Ground Water Hydrology

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Module No # 01
Lecture No # 01
Introduction: Ground Water (GW) Utilization and Historical Background

Welcome to this NPTEL phase two course on groundwater hydrology which is being developed by me DR.VR DESAI and my colleague DR.AMIR BANDAR are both from the department of Engineering IIT Kharaghpur. Now first let us start with this lecture number 1 module number 1 on introduction.

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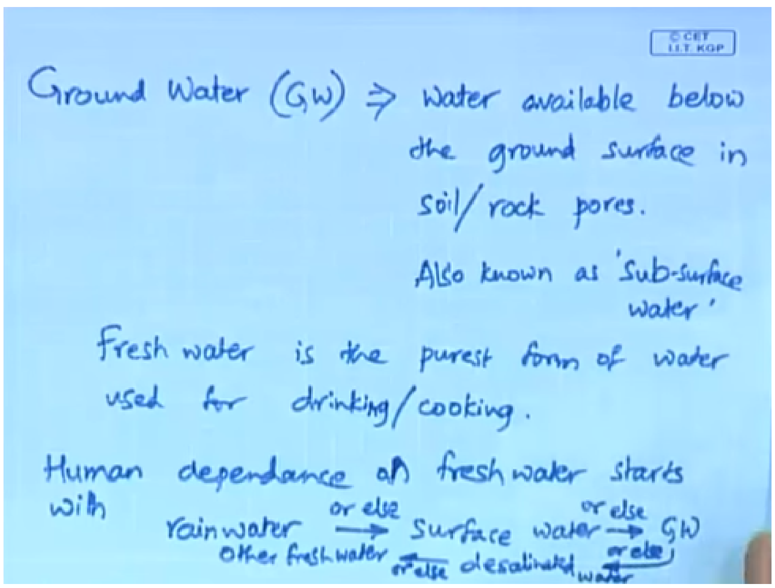

So here we will start with the basic the meaning of the word ground water and how it has evolved which I would like to abbreviate as a GW. So this is the ground water is the water available below the ground surface in soil or rock pores also known it is also known as sub surface water. For the simple reason that it is available below the ground and we all know that for sustain life water is the second most important requirement next only air and it comes even before food.

So water is used for various purposes right from the drinking and cooking as well as other purpose and the water the required for this drinking and cooking is known as fresh water. Fresh water is the purest form of water used for drinking, cooking the human depends on water on fresh water. Water in general or fresh water in particular its starts with the rain water or else surface water else or else ground water or else desalinated water or else other fresh water.

Here I would like to mention that the rain water as and when it is available okay we know that the duration of the rain water is very limited as well as many times a spatial extent of rainfall is also quite limited. So if the rainwater is stored can be store in the appropriate containers before it gets polluted or contaminated with other impurities in the atmosphere or on the ground surface okay that will serve as the best purpose because it has under the natural process of purification through this evaporation and subsequent condensation.

So and because of the spatial and temporal limitation of rainwater so our human depends if rainwater is not available then we have to come we have to sustain our life not only for human being so also for our flora and fauna the plants and animals. So they also need to sustain their life so therefore the depends moves one surface water. So here the this water may be available in any surface water body may be a river or a reservoir or a small size reservoir like such as tank or a pond or even a natural reservoir like lake okay.

So all this are as one and it also the surface water may also be available in the form of say this mountain ice caps next if that is also not available then obviously the human intelligence tries to explore water by that is digging below the ground and then getting this one hoping for most of the time succeeding and getting ground water which is generally available in well and other subsurface structure.

If that is also not available that means when rain water is not available surface water is not available ground water is not available but the area is closed to say a sea or any other source of marine water. So then we may go for say desalinated water. So this desalination is essentially the artificial process of evaporation and then creating a as when artificially fresh water and if that is also not available we may go for other source of water such as fog water or even mist or any other respond any other form of fresh water okay.

So therefore and as you can see so this the ground water here it lies this it is next only to rain water and surface water so therefore it provides the necessary that is water security spatially and temporally and because it process this water security. So it is very important to sustain life and many times it has been proved that.

