Availability and Management of Groundwater Resources
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Lecture - 36
Measurement of Rainfall, Index of Wetness, Infiltration Rate (Contd.)

Welcome you all in the part 2 of the module 8, thus measurement of rainfall, index of wetness and infiltration rate.

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So we have discussed in the part 1 about details about the rain that is the precipitation and its forms and how precipitation forms, what are the different types of the precipitation and what are the different types which important types which plays very important role in the formation of rain in our Indian subcontinent. In the part 1 we have seen that the orographic type of precipitation is very popular in our country because we are having the mountainous border in our subcontinent.

So which generally just enhance your procedure of the formation of the rain and we are getting compared to cyclonic and convective orographic type of precipitation in larger duration. Now in this part 2 we will discuss how we can measure the rainfall and what is the mean rainfall ? So this concept we will make ourselves clear and then we will move forward for the different concepts related to these issues.

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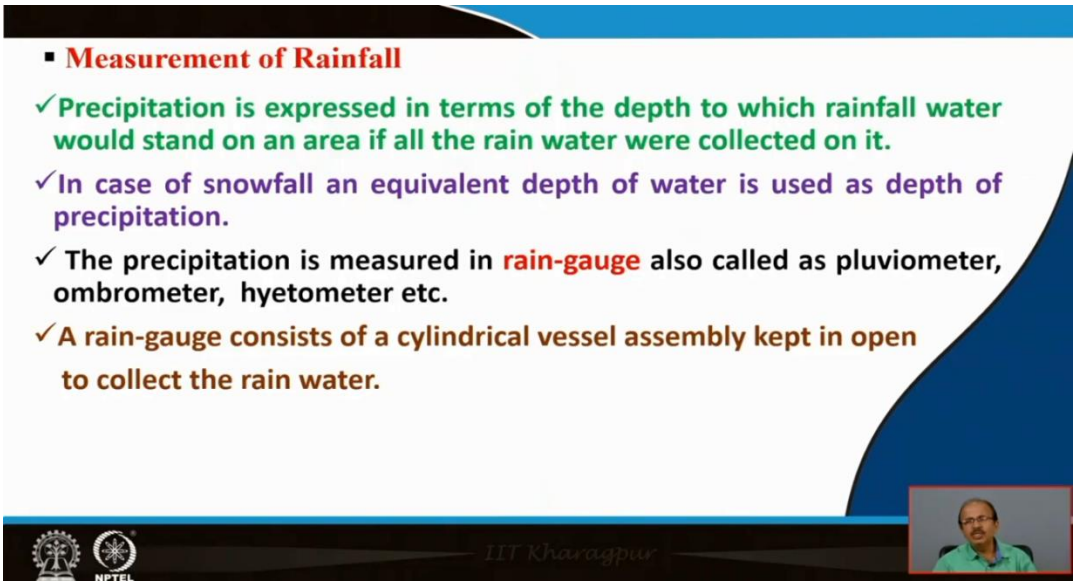

So see the measurement of rainfall is generally done why because we have to collect the water, which water? Rain water. So precipitation in general is expressed in terms of depth to which rainfall water depth in terms of depth of the water which is falling. So precipitation is generally expressed in terms of depth to which rainfall water would stand on an area, because generally precipitation is falling in an area if all the rain water were collected on it.

Suppose you are collecting total volume of the rain which is just coming to the earth's surface then its measurement is done in terms of depth of the rainfall. It is done in terms of depth of the rainfall and in case of snowfall it is also equivalent depth of the water which is used as the depth of the precipitation. So generally, this precipitation that is the rainfall is measured by an instrument called as rain gauge, it is called as rain-gauge;

Whose; another names are also very popular such as pluviometer, ombrometer, hyetometer etcetera. So this is the just your name of the rain gauge only pluviometer, ombrometer, hyetometer. So this rain gauge generally an instrument which collects the rain or it is just a cylindrical vessel not only cylindrical vessel one set of assembly of the cylindrical vessel which remains in the open field or open space and in this cylindrical vessel generally we are collecting the rain water when the precipitation takes place.

So this major rainfall measurement is a very important because then only you can able to know about the total quantity of rain in a year or in a day or in a month in your area in which you are very well trying to know about the ability of the groundwater resources. So we know that the rain water is the only reach our source, so if we are having the idea about the formation of rain or the duration of the rain or how to measure the rainfall;

So then we definitely we will have the idea also that in the year only this much mm of rainfall has taken place. So since; it is less than our average annual rainfall of our place so definitely this is not a very good year of in terms of rainfall. So if the recharging if the rainfall is in lesser amount definitely it will recharge to a lesser extent to the underneath aquifer. So that is why just we are knowing about how to measure the rainfall?

So generally through rain gauge and this rain gauge is also termed as pluviometer, ombrometer, hydrometer, so through this we can able to measure the rain which comes on the earth's surface.

