Surface Water Hydrology
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Lecture – 07
Measurement and Analysis of Precipitation

In this lecture 7 we will cover measurement and analysis of precipitation.

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This is important to know for a particular region, how much rainfall has occurred and there are different instruments are there known as rain gauges. So, how to measure the rainfall through rain gauges, that we will cover in this lecture and then we will see the different types of rain gauges that are used for measurement of the rainfall.

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The outline goes like this, first a very brief introduction, mostly showing what the requirements are when we are installing one rain gauge. The second thing was how we measured the precipitation. And third, the rain gauge network and there are different problems sometimes we face while collecting, and that after collection of the data to check its initial quality control, we will see how to correct it and how to detect it first. And finally, we will talk something about its summary of the entire lecture.

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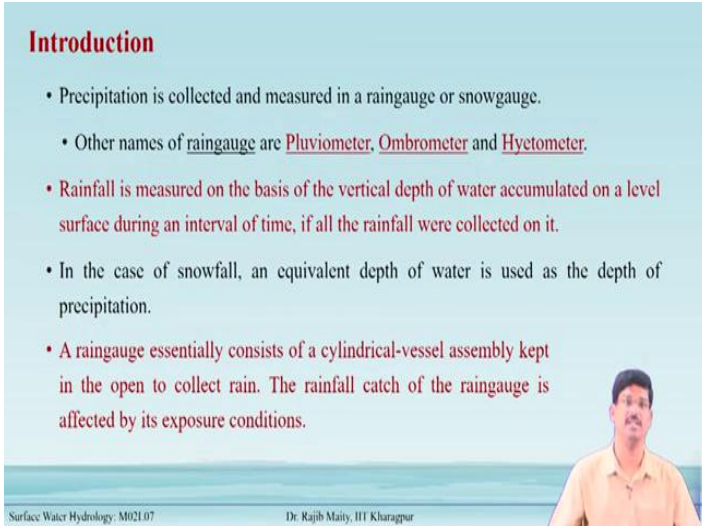

Introduction

When we measure the precipitation, use the instrument called rain gauge, and for the snowfall we use it as a snow gauge, there are other names are also there for rain gauges such as pluviometer, ombrometer or hectometer like these, these are all synonymous to the rain gauge.

When rainfall is measured, the basic thing is that we generally try to assess what is the vertical depth of water that is accumulated on a level surface during an interval of time and if all the water is collected on it. So, we take a surface and suppose that we take some particular duration of the time some most of the time, it maybe goes up to a day. So, if once in a day we collect, we can say that over 24 hours, how much rainwater is accumulated. So, that particular vertical depth is the way we saw the measurement of this rainfall.

That means, if on a particular date, the rainfall is said 100 mm that means, whatever rain has occurred if it is stored on a surface, the vertical depth of the accumulated water will be 100 mm. Now, in the case of snowfall, the direct water volume did not be equal to the snowfall volume. So, it generally contents are very less amount of water depending on the snow density.

So, what initially is done is that some equivalent water depth, so, it is melted and find out what is the equivalent to water depth that is used to denote that amount of the precipitation in case of snowfall. Then rain gauge is generally what happens it is content a surface which is kept originally and it is collected in a cylindrical vessel assembly which is kept open to collect the rain. So, once the rainfall catch of these rain gauges are affected by its exposure condition. So, if we keep it in some specific condition has to be maintained, so, that the nearby disturbances should not cause any erroneous collection of the rainfall in the rain gauge instrument.

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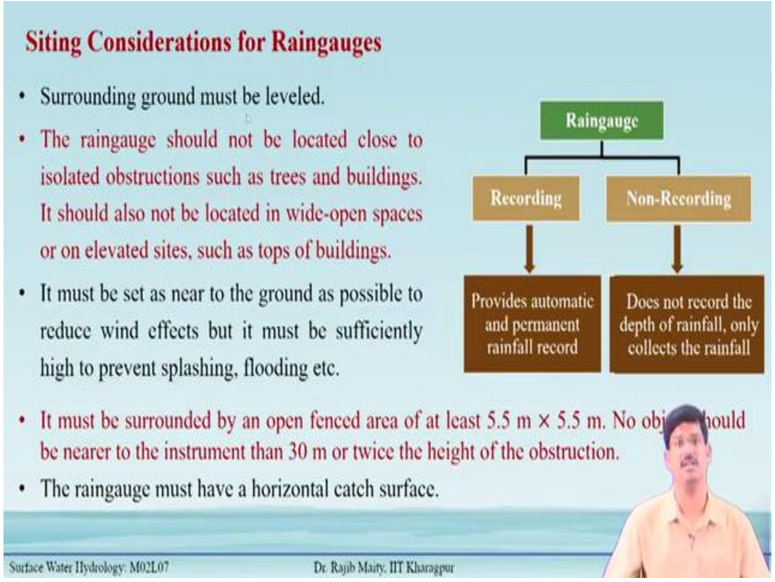

