Conservation Geography
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Module - 7
Biosphere
Lecture - 19
Soil

Namaste! Today we begin a new module which is Biosphere. Now, you will remember that biosphere is one of the four spheres on this planet. We have already looked at lithosphere, which is the rocky sphere or the solid sphere; hydrosphere, which is the watery sphere or the liquid sphere; atmosphere, which is the cache's sphere or the airy sphere; and now we are talking about the biosphere.

Now, biosphere is the living sphere. It is at the confluence of all the three other spheres lithosphere, hydrosphere, and atmosphere. Now, this is because most plants and animals need soil to live in or to get their nutrients from. They require water. And they also need air.

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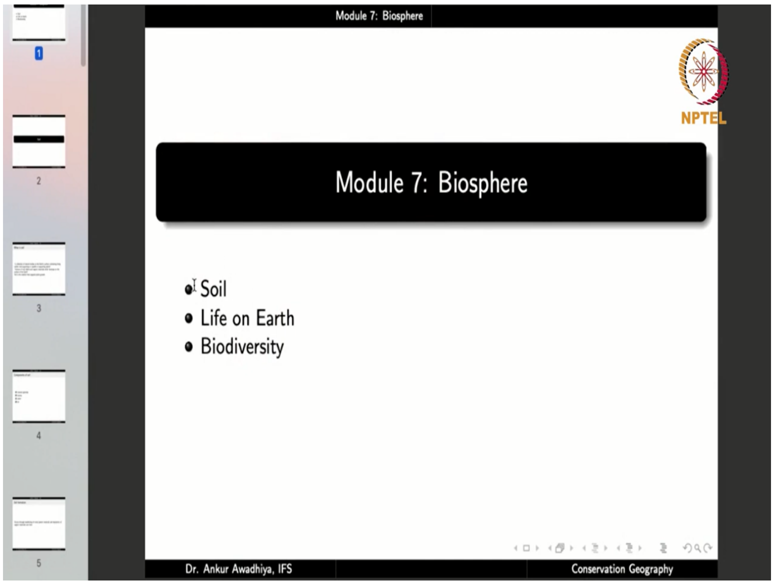

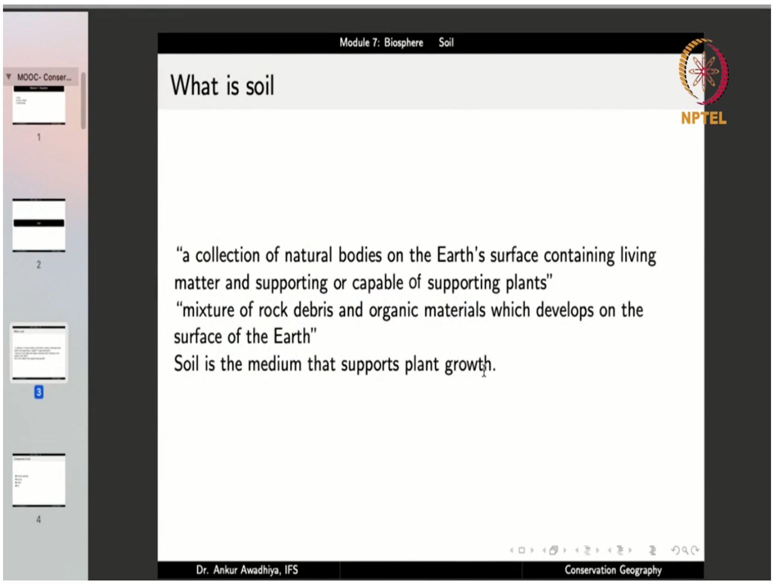

So it is at the confluence of all the three pheres that we have the biosphere and in this module, we will have three lectures soil, life on Earth, and biodiversity. So let us begin with soil. So what is soil? Soil can be defined as a collection of natural bodies on the Earth's surface containing living matter and supporting or capable of supporting plants.

So it is a collection of natural bodies, natural bodies of different sizes. So they can be coarse particles, they can be fine particles. And these natural bodies exist on the Earth's surface. And they either contain living matter or they support plants or they are capable of supporting plants, meaning that even if we have an area where these matter are not currently supporting plants, but they are capable of supporting plants even then we will call it a soil.