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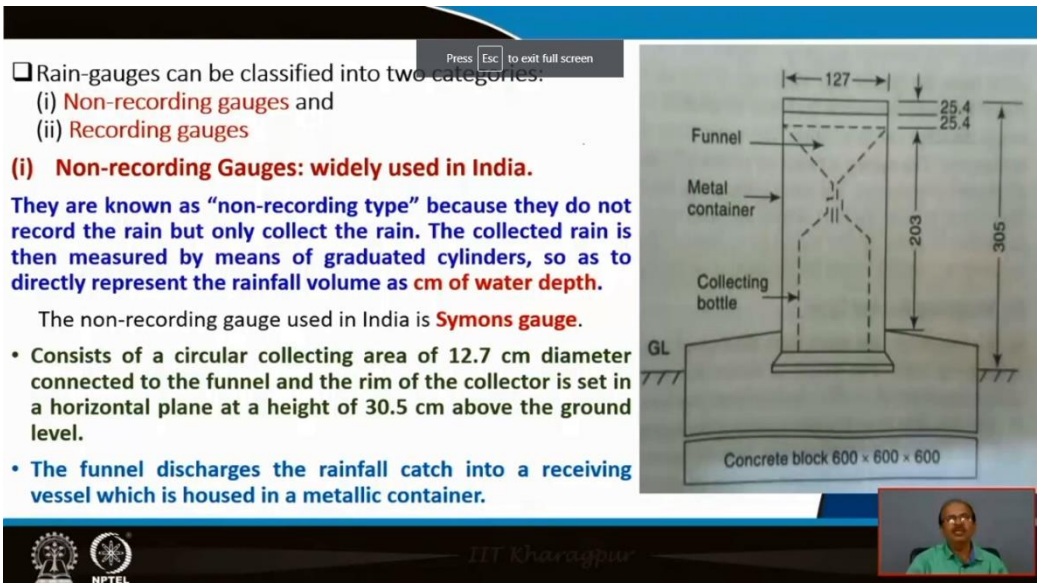

So rain gauges can be classified into two different categories that is one is the non-recording type of rain gauge and other is the recording type of gauge. So the two different categories if we are having the ability to know about the different types of the rain gauges, then we can have the very good monitoring of the rainfall also, see rainfall data is essential because we are knowing that the rainfall is the only source through which the recharge of aquifer can take place.

So for the; reproducible amount of water can be raised to the aquifer through the rainfall only. Yes, few surface water sources are also available which in some cases is just saturating the formations but in general the rainfall is the only source through which the aquifer is getting recharged during the rainfall period. So measurement of rainfall is important and the option of the measurement of rainfall is through equipment known as rain gauge with other different names also as I have discussed in the previous slides.

Now this rain gauge is of two different categories, one is the non recording gauge and other is the recording gauge. So non recording is they are called because they do not record the rain the non recording type rain gauge is not recording the rain rather it is just collecting the rain water sample. So the collected rain water is then measured by means of a graduated cylinder one cylinder is there you can see in the figure also that one cylinder remains here.

So as to directly represent the rainfall volume in the term of centimeter of depth we have read in the previous slide that rainfall generally we are denoting it in centimeter of depth. So the non-recording type of rain gauge is usually used in India rather the non-recording type of rain gauge in India is generally called as Symons's gauge it is called as Symons's gauge. So you can see in the figure also it consists of a circular this is the circular your collecting area supply collecting area of 12.7 centimeter this is 12.7 centimeter dia.

This one through this the rain will come and inside there is a funnel you can see here inside there is a funnel and this mouth this funnel tip is just entered into the your collecting bottle, so this is the collecting water. So this is generally the rim of the collector is set in a horizontal plane at a height of 30.5 centimeter above the ground, so you can see here total height is 30.5 centimeter. So here in this you can see that the funnel discharges the rainfall catch into a receiving vessel which is housed in the metallic container.

So a metallic container remains and in it remains the total assemble part is remain in this metal container. So the funnel discharges the rainfall catch which is coming here into the receiving vessel and this receiving vessel is also remaining in some metallic container.

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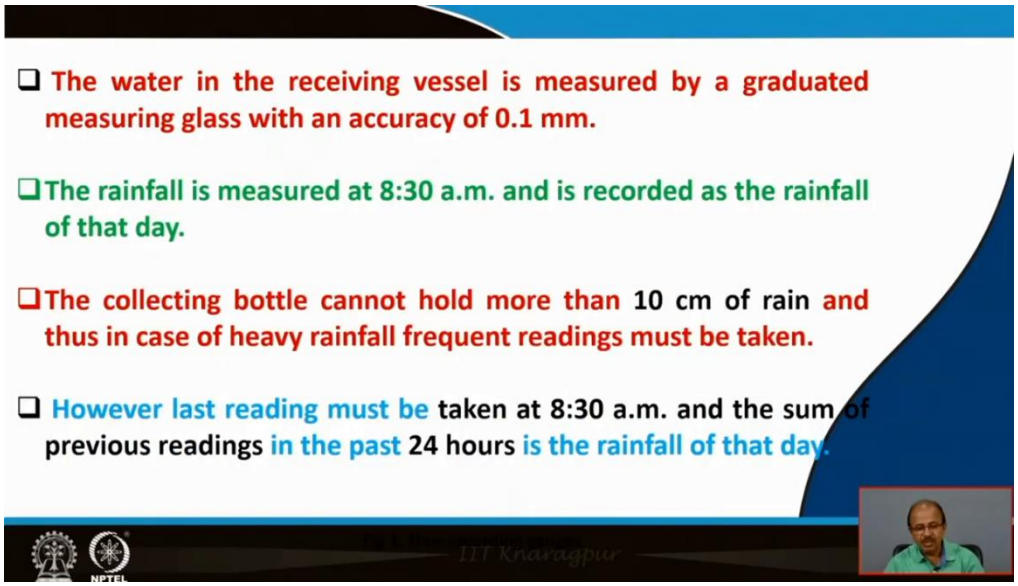

