Availability and Management of Groundwater Resources
Prof. Prasoon Kumar Singh
Department of Civil Engineering
Indian Institute of Technology (ISM), Dhanbad

Lecture - 37
Measurement of Rainfall, Index of Wetness, Infiltration Rate (Continued)

Welcome you all in the part 3 of the module 8 measurement of rainfall, index of wetness and infiltration rate. In the last two parts we have discussed about the how the rain is being measured, what are the different your rainfall measurement indices and the methods how arithmetic mean method poly concession polygon method we have learnt. We have also learnt about the different types of rain gas that is recording type, non-recording type of rain gauge.

So, through this your background now we will enter into the measurement of rainfall how the rainfall are being measured and how we can find out the index of wetness of the area and what are the different type of infiltration rates. So, in this slide we will discuss specially about your the different types of the measurement network and the average annual rainfall and the index of wetness.

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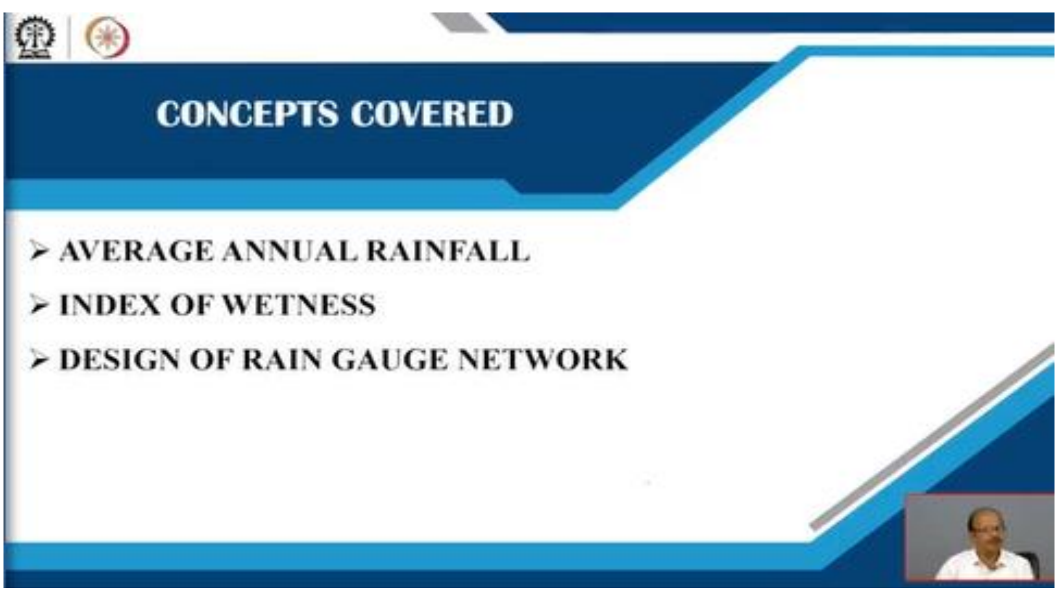

So, these things we will discuss. Why we are discussing? Because we have known from the very beginning of this course that rainfall is the only one factor which is responsible for recharging of the underneath aquifer. So, this rainfall measurement is very important component in the finding out the groundwater potential area on the earth's surface. So, we are having the we are knowing the processes of the precipitation then infiltration then percolation then runoff surface runoff groundwater runoff.

Now we came to know about that suppose the rainfall data is not available then how can we measure it. So, we can measure it with the help of the rain gauge and rain gauge is of two different types recording and non-recording type. Especially we are generally non-recording type we can able to measure about the rainfall amount and in the recording type rain case just it is giving it is recording the your rainfall not giving the amount.

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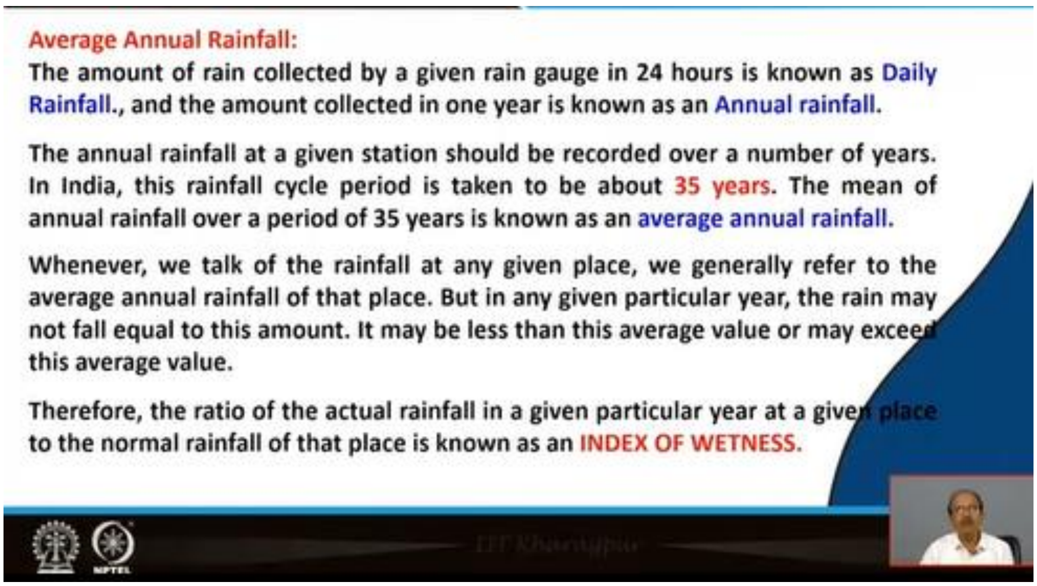

So, now we will discuss, what are the average annual rainfalls of any region because it is very important. So, the amount of rain what are being collected in a given 24 hour duration is generally called as daily rainfall. So, this amount of rain what we are collecting total in total 24 hour is called as daily rainfall and the amount of rainfall which is collected in one year is generally known as the annual rainfall.

