**Availability and Management of Groundwater Resources**
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**Lecture - 10**
**Introduction about Vadose and Saturated Zone**

Welcome to you all in the NPTEL course on availability and management of groundwater resources. Today, I will discuss the third part of the lecture vadose and saturated zone. Now as just we will recall the previous lectures, we have seen that for knowing about the availability of the groundwater resources within the earth's surface the several factors are playing their role. In the very first lecture we have seen that the hydrological cycle.

One of the important cycles on the atmosphere to the ground surface which plays very important role for the recharging of the groundwater resources inside the earth's surface.

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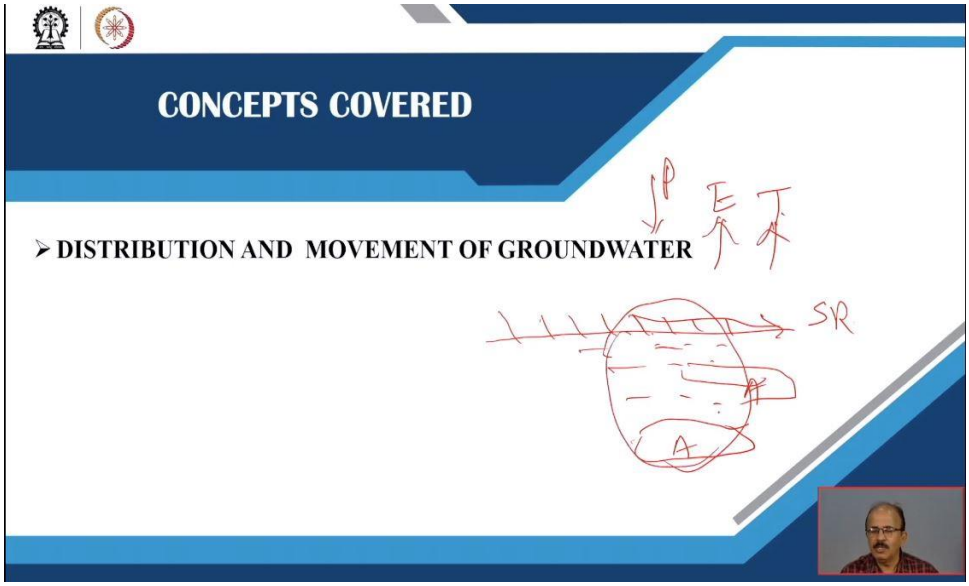


In the first lecture we have seen that suppose this is the earth's surface this is the earth's surface and in the earth's surface just within the earth's surface we were just receiving the rainfall amount. So, this rainfall drop just enters into the earth's surface the term if you will recall it was infiltration, now after reaching to the first top layer of the soil this raindrop then it goes inside further and the term here is the percolation.

So, infiltration and percolation process again sends the raindrop towards the gravity to a rock which bears the groundwater rock was termed as aquifer. So, just if you recall this the points

then you will find that the only and only recharge source of the groundwater is the rainfall amount. So, variation in the rainfall amount will play very important role in the accumulation of groundwater in the aquifer.

So, in the second lecture we have discussed how we can just see the different behaviour of the different types of rock formations. Whether each and every type of rock formation holds groundwater or any specific type of rock formations hold groundwater. So, since we have to find out the availability of the groundwater resources. So, just we have crossed the first and second part of the lecture series.

This is the third lecture series entitled vadose zone and saturated zone. So, what we are doing we are just entering into the inside the surface because, at the top of the earth surface we have seen the role of the hydrological cycles in terms of precipitation in terms of evaporation in terms of transpiration and in terms of surface runoff. These whole actions have been noticed in the first very first lecture.

Now, the different rock formations which are lying at different depths inside the surface will have different characteristics for holding the groundwater. Now but this rock formation which is termed as aquifer may be at server depth or at deeper depth will definitely have some media in between from the surface to the rock formation which holds the water. So, today we will learn about this total area which is very responsible for the accumulation of the groundwater resources in an aquifer.

So, this today we will learn how the raindrops first entering into the soil layer infiltrating into the soil layer will just accumulate inside the different layers of the soil and then it reaches to the formations. So, today we will try to discuss about the distribution and movement of the groundwater inside the earth's surface. What we have seen? We have seen that at the surface during the rain, the rain drops falls and this rain drops then enters that is filled infiltrated down.

