Availability and Management of Groundwater Resources
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Lecture - 19
Confined and Unconfined Aquifer and their Parameters (Continued)

Welcome to you all in the fifth part of the module 4 confined and unconfined aquifers and their parameters.

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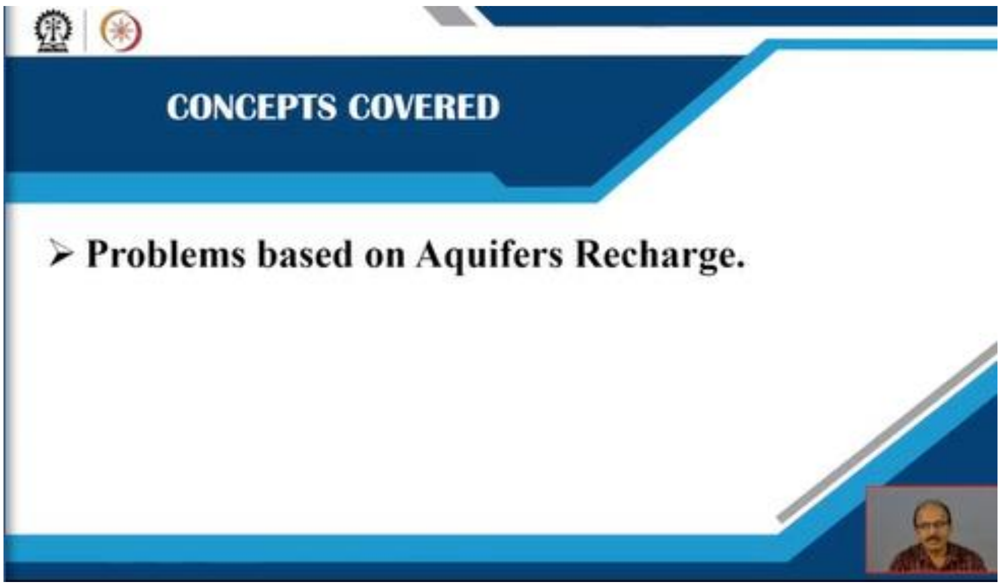

So, from the first part we have learned that the inside the earth's surface the rocky formations which usually termed as aquifers are the repository of the groundwater resources inside the earth. So, this groundwater resource remains in two different formations inside the earth but generally, we are inside the earth but at generally at the shallower depth we are getting the unconfined aquifer and at the greater depth we make it the deep aquifer that is the in the confined conditions.

So, it usually happens but this occurrence of confined and unconfined aquifers depends on the geological formations inside the earth’s surface. Sometimes we may get good amount of groundwater at one area and just adjacent to this area we may not get to the amount of groundwater resource. So, everything depends upon the different types of geological formations. The weathering and conditions of the exposed rocks, the number of pores within the rocks, the condition of the pores whether it they are connected not connected.

So, these all in total results for the occurrence of good groundwater condition in a particular area. So, in the last part of this model we will discuss about some of the problematic issues related with the aquifer recharge.

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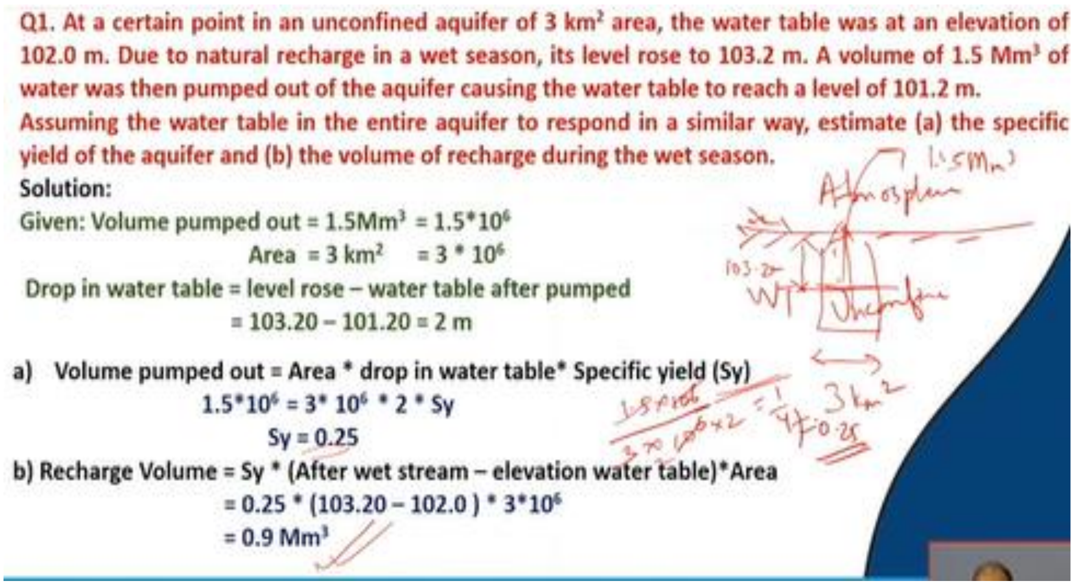

So, just it is a small problem.

