Availability and Management of Groundwater Resources
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Lecture - 56
Impact of Climate Change on Water Resources (Contd.)

Welcome you all, in the part 2 of the model 12 impact of climate change on water resource. So, what we have noticed is that water generally having impact because of the change in the atmospheric phenomena.

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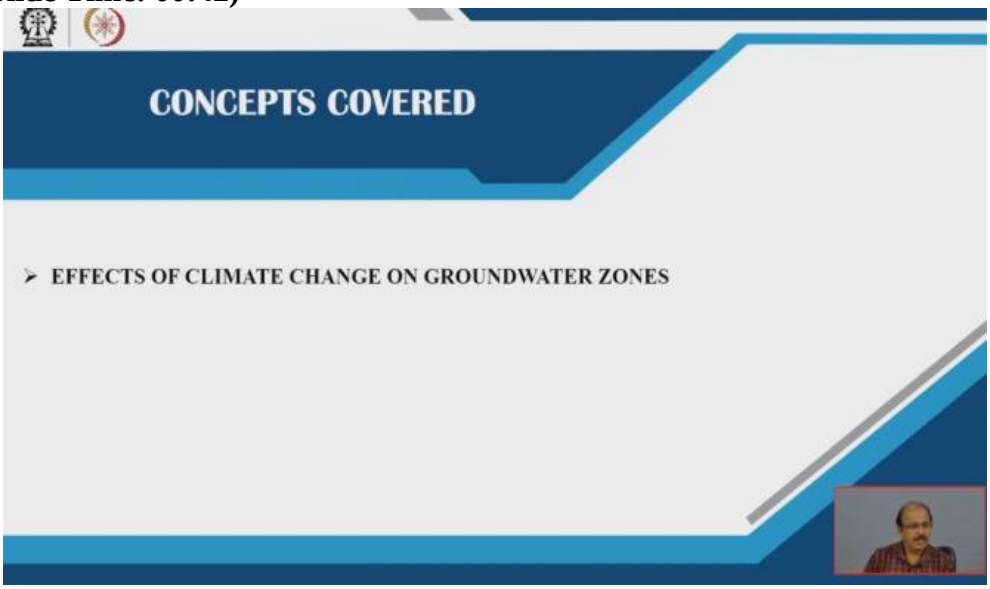

So, in this part, we will discuss what are the effects of climate change on groundwater zones, the zones, we have discussed in the previous lectures that generally the aquifers which is towards the groundwater, it remains in certain geological formations. So, these formations generally having the structure or having the characteristics which generally holds or restores the groundwater.

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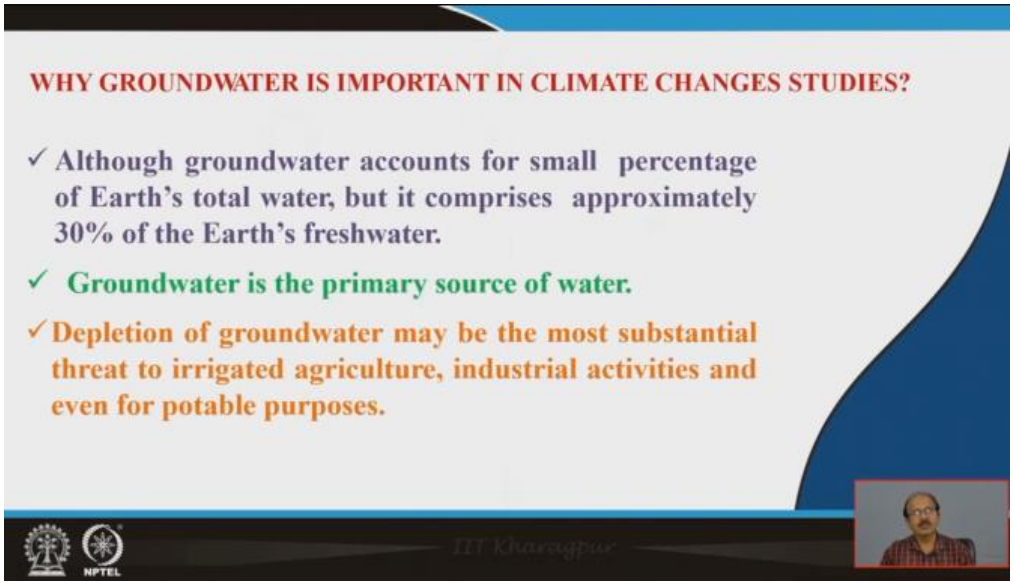

Now, generally, groundwater is important in climate change studies, why? Because, groundwater accounts for small percentage of earth's total water, we have seen while the distribution of water on earth surface that groundwater is having very small component, it is a very, very small amount, which is lying in general in an aquifer, but it comprises approximately 30% of the earth's fresh water.