Which means that if you consider a forest and after a severe forest fire all the living organisms in that area including the plants, they are dead. Now, if that happens, do we still call that area soil? The answer is yes, because even though there are no plants and animals on that area, currently, but this area is still capable of supporting plants. And so we'll say that this area still has soil that is left after the forest fire. So soil is a collection of natural bodies on the Earth's surface containing living matter and supporting or capable of supporting plants.

Another definition is it is a mixture of rock debris and organic materials which develops on the surface of the Earth. So the second definition focuses on the creation of the soil and it says that soil is nothing but a mixture of rock debris and organic materials. So we have the debris, which means we have fragments of rocks and we have organic materials and soil is a mixture of both of these, which develops on the surface of the Earth.

The importance of soil is that it is the medium that supports plant growth. And plants support all the life on this planet, because any animal would require plants as a source of food. Plants convert the energy of sunlight into food for all the living organisms by doing photosynthesis. And in the process of photosynthesis, they take carbon dioxide from the atmosphere, they take water from the land, they take nutrients from the soil and they make glucose or they make other carbohydrates.

And so the function of soil as a medium of supporting plant growth is also something that supports all the life on this planet.

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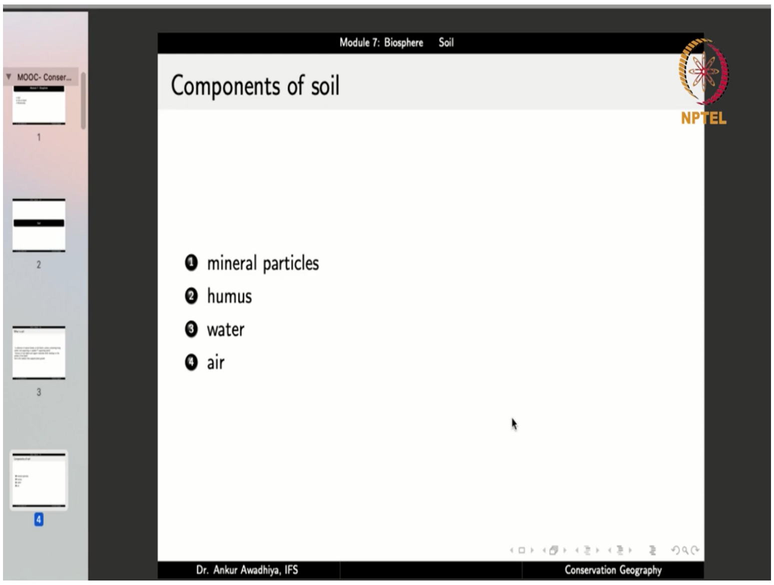

Now, what is soil made of? If look at soil, it is made up of four different things. We have mineral particles. Now, these mineral particles, they have derived from different rocks. So these are the fragments of rocks. And we had observed before that rocks are made up of minerals. There is no specific constitution of minerals in a rock. There is no specific composition, but the fact is that rocks are made up of minerals. And so when the rocks get broken down, these minerals become available.

So the first fragment is mineral particles. Second, we have humus. Humus is the organic material. So when we have plants, when we have animals then their excreta or their dead portions, after getting decomposed, they become humus. So humus is a organic material.

It is rich in carbon and it provides a large amount of chemical properties to the soil. It provides a large number of physical properties to the soil. It binds the soil together. It ensures that the acidity or the alkalinity of the soil does vary too much. It gives it a buffering agent.

So this is the second fraction. Third, we have water. So soils retain a lot of moisture. So if you take a sample of soil, you will find that it also has water plus the space between mineral particles that is not filled with humus or water that contains air.

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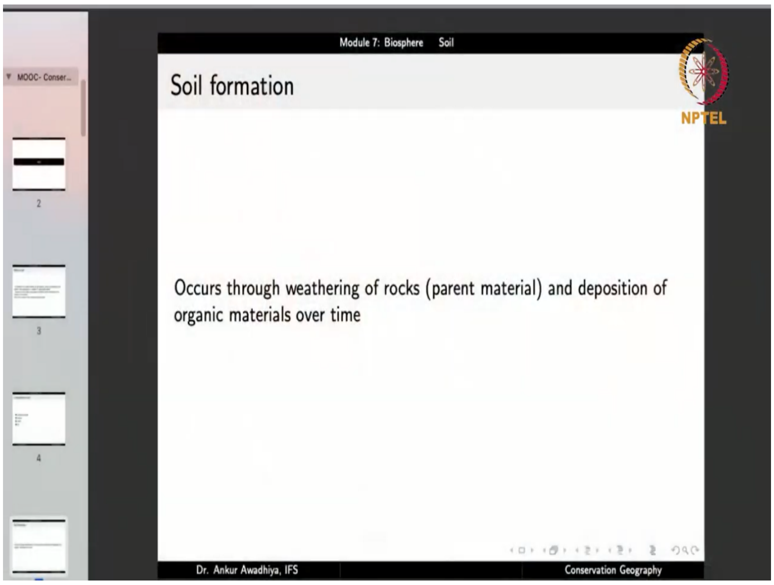

