Soil Science and Technology
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Lecture - 39
Soil Organisms

Welcome friends to this new lecture of Soil Science and Technology. And in this lecture, we will be trying to finish this soil organic matter, and then we will be discussing about the Soil Organisms. So, obviously in the last lecture we if we remember that we talked about different types of organic matter decomposition, how organic matter decomposed based on the organic matter quality, then we talked about different pools of soil, different pools of carbon, and then, you know, how organic matter forms.

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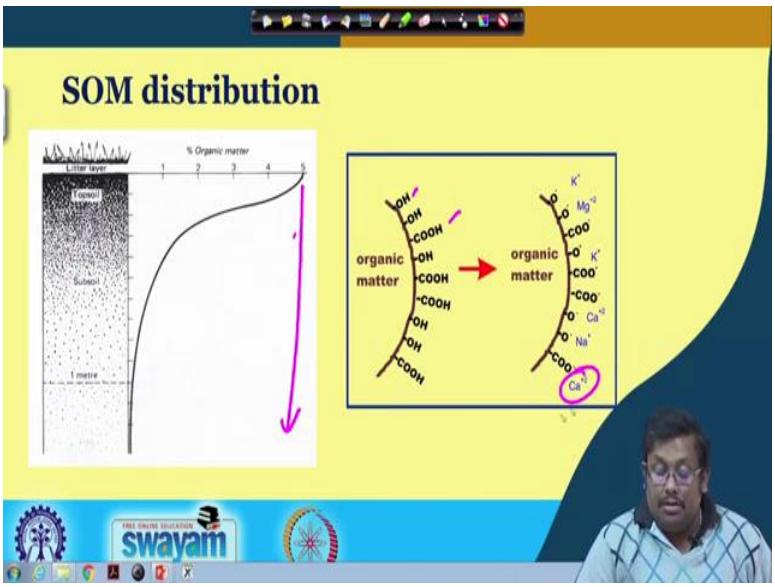

So, let us starts from here. And in this, in this in this slide, you can see the soil organic matter distribution. Obviously, if you see the top, you know, at the top layer of the soil, the concentration or the amount of organic matter is always higher as compared to the subsoil. So, as we go down from top layer to sub soil layer, obviously the organic matter percentage of organic matter always goes down.

And if you see the, you know, organic matter, obviously these hydroxyl groups, and you know acidic groups are there, and these groups basically undergoes dissociation, and

basically they attract these positive cations. So, we will discuss in details later on. So, this is just an, you know, this just gives an idea about how these organic matter attracts different types of cations onto their surface. So, distribution of organic matter depends from, it varies from one soil to another soil.

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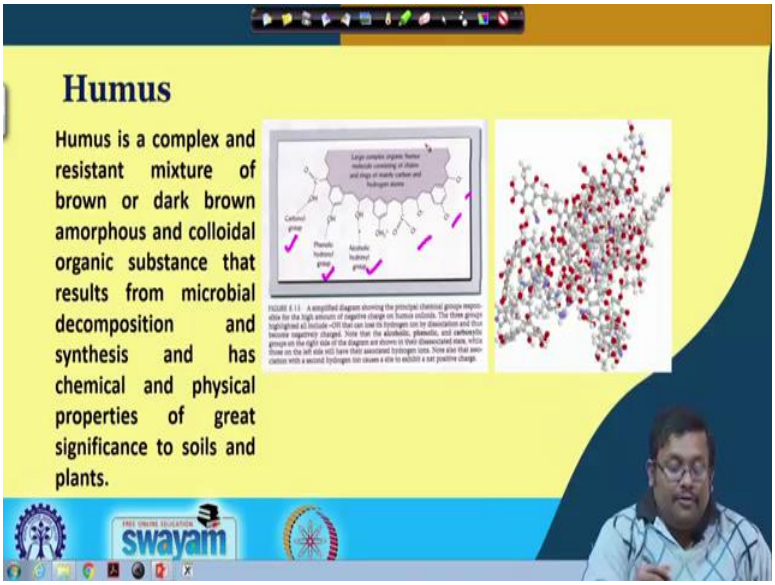

So, let us talk about the humus. Now, humus is a complex and resistant mixture of brown and dark brown amorphous and colloidal organic substances that results from microbial decomposition and synthesis and has chemical and physical properties of great significance of soil. So, it is we have already discussed that humus is a more resistant product; it is developed from different types of microbial decomposition. And you can see here, this is a three-dimensional view of a humus molecule which is very very complex.

And one other, you know, another simplified diagram showing the principal chemical group, which is responsible for high amount of negative charge on humus colloids. If you remember humus in case of humus, the CEC is quite couple of folds higher than that of the CEC of clay. So, obviously you can the three groups, we can see here are basically carboxylic group, sorry, basically carboxylic group, and then phenolic hydroxyl group, and alcoholic hydroxyl group. So, and also the dissociated forms are given here. So, you know this dissociated you can see, they are negatively charged. And as a result, they can attract these positively charged cations. And also some positively dissociated charge in

which can attract the negative, you know, the anions also, so that is the large, you know, you can see that is why it can absorb a large amount of plant nutrients for maintaining the soil fertility.

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So, what is basically, you know, this humus is composed of. So, the humic groups. If you if you see humic substances are aromatic type of structures, and the humic substance are classified. If you break down a humus, we will get basically three types of humic substances. One is called humic acid, another is called fulvic acid, another is humin. And these substances are classified based on their resistance to degradation and solubility in acids and alkali. So, we will see that later on.