Groundwater is the primary source of water also, because for every purpose for useful purposes for drinking purposes for even irrigational purpose, for your construction purpose, for your industrial applications purpose. So, every time generally we are just withdrawing the water from the earth's surface and the water is the groundwater only. So, depletion of groundwater is taking at several places, depletion may be the most substantial threat to the irrigated agriculture activities, industrial activities and even for potable purposes.

So, it is a matter to think over it that climate change because of the climate change there we are having the scarcity of the groundwater also, why we will discuss in the coming slides, but this groundwater is very, very important in climate change studies, several places we are seeing that people are facing the scarcity of groundwater, they are not having water inside the aquifer underlying the earth's surface for different purposes.

They are remaining in difficulties say for irrigation, they are having the agricultural field, but for irrigation they are having no water to irrigate the crops or fills.

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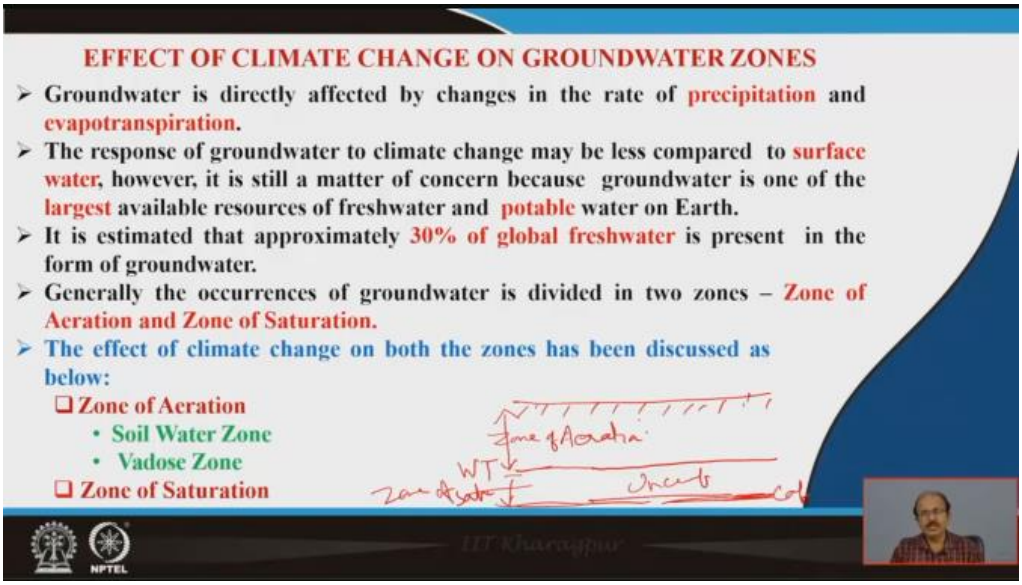

So, generally what we have seen that this groundwater is directly affected by changes in the rate of precipitation and evapotranspiration, just recall back when we were discussing about the hydrological cycle, we have discussed that the precipitation is the only source through which we can able to recharge the groundwater which is lying underneath the earth's surface in an aquifer.

So, if the rate of precipitation will change, definitely the rate of recharge will also get affected. So, rate of precipitation and rate of evapotranspiration means evaporation from the surface water sources and transpiration from the leaf surfaces. So, suppose the evapotranspiration will be more than what will happen the more of the water will go back to the earth's atmosphere. So, both the processes they are the components of the hydrological cycle.

Both the components if there will be any change in the rate of precipitation or in the rate of evapotranspiration, definitely the groundwater will directly be affected by these changes. The response of groundwater to climate change may be less compared to surface water, surface water because we are knowing that 2 important types of water surface water and example is pond water, lake water, river water and groundwater the water which is lying underneath the earth's surface.

So, but the response of groundwater to climate change is maybe less for the groundwater, but it is more for surface water, however, is still a matter of concern because groundwater is one of the largest available resources of freshwater and potable water on earth. It is the largest

available resource of freshwater as well as it is potable water on the earth, it is estimated that approximately about 30% of global freshwater is present in the form of groundwater.