Siting Considerations for Rain gauges

- The surrounding ground must be leveled.
- The rain gauge should not be located close to isolated obstructions such as trees and buildings. It should also not be located in wide-open spaces or on elevated sites, such as the tops of buildings.
- It must be set as near to the ground as possible to reduce wind effects but it must be sufficiently high to prevent splashing, flooding, etc.
- It must be surrounded by an open fenced area of at least 5.5 m X 5.5 m. No object should be nearer to the instrument than 30 m or twice the height of the obstruction.
- The rain gauge must have a horizontal catch surface.

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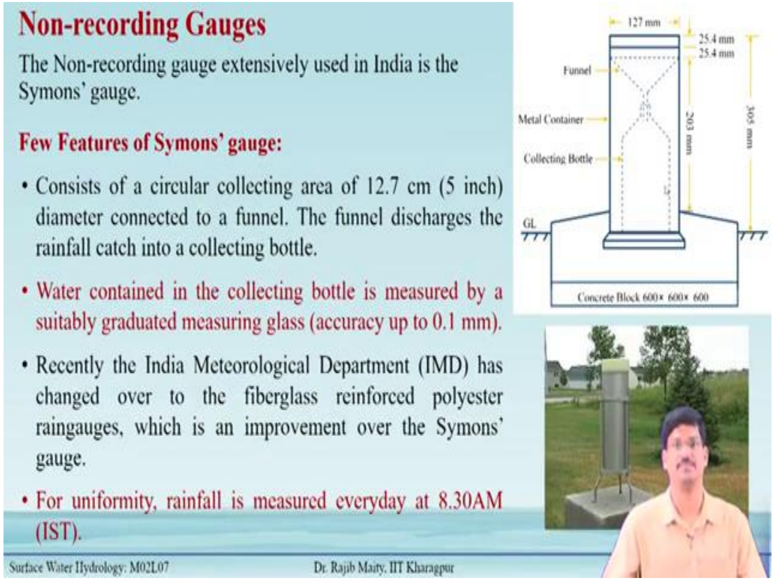

Non-recording Gauges

The most commonly used non-recording gauge is a Symon's gauge and there are a few features of the Symon gauge as shown here.

- Consists of a circular collecting area of 12.7 cm (5 inches) diameter connected to a funnel. The funnel discharges the rainfall catch into a collecting bottle.
- Water contained in the collecting bottle is measured by a suitably graduated measuring glass (accuracy up to 0.1 mm).
- Recently the India Meteorological Department (IMD) has changed over to the fiberglass reinforced polyester rain gauges, which is an improvement over the Symons' gauge.
- For uniformity, rainfall is measured every day at 8.30AM (IST).

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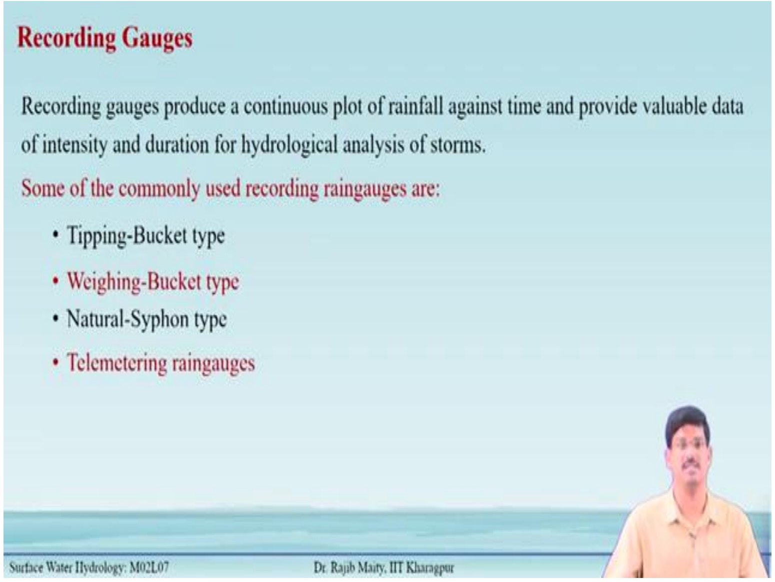