At a certain point in an unconfined aquifer of 3 km^2 area, the water table was at an elevation of 102.00 m. Due to natural recharge in a wet season, its level rose to 103.20 m. A volume of 1.5 Mm^3 of water was then pumped out of the aquifer causing the water table to reach a level of 101.20 m. Assuming the water table in the entire aquifer to respond in a similar way, estimate (a) the specific yield of the aquifer and (b) the volume of recharge during the wet season.

So, the term the questions we have understood properly. Now, we will go for the solution.

So, what we are seeing the recharge is very important then only the level of the water or the water table we move up. If there will be good recharge the water level will move up. If there will be not good recharge, the water will remain there only from the point from where it has been initiated to come down water.

So, the problems are basically based on recharge and for finding out the groundwater recharge the different formula are also in the groundwater subject different formulas there. We will discuss some of the important formula which are generally being practiced in Indian conditions just after this numerical.

Given: Volume pumped out = 1.5Mm^3 = 1.5*10^6

Area = 3 km^2 = 3 * 10^6

Drop in water table = level rose – water table after pumped

= 103.20 – 101.20 = 2 m

These are given the question also. Now first problem is just it has been asked estimate your specific yield of the aquifer and second the volume of recharge.

So, how much volume of water pumped out? This we have to find out first. So, what we are seeing from here, we can find out the specific yield also. Volume of water pumped out is equal to area into drop in water table into specific yield. So, this is the general equation through which we can find out the specific yield also.

a) Volume pumped out = Area * drop in water table* Specific yield (Sy)

$1.5*10^6 = 3*10^6 * 2 * S_y$

$S_y = 0.25$

b) Recharge Volume = S_y * (After wet stream – Elevation water table) *Area

= 0.25 * (103.20 – 102.0) * 3*10^6

= 0.9 Mm^3

So, in this way generally a very small problem we can solve if we are having some of the data related to the area, the volume of water being pumped out and the gap of water table in the different aquifer through which you have just starting the pumping. So, this is one of the very general problems related to the aquifer recharge.

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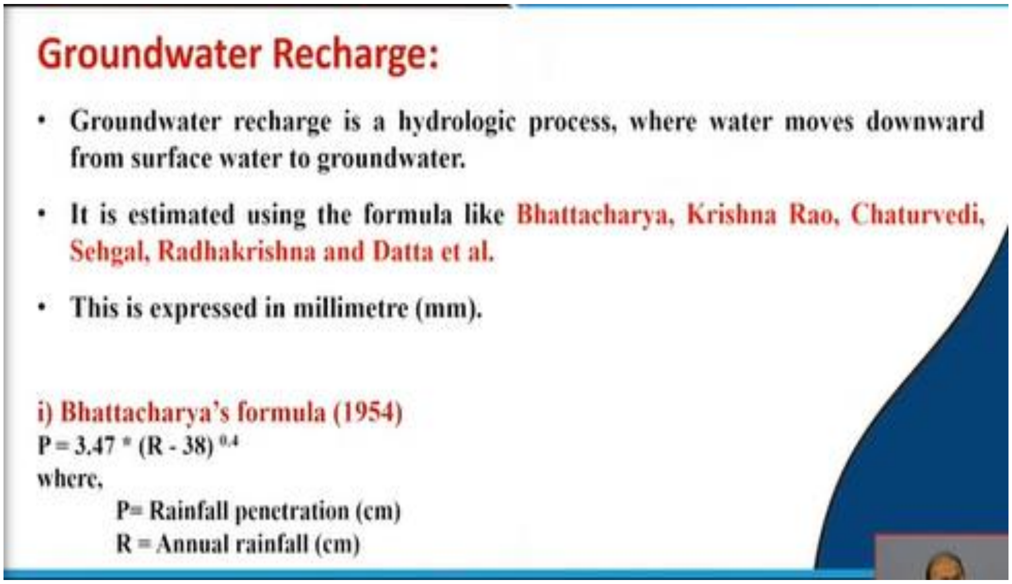

Next for the groundwater recharge, we have understood already the place from where we can have the source of water movement inside the aquifer. So, those areas generally the recharge area, recharge is the main cause for making the water level at a certain depth inside the aquifer formation. So, groundwater recharge, it is a hydrologic process where water moves downward from surface to groundwater.

So, maybe from the source of surface water through leakage etcetera through seepage to leakage etcetera or for the rainfall from infiltration, percolation etcetera. Now several in Indian conditions several scientists have worked related to the groundwater recharge and they have developed some formula and we are also working with this formula. Everyone should work with this formula and then take the average value and then see whether the values are coming near to the considerable point or not.

So, generally Bhattacharya, Krishna Rao, Chaturvedi, Sehgal, Radhakrishna and Datta et al formula are being used and these are expressed in millimetre. Just for example Bhattacharya formula. Bhattacharya formula is 1954 it was given;

$$P = 3.47 * (R - 38)^{0.4}.$$

So, Bhattacharya formula considered the two parameter that is the; rainfall penetration that is rainfall depth in centimetre and the average annual rainfall of the area. So, two important considerations are available with the Bhattacharya formula.