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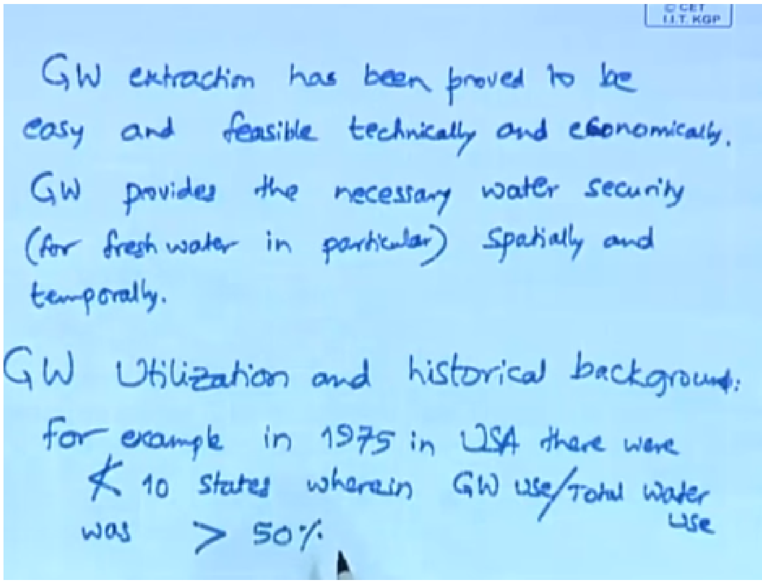

So this ground water extraction has been proved to be easy and feasible technically and economically. So this ground water provides the necessary water security for fresh water in particular spatially and temporal. Therefore the extraction of ground water or the rather the harnessing of the ground water is very important. Now let us go to the next item of this lecture that is the ground water utilization and historical background.

So coming to this ground water utilization I have already mentioned in introduction that how important ground water use to provide spatio-temporal security water security and this one in this ground water utilization. So this ground water utilization is done in the developed as well as developing world. In the developed world as well as in developed nations as well as developing nation.

So there has been significant amount of utilization of ground water because for the simple reason that it is providing additional water security. So now let us let me give an example of say this an example from the developing developed world and also an example from the developing world. So this is a for example in USA in 1975 in USA there were at least not less than 10 states wherein ground water use divided total water use was greater than 50%.

Because I am using the word not at least because I got this one the data from only for say 45 out of 50 states that is why I am using this word.

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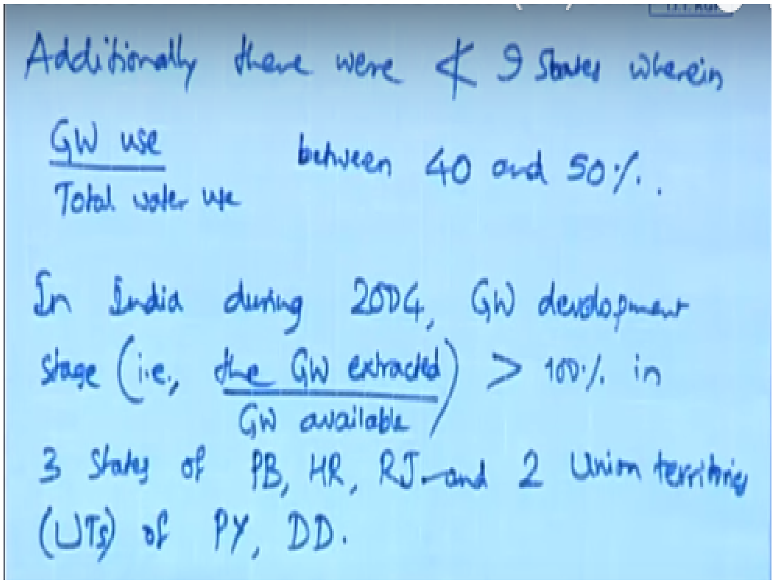

And added to this there were additionally there were not less than say nine more states nine states wherein this ground water use divided by total water use it was between 40 and 50%. So it can say nearly say at least 20% of the no 40% of the states in US okay depended significantly on ground water for their for carrying out their various activities.

Now and now let me provide an example from India the recent as one say in India during two thousand four. So the ground water development that is developing stage okay that is the ground water extracted divided by ground water available. So this was more than hundred percent in three state of Punjab, Haryana and Rajasthan.

Of course this is not a healthy sign but still it can realize the importance of ground water and we know that Punjab and Haryana are known as the agriculture power houses in India. So you can imagine the importance of ground water in likewise so in the national capital of territory Delhi also had a stage of ground water development of for more than 100%.

And during the same year so there were 5 more states that is Gurajat, Karnataka, TamilNadu, Uttar Pradesh and Uttarakhand and where in ground water the stage of ground water development was between 50 and 100% and so this was also the case Lakshadweep the union territory of Lakshadweep and of course I forgot to add here that is 3 states of Punjab and 2 union territories that is Pondicherry, Diu and Daman DD okay.

So this is PY for Pondicherry and DD for Diu and Daman likewise so this is a between and 100% the union territory of Lakshadweep had as 1. So like as you can say so let me present this in a tabular form.

