Soil Science and Technology
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Lecture – 01
Basic Overview of Soil

Welcome to this 1st lecture of Soil Science and Technology and in this lecture, we will cover basically the basic overview of soils.

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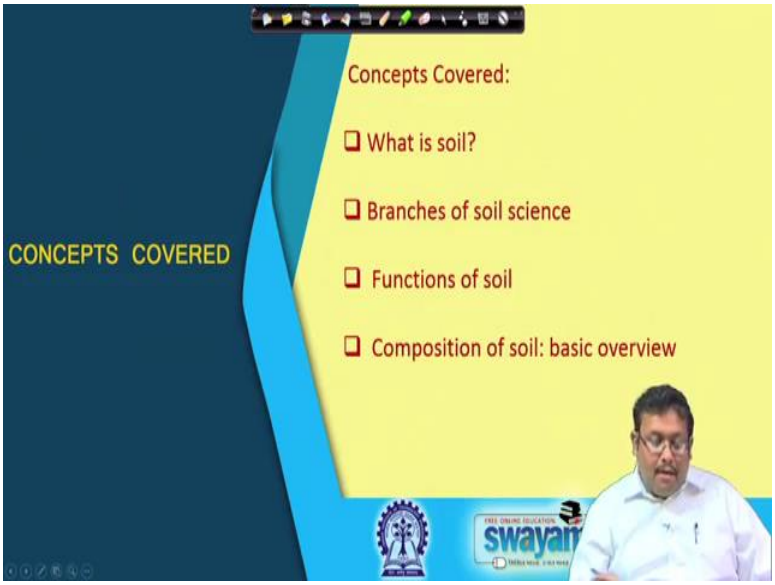

And so, let us see what we are going to cover in this lecture. First of all, we will cover what is soil; that means, what is the definition of soil, then we will talk about different branches of soil science, what are the different branches of soils. And then we will talk about what are the important functions of soil; why we are studying the soil science and what is the need of studying the soil science and finally, we will be talking about the composition of soils; that means the soil is composed of what? What are the different components of soil and we will have a brief overview of each of them.

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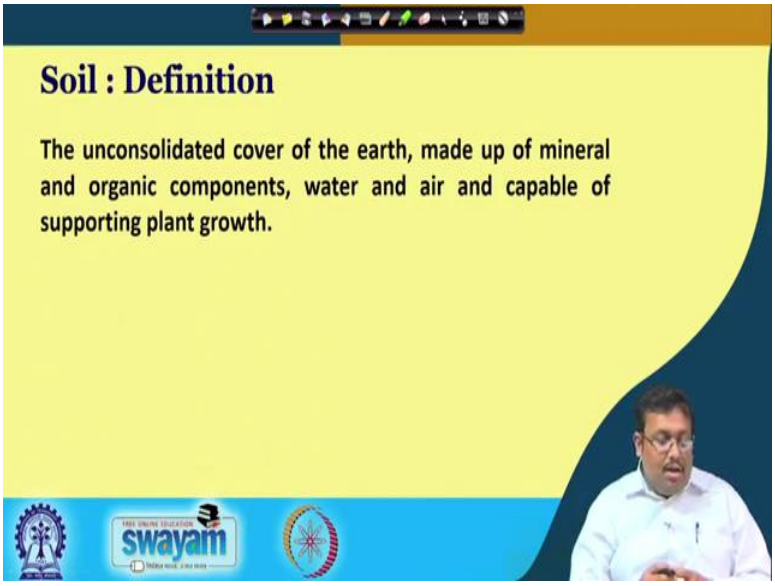

So, let us start. So, by definition soil is the unconsolidated cover of the earth made up of mineral and organic components, water and air and capable of supporting plant growth. So, again it is an unconsolidated cover over the earth and it is made of both mineral and organic components, water and air molecules and capable of supporting plant growth. So, soil is a heterogeneous mixture of different components. It is unconsolidated and it has to attain certain features to be termed as a soil and we will discuss that later on.

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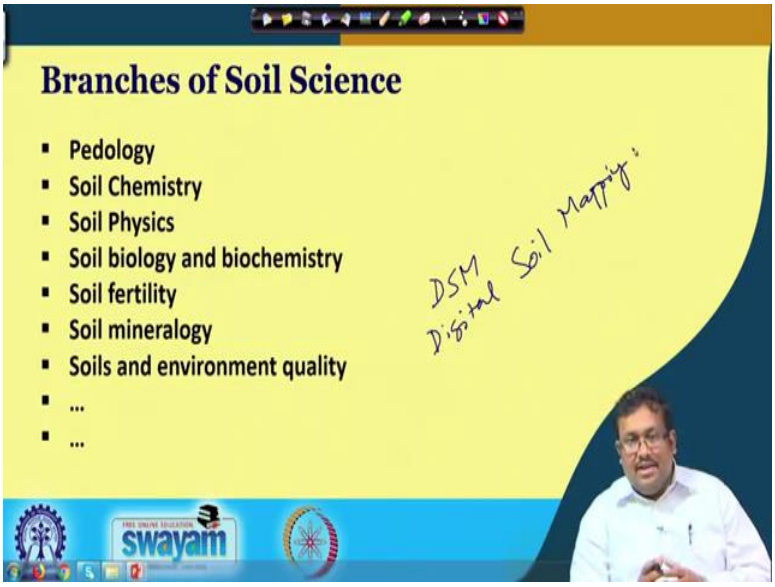

So, let us see, what are the different branches of soil science. So, these are different branches of soil science. I have listed couple of them but the new branches are evolving each and every day. So, the major important branches are Pedology, then soil chemistry, then soil physics, then soil biology and biochemistry, then soil fertility, soil mineralogy and soils and environmental quality. So, soil Pedology basically deals with the origin of soil and it is classification and it is several features. The soil chemistry basically deals with several chemical properties of the soil. Soil physics basically deals with physical properties of the soil; soil biology and biochemistry deals with different microorganisms and different organic colloids and organic molecules they are present into the soil.

