Soil and Water Conservation Engineering
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Lecture – 10
Soil Loss Measurement

Hello friends. Welcome back to NPTEL online certification course entitle Soil and Water Conservation Engineering and I am Rajendra Singh, professor in Agricultural and Food Engineering Department IIT, Kharagpur and we are in week 2, the last lecture; lecture 10 of this particular week and the topic is Soil Loss Measurement.

In this week we started with lecture 6 discussing about the soil loss estimation using universal soil loss equation; lecture 7, we devoted on finding out erosivity and erodibility which are two important components of universal soil loss equation; in lecture 8 and 9 we went through the modifications in universal soil loss equation that we saw modified universal soil loss equation and the wise soil loss equation and we saw how to utilize them and the last lecture of this week that is today's lecture we are going through soil loss measurement, that is how to measure soil loss.

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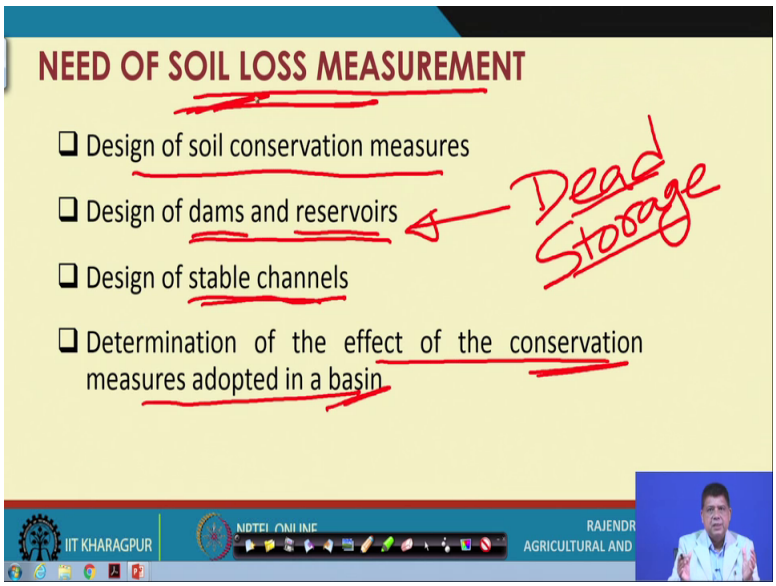

Now, the question is why do we need to measure soil loss, I mean that is important question. And, we need to measure soil loss because it is helpful in design of soil conservation measures, which helpful in design of dams and reservoirs, it helps us in

designing stable channels and also helps us in determining the effect of the conservation measures adopted in a basin.

So, if you want to design a soil conservation for a given area then what are the we have seen that in our introductory lectures we have seen that various kinds of soil conservation measures are possible, there are some agronomical measures, biological measures, then engineering measures of various kinds there. So, which combination or which soil conservation needs to be adopted for a given area that will be determined basically by the amount of or magnitude of soil loss that is taking place in that particular area. So, that is that is where we need to know the soil loss.

Then same we discussed about several types we discussed about the dams and reservoirs that whatever studied that is transported from a given area that is detach and transported from a given area finally, that is gets deposited into water bodies say reservoir or ponds or channels or rivers. So, obviously, when we design reservoir there is in the life of reservoir something defined is dead storage is there and dead storage is the provision of the storage while designing reservoir to accumulate silt or sand that will come into the reservoir over its life period.

So, we already know when we design reservoir we always know that some kind of siltation will always be there and we make a provision for that. So, how much there is storage or how much silt is expected over a given period of time of interest for us that can be only known if know the soil loss rather if we measure the soil loss in the upstream area. Similarly, based on this soil loss data we can design stable channels that is channels we know that when we design channel you always keep an eye on non erosive channels; that means, they should be should not be any further erosion taking place and certain velocity of flow. So, obviously, that will be governed by the soil loss that is being generated, so that means, we need the soil loss data.

And, finally, if we have adopted a certain kind of conservation measures in any soil consumption program in a basin, so, how effective that particular conservation measure or measures that we have adopted are, that will be only evaluated based on the measurements of soil loss or soil loss that has getting generated.

So, soil loss measurement is very important while designing or evaluating any of the conservation measures or conservation practices that has been adopted in a given watershed.

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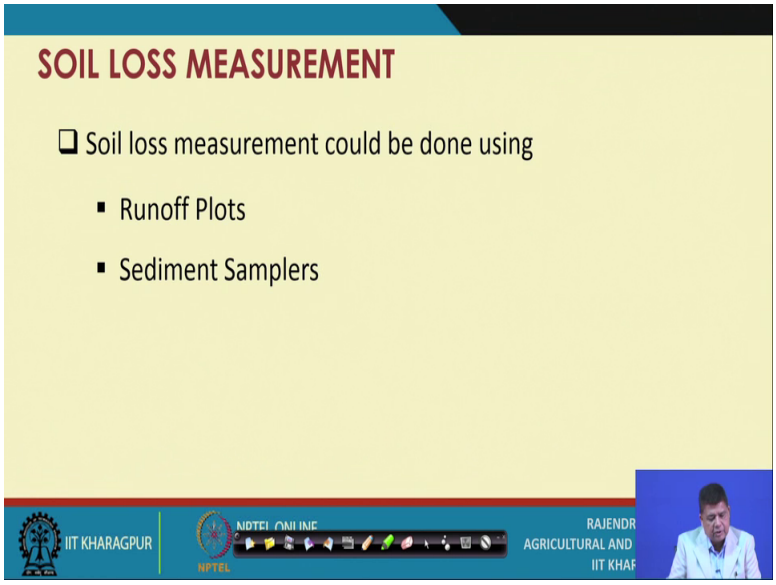

Now, coming to soil loss measurement there are two possible ways of measuring soil loss; one is runoff plots, another is by using sediment samplers. So, either of these can be utilized runoff plots or sediment samplers. Let us take how to use them one by one.

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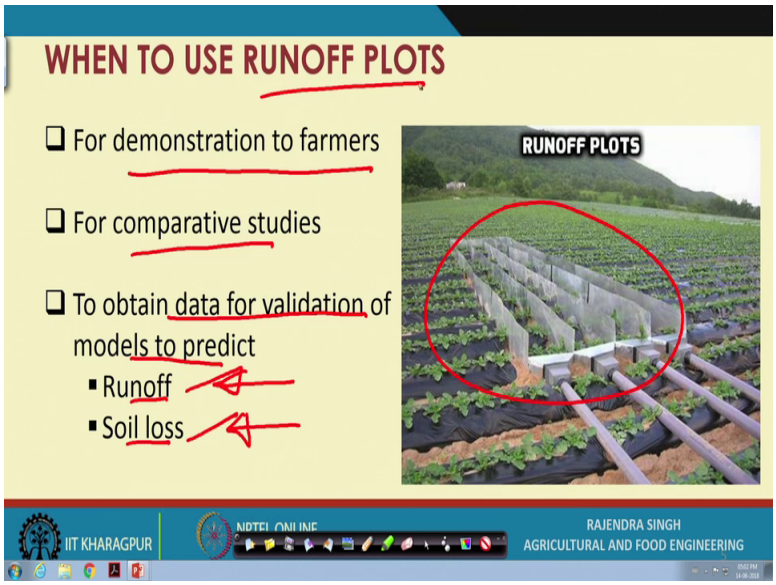

Now, question is when to use runoff plots? Now, runoff plots are preferred when we have to make any kind of demonstration to farmers in the field because they are more experimentally later they can they are typically they are they are in the field conditions. So, it is very easy for farmers to understand what we are trying to demonstrate them and that is why whenever we have to demonstrate soil conservation measure or any cultivation practice which is favorable then we use runoff plots.

