Availability and Management of Groundwater Resources
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Lecture - 11
Vadose and Saturated Zone (Continued)

Welcome you all in the part 2 of the model 3 vadose and saturated zone, once again we will discuss about the different issues with respect to the vadose zone.

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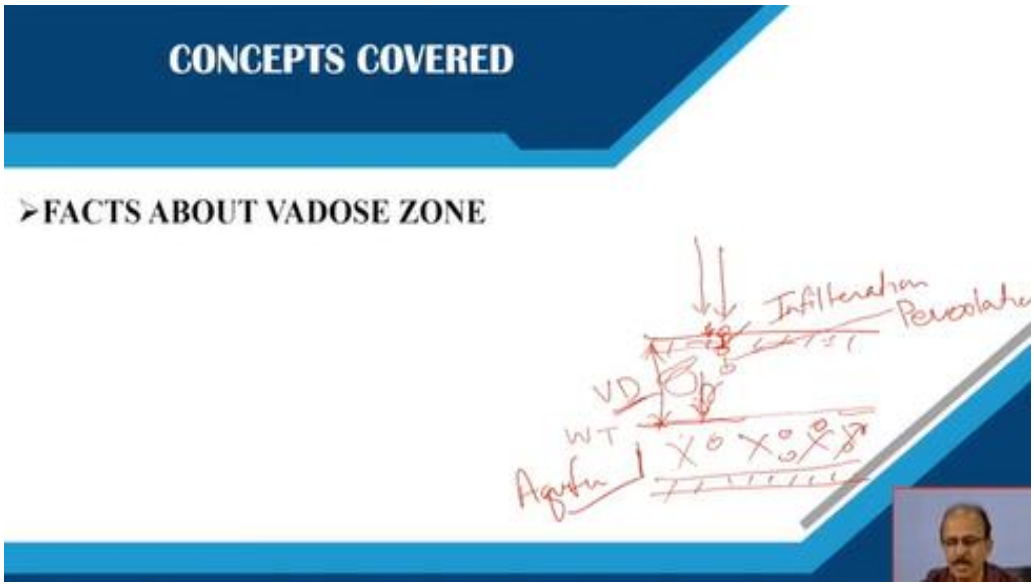

So, in this lecture we will try to understand about the different facts which are very well related with the vadose zone. As we know that the underneath the earth's surface, we are having a soil layer just beneath it we are having the soil layer and then some consolidated and unconsolidated rocks remain and then the level of the water came here just it came here. This usually we are telling it a water table if the underlying aquifer is the unconfined aquifer means it is having one impermeable layer beneath the earth surface.

So, this is the general concept related to the vadose zone area, this is the called as the vadose zone area. So, this area plays very, very important role why just recalls the previous layer chapters what we have discussed that precipitation ultimately reaches to the ground surface, this is reaching to the ground surface. So, from here it the first drop of the rain just enters into the soil layer. This process we have discussed as infiltration, this we have discussed as infiltration.

Now this drop of rain infiltrated drop of the rain water will again move downward and this process we have discussed as percolation. So, inside percolation is taking place out, from outside to inside infiltration is taking place. So, the rain water the precipitated water turns into the infiltrated water and then infiltrated water turns into the percolated water and ultimately with the down to the gravity it reaches to the area which is which are having some spaces in which the water remains.

So, this area in which the water remains generally we have called it as an aquifer, any rocky formation holding the water aquifer. So, this aquifer will ultimately accept the raindrop which has infiltrated and percolated down and the upper layer of this formation this is the geological formation is generally termed as water table. So, now we will discuss this thing later on in the later chapters we will discuss this thing but we will concentrate for this one at present.