And then percolated down and then reaches to the rocky formation which holds the water that is an aquifer. So, this is an aquifer. Now all the total amount of the raindrops not reaches through the aquifer that is the formations bearing the water body. So, what factors are playing

there? The factors we will try to discuss these factors today in terms of two important zones just inside the surface and the zone is zone of unsaturation and zone of saturation.

So, this we will learn today zone of unsaturation unsaturated zone and saturated zone. This we will learn because then only we can understand how the raindrops means the water which are being recharged will reach ultimately to the rocky formations.

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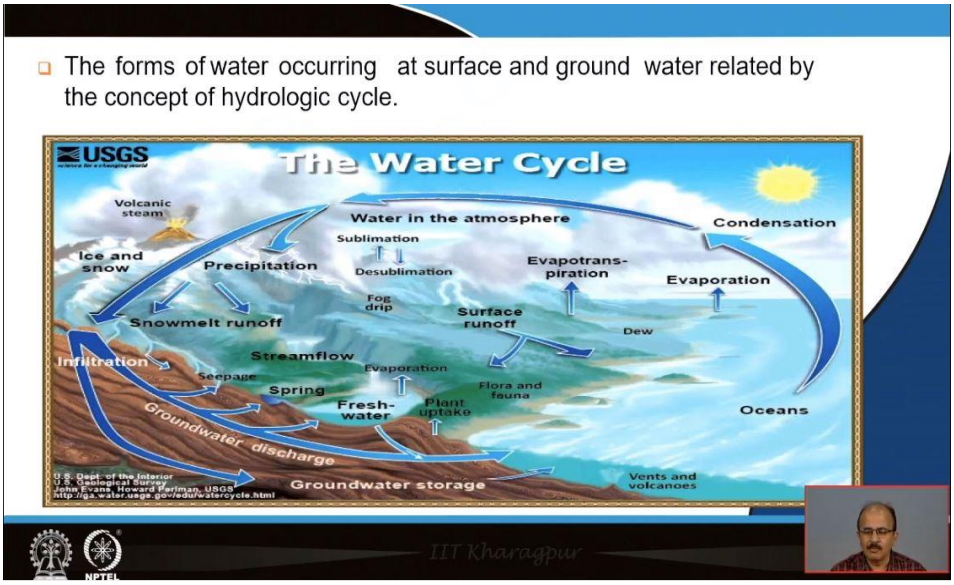


So, just we have seen in the very first lecture also we have seen the details working of the height components of the hydrological cycle. Now, these total concepts will play and then this will in this will be influenced by several factors which have already been discussed in the previous lecture.

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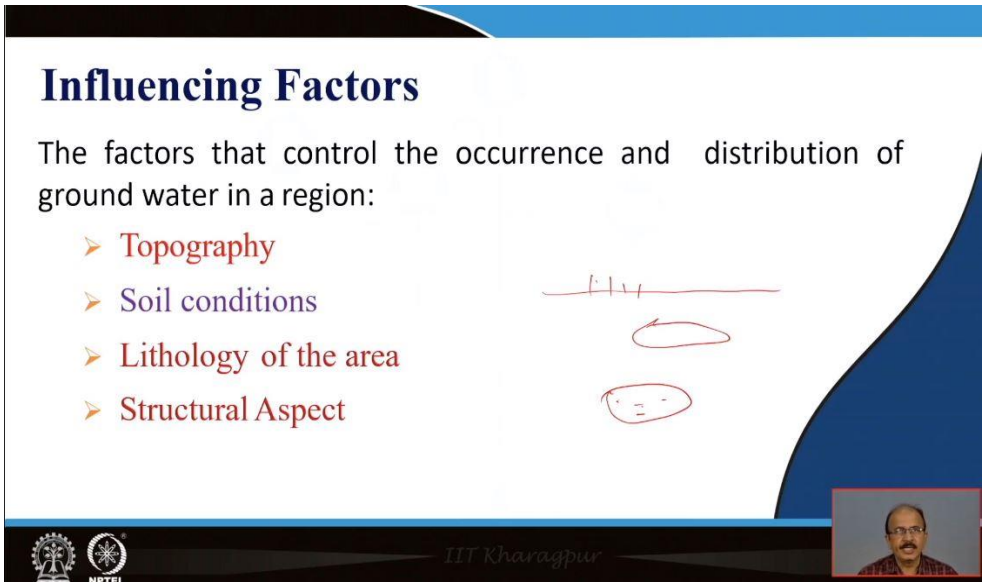

I am recalling you here also that occurrence and distribution of groundwater depends in different region by the different important factors and the factors are topography. Topography is one of the important factors soil conditions, if the soil will be porous definitely the amount of water will be more there. Lithology of the area what are the different rock types what we have discussed in the second part of the lecture.