Then for comparative studies; if you want to compare two kinds of cultivation practices or two kinds of conservation measures then obviously, we need to use runoff plot experiments in order to be able to tell which cultivation practices batter than the other or which measure is more suitable for a given area and of course, to obtain data for validation of models to predicts runoff and soil loss we have several models available for predicting runoff and soil loss I mean their they simulate runoff or simulate soil loss, so, just to be able to evaluate how this models are performing or validating the results of this models we need experimental data and then in that case we use runoff plots for conducting our experiments.

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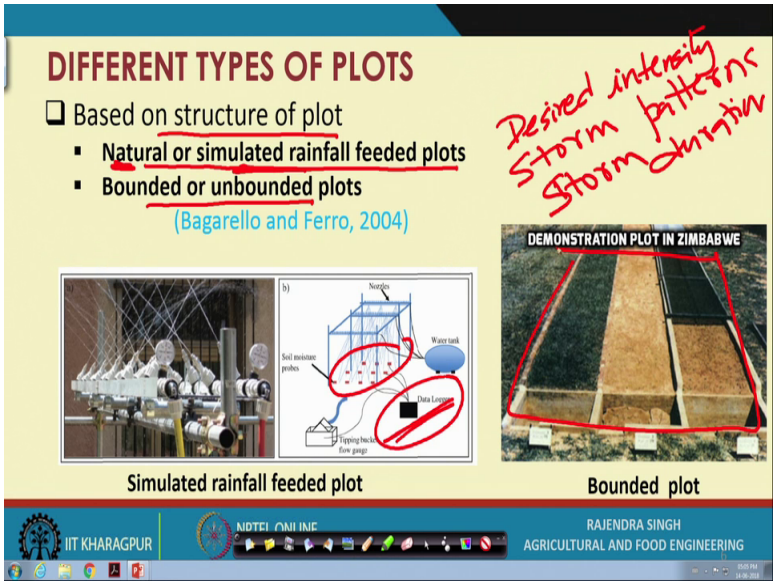

Now, there are different types of runoff plots and they are classified based on two things; one is based on structure of plot another is based on the structure based on the size itself. So, let us say we see the based on the structure of the plot then runoff plots are classified as natural or simulated rainfall feeded plots or bounded or unbounded plots, that is two

types of classification are possible in these cases. So, when we say natural or simulated rainfall feeded plots. So, natural plots the name itself suggest that is natural that is the rainfall conditions in the nature rainfall is natural rainfall, but in laboratory many a times during in the in the laboratory conditions we use plots with simulated rainfall.

And, the advantage of simulated rainfall is that ah say for example, this is the example of simulated rainfall feeded plot. So, here the advantage is that once the rainfall is being simulated by us so, we can create rainfall of desired intensity that is we can vary the intensity we can experiment with various kinds of storm patterns that is a rainfall first rainfall is very high intensity then low intensity then high intensity or high intensity then low intensity ah. So, all kinds of storm patterns we can simulate when we are simulating rainfall that then also the duration storm duration is another variable which we can always capture using the rainfall simulators.

So, that means, various kinds of variations are possible when we are simulating rainfall using rainfall simulators and also because they are put into laboratory condition most of the time so, obviously, it is also possible to use sophisticated measurements by say for example, we can use various kinds of sensors, we can use data loggers and we can also I mean various kinds of variations are possible when we use a rainfall simulated rainfall feeded plot which is generally done under control environment under laboratory conditions.

And, then the second type of ah plots are bounded or unbounded plots, so that means, boundary whether there is a boundary or not. So, here we say the example there is a boundary here so, it is an example of bounded plot, but if you go just outside ah to any field condition and that can be also a runoff plot because ah I mean we can say that it is a runoff plot because runoff will defiantly occur when then it can be in unbounded condition. So, it is a unbounded plots. So, unbounded plot are again quit natural where is bounded plots are little bit control because we are controlling things here. So, that is the based on structure of the plot.

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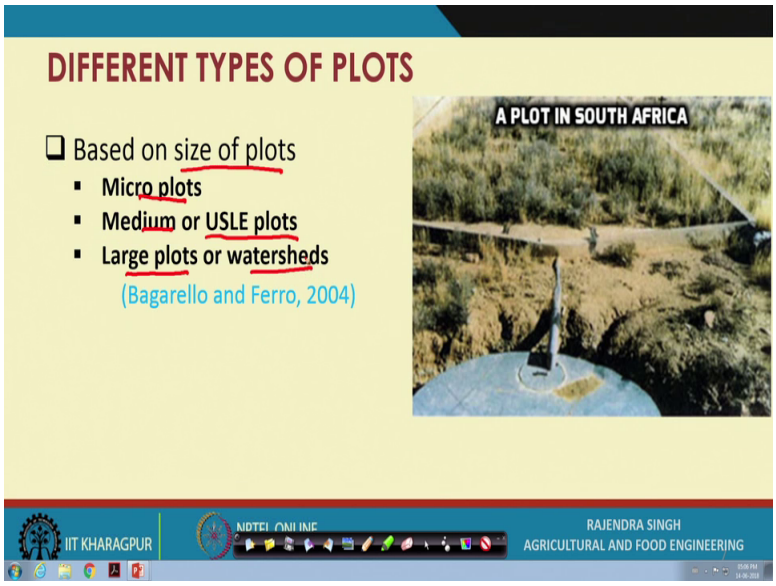

Then other classification is I already mention is based on the size of the plots and there are three types of based on size ah. Three types of runoff plots; micro plots, medium plots which are also referred to a USLE plots remember we discussed about the standard USLE plot so, these are standard USLE plots and their they can be the third one a large plots or even the watersheds and the natural conditions. So, they can also be called is a runoff plots. So, based on the structure based on the size runoff plots could be a varying types.