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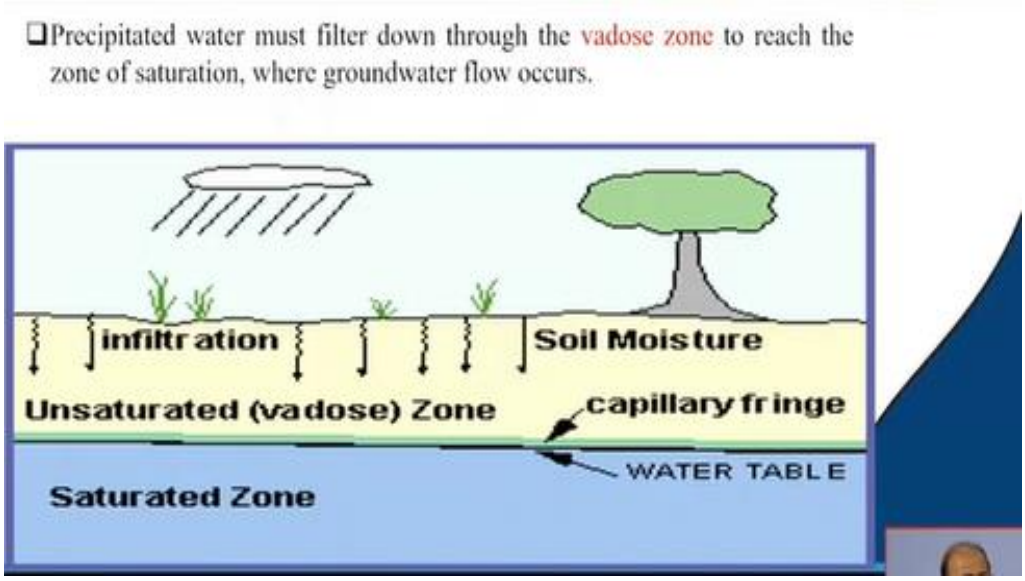

Now this we have seen that precipitated water must filter down through the vadose zone first, then only it can reach to the zone of saturation. So, earlier what we have discussed as an aquifer is nothing but it is the zone of saturation where generally groundwater remains and through this only the groundwater flow take place to one aquifer to another aquifer. In the diagram also you can see that infiltration is taking place through the soil layer.

Since infiltrated water is coming remaining within the soil here so soil is having some moisture soil moisture. And then below it is the unsaturated vadose zone we can see this is the vadose zone and just above the hydrogen these are the vadose zone we cannot say it as a saturated zone because saturated is only this one this is holding the water; this is just holding the water. So, this is called as saturated zone.

This is called as unsaturated zone and just and this is the upper part of the saturated zone. This one is the upper part of the cellular zone which is termed as water table and above to it few you can see a very little thickness area. We can just tell it as a capillary fringe, so it this is very important because we know that plants for making their foods process is termed as photosynthesis through stomatal opening it is receiving sunlight.

And through their roots it uptakes the water because water is also one of the constituent for making the food. So, this water being is being taken by the plant from the mostly from the capillary fringe area and from this water they are able to making their food.

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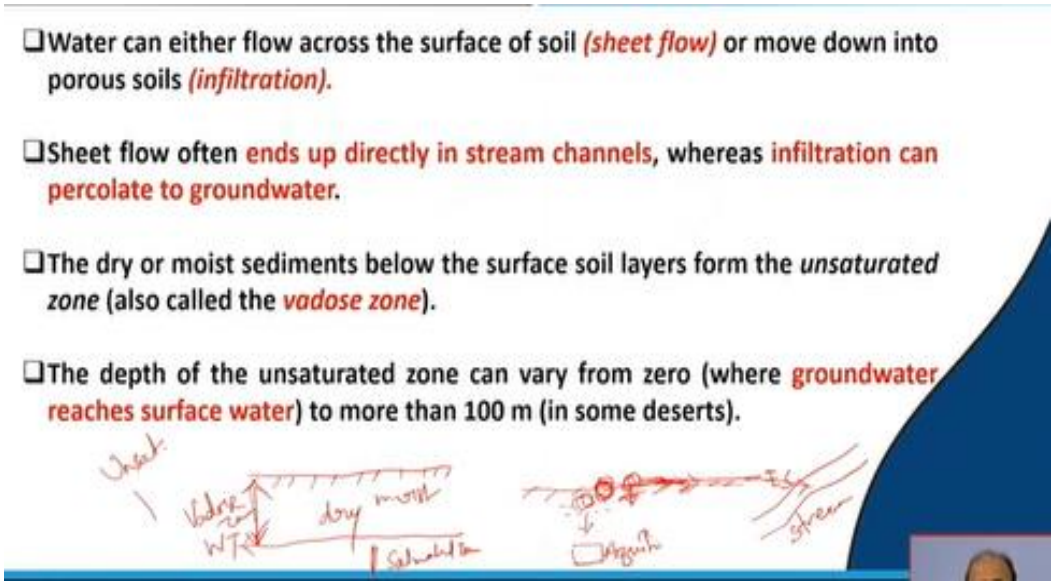

Now water can either flow across the surface of the soil which is termed as sheet flow or move down into the porous soil this usually happens. Suppose if this is the earth surface so if the rain drop will fall here so either it will flow across the surface of the soil this is called as sheet flow or

moved down into the porous soil these are the porous soil. So, either the it will just flow as a sheet flow surface of the soil or it will act as infiltrated water.