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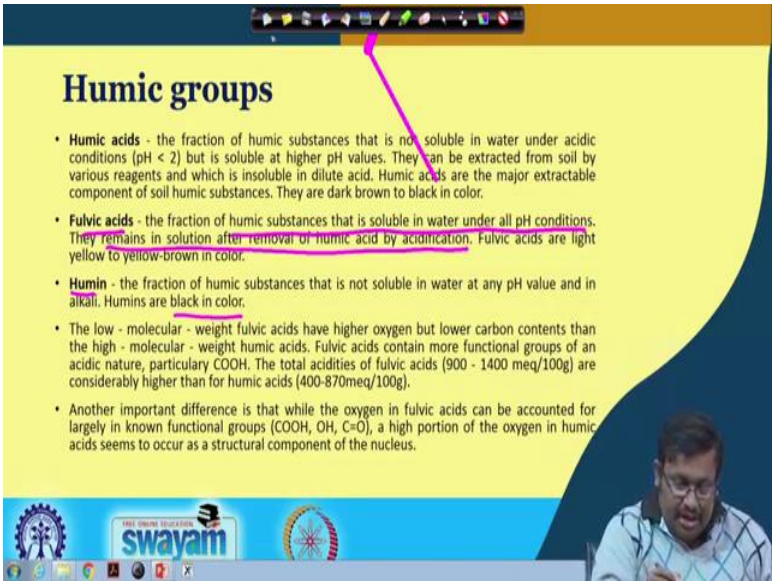

Again humic acid, fulvic acid, and humin; so, what is humic acid. The fraction of the humic substances that is not soluble in water under acidic condition that is pH less than 2, but is soluble in a higher pH values. And they can be extracted from soil by various reagents and which is insoluble in dilute acids. So, again remember that humic acid is insoluble in acidic condition less than pH 2, however it is soluble in alkaline condition.

The second important component is fulvic acid. And the fraction of humic substances that is soluble in water under all pH condition, and they remain in solution after removal of the humic acid by acidification. So, the fulvic acid is basically soluble under all pH condition, whereas humic acid is only soluble in the higher pH values. And third one is humin. The fraction of humic substances that is not soluble in water at any pH values and in any alkaline or in alkali. So, humins are black in colour.

So, remember that the low-molecular-weight fulvic acid, the fulvic acid has low molecular weight. They have high oxygen, but lower carbon content than high molecular humic acid. And fulvic acid contain more functional groups of an acidic nature particularly acidic group. And the total acidity of fulvic acid is 900 to 1400 milli equivalent per 100 grams. And are considerably higher than that of humic acid which has only 400 to 870 milli equivalent per 100 gram.

So, another important difference is that while oxygen in fulvic acid can be accounted largely in known functional groups, that is acidic group, phenolic group, and carbonyl

group, a high portion of the oxygen in humic acids seems to occur in a structural component of the nucleus. So, these are some important features of these fractions. Obviously, again humic acid is insoluble in acidic condition, soluble in alkaline conditions. Fulvic acid is soluble in all the condition, insoluble fraction is called humin, and it is black in nature. Fulvic acid contains more oxygen containing group more acidic in nature. And humic acid contain more carbon content, and it is more molecular weight, it is having more molecular weight.

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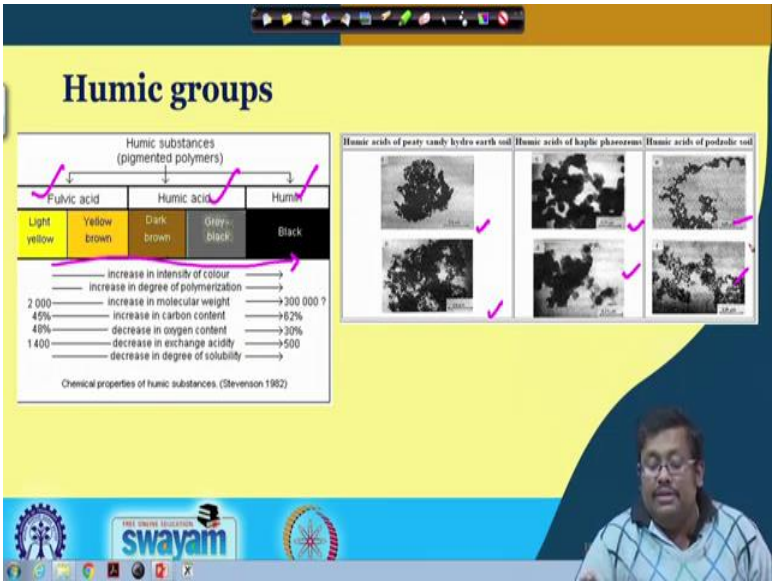

So, this slide shows that what are the different features of this humic fraction. So, if you can see, the fulvic acid are light yellow to yellow brown in colour, humic acids are dark brown to grey black in colour, and humin is black in colour. So, obviously if you go from fulvic acid to humic acid, increasing the intensity of the colour you can see here. So, when we are going from fulvic acid to humin humin, obviously you can see the intensity of the colour increases. Also increase in the degree of polymerization obviously, fulvic acid is simpler, however humin is much more complex.

And then increase in molecular weight obviously, it is quite understandable, because fulvic acid is low molecular weight, and increase in carbon content, decrease in oxygen content. So, remember fulvic acid contains more oxygen containing functional groups. And then decrease in exchange acidity, and obviously decrease in degree of solubility, because fulvic acid is soluble in all condition. Humic acid is soluble in only alkaline

condition, humin is insoluble. So, this shows a very good comparison of these three fractions. And obviously, these are humic acids of peaty sandy soil, and, you know, these are electron-microscope view of these humic acids.

