Availability and Management of Groundwater Resources

Prof. Prasoon Kumar Singh
Department of Civil Engineering
Indian Institute of Technology (ISM), Dhanbad

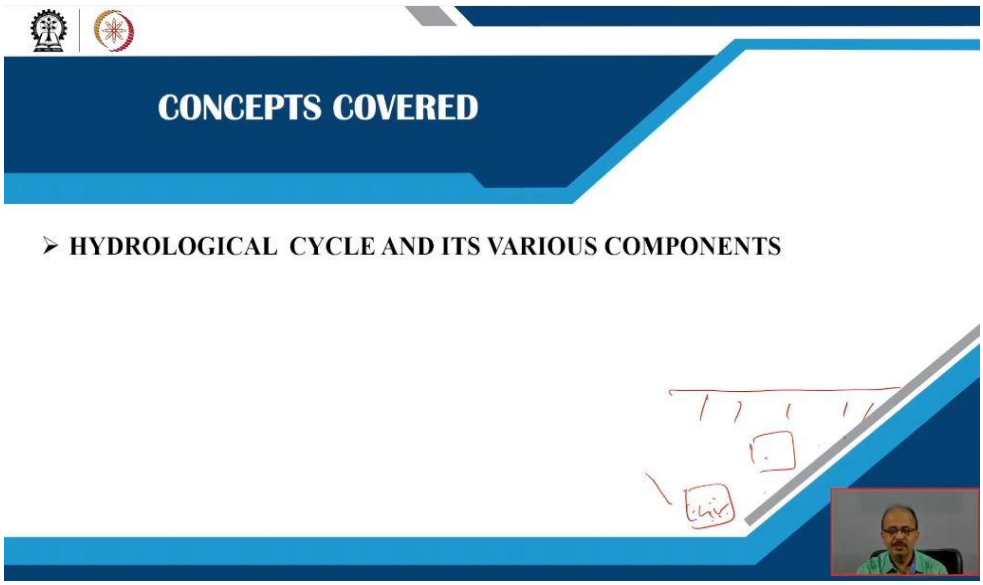
Lecture - 03
Hydrological Cycle, Need for Conservation of Groundwater Resources (Continued)

Welcome to you all in the NPTEL course subject availability and management of groundwater resources, the third part of the lecture 1. So, what we have seen in the last two part of the lectures of lecture 1 that groundwater remains within certain formation inside the earth's surface. So, this groundwater is remaining in certain rocks, sand generally the soft rock is a very good repository of the groundwater.

Because it is having large number of spaces porous spaces voids so, in it the groundwater remains there. So, this we have seen in the first lecture of lecture 1 part 1 we have seen the groundwater remains available in the rock formations and very good groundwater repository is the soft rock that is the sedimentary rock. Why? Because it is having good number of porous species.

So, sedimentary rocks are having good number of porous spaces so groundwater remains there. Whereas hard rock is having also some spaces but those spaces are not just like the porous spaces of sedimentary rocks. Those spaces are fractures and lineaments we can understand it that in this, just beneath the surface.

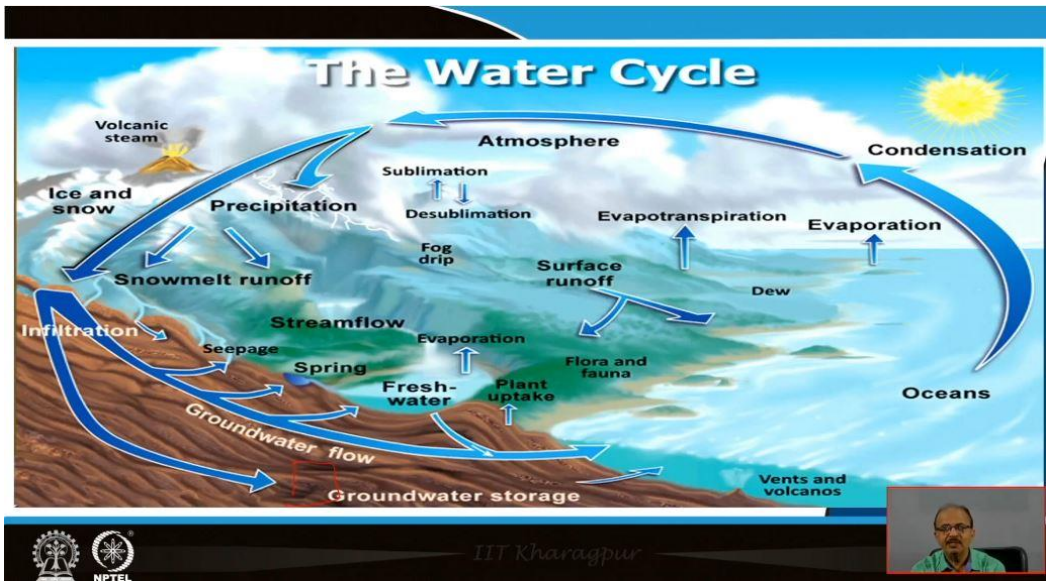
(Refer Slide Time: 02:00)



If you will see just beneath the surface, the rocks generally this is holding the water groundwater which is termed as a aquifer. We have discussed in the part one lecture and aquifer and this aquifer is remaining inside the earth's surface at different places. In some aquifer, we are having the plenty of groundwater and in some aquifer, we are having very lesser groundwater in the amount.