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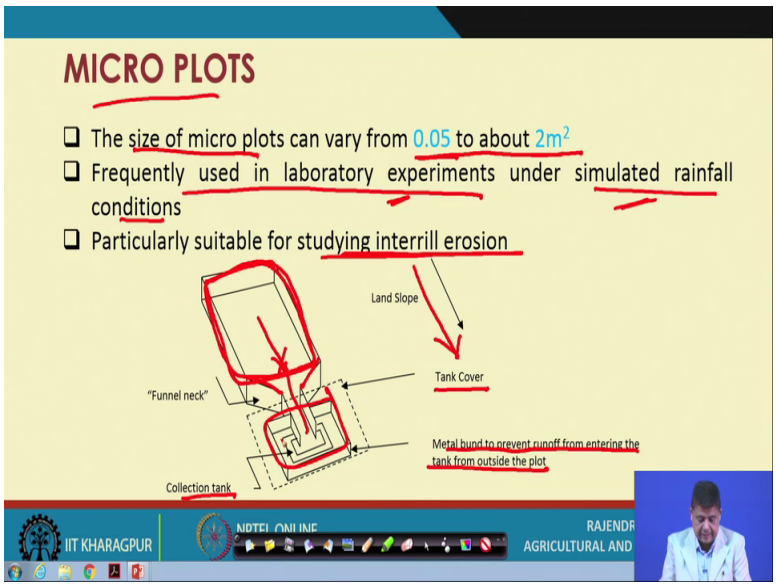

Let us go into details of various kinds of plots and let us begin with micro plots. So, the size of micro plots can vary from 0.05 to about 2 square meter. So, you can see that the size is really small and that is why the term micro is used. So, the size limitation is that side could vary over 0.05 square meters to about 2 square meters and because of their size advantage they are frequently used in laboratory experiments under simulated rainfall conditions. So, this is ah the micro plots are typically used in laboratory experiments and with simulated rainfall conditions.

And, they are particularly suitable for studying interrill erosion. So, we saw various kinds of erosion processes. So, in for interrill erosion micro plots are very suitable and this is the typical diagram of a micro plot, this is the land slope direction which we are see here.

So, here you can see that this is really the experimental area, this is where simulated rainfall is occur and whatever variables we want to measure we will be measuring and then at the end of this area a funnel kind of shape is provided in order to direct the flow and sediment being generated from the runoff plot to a collection tank and this collection tank all around this collection take metal bund is there to prevent runoff from entering the tank from outside the plots; that means, the flow should only come from the runoff plot that is why they are protected and of course, on top also there could be a cover on this tank, so that no kinds of external flow or pollutant can reach the flow.

So, this is how typically a micro pilots a plot looks like.

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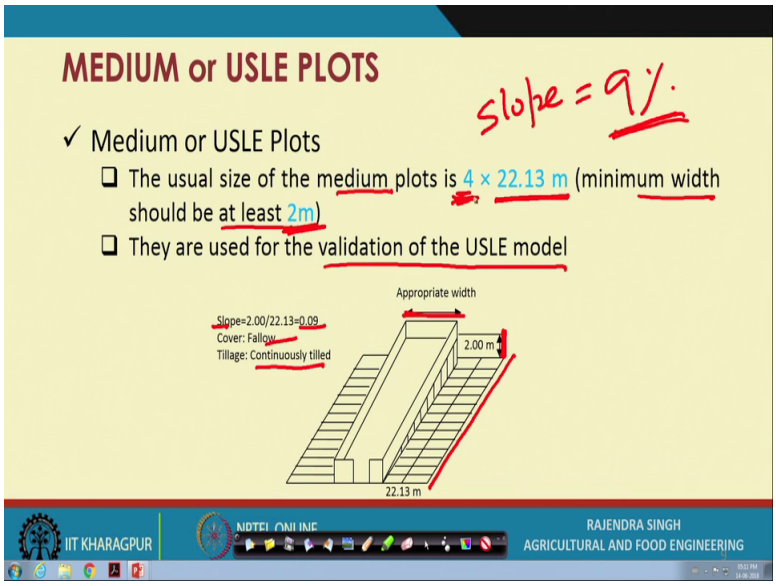

Then the second type is medium or USLE plot and this we have already seen that USLE plots are standard USLE plots are certain characteristics. We saw that the length is 22.13 meters and the slope is 9 percent, this is the standard requirement of a standard USLE plot. So, the usual size of the medium plots we use is 4 meters by 22.13 meters and the minimum width should be at least 2 meters. So, it should be minimum 2 meter by 22.13 meter and then it can go beyond.

And, they are used for validation of the USLE model. We saw that not only validation, but also we saw that while estimating universal soil loss equation while defining various components various factors be it conservation practice factor, be it crop management factor, be it topographic factor we always said that it is the standard USLE plot which is used as a reference that is all definitions they come with reference to the USLE plot and that is where other term used is medium runoff plots or medium plots.

And, here also I mean diagrammatically you can see that the length is 22.13 meters and width could be appropriate it say that it could be it should be minimum 2 meters, it could be up to 4 meters while and the elevation difference from the upstream to downstream is 2 meters and if you calculate the slope then 2 by 22.13 that is 2 meter fall over 22.13 meters length comes out to be 0.09 or the 9 percent slope which we have to maintain if it is a standard USLE plot.

And, other requirements are that the cover is fallow that there is no cropping done over the this plots and tillage is continuously tilled. So, they are continuously tilled in a some kind of tillage operation is done in up and down slope direction, but no cultivation takes place. So, these are the requirements of standard USLE plots and medium which is called medium when the width is between 2 meter to 4 meters. So, this is a second kind of plot.

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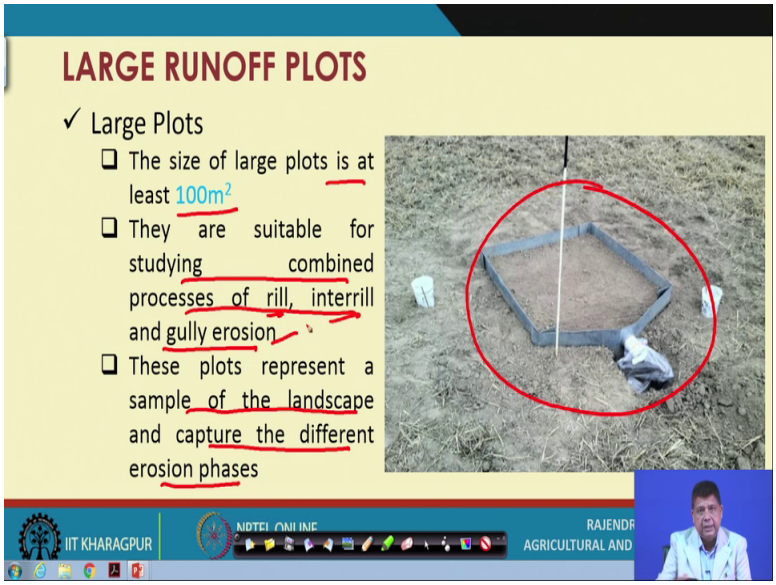

The other plot is of course, the large runoff plot and size of these plots could be at least 100 square meters. So, any plot runoff plot which is greater than 100 square meters is referred to as a large runoff plot and that is why we also said that even natural watersheds could be called as runoff plots and these are suitable for studying combine process of rill, interrill and gully erosion.

So, obviously, because they are very large in size very large in size so, obviously, all the erosion processes will take place whenever rainfall occurs whether under simulated condition or natural condition. So, that is why it is possible to reach the combine effect of the process like rill erosion, interrill erosion and gully erosion together.

