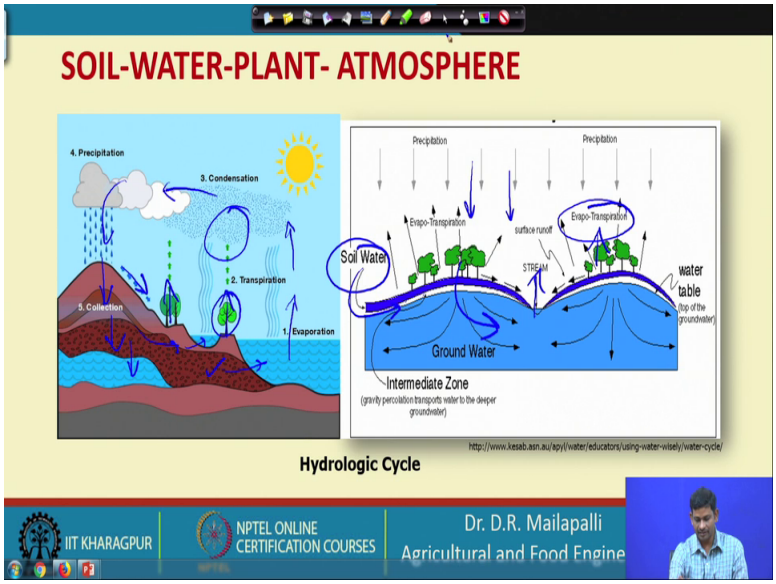
Irrigation and Drainage
Prof. Damodhara Rao Mailapallli
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur

Lecture - 02
Soil properties- 1

Hello friends welcome back. So, this is lecture number 2 of Irrigation and Drainage. Mostly in this will be focusing on Soil Properties.

So, the soil properties I mean divided into 2 lectures because, so this is the core of learning you know irrigation principles and also the drainage principles that is why we need to understand the basic soil properties so, that later you would not be you know feeling uncomfortable it is.

(Refer Slide Time: 00:54)



So, here if you see the water is the main connection between soil plant and atmosphere; so this is really a continuum. So, if you see here the hydrological cycle, so initially the water is going to evaporate.

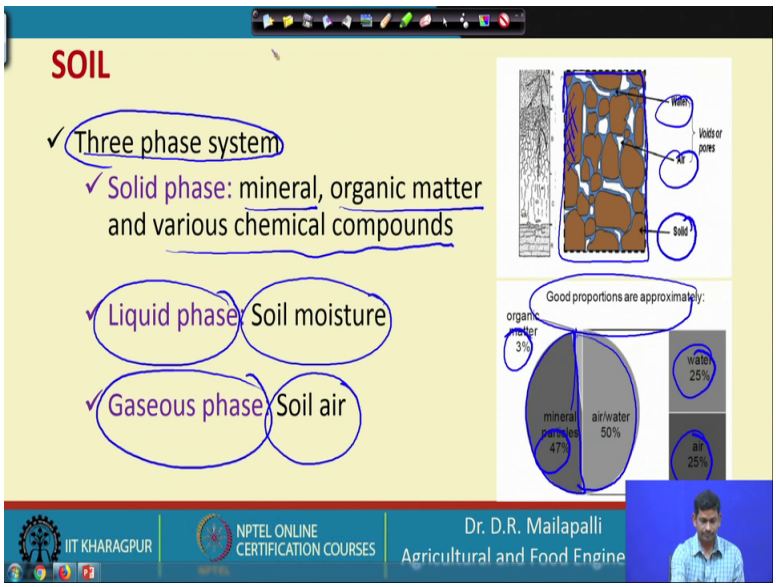
So, if you observe here basically the water evaporates from sea or any water a body, then after that it is going to condense in the atmosphere, then the condensation water is going to form clouds, and then clouds are going to precipitated down as rain fall and then once it is falling on the surface.

So, the some part of the precipitation goes as over land flow run off, then other part will infiltrate down in to this soil and then goes into the deferent soil layers. Then meeting the ground water some portion, then the base flow some water may going to the you know as the sub surface flow to the streams and finally it may go into you know the rivers or ocean area other water bodies.

So, a and also some portion of water which is transpired from the plant surface to the atmosphere. So, if you observed these so the water is basically is connecting the soil and plant and also the atmosphere. So, if so this is a very good example of the hydrologic cycle. So, here little bit elaborate view if you see, so both evaporation from the surface as well as you know plant body, so that is Evapo transpiration. So, that goes in to the atmosphere and precipitation as input to the system uh, then the same thing so some portion goes into ground water ok.

So, then the soil water which is a rely between you know in the unsaturated flow basically. So, in the soil which is on the surface will have the soil water. So that is basically important when you are talking about the plant. So, plant really observed or a takes the soil water. So, this is the main important you know the components of hydrological cycle ok.