Soil fertility basically deals with the fertility status of the soil; how soil is an important entity for sustaining the plant and how it is applied different nutrients to the plants. So, that is basically covered in soil fertility. Soil mineralogy basically deals with the different minerals and their structures and their characteristics and there is another major branch that is soil and environmental quality which basically deals with soil pollution and their remediation.

Now, I have kept couple of you know blanks because each and every day there are new branches of soil science are evolving; for example, there is a new branch of soil science called D S M or it is basically Digital Soil Mapping and this branch of soil has been very popular for last couple of decades and we will have a thorough discussion on what is DSM and what are their aspects.

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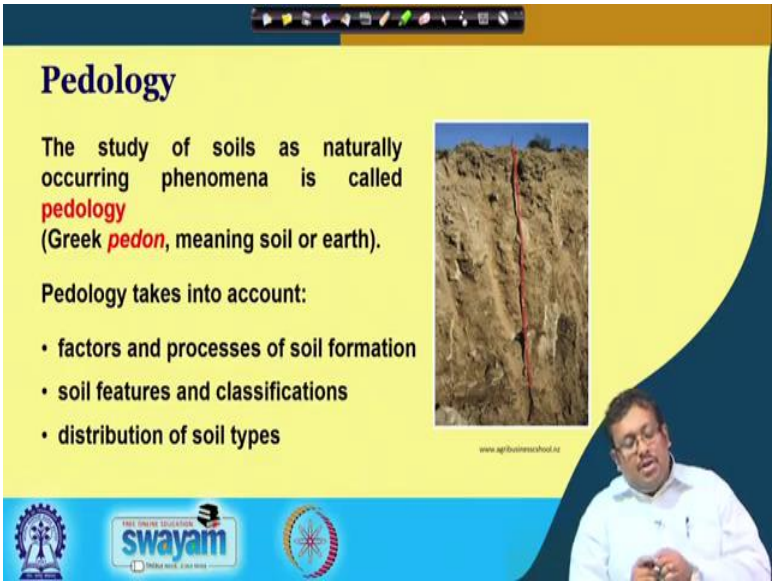

So, let us see what do you I mean what actually is pedology. So, pedology is basically the study of soils as a naturally occurring phenomena and this term pedology is basically derived from the Greek word pedon; that means, soil or earth and pedology basically talks about factors and process of soil formation and then soil features and their classification just like any other you know biological organisms, soil also can be classified into different categories. So, the soil you know pedology deals with that and also distribution of different types of soil. So, this is in a nutshell soil pedology.

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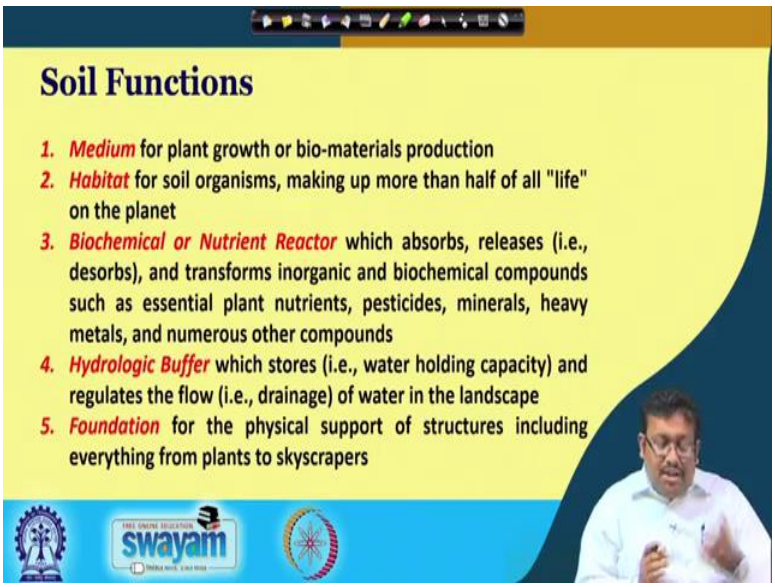

And what are the important functions of soil; well there are five major functions of soil. I have listed them here.

So, the first one it is a medium for plant growth this is the most important for our earth as well as for sustaining our life. Secondly, it is a biochemical or nutrient reactor which absorbs, releases that is dissolved and transform inorganic and biochemical compounds such as essential plant nutrients, pesticides, minerals, heavy metals and numerous other compounds. So, that is why sometime we use soil as a filter for depositing different types of harmful products or wastes. Soil also acts as a hydrologic buffer which stores and regulate the flow or the or you know in other words regulates the drainage of water in the landscapes and it basically gives the foundation of our physical support for the structures including everything from plants to skyscrapers for. So, from engineering perspective to agricultural perspective, soil is giving us support for everything. So, these are basically the major functions of soil.