So, two different terms we have understood one is the daily rainfall, within 24 hours rainfall is called as daily rainfall and within a year rainfall is called as an annual rainfall. But the annual rainfall at a given station should be recorded over a number of years. So, the rainfall especially the annual rainfall for any given station for any given area it should be recorded for a number of years.

Generally, in Indian condition this rainfall cycle period is taken in consideration of about 35 years. So, about 35 years duration is taken in India and the mean annual rainfall over a period of 35 years. So, over a period of 35 years is generally known as the average annual rainfall. So, this is known as the average annual rainfall. So, suppose we talk about the rainfall at any given place we generally refer it to the average annual rainfall of that place.

Whenever we are telling about the rainfall say 1200 mm of rainfall. So, it is not a daily rainfall but generally when we are telling about the one to zero mm rainfall so definitely it indicates about the average annual rainfall of that place. But in any given year in any given particular year the rain may not fall equal to this amount say in one year rainfall amount is 1200 mm but it is not necessary that in the next year also we will get the 1200 mm rainfall at the in the area, no it may be less it may be more.

So, it may be less than this average value or may exceed this average value. So, this condition may come up. So, this generally when we are talking about the rainfall, we are talking in the sense of an average annual rainfall not in the sense of daily or annual rainfall. Every time we are talking about in the sense of average annual rainfall, but it is also sure that this average annual rainfall amount we may not get in the next year we may get less than average annual rainfall amount of the rainfall or more than average annual rainfall amount of the rainfall.

So, for this the ratio of actual rainfall in a given particular year at a given place safe any place. So, to the normal rainfall of that place is defined as an index of wetness so it is very important. The ratio of actual rainfall in a given particular year at a given place whatever amount is coming and to the normal rainfall of that place is known as index of wetness. So, this is known as generally index of witness.

And through this also we can understand whether in terms of rainfall the year is good bad or normal. So, this thing we can understand. Because we are having the concept that the total 24 hour rainfall is known as daily rainfall total 365 days or yearly rainfall is only annual rainfall. But we cannot measure only the annual rainfall, daily rain fall and tell us this much mm or rainfall is for this place.

In India generally this period has been fixed and that period is about 35 years the mean annual rainfall of a period of 35 years is generally known as average annual rainfall. And when we talking about the rainfall at any given place generally it refer to average annual rainfall and this actual rainfall of the area divided by normal rainfall of the area is generally known as the index of wetness. So, this is generally known as index of wetness.

So, now with the help of index of wetness we can have the idea about the rainfall in a particular place.

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Now index of wetness is generally the ratio of actual rainfall in a given year at a place to the normal annual rainfall of that place. So, what it gives? It gives an idea of the wetness of the year; how much wetness is in the year and hence is a measure of deficiency of rainfall. It is a measure of deficiency of rainfall how? Say a 60% index of wetness suppose you are getting in an area 60% index of wetness to means what? Means a deficiency of rainfall of 40%.

So, deficiency generally 30 to 45% deficiency is generally called as large whereas deficiency 45 to 60% is called as serious and deficiency greater than 60% is known as disastrous. So, this is very important, any area is having; suppose greater than 60% then those areas is with the respect of your rainfall it is a disastrous area. Because deficiency is here you are more so that is deficiency. Now with respect to the average annual rainfall and annual rainfall one relation.

If annual rainfall is less than average annual rainfall annual rainfall what we are measuring throughout the year is less than your average annual rainfall which is generally decided after the monitoring of the last total 35 years of rainfall data. Then if the annual rainfall in a particular year in the annual rainfall is less than the average general rainfall then that very year is generally called as bad year or sub normal year.

So, it is called a bad year means in this year the rainfall has not taken place properly because even it is lesser than the annual rainfall. So, average rainfall is less than average annual rainfall and more rainfall then it is bad year. Average rainfall is near about equal to average annual rainfall until normal year or average year and annual rainfall if it is greater than average annual rainfall then definitely so much amount of rain has taken place in the land surface so it is a good year.

So, in terms of index of wetness we have understood that index of wetness if we are knowing we can tell for any year also in terms of rainfall whether the year is good, bad or normal. So, it depends upon the factor that average annual value if you are just comparing with the annual rainfall value then if annual rainfall is less than average annual rainfall then it is bad year. If annual rainfall is near about equal to average all rainfall, then it is normal year and if annual rainfall is greater than average annual rainfall then it is good year.