So, why the reason is that this aquifer is made up of the sedimentary rock whereas this one this aquifer is just your hard rock that is having the fracture and lineament. So, in this we are not getting the sufficient quantity of groundwater. Now, this space where we get the water is well known now it is an aquifer and aquifer remain throughout the earth's surface inside the earth surface which holds the ground water. Now, in this very third part of the topic our lecture.

(Refer Slide Time: 03:14)

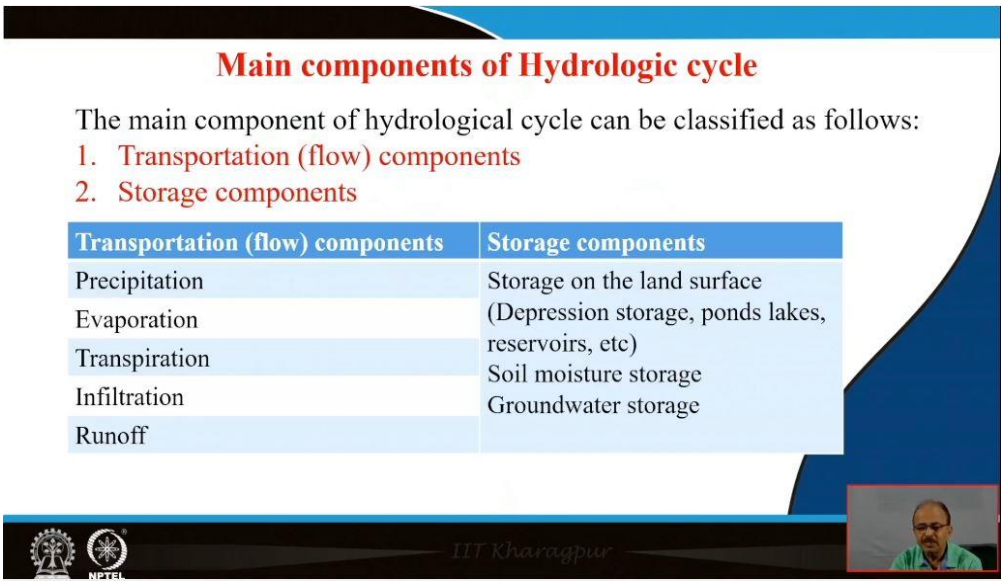


We will just see the hydrological cycle which we have already discussed. I have already discussed it in the lecture 1 part 2 lecture I have discussed. This hydrological cycle is a very important cycle which helps in the getting the groundwater resource inside the earth's surface and in the hydrological cycle discussion we have discussed that this hydrological cycle is having the components important components in the form of precipitation, evapotranspiration made up of evaporation plus transpiration and runoff.

So, there are several terminologies here you can see here the precipitation is there snowmelt runoff is there and these whole precipitated water or snowmelt water this tries to move inside the earth's surface through the process of infiltration. Infiltration and percolation the rain water moves inside the surface. And this rain infiltrated water the rain water which has infiltrated is then joins the rock which holds the groundwater.

And then the groundwater forms inside your rocky formation inside the earth's surface. So, this hydrological cycle plays very very important role for having the sufficient amount of groundwater resources inside the earth's surface.

(Refer Slide Time: 04:52)



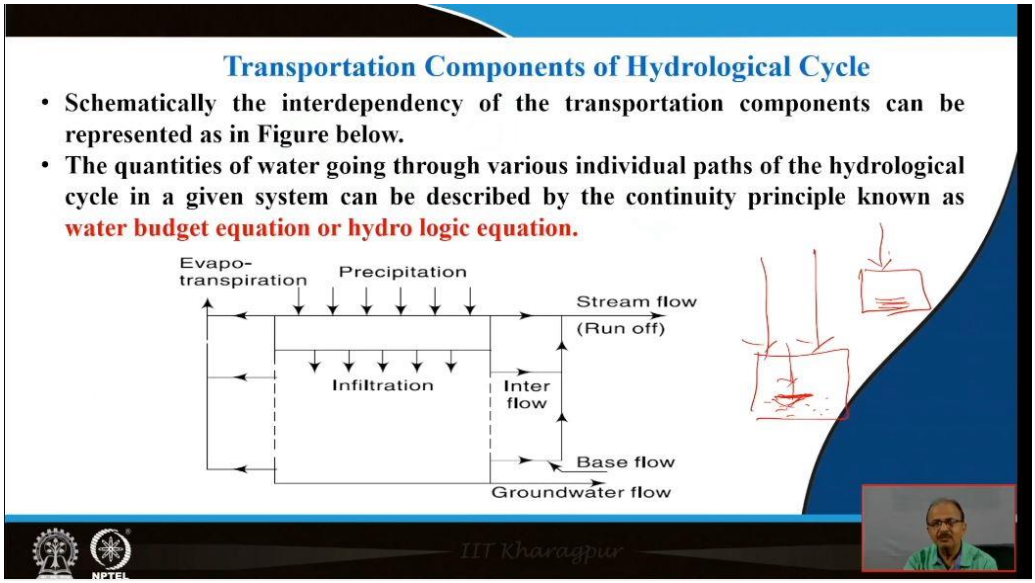
So, in the hydrological cycle we have seen the water comes in the nature and through the nature it moves down towards the earth surface. So, this cyclic process continuously works and we have already seen in the previous, lectures that within the earth surface, we are having some storage space in the rocks in the soils. So, in the rocks and the soils the water stores their water remains there.