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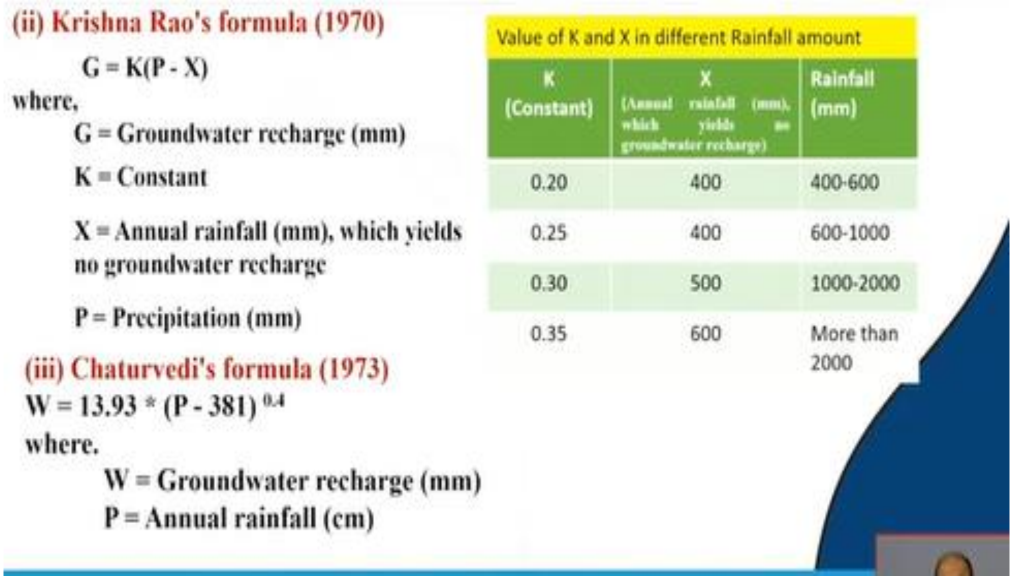

Now Krishna Rao's formula. Here also we can see Krishna Rao formula were given in the year 1970 in which G = K (P – X)

where G is the groundwater recharge in mm, K is the constant, X is the annual rainfall which yields no groundwater recharge with this parameter and P is the precipitation in mm. So, the Krishna Rao have also given one formula

$$G = K (P – X).$$

So, this formula if you will see just adjacent to it the value of K and X is given on the basis of rainfall amount.

If the rainfall amount is 400 to 600 then the K value will be 0.20 where K is the constant value. So, when the rainfall amount will be 400 to 600 mm in any area generally, we are taking K value 0.20 and annual rainfall is 400 for this area. Now when the rainfall amount varies from 600 to 1000 mm then we are taking the value K is going to be 0.25 for 400 annual rainfall value. Similarly, for the area 1000 to 2000 square millimetre rainfall, we are taking the K value constant value 0.30 for the annual rainfall of 500.

For the more than 2000 mm rainfall generally 0.35 constant value they are taken and 600 is the annual rainfall which is no groundwater recharge. Now, this is the one of the formulae for finding out the groundwater recharge Krishna Rao formula. Then Chaturvedi formula a very important formula

$$W = 13.93 * (P - 381)^{0.4}$$

where P is annual rainfall and W is the groundwater recharge.

So, the general concept is that the rainfall level will be related with the recharge, that is why every scientist they have taken the consideration of ground recharge with respect to the amount of precipitation. So, Chaturvedi in 1973 has given formula

$$W = 13.93 * (P - 381)^{0.4}$$

where P is the annual rainfall and W is the groundwater recharge.

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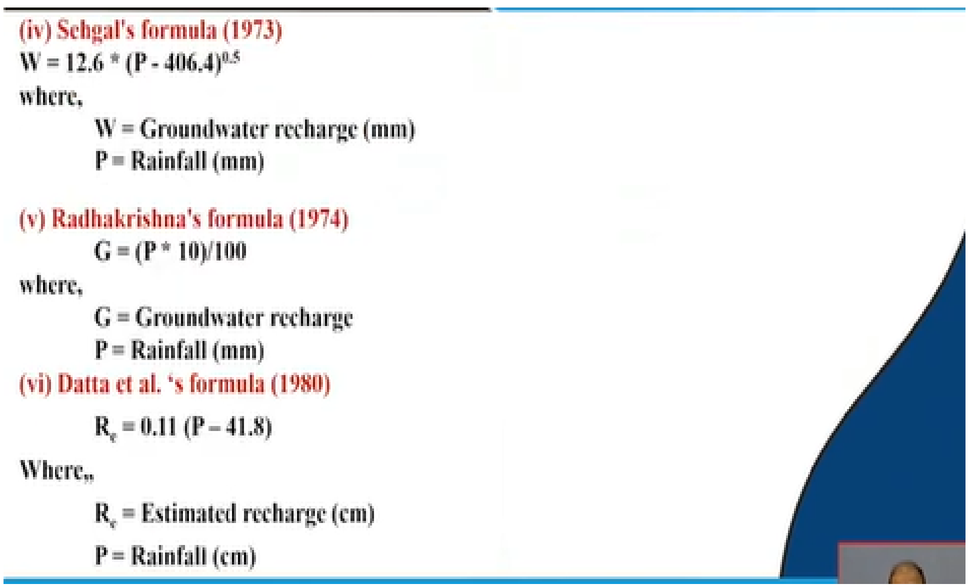

