Availability and Management of Groundwater Resources

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Lecture - 04
Hydrological Cycle, Need for Conservation of Groundwater Resources (Continued)

Welcome to you all in the part 4 lecture of lecture 1. We are having the concept now of the aquifer the rocky formation which is holding the water. The concept regarding the different components of hydrological cycle this we have also discussed in the previous part of the lecture 1. Now in this lecture we will discuss about the water balance equation and the need for conservation of groundwater resources.

This water budget about the water budget equation we have discussed in the previous lecture that is the part 3 lectures we have discussed already. This thing were there and here what we have seen that water budget is very, very important components for finding out the availability of groundwater resources in any area or even for the conservation of groundwater resources in any area.

But this whole water budget equation depends upon the important components of your hydrological cycle. So, this is very important and here we will discuss we will try to solve some chemical problem also with the help of the different components of the hydrological cycle.

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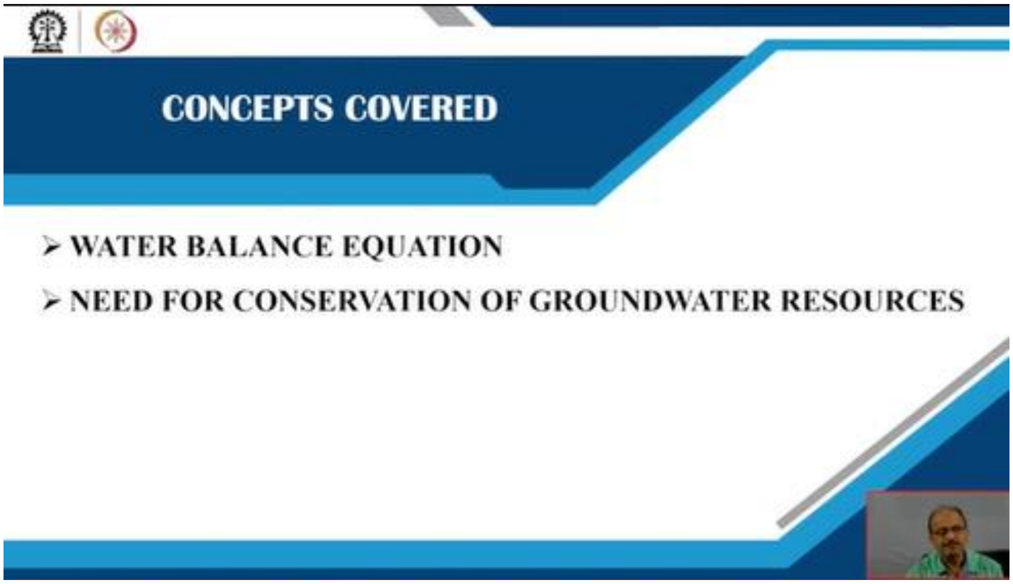

So, in this water budget equation if you will recall the concept of the hydrological cycle, we were having the transportation component that is the precipitation, evaporation, transpiration and the storage component that is the reservoir, groundwater reservoir then ponds lakes etcetera through which the water remains inside the earth surface. So, from the atmosphere to the earth surface the components of the hydrological cycle plays very-very important.

And on this basis, we can also derive the water budget of any area. Water budget of any area means how much water is available inside the surface and how much water we can just use because we are having the computation of the availability of the water resources with the help of the water balance equation. So, this equation we will try to learn here.

