Soil Science and Technology
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Lecture - 36
Soil Testing – I

Welcome friends to this week 8 lectures of Soil Science and Technology and in this week, will be covering some very very important topics of soil science and technology. We will be starting with Soil Testing which is one of the most important aspect of soil and then, we will be talking about soil organic matter and then, we will be talking about soil organisms and composting and all this kind of important issues.

So, in this first lecture of week 8, let us start with the soil testing. And in this, you know, soil testing, basically we will be covering what is soil testing first, then collection and processing of soil samples and then, soil testing for pH and electrical conductivity and then, testing for soil organic carbon and then major nutrients as well as soil testing kit.

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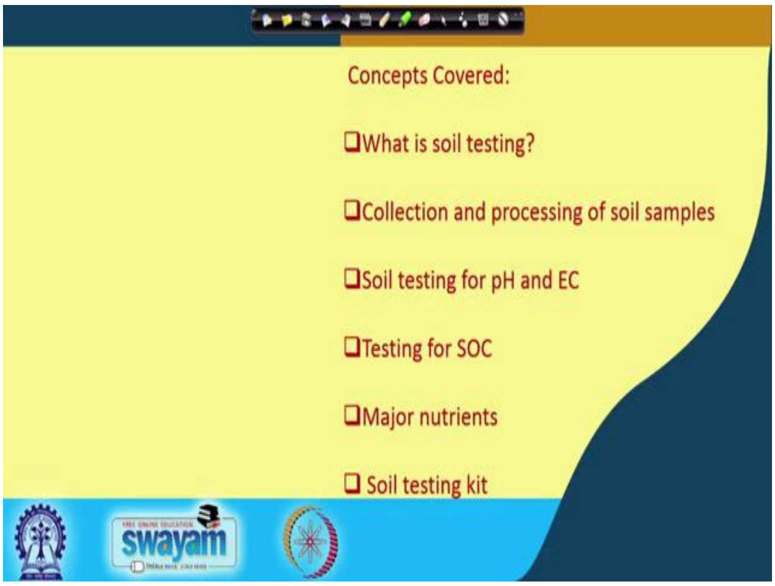

So, we will be covering, we will be trying to gain a basic overview of all these aspects in this topic of soil testing.

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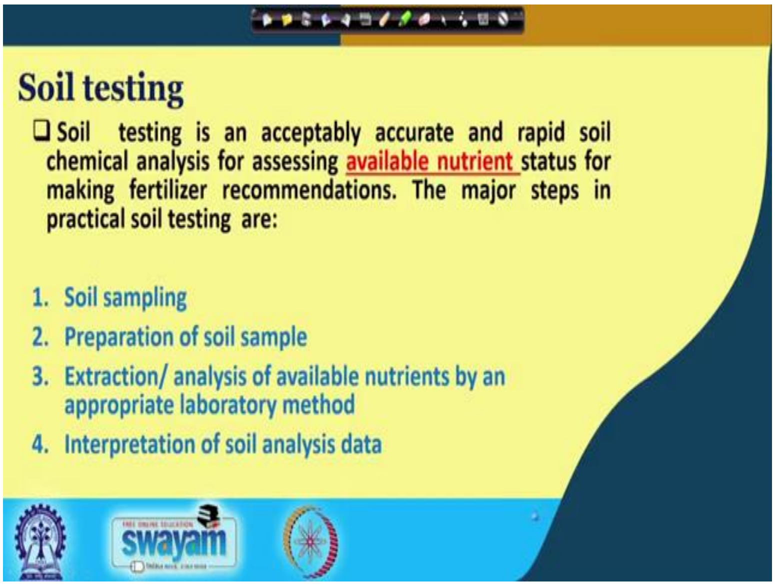

So what is soil testing basically? So, soil testing is an acceptably accurate and rapid soil chemical analysis for assessing available nutrient status for making fertilizer recommendation. And you know, whenever you want to do any recommendation for a farmer; in other words, you want to check the soil fertility status; that means, the soil is fertile or non fertile, you have to analyze the soil. And for analyzing the soil, this soil testing method basically analyze the available nutrients as you have already known that available nutrient is that fraction of the total nutrient which governs the growth and yield of crops.

So basically, it is measuring the available nutrient status for making fertilizer recommendation. And the major steps in the practical soil testing are basically, first of all soil sampling. This is the most important step and then preparation of the soil samples and then, extraction or analysis of available nutrients by an appropriate laboratory method. We will be discussing that. And finally, interpretation of soil analysis data.

So, this is also very very important and sometime we skip that, you know, but remember that this is the most, one of the most important step and you know by excluding this interpretation of soil analysis data, soil testing is incomplete. So, let us go ahead and see the first step, which is soil sampling.

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Remember, the soil sampling is one of the major source where most of the error occurs. So, we have to be very very accurate while collecting the samples because we want to collect some samples which is a true representative of a particular field. We should not take some samples which are not representative of the field.

So, I will discuss some of the, you know, cautions which you need to take care of while collecting the samples, but before that, let us see what are the different types of tools. So, you can see here there are different types of tools like khurpi, auger, spade, post hole, you know, diggers, hydraulic core samplers and all this kind of things. So, you can see here, there is a spade and there is a handled auger. Auger is a specialized kind of instrument for soil sampling and there are different types of auger depending on the soil types. Some are, you know, some augers are made for hard soil, some augers are made for very clayey type of soil. So, depending on the soil texture and soil condition, these augers can vary.

So, remember that, how many soils you know. So, first question comes in our minds. So, for soil testing, how many soil samples should we take? So, general rule is generally for 1 hectare of area, we take around 20 soil samples. So, generally, we do not take any soil sample from recently fertilized plot and then, bunds and channels and, you know, marshy tracts where the water is stagnant and then near area, you know, near area trees and then wells, compost piles, border areas etcetera because if we collect the soil sample from those area, they will not be true representative of the soil fertility.

