Availability and Management of Groundwater Resources

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Lecture - 01
Hydrological Cycle, Need for Conservation of Groundwater Resources

Welcome to you all in the NPTEL course on the subject availability and management of groundwater resources. Now today we will discuss the first part of the lecture 1 entitled introduction to the hydrological cycle.

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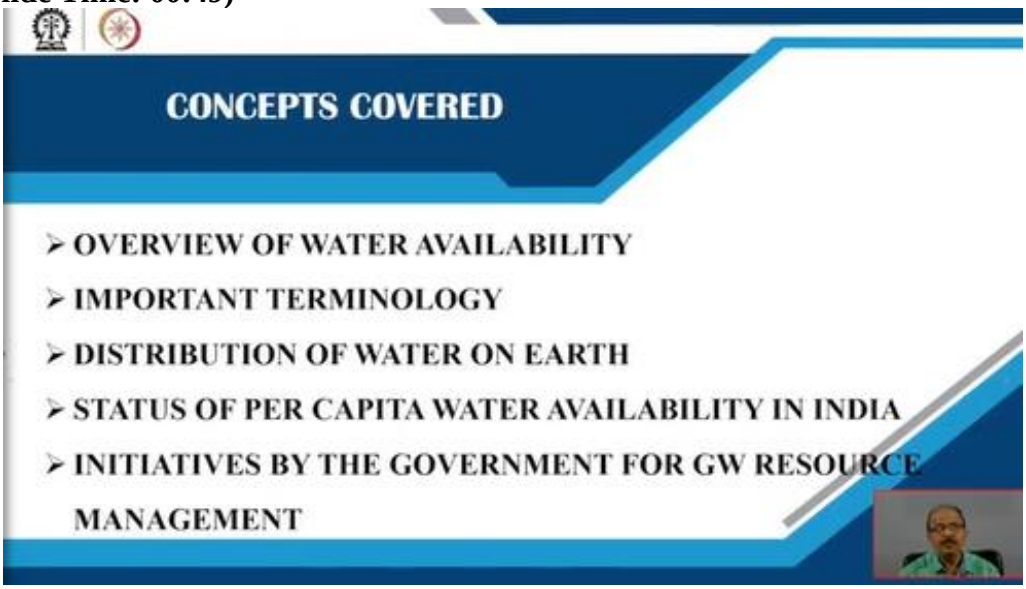

As we know the groundwater resources is one of the very important resource on the earth's surface. So, in this very part of the lecture we will cover the overview of the water availability on the earth's surface, some of the important terminologies how the water has been distributed on the earth's surface then the status of the per capita water availability in India and the initiatives by the government for the management of the groundwater resources.

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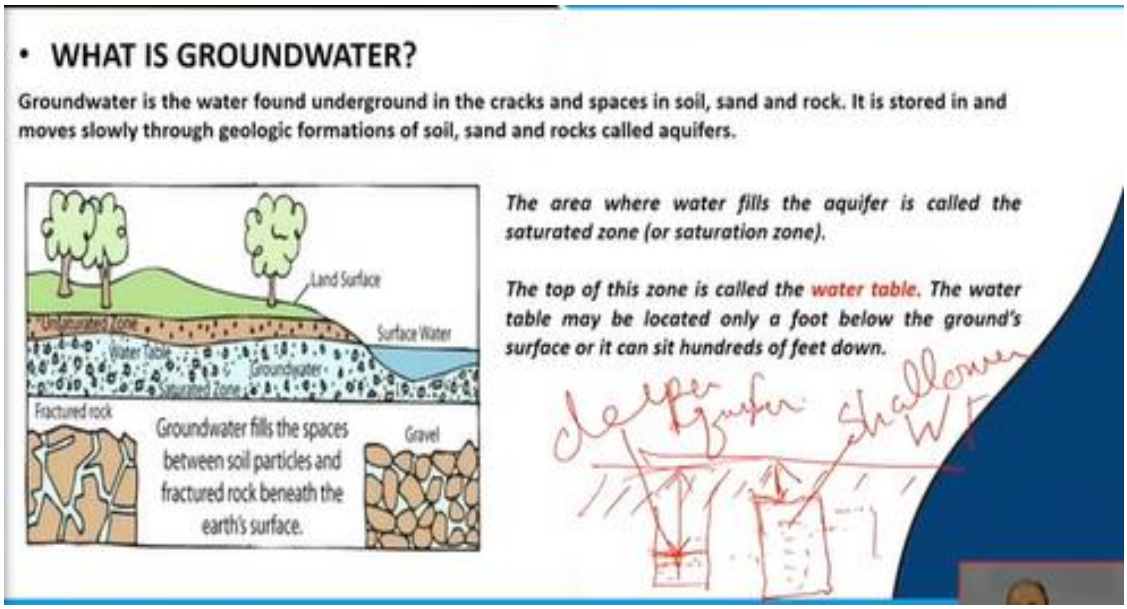

So, this groundwater itself reflects that it remains within the ground. So, there are several types of water but groundwater is the water which generally remains inside certain rocks, certain soil, sand etcetera inside the earth's surface. It is stored in the some of the small pore spaces within the rock surface within the sands of the different geological formations. So, this storehouse or this repository which remains within certain sands or rocks is termed as an aquifer.