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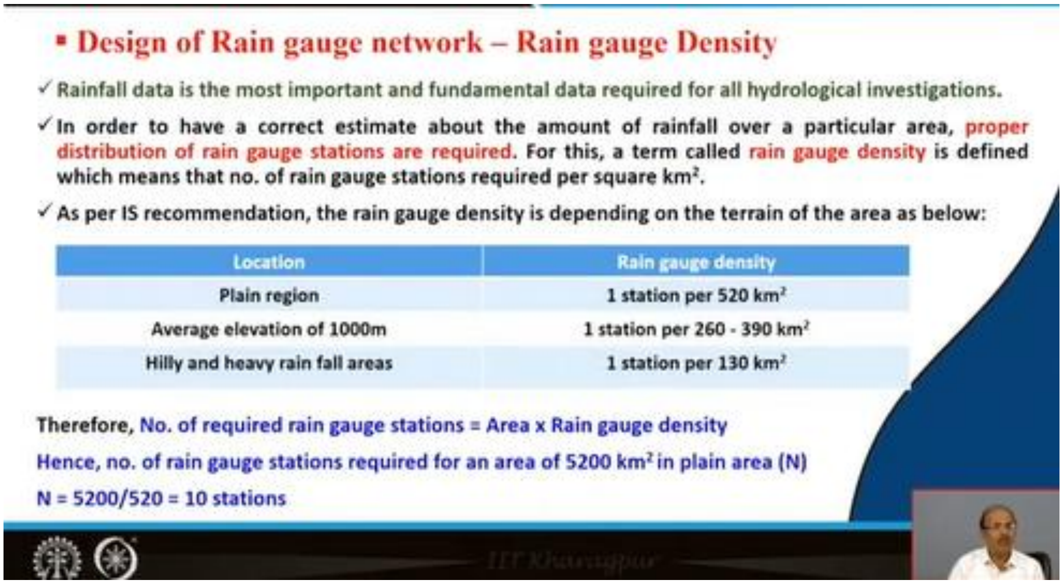

So, now with getting the knowledge about the year wise position with respect to your rainfall now we will see what are the rain gauge density or how the rain gauge are designed. So, generally rainfall data is the most important and fundamental data these are very important data rainfall data and for correcting the in order to have a correct estimate about the amount of rainfall over a particular area suppose if you want to have some estimation about the amount of rainfall in a specific area proper distribution of rain gauge stations are required.

Because in that case if you are having the distribution of rain gauge in a systematic manner then definitely you will get the correct estimate of the rainfall in that very area. So, for this a term called rain gauge density is defined which means that number of rain gauge station required per km^2 area. So, per km^2 area how much rain gauge stations required, this is very important.

So, then only you can get the correct estimate about the annual amount of rainfall over the area. So, as per BIS recommendation the rain gauge density is depending on the terrain of the area. So, what are the types of terrain on that basis one can decide your how many rain gauge networks will be there. So, for plane region suppose the region is plane and you have to monitor the rainfall in that area.

So, within 520 km^2 area you put one rain gauge or one station for measurement of the rainfall. So, if the area is plane then you put only one station per 520 km^2. If it is average elevation of about

1000 meter then put one station per 260 to 390 km^2. So, one station means one rain gauge network station per 260 to 390 km^2 and in hilly and heavy rainfall areas in both the condition in hilly area and the heavy rainfall areas.

Generally, one rain gauge network is being installed for measurement of the rainfall per 130 km^2 area. So, this is a general standard. Therefore, number of required rain gauge stations how many number of rain gauge stations required is equal to the area into rain gauge density. Suppose for example number of rain gauges stations required for an area of 5200 km^2 in plane area.

So, area is demarcated it is plane area, total area is 5200 km^2 then just divide the 5200 by 520 because it is a plane. So, one station as for the norms one station for 520 km^2 so it is coming to 10 stations. So, this thing also we are considering for the measurement of the rainfall or for the fixation of the rain gauge network stations.

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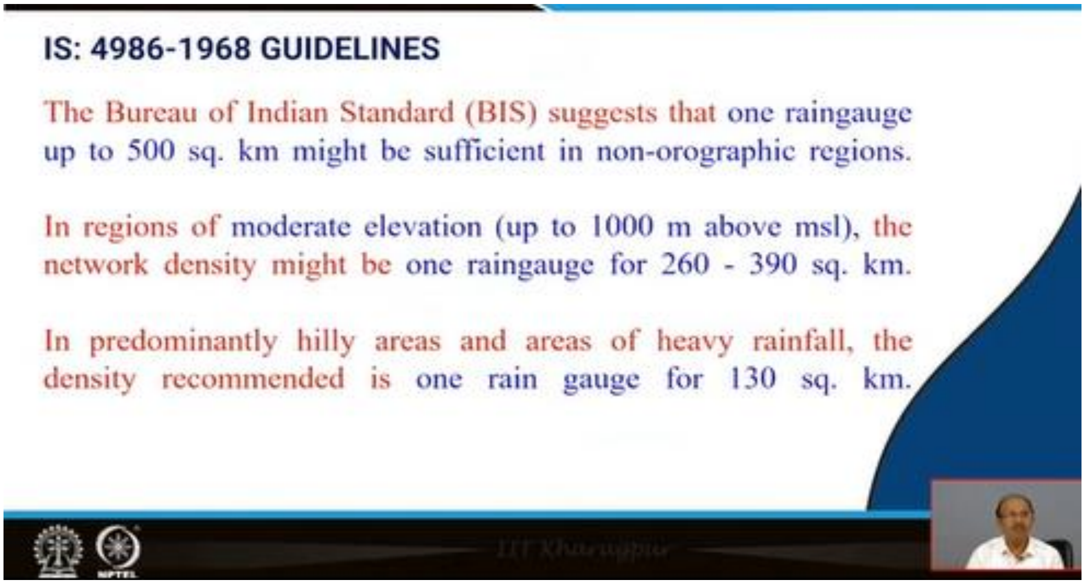