So, how to collect the soil sample? Obviously, you can see here, we are taking some zigzag pattern while collecting the soil sample because we are trying to cover the heterogeneity of soil fertility which is present inside the soil, in the field, because soil is very very heterogeneous. So, one portion of the soil of a particular space may vary in their fertility status from a soil which is very near to it. So, we must cover the hole in a zigzag pattern so that, we can get a representative soil sample. So, this is the rationale behind the zigzag soil sampling.

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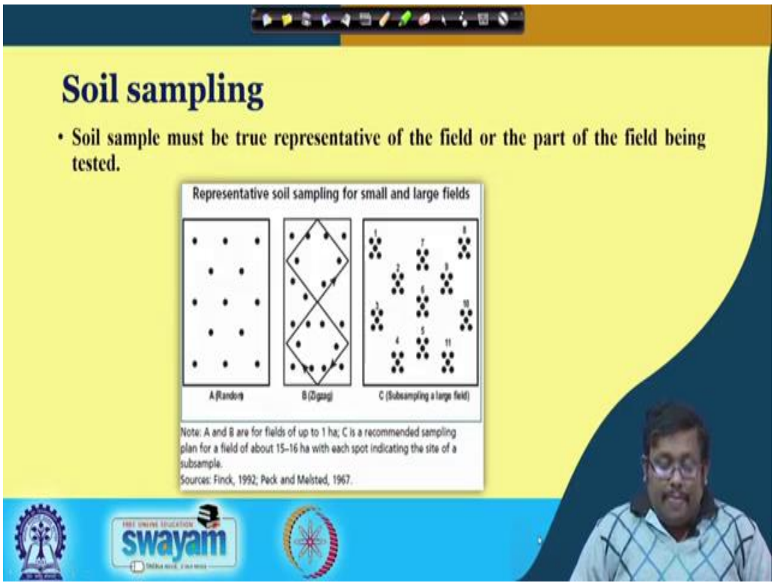

Now, soil sampling must be true representative of the field or the part of the field being treated because we can see, there are three different, you know, three different soil sampling scheme has been given. Now the scheme A is random, scheme B is zigzag which I have already talked about. So, this A and B schemes are basically we generally use for field up to 1 hectare of area. However, when the field is around 15 to 16 hectare of area, we will go for the scheme C which is called the sub sampling of a large field.

So, what we do? We generally, you know, generally take some, you know, nearby samples for a particular spot. We first select some particular spot and near this particular spot, we collect some 4 to 5 samples and then, we make a composite soil sample. So, this type of scheme is useful when the area is the very very large.

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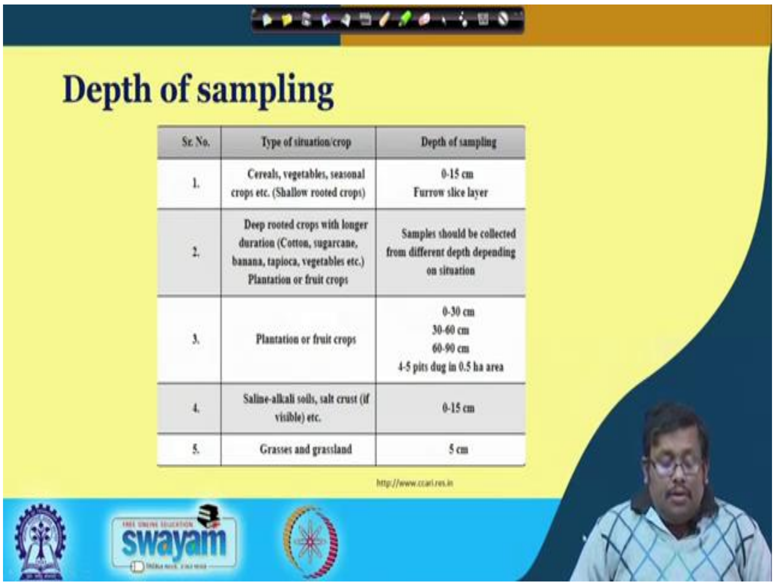

So, what is the depth of the sampling? Now the question comes what is the depth of the sampling. Well, it also depends on the type of the crops which are grown in that field, because you can see here in this table that, for cereals, vegetables and seasonal crop, generally depth of sampling varies from 0 to 15 centimeter. So, we generally collect the soil for most of the field crops from 0 to 15 centimeter depth.

However, in case of deep rooted crops and in case of longer duration crops like cotton, sugarcane, banana and then, we know, vegetables etcetera, we generally, you know, sample should be collected from different depth depending on the situation. For example, in case of plantation or fruit crops, we generally take from 0 to 30 centimeter or from 30 to 60 centimeter or 60 to 90 centimeter and 4 to 5 pits dug in generally half hectare of area.

And in case of saline alkali soil, which is a problematic soil, we have already discussed it in our previous lecture; we generally go for 0 to 15 centimeter and for grasses and, you know, grassland area we generally go for 0 to 5 centimeter. So you can see, depending on the crop which is standing or which is grown in that field; obviously, the sample depth or sampling depth generally varies.