Now Sehgal formula. Sehgal's formula is given in 1973,

$$W = 12.6*(P - 406.4)^{0.5}$$

where W is equal to ground voltage charge and P is the rainfall.

So, every place we are seeing the consideration of the W and P where W is the ground charge and P is the rainfall or where is in some of the scientists are taken the alphabet G for the ground water recharge. So, now Radhakrishna formula in 1974

$$G = \frac{P*10}{100}$$

So, he has given the year 1974 where G is the ground water recharge and P is the rainfall in mm. Datta et al formula given by in the year 1980 you can see estimated the charge

$$R_e = 0.11\ (P - 41.8)$$

So, here somebody has told about the groundwater recharge in the form of W somebody groundwater recharge in the form of G and estimated recharge in the form of Re. So, these are the few formulas which has been given by the different scientists for calculation of groundwater recharge in any area.

Since recharge is very well connected with the groundwater aquifers so here, we are just understanding few of the concepts what we have discussed throughout in the module four about the different concepts. So, just we are briefing our knowledge with the solving such small numerical based on this formula.

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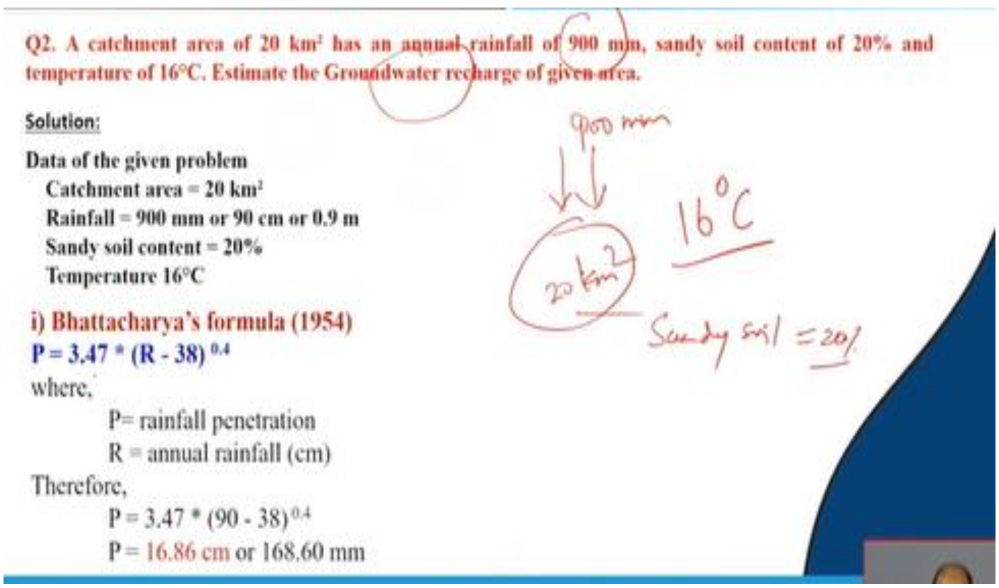

Now, there is a problem we are going to we have seen the different formulae. Now, there is a problem and the problem

One catchment area is there whose area is 20 square kilometre and this area is having the annual rainfall of 900 mm. The area is having a sandy soil and sandy soil content is about 20%. So, soil in which stand is about 20% and temperature of this area is 16^0C. Now, it has been asked estimate the recharge of the given area.

What formula we have seen? Generally, in the formula we have seen that it was related with the groundwater recharge and the precipitation. So, in the numerical also we are having the precipitation value and it has been asked the ground water recharge. So, we will apply to formula what we have understood just now.

Bhattacharya formula

$$P = 3.47 * (R - 38)^{0.4}$$

Just we are if we will put the value of R,

$$P = 3.47 * (90 - 38)^{0.4}$$

$$P = 16.86 \text{ cm}$$

we are getting the rainfall in terms of recharge in terms of 16.86 centimetre of the area.