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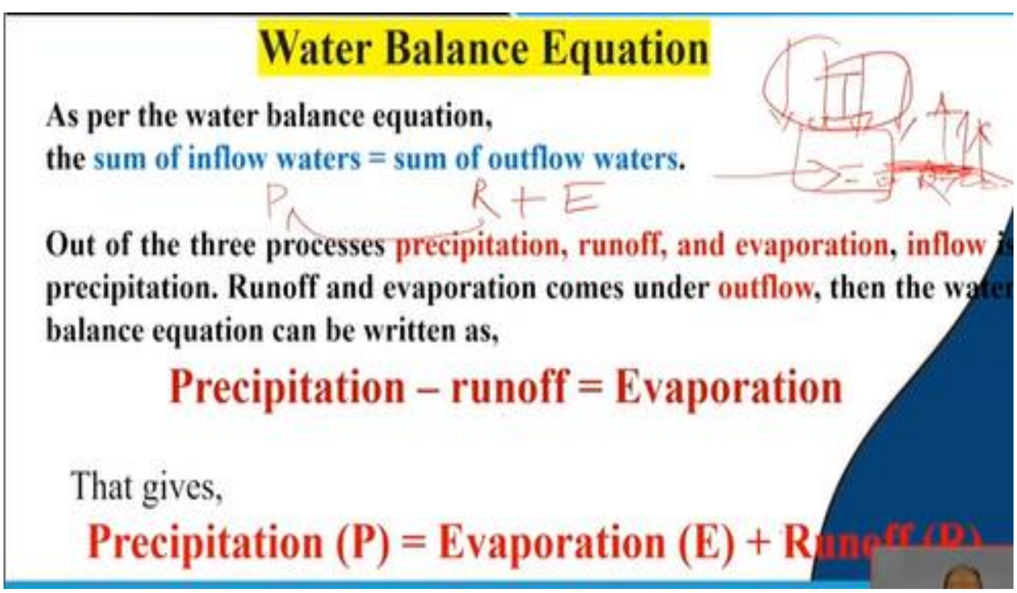

Now in this equation the total concept is that the sum of inflow water suppose this is the area in which we just find out the quantity of water resources in the area. This just this is our aim how to find out the available quantity of water in the area. So, the concept is because on the basis of the water budget equation or water balance equation.

The concept is that the sum of inflow water will remain equal to the sum of outflow water. So, this is the general concept the sum of inflow water equal to the sum of outflow waters. So, this is the basic concept and on the basis of this basic concept. Generally, the computation of the water resources is taking place and the availability of the groundwater resources can be find out. So, here the components of hydrological cycle will play a very important role in for finding out this.

Why? Because we are having the concept that precipitation runoff evaporation these are some of the components of the hydrological cycle. So, out of three process precipitation, runoff and evaporation the precipitation we are knowing that the rain drops on the surface run off the surplus amount of rain water if the infiltration will become zero then what will happen the surplus amount of rain water will follow the topography runoff and evaporation this storage space structure reservoirs, ponds like etcetera against send back to the atmosphere. So, these three important processes out of three important process precipitation, runoff, evaporation inflow because the sum of inflow water equal to sum of outflow water. So, inflow water is the only and only infiltration. Whereas outflow water means from this area the water is going somewhere this is the runoff and this is your evaporation.

So, these two comes under the outflow water. So, precipitation is the inflow water whereas some of outflow water is runoff plus evaporation so what means

$$\text{Precipitation} - \text{Runoff} = \text{Evaporation.}$$

If we will just do it this is the precipitation and this is the

$$\text{Precipitation (P)} = \text{Runoff} + \text{Evaporation}$$

So, ultimately if you will seeing this thing just we can conclude that the components of the hydrological cycles are playing very important role for the computation of the water availability in any area.

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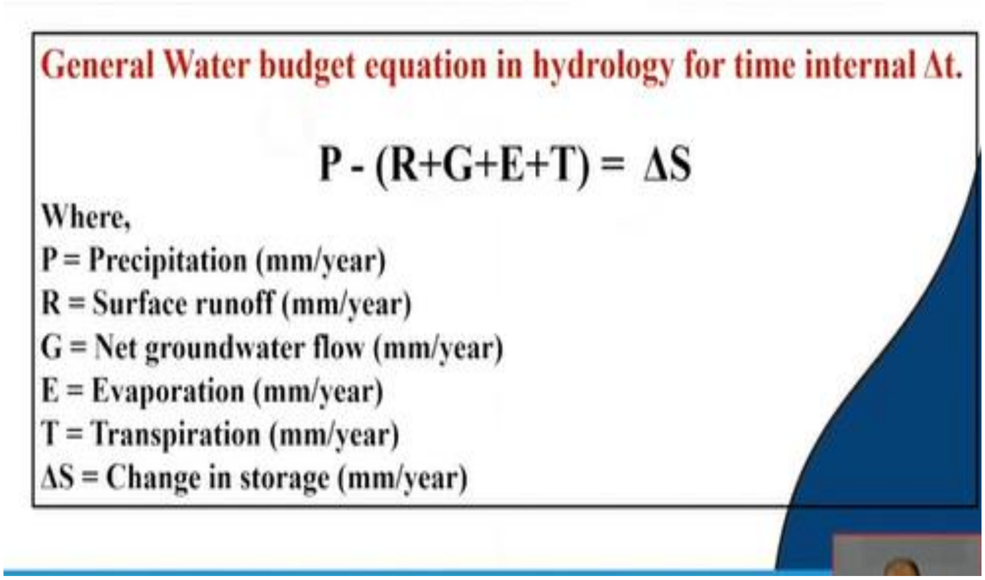

A further we will discuss this thing in this way that water budget equation for time interval t can be derived by the formula

$$P - R + G + E + T = \Delta S,$$

where P is the precipitation in millimetre per year.