(Refer Slide Time: 03:40)



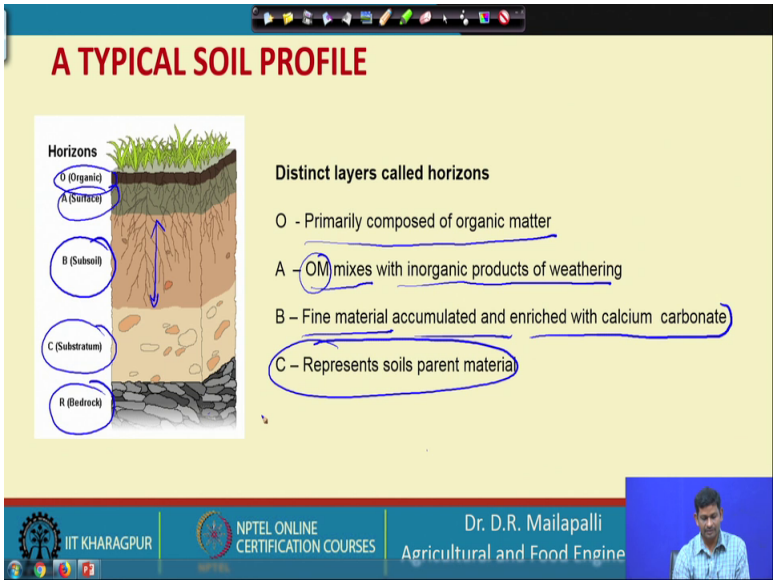
So, if you see the soil, so soil is a three phase system you know. So, the three phase system that that means, we see it here this is the soil you know the part of soil call if you

make it cross section right. So, you can see the solid particles like this and also there is always some space between soil particles. So, that is filled with you know the liquid phase and also the gaseous phase.

So, that is why the soil is three phase system, so water air and the solid. So, solid will have you know the minerals and organic matter, and also other you know chemical compounds. Where is the liquid phase is mostly the soil moisture, but also we can see the deserved chemicals which is in you know liquid form with in the soil moisture. And soil, air this is gaseous form and also we can see the gaseous chemicals.

So, the whole entity can be like 50 percent is of you know the solid portion 50 percent and remaining 50 percent air water. So, again the solid has solid particle has 47 percent minerals and 3 percent organic matter. And water 25 percent air 25 percent so this is equally divided; So, this is an approximate like a good proportionation of three phases and clearly see same.

(Refer Slide Time: 05:42)



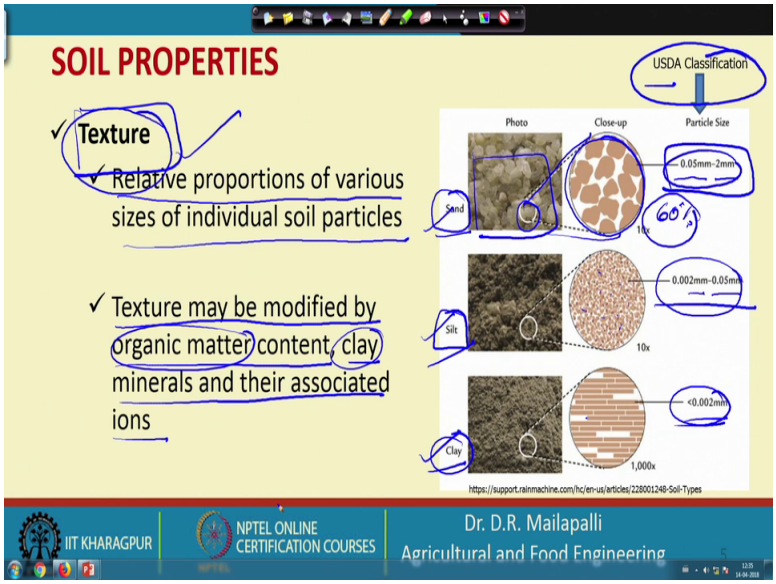
So, then so then this is typical soil profile yeah, so this is a typical soil profile if you see. So, if you go and take a look down in to the soil and make a cross section view , so it will have different horizons so that means, different layers. So, see here so this is O like O horizon, so that is called primarily composed of organic matter ok.

So, because on the surface will be lot of you know liter that means, lot of plan material which is accumulating on the surface in the over period of time, that will you know composed or decomposed in to organic forms. And later the next layer is surface. So, the surface will have organic matter this OM is the organic matter mixes with inorganic products of weathering ok.

So, then the next phase next layer will be subsoil. The subsoil will have fine material which is accumulated and enriched with calcium carbonate. You all know what is calcium carbonate right. So, this is like a white washing purpose; we use this calcium carbonate. So, the mostly this layer will contain you know the calcium carbonate and also the fine material; So, the last layer which is parent material so that is substratum. So, this parent material generally this will staying here for you know years like centuries we can say.

So, over that over that the other soil formation slowly have been taken place. So, this is the bedrock, which is the lying has support to the entire support, then below that you know their aquifers may be you know some other may be you can repeat the same layers. So, this all typical soil profile if you look at, and then and then soil properties ok.

(Refer Slide Time: 08:08)



So, here the soil properties are the first properties you are looking; is the soil texture. So the soil texture is relative proportion of various sizes of individual soil particles ok. Suppose you have you know you have taken a soil in your hand, if you see the a particles

soil particles, they are not are the same size they are you know different size of soil particles. So, that is why here the what proportion of these you know different size of soil particles will give the soil texture ok.