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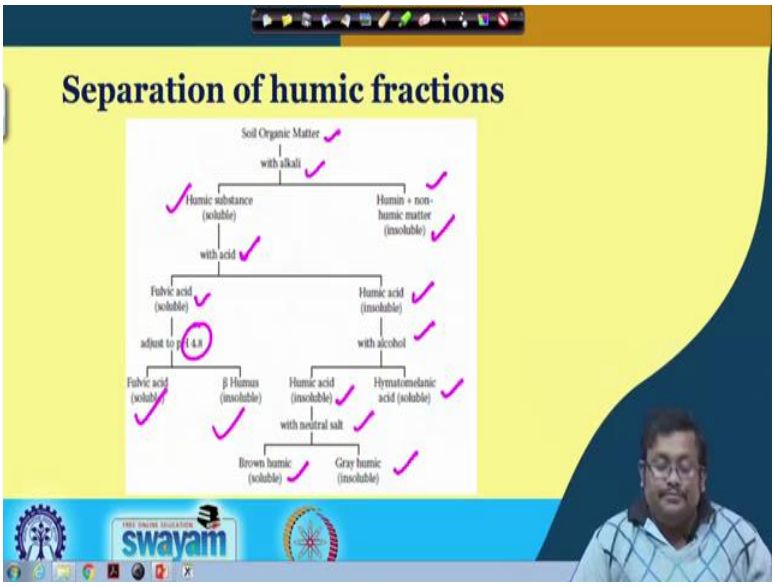

So, let us see how we can separate these humic fractions. So, this soil from the soil organic matter, we can separate these humic fraction based on their solubility. So, if you start with the soil organic matter, let us first, you know, treat with the alkali. So, it will separate the humic substances which will be soluble, and humin, and non-humic matter which are basically insoluble.

So, in the first step basically humin and non-humic matter are separated from humic substances. In humic substances contains both humic acid and fulvic acid. So, in the second step, when humic substances is react is mixed with the acid, obviously the fulvic acid will be soluble. However, humic acid will be insoluble, because we know that humic acid cannot be soluble in acidic condition.

So, this fulvic acid which will be soluble, then if we can adjust the pH to 4.8 obviously that will be separated into fulvic acid which is soluble, and beta humus which is insoluble and humic acid which was insoluble with acid reaction. If we reflex that with the alcohol, it will convert into two major fraction. One is hymatomelanic acid which is soluble, and another is insoluble humic acid. Now, this insoluble humic acid, when we treat with neutral salt it will again further divided into soluble brown humic fraction, and

insoluble grey humic fraction. So, you can see how based on the solubility, these fractions are separated from soil organic matter.

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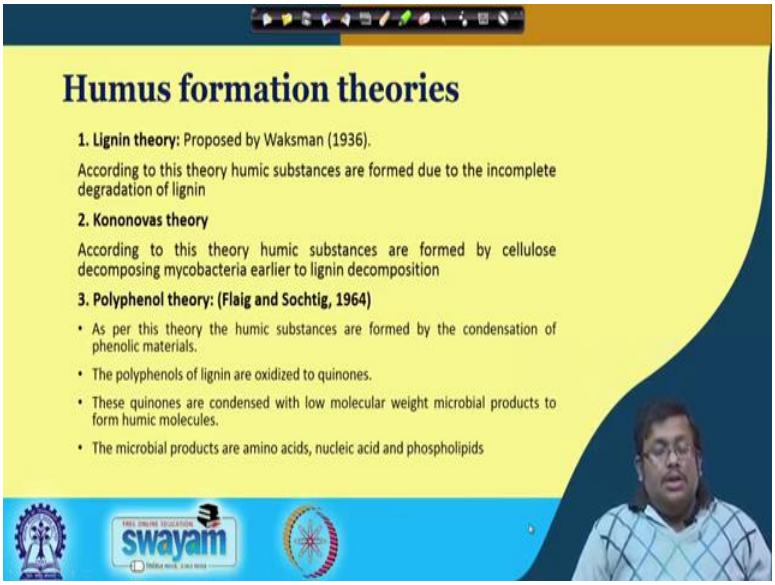

So, there are three different foom, you know, there are different humus formation theories obviously. The lignin theory which was given by scientist Waksman in 1936; then Kononovas theory, and then polyphenol theory which is the recent one given by Flaig and Sochtig in 1964. So, these theories basically show basically tells us about how this humus form formation takes place.

So, according to lignin theory, humic substances are formed due to incomplete degradation of lignin. And Kononovas theory says that humic substance are formed by cellulose decomposing mycobacteria earlier to lignin decomposition. Whereas, polyphenol theory says that as per this theory, the humic substances are formed from the condensation of the phenolic compounds.

And the polyphenols of lignins are oxidized to quinones. And these quinones are condensed with low molecular weight microbial products to form humic molecules. And the microbial product are amino acids, nucleic acids and phospholipids. So, these basically three theory shows the pathway through which these humus basically forms ok.

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So, what is the influence of organic matter into the soil, why we are studying this organic matter, because, you know, dark, you know, organic matter is dark in colour. So, dark in colour will facilitate soil warming. And also it will improve the physical condition of the soil, because divide of organic matters soil will be physically less I mean less I would say that when the soil contains more amount of organic matter, the soil aggregation formation is much more. And as a result, soil physical condition is improved.

And also soil, you know, these organic matter is a reservoir of plant nutrients because of high amount of charge which develops over its surface. The clay-humus complex has a better buffering and the exchange capacity and also organic matter can form stable complexes with some metals, and influences their availability to the plants by forming some chelated compounds.

And biodegradation of different chemicals like pesticides through the interaction with organic matter is an important phenomenon in relation to the human and animal health, we have already discussed it in our previous lectures. So, the organic matter is huge important as far as the soil physical, chemical, and biological properties are concerned.