It will reach to the porous soil and it will behave as a infiltrated water. So, this sheet flow which we have seen this sheet flow because this sheet flow will remain why because this area if the raindrop will fall here then this area previously it is remaining dry, so it is accepting the water it has accepted the water. Now the area has become saturated with water so then the ray it will this area will not accept the water it has become saturated.

So, it will not accept the water further means infiltration will be zero at this place then what will happen this water will move according to the topography. So, that is why this is water can either flow across the surface of the soil which is called as sheet flow or move down in the form of infiltrate water. Sheet flow ends up this sheet flow which is generated because of the saturation in the underlying soil layer will directly into move to stream channels.

If some stream channels are nearby or at distance also. Ultimately this sheet flow will reach to the stream channel this is the stream channel whereas infiltrated water this is infiltrated water already infiltrated from the top it will ultimately reach percolate it will ultimately percolate and reach to aquifer. So, these two conditions may exist either the water can flow through the soil which is really termed as sheet flow.

Or the infiltrated water will move down into the porous soil in the form of infiltration and ultimately the sheet flow will reach to the stream channels whereas the infiltrated water will percolate and then it will reach to the rock formations which are holding the water that is aquifer. So, the dry or moist sediments below the surface soil layers form the unsaturated zone. So, what happened? The zone is dry and moist it is dry earlier before the precipitation it is dry.

As well as moist also some amount of moisture may remain here some amount of water content may remain here. So, this zone till the zone of water table reaching, this is water table completely this zone is called as vadose zone and this zone is very important in terms of your aquifer

recharge in terms of the agriculture productivity etcetera. Many more research are going on for this vadose zone hydrology.

So, here this zone is termed as unsaturated zone, this is unsaturated whereas this zone which is termed as saturated zone and above the top of the saturated zone is termed as the water table, this is termed as the water table. Now the depth of the unsaturated zone can vary this; what we have pointed out as a vadose zone, the thickness of the vadose zone at different area different place on the land will vary, it would not remain the same at every place.

It may vary from zero to more than 100 meters. When groundwater reaches the surface water the artesian conditions are existing, so it may unsaturated zone may not remain there. So, it is zero vadose zone is zero there but in desert area if we will see the vadose zone is lying at a greater depth say more than 100 meters. So, this thickness of vadose zone varies from place to place, it is not necessary to have a common depth at every place on the land surface, it is not necessary.

So, this is one of the interesting facts because the vadose zone is very important, this is unsaturated zone and below it we are getting the saturated zone.

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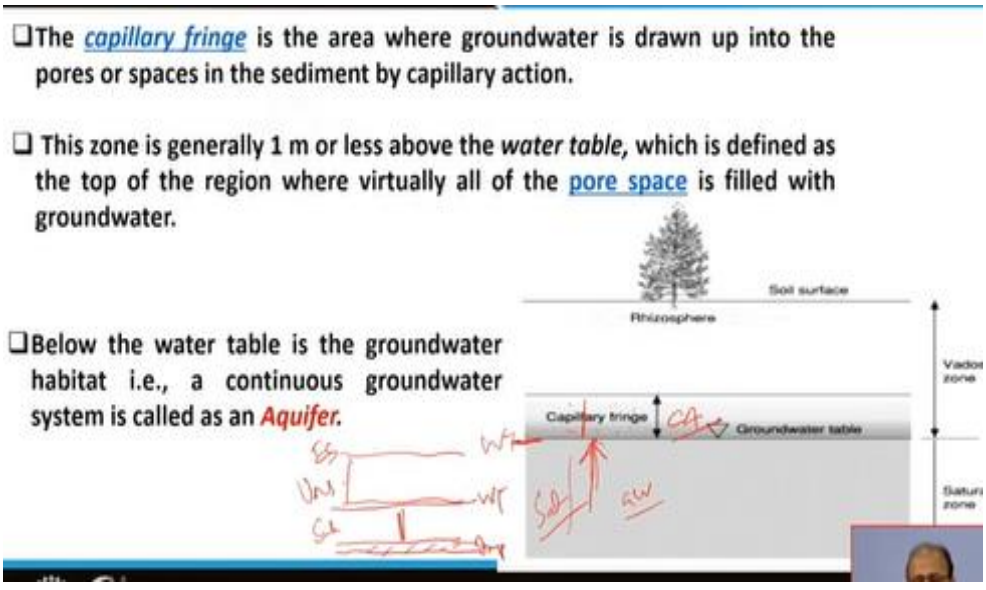