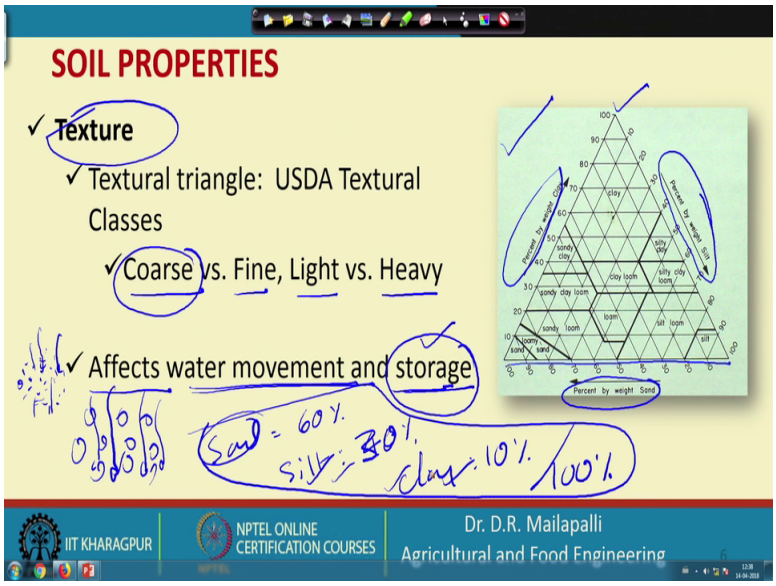
So, if you see this picture here the closely if you look at so this is from are the soil and if you take a little bit of portion from the soil and expose it here, and it looks like you know like the soil the size of the particle if you find like 0.05 to 2 mm and we call it as you know the sand, so we call it as a sand. And if you take you know little bit some other soil which has a 0.002 mm to 0.05 mm so that is called silt ok, so then if the soil particles size is less than 0.002 mm and this is call the clay. So, the mostly we will see sand, silt, clay. So, that constitutes the texture so we call soil texture and so but how do you determine the soil texture.

So, this sizes or based on USDA classifications that is United States Department of Agriculture. So, they have classified these soil sizes I mean soil types are soil texture classes we call, the sand will have the size between 0.05 mm to 2 mm whereas, silt will have size from 0.002 mm to 0.05 mm and clays the size is less than 0.002 mm, so is very tiny.

So, then texture may be modified by organic matter content, clay minerals and then associated ions. So, suppose you have the sand for example 60 percent sand you have right and if you mix with; So, in course of time so you have added you know manure or you added some clay content or something like it in that; So, definitely that will that will change the sizes this size.

So, some so your sand content may decrease or you know the fine material will increase. So, that is why the texture may reeled vary with the addition of organic matter and the clay contents or other minerals ok.

(Refer Slide Time: 11:34)



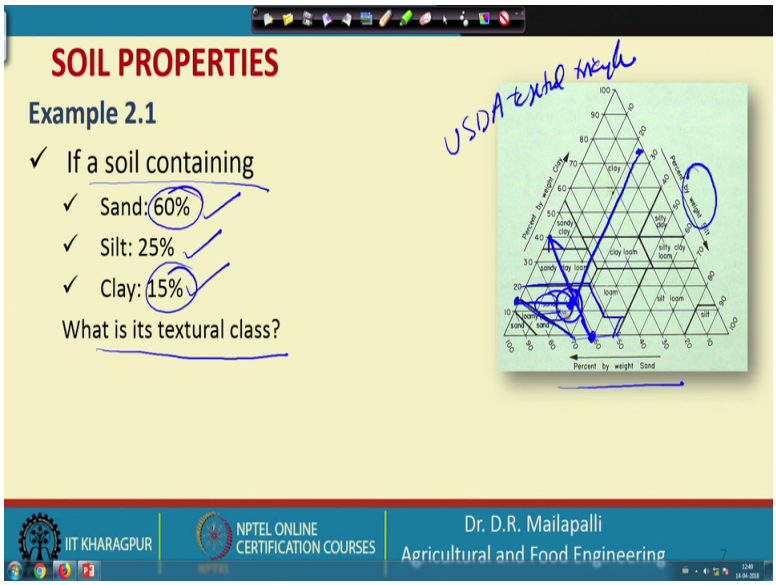
So, then generally this is this is I mean the texture is a represented with the this is called a textural triangle ok, so the triangle will have 3 sides; So, the 3 sides so this is bottom. So, this is iniquelatral triangle. So, in the bottom it is showing the percentage of sand here and percentage of clay on this side and percentage of silt on this side. So, if you come up with like numbers like, sand suppose you have sand 60 percent, you know silt you will soil has 40 per sorry let us say 30 percent, and clay will have 10 percent , so all together it comes 100 percent.

So, then you want to identify so this case belong to. So, which textural you know soil type. So, then this triangle definitely will help we are going to see that in the later slide. So, basically the textural triangle that is coarse verses fine and light verses heavy, you can clearly you know visualize this triangle based on the sand silt and clay content. So, this textural triangle or soil texture definitely will affect the water movement and the storage.

So, you have like you know coarse textural soil. Coarse textural in the sense you have particle sizes are really heavier, I mean larger particular size. So, that will help the water movement really easy like the faster compare to you have like tiny pores tiny particles right. So, that that means your sand content is less and your silt and clay content are more, so definitely that is going to influence your water movements; so here the water movement is going to be slower.