Now some guidelines in terms of BIS has given suggested one rain gauge up to 500 km^2 for non-orographic regions. Non-orographic means without having any plateau, mountain etcetera, so for definitely it is a plain area. In regions of moderate elevation up to 1000 meter above msl the network density might be one rain gauge for 260 to 390 km^2.

And predominantly hilly areas and heavy rainfall the one gauge for 130 km^2. So, near about the same thing what we have discussed just now.

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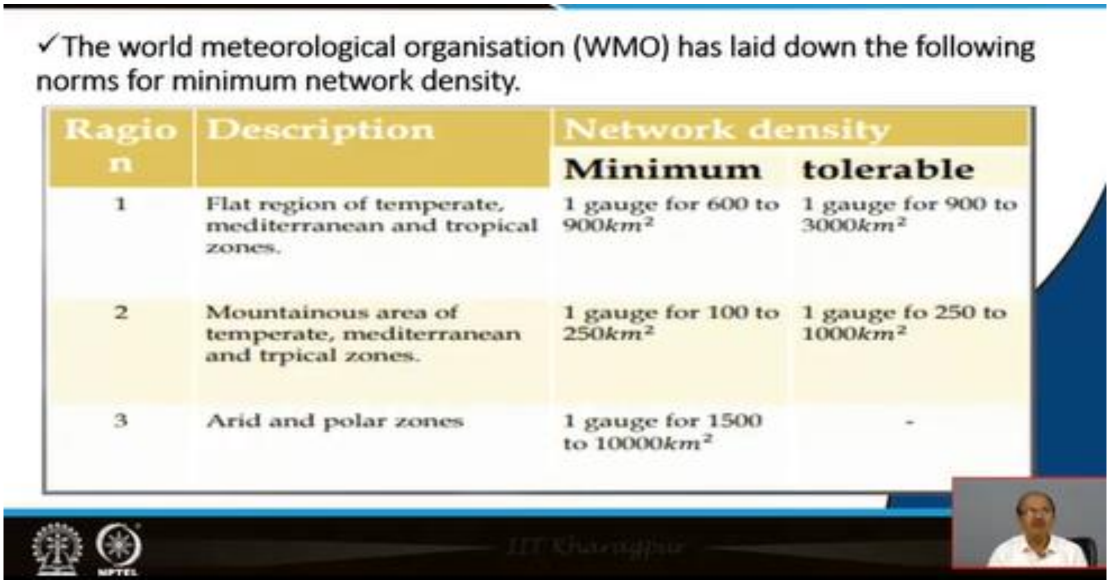

Now you know WMO has also given some network density your clarification. So, they have done flat region of temperate Mediterranean tropical zones. So, still it is flat region plain region so one gauge for 600 to 900 km^2 area is the minimum and total level is for 900 to 3000 km^2. When the; area description is mountainous area of temperate, Mediterranean and tropical zones one gauge for 100 to 250 km^2 area.

And tolerable limit is one gauge for 250 1000 km^2 area. So, arid and polar zones one gauge per 1500 to 10000 km^2 area. The point is that through the knowing the types of the topography with the flat or your hilly or mountainous then we should decide the number of stations what we have to fix, how many engage we have to installed. Because we know that if it is a plane area then one rain gauge is sufficient for measurement of the rainfall within 520 km^2 or 500 km^2 area.

So, in this way some consideration is required for your placement of the different rain gauge network because this rain gauge will ultimately give us the clear picture of the rainfall in the area. So, this thing we will discuss.