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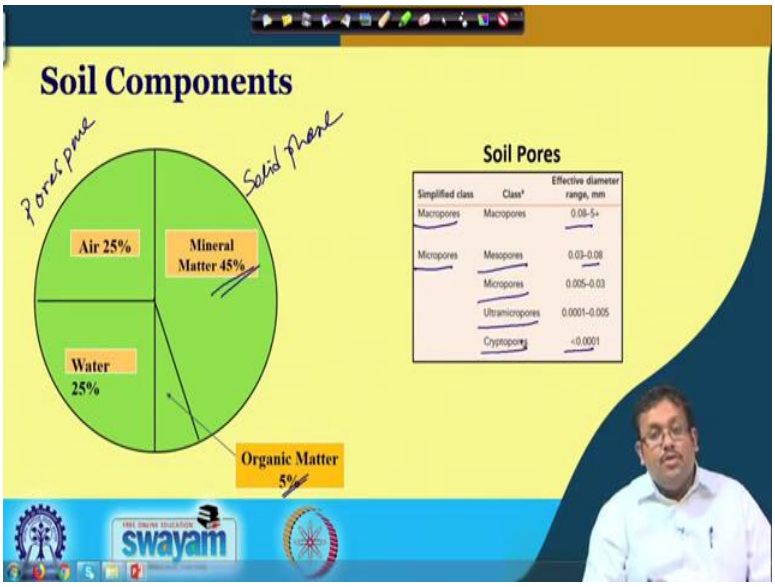

So, let us see how I mean soil is made up of what, components. So, if you consider the total volume of a soil or biologically healthy soil is 100 percent you see that the half of it volume is basically occupied by solid phase and the rest half is occupied by pore space.

Now, this pore space is shared by air and water. So, in a biologically healthy soil, there is approximately 25 percent of air and 25 percent of water residing in this pore space and the solid phase is basically composed of mineral matter as well as organic fractions. So,

mineral matter basically composed of 45 percent whereas, organic matter you know organic matter content is only 5 percent. But remember although there is a very few I mean the organic matter content is only 5 percent, it is one of the major important fractions soil that governs soil physical chemical and biological activities. We will talk about that in details later on.

So, if you see the soil pores, based on their effective diameter range in nanometre we have classified them into two major simplified classes like macro pores you can see and micro pores. And macro pores have effective diameter of 0.8 to 5 millimetre whereas, micro pores diameter basically ranges from less than 0.001 millimetre to 0.08 millimetre and depending upon their size variation, micro pores are also divided into four sub categories like major pores micro pores ultra micro pores and crypto pores. So, this is basically the overview of composition of a soil.

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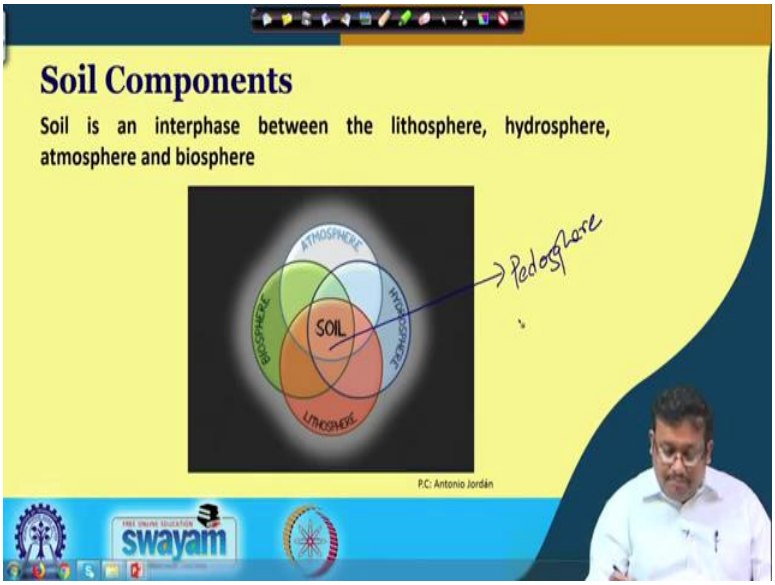

So, let us see, soil is I mean as it is evident from our previous slide that soil is composed of both mineral and organic matter as well as air and water. So, it can be easily you know concluded that soil is an interface between the lithosphere, hydrosphere, atmosphere and biosphere and the intersection or soil is also known as Pedosphere.

So, again the soil is composed of four different spheres. So, it is a basically intersection of 4 different spheres atmosphere, hydrosphere, lithosphere and biosphere. In the lithosphere, basically the mineral matter generally mineral matter comes into the

lithosphere; organic matter comes into the biosphere, atmosphere is basically soil layer and hydrosphere generally presents soil water.

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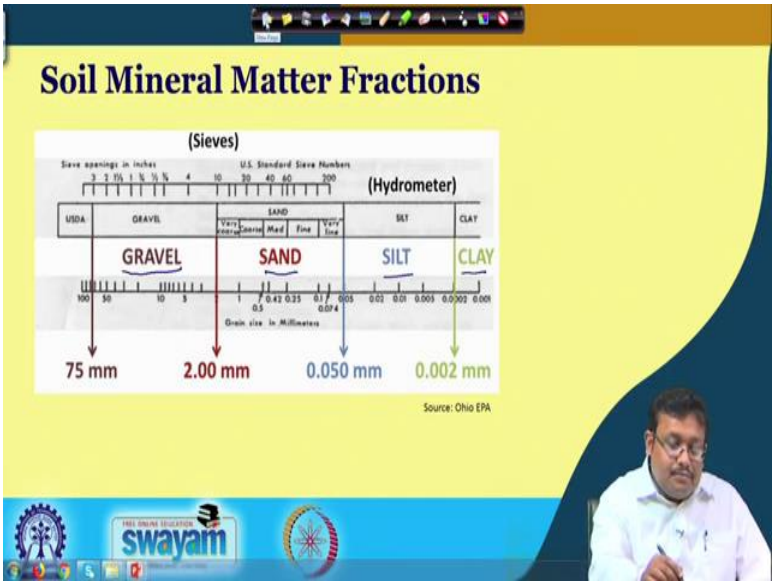

So, let us consider the soil mineral matter. Now, soil mineral matter fractions are basically divided into several separates or categories.