So, that is the reason the soil texture definitely affects water movement and the storage. So, storage in the sense, so you have the clay soils; So, clay soils what happens? It holds water and it does not transmit water. So, that is why it can store more water in case of you know clay soils right.

(Refer Slide Time: 14:20)



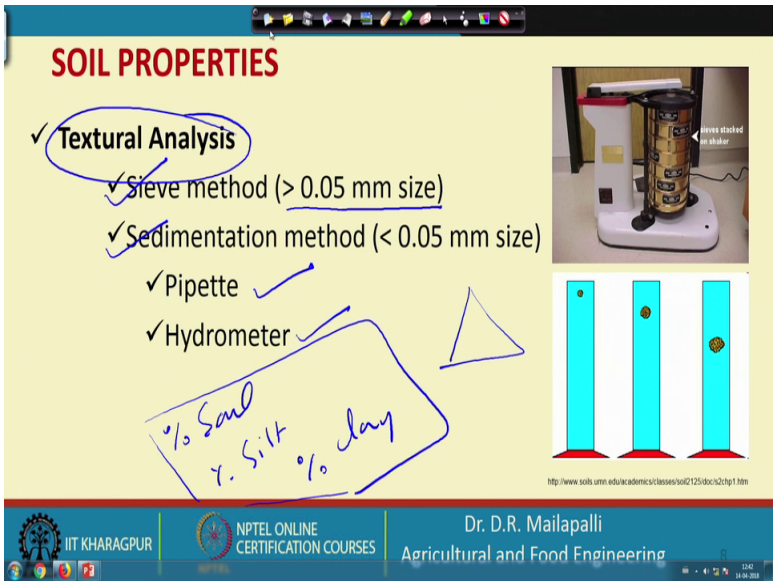
So, then the next is as a set we are going to see this example, so in this example if a soil contains sorry yeah. So, if supposed soil contains 60 percent sand 25 percent silt and 15 percent clay, so you want to find out what is that soil textural class. So, here so this is USDA textural triangle right this is triangle; and in this so the first thing is 60 percent sand. So, look here so this is the sand content right this is the sand, so 60 percent is here basically right.

So, now, what you have to do? You have to draw line in this direction this is 60 percent line right and then silt 25 percent. So, this is the silt and 25 percent is here and draw line parallel to this and this going to hit here ok, then clay 15 percent. So, 15 percent is here so look at here this is almost 15 percent and just joined the cross section.

So, write now the resulting 1 is really focusing at this point. Now, if you see here the bright lines, so look at this here this dark lines right from here to here and it says it says sandy loom. So, it is its not visible right now but let us see, so I will eliminate everything then if you see here.

So, finally, in this example so the textural class is falling under here and we say so in this condition like 60 percent sand, 20 percent silt, 15 percent clay falls under sandy loom class ok. So, in this way the textural triangle I will help was in finding out the which class of this particular soil constituents right yeah that is fine.

(Refer Slide Time: 16:50)

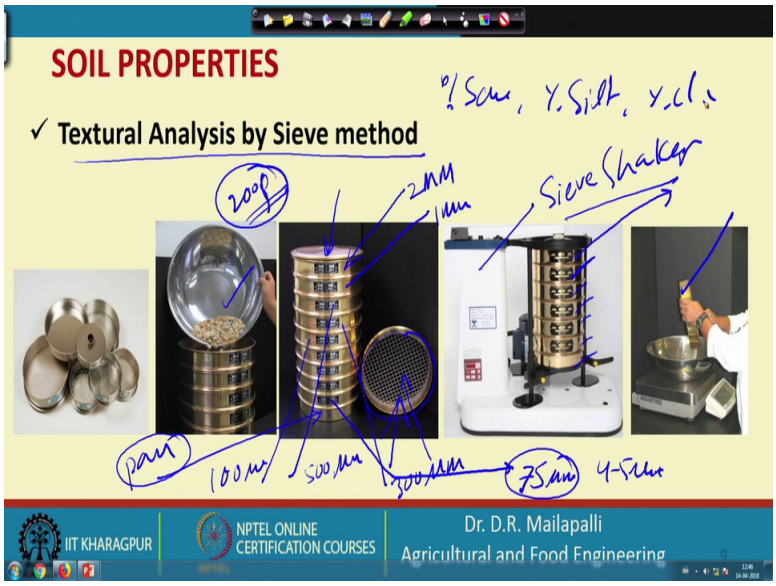


So, next is the so how to analyze this textural I mean soil textural, so how to analyze this soil texture. So, how to get you know the percentage sand and percentage silt and percentage clay, so this is very important how to get these from a soil.

For a given soil how do we measure percentage of sand, percentage of silt, percentage clay. So, ones you know these and definitely using you know the triangle, we can find out which class of this soil belong to. So, there are few methods their important methods or frequent methods you can say, so the first is a sieve method, so the second is a sedimentation method.

So, the mostly the sieve method I will be applicable to these particle size or sand size more than 0.05 mm. And sedimentation method I mean is the particle size finer than that, we are going to use either pipette method or hydrometer method. So, let us see the methods 1 by 1.