And the structural aspects whether any folding is there faulting is there. So, these whole factors are playing very important role for bringing the raindrops if these are the raindrops to the aquifer which is lying at maybe be at server depth or may be at deeper depth. So, aquifer may be at near to the surface or deep down to the surface.

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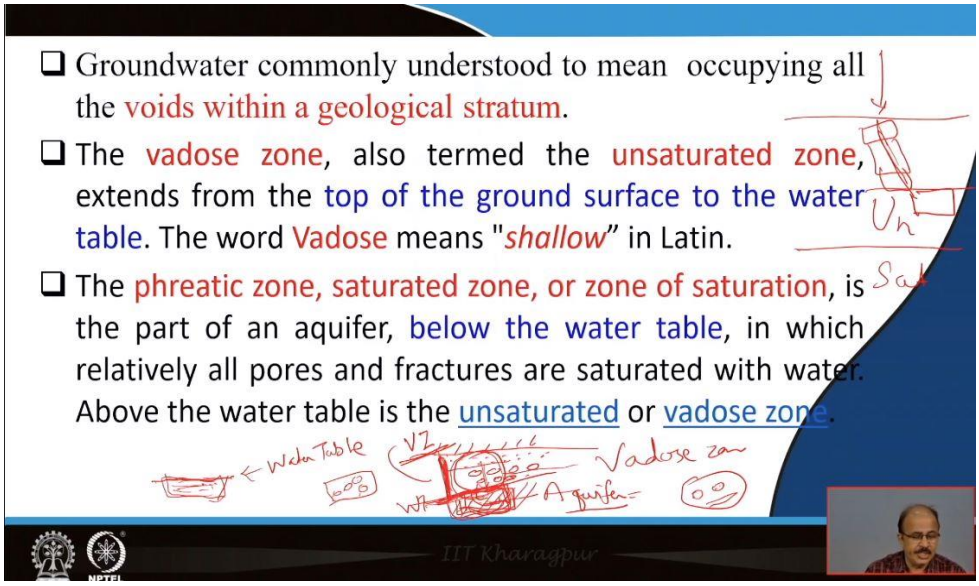


So, now in this lecture we will understand about the two important formations and the two important formation is first is the unsaturation for unsaturated formation and other is the saturated formation. So, the unsaturated formation is also termed as vadose zone, this is also termed as vadose zone. So, now this suppose this is the earth surface and the aquifer is lying somewhere here.

So, just beneath the earth surface is the soil layer just beneath the surface the soil layers then some unconsolidated and consolidated rocks are remaining here. And then one formation is coming porous formation is coming which directly holds or receive the drops of rain and forms the groundwater inside the earth surface. So, now this zone, zone means from here to here because this is an aquifer, we know any rocky formation which is holding the water.

So, groundwater resources generally lie within an aquifer and aquifer are nothing these are only the rock formations different rock formation we have discussed already in the second part of the lecture. We have already discussed the aquifer as a formation geological formation. So, this aquifer will receive how much amount of water depends on this important media and this important media is known as the vadose zone or unsaturated zone.

So, generally the voids within a geological stratum say if this is a rock and, in the rock, there are voids, so this will hold the water. So, this concept is clear now that the water will remain in certain pore spaces within a rocky formation. So, but from the earth surface to the rocky formation, there are some media which play very important role and this media is nothing but this media is termed as unsaturated zone which extends from the top of the ground surface to the water table.

Now, another just I am recalling you the term water table again because I have already discussed in the previous lectures water table is the upper part of any saturated formation any saturated formation means what means any aquifer this is an aquifer. Aquifer means rocky formation holding the water and the formation stop part of the layer of the water is termed as water table, this is termed as water table.