And, this plots represent a sample of the landscape and capture the different erosion phases which is again quit possible because of their lies size so, there could be natural variations within the landscape and of course, we have already said the different erosion phases be it phases of erosion we saw detachment, transport, depositions. So, because there is a they are rapidly large in size and natural landscape is their so, obviously, at

certain portions there will be detachment certain other portion there will be transportation and there might be a downstream side the slope condition should be search the soil gets deposited also. So, detachment, transportation and deposition all three phases of erosion it will be possible to study using the large plots.

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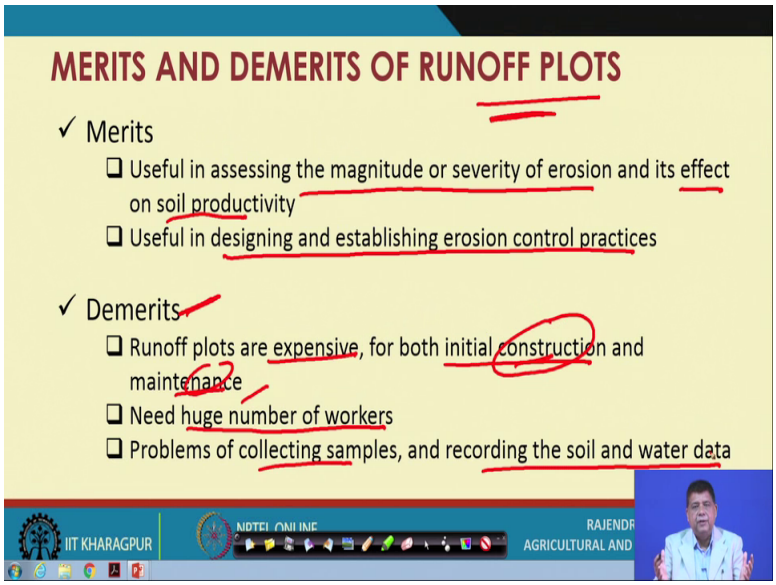

And, of course, there are certain merits and demerits of runoff plots. The merits are they are useful in assessing the magnitude or severity of erosion and its effect on soil productivity. So, obviously, whenever we required erosion data or what happens to the crop productivity then we can always use the runoff plots, that is the one advantage. And, they are useful in designing and establishing erosion control practices.

We already know that we discuss that why do we need to measure soil loss. So, obviously, we saw that whenever we have to design any kind of conservation practice or we have to evaluate any kind of conservation measure that is already adopted then we always need measure soil data and for that runoff plots are the best place to find

But, then there are certain demerits also of the rainfall plots and one of the demerits major demerits they are expensive for both initial construction and maintenance. So, both construction and maintenance of runoff plots is expensive unless and until it is too natural ah and we are not doing any kind of instrumentation or any kind of modification into the natural conditions, then it is natural otherwise if you want to really create runoff plot then both construction as well as maintenance is expensive.

And, as you most of the things are done in field condition soil laboratory conditions then obviously, huge amount of labor is required. So, large number of workers are required in order to be able to do experimentation or for maintaining runoff plots and the problems of collecting samples and recording the soil and water data they still remain because it is quite open quite large, if especially if it is large plots or if it is under natural rainfall conditions then measurements of or collection of samples is a problems. So, it is very difficult to collect the samples accurately, that is one of the demerits of runoff plots.

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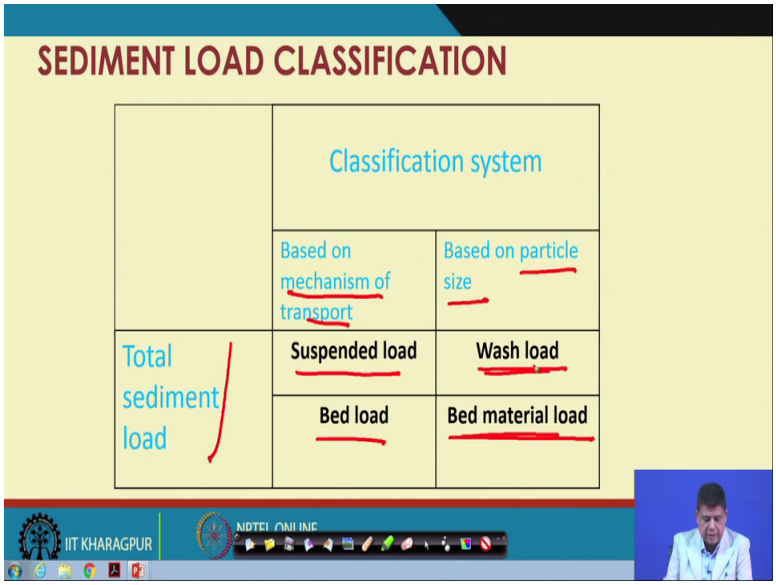

Then, we come to the sediment load classification the sediment is classified in two different ways that is based on transport mechanism and based on the practical size and total sediment load if we talk in both classification they are two components. If we talk about the classification based on mechanism transport then we call it is a suspended load and bed load that is the heavier larger particles that they are referred to is bed load and those lighter particles they which are transported in suspended form they are referred to a suspended load.

On the other hand on the base basis of particle size they are referred to is a wash load and bed material load. So, larger particles are referred to a bed material and the smaller ones are referred to a wash load. So, this is just a terminology which is which is use. So, one should be aware of this terminology.

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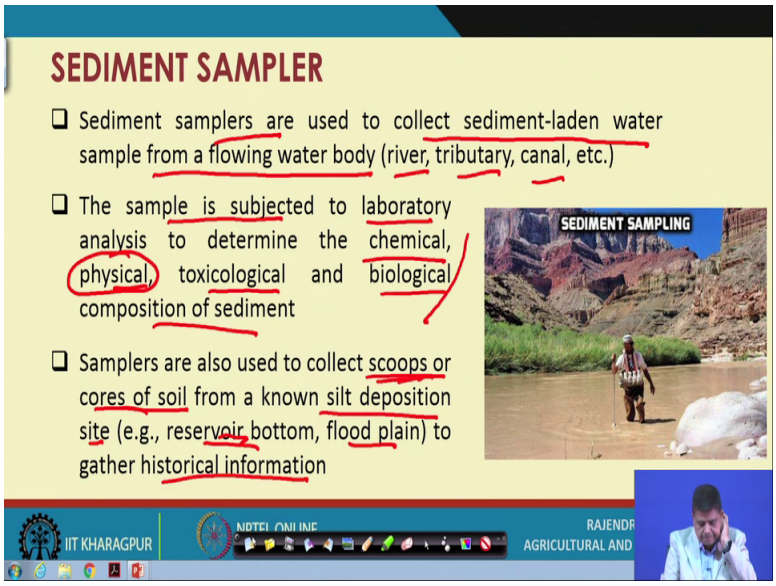

And, then the second type of measurement or a second source of obtaining the soil loss data is by use of sediment samplers and. Sediment samplers are basically used to collect sediment laden water samples from a flowing water body could be river tributary canal anywhere that is anywhere we want to find out the soil loss through then we can collect sediment samples.