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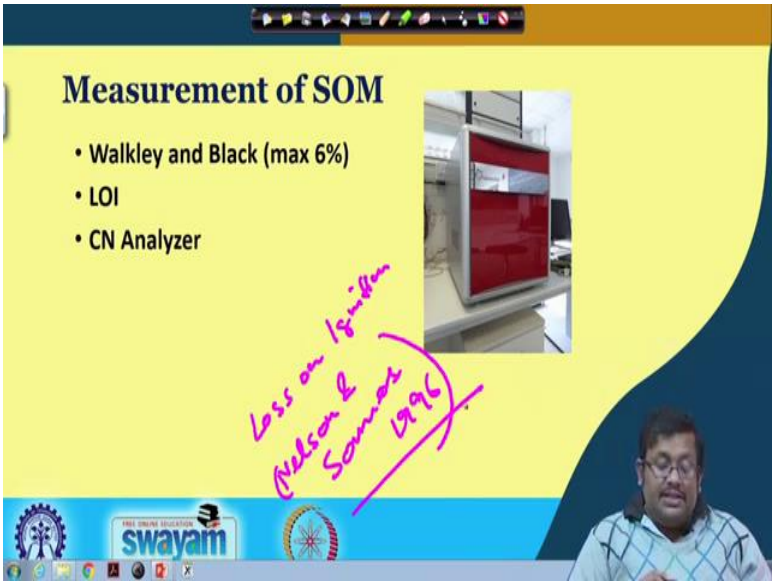

So, how we measure the soil organic matter, obviously we talked about this Walkley and Black method in our soil testing lectures. And, but remember that this Walkley and Black method, we can measure up to 6 percent of soil organic matter. When it is more than 6 percent of soil organic matter, generally we prefer two methods. One is called LOI or loss on ignition method, we call it Loss on Ignition method given by two scientist called Nelson and Sommers in 1996, which basically, you know, tells the what is the what is the, you know, it basically gravimetrically measures the loss of carbon when we put a known weight of soil within an oven, and, we know, we oxidize all the carbon at high temperature.

So, when the all the carbon which is present in the soil get oxidized to carbon dioxide obviously, there will be difference in the weight. And this weight difference will be measuring and gravimetrically, it will calculate the soil organic matter. And finally, CN analyser this is an advanced method Carbon Nitrogen Analyser. And generally in advanced, you know, soil testing lab, we use that and it is very very precise.

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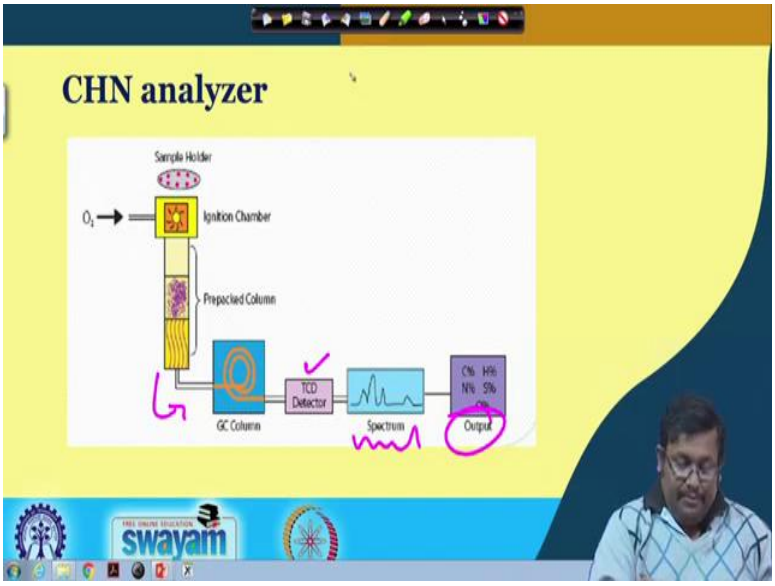

So, the so the working principle of CHN analyser in a there is a sample holder. And there is an ignition chamber, we incorporate oxygen through it. So, the sample is injected here there is a pre-packed column.

And ultimately the sample the carbon, which is present within the sample get to co oxidized to carbon dioxide, and this carbon dioxide move through these GC or gas chromatography column. And ultimately it is detected through TCD detector a thermal conductivity detector, and it will give the spectrum of the compounds, and from that we can calculate the concentration of carbon, hydrogen, and nitrogen ok. So, this is the principal of the carbon CHN or both are same CHN and CN analyser.

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So, how to manage the soil organic matter? Now, there are several ways to manage the soil organic matter. First of all, the conservation tillage is one of the important aspect. Then providing the cover crops, then crop rotation, crop residues applying, and then nutrient management, organic amendment, commercial humates; all these are different management strategies for maintaining the soil organic matter.

Obviously, conservation tillage helps in maintaining the soil organic carbon, because you know they less disturb the soil. Then cover crops, crop rotation, crop residues, all these add organic matter into the soil. And then organic amendments like different types of organic manure, when you apply different types of bulky organic manure, concentrated organic manure when you apply that also adds to the soil organic matter.

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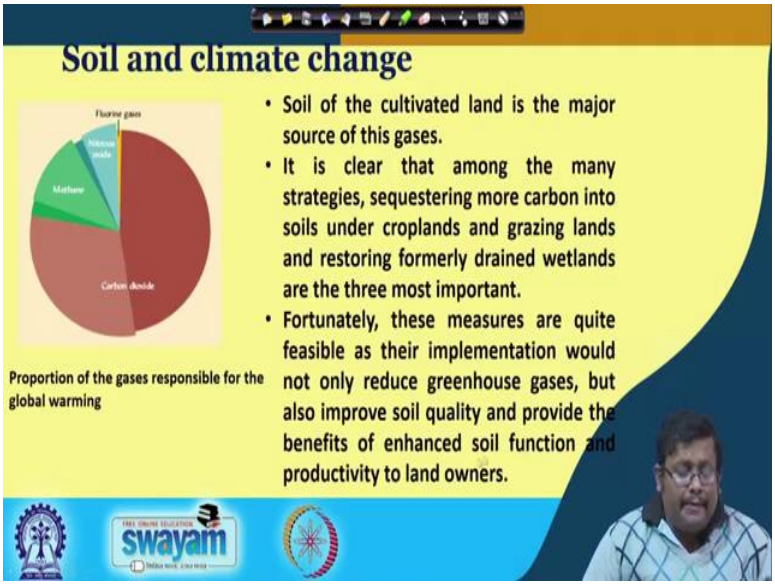

Now, what is the implication of soil organic matter in the climate change. Now, if you see here, this is the proportion of the gases responsible for the global warming or greenhouse gas effect. So, obviously carbon dioxide is responsible for a large portion of it apart from nitrous oxide, methane, and fluorine gases.