Now here we can see we have discussed already that capillary fringe is just the top part of the water table, if this is the water table so this is the area this area is called as capillary fringe us

thinner area. But it is having some amount of water also; this is having some amount of water. From where the water has come? The water has come from this place because this area is saturated one.

So, the capillary fringe is the area where groundwater is drawn up, this is groundwater it is drawn up where into the pore or spaces. In it also since it is also made up of soil so it is also having some pore species in the sediment how by capillary action, the capillary fringe just receive some amount of water say groundwater from the underneath or underlying aquifer. So, this zone this capillary fringe zone is generally one meter or less above the water table.

Condition is it will remain always above the water table never below the water table, thickness may be one meter or less than one meter. It also just like the thickness of the vadose zone it is not remaining common at every places, the thickness of the capillary Fringe also varies from place to place it depends upon the extent and depth of the aquifer underlying aquifer. So, this is the facts about the capillary fringe.

And the below the water table this is the water table is the groundwater habitat this is the groundwater habitat means a continuous groundwater system which we generally called again aquifer which type of aquifer we will discuss in the later class. But generally, the saturated formations, the saturated rocks which are bearing the water body are termed as an aquifer. So, now the concept we have made that this is the earth's surface below the earth surface are having two zones.

One is the unsaturated zone other is the saturated zone. This saturated zone underage having underlain by one impervious stratum that is why it is a saturated zone; this upper part of the cellular zone is termed as water table and from the surface of the earth to the water table a zone is remaining which is called as vadose zone. So, this zone is called as vadose zone and just above the water table a few meter thickness is the capillary fringe. This is the capillary fringe. So, this is about the details about our vadose zone.

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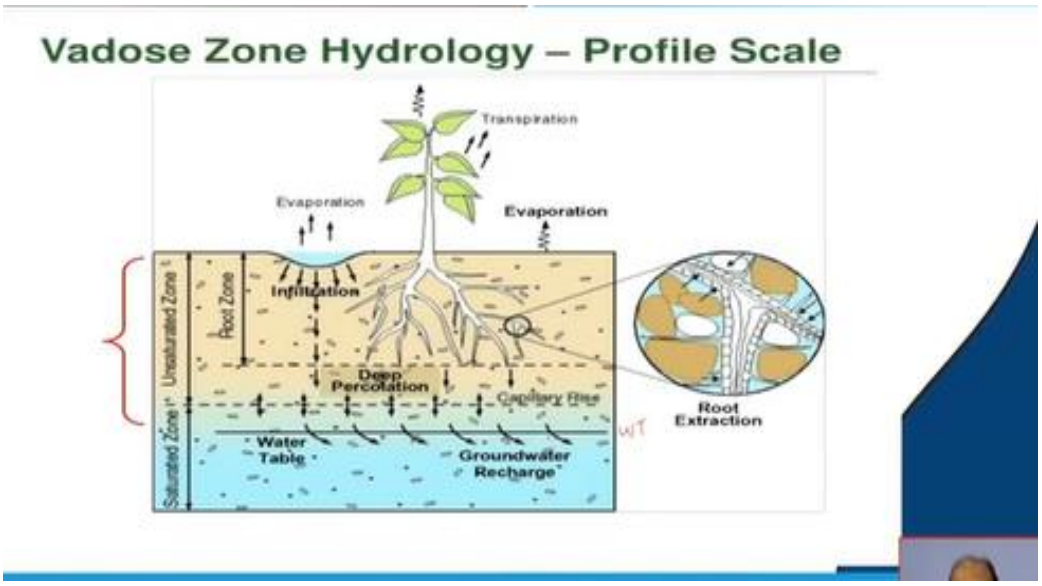

Now just see the hydrology I have told you this is a very important part of underneath the surface because lots of hydrological studies are based on the vadose zone only. Vadose zone is very important, it is just having the infiltrated water as well as percolated water plus it is also containing the root zone of any plant, so in this zone only the capillary fringe remains. So, these whole things are governed by the action within the unsaturated zone that is within the vadose zone.