Recording Gauges

Recording gauges produce a continuous plot of rainfall against time and provide valuable data of intensity and duration for hydrological analysis of storms. Some of the commonly used recording rain gauges are:

- Tipping-Bucket type
- Weighing-Bucket type
- Natural-Syphon type
- Telemetering rain gauges

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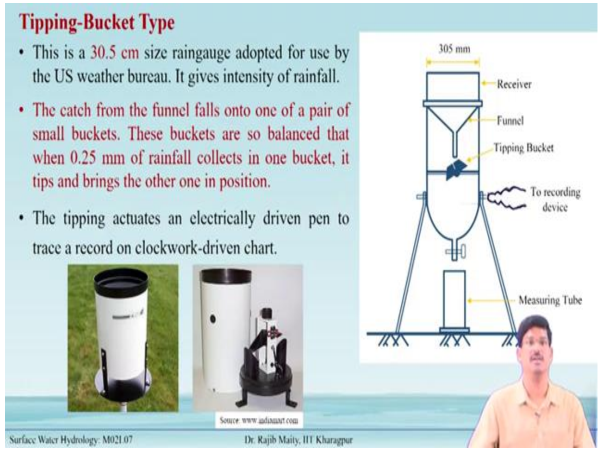

Tipping-Bucket Type: This is a 30.5 cm size rain gauge adopted for use by the US weather bureau. It gives the intensity of rainfall. The catch from the funnel falls onto one of a pair of small buckets. These buckets are so balanced that when 0.25 mm of rainfall collects in one bucket, it tips and brings the other one in So, you can see the arrangement in fig.1. It is an open bucket where rainfall collect and pass through the funnel and it just drops here. So, once this is filled so this is filled with the rainfall of 0.25mm and then it tips to the other side so, it drains and then the other side of the bucket comes below this funnel outlet. And again another 0.25 mm rainfall comes and again it tips on the other side.

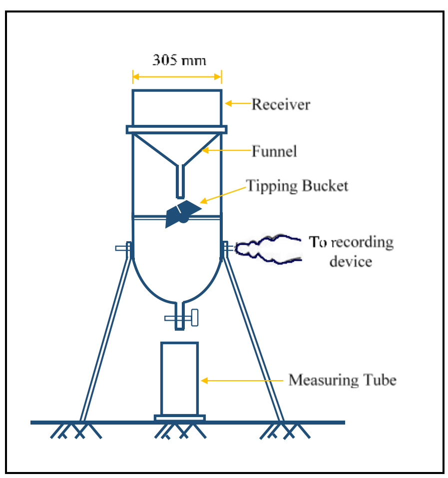

Fig.1 shows the tipping bucket type of rain gauge

So, each tip is recorded and each tip is equivalent to 0.25 mm, he tipping actuates an electricity-driven pen to trace the record on this clock-driven chart. So, there is a chart being prepared, where every tip is recorded when it was there. So, in between two tips, it is 0.25 mm rainfall.

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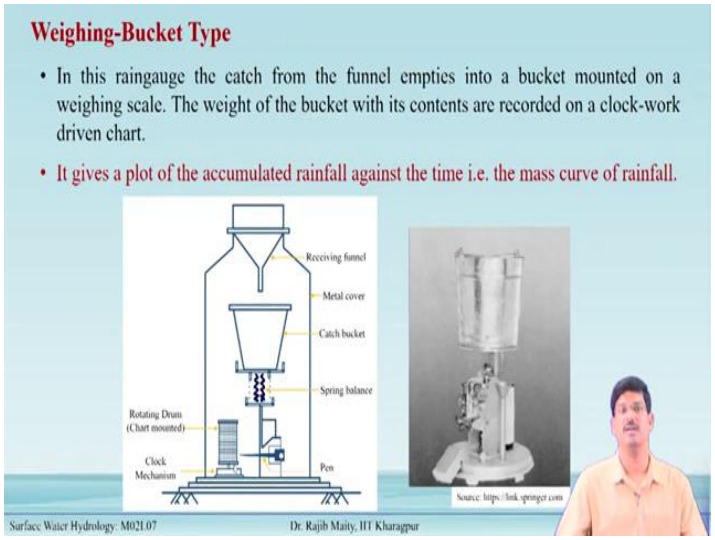

Weighing-Bucket Type: In this rain gauge, the catch from the funnel empties into a bucket mounted on a weighing scale. The weight of the bucket with its contents are recorded on a clock-work driven chart which is shown in fig.2. So, that more and more rain is collected in the bucket the weight machine it is going towards downward and this weighing machine is connected to a pen and that pen is giving a trace on a cylindrical drum and the cylindrical drum there is a paper wrapped. This drum rotates in a clockwise manner in a chronological way.