(Refer Slide Time: 18:10)



So, here I am going to show these textural analysis by using sieve method. So, in the sieve method what happens you will be having different you know sieves of standard sandy sizes sieves basically. So, you can see the picture here this is the sieve and now you are going to arrange the sieves on the basis of the opening size opening size. So, first will put the bigger opening sieve, then followed by the smaller and smaller smaller smaller ok.

So, it is like you so here if you see the stack of sieves right. So, here this sieve will be having maybe you know 2 mm 2 mm size dia, so this is called you know aperture. So, aperture is the number of openings pair a units square inch. So, then so then this could be you know 1 mm and this could be 500 micron micro meters sieve and this could be you know 300 micro meters sieve and like that so it goes.

So and the last one here we may have like you know 75 micro meters. So, that is what will be expecting in the last one and at the end this is called pan ok, so whatever the size which is finer than 75 mm will be collected in the pan so this is the thing.

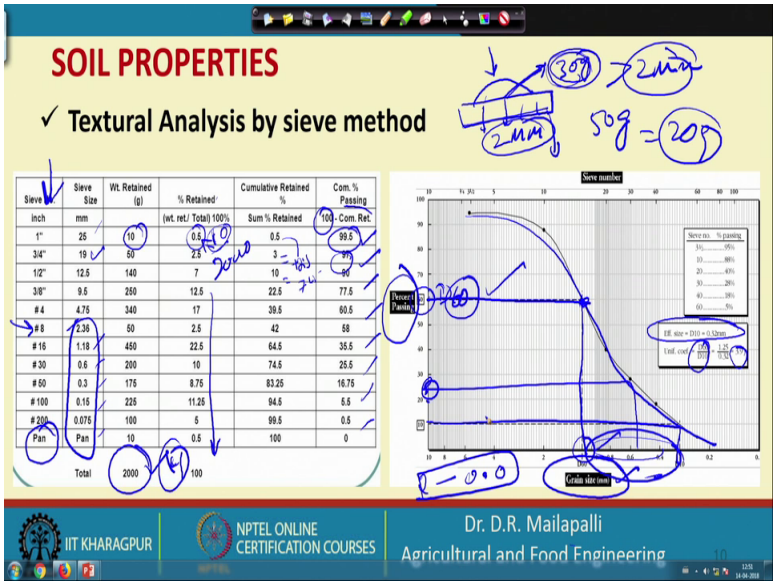
So, after making this stack of sieves arranging stack of sieves, you are going to you know put material just like here it showing. So, we gone to put material and top of the sieve right and this is called a you know sieve shaker sieve shaker. So, here you put the material may be around you know the 200 grams or may be 500 grams right.

So, put the material here and put it under you know sieve shaker and so sieve shaker it shakes it helps in shaking the sieves ok. Then after let us say 4 to 5 minutes of sieving, then you have to take of the sieves out; then you are going to what you going to do? You going to collect the material which is retained in each sieve ok, so that is what here if you see.

So, the material which is retain in the sieve is weight. So, here the total I mean total amount of materialist 200 grams and we are going to collect or we gone to weigh the material, which is retain on each sieve this sieve this sieve this sieve and also the pan, and then we are going to find out the percentages percentage of retention ok.

And then and then we are going to find out the percentage finer and we going to draw graph between size and percentage finer and then we are going to see what is the effective size and what is coefficient of uniformity right. So, these things we are going to find out with the textural analysis and finally our main objective is percentage of you know sand, percentage of silt and percentage of clay. So, these things we are going to find out.

(Refer Slide Time: 22:00)



So, let us see the next if you see ok, so this finally, what you are going to get. So, this is the sieve number so this is the sieve number you have you have put all the sieves together right, finally you have the bottom it is a pan and this is the sizes right? 25 mm

19 mm and so mostly we you know in our cases agriculture soils. So, we start with here right, so 2.36 is the size and they are following by all these you know sizes.

And so next they we are going to find out the weight retained in each sieves at the end of the experiment. So, here the total is around 2 kg used and find out percentage retain, so this is 10 divided by you know 2000, so that is that is what you get 0.5 right. So, the amount retained and divided by total amount. So, like that you are going to find out the percentages ok.

Then the cumulative so 0.5 and it going to add 0.5 this will be you know 0.5 plus this 2.5 right and this will be equal to 7 plus 2.5 is not it yeah so it goes. So, this is a cumulative; and then if you can subtract with the 100 percent you get the percentage finer. So, is a reverse. So, the percentage finer that means, so suppose this is the sieve right.

So, the amount of the material which is retained on this thing this is the percentage, suppose 30 grams 30 gram material is left on the surface. So, this is let us a 2 mm sieve, this is 2 mm sieve. So, 30 gram of material will have this size more than 2 mm right. So, that is the reason this 30 grams of material is not falling or not passing right, so the amount which is passing is rivers.