Now the water in the receiving vessel is measured by a graduated measuring class with an accuracy of 0.1 mm, so this is usually we are doing we are just collecting the rain water and in a vessel and this is just transferring into a measuring glass with an accuracy of 0.1 mm. So the rainfall one more point is very important that the rainfall in the non recording type is usually measured at 8:30 am in the morning and this is the measured value of the rainfall is the recorded rainfall amount of that very day.

So this usually cares will be taken that it should be measured at 8:30 in the morning by some trained person, because trained person is essential why because the sample you have to collect from the your container and then you have to put into the graduated cylinder you have measuring flask through which you can we can just have the idea about the total volume of the rain of the past 24 hours because it indicates the rainfall amount of that very period, so period is the last 24 hours.

So the collecting bottle cannot hold more than 10 centimeter of rain. So the more than 10 centimeter of rain is if it is falling on the surface so it would not create collect, then what can what will be the solution? The solution is that in case of heavy rainfall frequent reading must be taken just you collect the sample again you put the your empty cylinder there to collect the further

because rain is continuing heavy rainfall is going on so and the limit is also there that more than 10 centimeter of rain it would not collect.

Then the only procedure is to have the frequent readings during the heavy rainfall duration. Now last reading must be taken at 8:30 am because time is 8:30 am and the sum of the previous reading in the last in the past 24 hours is called as generally the rainfall of the day so that is called as the rainfall of the day. So the last reading must be at taken at 8:30 am and the sum of the total readings which has been taken in the past 24 hours that is just summed up and that will tell us the total rainfall of that particular day.

So this is the general procedure to which we are just collecting the rainfall amount to the non-recording type of rain gauges.

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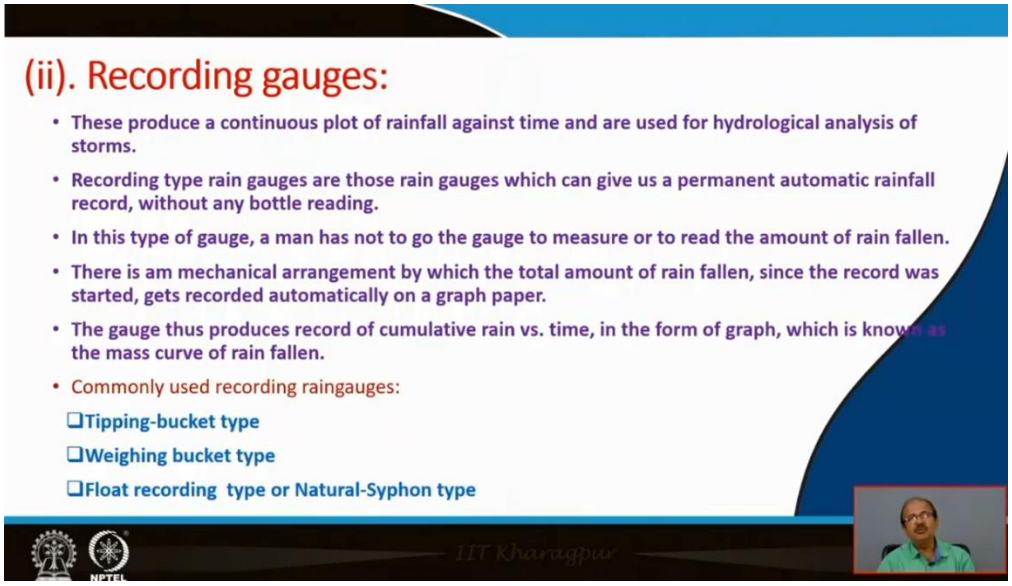

Now recording type of rain gauge, so here what is happening, these produce a continuous plot of rainfall against time and are used for hydrological analysis of storms. So generally the recording rate types of rain gauge are used for different hierarchical studies and recording type rain gauges are those rain gauges which can give us a permanent automatic rainfall record. So here the permanent rainfall record is coming but that is automatically no manual no person is going to check the water total volume.

So the it is called as recording because the rain is it is just giving us the permanent automatic rainfall record without any water reading, so no bottle is here if the water will remain definitely the volume will remain the volume element definitely the measurement will be there how much wall centimeter of depth of rainfall or how much millimeter of depth or rainfall. So this is the different types of the rain gauge, in this type of rain gauge a man has not to go man is not going to the gauge for measuring measurement or to read the amount of the rain falling.