So, soil of basically cultivated land is the major source of these gases, because when we cultivate the soil, it exposes the soil. And whatever carbon is present that will exposed, and that will be oxidized by, you know, by the oxygen which is present in the air. And ultimately, this carbon will, you know, will be released into the atmosphere in the form of carbon dioxide.

So, it is clear that among the many strategies, sequestering more carbon into the soil under crop lands and grazing lands and restoring formerly drained wetlands are the three most important. So, again sequestering carbon, so this is very important. Carbon sequestration what is carbon sequestration, carbon sequestration means we will prevent the movement of carbon from soil to atmosphere. So, how could you do that? So, another one way is to conservation tillage. So, in the conservation tillage, we are not exposing the soil. So, as a result the carbon oxidation and formation of carbon dioxide is reduced. So, it is a one of the strategy of, you know, of this carbon sequestration.

And that fortunately, these measures are quite feasible as their implementation would not only reduce greenhouse gases, but also they improve the soil quality and provide the

benefits of enhanced soil function and productivity to the owners. So, these are some strategies, and remember that that is why soil carbon sequestration is very very important nowadays ok. So, we have finished this soil organic carbon lecture.

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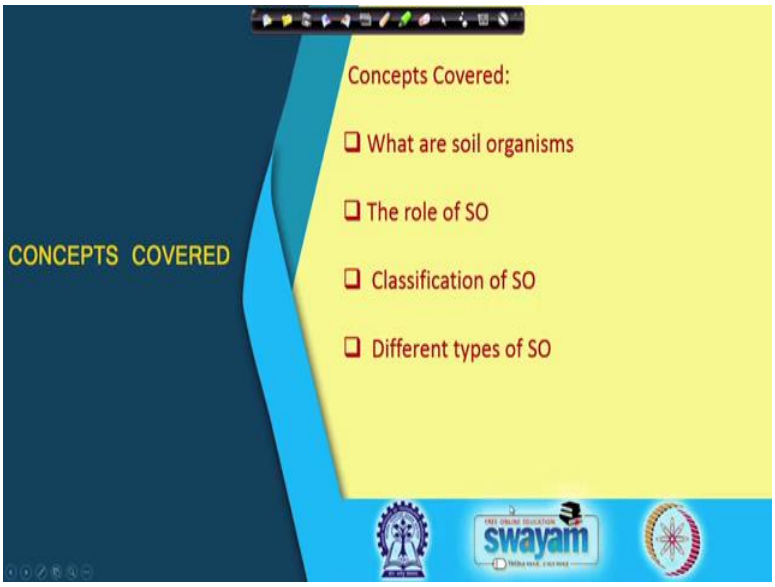

Let us go ahead, and start soil organism guys. In this lecture, we will be covering these following concepts. What are the different types of soil organisms, and then role the roles of these soil organisms, then classification of soil organisms, and different types of soil organisms.

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So, soil organisms are the, you know, the basically if we consider the soil, the soil is having abundant and millions and millions of living organisms which makes it a living and dynamic system. And these organism not only help in development of the soil, but also carry out a number of transformation facilitating in the availability of the nutrient to the plant.

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As you have I have we have already discussed in case of nitrification process. Say for an example, in case of nitrification process, it is mediated through different types of microorganisms. The ammonification is mediated by microorganism. The decomposition of organic matter is mediated by microorganisms, because, you know, it requires extracellular enzymes for oxidations. And, you know, for oxidation into carbon dioxides, so if you remember those things. So, all these are very very important.

Now, this role of microorganism in soil fertility is first of all if they helps in decomposing the organic matter, and also plant nutrient transformation through for through maintaining different cycles like nitrogen, sulphur, all these cycles. And then soil organisms are also useful for the preparation of different bio-fertilizers and compost, we will discuss compost too. And these bio fertilizers and compost will help in building, the soil fertility or increase the soil fertility for better crop growth. So, these are very very important, these without these microorganisms, the soil would be literally a dead system.

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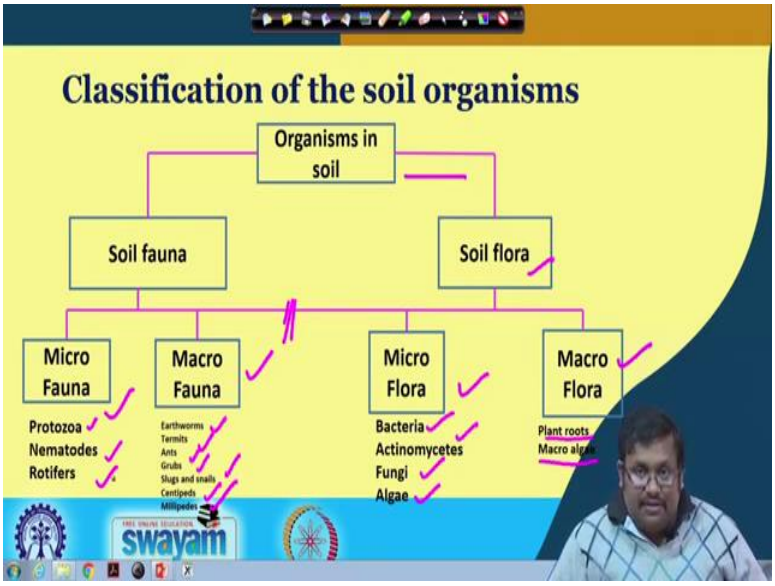

So, what are the class what is the classification of soil organism. So, organism in soil can be broadly classified into soil flora and soil fauna. Now, soil flora and soil fauna, we should, there should be a discontinuity here. So, basically organisms are, you know, soil flora. The soil flora is again divided into micro flora and macro flora. And within the micro flora and macro flora, the in case of macro flora, that is the plant roots and macro algae are there. And in case of micro flora, bacteria, actinomycetes, fungi, and algae are important.