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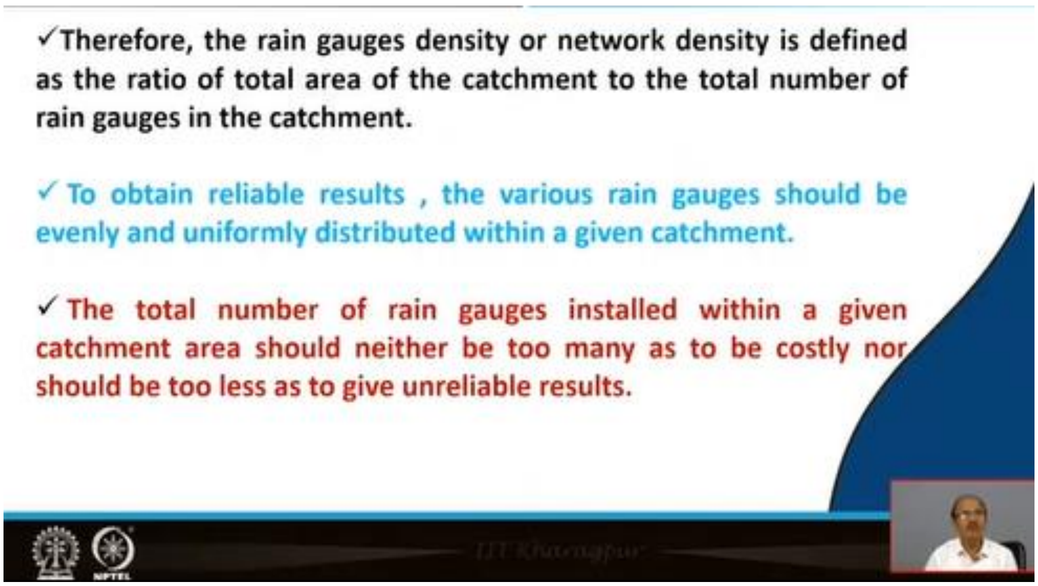

Now the rain gauge density or network density is generally defined as the ratio of total area of the catchment to the total number of rain gauges in the catchment. So, what is the total area of the catchment and what is the total number of the rain gauge in the catchment? For obtaining reliable results the various rain gauges should be evenly and formally distributed. So, this is very essential.

If you are you are willing to have a very good results related to the rainfall involved you, please distribute the rain gauge network to uniformly then only you can able to get the total picture of the rainfall in that very area. Otherwise, we know that in some sectors the rain is taking place in some sector it is not coming. So, in this way the clear picture related to the rainfall will be not there. So, it will just have certain error also.

Because of some non-functional rain gauge; network which we will discuss in just in the next slides. But the point is for knowing about the total rainfall amount in any area we should go for the; we should see the topography and then on the basis of topography we should move ahead for the fixation of the rain gauge network in the area. Now the total number of rain gauges installed within a given catchment area should neither be too many as to be costly or nor it should be too less as to give unreliable results.

So, this thing should remain in the mind while fixing the rain stations that large number of rain gauge network is not required because it is a costlier event. And second thing we should not have the lesser number of rain gauge network then it will give very bad result and reliable results. We will not have the correct picture of the rainfall status in the area. So, this thing we should keep in our mind. So, as per the topography we should think for the installation of the rain gauge.

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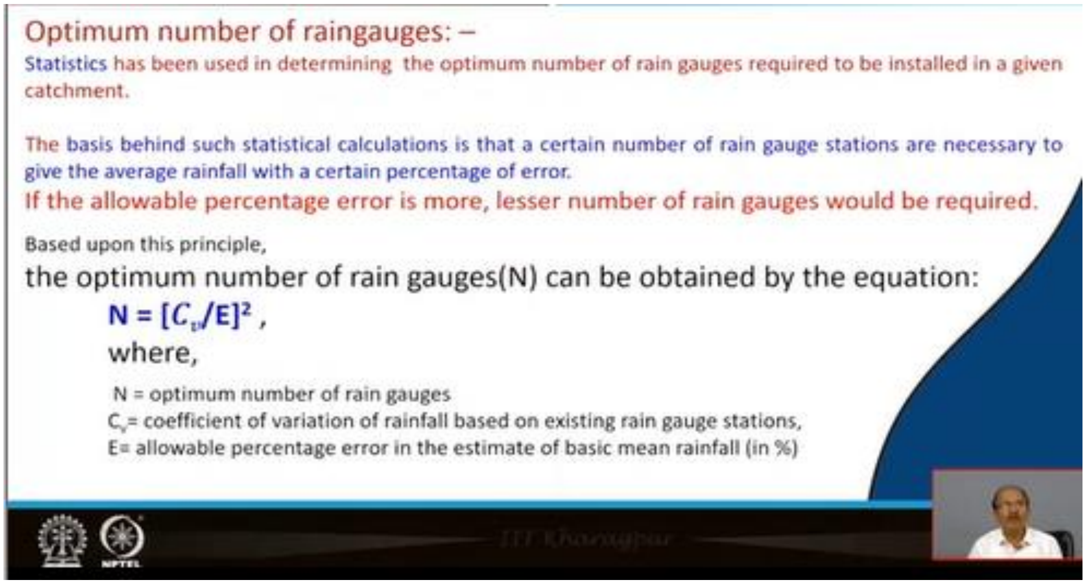

Now how many ring is the point is coming it is all right, the rain gauge network should be as per the topography. Then how many? So, optimum number of rain gauges is given by some statistical formula and for this it is just your statistics are being used in determining the optimum number of rain gauges required to install in a given catchment. The basis behind such a strategical calculation is that a certain number of rain gauge stations are necessary to give the average rainfall within a certain percentage of error.

So, certain stations are very essential this will only give you the greatest rainfall maybe with certain per error also. So, if the allowable percentage error is more; lesser number of rain gauge would be required. If suppose the percentage error is very high then less number of rain gauge would be required for knowing about the rainfall status. So, based upon this principle the optimum number of rain gauge can be obtained by the equation

$$N = [C_v/E]^2$$

where N is the optimal number of rain gauges.