So it is not no need and nothing to worry about to have the person in there just near to the rain gauge, so no not required. So there is an mechanical arrangement by which the two total amount of rain fall in there is just a mechanical arrangement by which the total amount of rainfall and since the record was started gets recorded automatically on a graph paper. So a one some automatic system is there which is just recording the total amount of rain and just making some graph on the graph paper also.

So the gauge thus produces record of cumulative rain versus time in the form of graph and generally this is known as the mass curve of rain fallen and this is called as mass curvature rain fallen, because in the recording time we have seen that here there the we are collecting the rain at 8:30 am one person expert person is just deputed there they took a go and collect the rain water whatever is remaining in the cylinder you please take it either you measure there or come to the lab and then measure it how much amount of the rain fall is there in the past 24 hours.

So since he is going at 8:30 am in the morning so definitely it is the record of your past 24 hours and then we can tell that this much amount of rain has taken place and this must centimeter of rain centimeter depth of rain or millimeter depth of rain has taken place. Now generally the recording type is a mechanically arranged automatic type it is just recording and making graph on the graph paper the gauge produces record of cumulative rain versus time total rain versus time.

So it reforms through the graph also and this graph is known as the mass curve of the rain fallen, generally this non-record recording type of rain gauges is divided into tipping bucket type, weighing bucket type and float type recording type or natural syphon type. So these are the common categories common recording categories of the recording type of rain gauges tipping

bucket type weighing bucket type and float recording type or natural syphon type, so these are a few of the recording type of rain gauges.

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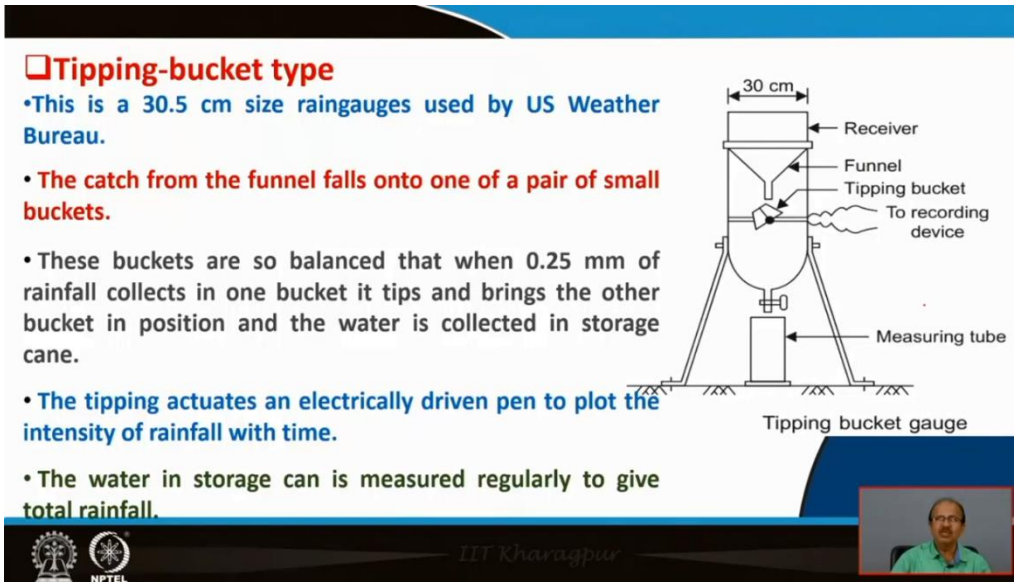

Now tipping bucket type is you can see in the figure also that it is the 30.5 centimeter rain gauges used by US weather bureau it is generally used by US weather bureau. The cash from the funnel falls into one of a pair of small buckets. So the rainfall which is being cast here is just falling on this you can see the receiver the funnel and through the funnel the rain water is entering into the tipping bucket type, this is just the your pair of small buckets.

So here what is happening these buckets are so balanced that when 0.25 mm of rainfall collects in one bucket so one bucket will collect 0.25 mm, it tips and brings the other bucket in position and the water is collected in the storage can. So this is generally taking place through which we can able to know about the details about the amount of rain which has taken place in the past duration. Now tipping actuates an electricity driven plan this tipping activity it actuates the electricity driven pen to plot the intensity of rainfall with time.

So just it is activating the electrically driven pen to just go and plot the intensity of rainfall versus time. So the water in storage can be measured regularly to give total rainfall, so this is the example of the tipping bucket type.

