiometer.

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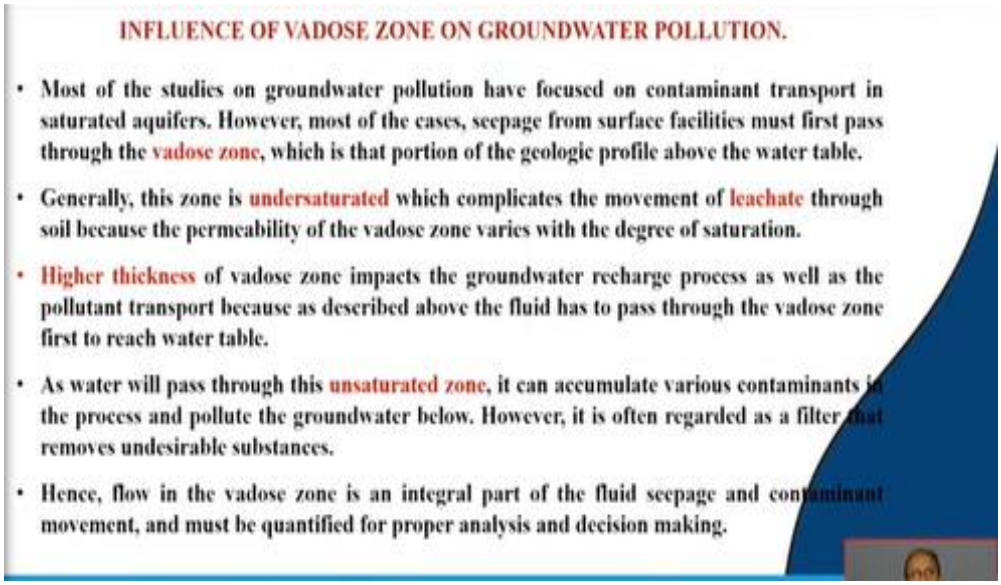

So, what it has been found that there are greater influence of vadose zone on groundwater pollution. What we have seen that nowadays the groundwater pollution problem is also there and the groundwater pollution problem are being influenced by the vadose zone. So, this there are several studies related to the ground pollution and all have focused generally that the contaminant transport in the saturated aquifers are because of the contaminants remain present in the vadose zone.

Then it is just seeping down and then meeting with the fresh groundwater. So, groundwater is being polluted. However, most of the cases separate from surface facilities must first pass through the vadose zone which is that portion of the geologic profile above the water table. So, what is happening? At some places at some studies also have proved that the; vadose zone in the vadose zone the water which are being just coming down infiltrating or percolating down.

If it is having some impurities then these impurities are being filtered also these impurities are being filtered in the vadose zone also. So, contribution of vadose zone in the ground water resource availability and management are too much only thing the detailed discussion about the

vadose zone of the specific area should be done before coming to the conclusion about the volume of groundwater available in the area.

Generally, the unsaturated zone means the zone just lying above the water table unsaturated zone that is the vadose zone which complicates the movement of leachate through soil just leeching the ground surface. This is the ground surface, this is the water table, so this is the unsaturated zone and this is the saturated zone. So, in unsaturated zone the leaching process takes place through the vadose zone only so it varies.

So, the permeability level is also different compared to the zone of saturation, saturated zone is having something different level. So, higher thickness of vadose zone impacts the groundwater recharge process as well as the pollutant transport because as described the fluid has to pass through the vadose zone first then it will reach to water table. Any fluid which is coming from the top will first pass through the vadose zone region then it will reach to the water table region.

So, as the water will pass through the unsaturated zone it can accumulate various contaminants in the process. Now, the fluid is coming towards the water table so various contaminants will be remain here in the unsaturated zone. It accumulates and pollute the ground water below because just if it will touch the water table, the water table is what? The groundwater level of the water level of the groundwater that is the water table.