You are seeing here evaporation are taking place from the open surface land surface, the water body is there say pond, lakes are there available rivers are available. Evaporation is taking place whereas from the leaves from the stomatal opening the water what are being received by this you are seeing from this vadose zone the water are being received by the plants for making their photos food photosynthesis.

The Surplus water is again moved back to the atmosphere in the form of transpiration. Cumulatively the evaporation and transpiration is called as evapotranspiration what we have discussed in the hydrological cycle. So, this unsaturated zone and saturated zone is divided by one your line of or you can say the height of the water table height of the water of the saturated zone which is termed as the water table, it is the upper part of any unconfined aquifer.

So, unconfined aquifer we will discuss in the later class what it is called as water table. And whatever we are seeing in the open dug waves from the top the level of the water that is nothing but that is the water table only. That is the water table of the aquifer in which the dug well is present. In the dug wheel we are having the water means the dug well is having the rock formations underneath which is porous which is saturated.

It is having the water and the upper layer of the water is the water table of the area. So, this is the general hydrology of the vadose zone, some more we will learn here.

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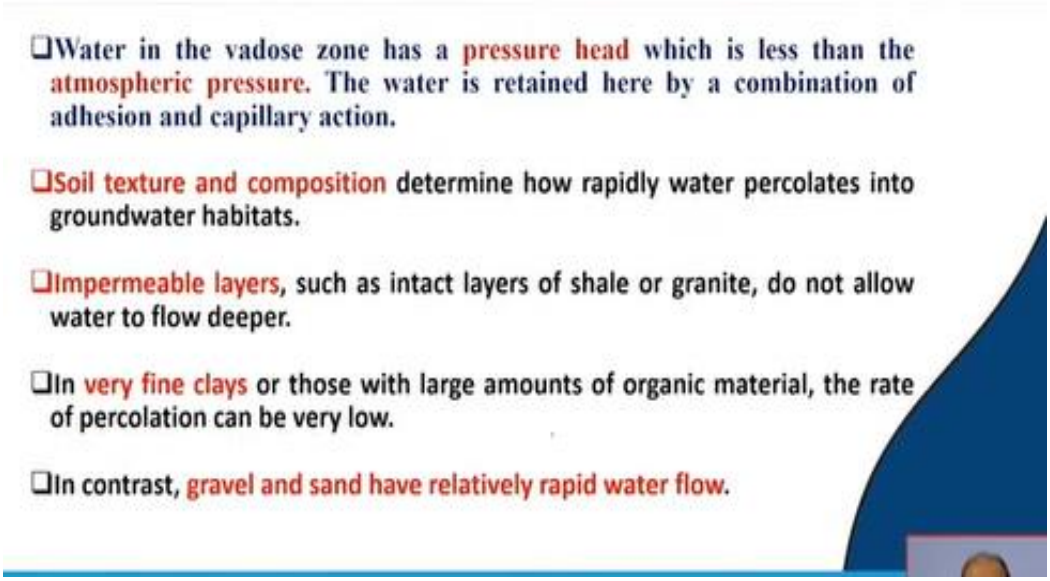

Water in the vadose zone has a pressure head, it is the water which remains in the vadose zone is having pressure head which is less than atmospheric pressure but this pressure is less than our atmospheric pressure. The water is retained here by a combination of adhesion and capillary action, some capillary action, adhesion is taking place so this water is retaining in the vadose zone. Soil texture and composition determine how rapidly water populates into the groundwater habitat.

This is very important, soil texture and composition because say if the soils clay silt sand we will see the clay silts sands finest to coarser but clay is porous but sand is clay is porous sand is also porous but you can see the sand is a very good aquifer but clay is not good aquifer. The point is

that the water will percolates and will remain in both the formation but the point is that form the aquifer point of view only the holding the water is not sufficient.