And generally, the occurrences of groundwater is divided into 2 zones, zone of aeration and zone of saturation. So, just recall back you perhaps it is in your mind also, that we have discussed already that if, say this is the earth surface. So, from the surface to the, this is the water table. So, from the earth's surface to the water table is generally termed as zone of aeration, this is the zone of aeration.

And from the water table to down this is the unconfined beds unconfined aquifer because one confining bed are here so, this is known as the zone of saturation. So, one is the zone of aeration and other is the zone of saturation. Generally, in this zone of aeration also few amounts of groundwater remain because soil is also taking some water through the roots plants are also taking water from their roots.

So, what are you happening must be some 2 different zones in which the groundwater remains the zones are the zone of saturation and the zone of aeration the zone of aeration and the effect of climate change can be seen on both the zones this we can see in both the zones were in the zone of aeration the effects maybe at soil water zone because soil water is also one of the important zone then the vadose zone, vadose zone is also there and second is the zone of saturation.

So, this we have discussed already in the previous lectures. So see, the effect of climate change is also important for the groundwater because the groundwater where it is occurring, the occurrence of groundwater are generally 2 important job that is the zone of aeration and zone of saturation and within the zone of aeration. The soil water zone and vadose zone are important one this we have discussed also.

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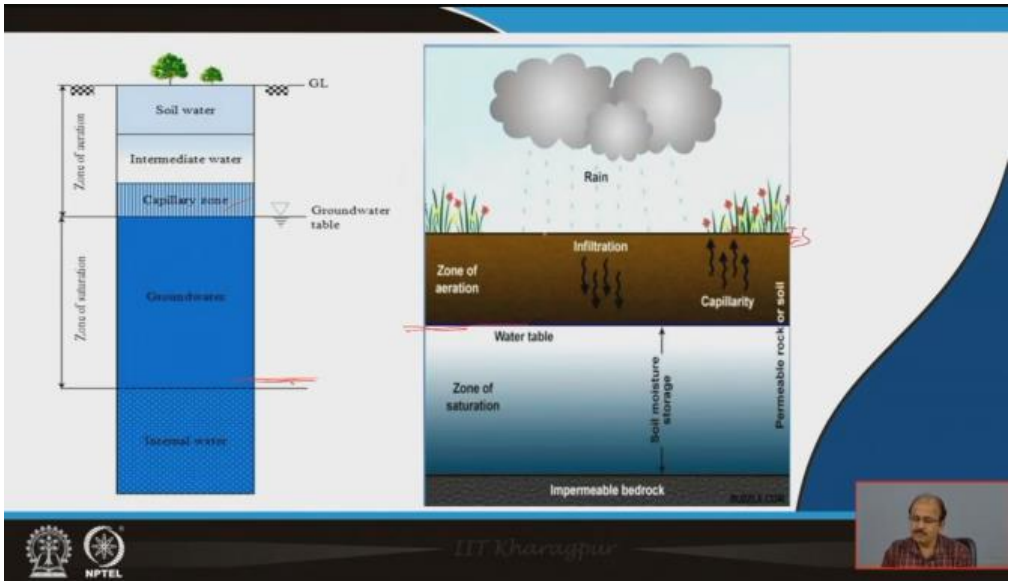

In this figure we can see a little bit more clearly that this is the zone of aeration in which we are getting the soil water zone, then the intermediate water and then the capillary water. So, these are and this is the ground level. So, this is the zone of aeration and this is the water table. What we have just now discussed this is the water table depth from ground level to water table is known as zone of aeration.

And from there this place to this groundwater table to some unconfined beds because this is the zone of saturation, definitely it will store water because when confining beds are remaining here to this is called as zone of saturation. So, what we are seeing here this is suppose in this figure also it will be clear that impermeable bedrock is there confining beds are here, zone of saturation is this one water table is this.

This line shows the water table and if precipitation will fall on the surface, this is the earth surface. So definitely the infiltration will take place percolation will take place and then only the water will lead to the water table.