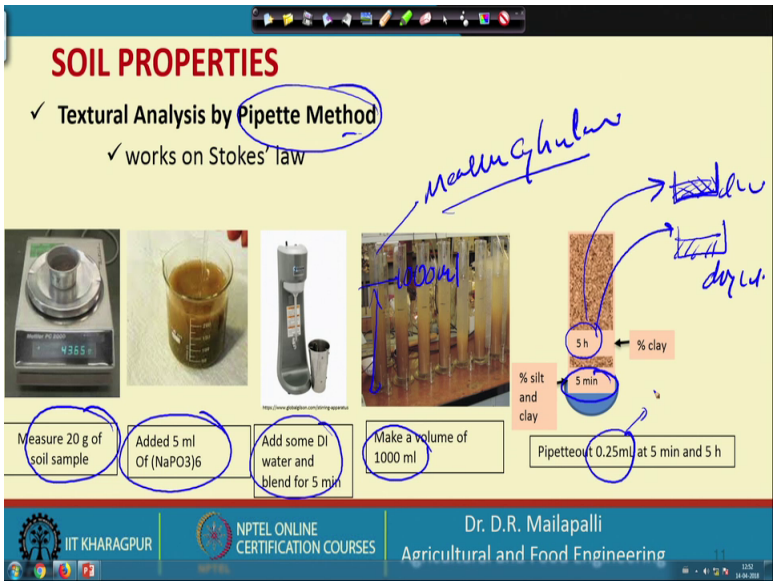
Suppose you have like you know 50 grams material is kept on top and 30 grams left and only 20 grams is past. So, you are going to see that what is percentage of past material or percentage of finer material. So, here we are going to draw a graph between you know grain size and then percentage of passing, so the graph looks like this ok.

So, this the graph goes like you know sinusoidal so here M mm. So, with this percentages we are going to see this is called this is 60. So, we called D 60 that means, 60 percentage of material is past 60 percentage of this 200 kg or 200 grams is past right. And then and then so if you if you want to find out what is D 60 just draw a line, which is you know crossing this curve here and the corresponding diameter is available here. So, this in this way we are going to find out D 60 and also the find out D 10 here right.

So, D 10 is D 10 is affective size right and also the coefficient of uniformity that is D 60 by D 10 so you get 3.9 right. So, this way but whatever percentage of sand silt clay so that is important. So, then you have to go back to the you know the USDA class and see. So, generally the USDA class if you see 2 2 what is that 0.01 something like. So, you use

you use the textural class and find out here right in here and you can find out the percentages here percentage of passing and so that that will that will give the. So knowing the size knowing the size here and finding of the percentages; So, this way you can find out the percentage of silt sand clay in textural analysis a sieve analysis.

(Refer Slide Time: 26:45)

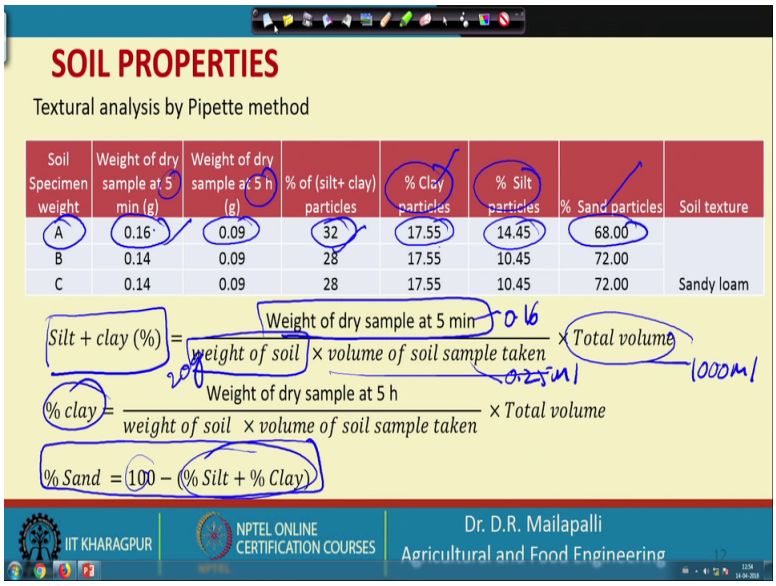


Now, so next is so next is textural analysis by pipette method this is called Pipette method. So, here unit a pipette and also the these are measuring jars. So, measuring cylinders right these are measuring cylinders. So, take 20 grams of soil sample right add 5 ml of sodium hexametaphosphate, so this is this is called dispersing exempt.

So, then also DI water so blend it just you know blended for 5 minutes, then here put it put the material in measuring cylinder and make up make up to you know these 1000 ml, so is like 1 liter. So, 1 liter then so what you have to do? So, the 2 times you count, if 5 minutes you take out you know the sample take out the water sample from this and find out the dry weight of the sample find out the dry weight of sample. Similarly after 5 hours take out the sample using the pipette and find out the dry weight of the sample dry weight this is also dry weight.

So, with these 2 measurements we can estimate percentage of silts, sand, clay. So, how I going to mix so here remember; So, we are gone we are taking here 0.25 ml of you know volume of solution each time ok. So, next we are going to see how we are going to find out the calculations are like this.