Now it is very clear it is a component of the hydrological cycle this whole are the component of hydrological cycle and this whole components gives us the water budget equation of any area.

But the concept should remain clear that the P is the precipitation of that very area surface runoff. Then the net groundwater flow is G groundwater, evaporation in E, transpiration in T and delta S is the change in storage. So, this is the general water budget equation and through this we can compute some small numerical with the concept only because see the concept is very important why I am telling you.

The concept is having that in hydrological cycle precipitation is one of the important components. Precipitation is the only source through which the generally the groundwater we are getting on the inside the earth's surface groundwater we are getting. Because we will get good amount of groundwater if we will have good amount of precipitation also, if we will have poor amount of groundwater precipitation then we will get the poor amount of groundwater also.

This is the general concept because some of inflow is equal to some outflow also. So, precipitation then the surface runoff just we are just subtracting the amount you can see from this equation also sub subtracting from precipitation the total amount of runoff the total amount of groundwater flow the total amount of evaporation and the total amount of transportation. This just we are adding it and subtracting it from precipitation.

So, what it is giving? It is giving the change in storage of water in that very area. So, this we are getting to the water budget equation.

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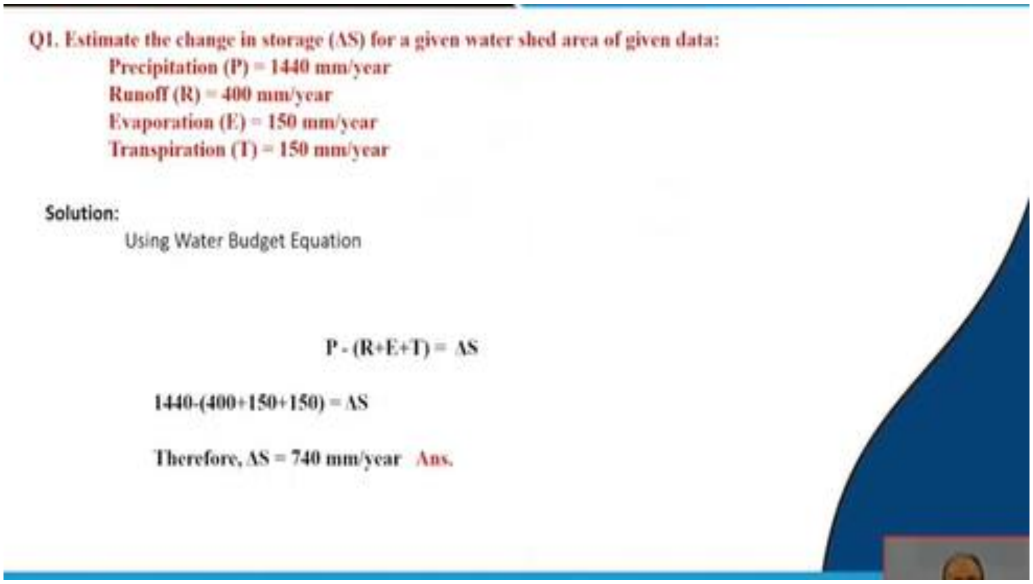

Now on the basis of the water budget equation we will solve few numerical problems for the computation of the availability of the groundwater resources in any area. So, for the competition of any amount of groundwater resources in any area we must take the help of the various components of the hydrological cycle. This value you have to take from certain government agencies or you have to monitor at that place.

And then only you can able to find out your value of the water resources in the area because you have seen the sum of inflow is equal to sum of outflow. So, water budget equation helps for this, so on this basis we will first take the first small numerical problem we will see here

Q1. Estimate the change in storage (ΔS) for a given water shed area of given data:

Precipitation (P) = 1440 mm/year

Runoff (R) = 400 mm/year

Evaporation (E) = 150 mm/year

Transpiration (T) = 150 mm/year

So, this is the value which you can monitor also or you can find out also. And through this if you will apply the water budget equation the equation is

$$P - (R+E+T) = \Delta S;$$

Just we will put the value,

$$1440-(400+150+150) = \Delta S$$

Therefore, $\Delta S = 740$ mm/year

the answer we are getting in the form of 740 millimetre per year.