So these are the four components of soil mineral particles, humus, water and air. Now how do soils form? Soil formation occurs through the weathering of rocks which is a parent material and deposition of organic materials over time. So there are two processes, we have the weathering of rocks and rocks are the parent material that formed the soil.

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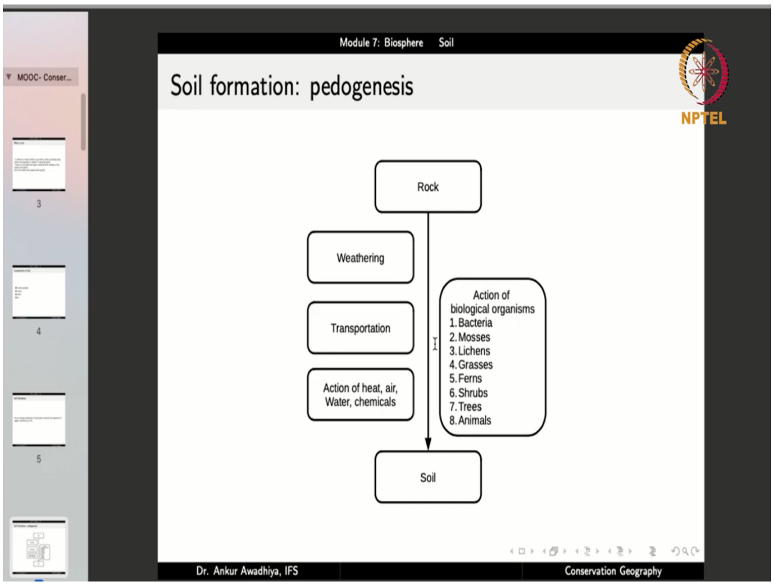

So the first process is weathering of rocks and the second process is the deposition of organic matter over time. And soil formation is also known as Pedogenesis and we can represent Pedogenesis as the conversion of rocks into soil. Now, this process will comprise of weathering, which is the breaking up of rocks, transportation of the broken fragments, action of heat, air, water and chemicals and also the action of biological organisms which generates humus into soil.

Now, these biological organisms can play a role in weathering, they can play a role in transportation or they can play a role in putting certain physical or chemical changes in the soil. And at the same time, they lead to the deposition of humus in the soil, the organic matter. Now, these biological organisms include bacteria, mosses, lichens, grasses, ferns, shrubs, trees, animals. So essetially all of different kinds of organisms can play a role in soil formation. And when all of these act together then rock gets converted into soil.

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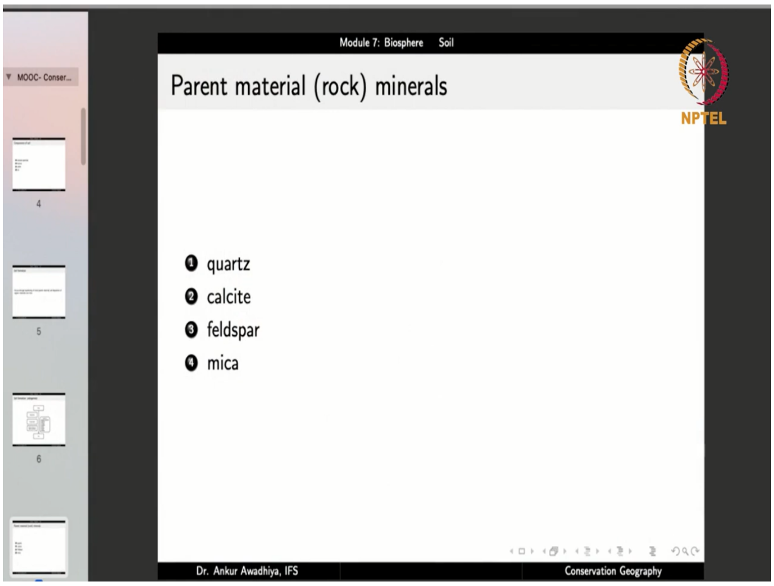