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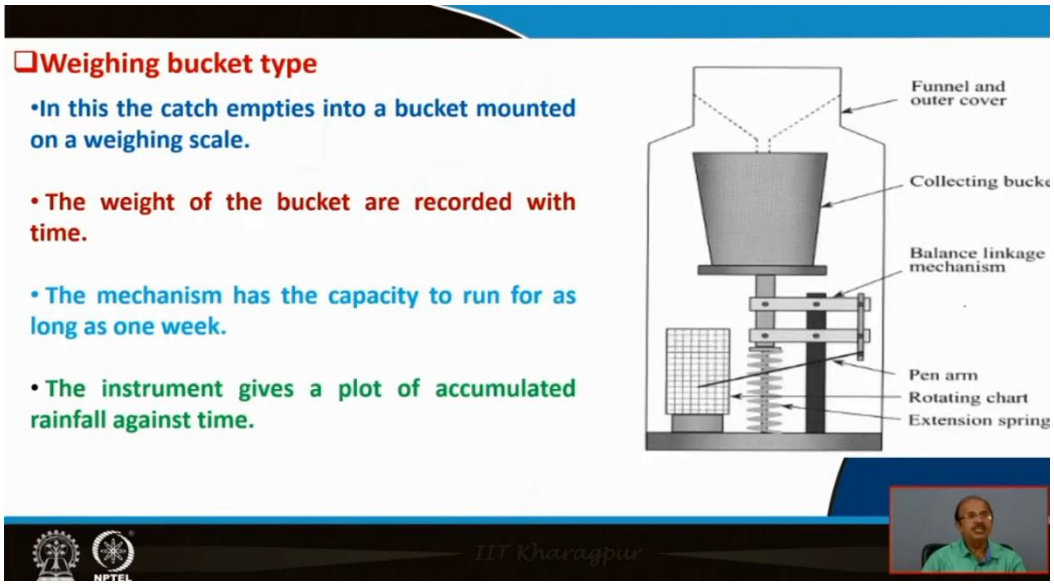

Now next is the weighing bucket type, in this you can see the bucket is mounted on where in the balance this is the weighing scale. So this is the funnel to which the through which funnel and outer cover is there and this is the collecting bucket and this bucket is just the based on the one your weighing scale the weight of the bucket are recorded with time just recorded with time and the mechanism has the capacity to run for as long as one week. So it has certain capacity also for it is working and the instrument gives a plot of accumulated rainfall against time.

So this is giving the total you can see here the pen arm is also there so as soon as the water is reaching in the your bucket this balancing linkage mechanism will starts and this will allow because you have seen these are connected with each one and this one so then the pen will just go and draft. So this is the pen will make graph and there is then we are getting the and your the total amount in the form of graph that is why it is the example of recording type of rain gauge.

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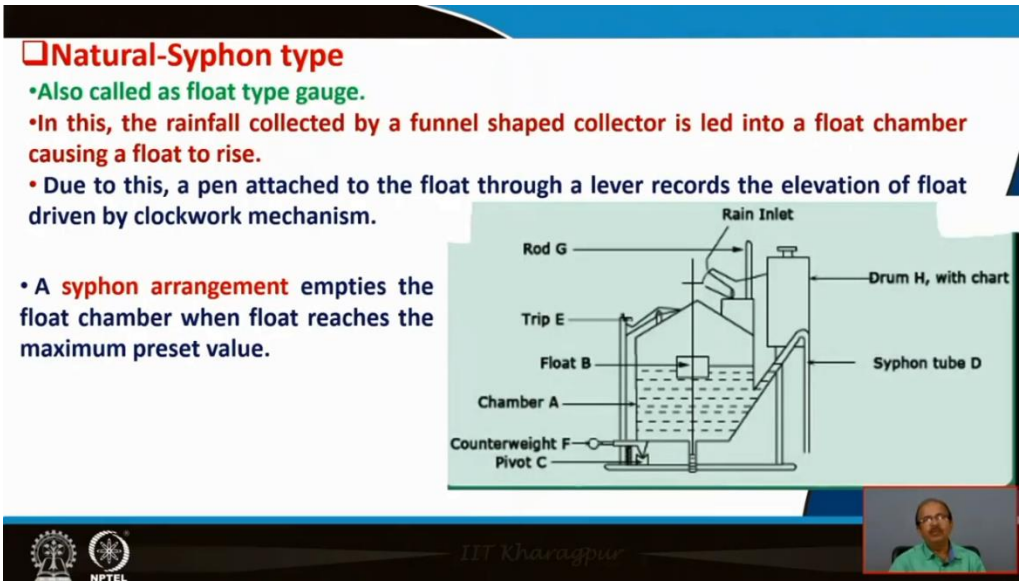

Third one is the natural syphon type of the recording type of gauge, it is also known as the flow type rain gauge. In this what is happening the rainfall is collecting by a funnel separate collector you can see on final separate collectors here to which the rain is just entering it is the this final separate collector is just attached with the float chamber which is causing a float to rise.

So what is happening the due to this a pen attached to this is the float chamber so a pen is here where you can see it is attached with the float chamber. And this pen is attached to a lever record it records the elevation of flow driven by clockwork mechanism. So just clockwise mechanically it is just moving and it is just recording the amount of rainfall has taken place. So a syphon arrangement the just what is once it is being filled up because of the syphon arrangement it empties the float chamber when float reaches the maximum preset value.

So when it is reached to the maximum value the because of the syphon arrangement the total volume of water rain water becomes empty from this float chamber. So this is about the third natural syphon type of the recording type of rain gauges. So now we have seen the different types of rain is available for the measurement of the rainfall. So if you are having the data or if you are willing the data of the rainfall then you can have the rain gauge and through the rain gauge;

You can just get the idea about the rainfall amount of the area in which you are just willing to know about the groundwater resources, how much volume of groundwater resources is available in our area. So this is the just the equipment through which we can measure the rainfall.