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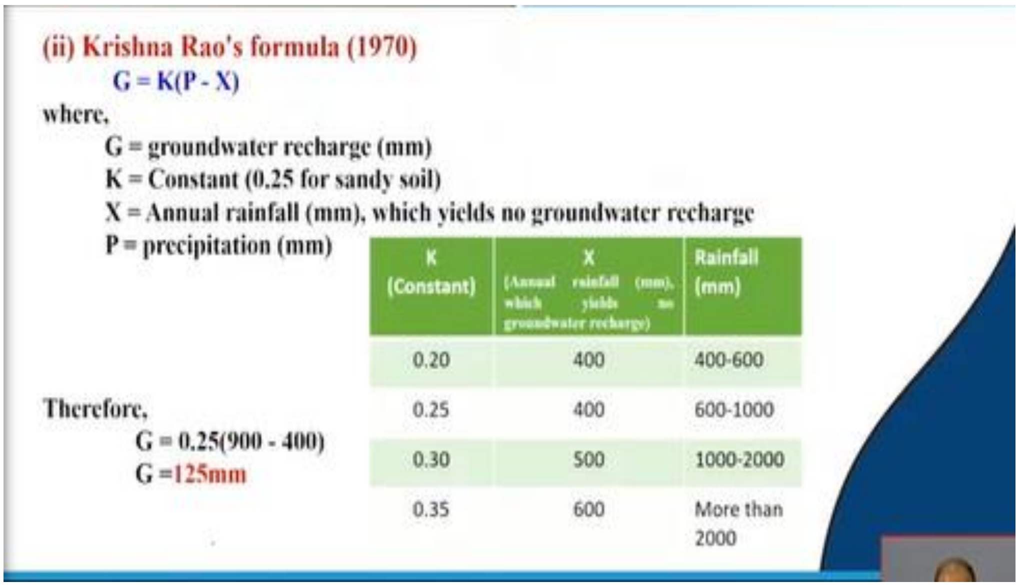

Now next Krishna Rao formula. We have seen there are also

$$G = K (P - X)$$

where G is the ground water charge, K is the constant, X is the annual rainfall and P is the precipitation.

So, in the question we have seen that rainfall amount is annual rainfall is 900 mm. So, annual rainfall amount is 900 mm. So, for 900 mm, which is coming under this the K value will be 0.25. So, 0.25 value we have taken and then annual rainfall is 900 just solving this

$$G = K (P - X)$$

$$G = 0.25 (900 - 400)$$

$$G = 125 \text{ mm}$$

we are getting the recharge of the value 125 mm.

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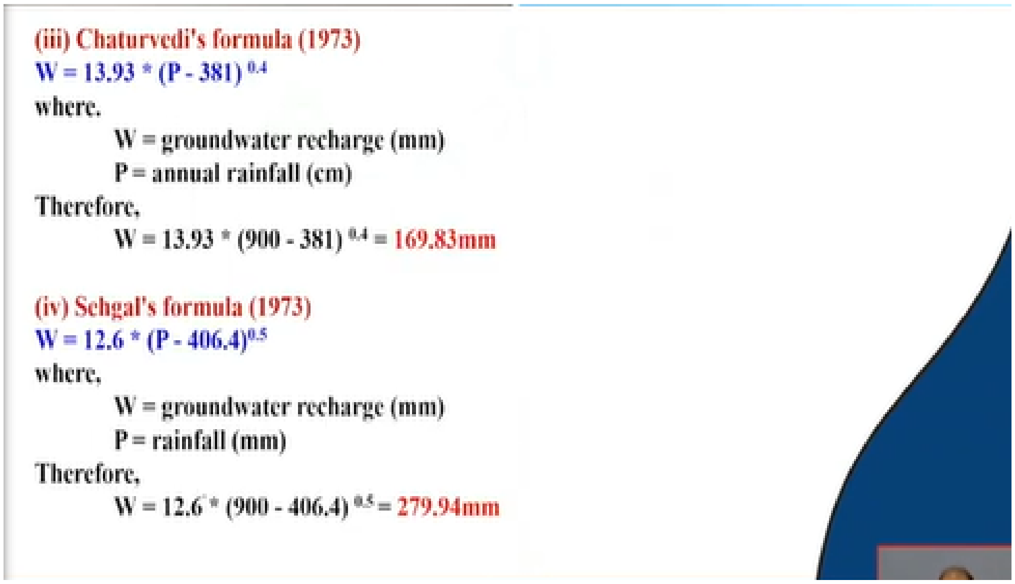

Now next Chaturvedi formula. On the basis of the Chaturvedi formula,

$$W = 13.93 * (P - 381)^{0.4}$$

groundwater recharge in mm is this much groundwater recharge is just to be our finding on the basis of this formula, P we are looking at 900 mm.

$$W = 13.93 * (900 - 381)^{0.4}$$

$$W = 169.83 \text{ mm}$$

So, the value is coming this much. So, in the Sehgal's formula,

$$W = 12.6*(P - 406.4)^{0.5}$$

$$W = 12.6*(900-406.4)^{0.5}$$

$$W= 279.94 \text{ mm}$$

Again, we are finding the ground water recharge taking the value of the rainfall which has been given 900 mm. So, while putting the 900 mm in the equation this equation the value of recharge is coming 279.94 mm.