Cv is the coefficient of variation of rainfall based on existing rain gauge stations and

E is the allowable percentage error in the estimate of the basic mean rainfall. So, by this $N = [C_v/E]^2$ is generally giving us the optimal number of rain gauge.

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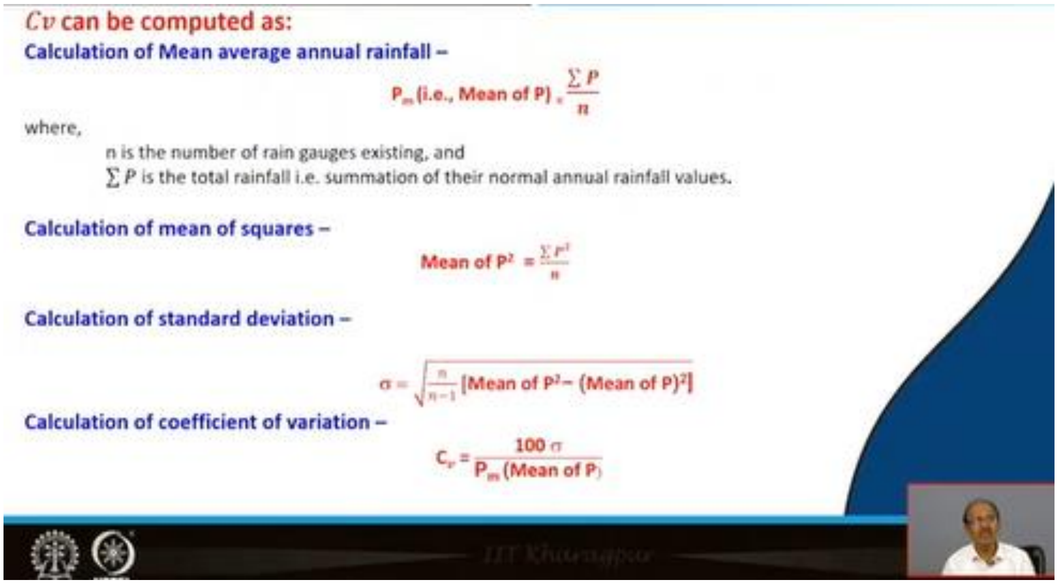

Now it can be computed also Cv can be computed, how? Cv calculation of mean average annual rainfall

$$P_m \text{ (i.e., Mean of P)} = \frac{\sum P}{n}$$

Where,

n is the number of rain gauges existing, and

$\sum P$ is the total rainfall i.e. summation of their normal annual rainfall values

Now calculation of mean of square is

$$\text{Mean of } P^2 = \frac{\sum P^2}{n}$$

Calculation of standard deviation –

$$s = \sqrt{\frac{n}{n-1}\left[\text{Mean of } P^2 - (\text{Mean of P})^2\right]}$$

Calculation of coefficient of variation –

$$C_v = \frac{100\ s}{P_m \text{ (Mean of P)}}$$

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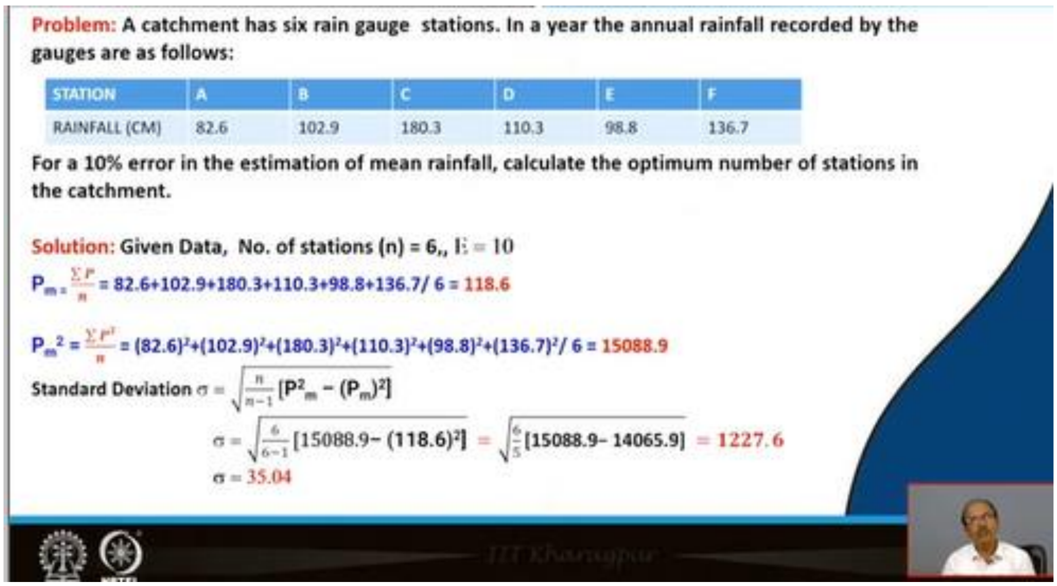

Now on the basis of these discussions we will solve some problem.

Problem: A catchment has six rain gauge stations. In a year the annual rainfall recorded by the gauges are as follows:

STATION	A	B	C	D	E	F
Rainfall (Cm)	82.6	102.9	180.3	110.3	98.8	136.7

For a 10% error in the estimation of mean rainfall, calculate the optimum number of stations in the catchment.