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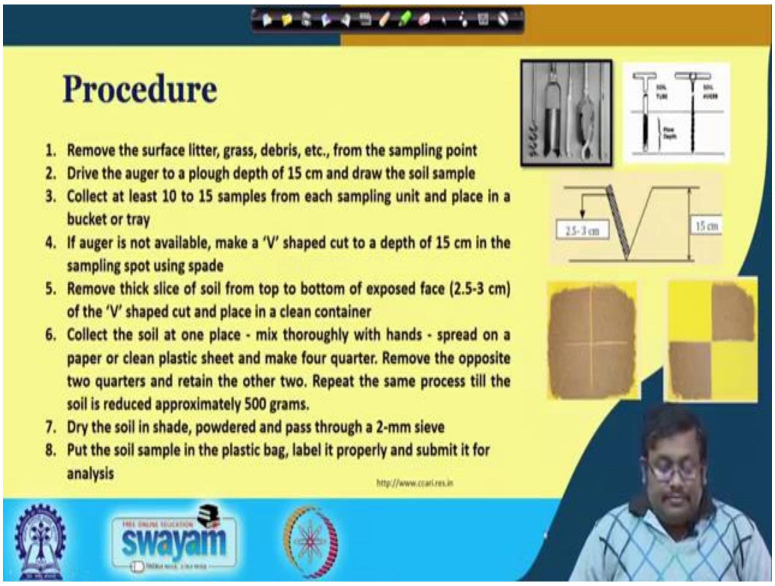

So, what is the procedure of collecting the sample? This is very very important. Now the first process is to remove all the surface litters, grass, debris etcetera from the sampling points. So, first you have to decide a sampling point and then you remove all the debris which is present on the surface. Now; if you have auger, you can see here, I have put some examples of augers.

So, these are different types of augers you can see. So, these are called tube augers. So, you can see here in the second picture here, this is called tube auger and we are inserting the tube auger and there is an another auger called, you know, screw auger. So, screw auger is very very helpful in case of hard soil. So, you can see, in case we have augers, we can drive the auger to a plough depth which is 0 to 15 centimeter and to draw the soil samples.

So, when using the auger we are collecting 10 to 15 samples from each sampling unit or in sampling point and place in a bucket or tray and mix it thoroughly. So, this is one way. The most popular way is when you have a spade instead of auger. Now using the spade what you do? You do a V shape cut just like this and up to 50 centimeter of depth because we are concerned about the field crops at this point of time.

So, once you get this plough, you know, V shape cut up to this plough depth of 15 centimeter, then you remove a thick slice. You can see here thick slice you know from top to bottom of the exposed face, that is, the thickness of the slice should be 2.5 to 3 centimeter. It is around 1 inch.

So, you take the slice of the soil which is 2.5 centimeter to 3 centimeter of the V shape cut and place in a clean container. Now collect the soil at one place and then mix thoroughly by hands and spread on a paper. As you can see here, we are spreading on the paper and then, you know, spread on a paper with a clean plastic sheet and make 4 quarters. As you can see, we have made 4 quarters.

So, once you make 4 quarter, remove the opposite 2 quarters. So, you are removing this one and this one and retain the other 2. just like here you can see here. We are removing this and retaining these 2. So, and we have to repeat the process until we got 500 grams of samples.

So, once you get 500 grams of samples, we will go ahead and we will dry the soils in shade and we will then, you know, powder it through different methods. We can either uses some mortar pestles to grind the soils or we can use some mechanized soil grinding machine to grind the soil and after grinding the soil, we will sieve it through a 2 millimeter sieve because you remember that by the definition of soil, soil is a material which has, you know, particle size of less than 2 millimeter. So, the highest particle in case of soil is sand and this is the highest particle size with 2 millimeter. So, less than 2 millimeter will collect. So, this is the representative soil.

So, once we collect the soil remember that, we have to put them into the plastic bag and clearly label because if the label is missing, then the total process will be meaningless. So, you have to clearly label all the information. First of all, the name of the farmer and the particular identification of that field and if possible, then we will take a GPS reading which we are taking right now in India and also we will be taking, we will be writing down the name of the previous crop and the crop which the farmer wants to grow in that field and all this important stuff you have to write down. So that, it will be useful for future recommendation purpose. So, this is the process of soil collection and soil preparation.

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So, let us see some photographs of the soil collection a soil preparation. As you can see, first of all, we are removing the surface litter and then, you can see here, you know, sample collected using a v shaped cut here; you can see this is a v shape cut and obviously, sample is thoroughly mixed then and then divided into 4 compartments, then opposite 2 compartment discarded and sample labeled and packed. So, these are the step by step process of collecting and processing the soil sample before we go for the standard analysis.

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So, while collecting the samples, we have to keep couple of things in our mind. First of all, the best time for sampling is before sowing and or planting. So, each sample should have a label describing the field identification, farmers name and address, previous crops and the crop for which nutrient recommendation is sought I have already talked; I have already told you that. And for soil sampling, special augers with a core diameter of 1 to 2 centimeter are convenient, but the small spades can also be used. In any case, a uniform slice of soil should be taken from top to bottom of the desired sampling depth. Now this is called GPS receiving unit.

Nowadays, we also use this GPS receiver unit for collecting and, you know, the GPS points and GPS basically we will collect, we will have a full lecture on GPS in coming weeks; however, you know this GPS basically collects the geographical position of a particular point.

It can be measure the latitude, it can measure the longitude of a particular point and sometimes, it measures the elevation from the mean sea level. So, using this GPS, we clearly mark down any soil sample and we can repeatedly go to that soil sample location after certain period of time to take further sample from that particular spot. So, that is a beauty of using GPS. So, GPS clearly marks the samples and clearly gives it a geographical context. So, let us see.