So, you can see the advantages of the components of the hydrological cycle also. By this we can just find out the water budget of any area.

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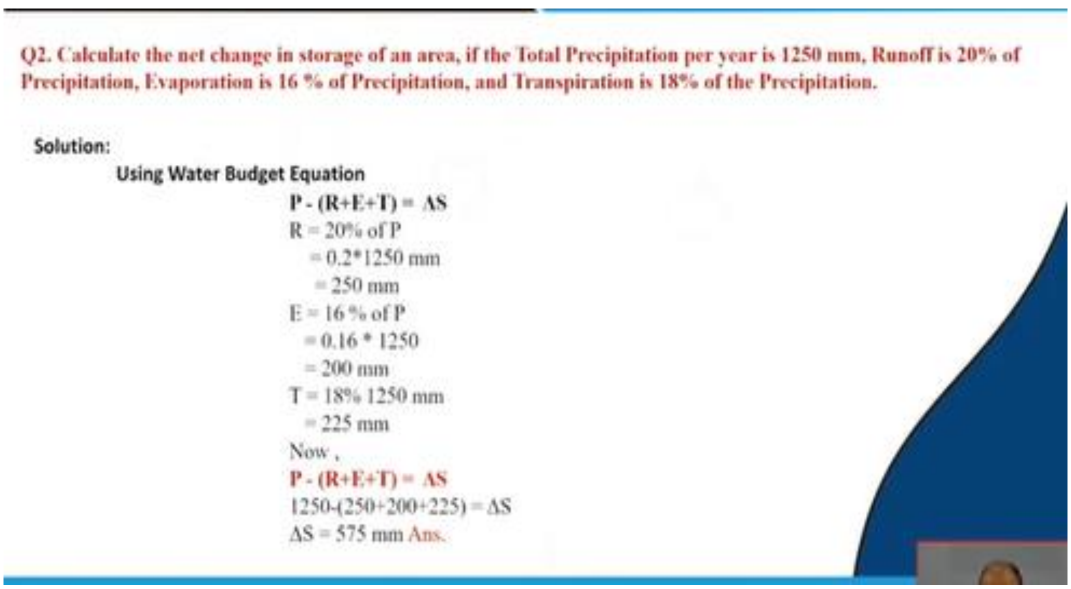

the next numerical we will see.

Q2. Calculate the net change in storage of an area, if the Total Precipitation per year is 1250 mm, Runoff is 20% of Precipitation, Evaporation is 16 % of Precipitation, and Transpiration is 18% of the Precipitation.

Solution:

This is also given here not the direct value is given here but the runoff is 20% of the precipitation, direct value of precipitation is given here runoff is the 20% of precipitation, evaporation is 16% of precipitation and transpiration is 18% of precipitation.

So, in terms of millimetre only the precipitation value is there all other values are in terms of percentage with respect to precipitation. So, again we will use the water budget equation

$$P - (R+E+T) = \Delta S$$

Given,

R = 20% of P

= 0.2*1250 mm

= 250 mm

E = 16 % of P

= 0.16 * 1250

= 200 mm

T = 18% 1250 mm

= 225 mm

Now,

$$P - (R+E+T) = \Delta S$$

$$1250 - (250+200+225) = \Delta S$$

$$\Delta S = 575 \text{ mm}$$

So this is the change in storage value. So, we can see that with the help of the various components idea we can also just find out the water budget of any location any area with the help of these components only the person. Components value may be in direct form or it will remain in the percentage form. So, this is very much helpful.