So, ultimately polluting the groundwater it is ultimately pulled in the groundwater below. So, in general the vadose zone is referred as a filter media. It is also behaving like a filter media many impurities or undesirable circumstances are being removed here while incoming towards the water table the water which is incoming just towards the water table it is filtering also. Hence what is there?

Hence flow in the vadose zone is an integral part of the fluid seepage and contamination movement very important. So, what is the contaminant transport status in the vadose zone? This is very important we should find out first then only we can have the assessment of the

groundwater pollution just in the zone of saturation. So, that is why several modelling aspects are also there.

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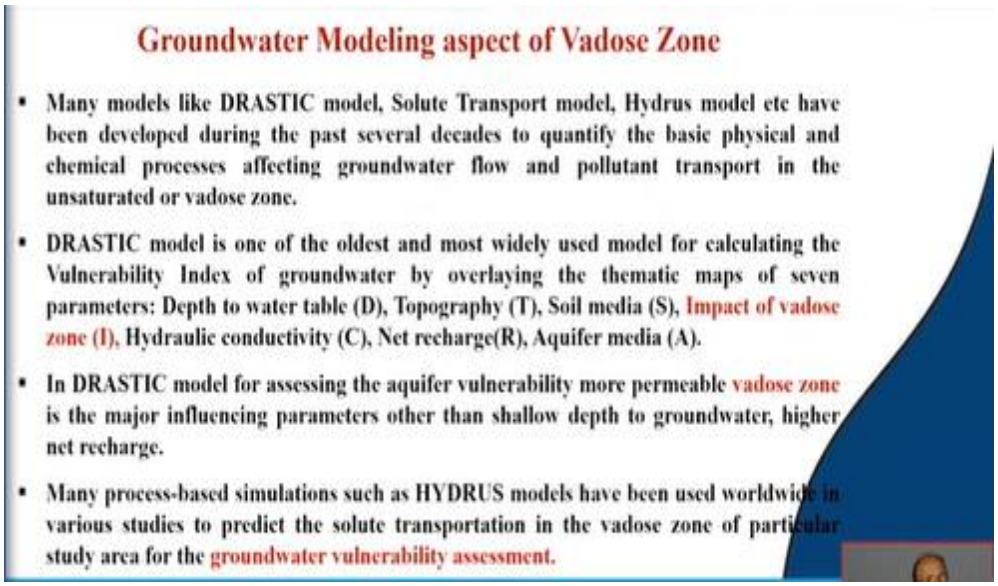

One important aspects of modelling is the drastic model very, very important aspect. This through this model lots of research works are going on, it is one of the oldest and widely used model with seven different vulnerability index parameters. It is showing this drastic model is just telling about how the aquifer has become vulnerable, whether the underlying aquifer is good or not. How much level of sickness it has?

So, this can be determined with the help of the drastic model in which seven different parameters are being monitored. The first is the depth to water table now you are clear because this is the surface this is the water table. So, we can measure the depth how much is the depth of the water table of any area where we are willing to have the assessment of the aquifer vulnerability. So, they have to water table second the topography surficial features.

What are the different surface features available on? What is the soil media? Which type of texture, impact of vadose zone. So, here impact of vadose zone is also one of the parameters. Now hydraulic conductivity how much the water can be moved near to recharge total recharge capacity of the area and the aquifer media. So, aquifer media what is the formations type. So,

what we have seen that this drastic model is a very important model for making the area just knowing about the vulnerability of the underlying aquifer.

And for the vulnerability assessment generally we are using the detailed characteristics of the vadose zone of the area.