This is termed as an aquifer. So, this type of water that is groundwater which generally remains within the ground it remains within certain spaces within the rock within the sand within the soil and this type of structure which remains within the earth's surface which holds the water that is groundwater is termed as an aquifer. So, aquifer is a very, very important storage house for the groundwater resource.

Now the area where water fills the aquifer that just suppose this is the earth's surface so within the earth's surface, we are having some rocks some sand. So, the area which fills these because these are the rocks which are having the availability to store the water. So, this aquifer termed aquifer so this aquifer is also known as the saturated zone within the surface. So, this is the zone of saturation means it is filled up with water.

So, the rock surface, the soil surface where the groundwater remains in plenty is generally termed as the saturated zone. So, inside earth surface we are having the saturated zone as well as unsaturated zone. So, now suppose for a minute that this is a rock and this rock is having the water level because this is a as we have discussed any rock which holds the water inside the earth's surface that is termed as aquifer.

And generally, the ground water which is the basic aim of discussion the groundwater remains within that very rock. So, this aquifer holds the groundwater quantity within its four spaces. So, now the upper level of this ground water saturation zone is termed as this is termed as water table. So, water table may be located at some shallower depth or it may be at greater depth or more than hundreds of feet down.

So, it depends upon the availability of the water inside the earth's surface. So, in another way we can understand this thing about the groundwater resource. See this is the surface so earth surface is having some structure inside it which is holding the water. At present we will understand only this much the rock this is holding the water and this water makes the saturated zone within their area.

So, this has become the saturated zone because it holds the water whereas this is also a rock but it is not holding the groundwater so it is unsaturated zone. It is unsaturated zone and this is the saturated zone. So, this saturated zone is having some layer of water inside it. So, now suppose this is the rock and this rock is holding the water inside it. So, this rock is holding the water up to this level only it is holding the water.

Whereas one more and this is the earth surface whereas one more aquifer is there means one more rock is there one more rock is there which is holding the water. So, this is also holding the water but the water table is just near to it means the level of the water inside it is near to the ground surface. So, here it is having lesser depth whereas here it is having greater depth. So, the point is that groundwater is not evenly circulated inside the earth's surface.

It is not so it remains at the uneven depth inside the earth's surface. So, since groundwater remains in certain rocks so the rocks hold the water and the level of the water will differ at different-different aquifer or different saturated zone. So, this level of the water varies inside the surface. Somewhere the level of the water within any aquifer remains near to the just beneath the earth's surface few feet below beneath the surface.
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Whereas in some saturated zone we are seeing that the level of the water that is the water table remains at a greater depth. So, this aquifer is termed as shallower aquifer, whereas this aquifer is termed as deeper aquifer. So, generally we are getting such type of aquifer shallower as well as deeper aquifer inside the earth's surface and within that aquifer only the groundwater remains.

So, this is the first fundamental concept that groundwater remains within the ground no doubt but it remains in certain rocks soil formations and that rock and soil formations are termed as aquifer and within the aquifer the water remains and the level of the water the top level of the water within the aquifer is termed as water table, aquifer is also termed as saturated zone. So, this water table means the level of the water in different aquifers varies place to place.

So, at some cases we are getting the shallower aquifer means the level of the water just inside the near to the surface at few feet, few meters below the earth surface whereas in some cases we are getting the deeper aquifer where the water table remains at a greater depth and that is what we are facing the problem of the getting the groundwater resource also. So, this is the basic problem.

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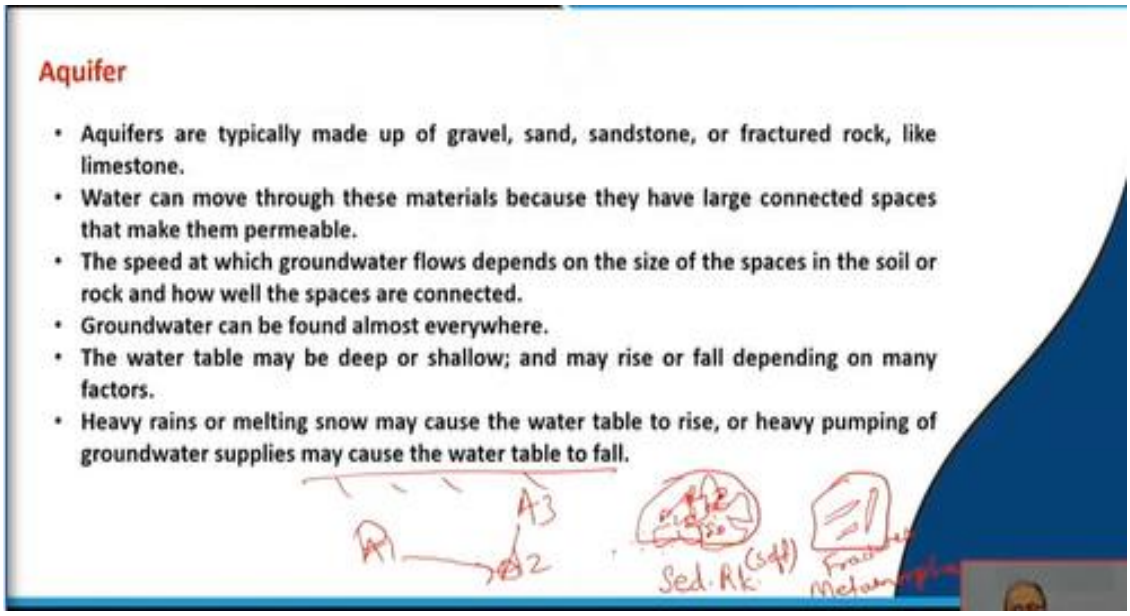

Now after this just within few slides we can understand we will see the few points we will see that aquifers are typically made up of gravel, sand, sandstone or fracture drop like limestone. So, this may be new for you but I am just simplifying it that these are the rocks which is lying inside the earth surface. So, inside we are getting the several types of rocks gravel, sand, sandstone, limestone these are very, very soft rocks known as sedimentary rocks.