(Refer Slide Time: 28:37)

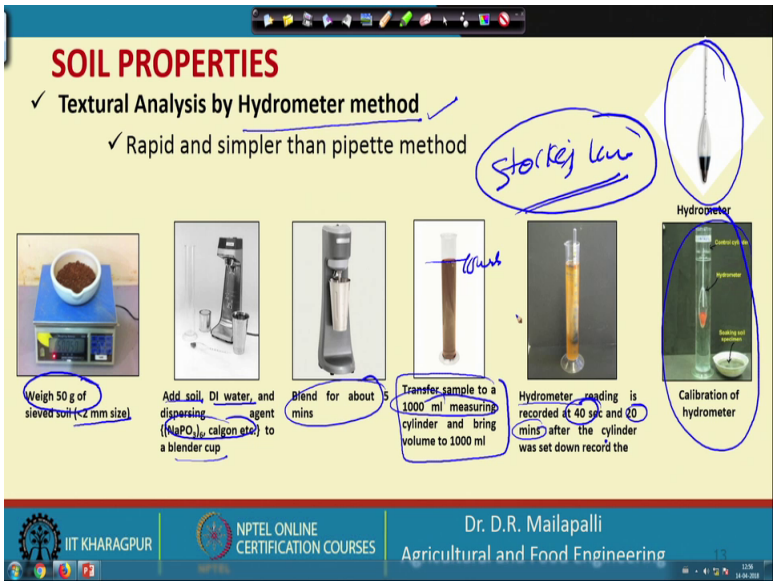


So, for example this is the soil specimen A right, so A is the soil specimen the soil. So, initially at 5 minutes time you have taken a sample and find out the dry weight is 0.16, at 5 hours you have taken the sample dry weight is 0.09. So, percentage of silt plus clay particles so that is estimated with this, so the weight of sample at 5 minute. So, this one right divided by weight of soil and volume of soil sample taken and total volume.

So, here the total volume is 1000 ml and volume of sample is 0.25 ml and weight of dry sample at 5 minute that is 0.16 this is 0.16 and weight of soil, so that is if you go back and see I think this is 20 grams. So, all together we will give you the 32 percent silt plus clay. Similarly, do it for clay here percentage of clay using this and you get 17.55.

So, subtracting 17.55 from 32, you get 14.55 that is the percentage of the silt and you already have percentage of clay, and knowing the total you can find out the percentage of sand particle. So, because the totally it makes 100 percent. So, knowing 17.55 14.45 so some of these two subtract of 100, you will give percentage of sand. So, this way we can find out percentage of silt sand clay from the pipette method. So, then we are going to see the other method so that is called that is called hydrometer method.

(Refer Slide Time: 30:42)



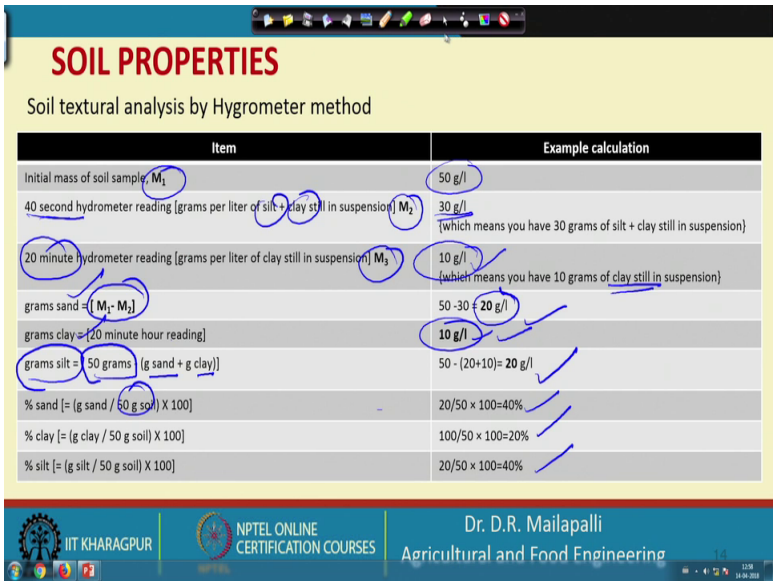
So, in hydro this is this is the hydrometer, so basically the hydrometer used for measuring the specific gravity of water any material. So, here what happens the 50 grams of soil is been weight, so the soil must be sieve through to 2 mm size.

So, then you are going to add soil and D I water as and also the dispersing agent to a blending pipe. So, you going to mix that for 5 minutes, then add that mix to these your 1000 ml measuring cylinder with D I water, so make it up to 1000 ml by using D I water.

So, then hydrometer is inserted in to the solution, and here 2 times 40 seconds and 20 minutes you have to you have to take two readings. So, hydrometer will have you know (Refer Time: 31:47) on top so and before that the hydrometer is been you know calibrated for different you know amount of the concentration of solutions. So, remember this hydrometer method and the previous pipette method they work based on the Stokes law right. So, the Stokes law ok.

So, Stokes law basically it tells the speed of particles like heavier particles verses lighter particles. So, when the velocity of fall that fall velocity depends on the size of the particle ok. So, that so based on that I mean you can find out the settling velocity and settling time and the particle diameter ok, so then here so this is the calculation if you see look at here.