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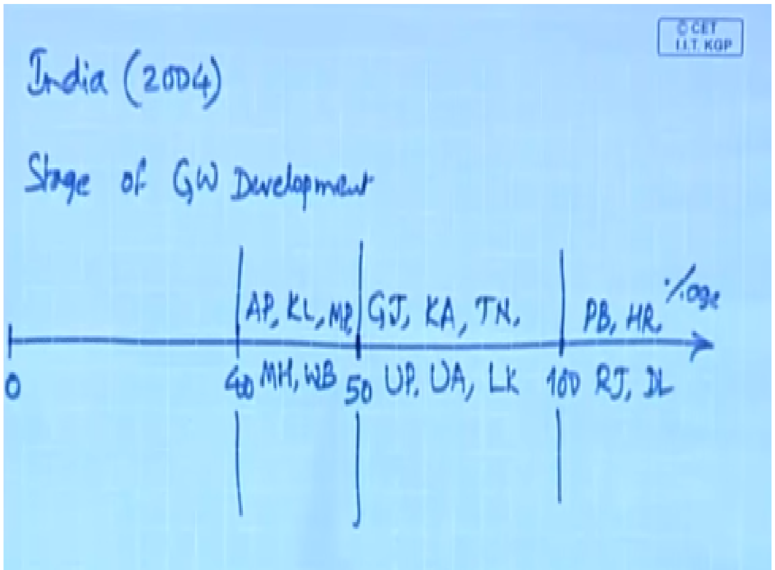

So that is India 2004 that is stage of ground water development so let me present this in scale here so this is 0 this is 50%. So this is all in percentile so this is 50% then this is 100% so here above 100% we had this is we had Punjab, Haryana, Rajasthan and the national capital territory of Delhi and between this 50 and this 100% we had Gujarat, Karnataka, Tamil Nadu, Uttarpradesh, Uttarakhand and Lakshadweep okay.

This 5 states and one union territory between 40 and 50% So there were few more states of Andhra Pradesh , Kerala then there was a Madhya Pradesh. Maharashtra, West Bengal. So you can imagine the importance of ground water utilization so here you can see it is say is a 1, 2, 3, 4, 5 and then say 10. So at least thirteen states which covering almost more than 50% of physical area.

50 to 60% of Physical area of India so they developed they depended on ground water for significant. So this explains the important of the ground water utilization in the developed world

as well as developing world such as India. Now let us come to the historical development of ground water and the historical background and we know that the one of the oldest river valley civilization the Indus valley civilization that time we have been records of ground water wells that is there were essentially open wells used for irrigation.

Or even municipal purpose also and also the Old Testament it contains number of references regarding ground water springs and wells. So around the same period in India so during the Mauryan Empire we know that the Ashokan the Mauryan empire under emperor Ashoka it extended it all the way from the present Afghanistan to so in the eastern India close to West Bengal and even to Assam and also there are records of ground water well supporting irrigation.

And even there were many wells were constructed so as to facilitate the travellers so the during those days so there were not many communication facilities. And so these one so there were many this one okay they that means so this is historically this one of course I like to show you here that it is the same thing that is before moving back to this one.

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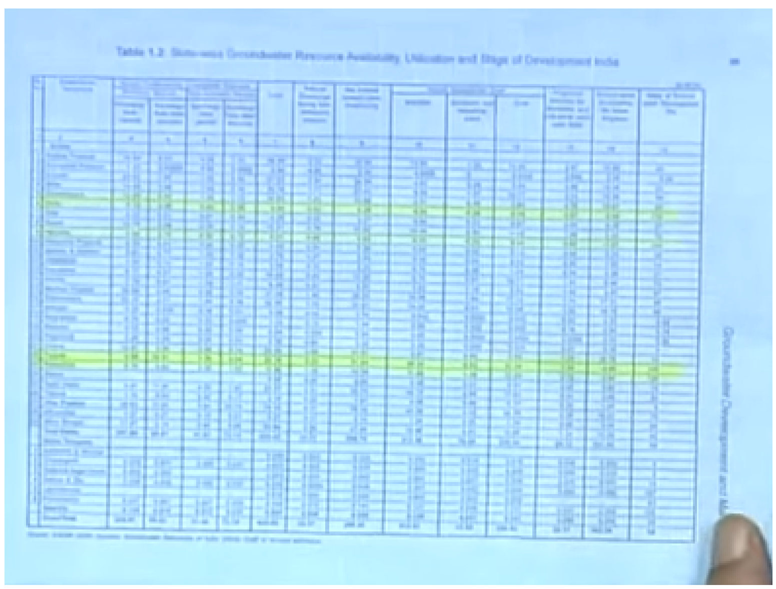

I would like to show you here the so which I mentioned here the state wise ground water resource availability utilization and all as you can see here let me I highlighted the one which is more than 100% in the similarly Punjab and Rajasthan more than 100% and hence this Haryana more than 100% and am sorry it is not very visible it is a because it is a two big table.