That is why the groundwater is generally being considered as a very safer water for the drinking purposes because, it remains inside the earth's surface. But if you will see the main component of the hydrological cycle mainly 2 types that are the transportation components and the storage components. So, in the hydrological cycles in during the previous lecture we have seen the precipitation the only and only source of the recharge at the earth's surface that is the precipitation.

So, precipitation is one of the important components of the hydrological cycle. Next is the evaporation, the water content which moves again back to the atmosphere evaporation. Transpiration is again the movement of water from your plants that is the stem part leaf parts etcetera to the atmosphere transpiration. Infiltration the movement of water inside the earth's surface towards the aquifer and runoff is the surplus rainfall amount which is not being allowed to move inside rather it moves towards the topography.

So, the hydrological cycle what I have discussed in the previous part that is part 2 of the lecture 1, here what is happening see just two different components are here transportation component and storage components.

(Refer Slide Time: 07:06)



So, in the transportation component what we have discussed already that in the transportation components we are having some continuity of the movement. So, continuity of the movement is generally described by some continuity principle and especially this is known as the water budget equation. Suppose you wish to find out the water availability of any region. If you wish to find out the water availability of any region then how can we evaluate the availability of the water in the specific area.

What should be our mode of thinking? How can we just evaluate? Because we want, we want to know how much water is available inside the surface. So, there again the principle is the same the hydrological cycle always run in the atmosphere you have probably you have heard that at some places you are having plenty of rains and at some places it remains dry. So, where the rain fall will be there definitely the recharge will be the chances of recharge will be there.

And suppose if the rainfall will be less this is also a place but the rainfall is less so the chances of recharges are also less. So, if the recharge will be less definitely the quantity of rainwater will move will come to the groundwater to the aquifer in more amount but if the groundwater will be

less, then what will happen the generation of groundwater will be less here. So, this is the equation and the water budget equation help us to find out the available water present inside the earth surface.

So, here also we take the help of evaporation, transpiration, precipitation, infiltration and runoff. Importantly, these are the 5 important components and precipitation is the only and only recharge source because, without knowing the amount of precipitation in any area it is very difficult to find out or to evaluate the quantity of water available inside the surface. It is very difficult.

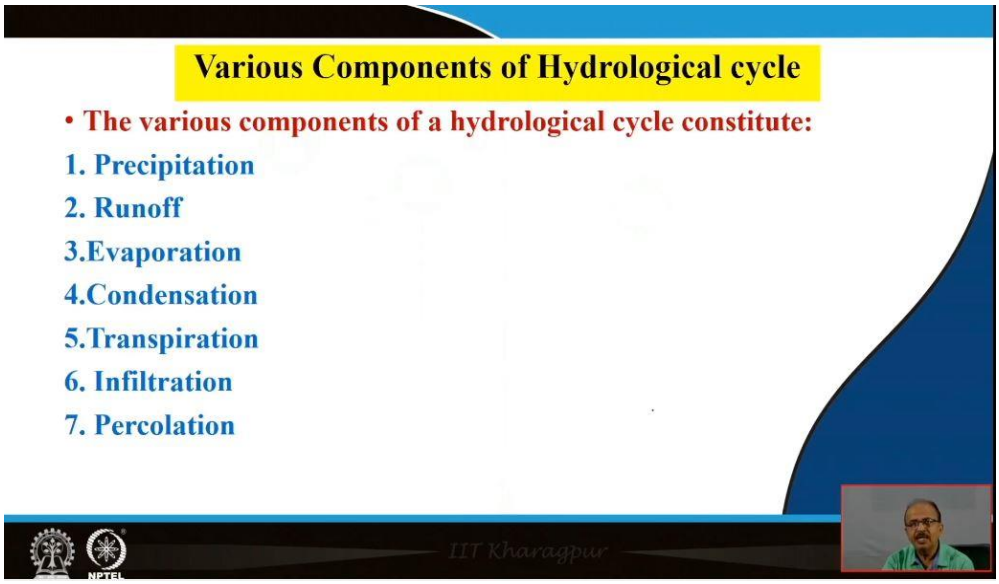
So, generally for the finding out the availability of the water resources we are generally using the water budget equation and the water budget equation is showing the different paths of this hydrological cycle only. The different parts of the hydrological cycle only because we have seen in the previous slide. It has the transportation components as well as it has the storage components it has storage components also.