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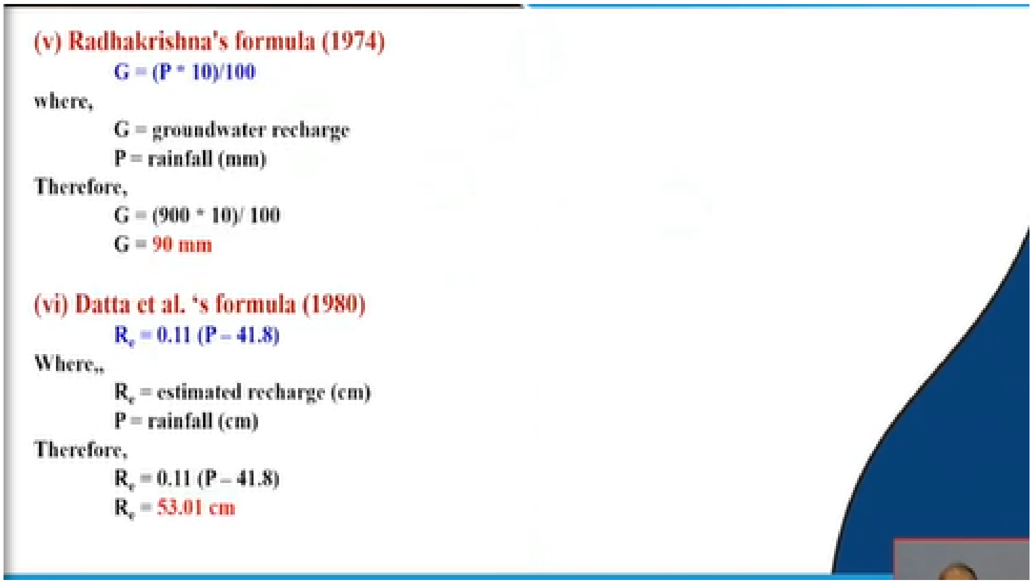

So, here what we are seeing that now again the Radhakrishna formula,

$$G = \frac{P*10}{100}$$

We are seeing if we will put the value

$$G = \frac{900*10}{100}$$

$$G = 90 \text{ mm}$$

In Datta et al formula we will put the value of P

$$R_e = 0.11\ (P - 41.8)$$

$$R_e = 0.11\ (90 - 41.8)$$

$$R_e = 53.01 \text{ cm}$$

then the value of the ground recharge is coming 53.01 centimetre.

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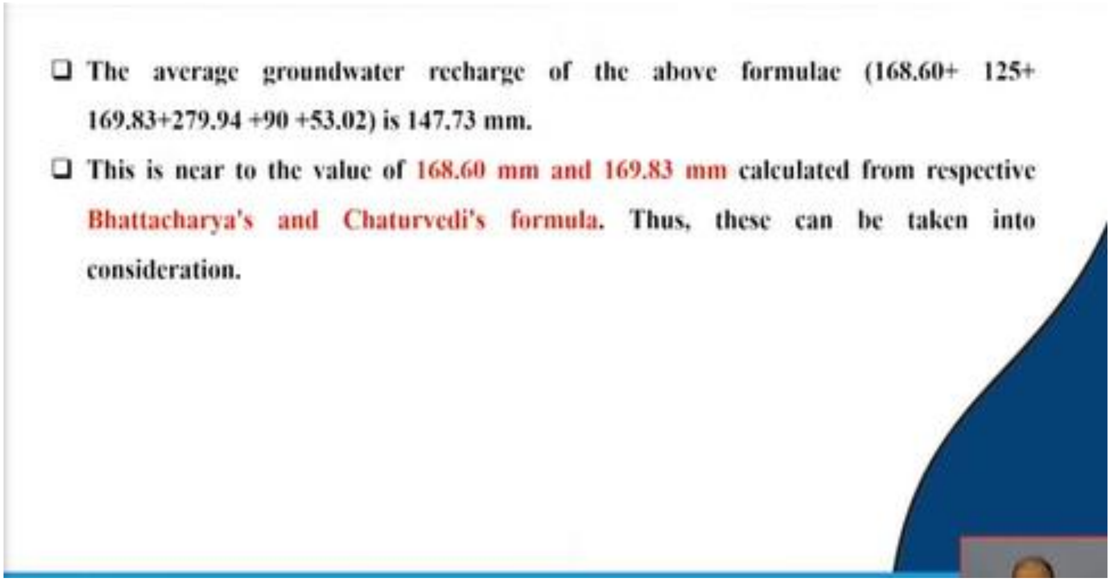

So, what is the point? The point is that the average ground water recharge through the above formulae is this much coming to 147.73 mm. So, this value is coming by different formula when we are just putting the value of 900 mm in the equation which is very near to if we will see the 147.73 it is very near to the value of 168.60 mm and 169.83 mm which is calculated through by the formula of Bhattacharya and Chaturvedi respectively.

So, we can see that since the Chaturvedi formula and Bhattacharya formula we are getting this much value and the value when we are just summing the taking the average it is coming to this much. So, we may say that the Chaturvedi and Bhattacharya formula is much more good with respect to other formula for finding of the recharge of any area. So, this is the basic point related with the problems related to the ground water charge in any aquifer conditions.