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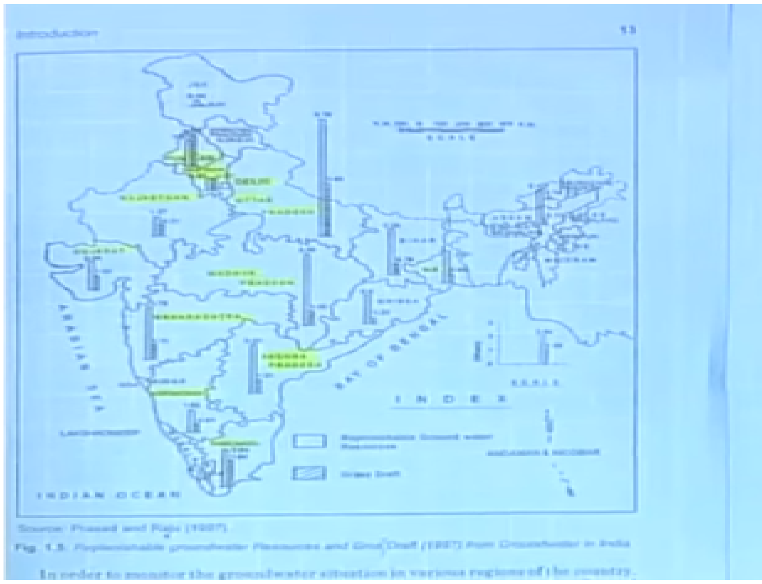

So like that this one okay let me also share with you the replenish able ground water resources in India. As you can see here in the states of Punjab this Haryana Delhi then almost in Rajathan also this is this one. So here there is significant amount of the ground water utilization added to that the states of Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Tamil Nadu and say West Bengal Uttar Pradesh of course here it also this is an old map of India.

So therefore it does not show the new states of Uttarakhand which is cardout of Uttar Pradesh and this Chhattisgarh which is cardout of Madhya Pradesh and Jharkhand which is cardout from this one. So as you can see here a significant area of course Andhra Pradesh also so in all this states that is the stage of ground water development is at least 40%. So you can imagine the importance of ground water.

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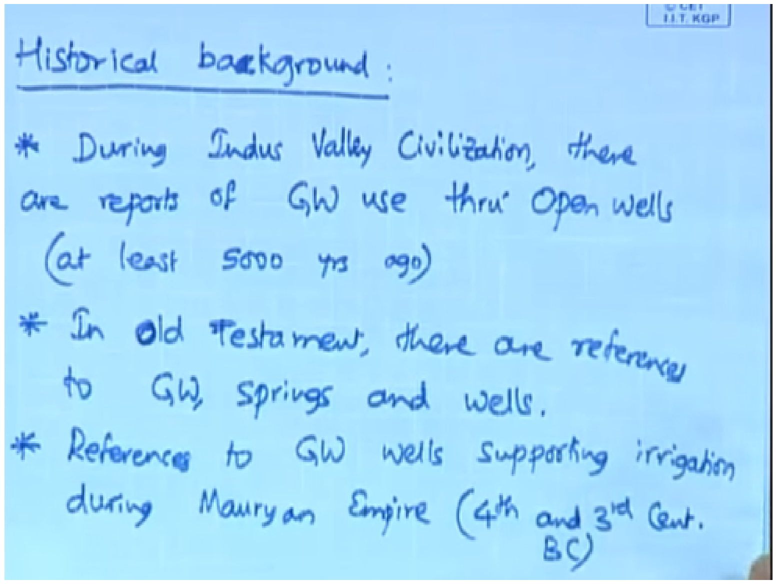

So now let us come to that is come to that historical back ground so here during Indus valley civilization there are reports of ground water use through open wells. So this is at least five thousand years ago similarly so in old testament there are references to ground water, springs and wells around the same time in India so there are there are mentioned reference to ground water wells supporting irrigation during a Mauriyan empire.

So that is fourth and third century BC so like this we can say how important is ground water is which is realized by human beings in this one and also now let me also bring it to you very interesting technology of horizontal wells. So we are under a impression that though this ground water wells are essentially vertical wells it is not exactly.

So there are many examples of horizontal wells and these horizontal wells are supposed to or it has been proved that this horizontal wells have even great of yield than the vertical ground water and in this regard I would like to mention you mention to you the about connate which are the horizontal wells which were found in which were initially developed in say Iran.