The water must move also from its own place to another place and from another place to its own place. So, this movement is also required in hydrological term we term it as a permeability ability to transmit or move the water. So, that is why soil texture and composition is very important for deciding the good saturated zone underneath the earth's surface. Then impermeable layers such as compact rocks consolidated rocks like shale, granite.

Shale is the consolidated sedimentary rocks; granite is an igneous rock very hard and compact. So, they are not allowing to flow deeper. That is why the what we have discussed in the previous slide, if this is the earth's surface so this zone is unsaturated zone which term which was termed as a vadose zone and this zone is saturated zone. So, this zone we have turned it as an aquifer why because it is having a impermeable stratum beneath it.

So, if this intact layer of shale or granite will come here definitely, they would not allow the water to move down so what will happen the water will remain stored here. So, it will become a very good groundwater habitat, so the point is that impermeable lever layers generally if lying above or below then they are not allowing the water to flow up and down and this decides the type of the aquifer also.

We will discuss in the later class; this decides the unconfined and confined aquifer. So, here we will only discuss this thing about the vadose zone. Now in very fine clays or those with large amounts of organic material the rate of population can be very low. I have told you if you will compare with clay and sand is a good aquifer but clay is not good aquifer why clay may be porous, a clay is having the porosity it may be porous.

But point is that large amounts of organic material if it will remain or very fine clays if it will remain, in both the condition the rate of percolation will be very low. So, if the rate of percolation will be low definitely the water will not move down and if the water will not move down definitely it will not make a good groundwater habitat. So, in general gravel and sand have

relatively rapid water flow or gravel and sand is relatively a very good aquifer in from hydrological point of view.

If you wish to know about the details, we will discuss it in later on lectures but I am telling you that aquifers best aquifer is gravel and sand and these are considered as the best aquifer why because these are having the ability to store the water as well as to permit to move the water. So, that is why these are a good aquifer for gravel and sand.

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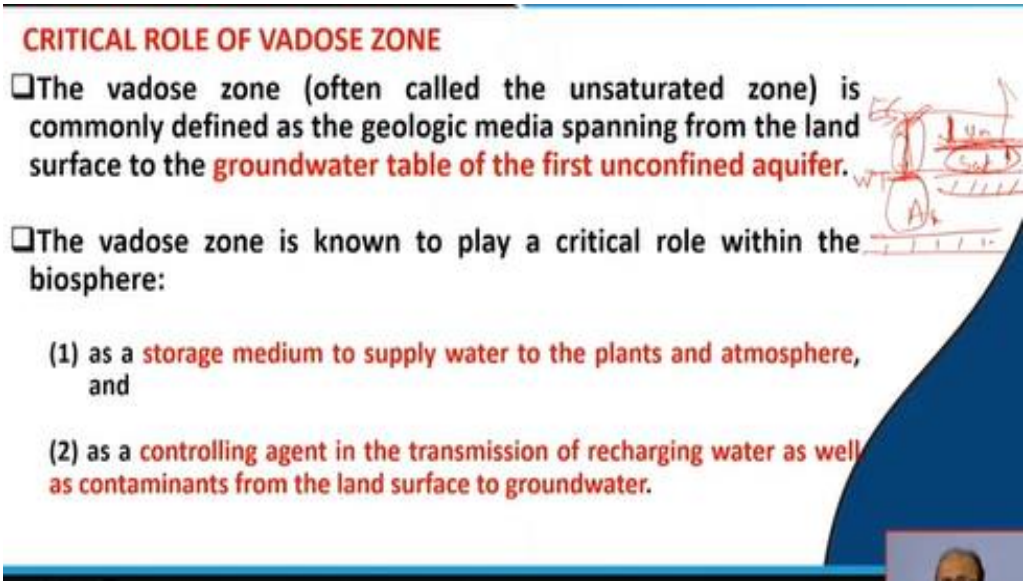

Now as I have discussed that vadose zone is a very important zone from hydrological point of view. See the vadose zone which is called as unsaturated zone is a type of geological media which is spanning from the land surface to the groundwater table. If you see the earth's surface then earth surface to this layer water table and this is the aquifer, this is the impermeable stratum. So, here in this case vadose zone we are seeing that this is also a geological formation.