And that simply means the collecting the sediment laden water sample and then we take this sample to laboratory analysis for determine the chemical, physical, toxicological or biological composition of sediment. Depending upon the nature of the study what is the objective of study we can do all or we can limit our analysis to any one are two category most of the time we definitely do the physical analysis.

And, then samples are also collected to collect scoops or cores of soil from a known silt deposition site, for example, reservoir bottom flood plain to gather historical information. So, obviously, the idea here is not to really find out the magnitude, but to find out how old the sediment are actually. If we take from a reservoir bottom then sediment because the life of reservoirs could be 50 years, 100 years so, obviously, the sediments that is deposited could be could also have a longer life of 50 years to 100 years.

So, that is basically the area of collecting using this scoops or cores kind of samples in this case.

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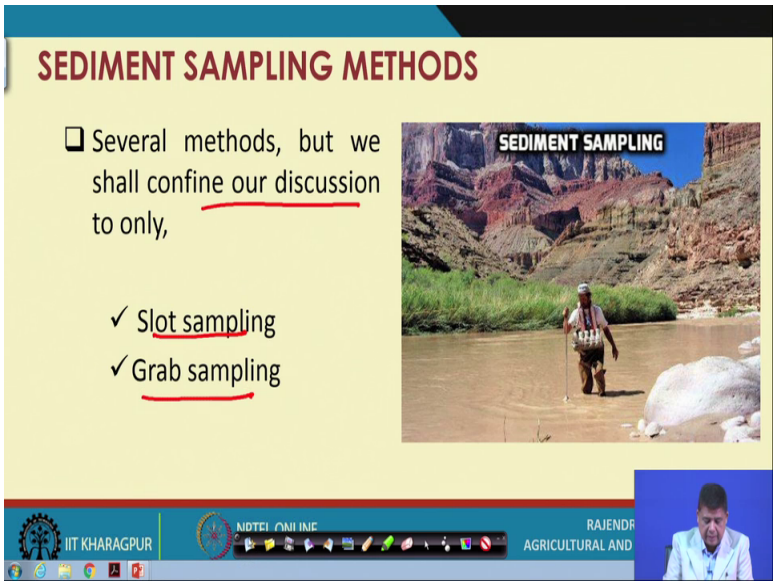

Then coming to sediment sampling methods they are several possible methods, but we will confine our discussion only to two types that is slot sampling and grab sampling. These are the two sampling methods we will discuss in the in the class and let us start with the slot sampling.

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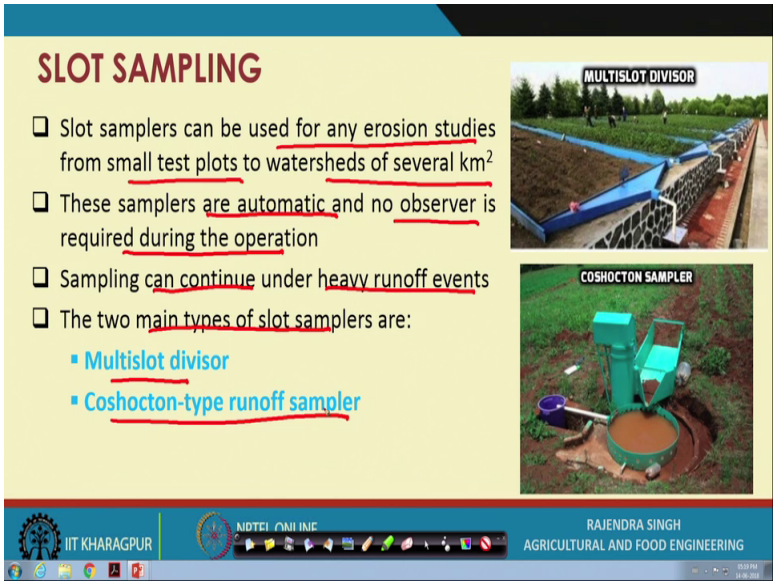

That slot samples samplers are used in any erosion studies from small test plots to watershed of several square kilo meters; that means, there is no limit I mean various kinds of slot samplers are available which can use for smaller or larger study area and

this samplers are typically automatic and no observer is required during the operation. So, all around the clock data could be obtained.

And, also the sampling could continue under heavy runoff events. So, various limitations which are there with the runoff plots they can be taken care of using the slot samplers and the two main types of slots samplers are multislot divisor and Coshocton-type of runoff sampler. These are the two types of major runoff samplers which are used in this case.

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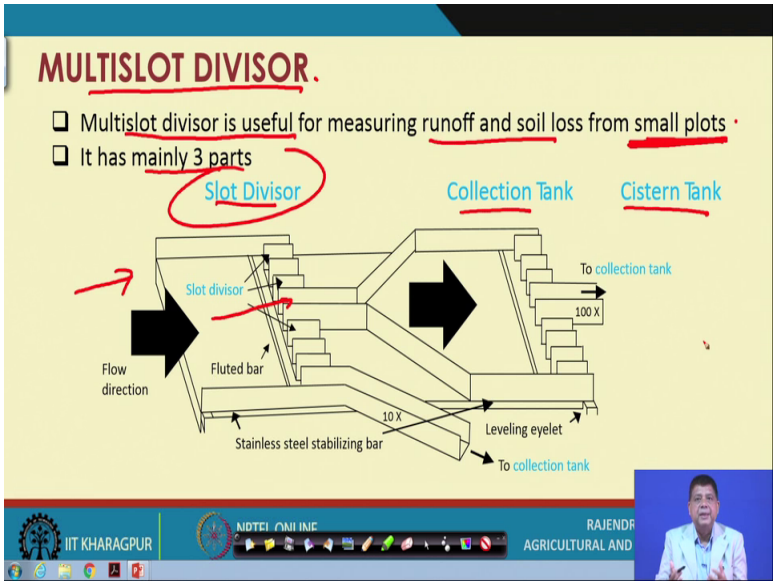

So, let us talk about the first kind of ah sampler, slot sampler that is multislot divisor and multislot divisor is useful for measuring runoff and soil loss from small plots. So, this is the this is the qualifying statement that multi slide divisors are preferred for small plots and typically this multislot divisor have three pots parts; slot divisor, collection tank and cistern tank.

So, here you can see here this slot divisor which is the major component that is here you can see. So, basically this is the flow direction and the water or sediment laden water re enters the divisor, it is gets there are slot divisors here. So, sample gets divided into the central one and then it final reaches the collection tank and cistern tank where it gets collected and where the sediment characteristics are the not only characteristics, but also the quantity and quality of samples are analyzed.