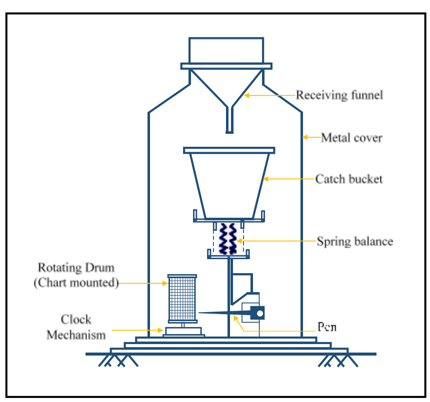

Fig.2 shows the weighing bucket type of rain gauge

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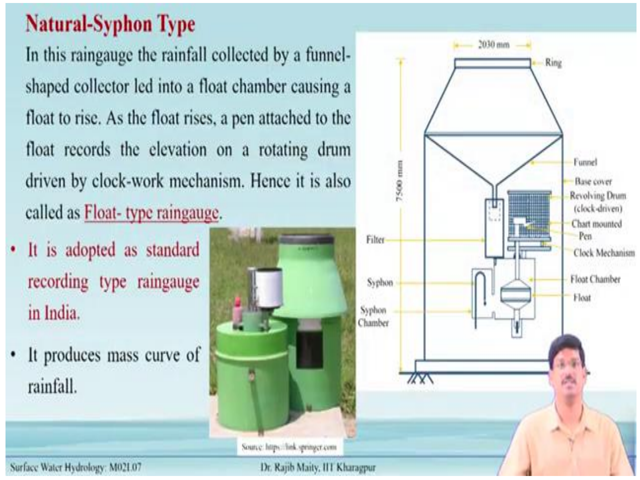

Natural-Syphon Type: In this type of rain gauge the rainfall collected by a funnel-shaped collector led into a float chamber causing a float to rise. As the float rises, a pen attached to the float records the elevation on a rotating drum driven by a clock-work mechanism. Hence it is also called a float type rain gauge.

In fig.3 there is a pen and on a graphic arrangement is there, where there will be tests as more and more rain is being collected. And so, this pen is not on the weighing bucket here it is this now collected on a floating system. So, more and more water is being collected this floating will go up and it will be drawn here. Now, if it goes to a certain height, then automatically this goes to an automatic syphon system here. So, it will empty the entire chamber again.

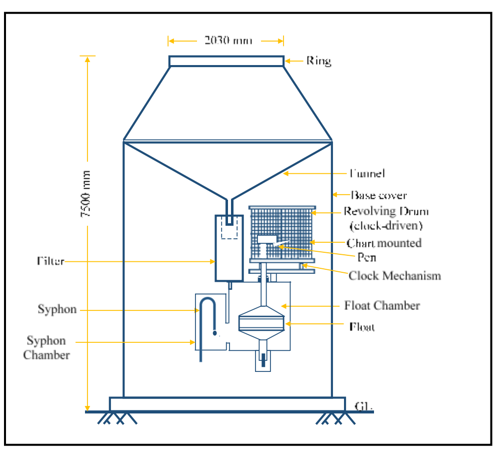

Fig.3 shows the natural syphon type of rain gauge

So, it is emptying the entire chamber once it is filled up. It may need to more irregular visit to the site and allows us to more gap between ways you can go and collect this graph paper. So, in this graph, what rainfall occurs and being accumulated it will be shown by a graph but once in a while when the syphon occurs, there will be straight downward the straight line will be seen and those downward traces of this graph will indicating that that particular moment the chamber was syphoned to make it emptied again. It is adopted as standard recording type rain gauge in India. It produces mass curve of rainfall.