See, here storage on the land surface when the rain falls probably you have noticed also when the rain falls it tries to fill up the depression storage small-small storage structure first. So, this rain stores rain water stores in the depression storage then it also fills ups the ponds, lakes, reservoirs which are present on the earth's surface. So, after this the soil moisture is storage is also here why because the plants prepare their food by the process of photosynthesis.

They require water also and the water moves through the roots to the plants to the leaves from the moisture taken by the soil only. The soil moisture water helps in the preparation of your food that is the process of photosynthesis. So, next component storage component is the groundwater storage. Groundwater storage is nothing but this is just the aquifer this is just the aquifer in which the water remains.

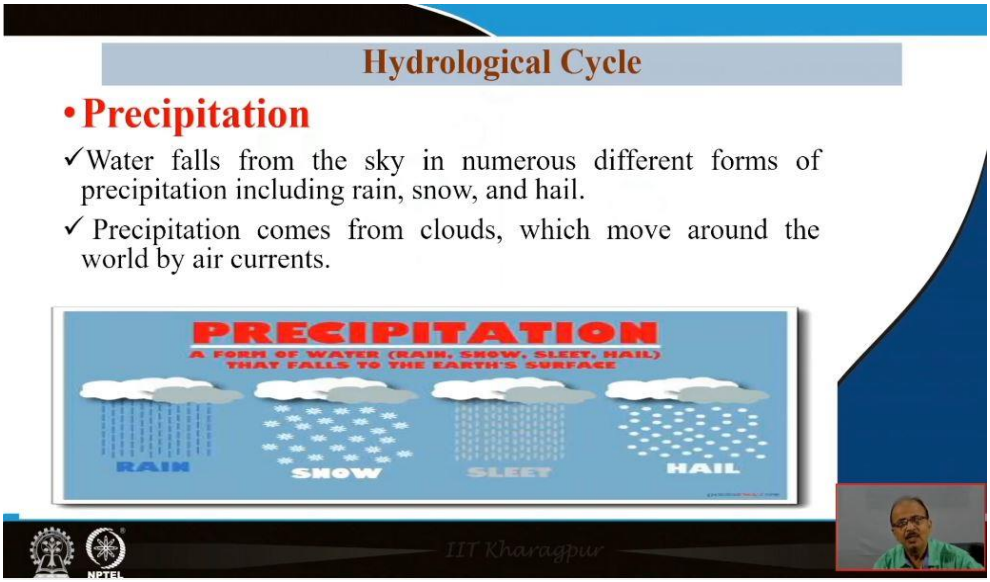
So, what we have seen the hydrological cycle is having two important components transportation and storage components and these two components are only responsible for the formulation of your water budget equation. So, to the water budget equation we can find out the quantity of water available at any area beneath the surface. So, this can be found out.

(Refer Slide Time: 12:06)



So, here what we will do? First, we will describe about the different components in brief and then we will look after how the water budget equation works.

(Refer Slide Time: 12:20)



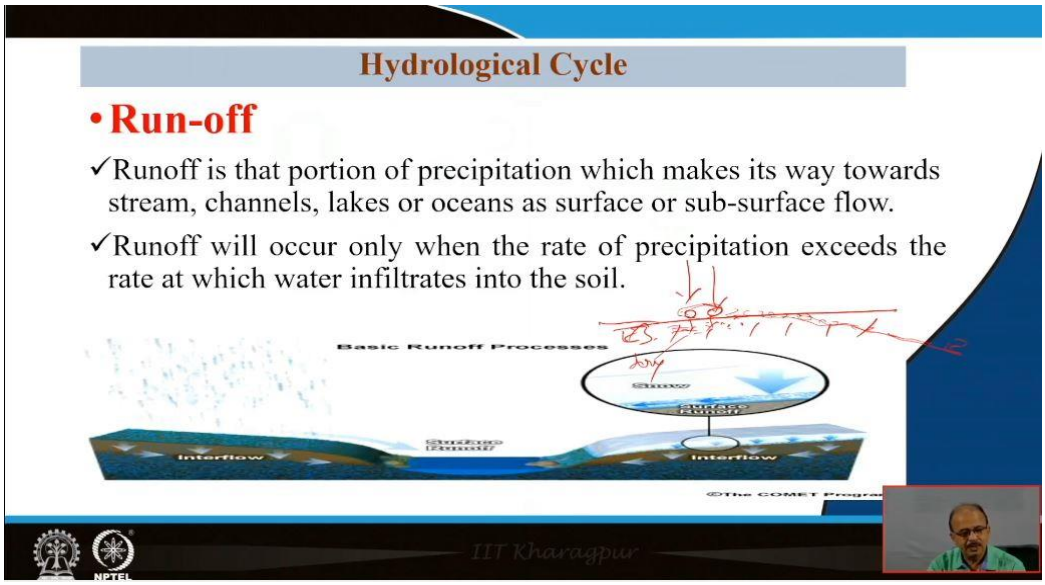
So, if precipitation regarding precipitation we are knowing that water falls from the sky in the different forms of precipitation. Different forms mean rain snow, hail etcetera these are the different forms of the precipitation and generally it comes from the clouds which move around the world by some air currents. So, that is why precipitation occurs at different time intervals especially in the monsoon season we get the precipitation in huge amount.