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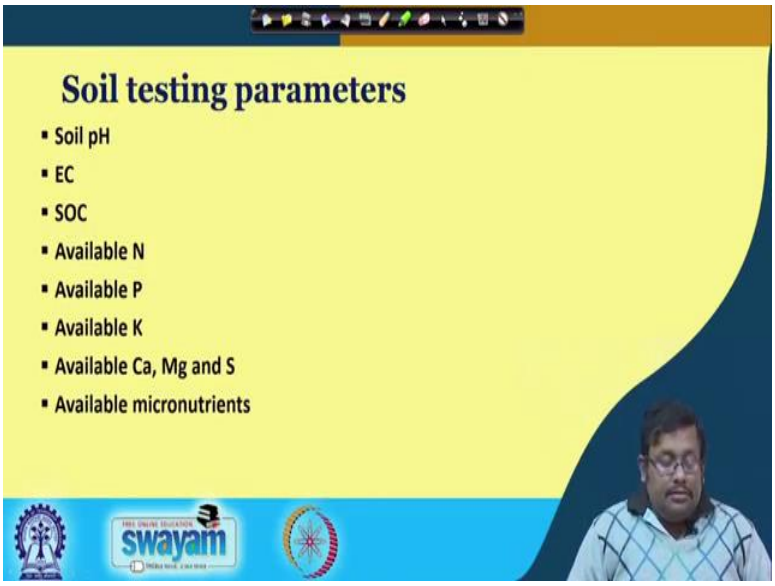

So, we have collected the samples and we have processed the samples. So, let us see what are the important soil testing parameters. So, in the laboratory generally, we measure soil pH, soil electrical conductivity, soil organic carbon, soil available nitrogen, soil available phosphorus, soil available potassium and then available calcium, magnesium and sulphur and available micronutrients. So, these are the general, you know, soil testing parameters.

However, in a routine soil testing laboratory you will see that, they are going for soil pH, EC, soil organic carbon, N, P, K and it requires specialized kind of, you know, instruments for measuring the available micronutrients like atomic absorption spectrophotometer or ICP spectrophotometer. And also, available calcium, magnesium, sulphur is also done in some special cases. So, generally for, you know, in the normal soil testing labs in India, they generally go and, you know, measure these first six important parameters. ok.

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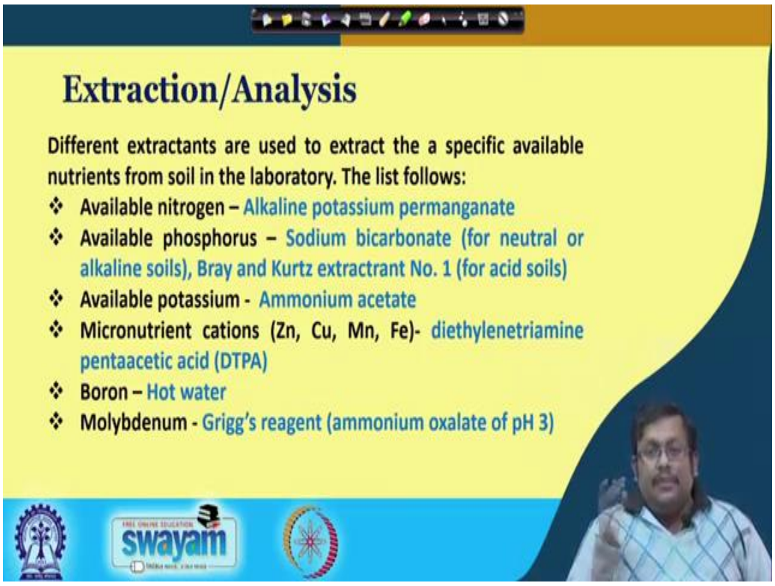

So, once we collect the samples, the next step we the process the sample, the next step is to measure it through some standard methods. And remember that, for all these macronutrients and micronutrients like available nitrogen, phosphorus, potassium and then different micronutrients boron, molybdenum, we have to make sure that we will be extracting all the nutrients in the extracting solution and using that extracting solution further, we will measure their concentration.

So, the step is, basically the idea is, the soil basically attract or adsorb these cations and anions on their surface due to different types of charge and bonds. So, these cations and anions have to come into the solution before they can be measured through different instruments. Now, for releasing those anions and cations into the soil solution or into the extracting solution, we need to use certain kind of extractants or chemicals.

So, there are different types of chemicals based on different types of parameters. So, you can see here, I have listed couple of them. So, for available nitrogen, we generally use alkaline potassium permanganate extractant and for available phosphorous, we generally use, mostly we use two methods based on the soil pH. So, first of all is sodium bicarbonate for neutral or alkaline soil. We call it Olsen method. Another is call the Bray and Kurtz 1 method. So, it is useful for acid soils.

And for available potassium, we will be using neutral normal ammonium acetate. And for micro nutrient, we will be extracting the micronutrient basically zinc, copper, molybdenum and iron using DTPA method. DTPA is a chelating agent and the full name of DTPA is diethylenetriamine pentaacetic acid and for boron, we extract using hot water and in case of molybdenum, we use Grigg's reagent which is basically ammonium oxalate of pH 3.

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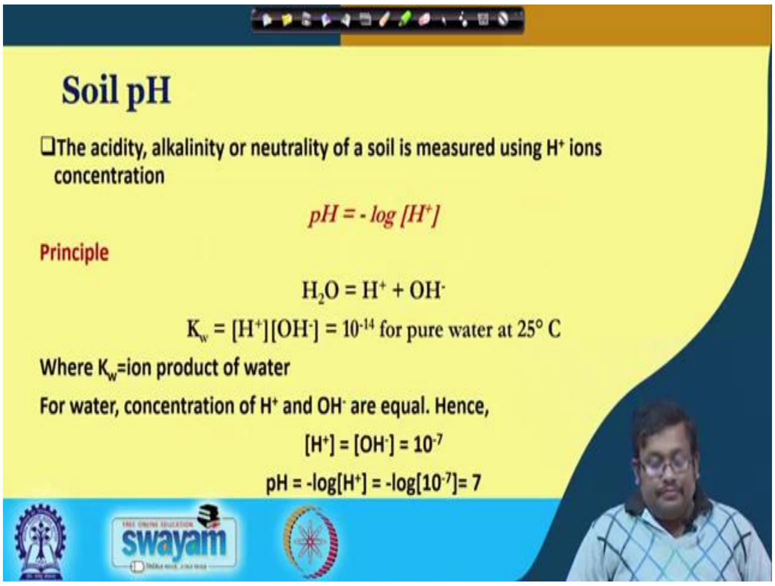

So, these are some well-known extractants which generally, you know, scientists use in the soil testing lab to extract different nutrients, whether they are macronutrients or micronutrients. Now let us start, you know, let us start discussing the major parameters which most of the soil testing laboratory do in our country or in India. Let us start with the soil pH.