Solution: Given Data, No. of stations (n) = 6, E = 10

$P_m = \frac{\sum P}{n}$ = 82.6+102.9+180.3+110.3+98.8+136.7/ 6 = 118.6

$P_m^2 = \frac{\sum P^2}{n} = (82.6)^2+(102.9)^2+(180.3)^2+(110.3)^2+(98.8)^2+(136.7)^2/ 6 = 15088.9$

Standard Deviation $s = \sqrt{\frac{n}{n-1}[P^2_m - (Pm)2]}$

$$s = \sqrt{\frac{6}{6-1}[15088.9 - (118.6)^2]}$$

$$s = \sqrt{\frac{6}{5}[15088.9 - 14065.9]}$$

$$s = \sqrt{1227.5}$$

s = 35.04

We have then this is root just taking the taking out the root it is giving the value 35.04. So, sigma is coming to 35.04.

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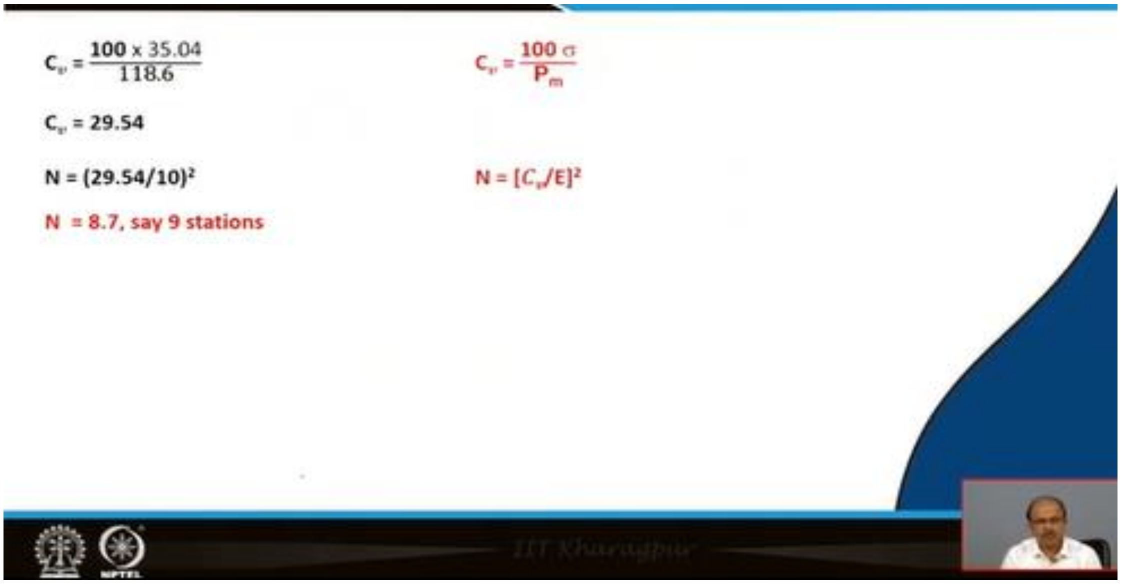

Now just we will put the value in this because sigma we have to find out and this also, $Cv = \frac{100\,\sigma}{P_m}$

$Cv = \frac{100 \times 35.04}{118.6}$

Cv = 29.54

N = $[C_v/E]^2$

N = $(29.54/10)^2$

N = 8.7, say 9 stations

So, if there will be three more station because six stations are there in the catchment if there will be nine station then we will have a very good information about the total rainfall in the catchment. So, in this way we are just calculating and we are fixing the network stations.

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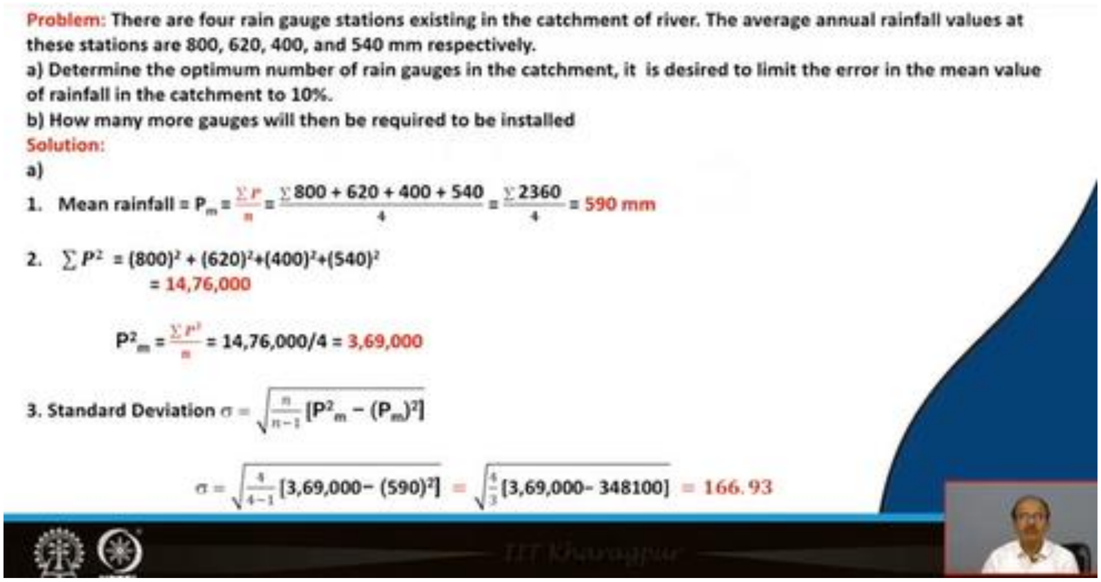

So, now we will see the next problem.