Now, when we talk about soil, what are the parent minerals that are formed in the soil? The materials are derived from the rocks and the primary materials include quartz, calcite, feldspar, and mica. So these are the four minerals that form the majority of mineral component of most of the soils. So these are the four minerals that we commonly find in different soils. Now, let us have a look at weathering.

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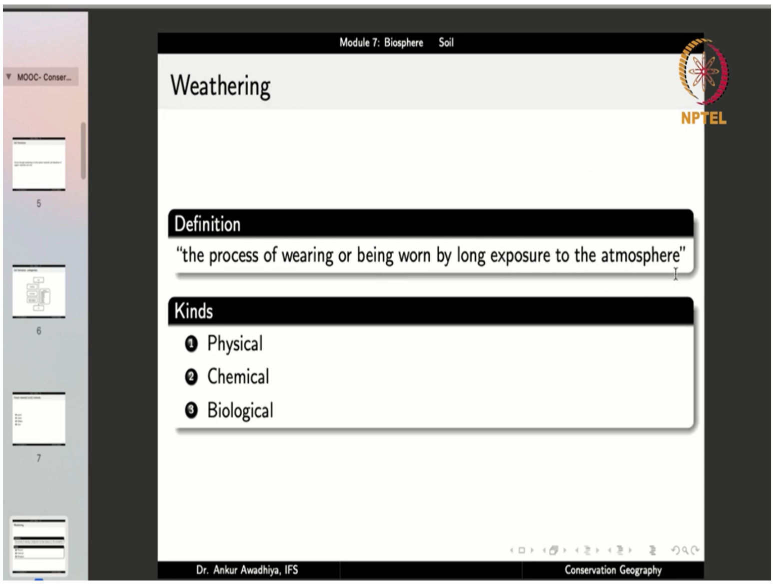

We have discussed weathering before, and weathering is defined as the process of wearing or being worn by long exposure to the atmosphere. So essentially, it is a process of wearing or a process of being broken into smaller fragments. So through the process of weathering, the rocks get broken into very small fragments and weathering occurs by long exposure to the atmosphere.

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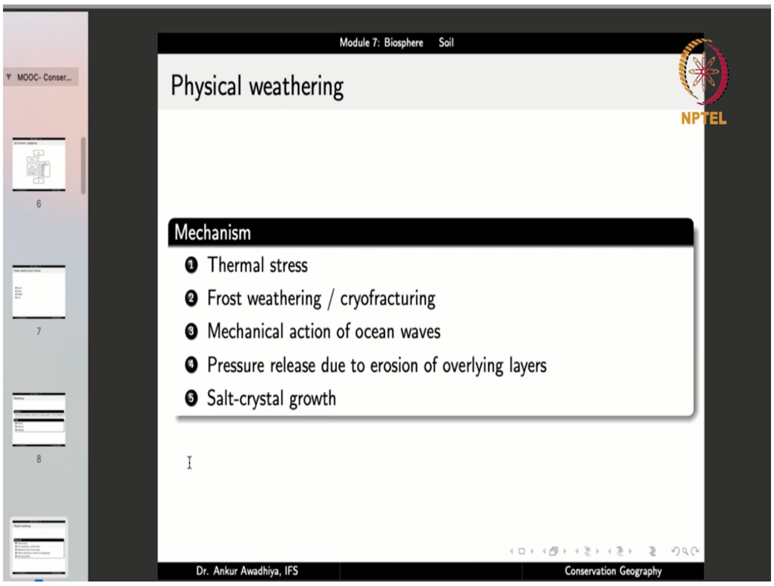