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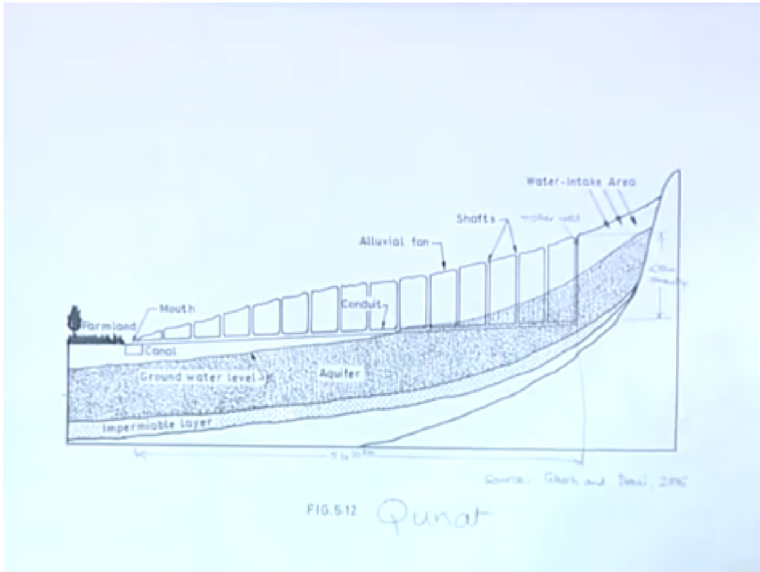

So this is a typical connate as you can see here in this this is a horizontal so this is essentially is the connate and the this the deepest well is known as mother well and this is the water intake area so basically this is a hilly area or a mountainous area where there is a significant amount of rainfall and this mother well as a depth of around 50 meters or less than that and there have been examples of mother well which are even as deeps as 100 meters.

Say one mother well as been report to be around say 250 meters deep also and then so here so the unlike the mountain slope which may be very steep so this the bed slope of this connate which is essentially a horizontal well horizontal and mild sloping well. So this is the slope direction so this is the mild slope and it reaches the ground and once it reaches ground. So for the significant portion there is a surface canal and through this surface canal the water is conveyed to the farmlands and or irrigated land.

And in between the mother well and this surface canal so there are number of this shafts okay and this is the quantity of the connate which is which forms the horizontal well. And so this number of shafts or the one which provides access to this drilling this canal and so this canal this cannot so this cannot was a the technology of drilling this connate where in this water from the aquifer was brought in through the mild sloping horizontal almost horizontal candid of the connate.

In to the surface canal and then on to the farmland okay this was very much perfected by people in Iran almost 3000 years back and here so the length of the canal connate am sorry was of the order of the say 5 to 30 kilometers. Most of the connate are existing even now and so they there it is been reported that there are at least 20,000 connate existing Iran even now.

And which will supply at least which will supply at least 35% of the entire water requirement in Iran ok. So here I would like to mention here that is how important it is the ground water essentially so this is a horizontal well at technology which was very much perfected in Iran and from there it went moved on to this morocco and this other north African continental regions and then it moved as far as Spain in Europe.

So like this so this extraction of this historically this ground water has been extracted not only through this the vertical wells also through the Horizontal wells and now let me bring it to you.

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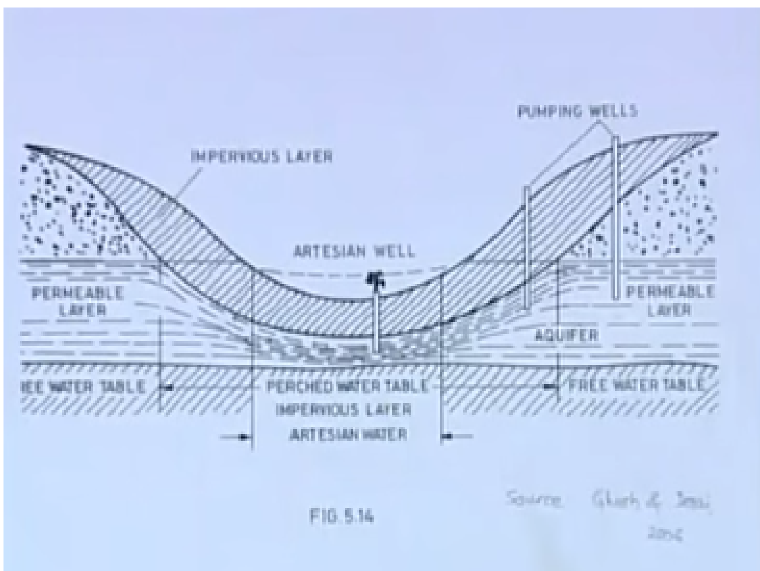

So this is a the you must have heard of the artesian well and here so in this artesian well it is basically it was developed initially somewhere in France in a place called Artois and in this cases this place is basically a pressurized well. So here have that is free water table is somewhere here and then in this region where the ground surface is below the free water table.