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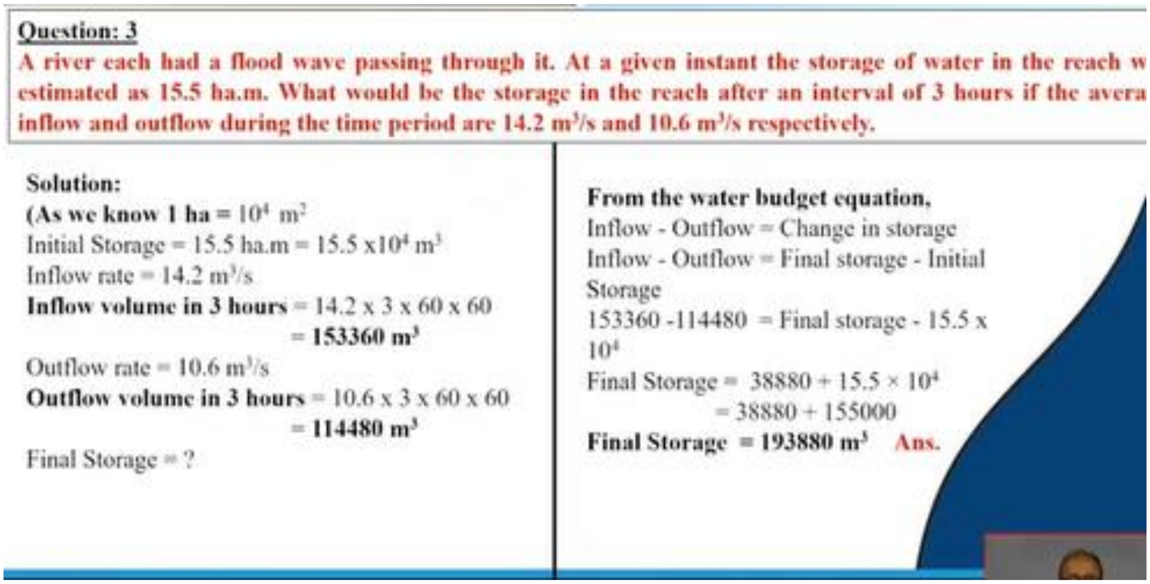

So, now we will see the question number 3 of the water balance equation we have seen question one and two in which we can find out your quantity of water or the storage of water. So, now the question 3 is

Q3. A river each had a flood wave passing through it. At a given instant the storage of water in the reach was estimated as 15.5 ha.m. What would be the storage in the reach after an interval of 3 hours if the average inflow and outflow during the time period are 14.2 m^3/s and 10.6 m^3/s respectively.

Solution:

Now what would what would be the storage in the reach after an interval of three hours this is the question after three hours what will be the total quantity of water. If the average inflow and outflow we have seen for in the water balance equation we have seen the total inflow equal to total outflow.

Given:

(As we know 1 ha = 10^4 m^2)

Initial Storage = 15.5 ha.m = 15.5 x10^4 m^3

Inflow rate = 14.2 m^3/s

Inflow volume in 3 hours = 14.2 x 3 x 60 x 60

= 153360 m^3

Outflow rate = 10.6 m^3/s

Outflow volume in 3 hours = 10.6 x 3 x 60 x 60

= 114480 m^3

From the water budget equation,

Inflow - Outflow = Change in storage

Inflow - Outflow = Final storage - Initial Storage

153360 -114480 = Final storage - 15.5 x 10^4

Final Storage = 38880 + 15.5 × 10^4

= 38880 + 155000

Final Storage = 193880 m^3

So, this value will be 193880 cubic meter per second will be the final storage in that very reach. So, with the help of water budget equation we can solve such type of problem which is related to your water balancing. Next example we will again see.

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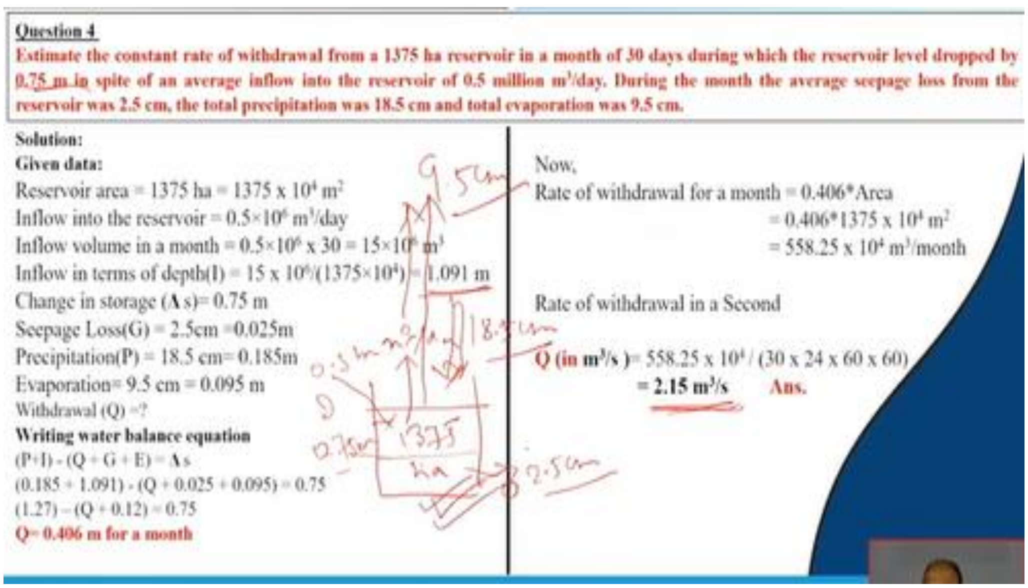