(Refer Slide Time: 32:47)

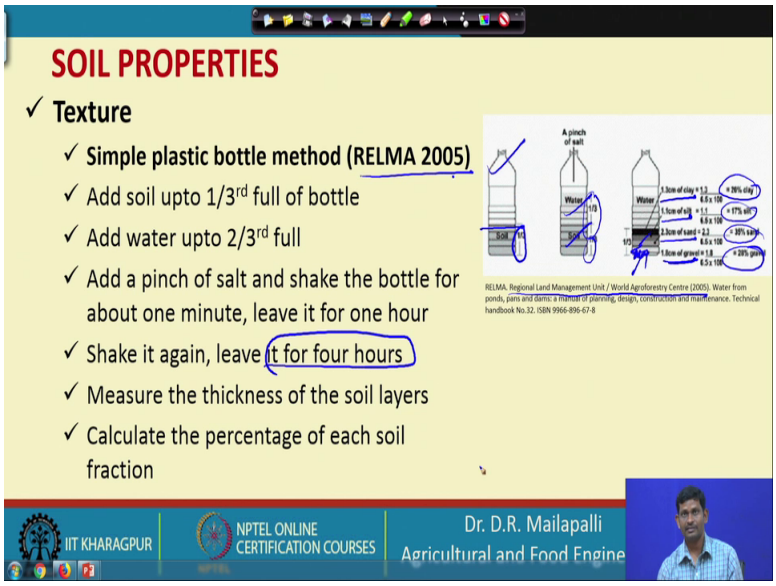


So, initial mask is M 1 that is the 50 gram per litter for example and 40 seconds of hydrometer reading. So, so that means immediately these sand is going to settle and whatever the particles which are in the suspension or silt and clay in forty 40 seconds. So, that that is M 2 you get 30 suppose you got 30 gram per liter, and 20 minutes time so this silt is going to settle and only clay is under suspension so that is M 3.

So, you get 30 milligram 10 gram per second so that gives this clay. So, grams M 1 minus M 2 will gave 20 grams. So, that that is the sand and clay this is 20 minutes reading whatever you got this one, so that is clay and if you can subtract uh, so this and this so that will that will give.

So, like you got silt is equal to 50 grams total material, sand plus clay so that will give this is silt. And then knowing the total amount, you can estimate the percentages individual percentages. So, this way you can measured the soiled I mean percentage of sand, silt, clay using hydrometer.

(Refer Slide Time: 34:23)

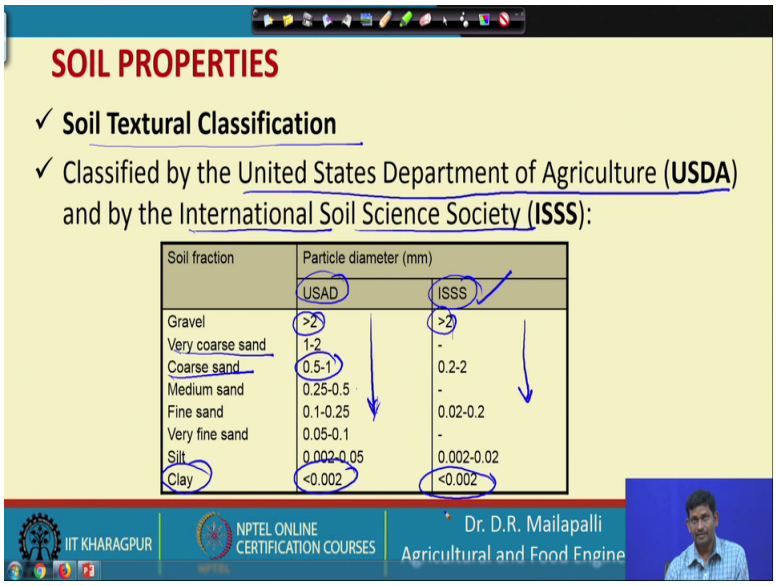


So, then next is so there is a very easy method you can do it home, so this is basically given by RELMA R E L M A. So, that is a Regional Land Management Unit World Agroforestry Center 2005. So, in this only thing you have to require is a bottle the plastic bottle you can say. So, put the soil I filled up a plastic bottle the soil up to one third of the volume, and then add water to another one third right, so this is water this is soil.

So, then shake the bottle well right. So, then what have to do leave it for 4 hours. So, then you can find out the settlings ok, so here whatever settle need the bottom. So, that will be the gravel and the next layer is the sand and next layer is the silt and next layer is the clay.

So, knowing the depths of settlement so you can find out the percentage of clay, silt, sand and then gravel ok, so this way this method works it is very easy method.

(Refer Slide Time: 35:37)



So, then so the next is going to be so the whole soil textural class, if you see the soil textural classification uh, so basically as I mentioned it is given by USDA right and then also there is a international soils and society ISSS. So, this USDA class and this is ISSS class. So, gravel which is greater than 2 mm right and this is also greater than 2 mm and very coarse sand this is very coarse sand and coarse sand 0.521 mm and followed.

So, this sizes decreasing if you observed down and finally the clay will have less than 0.002, and the same is suggested by ISSS so and so finally here in this class what we learn today? Though we learnt the important of water; So, which connects basically the soil plant and atmosphere and then and then of the hydrologic cycle.

So, then after that the what constitutes a soil and then how the soil class I mean soil properties like soil texture is been measured or represented right and we studied sieve analysis. So, using sieve analysis you can estimate percentage of silt, sand clay and similarly there is there are other two methods basically worked on Stokes law or segmentation method. So, that is one is pipette method, then other one is hydrometer method hydrometer method.

So, the finally, after knowing the percentage of silt sand clay using textural triangle, will be identifying what the particular soil textural class. So, thank you. In the next class we are going to work on the other soil property like soil structure, bulk density, the particle density and other things ok.

Thank you so much.