So, what has happened? So, what has happened the vadose zone which is generally called as unsaturated zone, unsaturated zone means having no water or very less water but compared to saturated zone it is having very low amount of water within it. But generally vadose zone is termed as unsaturated zone and it extends from the top of the land surface to the water table. So, this is the aquifer in saturated formation so this is the water table.

So, from here to here this depth is termed as the vadose zone, so vadose generally means in Latin shallow generally, the word in Latin is termed for shallow. So, this is the zone which plays very important role in the growth of the plants in the contaminant transport to the groundwater resources. So, this vadose zone is a very important zone. So, today we will learn about two important zones.

Because, see the rain water rain water will definitely reach to the aquifer then only it can store the ground water. So, in between this is the path, so what are the characteristics of the path we will try to learn today and this will we will learn in the heading vadose zone and

saturated zone. So, first we have already understood what is vadose zone? Vadose zone is nothing but it is just the distance from the inside earth's surface to the top of the water table.

This is called as vadose zone. Now, the saturated zone another term is because, vadose zone is unsaturated zone another term is saturated zone or the zone of saturation or the phreatic zone, three different names for the same meaning saturated zone or zone of circulation of phreatic zone is the part of an aquifer, aquifer why because this is just holding the water below the water table this is the water table.

So, this zone which is below the water table is known as the zone of saturation of phreatic zone or subjected zone. In which all pores and fractures because this is a rock and rocks are having pores or fractures. So, in which all pores and fractures are saturated with water means filled up with water these are filled up with water. So, since the rocks are having number of pores as well as fractures and these rocks are being filled up with water.

So, these are called as saturated zone. So, just below the water table the formations holding the water is known as saturated zone.

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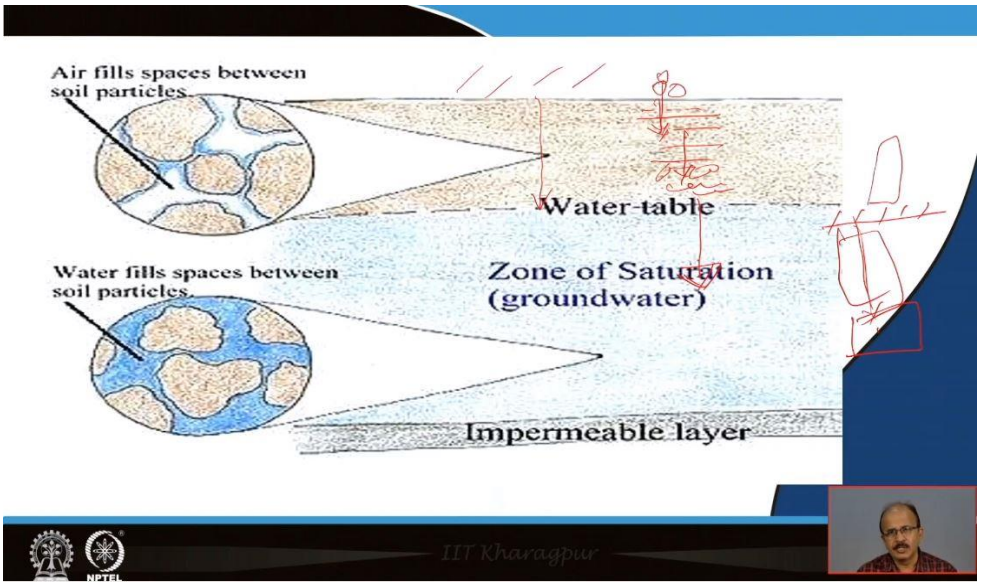


So, now we have seen that this destination from the earth's surface to the aquifer because here only the groundwater will remain the topic of the lecture is availability and of groundwater resources and management of groundwater resources. So, availability part where the groundwater will remain available can be clearly understood if we are having the clear concept about the first the hydrological cycle.

We have already generated the concept then the rock formations the rock formation the formations which holds the groundwater and the movement of the raindrops for just transforming it into the groundwater. So, this zone area is very important and this can be clearly understood by the concept of vadose zone, vadose zone means unsaturated zone and the saturated zone that is your zone of saturation that is the phreatic zone.