So, we will be basically covering soil pH, soil electrical conductivity, soil organic carbon, then available N, P, K. We will not cover, you know, micronutrients extractions; however, we will be showing you some advance methods for measuring the micronutrients. So, the soil pH is basically, you know, the acidity or alkalinity or neutrality of a soil which is measured using, you know, proton concentration or H^+ ion concentration.

So, as you know that pH is basically negative logarithm of hydrogen ion concentration. And principle says that when, water is hydrolyzed, it produces 1 proton and 1 hydroxyl group. And obviously, this K_w is basically 10-^{14} for pure water at 25° C where K_w is basically the ion product of water. So, for water, the concentration of H^+ and OH^- are basically equal because water is neutral. So, H^+ concentration will be equal to OH^- and this is equal to 10^{-7}.

So, pH of water is always 7 because it is neutral, but whenever pH of any soil or any material goes beyond 7, it is alkaline or below 7, it is acidic in nature.

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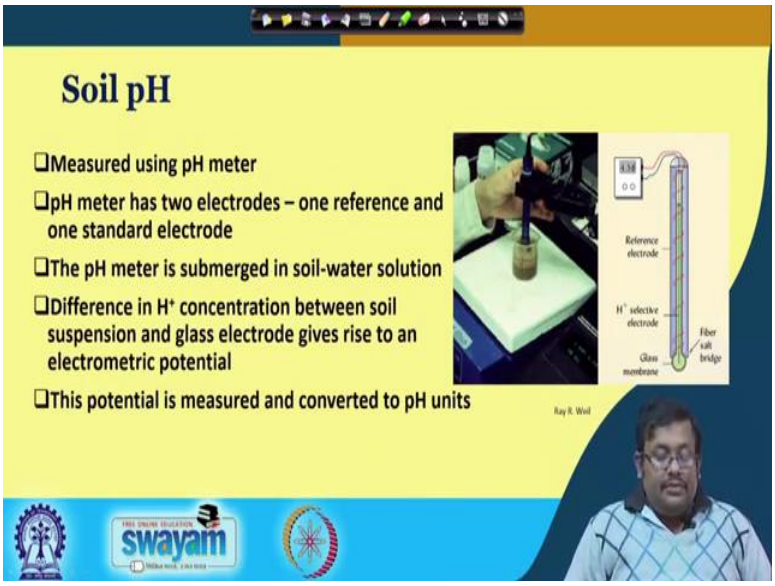

Then let us see how we measure the soil pH. So, generally we measure the soil pH in the lab using a pH meter. So, you can see here, you know, I have shown here a pH meter. Now pH meter basically has two electrodes. One is called reference electrode, another is called standard electrode. Now the pH meter, basically we submerge it into the soil water solution. How we create the soil water solution? We will discuss.

So, this beaker is basically containing the soil water solution and basically we are dipping this pH meter. Now in the pH meter, you can see it is basically glass electrode. So, it is basically a very very thin glass membrane which is very much sensitive to H^+ ions. So basically, this is proton selective electrode and which is surrounded by a, you know, reference electrode with a fiber salt bridge and this reference electrode and this glass membrane electrode basically combines together to measure the soil pH.

Now, the difference in H^+ ion concentration between soil suspension and glass electrode gives rise to an electrometric potential. When we dip this electrode into the soil water suspension, there is a potential difference which develops between these glass membrane electrode and the reference electrode and which basically generates a electrometric potential and this potential is measured and converted to the pH units. So, this is basically in short form or in a simpler form, it is basically the principle of measurement of soil pH.

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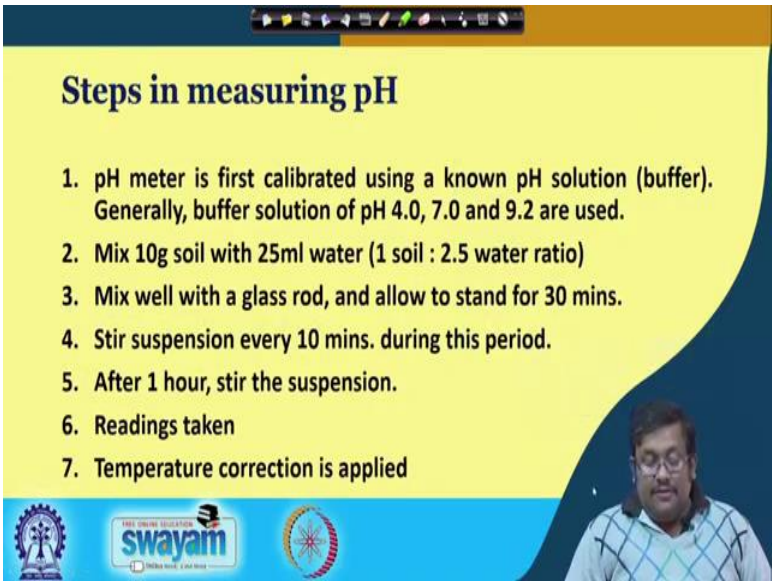

Now these are some steps of measuring soil pH; obviously, pH meter is first calibrated using a known pH solution and we call it buffer. Generally we use three buffer for calibrating the pH meter. That is, pH 4.0, pH 7.0 and pH 9.2. And then, what you do? We create a 1:2.5 soil water suspension by mixing 10 gram of water with 25 ml of deionized water, then we mix well with, you know, with glass rod and allow it to stand for 30 minutes with intermittent stirring. And then, we can stir the suspension every 10 minutes during this period. Now, after 1 hour, we have to further stir the suspension and then we will take the reading and if there is a change in the ambient temperature, obviously, temperature correction has to be made.