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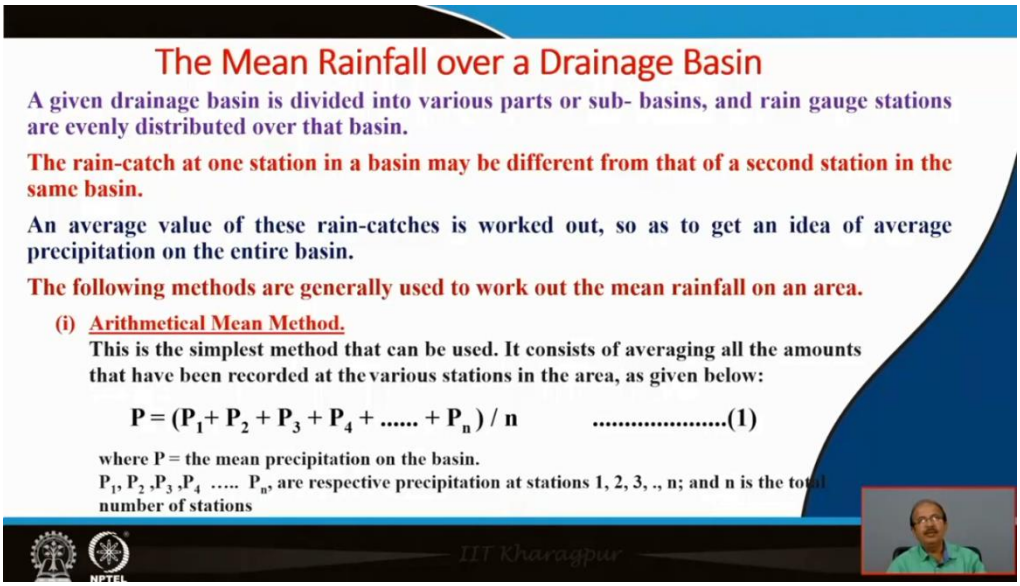

Now this is one of the important issue that how to collect the mean rainfall over a drainage basin. So suppose you are willing to know about the mean rainfall, so what are the different your points which are related with this. Because it is a very important generally we are for hydrological applications of our hierarchical different type of studies generally we require the mean rainfall average annual rainfall data.

So how can we measure this thing so a given drainage machine just a catch material university of catchment area is divided into various parts of sub-basins and so suppose one area in which you wish to know about the different issue about the different types of the your just to arrange the rain gauge network, so how you can find the because once you will decide about the rain gauge network then the thing is that you have to find out the mean rainfall value.

So because you have just installed the rain gauge stations through which you are just getting the amount of rainfall also, so how can we monitor or we can just analyze the mean rainfall over a catchment area. So what is happening the rain catch at one station because this is your area total drainage area, so it is just been divided into some different your areas. So that what is the benefit?

So that this will be divided into different parts because in each part we can install some rain gauge and we can monitor the amount of rainfall of the total sap catchment area. So here what is happening? The rain catch at one station in the basin because here whatever rain will fall it not necessarily the same amount of rain will be here only, no never. So since the variation of the rainfall amount takes place in a catchment base area or in a drainage basins.

So that time what we are getting we are getting the different values of rainfall in the different sub basins or sub your parts because total parts is divided into several parts and in the several parts we are having the value of the rain. So just we have to find out the mean rainfall of the area total area. So what are the methods so there are methods through which we can find out the mean rainfall.

And the first method is the arithmetical mean method this is just the very simple method arithmetical mean method is the very simple method, it can be used by just averaging all the amounts of the rain fall recorded at various rain gauge network stations. So at various rain gauge network stations just we have recorded the different amounts of the rainfall and thus then what we are doing just we are summing it just and dividing it with the number, so we you can see that the

$$P = (P_1 + P_2 + P_3 + P_4 + ... + P_n) / n$$

where P = the mean precipitation on the basin.

P_1, P_2 ,P_3 ,P_4 ….. P_n, are respective precipitation at stations 1, 2, 3, ., n; and n is the total number of stations

So this is getting the through this method athletic mean method we can get the idea about the mean rainfall of the machines or the catchment area.

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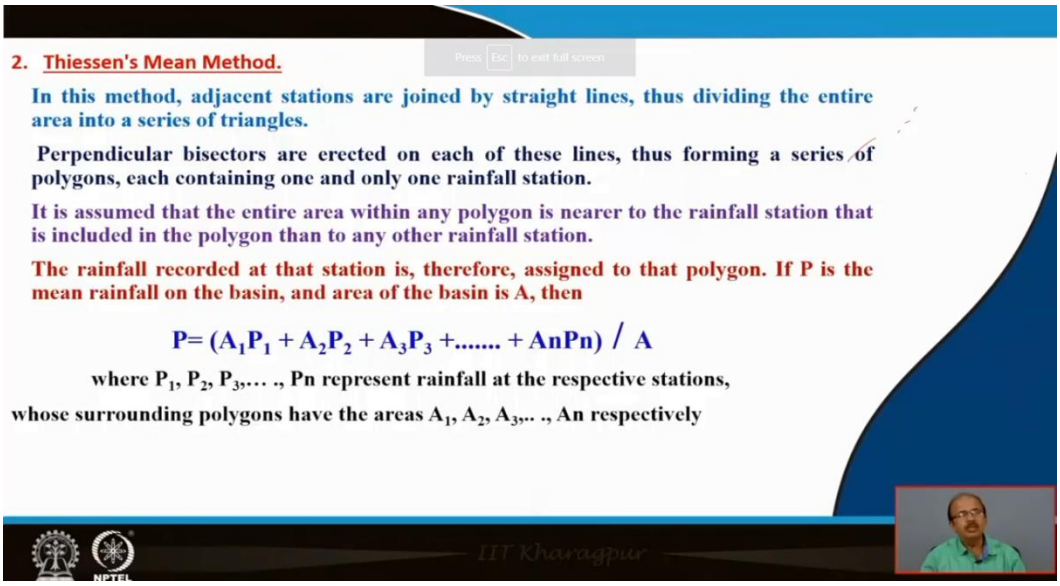