Now, from the perspective of soil science we generally term a soil which has particle size diameter of less than 2 millimetre, anything greater than particle size 2 millimetre we generally do not term them as soil. For example, if you can see the size distribution here we can see gravels, sand, silt and clay based on the particle size diameter; however, the gravel is not technically comes under soil definition because it has greater than 2 millimetre particle diameter and the fraction which comes below 2 millimetre diameter particle size is again differentiated into three major categories one is sand, another is silt, another is clay. So, sand is having according to the I mean this scale is basically given by United State Department of Agriculture or U S D A. So, according to them the sand has diameter from 0.05 millimetre to 2 millimetre whereas, silt comes under 0.05 to 0.002 millimetre and clay has their size less than 0.002 millimetre.

So, it is evident that clays the most finer fraction among all the mineral fractions of soil.

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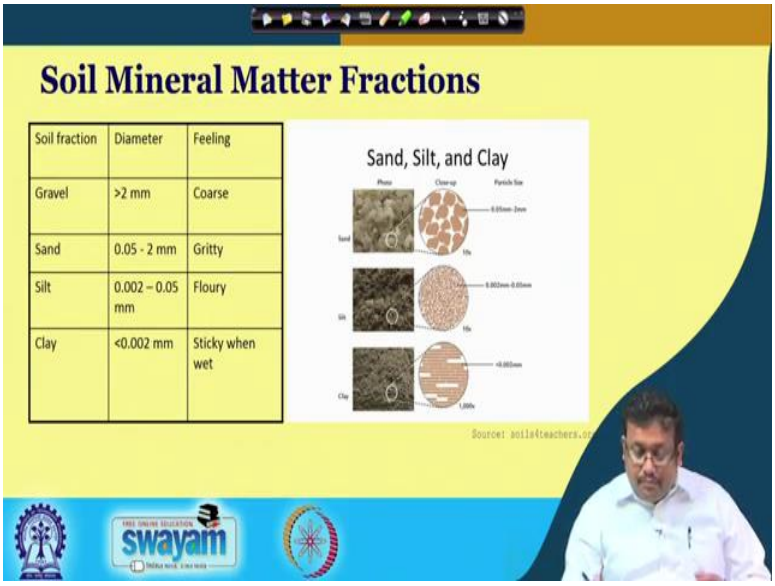

And there are several categories, I mean based on these sand, silt and clay their properties also varies widely; for example, I have given here if you consider gravel which is not technically soil. If you feel it with your thumb and finger, you will feel it is coarse in nature; obviously, sand if you feel it your thumb and finger, you will see it is gritty in nature, silt is you will feel it floury in nature; however, clay is basically sticky when it is wet and in the right, you will see that it is the you know I have shown you that the relative sizes of sand silt and clay. As you can see I mean fine you know clay fractions are very very fine and they have less than 0.002 millimetre and we need high magnification almost thousand magnification you can see here; however, sand is the core set fraction and in between the sand and clay the silt fraction is present which has particle size diameter ranging from 0.002 to 0.05.

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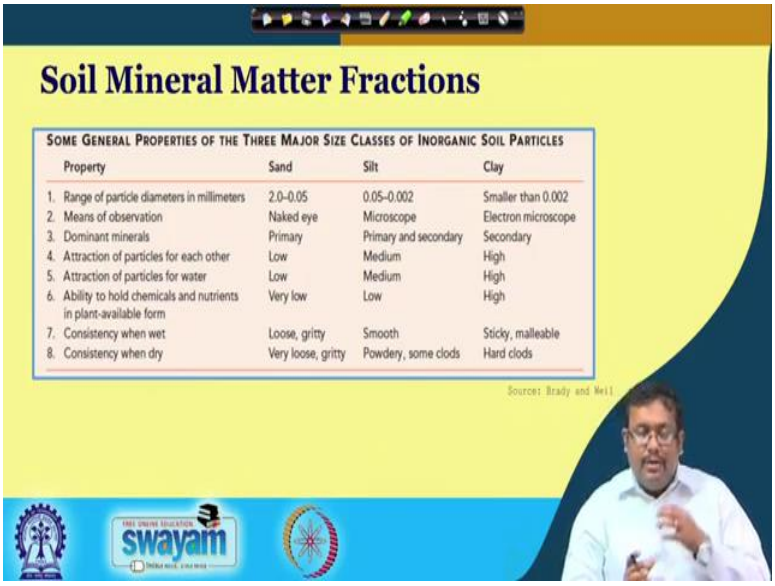

So, based on these, I mean sand silt and clay fraction we also call them soil separates. Now, these soils separates has their variation in soil properties, a variation in their properties. For example, as you can see the first property is a range of particle diameter in millimetre; obviously, we have talked about it; however, if you consider the means of observation how can you see these particles. Obviously, sand can be seen in naked eyes whereas, silt can be seen in with the microscope and clay fraction is so fine that it can only be seen with the help of electron microscope.

Now, in case of sand and silt fraction, you will see dominance of primary minerals and secondary minerals some amount of secondary minerals in silt; however, the clay is basically dominant, clay will have dominance of secondary minerals. Now, we will discuss in details what are the primary minerals and what are the secondary mineral just to give you an idea primary minerals are the original minerals which are present in the rock from where the soil basically develops and secondary clay minerals is a I mean it is a altered form of primary mineral due to different types of physical chemical and biochemical effects and if you consider attraction of particle for each other; obviously, the sand does not show any attraction of particles whereas, silt shows medium attraction between each other; however, in case of clay, you will see high attraction and these develops due to different types of physical and chemical properties.