That is the aquifer which is just holding the groundwater resources inside the surface. Here, also we can see, this is the water table, why it is a water table? Because it is the top part of the zone of saturation, it is the top part of any aquifer. So, any aquifer now here, one important point is which type of aquifer but now I will not discuss here I will discuss it later on here, this aquifer is the unconfined aquifer because one impermeable layer is just underlined to it.

So, this zone of saturation top part is termed as water table so this is this is totally the zone of saturation where the pore spaces are filled with water. So, the spaces you can see here between the soil particle water remains but here in the unsaturated zone means this is the ground surface and this is the depth from ground surface to the top of the water table. So, here what we are seeing the air phase spaces between the soil particles not the water.

That is why it is called as unsaturated zone. So, one is the unsaturated zone and then the saturated zone. So, this usually happens inside the earth surface and then that is why the water infiltrates and then percolates and then reaches to the aquifer if this is the aquifer. So, the raindrops from the surface infiltrated down then the different layers of the soil first layer of the soil second layer of the soil third layer of the soil of several layers of soil.

Then small rock is unconsolidated rocks are there, consolidated rocks are there. So, through it the raindrop passes and then reaches to the aquifer this is the aquifer because, it holds the groundwater and the top of any aquifer any aquifer means the top of any unconfined aquifer we will understand it just now and unconfined aquifer is termed as water table. So, the area here from water table inside or just below the water table area is termed as zone of saturation.

And the area above the water table to the ground surface is termed as unsaturated zone or vadose zone. So, two important zones are here. Now after understanding these two terms that is the unsaturated zone and saturated zone.

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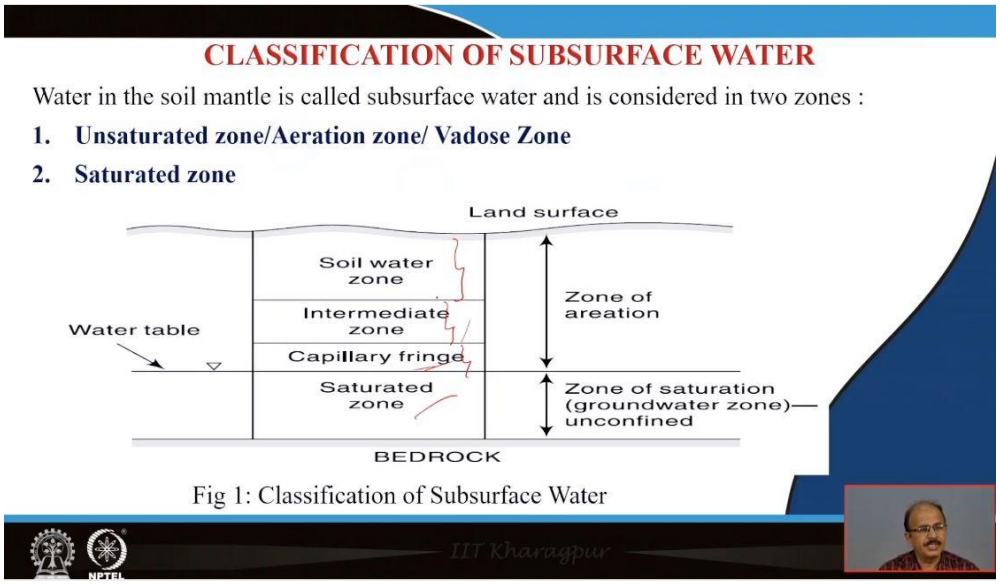


Now we will try to learn some more details about this through the picture also just you see here one diagram is there the land surface and in and just beneath it we are getting one layer which is known as soil water zone then the intermediate zone and then the capillary fringe, three important terminologies till it reaches the water table. So, in the previous slides we have learned this much area is unsaturated area and this much area has saturated area.

Here also the concept is the same the different name is there aeration zone and vadose zone, all three different names are having the same meaning. The point is that here the pore spaces of the soils and rocks are generally filled up with air. Whereas in the saturated zone the pores places within rocks and soils are filled up with water. So, this is the zone of saturations and this is the zone of addition or unsaturated zone or vadose zone.

But see here, just beneath the surface the first thickness of layer of the soil is known as soil water zone. This is just underneath the earth's surface, the first layer which we are getting is the soil water zone. Beneath it a layer remains is the intermediate zone and lastly because just now we are approaching towards the water table. So, the third layer which we are getting in the unsaturated zone is the capillary fringe and then the saturated zone is coming.