And in case of soil fauna, there are some macro fauna and micro fauna. And in case of macro fauna, obviously earthworm, termites, ants, grubs, slugs, snails, centipedes, millipedes are important. And in case of micro fauna obviously, protozoa, nematodes, and rotifers are important. So, you can see here basic overview of the soil organism classification ok.

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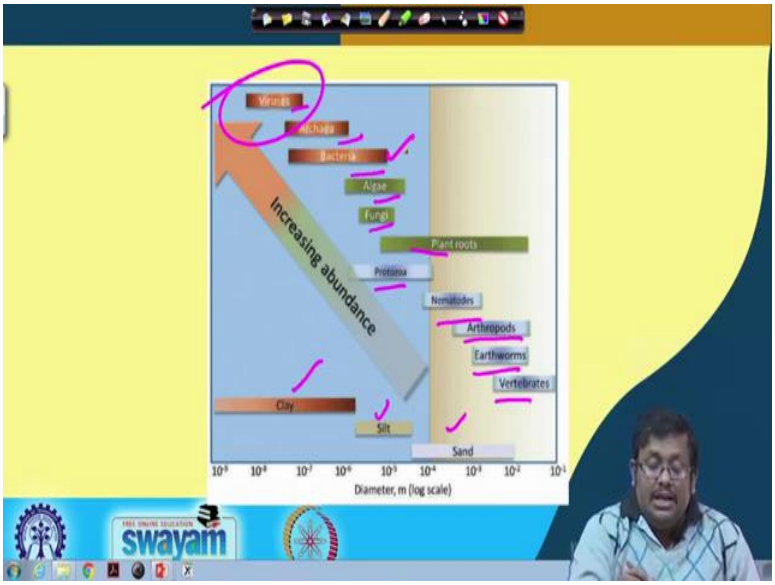

So, what is the size, relative size differences of these organisms? So, you can see if we consider sand, silt, and clay obviously, the sand is the coarser portions. So, vertebrates here, so earthworms are in the sand, arthropods, obviously nematodes. Then protozoans, you know, comes in between then plant roots, then fungi, algae, bacteria, archaea, and viruses.

So, remember that viruses are the most minute fraction, and in the soil micro flora, obviously bacteria are the smallest organisms ok. So, algae and algae comes in between bacteria and fungi, and in between algae and bacteria, there is also actinomycetes.

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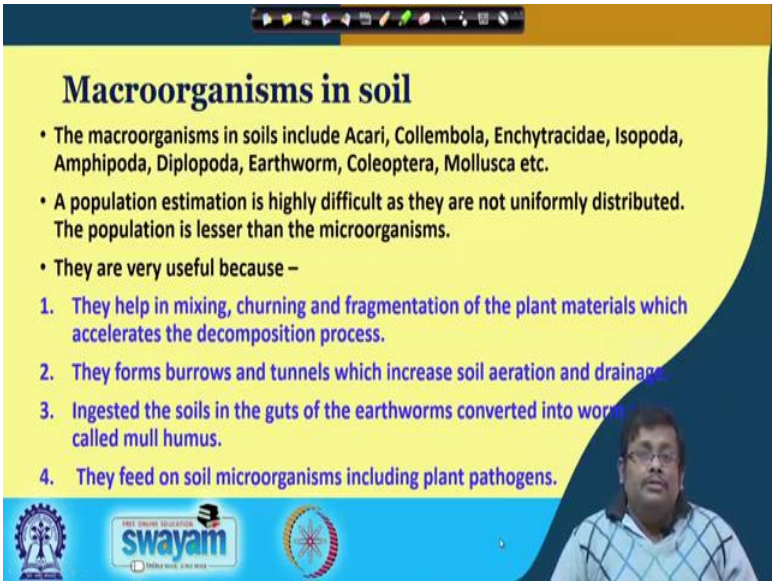

So, let us start with the macroorganisms in the soil. So, the macro organisms in the soil include different different organisms like acari, like collembola, like, you know, like isopoda, then amphipoda, earthworm and so on so forth. So, a population estimation is highly difficult as they are not uniformly distributed. So, the population is lesser than the microorganism. Remember that, in the case of macro organism their population is lesser than the microorganism. And why they are very very useful? They are very very useful, because they help in mixing, churning, and fragmentation of the plant materials which accelerates the decomposition process, because for decomposition we need to break down the soil organic matter first.

Secondly, they forms burrows and tunnels which increases soil aeration and drainage, so that is also important, because without the, you know, presence of oxygen, this oxygen, you know, organic matter decomposition does not take place. And they also ingest the soil into the guts of the earthworms, and you know and they converted into a worm cast, we call them mull humus, other name is vermicompost we will discuss that. And they also feed on microorganisms including plant pathogens. So, these are some of the, you know, utility of these macro organisms.

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So, let us start with the earthworms. Now, earthworms can be of two type. One of this one is called epigeic type of earthworm, another is endogeic earthworms. Epigeic earthworms are surface feeders, so they remain on the surface feed on the surface litters. Endogeic are feed on the different materials within the soil.