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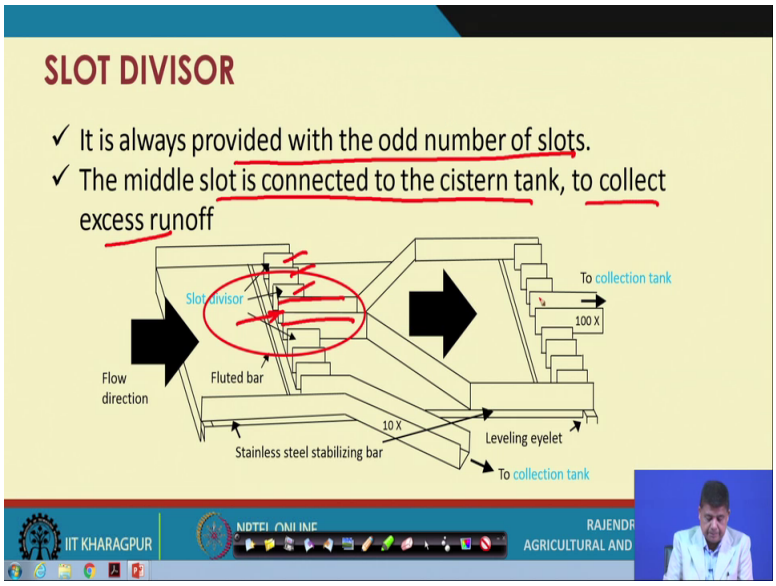

The details of slot divisor are given here the ah. It is always provided with the odd number of slots. So, these are the slots which is you can see here. So, the slots are always provided in odd numbers and the middle slot is connected to the cistern tank to collect the excess runoff. So, as you we saw in previous also it is always the middle slot which is collected which is use for collection of the water sediment laden water.

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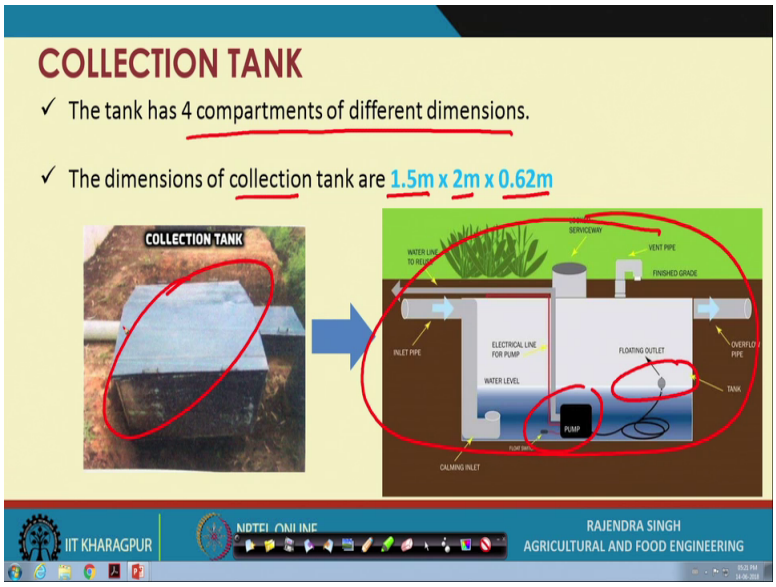

Then collection tank has four compartments of different dimensions and the typical dimension of a collection tank are 1.5 meters to 2 meters times 0.62 meters and the type

of compartments that are used are the are various kinds of sophistications are possible there they could have certain provisions for pumping water out they could have a floating chamber that is a float could be there which can automatically record the water level and so on so forth. So, this variations are possible are what is what is there in this collection tanks and what are the four compartments about.

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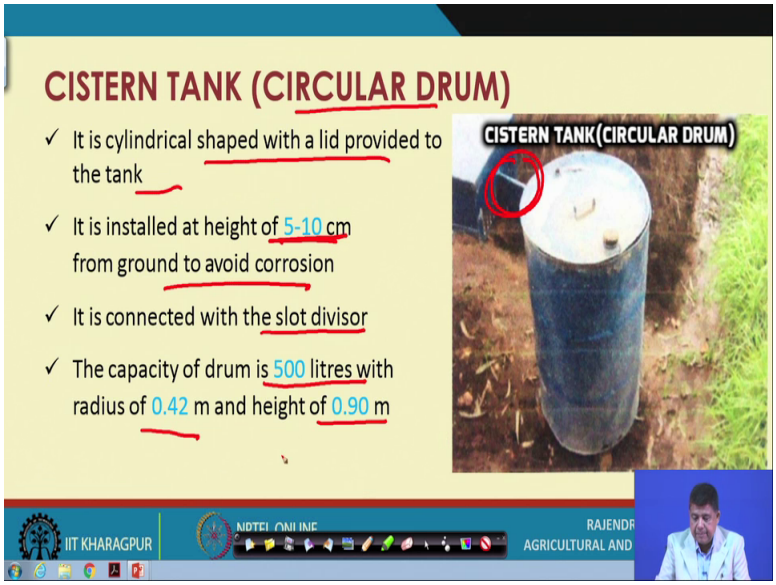

And, then finally, we have a cistern tank which is nothing, but a circular drum and the cylindrical shaped with a lid provided to the tank which is quite obvious, so, to cover any kind of foreign elements entering the sample and typically it is installed at a height of 5 to 10 centimeters from the ground to avoid corrosion because some typically metallic cylinder.

And these one is connected to slot divisor as you can see here, these connected with slot divisor so, the water sample gets collected here and a capacity of drum is typically 500 liters with radius of 0.42 meters and height of 0.90 this a typical value, but anything any variations are possible as far as cistern tanks size and dimensions are concerned.

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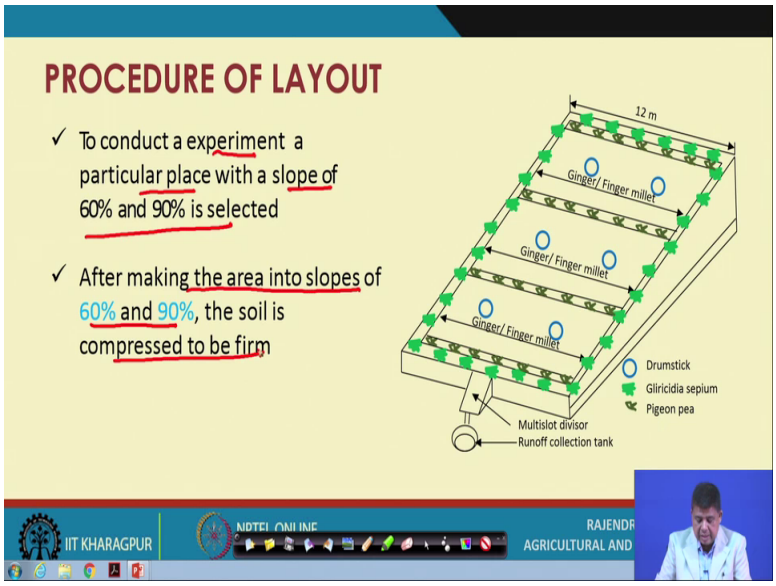

Then coming to procedure of layout basically if just this just to an idea about how in field conditions these are used. So, for conducting experiment we have to select a particular place with the slope of say 60 and 90 percent let us say for example, it could the slope could vary and after making the area into slopes of 60 and 90 percent the soil is compressed to be firm. So, soil conditions have to be made such that they look they are in natural condition that is bulk density of the soil ah of the natural soil condition has to be preserved.