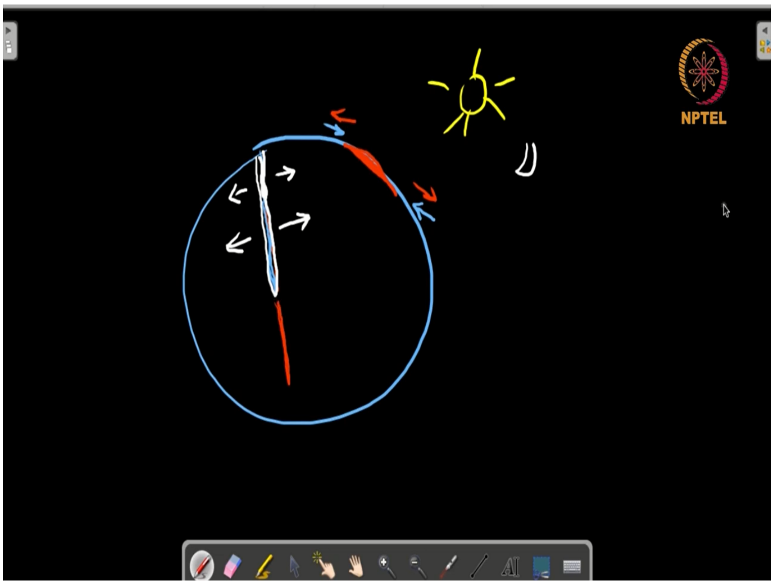

Now, there are three different kinds of weathering - physical, chemical, and biological weathering. Physical weathering could include mechanisms such as thermal stresses, which means that if there is a rock and when this rock is exposed to the Sun, then in the daytime, the portion that gets exposed to the Sun, it becomes warmer. And when it becomes hot, it expands. And in the nighttime, this portion becomes cool and it contracts back.

So essentially, this process of continuous expansion and contraction of the rock can lead to the development of certain breakages in this rock, or fractures in this rock. And when the rock breaks, it breaks into fragments and this breakage is weathering. So rocks can break because of thermal stresses. This is a mechanism of physical weathering.

Another is frost weathering or cryofracturing, in which case, if water enters into the rock, then after a while this water, when it cools, especially in those areas that are very cold areas, then this water will get converted into ice. And the volume of ice is greater than the volume of water, and so there will be an outward force that gets applied to this area. And when this outward forc is applied then the rock developed cracks.

And when this process goes on and on, because once you have the crack, then water can enter to a greater depth, which means that next time when it cools then a larger portion will get converted into ice. So now we have a larger block of ice inside, which means there will be an even greater amount of force that gets applied, which means that you get an even greater crack. And then this way, the rock becomes cryofactured.

Another mechanism is the mechanical action of ocean waves. Now, we have observed before that the ocean waves, when they bump against the rocks, they can break the rocks, and they can result in very large size formations such as cliffs or terraces or sea caves or the sea stacks. Now, when such an action occurs, then the portion that has been broken down, that is the weathered portion of the rock.

Not just through the mechanical action, but the sea waves can also make use of the sand that they carry and this sand can act as a sandpaper to further weather the rocks. So this is another physical weathering mechanism.

Yet another mechanism is the release of pressure due to erosion of overlying layers and we also have the salt crystal growth which is very similar to cryofracturing, but utilizing the growth of salt crystals. And this is very commonly observer near the sea coast.

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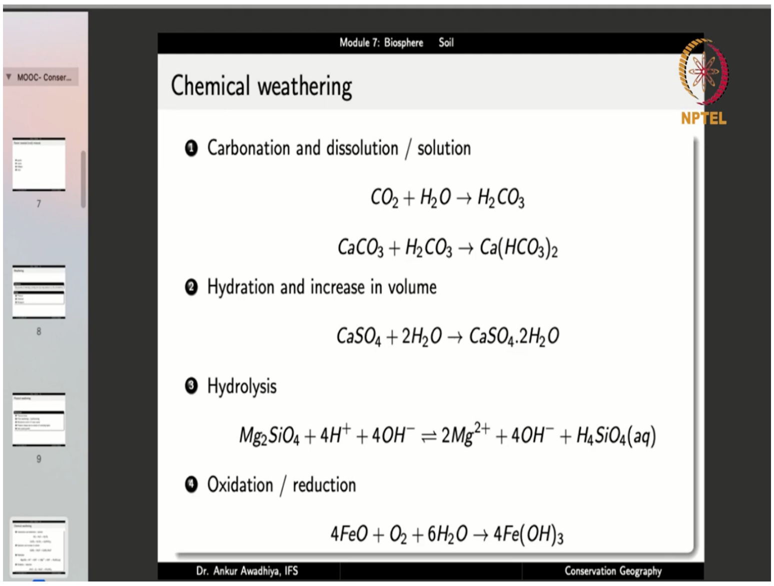