So, in unsaturated zone we are having three important zones, different zones and three important zones are soil water zone first one then the intermediate zone and then the capillary fringe. These are also very important for scientific studies these zones are very important. For the growth of the plants these zones are very important the uncertain zones are very important

because you know for the sake of the photosynthesis propagation of food of plants, plants usually need water.

So, these waters are being captured from the unsaturated zone only. So, how these phenomena take place, we will discuss later on but here the important point is beneath the surface three important layers are remaining till the water reaches to the water table. The top one is the soil water zone just beneath is the intermediate zone and then in the last the capillary fringe then water table comes as soon as the water travels is coming.

It means the zone below it is the saturated zone and zone above is the unsaturated zone. Unsaturated zone is called as vadose zone or the zone of aeration why zone of aeration because, it the pore spaces within the soils and rock formations in this zone is usually filled up with the air. Whereas, in the zone of saturation the pore spaces within the soils and rock formations are usually filled up with water that is why it is zone of saturation and this is unsaturated zone.

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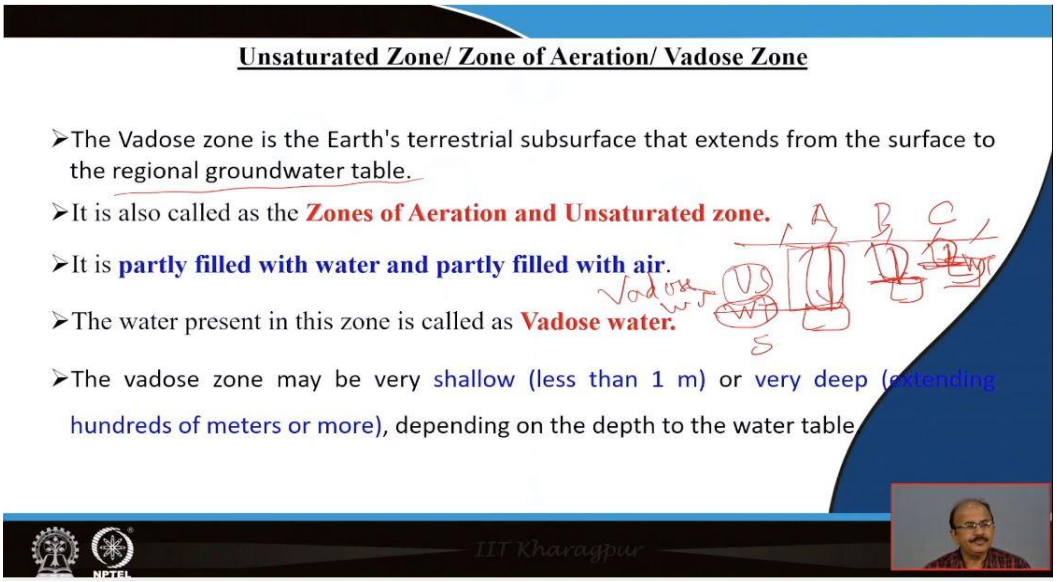


Now, next the vadose zone is the earth terrestrial subsurface that extends from the surface to the regional groundwater table. So, there in the previous slides we have understood about till the water table now one different term has come regional groundwater table. So, why because the water table varies from place to place, it will not remain at the same depth at every place on the earth surface. So, it varies from place to place.

So, it varied from place to place means what? Means suppose if this is the surface and these are the different aquifers which are lying inside the surface. So, the depth of the aquifer from the earth's surface will vary at different places. If the depth of the aquifer will vary at different places, then definitely the depth of the water table because the upper part of any rocky formation is known as water table.

So, this rocky formation holding the water in water table so we are seeing here that this aquifer depth is different from this one and it is different from this one. So, we may get the shallower groundwater water table we may get the deeper water table that is why the term regional groundwater table has come. So, at different place the depth of vadose zone will vary at say this is the place A the depth of the vadose zone is this much.

This is the place B the depth of the vadose zone is this much; this is the place C the depth of the vadose zone is this much. So, it varies with respect to the original groundwater table of the area, it is definitely a zone of aeration because the pore spaces within the soil and rock formations are being filled up with the air. However, it is partly filled with water and partly filled with air also.