Now, ability to hold chemicals and nutrients in plant available form you will see that, sand is having very low amount of water you know chemical and nutrient holding capacity whereas, clay has very high amount of water and nutrient holding capacity in plant available form; whereas, silt is having medium or I mean low amount of water holding capacity. Now, sand is also having loose and gritty consistency whereas, clay is having very sticky and malleable consistency and silt is having in between that is smooth consistency. And consistency when dry will change to very loose and gritty for sand; whereas, in case of clay it will become a hard clods and in case of sand silt it will become powdery and sometime it will form some clods.

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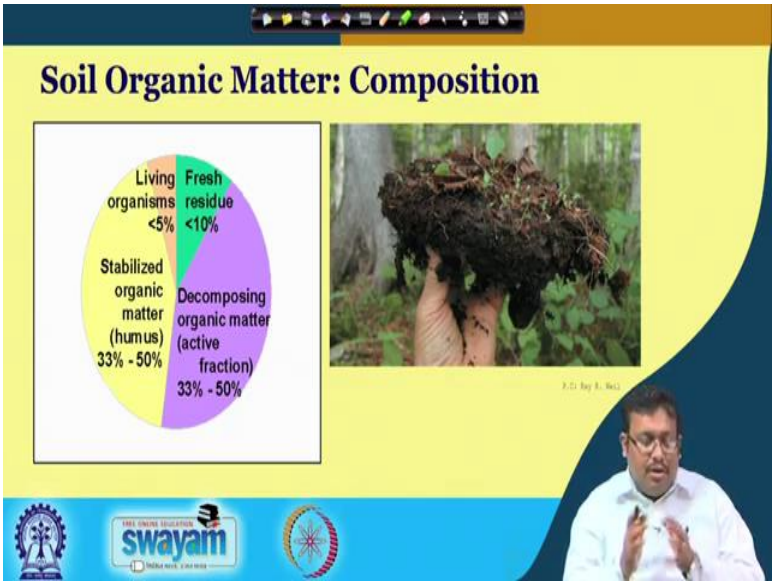

So, let us talk about the soil organic matter and it is composition, in soil organic matter although it is present in only 5 percent volumetric basis. It is very important fraction of soil and if you consider again the total volumetric composition of soil organic matter you will see that the living organism you know the living organism which are present in the soil consists less than 5 percent of the total soil organic matter, fresh residues just means you know fresh leaf fall and fresh dead bodies of animals and all these things, they constitute about less than 10 percent.

Whereas, decomposing organic matter which is called the active fraction of soil consists about 33 to 50 percent. As we can see in the right picture, we are having a active fraction of soil which we can generally see at the top of any soil specially when do you have any

forest like areas, you will have this type of surface of the soil which is basically decomposing organic matter organic fraction and the 33 to 50 percent is basically called humus and humus is a stabilized organic matter. That means, it is a kind of altered product from the original organic fractions and it is the most important fraction among soil organic matter that controls the soil physical, chemical and biological properties and we will discuss in details about the composition and how humus forms in the later classes.

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So, basically the composition of soil basically tells us whether a soil is fertile or not. Or in other words, soil is you know good or bad for example, in the left picture, you can see the left most soil is having high amount of organic matter as we can see the earthworms can be seen and the rightmost soil is basically you know low amount of organic matter. So; obviously, the physical chemical and biological properties the soil will be better in that soil which are having high amount of organic matter and these are this soil will be helpful for better growth of the plant as compared to the other soil. And as I have told you that organic matter is also having high amount of water reading capacities that is soil which has high amount of organic matter also will show high amount of water holding capacity.

For example, in the rightmost picture as you can see, the first this container contains and this container contain two different soil with varying amount of organic matter. So, this

container contain high organic matter and this container contain low organic matter soil and as we can see due to the change in content of organic matter or soil organic matter, the water holding capacity changes; that means, the water has penetrated less in case of this soil as compared to this soil. So; that means, the first soil with high amount of organic matter showing higher water holding capacity and this is very good for better growth of the plant because plant will have more water in this type of soils.

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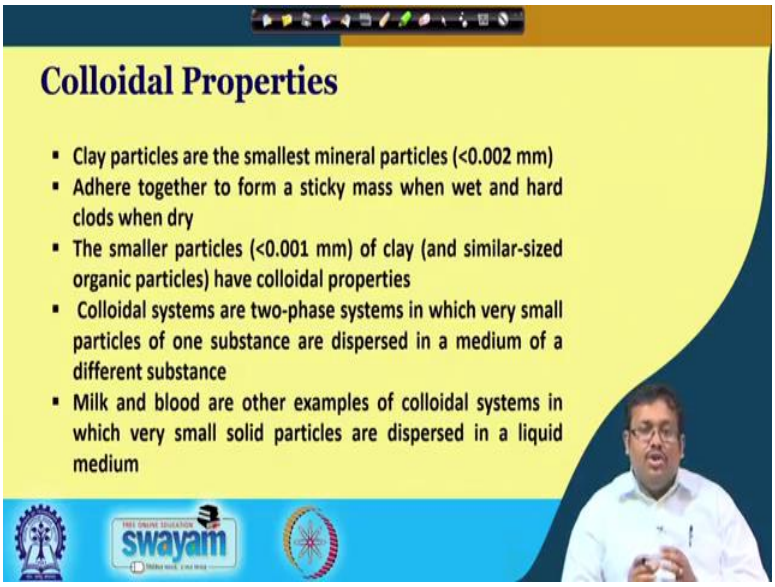

So, remember one thing; both clay and this organic matter these two fractions are the most chemically reactive fraction in the soil and clay particles which are smaller than 0 point I mean which are smaller than 0.001 millimetre and most of these organic you know particles are have are basically you know colloidal in nature because they shows colloidal properties.