So, this is the important this precipitation is the only recharge source I am telling you this is the only recharge source which generally helps us in the recharging of the groundwater inside the earth's surface. So, if the precipitation is good of any area definitely the recharge of the wells in those very areas will remain good, if the precipitation will poor then it is very difficult to get good quantity of groundwater at this place.

So, precipitation helps in the formulation of our groundwater. But I have told you not the total amount of precipitation are going down to the surface this is very important I have already shown you the distribution of water also very few quantity of water remains in the form of groundwater, why? The reason is very clear that sometimes we get the erratic pattern of precipitation throughout the year.

So, the year in which we get the very good amount of precipitation definitely the recharges in the aquifers will be good. Otherwise, when there will be some erratic pattern means having lesser precipitation below the average annual rainfall amount of the area then, what will happen the recharge in the wells will be lesser. So, that is why precipitation plays very important role for the formation of groundwater inside any aquifer. So, this is the first component.

(Refer Slide Time: 14:30)



Second is the runoff, I have discussed already that those portions of the precipitation which makes its way towards stream, channels, lakes or ocean as surface or subsurface flow. I have

discussed already suppose this is this is the earth's surface and the precipitation is here precipitated water is coming down towards the earth surface this is the earth surface. So, what will happen the first the raindrop this will tries to move down.

Why? Because this area is totally dry, this is dry area. So, dry area so this water will come down. As soon as this area will become saturated as soon as this area will become saturated then what will happen this area will become saturated then the it will stop to enter the this raindrop will stop to enter inside the earth's surface further because this area has become saturated.

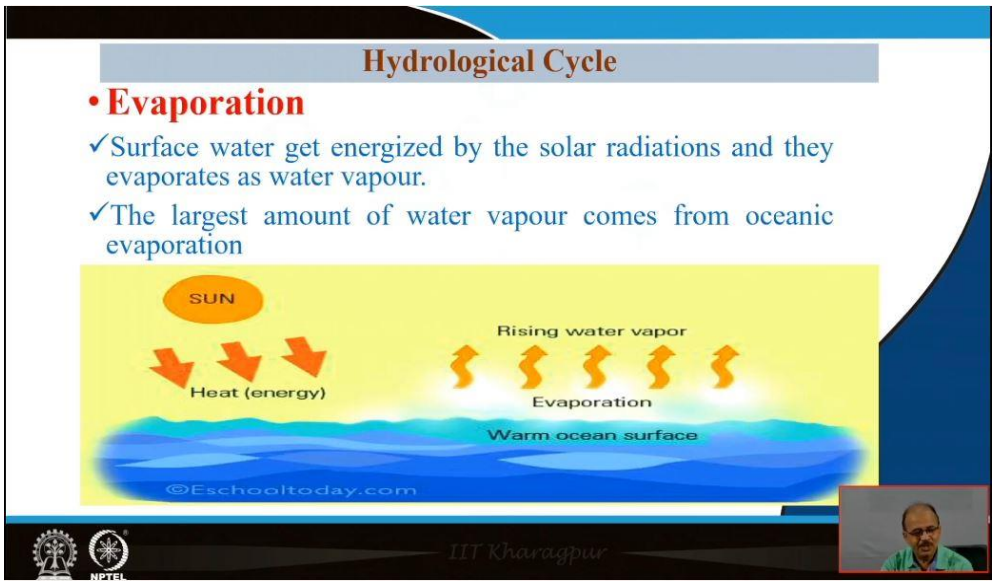
So, now the rain in this infiltrated rain water will not infiltrate down rather it will move towards the topography of the earth's surface. Suppose topography is in this way this is the earth surface. So, this surplus rainwater because now; it is not going down why it is not going down because this area has become saturated. So, it is not allowing the rain drop to move in inside. So, then this surplus amount of rain water will follow towards the topography and this is called run-off.

Now, generally we see it after few minutes or few hours of the rain on the earth's surface perhaps you have noticed that huge amount of water is going far away and ultimately it is reaching ultimately it is just meeting the any river or stream channels etcetera. So, this is the runoff occur only when the rate of precipitation exceeds the rate of pressure exceeds the rate at which the water infiltrates into the soil.