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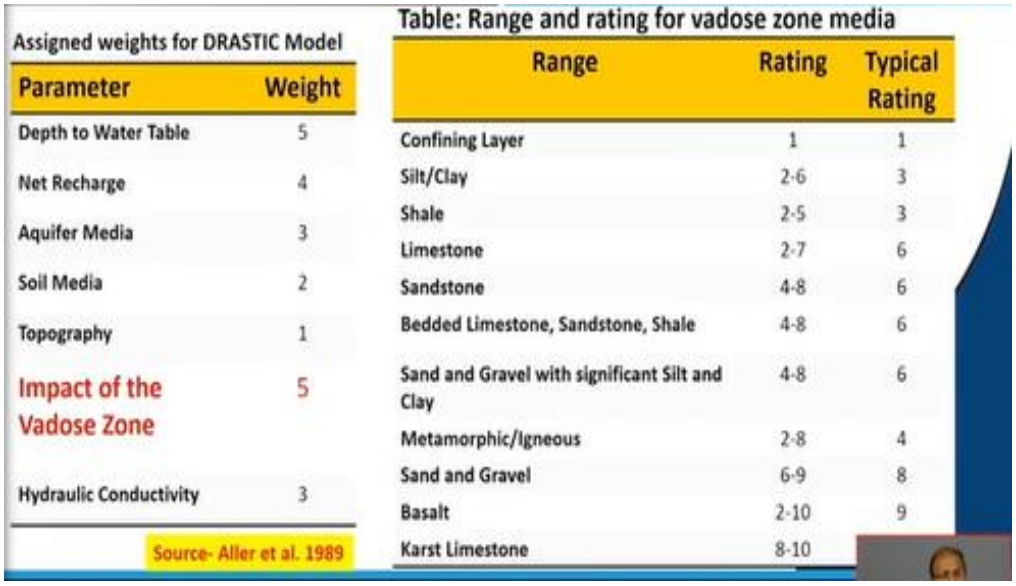

Assigned weights for DRASTIC Model

Parameter	Weight
Depth to Water Table	5
Net Recharge	4
Aquifer Media	3
Soil Media	2
Topography	1
Impact of the Vadose Zone	5
Hydraulic Conductivity	3

Source- Aller et al. 1989

Table: Range and rating for vadose zone media

Range	Rating	Typical Rating
Confining Layer	1	1
Silt/Clay	2-6	3
Shale	2-5	3
Limestone	2-7	6
Sandstone	4-8	6
Bedded Limestone, Sandstone, Shale	4-8	6
Sand and Gravel with significant Silt and Clay	4-8	6
Metamorphic/Igneous	2-8	4
Sand and Gravel	6-9	8
Basalt	2-10	9
Karst Limestone	8-10	

And the these are some of your parameters as I have discussed depth to water table, net recharge, aquifer media, soil media, topography, impact of vadose zone, hydraulic conductivity. You can see the impact of vadose zone which has given also 5 from 1 to 5 the 5 weightages have been given for impact of a vadose zone and depth to water table. So, in the side table you can see the different layer has been rated 1, 2, 3 the different 1 to 10 the rating is done here.

And then the on the basis of the different findings of the area the different study of the area it is just an example of any study. We can see the different grading is also done for confining layer 1 silt and clay 2.6 so in this fashion you can see that the different ratings are available and these different ratings are generally deciding the type of the aquifer media in the area and the vulnerability assessment of the underlying atmosphere.

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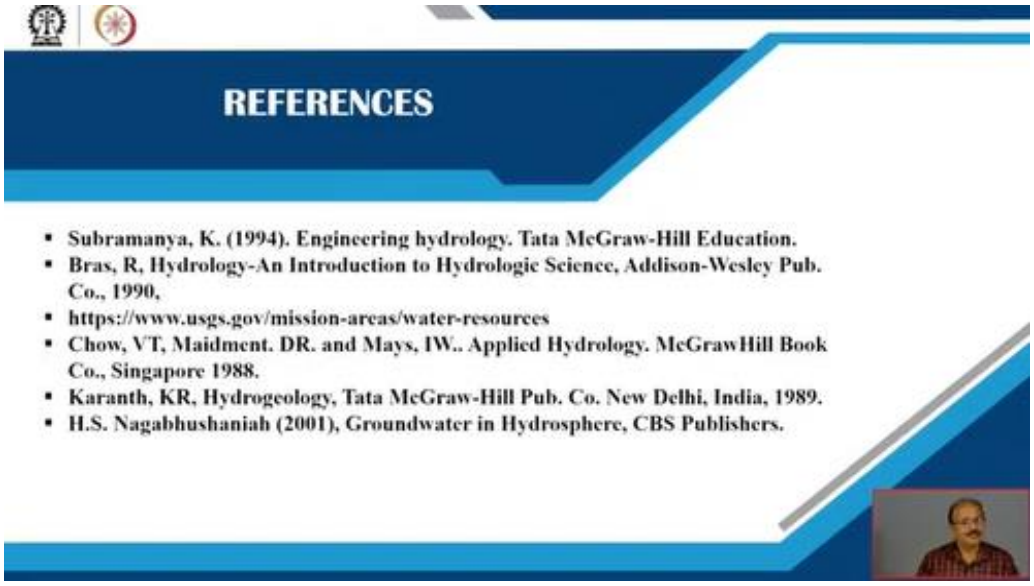