The geophagus species of earthworms, you can see this is an epigeic earthworm, and these are the burrows made within the soil by endogeic earthworms. So, the geophagus species of earthworms is, you know, ingest materials per day which is 5 to 36 times of their body weight. And the worm cast, they create is rich in nitrogen, phosphorus, calcium, and the casting rate is 2600 tons per hectare per year. So, it is a huge amount of, you know, cast worm cast they produce per year, which further helps in building the soil fertility status.

So, earthworm-worked soils are generally have high porosity, high water holding capacity, then water infiltration rate, water stable aggregates, and different nutrients you can see. The burrows which are made and these are helpful for water movement, and also they helps in aggregation of the soil. And the earthworm increases the surface area, and the availability of organic matter for microbial action by mixing it thoroughly within the soil. So, these are some activities of the earthworms, beneficial activities of the earthworms.

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Another important is vermicompost, we will discuss vermicompost details in the next lecture. So, earthworms are being used for hastening the decomposition of the farm produce and waste for composting, and the product is called the vermicompost. And the species which are generally used for vermicompost are Eisenia foetida, Eudrilus engeniae, and Perionyx excavates. Eisenia foetida is reported to be the more efficient than others. So, you can see this is the vermicompost which is made through the earthworms, we will be discussing this vermicompost later on.

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Termite, termite also disturb the soil while preparing the nest. So, they are also important for water and air movement within the soil.

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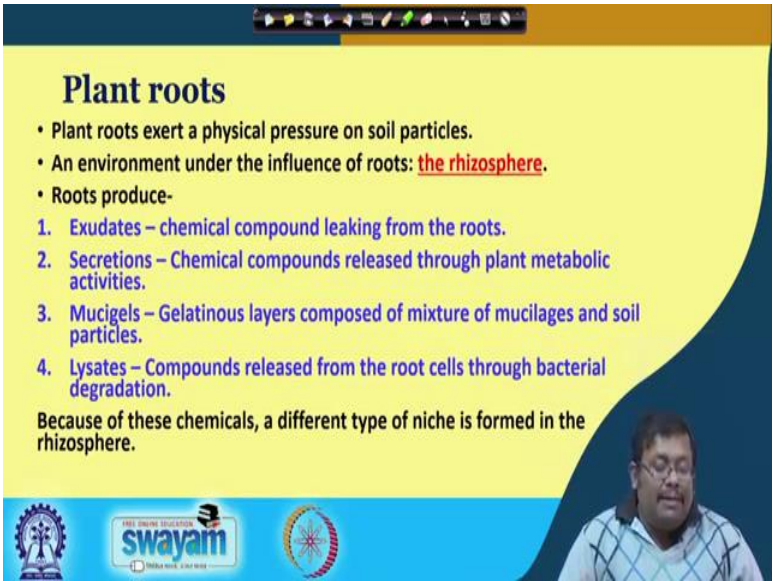

Plant roots, they are macro flora. Plant root exert a physical pressure on the soil particles, you know, influencing their aggregation. And also the environmental, you know, remember that rhizosphere, this is very important term. So, this rhizosphere is an environment under the influence of the roots. So, this is very important habitat for microorganisms.

And also the root produce different types of chemicals like exudates, secretions, mucigels, lysates, which are also like helpful for different types of nutrient transformation, at different and accelerating different bio-chemical processes. So, because of these chemicals a different types of niche is formed in the rhizosphere. Remember rhizosphere is very very chemically active and biologically active zone, where different types of nutrient transformations are going on.

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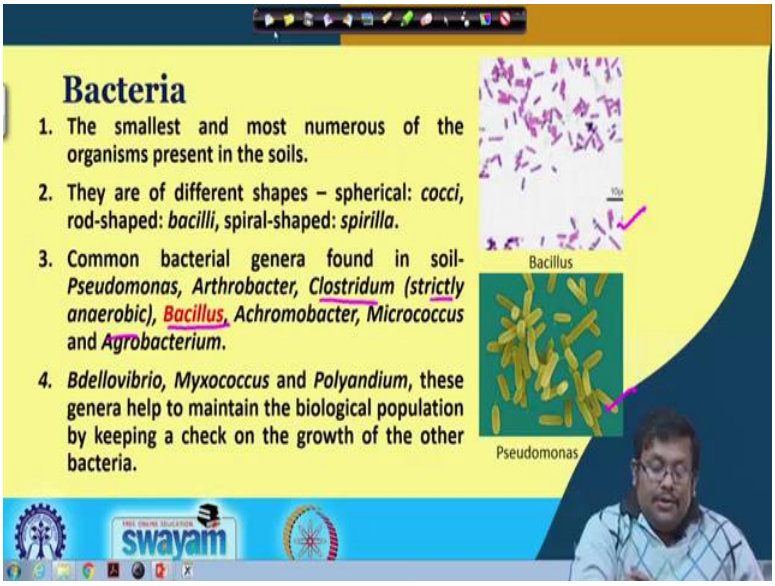

So, let us start with the bacteria. Now, bacteria is the smallest and most numerous of the organism present in the soil. And they are having different types of shapes like spherical, known as cocci, you know, you know, spherical, cocci, rod-shaped, you know, bacillus, and spiral-shapes are known as spirilla.

And common bacterial genera found in soil are, you know, pseudomonas, then arthrobacter, clostridum, bacillus, achromobacter, micrococcus and agrobacterium. Remember that I have highlighted this bacillus, because this is the most abundant soil bacteria you can see here bacillus here. And followed by pseudomonas, pseudomonas is the second most abundant bacteria in this soil, and this clostridum is strictly anaerobic.

Now, apart from this soil bacteria also, the soil also contains some other bacterias like bdellovibrio, myxococcus, and polyandium. And these genera help to maintain the biological population by keeping a check on the growth of the other bacteria. So, this is very very important for maintaining the biological equilibrium within the soil.