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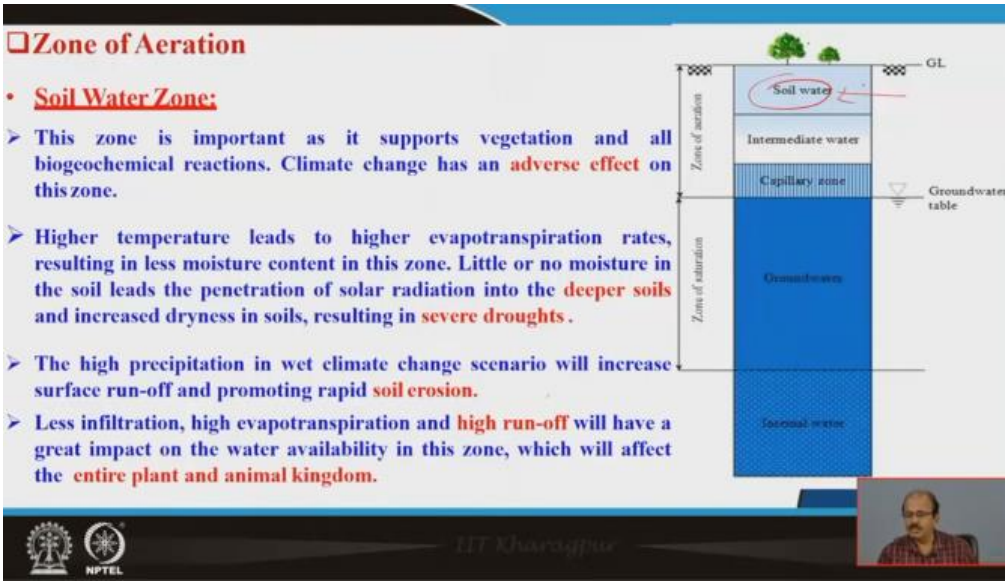

So, the impact of climate change first we will discuss for the soil water zone because it is the zone of aeration and in the zone of aeration soil water zone is the first zone. So this zone is important and it supports this is the soil water zone this zone is important as it supports vegetation and all biogeochemical reactions. This zone is supporting the vegetation and all biogeochemical reactions.

Climate change has an adverse effect on this zone, this zone is having an adverse effect of climate change, higher temperature leads to higher evapotranspiration rates. So, in during the pre-monsoon season or summer season what we are getting? We are getting high temperature. So when the temperature will be more definitely the evaporation as well as transpiration rate will be more then what will happen resulting in less moisture content in those zones.

Definitely if the temperature will increase on the earth's surface, definitely the moisture content of this soil water zone will also decrease. So, it is resulting in less moisture content in this zone, little or no moisture in the soil leads the penetration of solar radiation if there will be no water then what will happen penetration of solar radiation will take place into the deeper soil and then what will be the result, increase the dryness in soil and ultimately severe droughts take place.

So, this is see here, the impact of your climate change can be clearly shown by the dryness of the soil layers, different soil layers, they will dry because the temperature is more so, more evaporation will take place more transportation will take place definitely the moisture content will become less or 0 and then what will happen the solar radiation will penetrate down into

the deeper layers of the soil layers and eventually increase dryness in soil and ultimately the severe droughts take place.

So, high precipitation this is the case of high temperature now, high precipitation in wet climate change scenario will increase the surface runoff suppose more precipitation will take place on the earth's surface then what will happen then if more precipitation will take place then there will be first infiltration percolation and then the it will reach to the water table it will saturate the aquifer it will fill up the water in the aquifer.

And then what will happen then it would not infiltrate or percolate rather it will turn into the runoff. So, when there will be high precipitation, definitely the increase of surface runoff will increase and that will what will happen if the runoff will increase the it will promote the rapid soil erosion. So, see, when the temperature is high the evaporation and transpiration become high the moisture content in the soil water zone becomes less.

And then the solar radiations enters into the soil layers gradually goes down and it dries all the bottom layers of the soil and ultimately what happens severe drought take place, but when the precipitation is high during the wet season, then what is happening the water moves through the surface which is termed as surface runoff. So, when the high precipitation will be there, there will be high surface runoff and when there will be high surface runoff definitely there will be more soil erosion or rapid soil erosion.

So, these are the impacts of climate change now, less infiltration is taking place, high evapotranspiration is there and high runoff is there then what will happen will have a great impact on the water ability in the zone which will affect the entire plant and animal kingdom. So, just you can imagine that if there will be less than infiltration means it would not allow water to move down high evapotranspiration is there and high runoff is there means.

If runoff is high means the infiltration, percolation is very, very low then what will happen then where will be the water? Water will actually moving that is in the atmosphere in the form of evapotranspiration and to the distant area in the form of runoff and infiltration has become less than what will happen water ability in the area will become affected. So, if the water ability in the area of zone will become affected definitely it will affect the entire plant and animal kingdom. So, this is the impact of climate change on the soil water zone of the zone of aeration.