Whereas in some cases we are also getting groundwater in some fractured rock which is the type of metamorphic rock in which we are getting the fracture or lineaments. So, the first point of this slide is that aquifer we have already understood that aquifers are nothing but these are just the rocky formation which is holding the water that is the groundwater. So, these aquifers are typically made up of soft rock or hard rock.

So, if the rock is having very good amount of pore spaces, then that will hold good amount of groundwater also, whereas in some cases the groundwater remains in small fractures or lineaments within any hard rock. So, the point and the concept is that this groundwater what we are going to discuss in this subject availability and management of groundwater resources we must understood first that how and at which places the groundwater remains available.

So, the general concept is that the groundwaters will remain available in certain rocks or the geological formations, sand etcetera. So, generally the groundwater remains in soft rock known as sedimentary rock and the example is gravel, sandstone, limestone etcetera. These are the sedimentary because in these sedimentary rocks we are getting very small pore spaces. Suppose this is the sedimentary rock.

So, these sedimentary rocks are having some grains some mineral grains but in between the grains are having the spaces. So, here we are getting the space here we are getting the space. So, these are the mineral matters and here we are getting the space. So, point is that in the sedimentary rocks we are having lots of option to store the water. Why? Because we are having the plenty of pore spaces.

So, water will remain here, more clearly, I am just telling you that this is one rock and this is another type of rock. This rock is having good number of porous spaces. So, first I will draw these one four spaces and then the grains are just interlinked with each other. So, this type of rock is known as sedimentary rock because this rock is having good number of pore spaces. Whatever is being filled these are the porous places and with the water remains.

Whereas this is also a rock inside the surface but this rock is having not put a good number of pore spaces. But in between it is having some fractures, some small lineaments, some fractures. So, here large number of pore places we are getting why because this is a soft rock that is the sedimentary rock this is sedimentary rock this is soft one. Whereas this is having these are the pore spaces whereas in this is your lineaments fractures etcetera.

So, what is happening here? Here we are getting the metamorphic rock. In metamorphic rock which is a hard rock but derived from the parent sedimentary rock. We are having some space and these spaces are termed as your fractures and lineaments. So, what we have seen? We have seen that the rocks inside which the groundwater remains are generally sedimentary rock or the metamorphic rock.

In sedimentary rock the water will remain within the pore spaces present between the interlinked grains whereas in the metamorphic rocks the hard rocks we are getting the groundwater but in a lesser amount, why? Because it remains in the fractures or lineaments. This type of the distribution remains within the surface. That is why at some places we are getting plenty of groundwater resource through the well or dug well or tube well.

But at other places we are not getting good amount of groundwater through well, dug well tube etcetera. This is the basic region because at one place we are getting good amount because the area is having good sedimentary rock which is having plenty of pore spaces which can hold large amount of groundwater but other places which is having not good amount of groundwater resource is because the area is having hard rock area the rock is having only the pore space, only the fractures and lineaments.

So, these concepts should we build in our mind about the availability. Why we are getting groundwater at some places in a very good amount and another place we are not having so why? So, the question and the answers are here only because the availability of the geological formations that is the rocks. Now third point is the speed at which groundwater flow depends on the size of the spaces in the soil.

So, inside also it is not so that outside we are seeing the flow of the river water. Inside also the; water moves from one aquifer to another aquifer. So, inside the surface suppose this is the earth's surface so inside also if aquifer one is here for two is here aquifer three is here so what is happening inside also it follows the gravity it moves towards the from aquifer 1 to aquifer 2 aquifer 3 to aquifer 2 in this way groundwater flows inside the earth's surface also.

And what we have seen in the nature groundwater is sufficient almost everywhere but it depends the quantity depends according to the geology of the area. So, we have seen just now that the level of the water which is generally known as the water table it may remain shallower it may

remain deep. So, somewhere it may rise or somewhere it may go down so, this also generally happening in the nature.

Sometimes perhaps in the during the monsoon season when we are having the plenty of rain that time if you will see in any well any dug well if you will see you will notice that the level of the water what you have notice already during the summer period because after summer the monsoon has come. Then the level of the water has just moved up. Why? Because the saturation level inside the rock has also exceeded.

So, that is why the water table sometimes remains up or sometime it fells down. So, heavy rains or melting of snow may cause the water table to rise or heavy pumping so when the heavy rain is there or melting of snow is there, we can see in the well that the level of the water table is rising up whereas when sometimes we are also pumping the water huge amount of pumping, we are doing for certain purposes.

That time you will notice that the level of the water in the well which is the water table it falls gradually. When you will start the pumping, you can notice the level when you just off keep it off just you, please note down the level you will find the difference the level has gone down. So, in this way the water level inside the earth's surface is varying.