These are two very important fractions in the soil which are chemically reactive because of different charge development and what are these different types of charges, we will discuss when we will in the later classes. Now, colloidal system by definition you know that colloidal system are two phase system in which very small particles of one substance are dispersed in a medium of a different substance. So, one is dispersion phase and is a dispersion medium and some examples are milk and blood which are examples of colloidal system in which very small particles are dispersed in a liquid medium. So, in

case of soil these clay and organic matter are the two important fractions which show colloidal properties.

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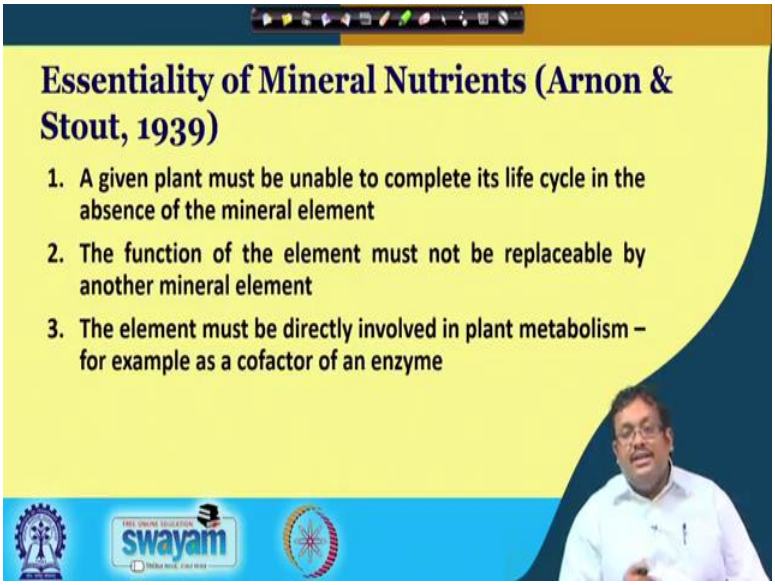

Now, let us talk about the important minerals or I mean the mineral nutrients of the plants. As you know that one of the major function of the soil is to sustain the plant over the earth surface. So, soil is basically, I mean soil requires these nutrients to be taken from the soil and these nutrients which are essential for the growth of the plant are called essential nutrients. Now, there are several elements present in the earth surface as you know, but only 16 to 17 elements we call them as essential elements or mineral nutrients of the plants. Now how would we decide that which mineral is essential or not?

So, these criteria of essentiality of mineral nutrient was given I mean by these two scientists called Arnon and Stout in 1939 and these three criterias basically, I mean governs whether an element is essential for plant or not; for example, the first criteria is the given plant must be unable to complete it is life cycle in the absence of mineral element or that particular mineral element. So, it cannot complete it is life cycle without that particular mineral element.

The second criteria is the function of the element must not be replaceable by another mineral nutrient and third one is that element must be directly involved in plant metabolism, for example, as a cofactor in the enzyme. So, when an element you know confirms all this criteria, then we call that element as an essential nutrient for plant.

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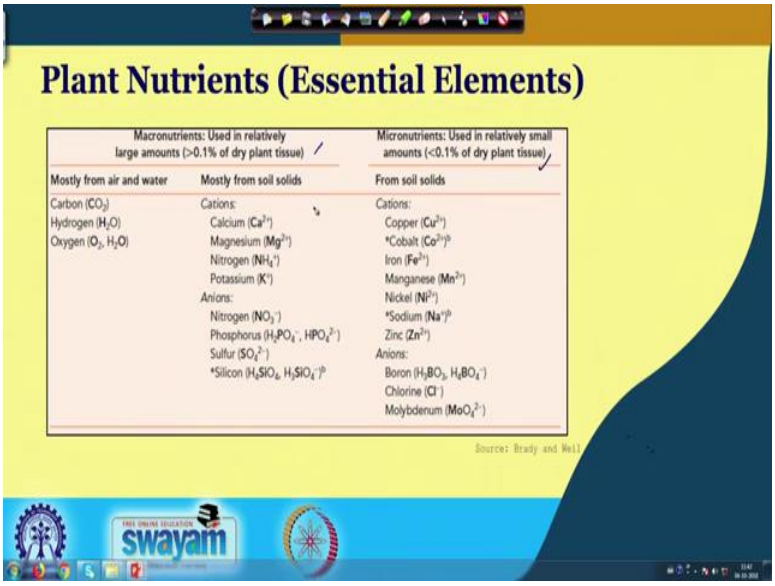

So, if you see the essential nutrient of the plant we broadly classified them, I mean for example, the carbon hydrogen as you can see in this table, we broadly classified them into macronutrients and micronutrients. So, macronutrients is basically required in relatively higher amount that is greater than 0.1 percent of the dry plant tissue. Whereas, micronutrients used in relatively small amount that is less than 0.1 percent of the dry plant tissue, but irrespective of their quantity required, they are essential; that means, even if a micronutrient is absent into the soil, plant cannot complete it is life cycle. So, carbon hydrogen oxygen we call them structural elements and they you know the plants basically you know get this carbon hydrogen oxygen from air and water; however, the other 17 elements are divided into these macronutrients and micronutrients.

Now, among macro nutrients; obviously, as we can see the nitrogen, phosphorus, sulphur is there and in you know calcium, magnesium, nitrogen and potassium is there and in case of micronutrients copper, iron, manganese, nickel, zinc. In case of anions, boron, molybdenum, these are important and we will discuss in details in the later classes.