So there the water is under pressure okay and here if we make if we puncture this one then the water will gush out of this artesian well and so it will we will give out water in the form of natural fountain. So this region where in the ground level is below the water table so that is known as the region of the artesian water where there is a raised water table. And so if we puncture this artesian aquifer so there will be huge amount of we can get a lot of water.

So this artesian wells also were developed sometime in the middle of this one and added to this is the so in the in 804 there was a instance of first deep tube well which was dug in and around Calcutta. And so it had a depth of 500 meters and so this tube well was the can say is the major this one it indicates the major milestone in ground water harnessing or development.

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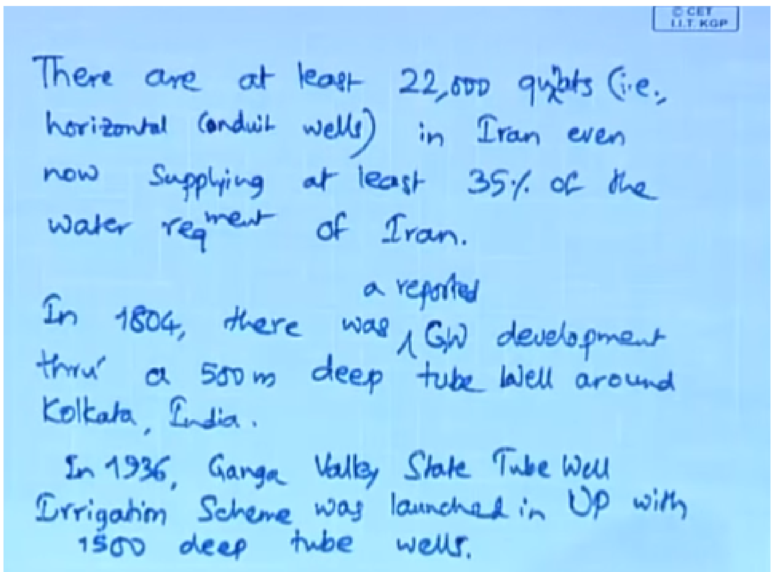

Likewise in 1966 so this ganga valley state tubal irrigation scheme so here I would like to mention so that is the so there are at least 20,000 connate that is horizontal Condit wells in Iran even now supplying at least 35% of the water requirement of Iran so you can imagine how important it is and added to that is say that is the in 804there was ground water development through a 500 meter deep tube well or say bore well around Kolkata in India.

So there was a reported okay and so in 1966 ganga valley state tubal irrigation scheme was launched in UP with 1500 deep tube wells of course there are been parallel there are been many development in western world also. And so obviously came it all shows how important is the ground water development.

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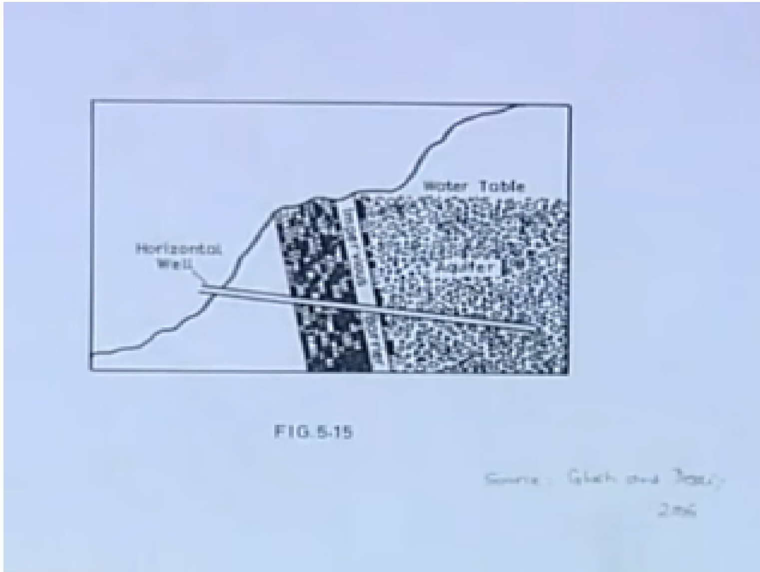

And here let me also show you an example of horizontal well as you can see here is an aquifer with water table here and that is the there is a sloping slide and this aquifer is bounded by impair case barrier and then say some rock formation here so through this there is a this horizontal well and of course the depending upon the water table. So this we can ground water can be harnessed through this horizontal valley well.