Now next second method related to the measurement of the mean rainfall is the Thiessen mean method or Thiessen polygon method. So in this method what we are doing we are just suppose three four stations are available here just stations are available different rain gauge network stations are there. So these stations are joined by straight lines and then what we is being done is just drawn the bisectors from the different your areas;

And then perpendicular bisectors are corrected on each of these lines and forming a series of polygons and each containing one and only one rainfall station. So it is generally assumed that the entire area within any polygon is near to the rainfall stations. So if this area is falling within one within a polygon then it is generally assumed that the entire area is having the rainfall amount what we are measured in this area.

So here the rainfall recorded at the station is assigned to that polygon and if P is the mean rainfall of the basin then of the area A then

$$P= (A_1P_1 + A_2P_2 + A_3P_3 +..... + AnPn) / A$$

where P_1, P_2, P_3,… ., Pn represent rainfall at the respective stations, whose surrounding polygons have the areas A_1, A_2, A_3,.. ., An respectively

So by arithmetic mean method and these are mean method we can able to find out the mean rainfall.

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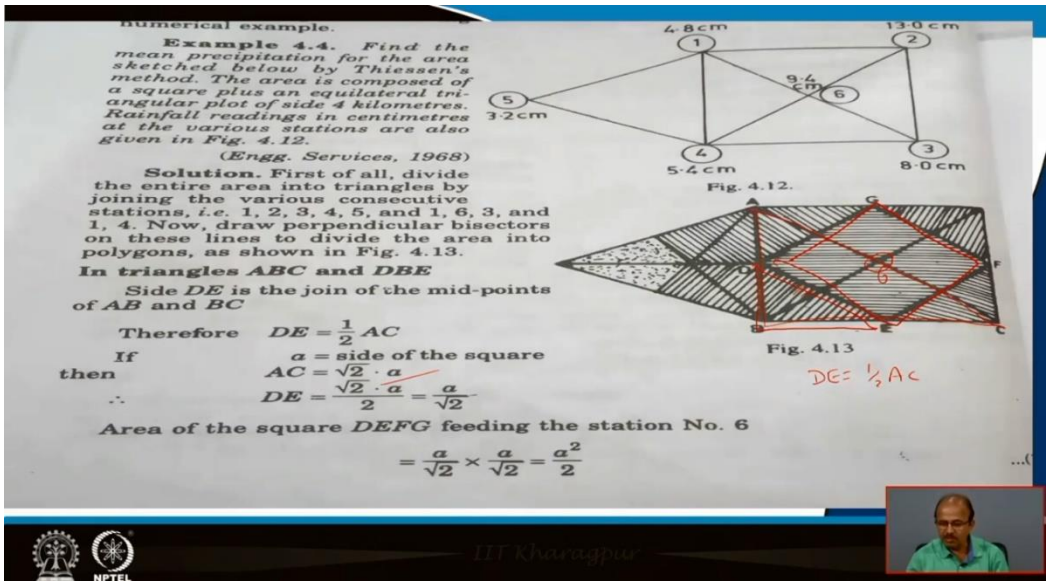

And on the basis of this reason mean method I am just solving one numerical you can see here find the mean precipitation for the area sketched below by thiessen method. So this is the area and this area question is to find the mean precipitation for this area. The area is composed of a square one square is there and plus one equilibrium triangle plot of side 4 kilometers, so side is 4 kilometer, rainfall leading in centimeter at the various stations are also given here.

So you can see for a station one 4.8 centimeters rainfall, for two 13.0, for three 8.0, four 5.4, six 9.4 and five 3.2 centimeter. So this is generally the problem is to find the mean rainfall stations if the of the area which is scarce as a your which comprises of the square and equilateral triangle and side of the area is whose side is 4 kilometer. So this is the problem. Now what to do? First of all just divide the entire area because this is the problem this you have to do so first of all divide the entire region into triangles.

So joining the various conjugative stations 1, 2 so 1, 2, 3, 4 just and 1, 6, 3 and 1, 4. So just it is making the triangle first and then perpendicular bisectors and then you can see that the area this is just joined and 1, 2, 3, 4 triangle this is square area this is equilateral. So in this way first of all the first job is to put the triangle form then the bisectors so first of all divide the entire area into triangles by joining the various consecutive stations 1, 2, 3, 4, 5 and 1, 6, 3, 1 and 4.