There are four rain gauge stations existing in the catchment of river. The average annual rainfall values at these stations are 800, 620, 400, and 540 mm respectively.

a) Determine the optimum number of rain gauges in the catchment, it is desired to limit the error in the mean value of rainfall in the catchment to 10%.

b) How many more gauges will then be required to be installed

Solution:

a)

1. Mean rainfall = $P_m = \frac{\sum P}{n} = \frac{\sum 800 + 620 + 400 + 540}{4} = \frac{\sum 2360}{4} = 590$ mm

2. $\sum P^2 = (800)^2 + (620)^2 + (400)^2 + (540)^2$

$= 14,76,000$

$P^2{}_m = \frac{\sum P2}{n} = 14,76,000/4 = 3,69,000$

3. Standard Deviation $s = \sqrt{\frac{n}{n-1}[P^2{}_m - (Pm^2)]}$

$$s = \sqrt{\frac{4}{4-1}[3,69,000 - (590)^2]}$$

$$s = \sqrt{\frac{4}{3}[3,69,000 - 348100]}$$

$$s = 166.93$$

And we have calculated only the mean rainfall then square of mean and then standard deviation we have also find out with just putting the values of the findings.

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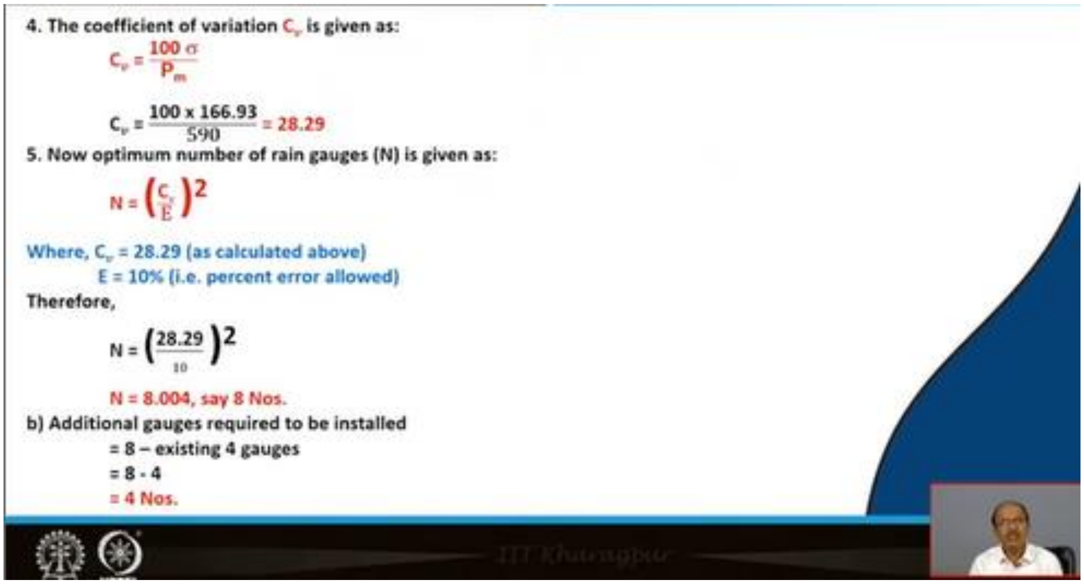

4. The coefficient of variation C_v is given as:

$$Cv = \frac{100\sigma}{P}$$

$$Cv = \frac{100 \times 166.93}{590} = 28.29$$

5. Now optimum number of rain gauges (N) is given as:

$$N = \left(\frac{C_v}{E}\right)^2$$

Where, C_v = 28.29 (as calculated above)

E = 10% (i.e. percent error allowed)

Therefore,

$$N = \left(\frac{28.29}{10}\right)^2$$

N = 8.004, say 8 Nos.

b) Additional gauges required to be installed

= 8 – existing 4 gauges

= 8 - 4

= 4 Nos.

So, additionally four number of gauges is required for finding out the total rain gauge or rainfall status in the area. So, for these additional four number of rain gauges are required. So, what we have seen in this lecture that index the rainfall which is just going deliver 24 hours if it is having 24 hours data then it is daily rainfall. For a month it is monthly rainfall for a year it is early rainfall and for 35 years it is average annual rainfall.

And with the calculation with the average rainfall and annual rainfall we are getting the index of wetness and on the basis of index of wetness that is we are getting good, bad and normal year. And then we have also studied in lecture about the optimum number of rain gauges required in any particular catchment or in any particular area for getting the correct figure of the rainfall in that very catchment or in that very area. So, with this, thank you very much to all.