Since, it is filled with air so it is also called a zone of aeration the water present in this zone means this is very important zone the unsaturated zone the vadose zone, this is water table and this is the saturated zone, so this is the water table. So, this water which remains partly filled with air and partly with water is termed as vadose water this is termed as vadose water. So, that water is the amount of water very little amount of water compared to the saturated zone water is termed as vadose water.

And this vadose zone may vary from less than one meter that is shallower hydrogen a very deep more than hundreds of meters or further deep. So, depending on the depth of the water table this vadose zone varies from place to place at different places the vadose zone where is even in different seasons also, the thickness of the vadose zone varies from place to place. So, this is very important information’s for the distribution.

Or the movement of the raindrop water to inside the earth's surface through different media to the aquifer. So, that is why vadose zone is very important zone with respect to the groundwater resources.

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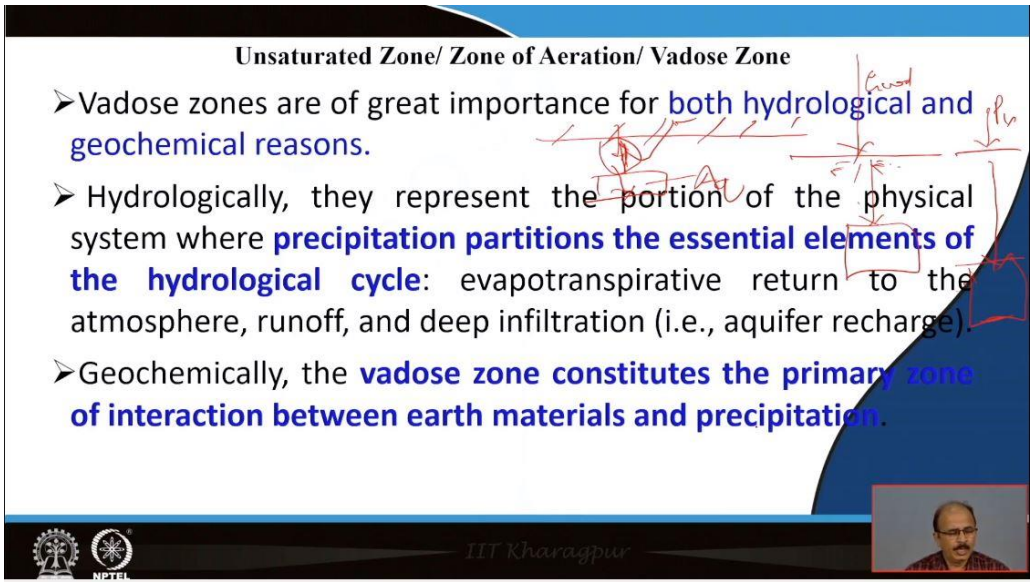


Now, these unsaturated zones of vadose zones are very important from the hydrological study of point of view as well as from the geochemical study point of view. From both types of study hydrological studies as well as geochemical studies this vadose zone is very important. Why? Because, hydrologically they represent the portion of the physical system where precipitation partitions the essential elements of the hydrological cycle.

So, here what is happening say this is the earth's surface and the this is the zone, this is just the aquifer and this is the vadose zone and the raindrop enters into it so it brings certain minerals with it also essential elements with all it also. So, in this zone this zone is responsible for sending these essential elements or some contaminants to further down to the aquifer or to send back to the atmosphere in terms of evaporation transpiration etcetera.

So, that is why hydrologically hydrological study point of view this is a very important role. I have told you from the variation in the seasons, seasonal variations in the different seasons the depth of the vadose zone will vary differently at different place on the earth's surface. Suppose in area an area is which is having very good rainfall amount is here and this is also one area which is having very poor rainfall amount.

So, here, where the rain fall is very poor very scanty. So, what is happening the depth of the vadose zone will be more, why because the zone of saturation which the rocky formation which is holding the water may dry and then it comes down. But suppose an area is having very good rainfall amount then what is happening the soil will remain saturated and then

what will happen the area the zone of saturation means the aquifer means the rocky formation which is holding the water here the area will vary.

Because here the hydrogen will be lesser. So, hydrologically it is very important to have the greater depth study of the vadose zone. Geochemically also, why geochemically? Because vadose zone consumes the primary interactions of between earth materials and precipitations. Earth materials are already inside the surface and precipitated water is coming down. So, what will happen? There may be some interaction between or among the elements.