Now draw perpendicular bisectors on these lines, so on each lines into draw perpendicular bisectors. So this we have done here you can see the perpendicular bisector is there on each line. So then to divide the area into small polygons so this has been done now in triangle ABC and DBE you can see this inside D is the join of the midpoints of AB and BC. So in this is the A and this is B so ABC and this is DEF, so G.

So these are the some of the in the triangle ABC this one ABC and triangle DBE this one. So side D is the join of the midpoints so side D this one is the join of the midpoints of AB and BC.

$$DE = \frac{1}{2} AC$$

Now if A is the side of the square because a 1 is this is the square and this is the equilibrated triangle so

$$AC = \sqrt{2}\, a\ .$$

$$DE = \frac{\sqrt{2}\, a}{2} = \frac{a}{\sqrt{2}}$$

Now Area of the square DEFG feeding the station no. 6

$$= \frac{a}{\sqrt{2}} * \frac{a}{\sqrt{2}}$$

$$= \frac{a^2}{2}$$

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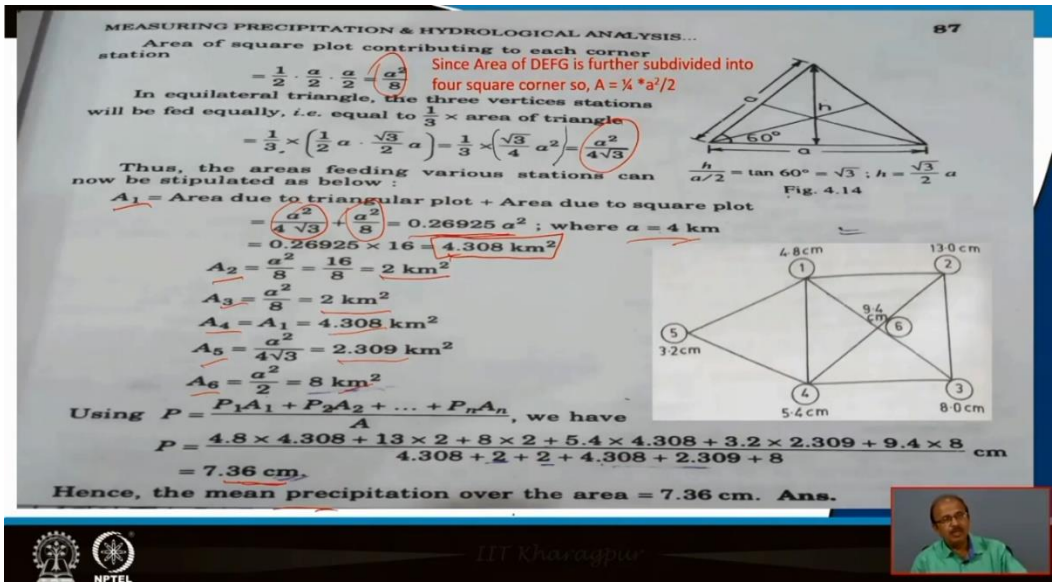

Now in this just area of the square plot contributing to each corner station will be

$$\frac{1}{2} * \frac{a}{2} * \frac{a}{2} = \frac{a^2}{8}$$

why? Because area since area of DEFG further subdivided into four square corner. So

A= $\frac{1}{4} * * \frac{a}{2} * \frac{a}{2} = \frac{a^2}{8}$ So this will become the this will come to the $\frac{a^2}{8}$. Now this is for the square plot now for the equilateral triangle the three vertices station will be fed equally that

$$\frac{1}{3} * \left(\frac{a}{2} * \frac{\sqrt{3}\, a}{2} \right) = \frac{1}{3} * \frac{\sqrt{3}\, a^2}{4} = \frac{a^2}{4\sqrt{3}}$$

So this area feeding various stations can be stipulated as below where how

A1= area due to triangular plot area triangular plot + area due to square plot.

A1 = $\frac{a^2}{4\sqrt{3}} + \frac{a^2}{8} = 0.26925\ a^2$

A2 = $\frac{a^2}{8} = \frac{16}{8} = 2\ km^2$

A3 = $\frac{a^2}{8} = 2\ km^2$

A4 = A1 = 4.308 km^2

A5 = $\frac{a^2}{4\sqrt{3}} = 2.309$

A6 = $\frac{a^2}{2} = 8\ km^2$

using

$$P = \frac{(\text{A1P1} + \text{A2P2} + \text{A3P3} + \ldots\ldots + \text{AnPn})\ 16}{A}$$

We have,

$$P = \frac{4.8 * 4.308 + 13 * 2 + 8 * 2 + 5.4 * 4.308 + 3.2 * 2.309 + 9.4 * 8}{(4.308 + 2 + 2 + 4.308 + 2.309 + 8)}$$

$$\text{P} = 7.36$$

mean precipitation over the area. So this is all about the finding the mythology about the mean precipitation of any area, so with this thank you very much to all.