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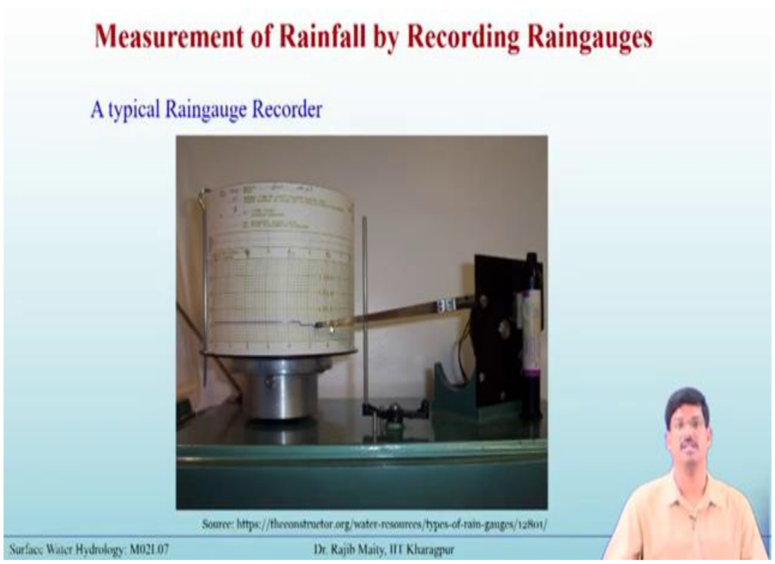

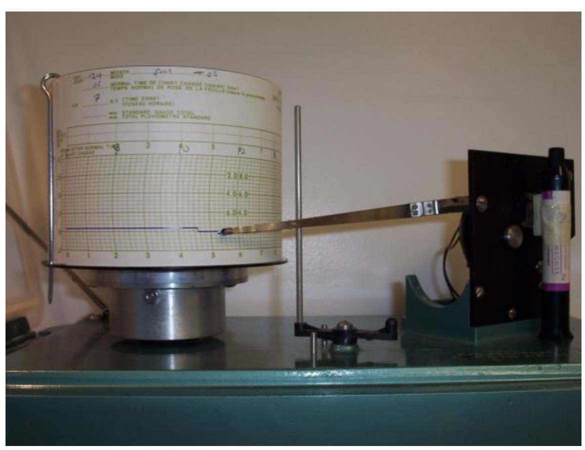

Fig.4 shows the a typical rain gauge recorder

A typical rain gauge shows in fig.4 where the element when it is wrapped on a cylindrical drum and there is a pen that put the stress here one typical rain gauge recorded that you can see in fig.4 how these things if there is by either by proton if this moves vertically, so this pen is also moving on this drum. Now, this drum is rotated on in a clock time so that it rotates over actual time with the clock and this keeps on stressing the line.

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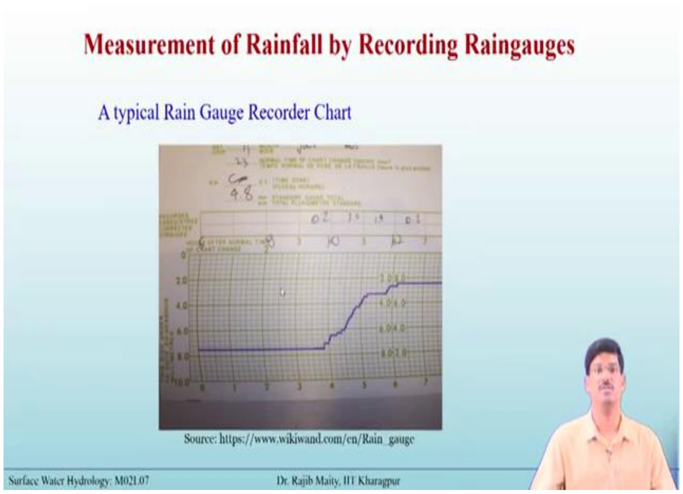