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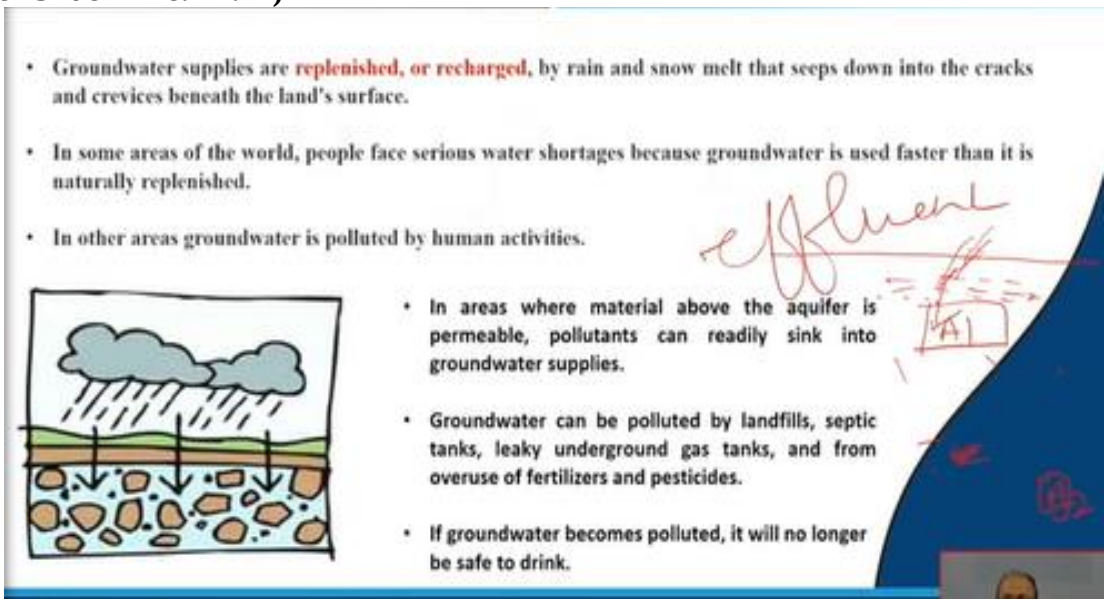

Now this groundwater suppose you have just withdrawn the water from any well but generally you will notice suppose throughout the day you have just withdrawn the water for certain purposes maybe your potable purposes, may be your commercial purposes just you have taken out the water from the well. If you will notice the next day again the level of the water has come to that place from where you have started just in the earlier days.

So, why and how because these groundwater supplies are replenished or recharged it can be replenished from, I have told you just inside we are having several types of aquifers, aquifer 1 is here aquifer 2 is here aquifer 3 is here so, in this way what is happening is suppose you are

withdrawing the water from aquifer 1, So, the level of the water may go down water table may go down but this level is go down.

But after if you will be leaving it for a period if you will notice it the level again come to this place. So, what is happening? The water from this aquifer is just replenishing or recharging the aquifer 1 why because of the gravity because water inside also flows according to topography just like on the surface of the earth where the water flows according to the topography. So, inside also we are noticing that if we are just pumping out the water this level of the water again comes to your original place after few hours or few minutes.

So, this groundwater resource is generally naturally the plan it is replenishing naturally. In areas where material above the aquifer is permeable it is very important point. So, in areas where material above suppose this is the area and this is the aquifer just this is the aquifer this aquifer 1 is here and this aquifer 1 is having some formation which is permeable which is permeable. So, this aquifer is a place from where we can withdraw the water or a place where the water remains.

And this area is become permeable it is naturally permeable area means permeable means availability to transfer the water. This is called as permeability. So, the aquifer is just the material is permeable just above this aquifer then what will happen suppose if any pollutant will come from certain activities. So, that activity suppose from this the pollutant is coming to this place means the material above the aquifer which is a permeable material.

Then what will happen this pollutant will directly sensitive permeable is having the availability to transmit. So, this pollutant is directly entering into the groundwater resource and thereby making the groundwater pollution. So, this is also one of the very, very important concepts. Why the groundwater has become polluted? The reason is that we have seen that the groundwater where it remains it is a saturated zone fill of water that is why saturated fill of water.

So, above and the structure is known as the aquifer, but what is happening. Just above it if the permeable zone remains then what will happen, the pollutants can readily sink into the groundwater source this groundwater reservoir is their aquifer is groundwater reservoir just a rock holding the water. So, this pollutant will move to the groundwater and thereby the groundwater pollution will take place.

See another aspect is that groundwater can be polluted by landfills. There are several landfills area also septic tanks people are making septic tanks at for houses for industrial activities etcetera. Leaky underground gas stands inside the earth surface also there are several pipelines to which the gas is being passed. So, if it has some leakage then what will happen the groundwater pollution will take place.

Even from the fertilizer and pesticides which are being used for the agriculture activities they are also polluting the groundwater resource inside the earth surface. General concept is that groundwater is inside the earth so there will be very difficult to have the pollution of the groundwater. But no, I told you if at any aquifer just above it will remain the permeable zone then there are more chances to get the groundwater pollution in that very specific water.