Here the 4th question

Q4. Estimate the constant rate of withdrawal from a 1375 ha reservoir in a month of 30 days during which the reservoir level dropped by 0.75 m in spite of an average inflow into the reservoir of 0.5 million m^3/day. During the month the average seepage loss from the reservoir was 2.5 cm, the total precipitation was 18.5 cm and total evaporation was 9.5 cm.

Solution:

Very interesting question related to the water balance equation. So, generally in some area we may get such type of situation somewhere incoming is also there outgoing is also their precipitation is also coming on evaporation and transpiration is also going on.

Given:

Reservoir area = 1375 ha = $1375 \times 10^4 \ m^2$

Inflow into the reservoir = $0.5\times10^6 \ m^3$/day

Inflow volume in a month = $0.5\times10^6 \times 30 = 15\times10^6 \ m^3$

Inflow in terms of depth(I) = $15 \times 10^6/(1375\times10^4) = 1.091$ m

Change in storage (Δ s) = 0.75 m

Seepage Loss(G) = 2.5cm =0.025m

Precipitation(P) = 18.5 cm= 0.185m

Evaporation= 9.5 cm = 0.095 m

Withdrawal (Q) =?

Writing water balance equation

$(P+I) - (Q + G + E) = \Delta s$

$(0.185 + 1.091) - (Q + 0.025 + 0.095) = 0.75$

$(1.27) - (Q + 0.12) = 0.75$

Q= 0.406 m for a month

Now,

Rate of withdrawal for a month = 0.406*Area

$= 0.406*1375 \times 10^4 \ m^2$

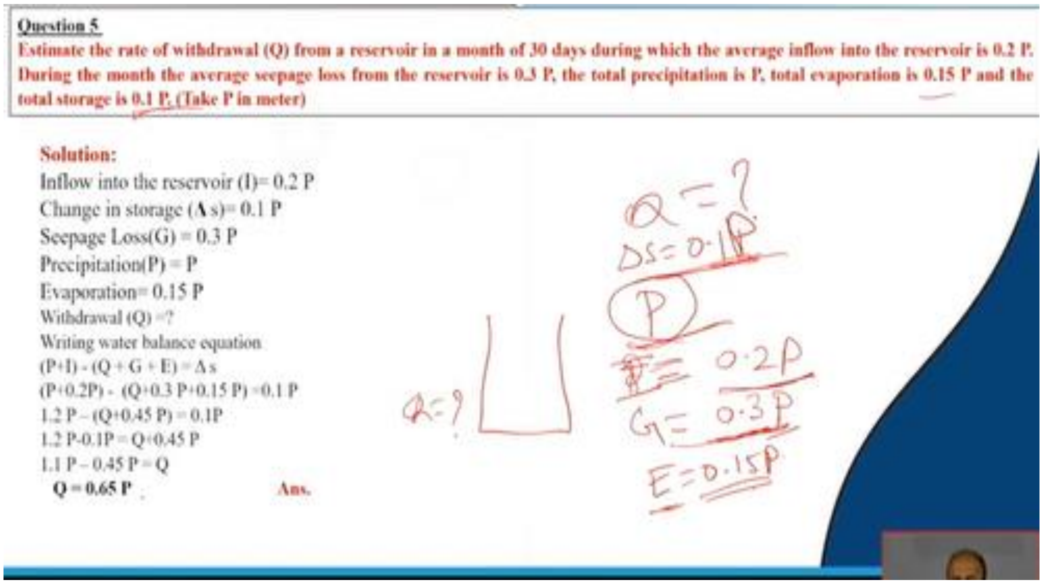
$= 558.25 \times 10^4 \ m^3$/month

Rate of withdrawal in a Second

Q (in m^3/s)= $558.25 \times 10^4 / (30 \times 24 \times 60 \times 60)$

$= 2.15 \ m^3/s$

We are getting 2.15 cubic meter per second the rate of withdrawal in a second from this very reservoir. So, this is a very interesting question related to the water budget equation.