So, when the infiltration will stop the runoff will increase. So, this is the main aim of the point is that nowadays what is happening? We are getting very concrete road at every place means the area is not allowing not allowing the water to move inside. Why? Because the places where earlier the soil remains those places have been covered from some concrete. So, what happened?

The runoff has increased at that place because there is no scope of infiltration there because no soil no infiltration then what will happen, the precipitated water will ultimately takes the safe place of the your topography and through the topography it will move to some distant place and ultimately it will join to some runoff or some steam channel or rivers etcetera. So, this is the second important component of the hydrological cycle.

(Refer Slide Time: 17:40)

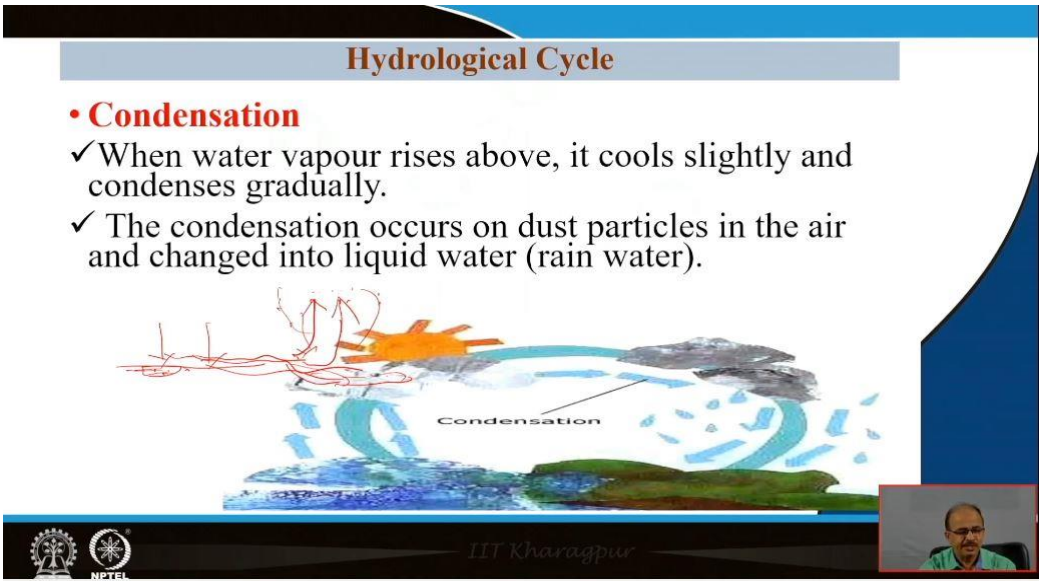


Third is the evaporation. So, what happens the surface water sources that are the rivers, ponds, lakes, your storage reservoirs etcetera. These are having the surface and the through this surface this surface water get energized by the solar radiations and they evaporates in the form of water vapour again back to the atmosphere. So, again it is going back to the atmosphere.

The largest if you will see the largest amount of water vapour quantity we are getting just near to the oceanic areas. Through the seas and oceans, the largest amount of water vapour in the form of evaporation we are getting on the earth surface in the nature. So, how important hydrological cycle you can later understood from this place that this whole component precipitation, evaporation, transpiration.

These whole components are there and it is very tough to find out which is the first component this is the second component that is why since it has no start and no end. So, that is why it is considered a cycle and this cycle are very important why for the generation of the groundwater resources on the earth's surface. So, the third important component was your evaporation.

(Refer Slide Time: 19:11)



Now, next is the condensation. See when the precipitation will take place this precipitated water will try to move down this precipitated water will try to move down. So, infiltration process will take place. Now, if infiltration is not there means it is if the area has become saturated it is not allowing water to move inside then what will happen the surface runoff will increase this surface runoff will increase.

So, runoff will increase then again, the next component is your evaporation. Evaporation means through the soil through the ocean or some other surface water sources that is the ponds lakes by the help of solar radiation it this water means the oceanic water, ponds water etcetera this will again try move up to the atmosphere. So, this will again move up to the atmosphere. Then what is happening?