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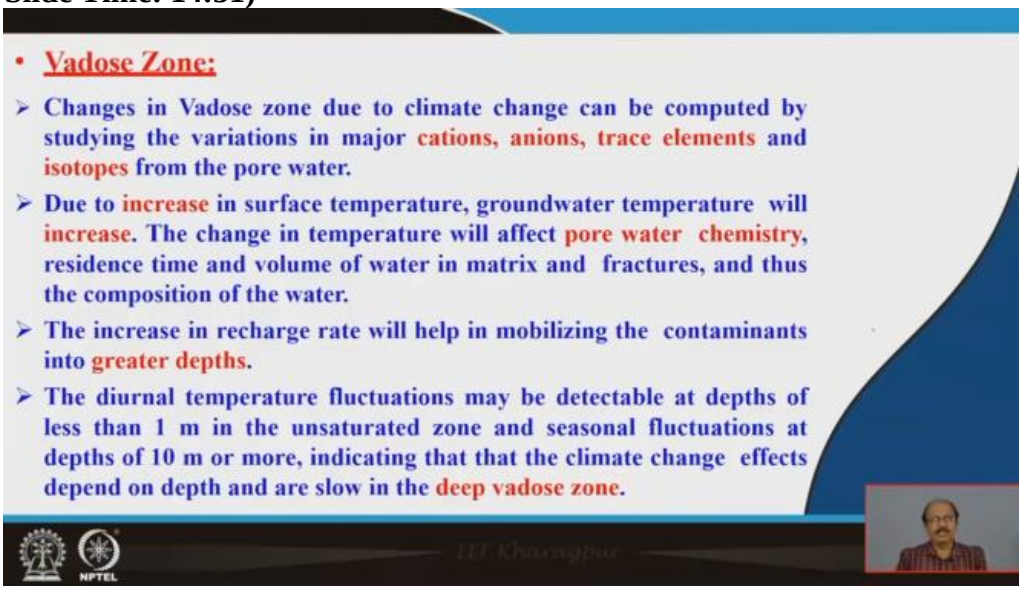

Now, vadose zone if there will be changes in vadose zone because of the climate change. Then what will happen the variations in major cations, anions, trace elements and isotopes will take place the various concentrations of cations, anions, trace elements and isotopes will remain present because of the changes in the vadose zone due to the climate change due to increase in surface temperature, groundwater temperature will increase.

If surface temperature will increase the groundwater temperature will also increase the change in temperature will affect pore water chemistry, residence time and volume of water in matrix and fractures and therefore, the composition of the water. So, whole composition of water will get affected. So, the increase in recharge rate, if the recharge rate will increase, it will help in mobilizing the contaminants into greater depth the contaminants will raise to a greater depth because recharge rate has increased.

So, the diurnal temperature fluctuations may be detectable at depths of less than 1 meter in the unsaturated zone and seasonal fluctuations at the depth of 10 meter or more. This indicates that the climate change effects depend on depth, and are slow in the deep vadose zone effects are slow. So, in the vadose zone also we have seen by these facts that because of the climate change the total cations anions trace elements isotopes chemistry are changing.

So, the diurnal temperature fluctuations may be detectable at depths of less than one meter in the unsaturated zone and the seasonal fluctuations at depth of 10 meter or more indicating that the climate change effects depend on depth and are slow in the deep vadose zone. So, the

climate change effect is affecting the chemistry of the cation's anions trace elements and isotopes in the area and due to increase in surface temperature.

The groundwater temperature also increasing and because of the change in temperature, it is affecting the pore water chemistry of the region.