And this formation is starting from the land surface just underneath the land surface up to where up to the groundwater table of the first aquifer whatever first aquifer meeting. Why first aquifer? Because it is not sure that here only the formation will remain after this much gap maybe the vadose zone is remaining up to this and one aquifer is coming here saturated zone is coming here. So, this is become saturated this unsaturated.

So, where vadose zone is up to here only not up to here. So, whatever the thickness from the surface down to from the earth's surface to the water table of the first unconfined aquifer is generally called as the vadose zone. So, it plays very important role also which type of rule has a storage medium to supply water to the plants and atmosphere because from here from vadose zone we have seen that one thin layer of water remains.

This water is just coming by the capillary action from the saturated zone called as capillary fringe. So, in this water means the water which remains in the vadose zone generally helps to the plants for the making the foods through the photosynthesis process as well as the because of the evaporation process the water from this zone will just move to the atmosphere in the form of evaporation.

So, it is a medium storage medium to supply water to the plants and smooth atmosphere, again in the atmosphere some water body is remaining maybe from the just from the operation from the surface. And secondly as a controlling agent in the transmission of recharging water it is controlling how much water will be recharged to this formation this is the saturated formation, this is unsaturated formation so it this is the deciding media.

This media will decide how much water this formation will receive only the only infiltration and percolation will never help; this geological media is also very important this geological media is the vadose zone media for recharging this geological formation. If the hard rocks will remain here and the compact and hard rocks will have no porosity no pores or wide spaces, then definitely the infiltrated and percolates water will never come and never reach to the groundwater habitat which generally lies in the unconfined aquifer.

So, this vadose zone plays very important role in terms of the storage medium to supply water to the plants as well as to the atmosphere and second it is the deciding area which plays very important role in the recharging of the underlying aquifer. Because this will decide how much water will reach here and secondly the contaminants as well because on the land surface, we are knowing several types of contaminants are, even underneath the soil layer also.

Pesticide her lots of pesticide fertilizers are lying because of the agriculture processes. So, how much contaminants will be received by this saturated formation who will detect, who will direct this process, the direction of this process will be from the vadose zone only. Vadose zone will only decide how much contaminant will move to the saturated zone or this contaminant will go to in certain other direction.

So, what we have listened in this lecture that the earth interior is having the different zones, the different zones is being directed by the different types of the textural compositions. We have seen that just beneath the earth surface we are having the soil formation; this soil formation is receiving the precipitated water inside it and then it this water is percolating down. And ultimately reaching to us zone that is also a formation geological formation in which the water stores at this place.

Why water is storing? Because underneath it is having the impervious stratum below it the geological formation is not allowing to move down further. So, what is happening? The from the earth's surface down from the surface to the level of the upper level of the first find unconfined aquifer, first find is very important because the unconfined aquifer generally or any aquifer generally lies at different depths at different places.

It is not necessary to have all the aquifers beneath the surface at the common depth. So, generally it the depth varies from place to place. So, just from the down from the surface to the upper part of the unconfined aquifer which is designated as the water table is the area called as vadose zone. This we have learned from this lecture the area called as vadose zone and this vadose zone area is the saturated zone this vadose zone area is called as unsaturated zone.

And below the water table area is called at saturated zone. So, vadose zone plays very important role in terms of hydrological studies as well as in terms of the plants uptake because plants are also taking water for the making their food for the process of photosynthesis, they are also receiving water from the vadose zone area only. And in the vadose zone just above the water table a smaller thickness area small thick thickness very less say less than one meter thickness area is having the water.

The point is from where this water is coming? This water is coming by the capillary action and from the underlying saturated formation. Saturated formation in the thing but it is an aquifer. So, this aquifer sends few amounts of water because it is full of water, so this aquifer is sending few amounts of water to the upper area by the action of capillary action. So, this water is helpful for the plants for uptake.

And also, the water which remains in this area will ultimately going to the atmosphere it is going back to the atmosphere so this vadose zone hydrology is important, it decides lots of factors for the concentration of the different contaminants at different depths also. Because it is this where vadose zone will only direct the amount of water to reach at the underlying saturated formation. So, with this I am just concluding these facts that vadose zone is unsaturated zone and below it lies the saturated zone that is called as a thick aquifer. Thank you very much.