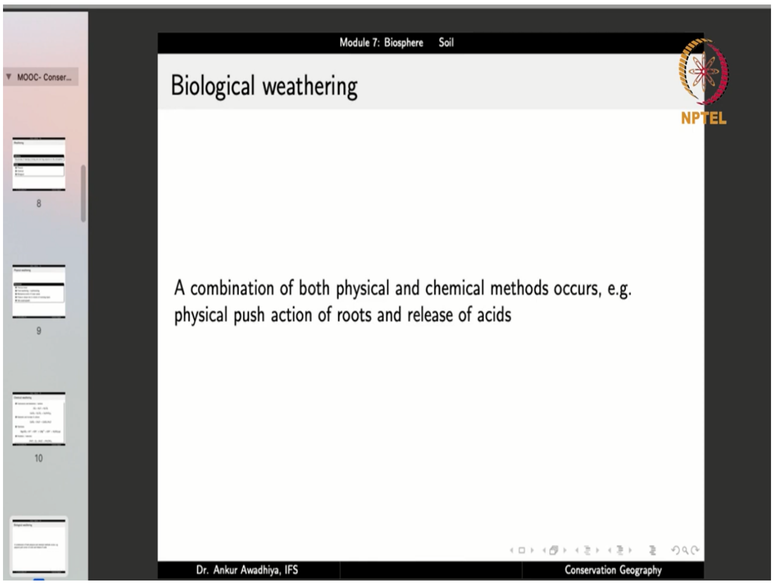

Chemical weathering, as we have seen before, includes chemical reactions such as carbonation, desolution, or solution, hydration with increase in volume, hydrolysis, oxidation and reduction reactions. And biological weathering is a combination of both physical and chemical methods, such as the physical push action of roots and the use of acids.

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Now, once all of this has happened, then we have a rock that has been broken down into smaller fragments. Now, how does this fragment turn into a soil? So that would depend on a number of other factors. So soil formation is dependent upon these six factors. The first and the most important one is the parent material or the rock. Now, different rocks have different minerals in them. And so the soil that will get formed will depend on the kind of parent material that it has begun from.

So for example, the felsic rocks will give rise to very different soils, the morphic rocks will give rise to very different soils. At the same time, the ease of weathering of a rock also depends on its own structure, its own composition. Now, if a rock is easily weatherable rock, it's a soft rock, then it will very soon be converted into soil. Common examples are the sedimentary rocks, especially those that are rich in calcium carbonates.

On the other hand, those rocks that are very hard, that are very strong, they take a lot of time to convert into soil. Good examples are the igneous rocks. They are very hard. So soil formation is dependent on the parent material or the rock to begin with. It is also dependent on the relief of the area, which means what is the difference between higher elevations and the lower elevations.

Now, if an area is a flat land, in that case, we will not find water that moves at a very faster speed, whereas if the area is having a high relief, so there are certain areas that are very high, there are certain areas which are very low. In such cases, water will move at a much faster rate and when water moves at a faster rate then we will have more amount of mechanical weathering of the rocks not only because this water will be bumping against the rock, but at the same time the fragments that it carries will also lead to erosion of these rocks.

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So relief also plays a role. Relief also determines where these fragments will get collected. So for instance, if we have a hilly area and there is lot of weathering that is happening in this area, where would these fragment go? So it turns out that these fragments will move down because of gravity and they will get accumulated here.

So in this case, this area will have soil very quickly whereas, this area will not have soil that quickly. So the relief determines not just the action of various agents of weathering, but it also determines where the soil or the mineral particles will get accumulated. Next, we have climate. Now, many of the physical and chemical processes of weathering are dependent on climate. So when we talk about thermal stresses, it depends on what is the difference between the daytime and the nightime temperatures. If the difference is very much, then there are large physical stresses that get developed.

If the area has a more equiable temperature, which means that day are night temperatures are not that different, then probably thermal stresses will not play a major role in the weathering of the rocks. Similarly, when we talk about chemical reactions such as solution or dissolution, now that is dependent on the availability of water. So this will not be a major factor in the case of arid areas which do not have a lot of rainfall, but they will be very important factors in areas that receive a heavy rainfall.