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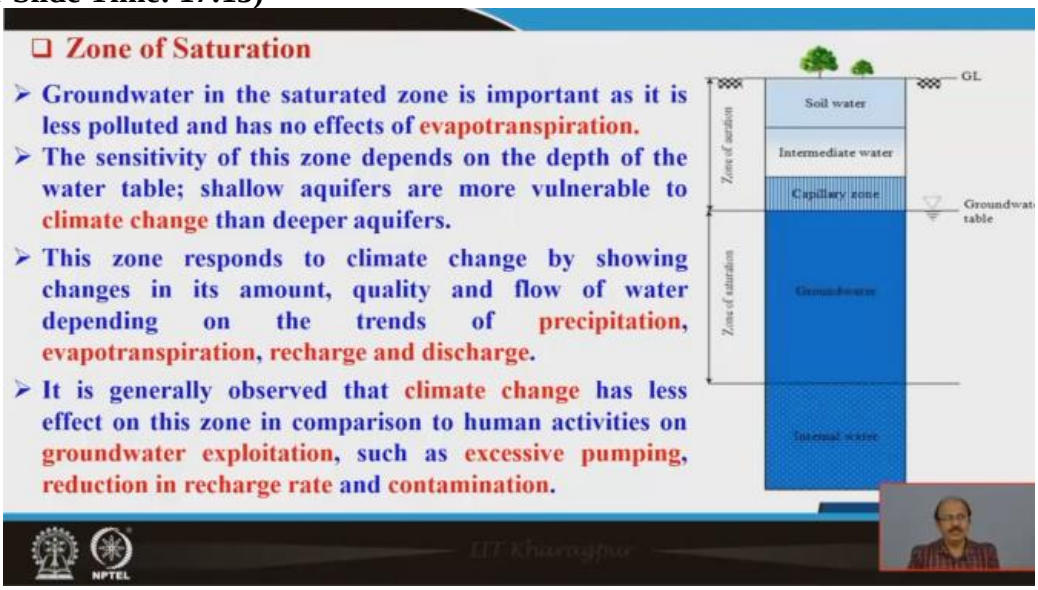

Now, zone of saturation, so, this was the effect of the zone of aeration now, zone of saturation. So, in the zone of saturation we are knowing the zone from the water table or groundwater table to the depth of confining beds, confining beds means impermeable beds. So, it will store water that is why it is zone of saturation. So, groundwater in the saturated zone is important as it is less polluted, this zone is less polluted and also water of this zone has no effects of evapotranspiration.

So this zone water is having no effects of evapotranspiration, the sensitivity of this zone depends on the depth of the water table. How far the water table depth is there shallow aquifers are definitely more vulnerable to climate change than the deeper aquifers. So shallower aquifers are getting affected because of the change of the climate change than the deeper aquifers this zone response to climate change by showing changes in its amount, amount of groundwater, then the quality of groundwater.

And flow of groundwater depending on the trends of precipitation, evapotranspiration, recharge, and discharge behaviour of the aquifer. So, generally because of the climate change, the amount of groundwater generally varies why? Because of this chain, it is affecting the

precipitation, recharge and discharge of the area. It is generally observed that climate change has less effect on this zone in comparison to human activities.

Generally, climate change has a very less effect on this zone, zone of saturation, in comparison to human activities on groundwater exploitation, such as excessive pumping, reduction in recharge rate and contamination, see, anthropogenic activities are utilizing more amount of water because of the different purposes. So human activities are definitely affecting more to this zone of saturation, then the change in the climate. So climate change has less effect on this zone.

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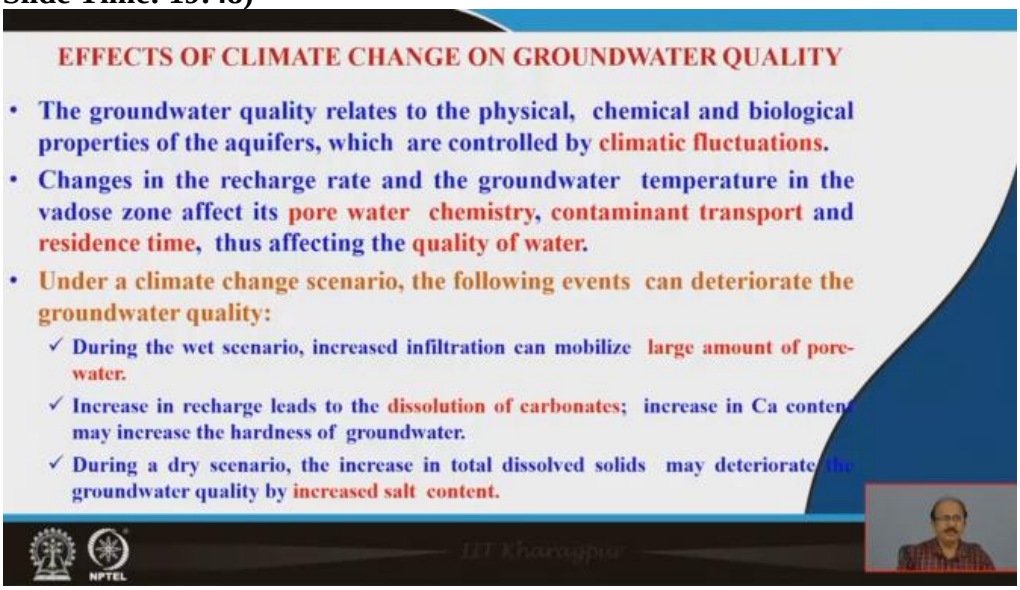