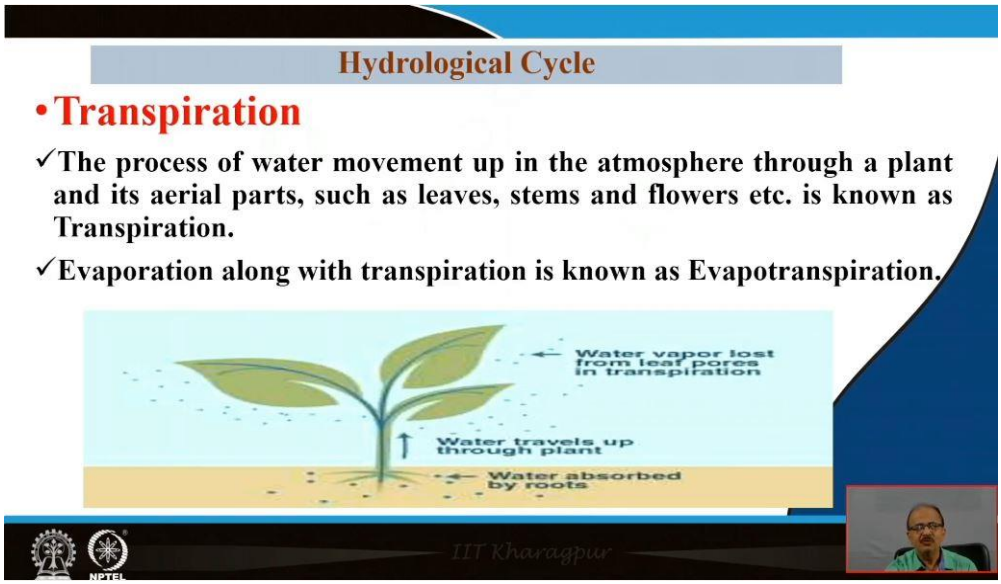
This will this your water this evaporated water will again try to condense at certain height of the atmosphere and it condenses and in condense wear because in the atmosphere we are having the dust particle also. So, this condensation takes place on dust particles in the sphere and in the atmosphere, it just changes again in the form of liquid water that is the rain water. So, we can see how the components are very closely mutually interrelated with each other.

All the components are very closely related to each other. If one will fail definitely the process will have the problem and that is why because of the components failure we are facing the groundwater scarcity problem at different places of our group. Different places not only in India

in world also if you will see they are having the groundwater problem. Because the groundwater is the only type of water which any human can consume.

It can become it is the only potable water which is used for the cooking and drinking purposes. So, and for this we must have the clear concept of the hydrological cycle, because we wish to have the quantification of the groundwater resources at any place. So, for this we require the detail parameters value of the area means your total amount of the water present in the area then only we can find out the available water resources inside the earth's surface.

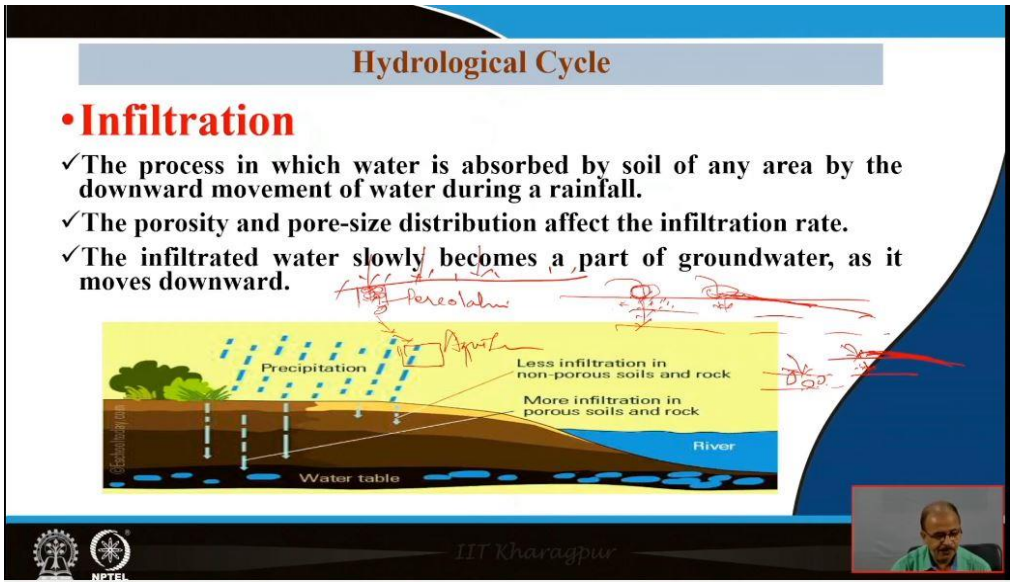
(Refer Slide Time: 22:15)



So, next is the transpiration I have discussed already the process of water movement up in the atmosphere through a plant or its aerial part. Aerial parts we are knowing it is leaves stems and flowers. Generally, in the leaves there are opening known as chromatin openings through which the water moves up into the atmosphere or back to the atmosphere by the process of transpiration.

When we are combining these two evaporations which generally remain maximum in the ocean and seas and transpiration from the aerial parts of the leaves when we combine both evaporation and transpiration it is known as evapotranspiration very important components of any hydrogen cycle. So, this is very-very important component.

(Refer Slide Time: 23:04)



Now, infiltration it is very important, infiltration is also very important because the process in which water is absorbed by soil. It is not necessary that at every place of the earth's surface will have equal amount of infiltration rate. Infiltration rate is very important because suppose you just pour the water here the quantity of water which you are pouring here may go down here.

But at other place same quantity of water, you are pouring but this water is not going down rather it is just flowing and it is following the topography of the area. So, what has happened? We have just pour water here this water moves down means this layer of the soil is having good amount of pore size. Pore siz e means having the availability store house within it this soil layer is having the storehouse.