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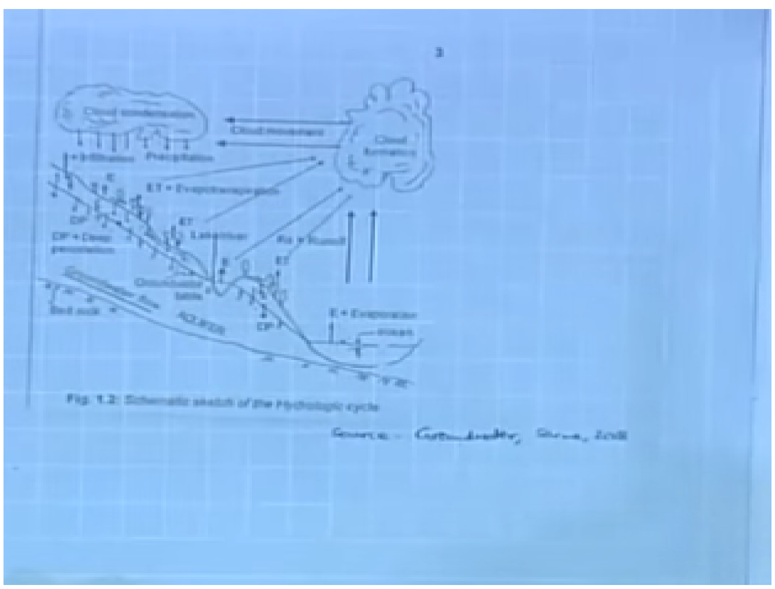

So now let us come to that is the ground water in hydrologic cycle so here I would like to which is also known as the water cycle. And here so this is a schematic diagram and as you can see so this is the ground surface so this is a surface water body such as lake or a river and so this is the groundwater table which represents the level of the saturated ground water which also joins the sea or ocean.

And here so there is a evaporation from ocean surface or land surface through air transportation as well as from the surface of surface water bodies such as lake or river as well as through this plants and then all this evaporated water. So it gets accumulate in the clouds which are formed here and then so this clouds they move and then so there will be a cloud condensation and then there will be a precipitation which is which may be either solid form through snowfall or hailstorm or whatever.

And so this precipitated water it will percolate through the ground surface and eventually it will form. So water known as the aquifer which have water bearing state and of course here there is bedrock also. And the so there are also among the aquifer they are confirmed as well as unconfined aquifers and then so there is a so this confined aquifers which are at the deeper depths so they get their water from this deep percolation.

So here this is a deep percolation and then this is the shallow or the top or the water table aquifer is also known as unconfined aquifer ok and so now coming to this the hydrologic cycle.

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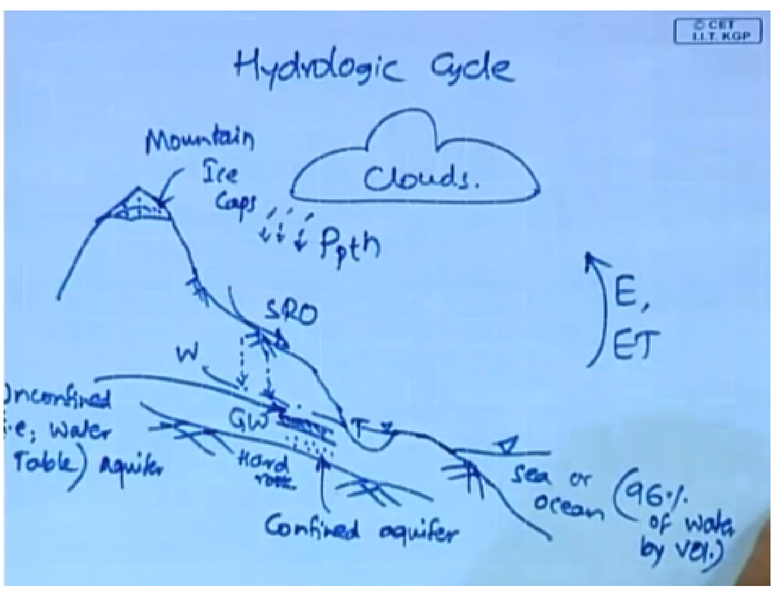

We know as that so quantitatively so we can represent the same thing that is hydrologic cycle so here we can say this is so this is the clouds and here so this is the atmospheric segment of the hydrologic cycle and then so here there is also so there is a this is a evaporation and evaporate transportation and then here so this is a precipitation okay and then so there is a so this is the surface runoff and then so there will be infiltration and then so here there will be.

So this is the groundwater table and so here this is the ground surface so this is the surface water body and then here you can say this is a sea or ocean okay. So essentially so this is a cycle and in this case now let me explain you the various quantities involved here and as you can see. So this sea or ocean so this represent almost say ninety six percent of water by volume and of course here there are these.