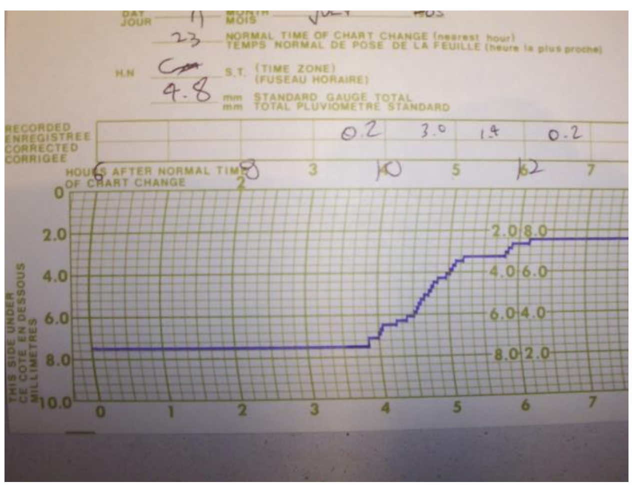
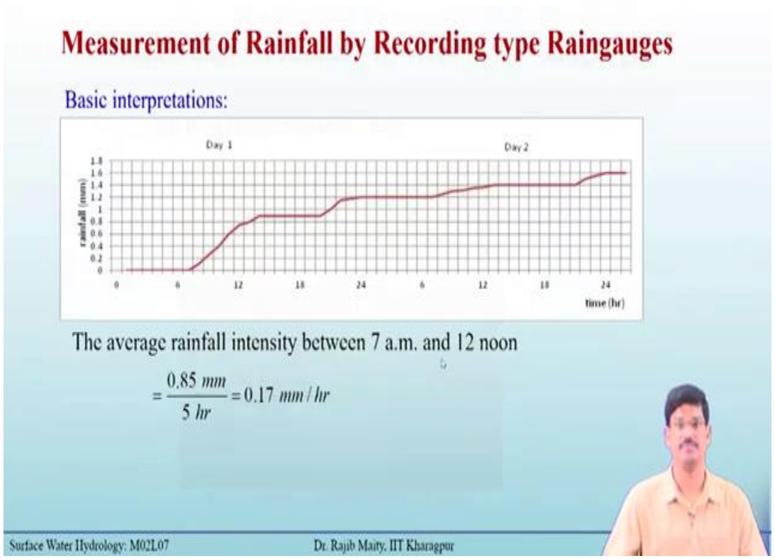
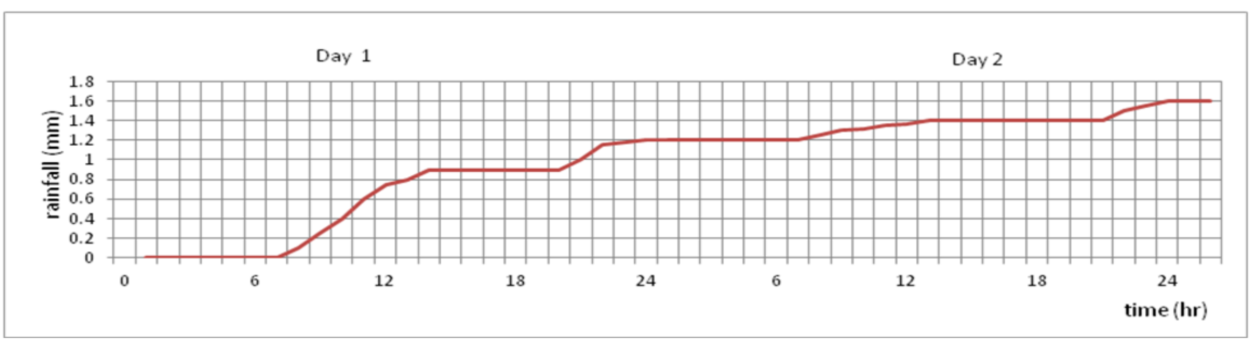


Fig.5 shows a typical rain gauge recorder chart

So, if I take out that particular paper and just flatten it, we may see a trace which is shown in fig.5. Here it is flat that you can see. So, that means the drum is rotating, but the pen is fixed horizontally and once it has started going up. The pen is moving in that direction which means, the rain is happening again. The rain stop at this particular point it remains again horizontal and again it starts small rainfall, again it goes there. Once it is horizontal that means, there is no rain, once it is moving upward there is rain, and we can get the intensity also that means the slope of this one so, if it is very steep that means the intensity is high, if it is less slope, then we can say the intensity is les(Refer Slide Time: 15:57)



Basic Interceptions:



The average rainfall intensity between 7 a.m. and 12 noon

$$= \frac{0.85\ mm}{5\ hr} = 0.17\ mm/hr$$

Total rainfall in Day 1 = 1.2 mm

And total rainfall in Day 2 = 1.6 – 1.2 = 0.4 mm

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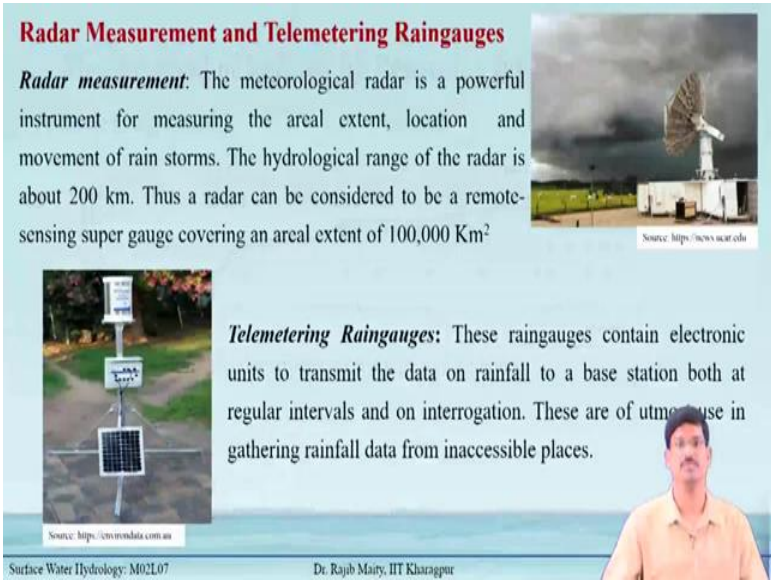

Radar Measurement and Telemetering Raingauges

Radar measurement: The meteorological radar is a powerful instrument for measuring the areal extent, location, and movement of rainstorms. The hydrological range of the radar is about 200 km. Thus a radar can be considered to be a remote-sensing super gauge covering an aerial extent of 100,000 Km^2

Telemetering Rain gauges: These rain gauges contain electronic units to transmit the data on rainfall to a base station both at regular intervals and on interrogation. These are of utmost use in gathering rainfall data from inaccessible places.

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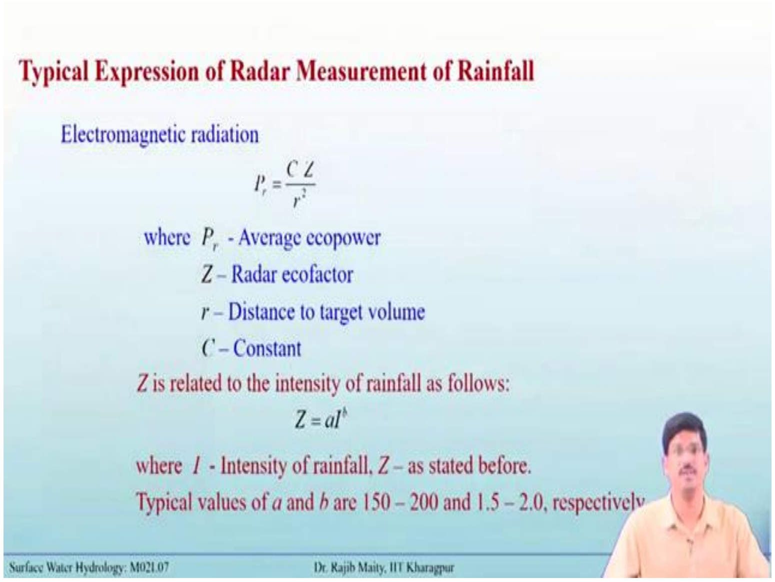

Typical Expression of Radar Measurement of Rainfall

Electromagnetic radiation

$$P_r = \frac{C\ Z}{r^2}$$

where, P_r - Average eco power

Z – Radar ecofactor

r – Distance to target volume

C – Constant

Z is related to the intensity of rainfall as follows:

$$Z = aI^b$$

Where I - Intensity of rainfall, Z – as stated before.

Typical values of a and b are 150 – 200 and 1.5 – 2.0, respectively.

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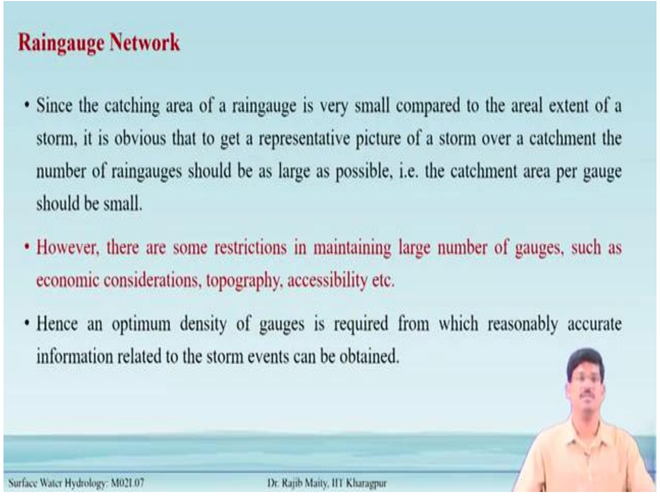

Rain gauge Network

Since the catching area of a rain gauge is very small compared to the areal extent of a storm, it is obvious that to get a representative picture of a storm over a catchment the number of rain gauges should be as large as possible, i.e. the catchment area per gauge should be small.