Now we will move for the 5th question related to the water budget equation. So, in this sometimes it has been asked at several places

Q5. Estimate the rate of withdrawal (Q) from a reservoir in a month of 30 days during which the average inflow into the reservoir is 0.2 P. During the month the average seepage loss from the reservoir is 0.3 P, the total precipitation is P, total evaporation is 0.15 P and the total storage is 0.1 P. (Take P in meter).

Solution:

Given data:

Inflow into the reservoir (I)= 0.2 P

Change in storage (**Δ** s) = 0.1 P

Seepage Loss(G) = 0.3 P

Precipitation(P) = P

Evaporation= 0.15 P

Withdrawal (Q) =?

Writing water balance equation

$(P+I) - (Q + G + E) = \Delta S$

$(P+0.2P) - (Q+0.3\ P+0.15\ P) = 0.1\ P$

$1.2\ P – (Q+0.45\ P) = 0.1P$

$1.2\ P-0.1P = Q+0.45\ P$

$1.1\ P – 0.45\ P = Q$

$Q = 0.65\ P$

So, in this way because here every term were just connected with the P so rate of withdrawal is 0.65P. So, we have seen five different types of numerical related to the water budget equation. So, in this way we can compute we can calculate we can just estimate the change in storage of water at any reservoir at any stream's etcetera.

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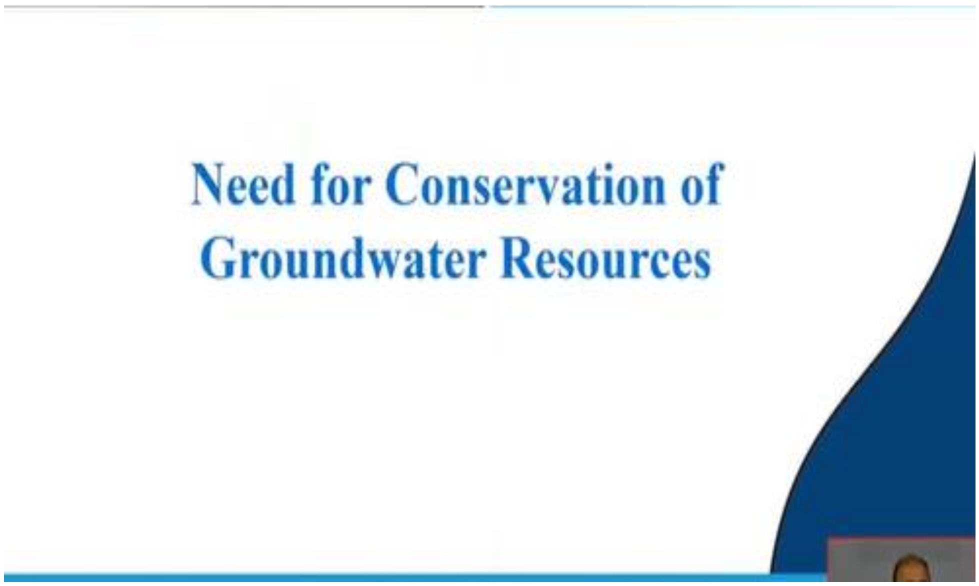

Now after knowing this water budget equation just, we will see what are the different needs for conservation of water resources.

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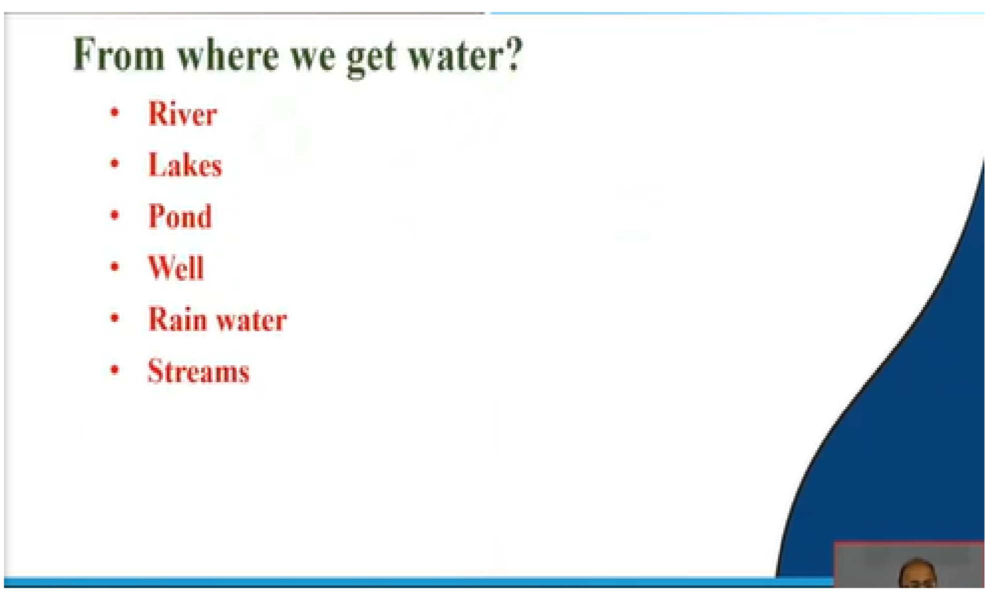