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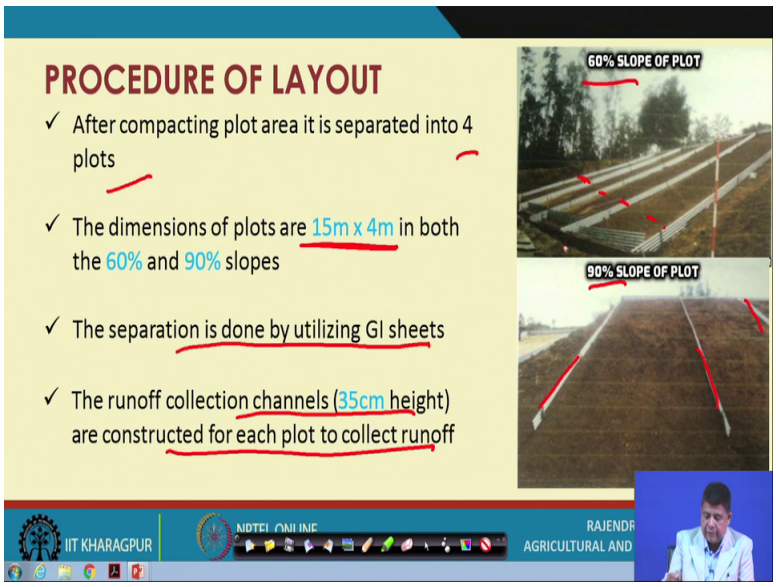

And, then after completing the plot area it is separated into four plots, as you can see here different plots are created and dimension of plots typically are 15 meter by 4 meter in both the slope conditions and the separation is done typically by GI sheets. So, you see that GI sheets are being use for creating the separate plots and runoff collection channel channels are constructed for each plot to collect the runoff. So, that is outside this area there is a runoff collection example also is collected.

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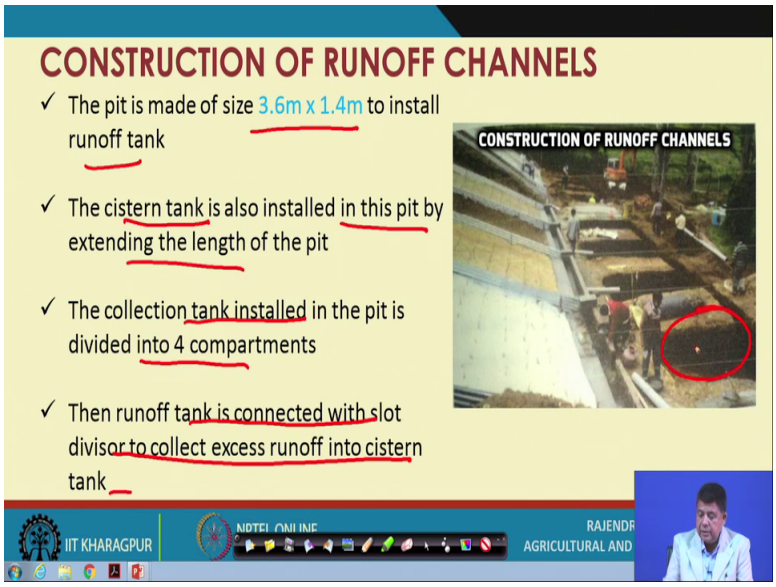

And, then we have to create this pits here as you can see here of varying sizes typical size 3.6 meter into 1.4 meter to install runoff tank and of course, the cistern tank is also installed in this pit by extending the length if required. And, collection tank installed the pit is divided into four compartments with that we have seen and then runoff tank is connected with a slot divisor to collect excess runoff into cistern. So, from this plots multi slot divisor is put here and then this been collected into tanks.

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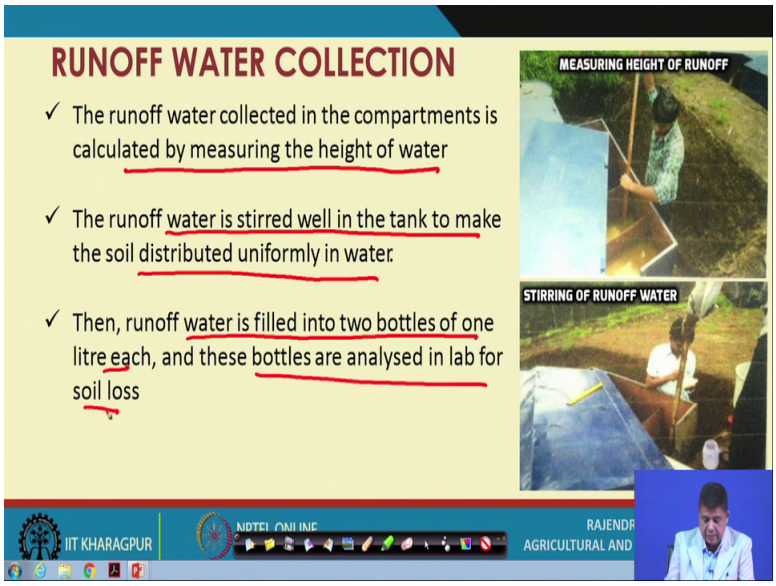

And, once the runoff water is collected into the compartment the total it is volume is calculated by measuring the height. So, once you height is measured we know the dimension so, total volume we can know. And, then finally, runoff water is stirred well in tank to make the soil distribution uniform in water and then runoff water field filled into two bottles of one liter each and these bottles are analyzed in lab for soil loss. So, soil loss measurement is done in laboratory conditions.

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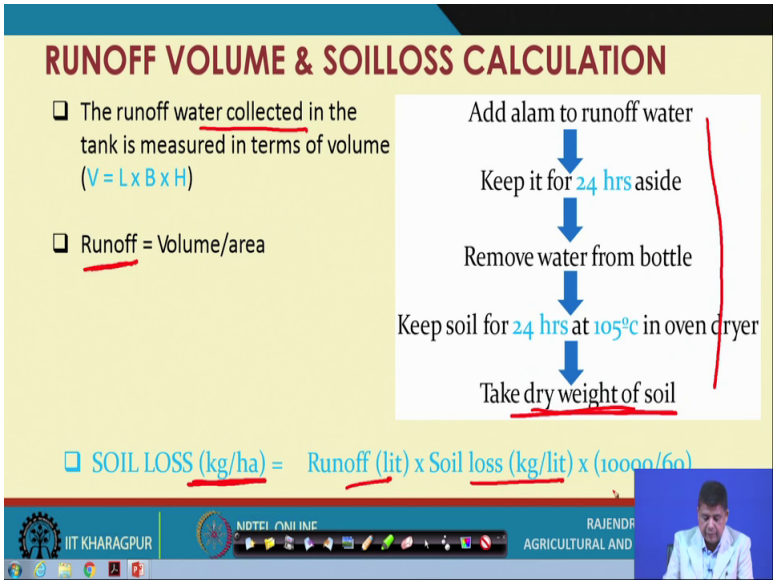

And, once we know the total runoff volume we know the runoff volume then and the area we known. So, the magnitude of runoff is calculated and then obviously, in under laboratory conditions we can find out what is the total dry weight of the soil that has been collected with samples and the soil loss there can be estimated in kg per hectare.