Now these are few of the references.

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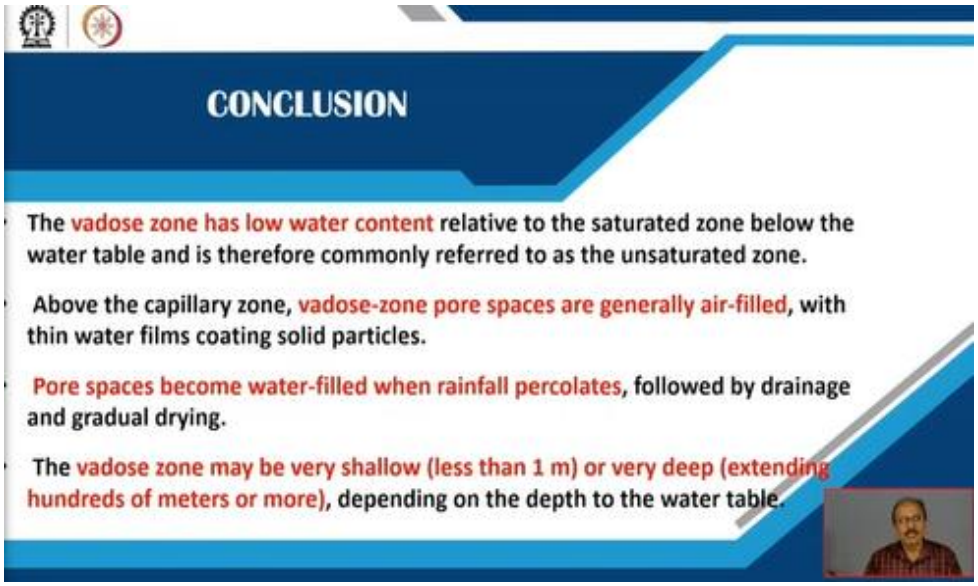

So, now I am concluding the topic vadose zone and saturation zone, so this is being concluded now. The vadose zone has lower water content relative to the saturated zone below the water table and is therefore commonly referred to as the unsaturated zone. So, now I am concluding the topic of the model 3 vadose and saturated zone, the vadose zone we have understood now has low water content related to the saturated zone below the water table.

Because we have seen that the underneath the earth's surface the first zone is just lying underneath the earth's surface is the unsaturated zone or the vadose zone or the zone of aeration.

It has low water content because here the spore spaces are also filled up with the air whereas the bottom layer of the unsaturated zone the one layer is water table and this water table differentiates the zone of unsaturation and zone of saturation.

So, now I am concluding the topic vadose and saturated zone. We have understood clearly that beneath the earth's surface the first zone is the vadose zone, zone of unsaturation. Then water table is coming and below the water table is the zone of saturation. So this, already have been discussed. Now this point is also clear this is the concluded point. So, this point is also very much clear that in the zone of unsaturation that is the zone of aeration generally the pore spaces are being filled up with the air and water.

But in the case of zone of saturation the pore spaces of the formations are filled up totally with water. So, the zone of aeration will have different sub zone also, we have seen that the zone of unsaturation is divided into soil water zone, intermediate zone, then capillary zone and then comes the groundwater water table and below the water table is the zone of unsaturation. So, this is the general concept about this zone.