But prior to it we should know what are the sources of water. So, we have seen already river, lakes, ponds, well, rain water, streams these are the very good sources for getting the water but we have seen already the sources of water, we have seen already the formations which are holding the water, we have also seen that the different activities are utilizing the water withdrawing the water.

So, the area the aquifers the formations are coming under stress they are coming under stress. So, at different places on the earth's surface the aquifer remains in stress conditions, stress condition means the aquifer is not having the whole quantity of water that may have diminished that the level of the water has depleted down so the aquifer has come into the stress. So, aquifer has come into the stress means what the stress of water resources. So, what are the factors now what are the factors for coming to this situation.

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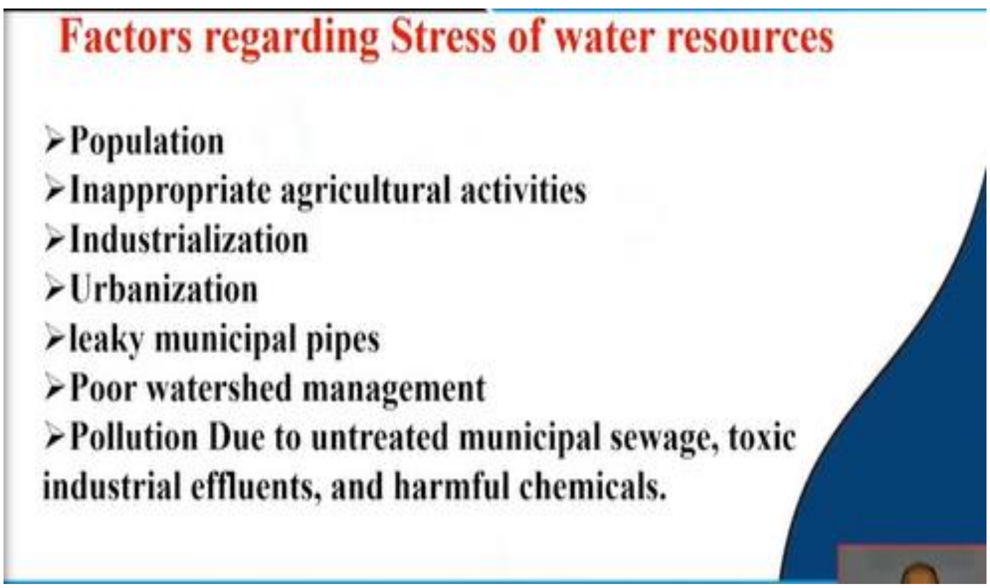

So, the factors regarding stress of water resources are, first the increase of population, populations are increasing. Second inappropriate agriculture activities it should be scientifically so that minimum water can be used but the water resources has come to stress because of inappropriate agricultural activities, increasing industrialization as well as urbanization every place the construction activities are going on and for this the requirement of water are there.

So, the local and regional aquifers are coming under stress, leaky municipal pipes are remaining which is also wasting the water, poor watershed management is not good poor watershed management is there. So, this is also one of the sources of keeping the water resource under stress and lastly the pollution due to untreated municipal waste, toxic effluents and harmful chemicals directly to the underground aquifer.

So, this will pollute the water fresh water that is groundwater which will again become of no huge. So, these are few of the factors through which our water resources are coming under stress so we should keep in mind and then we will learn the future aspects of the how to conserve the water resources and what are different strategies for the conservation of the water resources in the next chapter. Thank you very much.