So climate also plays a role. When we talk about cryofracturing, it depends on temperatures going so low that water freezes into ice. Again, a role climate. So climate also plays a major role in soil formation. Similarly, vegetation and other life forms, they also play a role. Why? Because we have the biological weathering. So if an area has vegetation and life forms, then biological weathering also plays a role, but it does not a role in those areas that do not have vegetation or life forms.

At the same time, humus is an important constituent of the soil and humus can only be there if you have vegetation and life forms because it is derived from living materials. So vegetation and life forms also play a role in soil formation. Human activities also play a role. Why? Because in certain areas we are breaking up the rocks. We are doing mining operations and in those areas, the rocks are very easily getting weathered into smaller fragments.

On the other hand, in certain areas, we are doing protection activities, which are saving the rocks from getting weathered. So human activities also play a role. And time plays a very important role because the activity of various agents of weathering, whether it's physical, chemical, or biological, it takes time.

A rock will not break down into fragments in a day. It'll take many days or perhaps many months or even many years for the rock to break apart into smaller fragments. So it is possible that you have a rock, you have good agents of weathering, but still you do not find the rock getting weathered because this area has just come up. The rocks were not exposed to the agents of weathering for a very long period of time and with time, these rocks will also get weathered.

So time is a very important factor in soil formation. So soil formation is dependent on the parent material or the rock, especially its hardness and constitution, the relief of the area, the climate of the area, vegetation and other life forms, human activities, and time.

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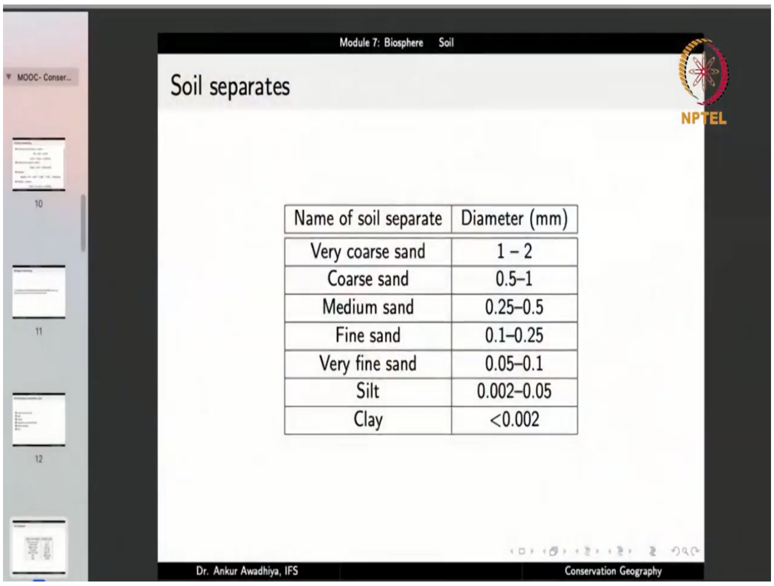

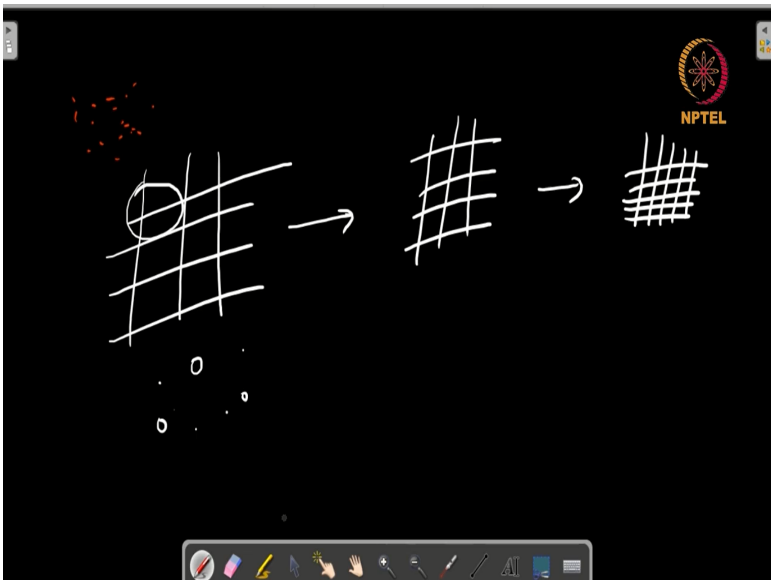

Now, what does soil look like? So if you take soil, you can separate it on the basis of the fragment size. So we can have different soil separates in a sample of soil. So essentially, what we do to look at soil separates is that you take a sample of soil and you put it through a sieve. So you take the soil, you crush it or essentially you dry it and you handle it in such a way that the particles separate from each other and then you push it through a sieve.