So, groundwater becomes polluted it will be no longer and no safer for the potable purposes for the drinking purposes. So, the two concepts we have understood till now. First concept is that the groundwater is remaining available in certain rocks within the earth's surface. The rocks which is holding the groundwater is termed as aquifer this aquifer is a saturated zone. It is having the level of the water inside it.

The upper level of the water is termed as groundwater table water table. This water table may remain just near to the earth's surface or may remain at the deeper depth. That is why at certain places on the earth surface we are getting the water in a well to just two or three meter down whereas in some well on the earth surface we are getting the water at 100 or 200 feet down. So, the reason is that at some places the water table remains near to the surface.

At some places the water table remains at greater depth. So, it is very difficult to withdraw the water from the deeper aquifer. Generally, the rocks which are holding the groundwater is the sedimentary rocks. Sedimentary rocks is having very two good important properties. First it is a having good storage capacity which is known as storativity. This is a very good storage space it is having good number of porosities means number of pores divided by volume is called as porosity.

So, sedimentary rocks is having a good porous rock whereas metamorphic rock is having less porous I have told you generally in metamorphic rock which is a hard rock the groundwater remains in some cracks or lineaments some fractures. So, this is the basic difference of the two different rocks or the two different types of aquifers which are present inside the surface in which the groundwater remains.

Another concept we have understood that this groundwater may become polluted. How? We have discussed already that if the permeable material will remain just above or near to the aquifer and if some sort of effluent, effluent means some industrial influence from waste water from some industry is coming and just dropping near to the permeable formation. Then this permeable formation will just allow the effluent the toxic chemicals to go inside the groundwater quantity.

And this whole groundwater will become affected become polluted. So, these two important concepts we should keep from the very beginning.

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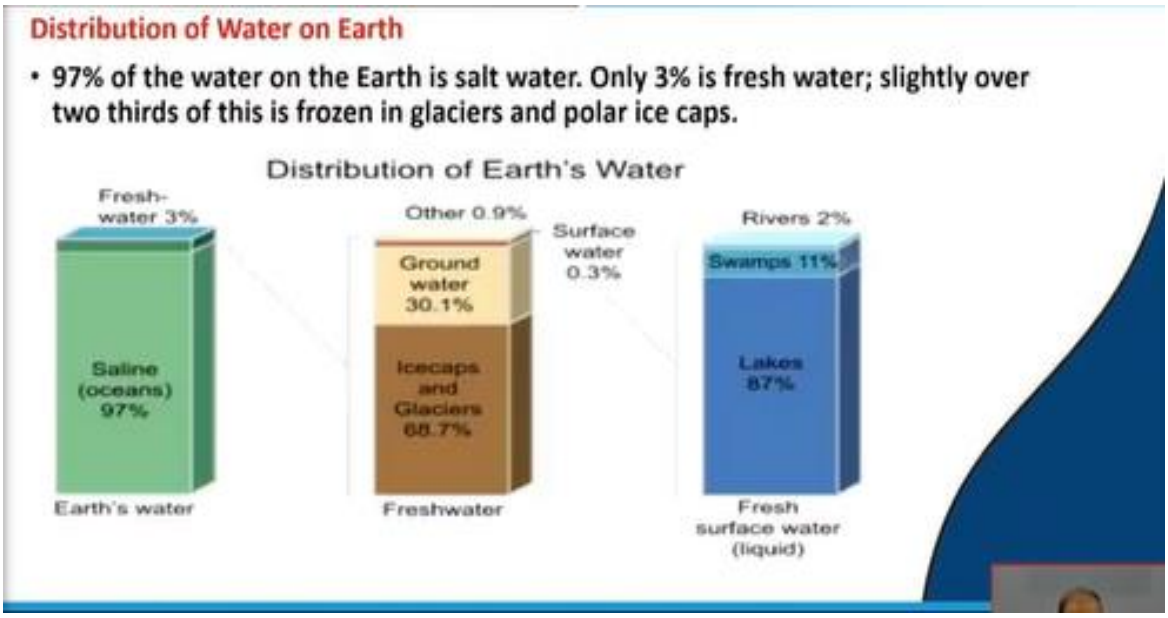

Now apart from this we will just see how the distribution of water remains on the surface. The first concept we have understood where the water will remain inside the earth. Now just we have our look on the distribution of water on the earth. So, 97% of the water on earth is salt water 97% of the total 100 water we will see we are having the continents as well as water in our globe if you have noticed that 97% of water in the salt water which remains in ocean on seas.

So, only 3% of water remains such a fresh water and if you will see closely about its distribution this fresh water is having about sixty 68.7% in the form of icecaps and glaciers 68.7% about ice caps and glacier remains packed at certain places. So, of very little you do not know used. Now rest 0.3% water flows on the earth's surface which is known as surface water in the form of streams, rivers, lakes, ponds etcetera.

Some other type of water also remains present on the surface which is 0.9% but the groundwater remains only 30.1% of the total fresh water of 3% which remains within certain formations that is the aquifer. So, this is the important point that since 97% of water is we cannot use since it is having saline in nature. So, fresh water remains only 3% and out of this freeze 3% only the groundwater is 30.1% rest remains in the form of icecaps and glaciers and the surface water and others.