So, from this different formula, we can find out about the details of the average groundwater recharge of any formation. This much we should know about the different formula to which we can compute or calculate these values of the average groundwater recharge of any area.

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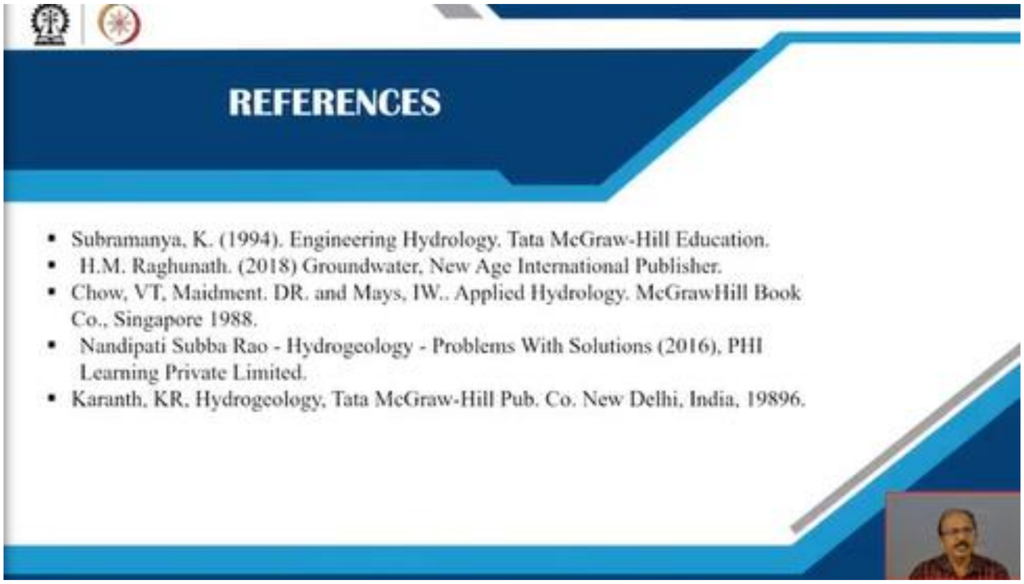

Now after these are the few of the references which I have considered. So, you can also go through these references for some better understanding.

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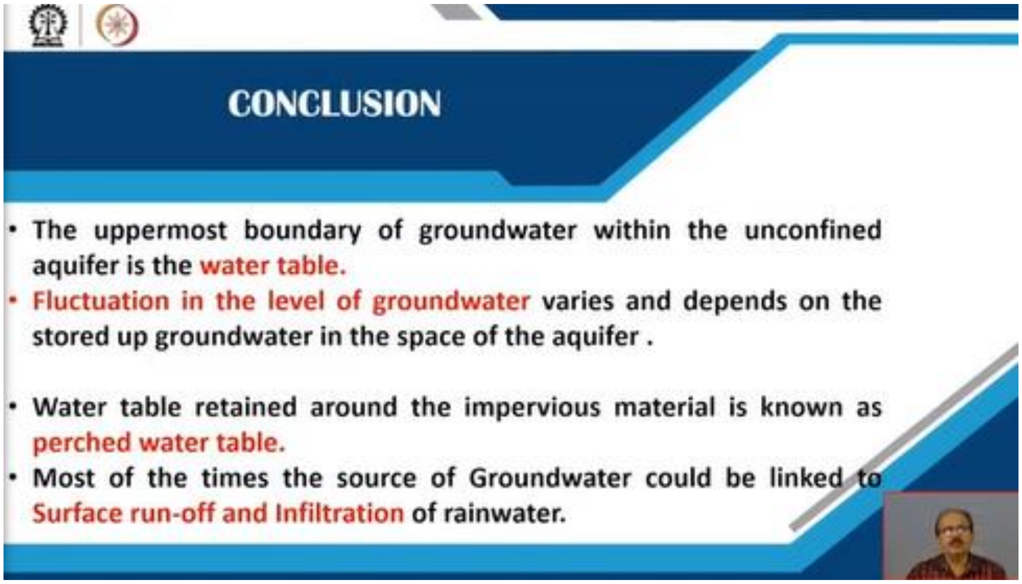

And then the conclusion of this module is very well accepted that we are having only two type of important formations that is one is the confined aquifer other is the unconfined aquifer. In confined aquifers generally the impervious lies just beneath the rock formations of the holding the water and the top portions remain the direct contact with the atmosphere. A very good example of this confined aquifer is the open dug well in which we can see the level of the water also.

But this level of the water will vary in different seasons, in the summer season you can see greater depth than in monsoon season again the level comes up and during the post monsoon season it again varies. So, in different type of climatic behaviour the variation of the water table is there and this fluctuation of water table tells us a great about the different types of understanding of the water storage capacity of the formation.

Now, the water table generally retained in some of the aquifer we have seen that the impervious stratum at the top also at the bottom also. So, when it remains at the top and bottom as well, then this type of aquifer is termed as confined aquifer. Here the water remains on the great pressure because at the top also no scope for move up and at the bottom also impervious stratum is there. So, they are not allowing the water to go down. So, here the water remains on a great pressure.