However, there are some restrictions in maintaining a large number of gauges, such as economic considerations, topography, accessibility, etc. Hence an optimum density of gauges is required from which reasonably accurate information related to the storm events can be obtained.

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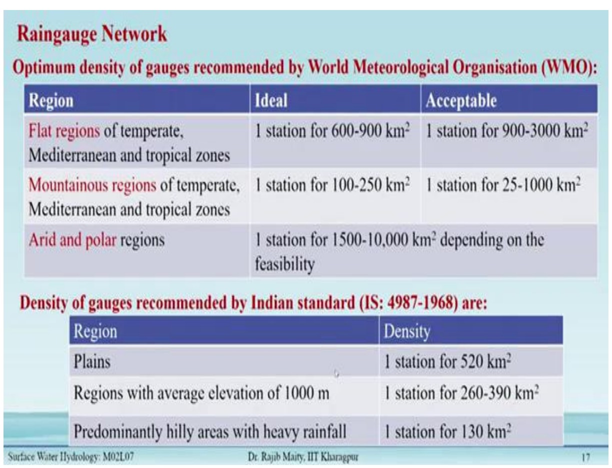

Rain gauge Network

The optimum density of gauges recommended by the World Meteorological Organization (WMO):

Region	Ideal	Acceptable
Flat regions of temperate, Mediterranean and tropical zones	1 station for 600-900 km^2	1 station for 900-3000 km^2
Mountainous regions of temperate, Mediterranean and tropical zones	1 station for 100-250 km^2	1 station for 25-1000 km^2
Arid and polar regions	1 station for 1,500-10,000 km^2 depending on the feasibility	

The density of gauges recommended by Indian standard (IS: 4987-1968) are:

Region	Density
Plains	1 station for 520 km^2
Regions with average elevation of 1000 m	1 station for 260-390 km^2
Predominantly hilly areas with heavy rainfall	1 station for 130 km^2

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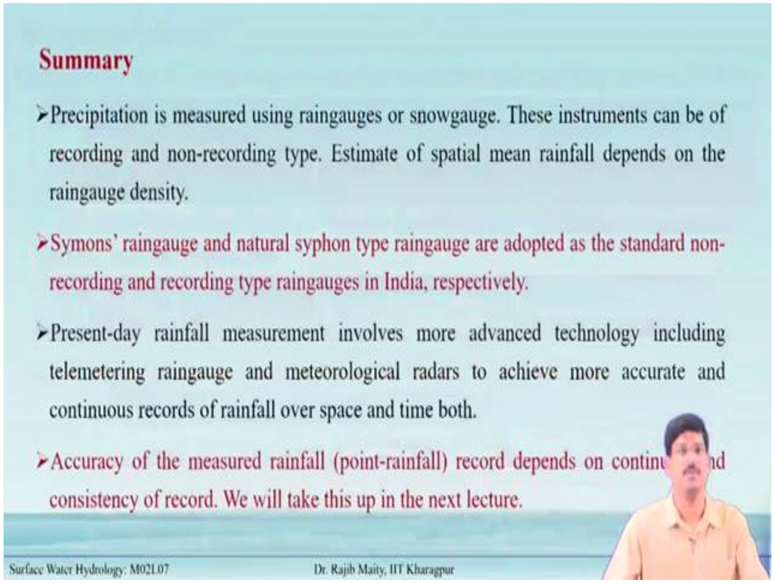

Summary

In summary, we learned the following points from this lecture:

- Precipitation is measured using rain gauges or snow gauges. These instruments can be of recording and non-recording type. Estimate of spatial mean rainfall depends on the rain gauge density.

- Symons' rain gauge and natural syphon type rain gauge are adopted as the standard non-recording and recording type rain gauges in India, respectively.

- Present-day rainfall measurement involves more advanced technology including telemetering rain gauge and meteorological radars to achieve more accurate and continuous records of rainfall over space and time.

- The accuracy of the measured rainfall (point-rainfall) record depends on continuity and consistency of record. We will take this up in the next lecture.