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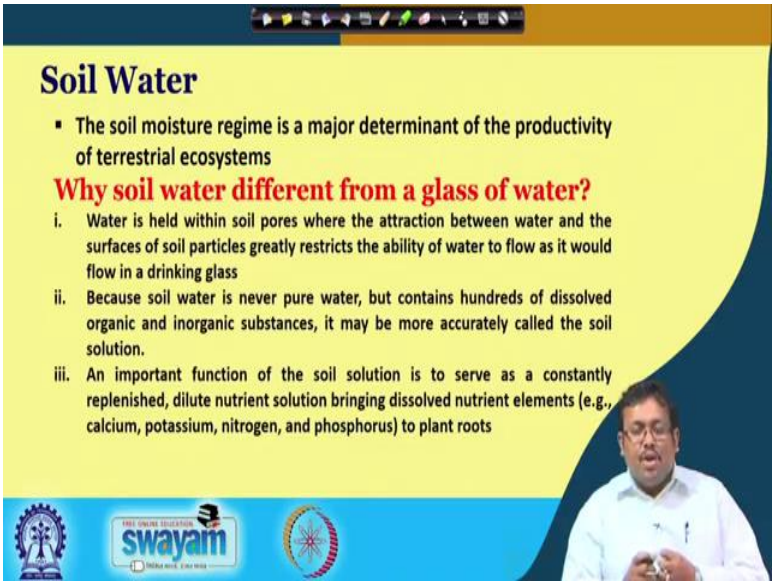

So, soil water, now soil water or soil moisture regime is a very important on major determinants of productivity of the terrestrial ecosystem and soil water is different from a glass of water because it behaves differently into the soil. And we will talk in details about the soil water what are their characteristics and what are their different types of types of attractive forces which are present into the soil for holding these soil water we will discuss in details in the later classes.

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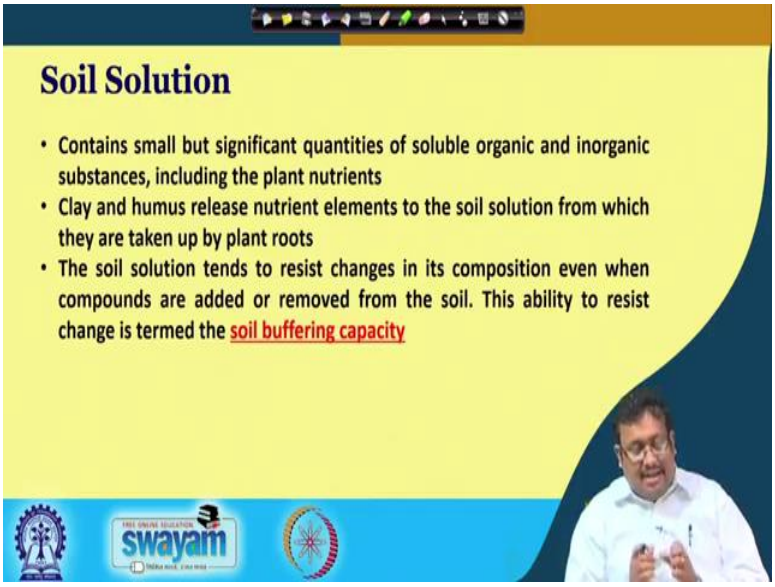

And another important term is soil solution. Now, soil solution is another name of soil water because it contains a significant quantities of soluble organic and inorganic substances including the plant nutrients and these clay and humus releases basically in the nutrient element to the soil solution from which the plants uptake those nutrients.

Now, the soil solution tend to resist any change in its composition even when compounds are added or removed from the soil and this ability of soil solution is termed as the soil buffering capacity and is very important and we will discuss this term later on in details.

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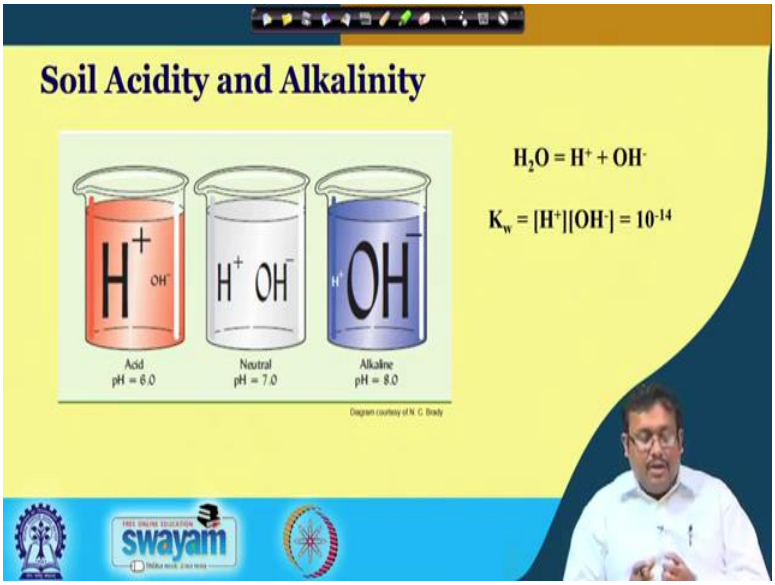

Now, another important term is soil acidity and alkalinity you know that you know it is measured through pH and pH is basically the negative logarithm of hydrogen and concentration. So, a soil which is having pH of 7 is basically neutral whereas, a soil having the pH greater than 7 is called alkaline and when it is pH goes below 7, we call it acidic soil.