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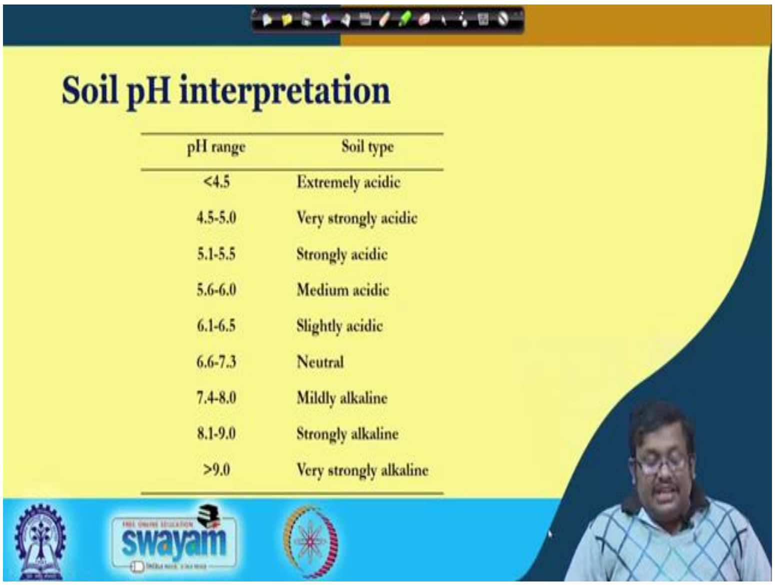

So, once we get the pH value directly from the pH meter, the next step is the interpretation. Without interpretation, you know, soil testing is incomplete. So, you can see soil pH, they have divided into different pH ranges starting from extremely acidic to very and strongly alkaline and you can see slightly acidic and neutral range basically they are saying that the neutral range is 6.6 to 7.3. So, it varies from extremely acidic condition to very strongly alkaline condition and there is some intermediate grades; obviously.

So, depending on in which range your tested soil pH comes, you will basically recommend, you will basically identify whether the soil is alkaline or acidic or mildly alkaline or mildly acidic and based on that you will give the recommendation. Obviously, if you remember our soil acidity lecture, if the soil is acid, we will go for lime application. If the soil is alkaline, we will go for Gypsum application.

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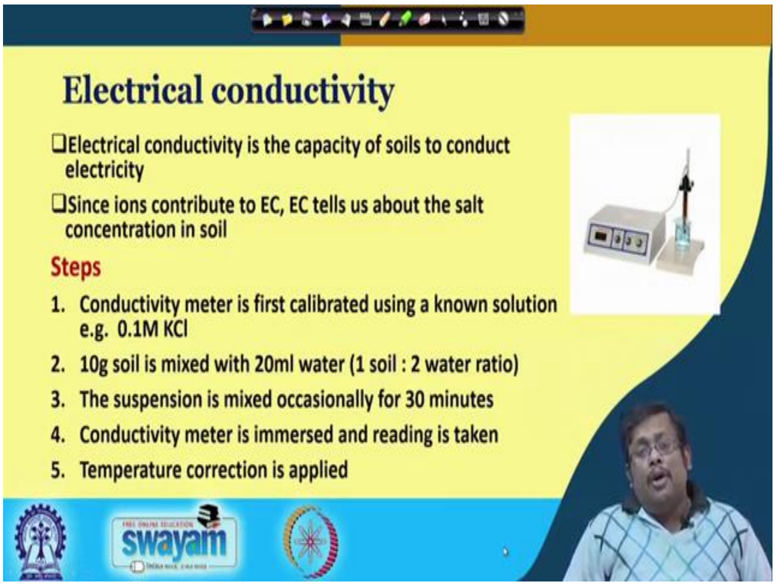

The next important, you know, parameter is electrical conductivity. An electrical conductivity is the capacity of soil to conduct the electricity. So, basically, you know, since ions basically contribute to electrical conductivity and EC basically tells us about the salt concentration of the soil. So, basically soil contains some salts and these salts basically contain several ions and electrical conductivity is maintained through ions movement. And so, this is how, this is why it is called the electrical conductivity and electrical conductivity we generally measure in terms of, I am sorry; the electrical conductivity basically represent the soil salinity.

Now these are again the steps of soil salinity measurement using conductivity meter. Now you can see here, I have shown here one conductivity meter. Here again, we have to make 1:2 soil water ratio and then, you know, the suspension is to be mixed occasionally for 30 minutes and then conductivity meter has to be immersed and reading is taken and then temperature correction has to be applied. So, all these steps are important.

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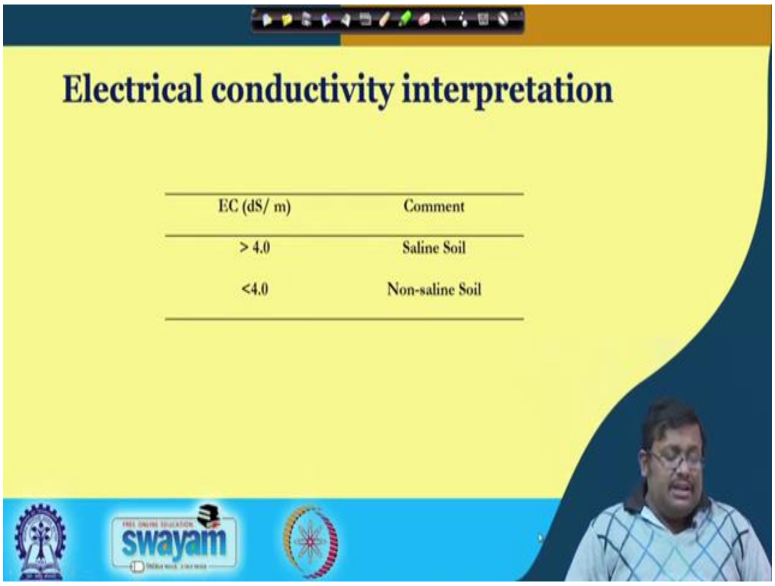

And basically, finally, the interpretation says that when the electrical conductivity is greater than 4 dS/m, it will be saline soil and when it is less than 4 dS/m, it will be non saline soil. So, this is the final interpretation.