So, itself we are having a very very lesser quantity of groundwater inside the earth's surface in the form of fresh water. So, if you will see the statics of the surface water here the surface water covers about 87% in the form of leaks it is 87% water in the form of lakes and ponds 11% in the form of swamps and rivers 2%. So, this is just the distribution of the surface water. So, importantly we are having the two important types of water the surface water and the ground water.

In this subject we will discuss specifically the about the availability and management of the groundwater resources because this groundwater we are directly drink taking it for our drinking purposes. So, it should not remain contaminated it should be in the fresh form. That is why we can take it. So, every life forms are depending on the availability of the groundwater resources.

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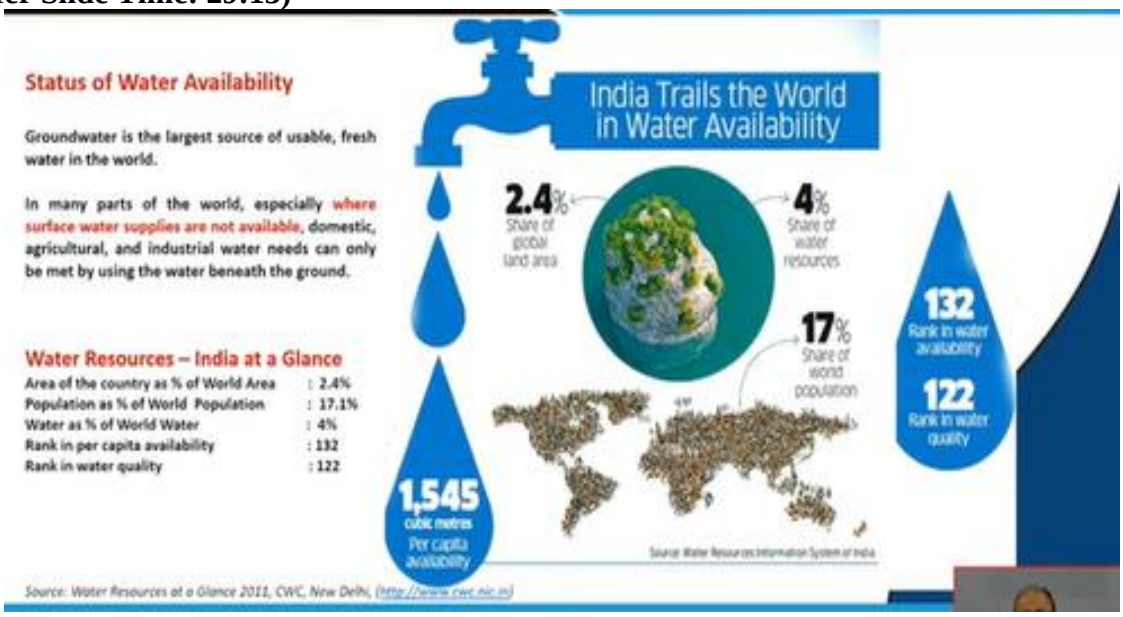

Yes, just have a glance on the water resource of India in countries in which we are living we are having if you will just compare it from the world area, we are having 2.4% area. And this 2.4% area the population is about 17.1% of the world population in our country we are having 17.1% of the world population. Water as well percent of world water if you will see we are having our Indian subcontinent is having only 4% of the total your world water statistics 4% only.

Per capita availability ranking if you will see only one 132 per capita availability whereas in water quality if you see the water quality because quality is very, very important, we are having the ranking of 122. So, what is the important part? Important part is that in many parts of the world especially where surface water supplies are not available, domestic agriculture and industrial water needs can only be met by using the water and that water is especially the groundwater.

So, you may get surface water insufficient but if not, you are getting the sufficient surface water you have to have the application for taking out the groundwater resource from inside the surface and use it.

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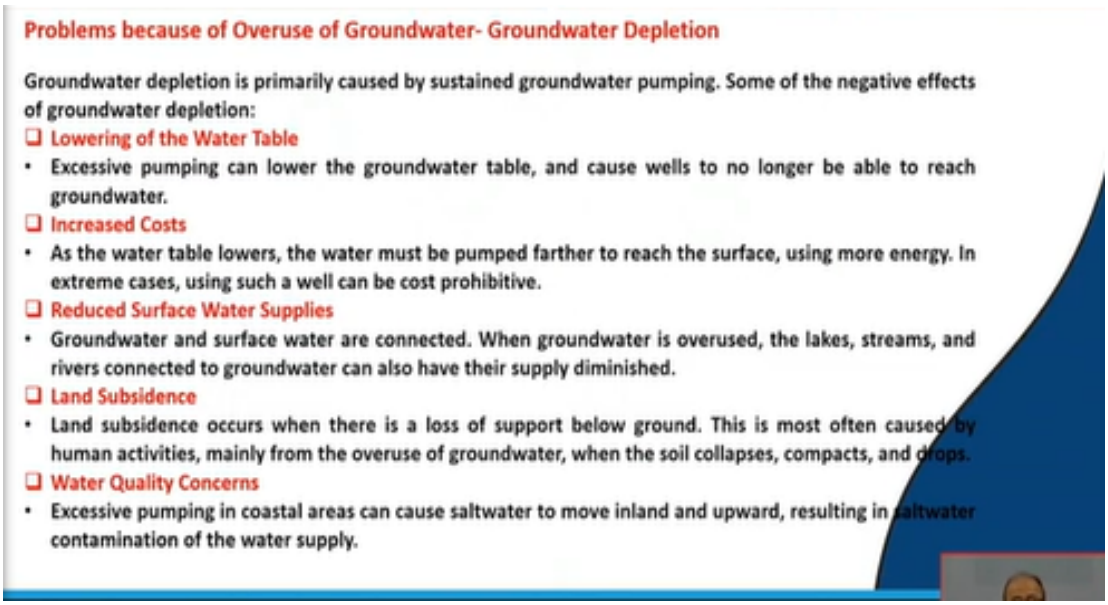