Now effects of climate change on groundwater quality. So, what are the effects on groundwater quality because of the change in climate, so the groundwater quality really relates to the physical, chemical and biological property of the aquifers, which are controlled by climatic fluctuations, changes in the recharge rate. And the groundwater temperature in the vadose zone affects is poor water chemistry, contaminant transport, residence time and thus affecting the quality of water.

Under a climate change scenario, the following events can deteriorate the groundwater quality under the climate changing scenario, some of the events important events which can deteriorate the groundwater quality are during the wet scenario increase filtration can mobilize if the infiltration will be more the large amount of pore water will be there, increase in recharge leads to the dissolution of carbonates, increasing the calcium content.

And may increase the hardness of groundwater during a dry scenario, what is happening the increase in total dissolved solids which may deteriorate the groundwater quality by increased salt content. So, this is the effect of climate change on groundwater quality.

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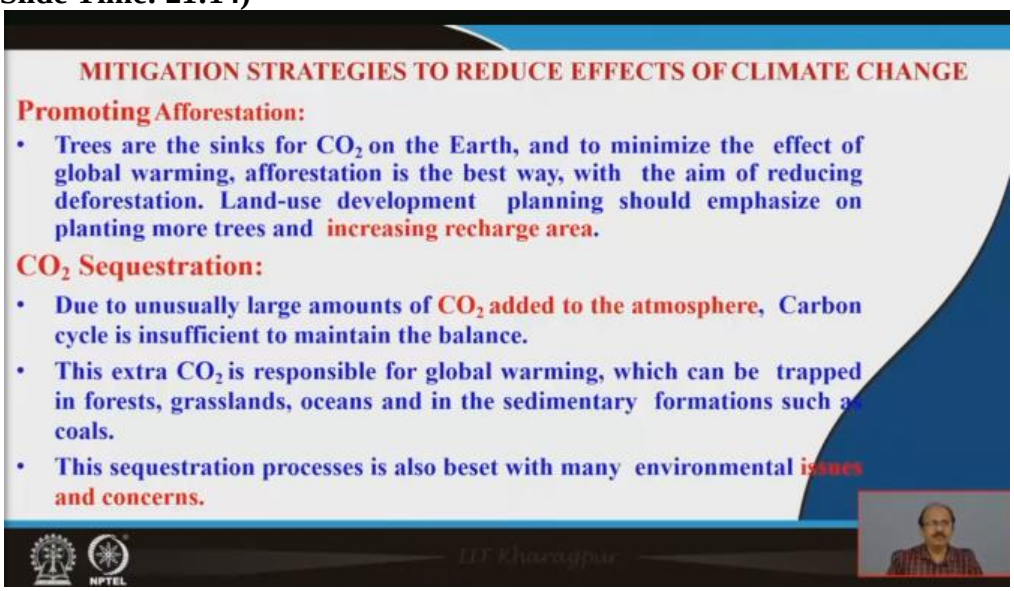

Now, what are the mitigation strategies to reduce effects of climate change the mitigation strategies and trees are the sinks for CO_2. This can be done by promoting afforestation and CO_2 sequestration. So, in promoting afforestation trees are the sinks for CO_2 on the earth and to minimize the effect of global warming. Afforestation is the best way with the aim of reducing deforestation, land use development planning, should emphasize on planting more trees and increasing the recharge area.

So if there will be more trees definitely the recharge in the area will increase because the water will moves to the under ground surface or the layers of the soil from the roots, different roots of the branches, roots of the trees so here the trees are good sinks for CO_2 on the earth and also to minimize the effect of global warming. Now CO_2 sequestration can be done due to the unusually large amount of CO_2 added to the atmosphere.

Carbon cycle is insufficient to maintain the balance. This extra CO_2 is responsible for global warming, which can be trapped in forests, grasslands, oceans and in the sedimentary formations such as coals. This sequestration processes is also beset with many environmental issues and concerns. So with this, thank you very much to all.