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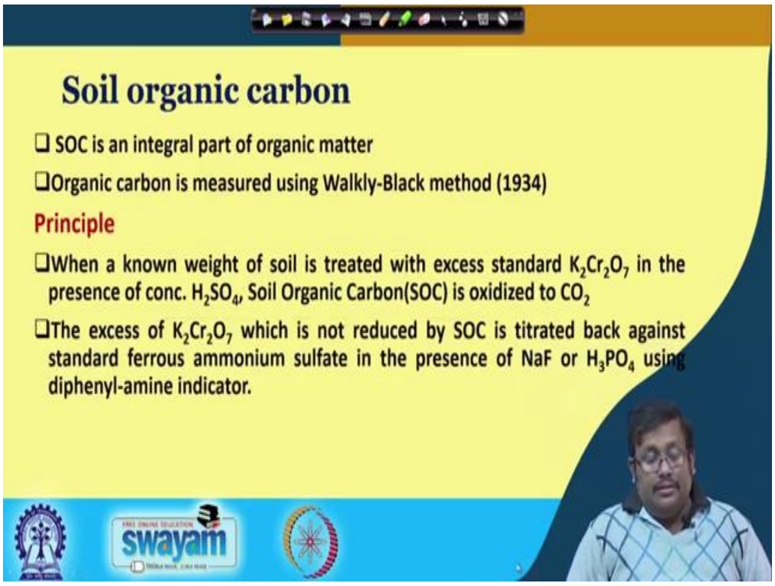

Now, third important and one of the most important is soil organic carbon. Now soil organic carbon basically we measure through a method given by two scientists called Walkley and Black in the year 1934. And basically, the principle of this method is basically, when a known weight of soil is treated with excess standard $K_2Cr_2O_7$ or potassium dichromate in the presence of concentrated H_2SO_4, soil organic carbon is oxidized to carbon dioxide. And the excess of $K_2Cr_2O_7$ which is not reduced by SOC is titrated back against standard ferrous ammonium sulphate in the presence of sodium fluoride or H_3PO_4 using a diphenyl amine indicator. So, it is very very simple.

Remember, a soil contains high amount of organic matter, soil contains, you know, I am sorry, varying amount of organic matter. Especially in Indian soil, it is very very low. So, when we treat a known, you know, weight of soil with concentrated H_2SO_4 at excess of standard $K_2Cr_2O_7$. Basically they are oxidizing agents. So, they basically oxidize whatever carbon is present in the organic matter in the soil and ultimately they generate carbon dioxide.

So, obviously, when this carbon will be oxidized, this $K_2Cr_2O_7$ will be reduced. Now, the excess of $K_2Cr_2O_7$ which still remains and is not reduced, we have to calculate that by using titration against a standard ferrous ammonium sulphate and for that, we need, we know, we need an indicator for indicating the color change that is diphenyl amine and there should be H_3PO_4 also. So, this is the soil organic carbon measurement protocol, you know, principle.

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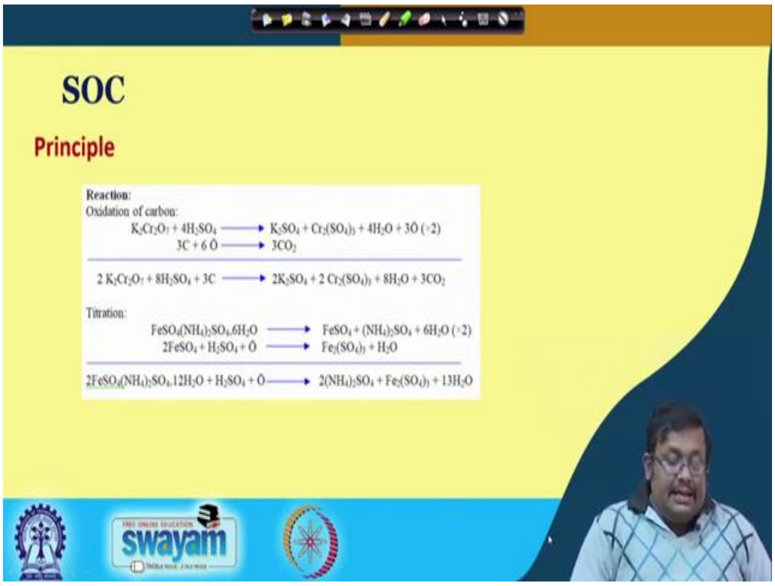

And this is the reaction which is involved. So, you can see here $K_2Cr_2O_7$ and H_2SO_4 basically reacts with the carbon to produce the potassium sulphate and then chromic sulphate and finally, water and carbon dioxide.

So basically, these are the oxidizing agent then, these carbon gets oxidized and this $K_2Cr_2O_7$ is basically reduced to K_2SO_4 and then, you can see here in the titration step, basically ferrous ammonium sulphate is acting to this ultimately producing the ammonium sulphate and then ferric sulphate and water. So, this is the reaction in a nutshell for this organic carbon.