So, this should be because we are having some limitations also. Now what are the problems of the overuse of groundwater resources suppose we are using it but not replenishing the groundwater resource then what will happen the problem will take place in the form of groundwater depletion. Groundwater will deplete the level of the water will move down and down. So, and if you will not think of for its management a day will come when the well will become dry.

And this is the situation we are facing in several parts of our country also where earlier the persons who were living in the villages, they were having good amount of sufficient amount of groundwater in their wells but at the present day they are not having such type of well in through which they can take out the water and use for their day-to-day livelihood works. So, what are the causes? The groundwater depletion.

How it is taking place? Lowering of the water table. Already I have discussed that if you will excessive pump from any dug well it will just lower the groundwater table and cause wells to no longer be able to reach the groundwater. So, excessive pumping is a very dangerous and generally it is excessive pumping are also being done why for irrigation purpose the farmers they need water because they have to do irrigation.

So, they are not having sufficient amount of groundwater but anyway they are just pumping continuously taking out the groundwater continuously. So, what is happening? The water table is going down and down. Secondly increase cost. As the water table lowers, now the water table has become lowered the water must be pumped further to reach the surface. Then what will happen? More capacity pump you will use more energy it will be used then the cost will also go high.

So, in another way we are again going to increase the cost in the for the sake of taking out the water withdrawing the water from the earth surface. Now reduced surface water supplies suppose ground water and surface water are connected it remains connected. So, what is happening

groundwater is overused? The lakes if you are over using the groundwater then lakes streams and rivers which are they are also connected to the groundwater.

And then what will happen they will again start to become dry. Why? Because they will supply their water; when surface water will reach to the ground water in a rock which is drying inside the rock. So, gradually the river water will become dry. So, in this way what we are seeing that if we will overuse the groundwater resource then we will face the groundwater depletion problem.

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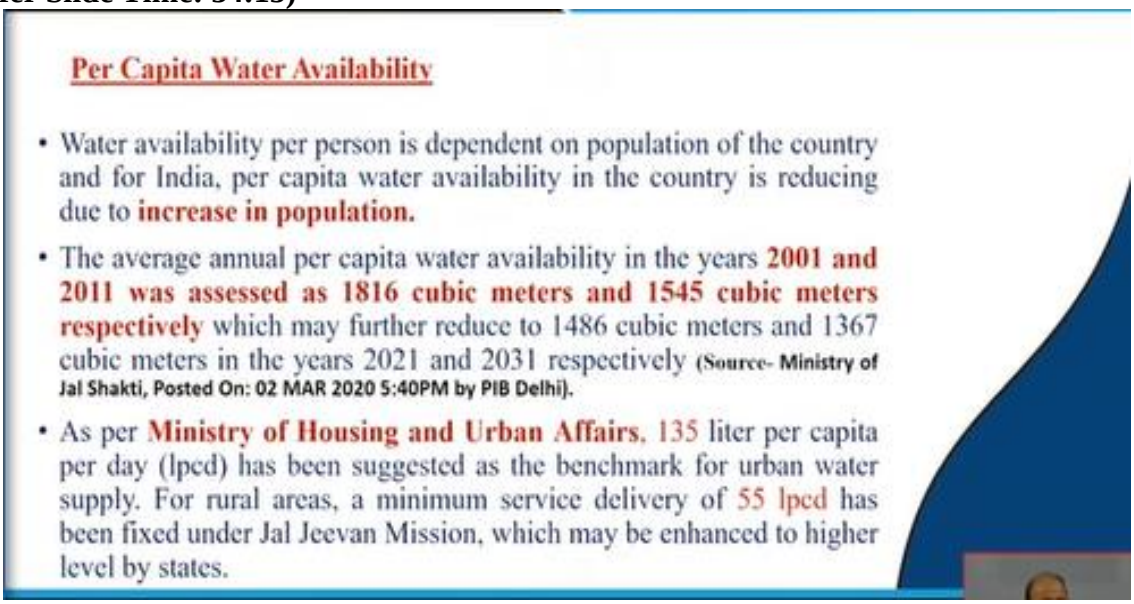

If you will see the per capita availability of our Indian condition, we are having only an only135 litre lpcd 135 litre per capita we are having for the urban water users whereas for the rural we are having the 55 lpcd according to the ministry of housing and urban affairs. This is the per capita water availability. Population wise we are seeing that in our India we are getting the groundwater problem, why? Because we are having the increase in population.

Gradually our population are increasing. So, the per capita availability is also decreasing day by day.