And they may contaminate the groundwater resources which lie further down to the vadose zone. So, this vadose zone is very, very important from the study point of view from the groundwater movement point of view.

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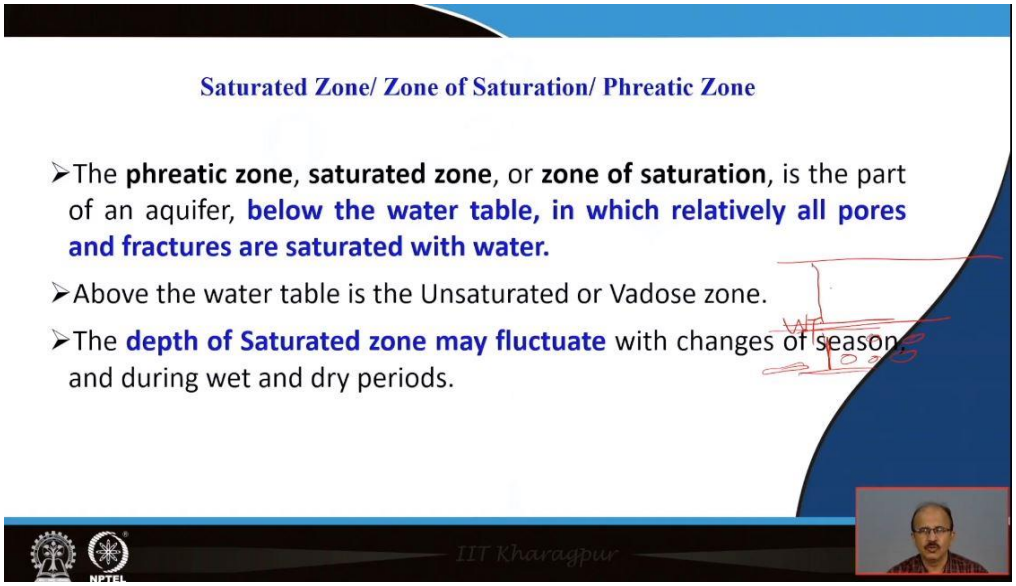


Now, saturated zone, the first what we have understood we have understood about the unsaturated zone. Unsaturated zone we have clearly understood that this is the zone just lying beneath the surface to the water table. So, this is the water table and this depth the total depth from the ground surface to the water table is termed as vadose zone or the zone of aeration. So, zone of aeration why?

Because soils and rock formations the spaces in the soils and rock formations are generally partly filled with water partly with air. The name of the water is generally termed as vadose water what we are getting in the vadose zone and just below the water table is the zone of

saturation. So, this vadose zone is having the different layers also we have seen and I will discuss these different parts of the vadose zone in the next part of the lecture.

Now I will just discuss already I have discussed the vadose zone now the second important zone that is the saturated zone that is the zone of saturation or the phreatic zone. So, the phreatic zones, saturated zone or the zone of saturation three different names for the same area is the part of an aquifer, it is a part of an aquifer is nothing but it is a rocky formation holding the water holding the water means groundwater, below the water table.

So, this is the water table and the formations are lying here this is an aquifer. So, below the water table in which relatively all pores, whatever the total number of pores are here all pores and fractures the two important terms are here pores why pores word has come because the rocks may be sedimentary origin means soft rocks are there. In soft rocks generally, we are getting the pores whereas in hard rocks we are getting the fractures or lineaments.

So, in the pore spaces in or in the fractures generally the groundwater stores inside the aquifer so in these two places all pores and the fractures are relatively filled up with good amount of water means the saturated with water. Since, the zone below the water table all the pore spaces and the fractures are filled up with water plenty of water. So, this zone is therefore termed as zone of saturation, this zone is generally termed as zone of saturation.

And just above the water table just about above the water table the zone is termed as vadose zone. So, the depth of saturated zone may fluctuate with changes of seasons, this may fluctuate with changes of season and during wet and dry periods. I have given you the importantly that during the wet season and dry season the depth this depth will vary from place to place.

So, the depth of saturation or the depth of saturated zone may fluctuate with the change of season. And also, during the wet season and dry season it will vary from place to place. We will learn this much in this lecture. Now the next part will be discussed, thank you very much.