So these are the mountain ice caps and of course here there is also this is a so this is the ground water in this confined and unconfined aquifers. So here i would like to see this I like to so this is the unconfined that is water table aquifer at the top and here so this is the just schematically showing this one. So this is the confined aquifer at the bottom below that so this is the hard rock here so like this and as I was mentioning.

So this sea or ocean water represents 96% of the water volume so the only remaining nearly 3 to 4% is the fresh water and as you can show.
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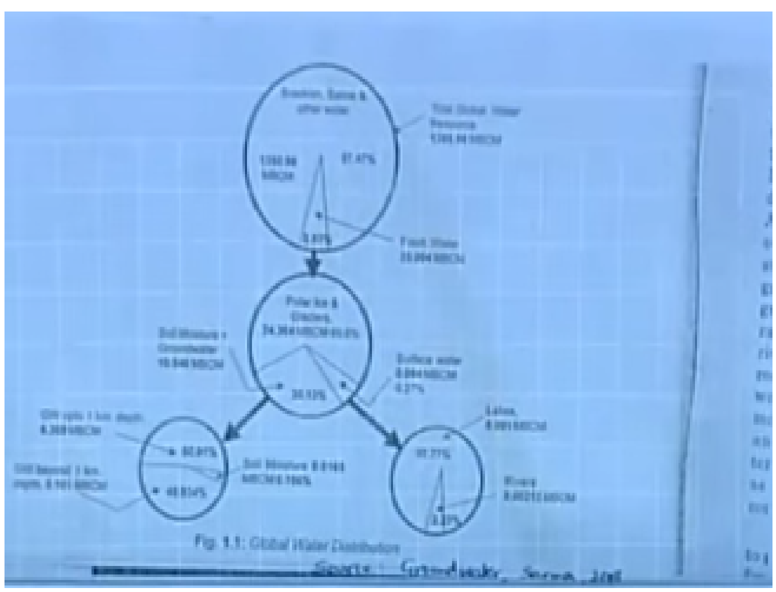

Let me show you here and so this is the brackish or saline or other water which represents a almost a 97 and half % of the total volume of water on the earth and only this 2 and half % is the fresh water and of course this 97 and half % we cannot use it for our to maintain the metabolic activity of a human beings, animals and plants.

And this 2 and half % of water and is out of this so nearly 70 % is stored in the polar ice and glaciers and then so this 30% is stored in ground water. And of course very little say one fourth of a percent are fresh water available in the surface water bodies and here at this so therefore as soon as we can see. So this polar ice or glaciers there available only in the cold regions or cold mountains region.

Whereas ground water is available almost everywhere the fresh ground water so and here so this fresh ground water up to say 1 kilometer depth so it is a nearly half of that one and then below 1 kilometer depth. So it is the remaining half and then of course very small percent of that is soil moisture. So here so this as you can see this hydrological cycle so the there is a significant amount of this one and let me go back to you again this hydrologic cycle.

So although the entire water the global water volume is of order of say around 1400 million kilometer cube. So out of that so nearly 96 say 96 to 97 is brackish or salt water or marine water. So therefore so this as you can see this 97% of water is useless so it is only remaining 2 to 3 % of water 2 and half % of water.

So out of this so one third of this is available in ground water and this ground water is available in say almost all the regions rather than the mountain ice caps. So the mountain ice caps are available only in the mountains region or the polar region whereas this ground water this fresh ground water is practically available everywhere.

So therefore how important it is to that is manage the ground water to maintain this one supply and demand and so that this water table. So as we can see here so this water table so it should be at the reasonable depth below the ground it should not be too deep it should not be too shallow. So if it too shallow then it may create a water logging or that is a drainage and water logging problems.

And if it is too deep then this extracting of this ground water will require lot of energy lot of costs many times these days we have the this high capacity pumps which are being used to extract a ground water like multi stage submersible pumps and so on. So their use for extracting the ground water through this wells ok so therefore to make it technically as well as economically sustainable as well as ecologically sustainable.

We need to maintain a balance between the ground water availability ground water supply and demand. So by so that we can maintain the depth of the water table healthy depth of the water table which is neither too shallow not too deep and we can also maintain the balance between the ground water supply and this ground water demand.

So there by we can provide the water security in the form of fresh ground water which is practically available everywhere in the nearly 29% of the land surface on earth. On the other hand so this at the same time this the recent this climate change associated impact so they are also affecting this one. So that is their affecting this one and this climate change impacts are causing the mountains caps to the polar ice as well as glaciers.

Of course let me also write this is a glaciers the melting of glaciers and polar ice and so therefore it is extremely important to see that so they water which is melted because of the climate change and the global warming effect so is stored in the form of ground water and so in the next lecture we will see the other aspects of so this thank you