In the storehouse it is just storing the water which you are pouring here, but this is another form of the soil which is having no pore spaces. There is no pore space here we are 1 2 3 pore space but here there is no porous space. So, you are just pouring it here water you are pouring but what is happening this water is not coming down what is happening this water is just moving towards the topography.

So, this shows how the important one component and the component is infiltration. This infiltration is a very important component. It shows about the availability of the water inside the

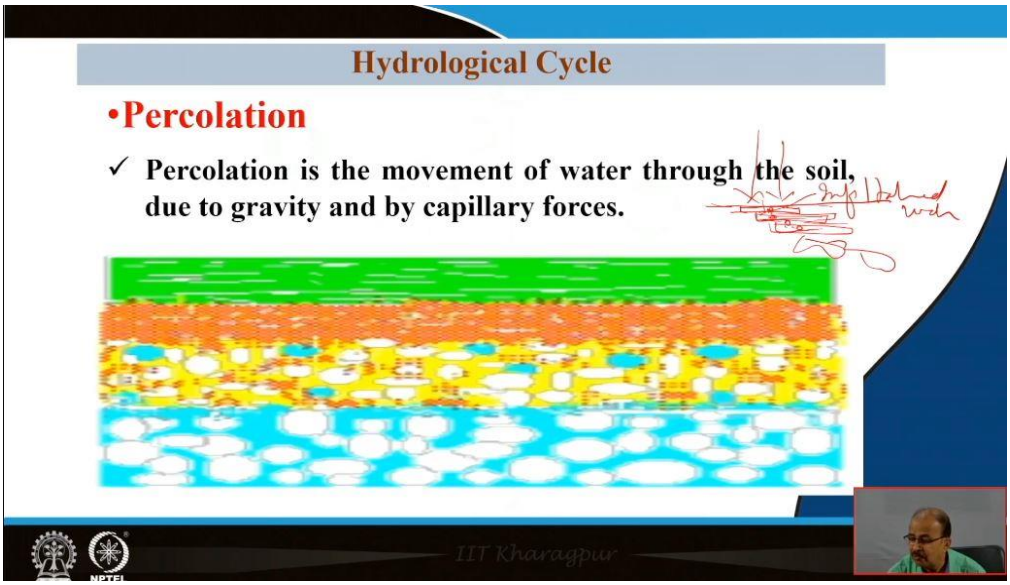
earth's surface if the infiltration rate of any surface if any area is good definitely the area is having some water. But if the infiltration rate is pure definitely those area is having no water.

So, for this for the quantification of the availability of the water resources we are also finding out the infiltration rate of the area there are many instruments doubling infiltrometer one of the instruments through which we are just finding the infiltration rate of the any area and this infiltration rate depends on the porosity and pore size distribution in the soil or the rock in which the groundwater remains.

We have discussed in the first lecture of first part of the lecture. So, infiltrated water slowly becomes a part of groundwater yes, gradually because we have discussed and those days those lectures, we have discussed already that this is the earth's surface. And the rain water is coming to the earth's surface then what is happening the rain water amount of rain water is entering into the surface this soil layer some infiltrated now this water has become infiltrated water.

Now, this soil layer will just send the water in the form of process known as percolation. So, percolation taking place from top soil layer to bottom soil layer. And then this infiltrated water which has just turned into the percolated water will gradually, gradually, gradually raise to the formation which holds the groundwater which is known as the aquifer. So, this is known as the aquifer so this for infiltrated water slowly becomes the part of the groundwater why because it moves downward.

(Refer Slide Time: 26:46)



Percolation, this is one of the next important components of the hydrological cycle in which the movement of water takes place through the soil layer due to gravity and capillary forces. So, what is happening the precipitated water is first reaching to the surface layer of the surface of the earth. So, this precipitated water will first tries to move downward this will become the infiltrated water.

Because this process movement of rain water from the atmosphere to the earth surface inside the surface is known as infiltration. So, this is known as infiltration but again inside the earth surface is are having several layer of the soil first and then the rocks come. So, what is happening the infiltrated water is now just changing it into the percolated water. How? Because, the top layer of the soil will move the water to the bottom layer of the soil.

So, movement of water from the first top layer of the soil to the next top bottom layer of the soil is known as percolated water and it is because of the gravity and capillary forces. So, what we have seen in this lecture that hydrological components are hydrogen cycle is having two important components transportation components and the storage components. All the transportation components are having importance for the generation of groundwater inside the earth's surface.

And among which the importance of parameter or components of the hydrogen cycle are precipitation the only and only recharge source on the surface the runoff surface runoff, we will discuss this thing gradually when we will move ahead then evaporation transpiration and the next is the groundwater runoff. This groundwater runoff ultimately makes the groundwater inside the earth surface which remains in the aquifer. This is all about the lecture on the specific topic thank you very much.