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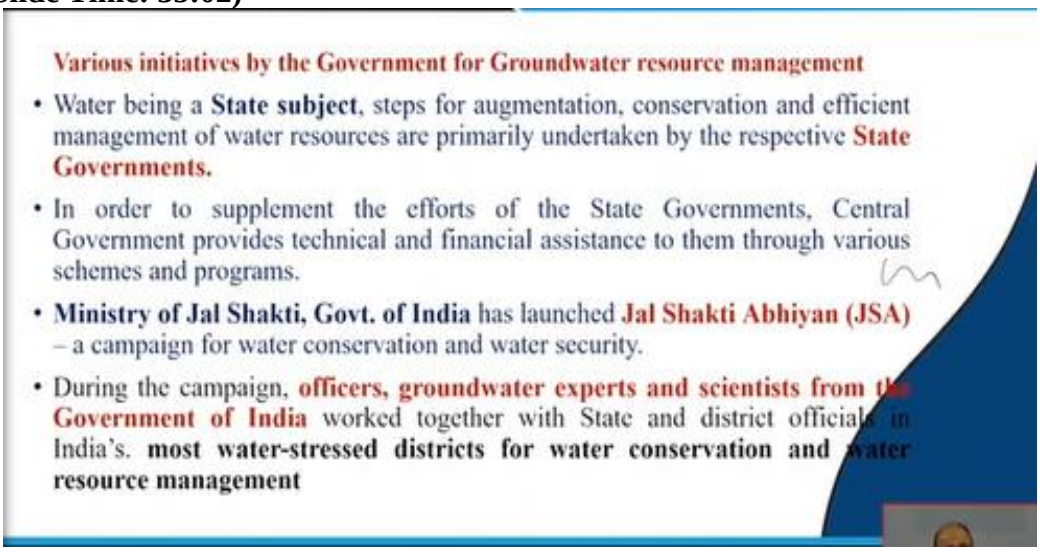

Now some initiatives are being taken by the government water being water is a state subject it waters itself remains a state subject. So, steps for its augmentation conservation and efficient management are the prime duty of the state governments only. However, the central government they are generally technically and financially helps to the state government for various schemes and programs through which the conservation measures can be done.

Ministry of Jal Shakti, government of India has launched Jal Shakti Abhiyan a campaign a very good campaign for water conservation and water security in our country. And during this campaign the officers groundwater experts scientists from the government of India all sit and work together with the state and the central and they just demarcating the water stressed districts within the state.

And then they are just proposing for the water conservation and water resource management plan and in this way the government is helping for the conservation of these valuable water resources.

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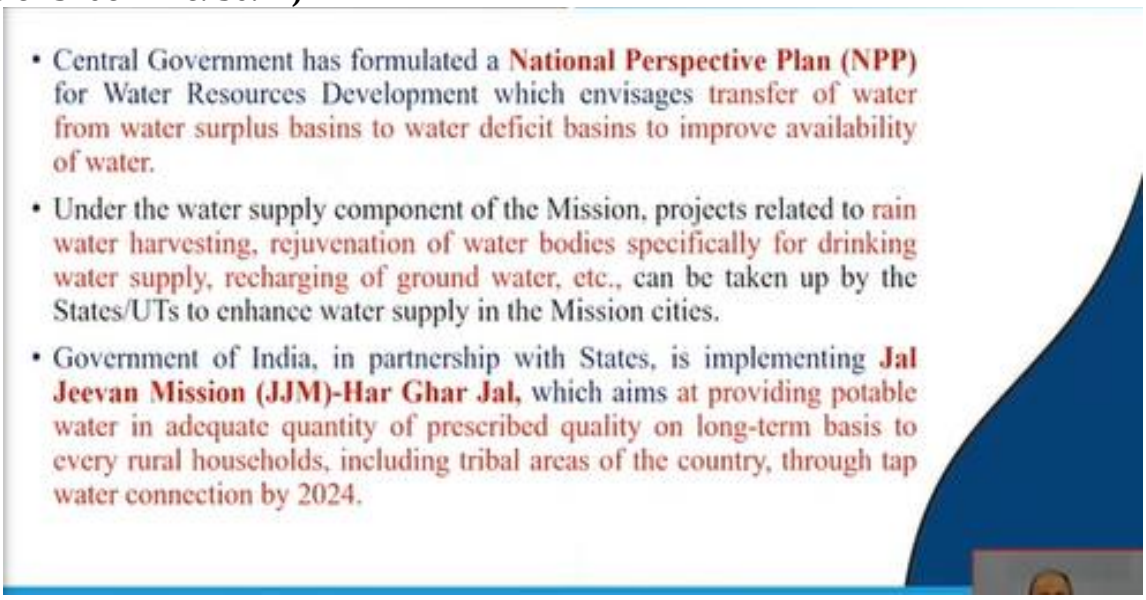

Central government is having also very national perspective plan etcetera through which it transfers of water from water surplus basins to the water deficit basins to improve the availability of water. So, through this national prospective plan it can be used because we have learnt that some places may have the sufficient amount of groundwater resources whereas some places may not have.

So, through this plan the transfer of water from one basin to another basin can be done. Government of India in partnership with the states is implementing Jal Jeevan Mission Har Ghar Jal which aims at providing potable water in adequate quality of prescribed on standard quality on long term basis to every rural households including tribal areas of the country through tap water connection by 2024.

So, this is a very good movement by the government of India Har Ghar Jal. So, this is about the very first topic about the availability and the management of the groundwater resources. This is all about the lecture on the specific topic. Thank you very much.