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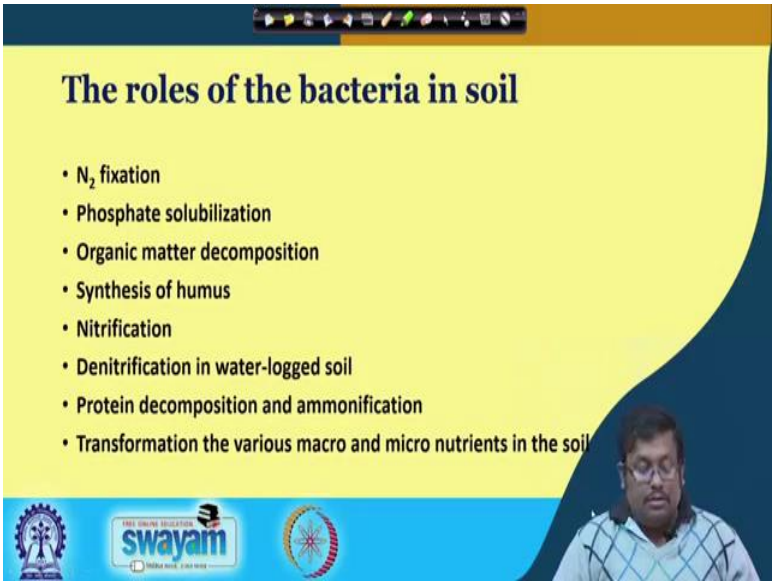

So, what are the roles of bacteria in the soil, obviously you know that nitrogen fixation is an important role. You have already, you know, we have already discuss about the rhizobium, and how they fix atmospheric nitrogen, then phosphate solubilisation, organic matter decomposition, synthesis of humus, nitrification, denitrification in water-logged soil, protein decomposition ammonification, transformation of various macro, micro nutrients in the soil. So, all these are very, you know, mediated through bacteria in the soil. So, these are these are very very important, you know, activities of the bacteria.

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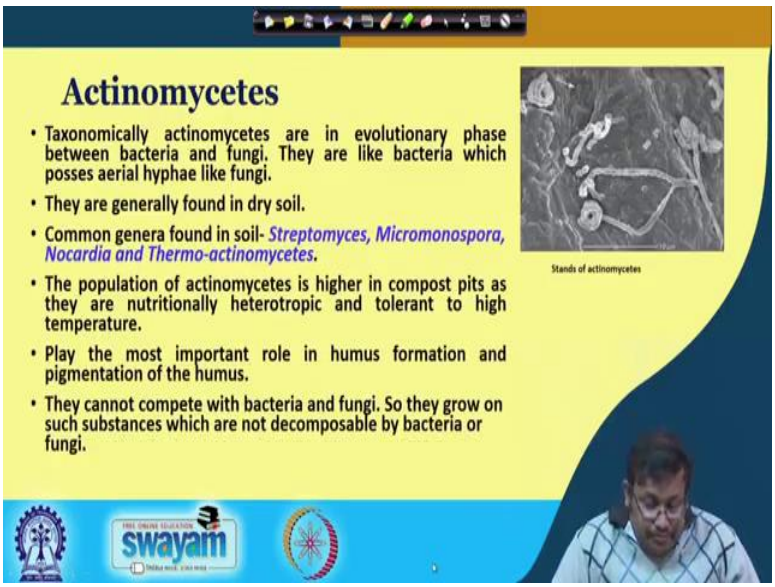

The second important is actinomycetes. Now, taxonomically actinomycetes are in the evolutionary face between bacteria and fungi, because they are called fungi like bacteria, because they are like bacteria which possess aerial hyphae like fungi. So, you can see here strands of actinomycetes. Now, they are generally found in dry soils, and common genera found in soils are Streptomyces, micromonospora, nocardia, thermo-actinomycetes. Remember that the population of actinomycete is high in compost pits. In fact, they are the highest, you know, microorganism highest population microorganism, which are present in compost pit. And they are nutritionally heterotrophic and tolerant to high temperature.

And they play the most important role in humus formation, and pigmentation of the humus. And they cannot compete with bacteria and fungi, so they grow on such substances which are not decomposable by bacteria and fungi. So, these are some important points of actinomycetes remember that streptomycetes. Streptomyces is a most important soil actinomycetes, and they are the most abundant soil actinomycetes.

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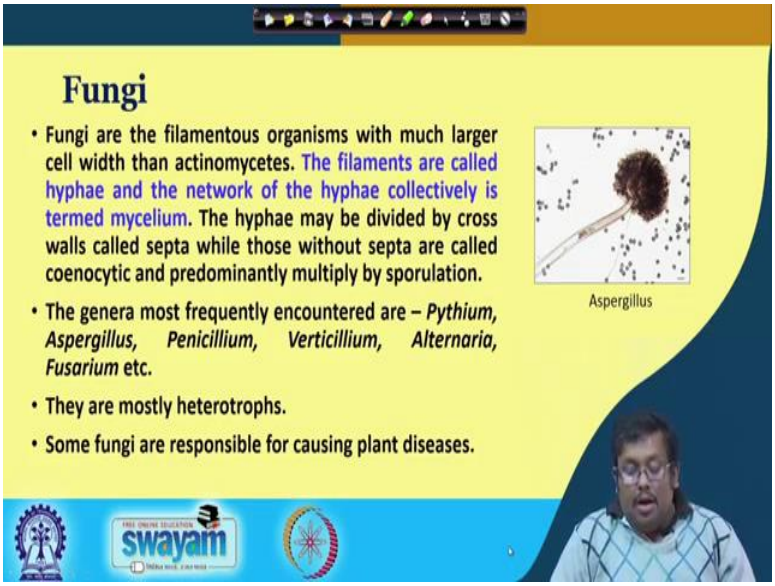

So guys, so let us wrap up here in this soil microorganisms. And in the next lecture, we will start we will we will try to finish this soil microorganisms as well as we will talk about the composting methods also.

Thank you.