Above the capillary zone where those zone porous places are filled up with air and thin with thin film of water in the spaces pore spaces. Pore spaces become water filled with when rainfall percolates followed by drainage and gradual drying, when rainfall will percolate suppose in the top of the layer when rainfall will percolate. So, then what will happen the earlier say this is the surface though this is the soil of the; this formation.

This is the pores process of this incident formation. So, what will happen? This formation will have only the air because it was dry now. So, it is having only air but as soon as the rain will fall or some as soon as the rain will fall then what will happen this will infiltrate and percolate. Then what will happen? This is already having the air. So, it will just arrest the drop of water also so that is why the zone of aeration will have the air and water in their pore spaces.

But what will be the case of zone of saturation? Zone of saturation the pore spaces will never have the air, always remain filled up with the water because it is zone of saturation, total water is

only here only. So, the vadose zone may be very shallow or maybe very deep it depends on the different depth of the water table at different places on the earth surface. So, at some place of the earth's surface we may get a vadose zone for a very small area and in some other place on the land surface we may get vadose zone to a larger thickness area.

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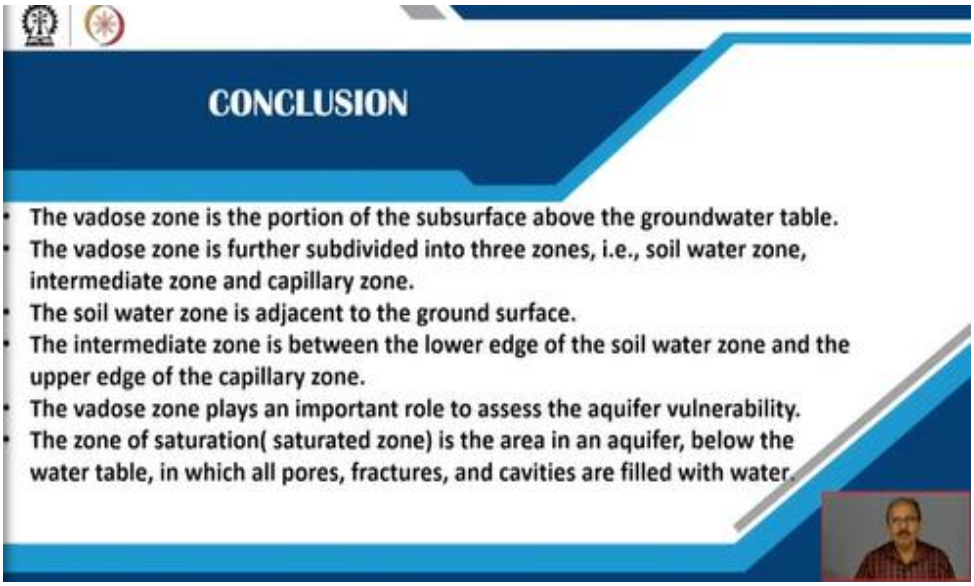

Now the vadose zone is the portion of the subsurface above the groundwater table, it is clear now. The vadose zone is further subdivided into three zones, soil water zone, intermediate zone and capillary zone. Soil water zone is adjacent to the ground surface, which zone remains adjacent to the ground surface that is soil water zone. The intermediate zone is between the lower edge of the soil water zone and the upper edge of the capillary zone.

The vadose zone plays an important role to assess the aquifer vulnerability. The zone of saturation is the area in an aquifer below the water table in which all pores, fracture and cavities are filled with water. See this course is not only for your academic purpose, whatever points I am giving in the lecture material these will also help for your competitive exams. Just for example which water zone is remains adjacent to the ground surface below the ground surface that is the soil water zone.

So, soil water zone is the part of saturated zone unsaturated, part of unsaturated zone. So, in this way try to make concept for availability and the management of groundwater resources with the detailed discussion of the vadose zone and saturated zone. Thank you very much.