Confined aquifer, water table is related with the unconfined aquifer whereas surface related with the confined aquifer. So, here one more type of aquifer in this model we have learnt that is the first water table when the water table retained around the impervious stratum material. So, this is just the perched water table generally we are getting it in the unconfined aquifer small area, very limited water content.

But generally, we are getting such type of aquifer also at some places inside the earth's surface. Most of the time, the source of groundwater could be linked with the surface runoff and infiltration of rainwater. We have seen the infiltrated rain the precipitated rain just infiltrated inside the surface in the soil layer then from the soil layer to the bottom soil layer percolation takes place and then towards then comes and ultimately joins then formation rock formation which is generally termed as aquifer.

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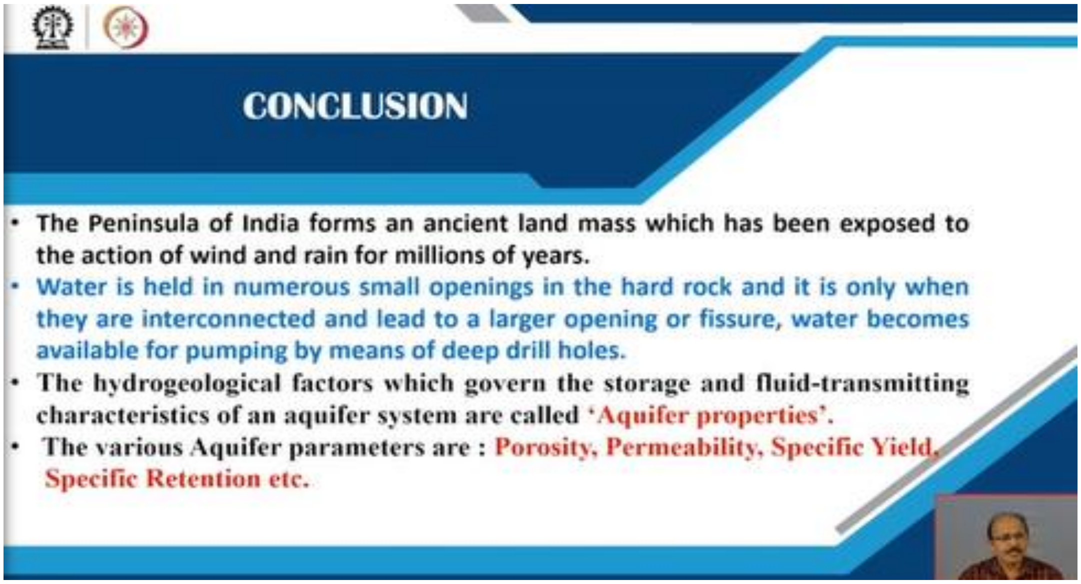

So, the aquifer is actually holding the groundwater inside the earth's surface and we have also seen that the Indian peninsula which is the having the ancient landmass, there are most of the hard rock area, in the hard rock area these rock areas having also groundwater. But these groundwater remains in the fractured and some of the joints and cracks in the rocks because of the wind and rain these are the weathering action which has taken place.

And then only in the hard rock areas in the Indian peninsula region, we are getting the groundwater there. Water is held in numerous small openings in the hard rock and it is only when they are interconnected and lead to a larger opening official. So, this is very important then only by means of some pumping or deep drill holes we are just taking out water from the hard rock areas. So, in the hard rock areas in the soft rock areas, there are no problem because the rock itself is of very unconsolidated one, it is porous one.

So, it will hold water we can tap water, just to without any problem we can take the water. But in the hard rock areas the water will remain in the fractured portion in the small cracks, fissures etcetera only this and these cracked fissures are generating because of the weathering action because of the weathering external of the natural agents that is wind, air etcetera. So, in the soft rock as well as in the hard rock both the areas, we are getting the groundwater.

But the good aquifer we are getting in case of the soft rock areas, in the hard rock areas we may get the good aquifer but at greater depth and on that also in the fractures or joints of cracks only of the formation we are getting the ground water. So, the hydrogeological factors which go on the storage and fluid transmitting characteristic of aquifer systems are generally called as an aquifer parameter and we have read about few of the important parameters.

The parameter will be discussed in the later classes, but these few parameters are very well related with the formation which is holding the water that is porosity, how many pore spaces are there, wide spaces are there. Because these wide spaces; will ultimately accept the water which will come through infiltration and percolation. So, permeability also important for formation aquifer. Why? Because it should have the behaviour of either receiving or sending the water from it.

So, this is also very important specific yield and specific retention also related with the porosity. Because if the yield is good definitely the formation is having sufficient amount of water and this water can be taken out for the different purposes. So, these are some of the things which we can we have discussed in this module in a greater detail about the confined and unconfined aquifer. So, in the next model we will discuss some more concepts about the porosity, permeability, these are the aquifer parameters which we will discuss in the next model. Thank you very much.