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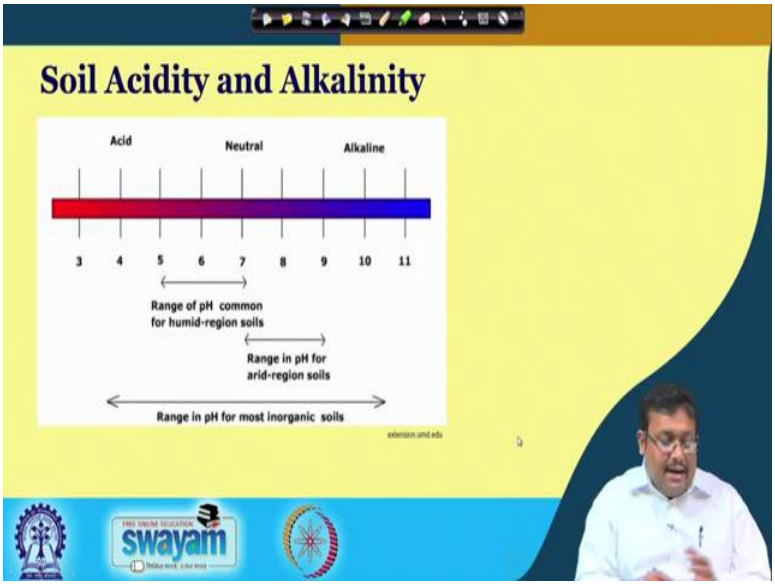

And this chart basically shows the ranges of acidic soil, neutral soil and alkaline soil and remember one thing, for growth of the plans for updating of the nutrients the most optimum range of pH is 6.5 to 7.5. So, all the nutrients are available in optimum quantity or rate in this pH range.

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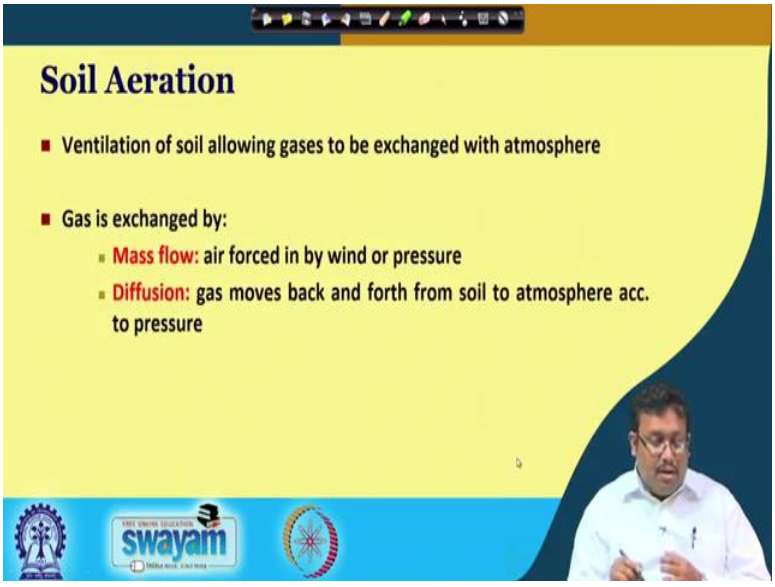

Soil aeration is ventilation of soil allowing gases to be exchanged with the atmosphere and gas is basically exchanged by two major forces; one is called mass flow, another is diffusion. The mass flow is air force by wind or pressure whereas, diffusion when the

you know when gas moves from along the concentration gradient; that means, from high concentration to low concentration.

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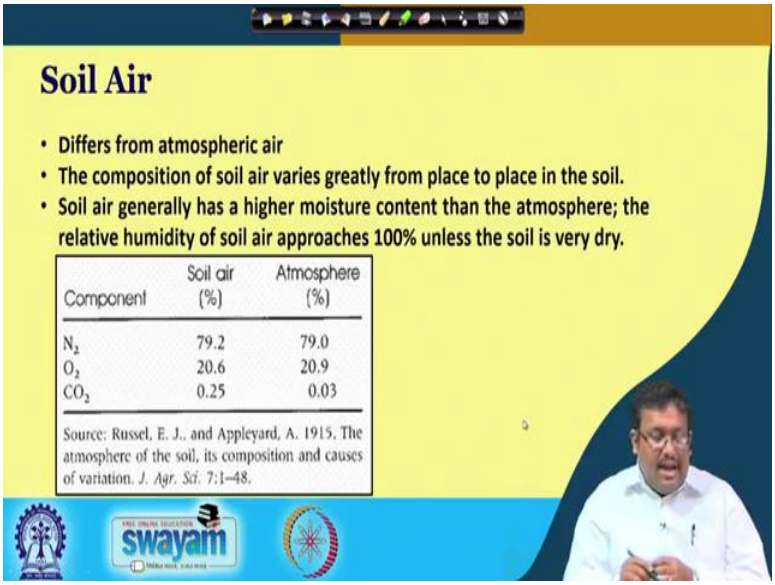

Now, composition of soil air it you know; obviously, differs from the soil air from the atmospheric air. So, the composition of soil air varies greatly from one place to another place and soil air generally has a higher moisture content some time it reaches the humidity of 100 percent unless soil is very dry. And as you can see from this table soil, air in case of you know a comparison of soil air and nitrogen and soil layer contains 79.2 percent nitrogen almost similar in atmosphere.

Whereas, oxygen also is same; however, carbon dioxide you can see almost 10 time increase in case of soil air then that of atmosphere because of high amount of respiration which is going on by different microorganism present into the soil. So, that is why soil air is having high amount of carbon dioxide than that of atmospheric air.

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So, the reference is basically that nature and properties of the soil by Nyle C Brady and Ray R Weil. So, you can follow this book for gaining a better understanding of these things. So, hopefully you have learned something new.

Thank you.