So, runoff in liters soil loss in kg per liter and then obviously, for area we can also always use or for unit we can always conversion of unit we can use.

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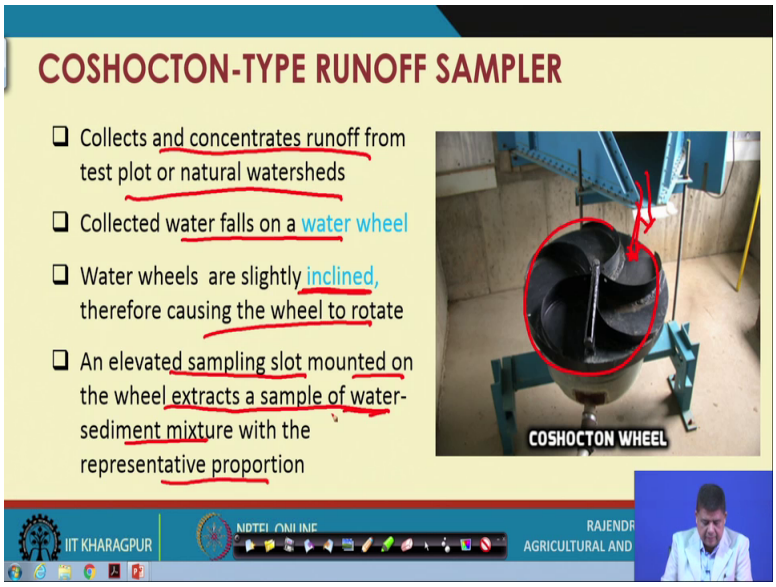

Then, the next type of sampler is Coshocton-type runoff sampler and it collects and concentrates runoff from test plot or natural watersheds. So, the first one multislot divisor was from a small plot, this can be use from large watersheds as well and here the collected water falls on a water wheel. So, this is a water wheel basically, on which the collected water from here falls and this is this water wheel is slightly inclined therefore, causing the wheel to rotate. So, because it is slightly inclined so, whenever water falls here because of the momentum this wheels start rotating.

And, then an elevated sampling plot mounted on the wheel is used for extracting the sample of water sediment mixture with the representative proportion and just now as we saw the total volume of runoff can be measured and from analyzing this sample we can find out how much soil loss is there, soil weight is how much weight of the dry soil can be found out and then the proportional soil loss in kg per hector we can calculate for Coshocton-type wheels also, like within multislot divisor.

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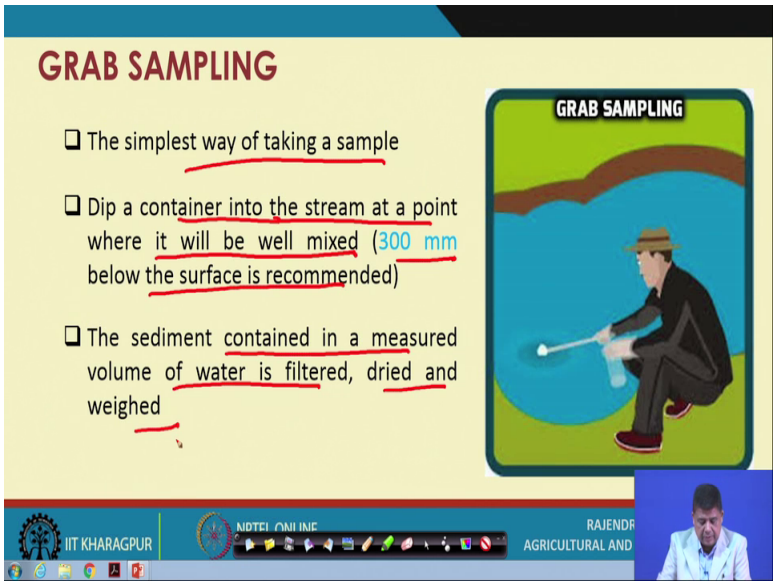

Then the other case is which we discuss is of grab sampling; that is an grab sampling is the simplest way of taking a sample. So, here a container is dip into the stream at a point, where it will be with the water and sediment will be well mixed. Typically, 300 millimeter below the surface is recommended and the sediment contained in a measured volume of water is filtered dried and weighed and then finally, we can find out the total soil loss from a given area.

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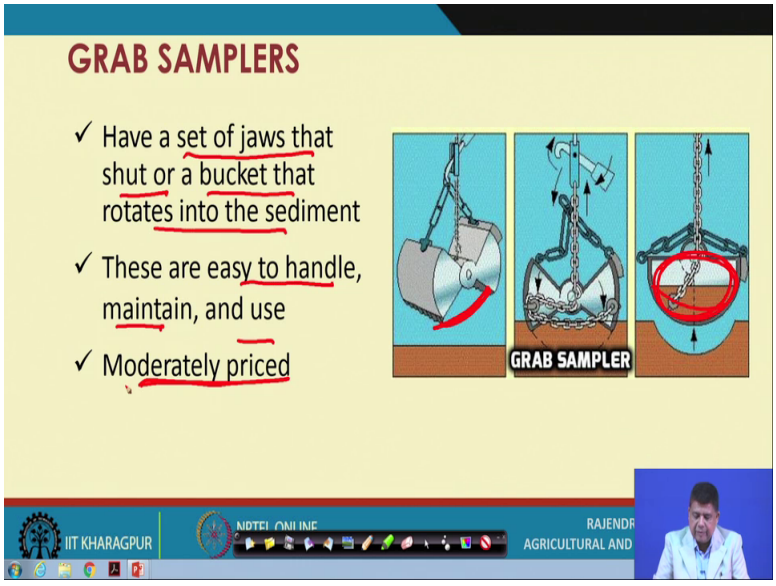

And grab samplers could be of various kinds ah. So, they can have a set of jaws that shut say, for example, here. So, wherever you want you can shut them, so that sediment sample gets collected or they can be a bucket shape which rotates into rotates into the sediment laden water for collecting the sample. So, you can see here these soil sample is collected and typically grab samplers are preferred because they are easy to handle, they are easy to maintain and easy to use and they are quite economical also, they are moderately priced. So, that is why this grab samplers are quit commonly used.

So, with this we come to end of this. So, soil loss measurement we saw, either we can use runoff plots or sediment samplers and as far as sediment sampling is concerned we saw multislot divisor, we saw Coshocton-type of wheel or simply grab samplers can be used for getting the samples and then using laboratory experiments knowing the volume of water and the magnitude of soil, we can find out what is the total magnitude of soil loss from a given area.

Thank you very much.