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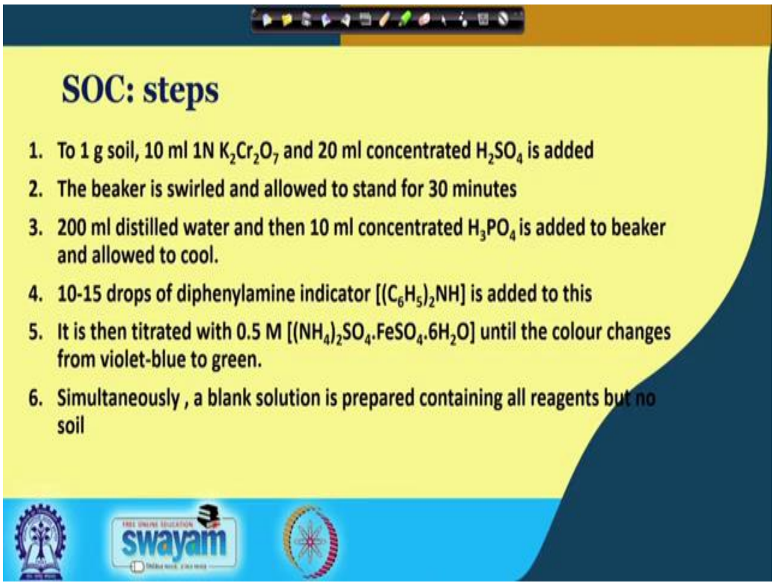

And these are the steps of measurement of organic carbon. I am not going to detail all the steps. Just I am putting this in the slides to, you know, for your ready reference in the future.

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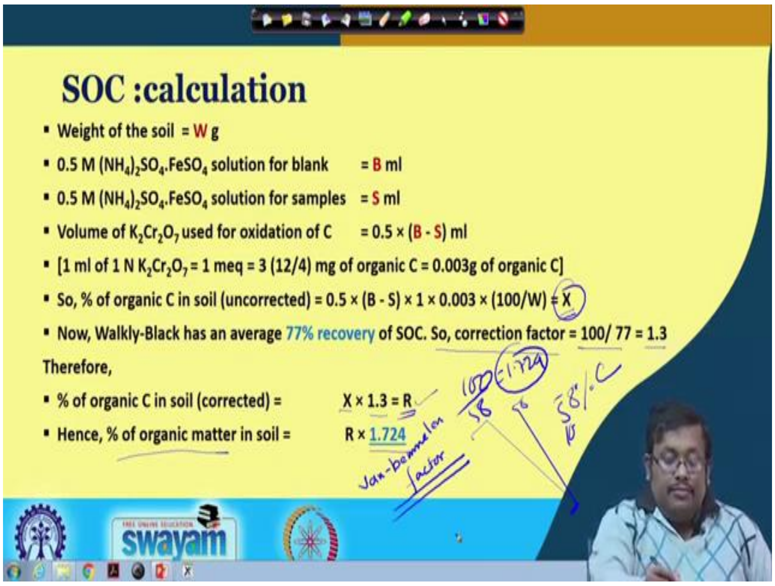

Just to know that, I have, I just need to mention a couple of important points; in this slide, basically, the soil organic matter calculations are given. So, you can easily see how we calculate the soil organic matter. Just remember, after we calculate the percentage of organic carbon using this method. Suppose it is a X. This Walkley Black method has average of 77% recovery. So, it cannot go for 100% recovery. So, when we go for 77% recovery, the correction factor obviously, will be 100 over 77 that is 1.3. So, percentage of organic carbon is, or true percentage of organic carbon or corrected is X into 1.3 which is now denoted by R.

Now once you calculate the percentage organic carbon, how to get the organic matter percentage? Remember that organic matter contains 58% of carbon. So, if you see 58% of carbon and if you see, so 100 by 58, you will get 1.724 and this is why, to get the percentage of organic matter from the percentage of organic carbon, we have to multiply with this 1.724. And this 1.724 is known as Van-bemmelen factor. This is very very important. Van-bemmelen factor, 1.724 and this 1.724 basically comes from this assumption that organic matter contains 58% of organic carbon.

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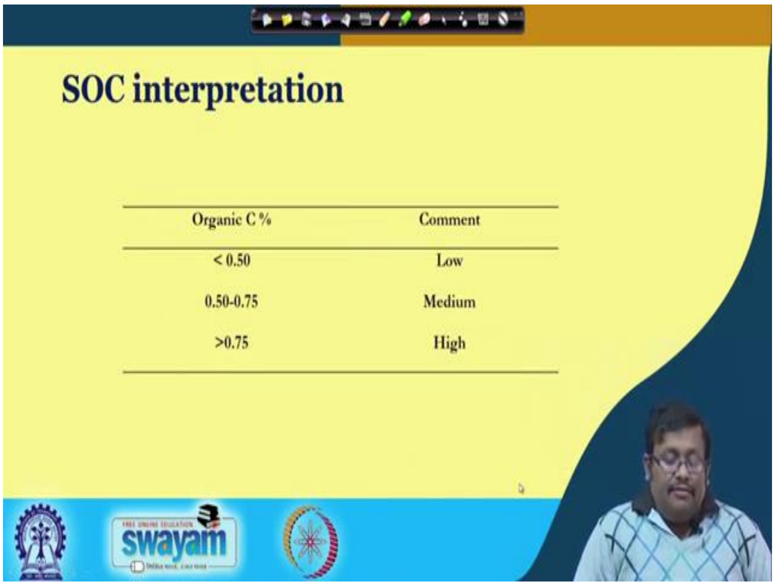

So, this is the final organic matter percentage and final interpretation of organic carbon percentage on the basis of organic carbon percentage. If it is less than 0.5%, then it is low. In Indian condition, obviously. In medium, 0.5 to 0.75 and while it is greater than 0.75%, it is high. So, in Indian condition remember that, the average organic carbon, national average of soil organic carbon is 0.5% or below. So, our soil contains very very less amount of organic carbon. So guys, I will be stopping here in this lecture in this session and in the next lecture we will be trying to finish the soil testing and till then, bye bye and let us see in the next lecture.

Thank you.