Now, in any sieve, the particles that are larger than the mesh size, they will stay on the top and the particles that are smaller, they will pass through. So in this way, we can use sieves or meshes of different sizes. So we have a coarse mesh followed by a fine mesh followed by an even finer mesh. And in this way, we can separate the soil into its constituents on the basis of their sizes. And when we do that, these are the fragments that we will get.

Those oceans that have a diameter between one to two millimeter, they are known as very coarse sand. Fragments about two millimeter in size are not classified as soil separates, we call them either rocks or pebbles or rock fragments. Then on a final scale, we will have particles between point five to one millimeter in size and we' call them as coarse sand.

Particles between point two five to point five millimeters in diameter are medium sand, then we have fine sand from point one to point two five millimetres, very fine sand from point zero five to point one millimetre, silt, which is point zero zero two millimetres to point zero five millimeters and clay comprising of all those fragments that have a diameter of less than zero ppoint zero zero two milimeter.

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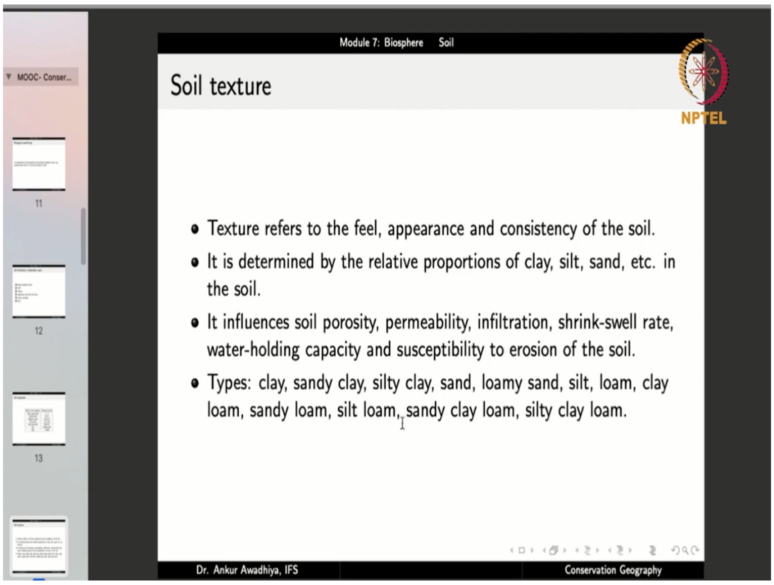

So this is soil separates. When we talk about soil separates, we are classifying the fragments in the soil on the basis of their sizes. And the amount of these different soil separates or their ratios will determine the texture of the soil. Now, texture refers to the feel, appearance, and consistency of the soil. What does the soil feel like?

If you hold it in your hands, does it feel as a very coarse soil? Or does it feel like a very fine soil? What is the appearance of the soil? Does it look like comprising of coarse material? Or does it look like comprising of finer materials? What is the consistency of the soil? Is it having a uniform consistency or is it having certain areas that have bulks and certain other areas that are very fine?

So texture refers to the feel, appearance, and consistency of the soil and it is determined by the relative proportions of clay, silt, sand, etc. in the soil. So essentially, it is determined by the relative proportions of various soil separates. Now, texture influences soil porosity, permeability, infiltration, shrink and swell rate, water holding capacity, and susceptibility to erosion of the soil. And we look at these different features in a short while. And soil texture is classified into a clay texture.

So a clay texture means that you have an abundance of clay, that is most of the particles in the soil are very fine in diameter. Then we have sandy clay, we have silty clay, which means that we have clay with sand or clay with silt. Then we have a sandy texture, which means that the majority of the fragments are sand.

We have loamy sand. Now loamy sand means that you have a combination of clay, silt, and sand, but it is towards sandy texture. Then we have silt, we have loam. Loam is a very good mixture of clay, silt and sand. Clay loam, sandy loam, silt loam, sandy clay loam, and silty clay loam.

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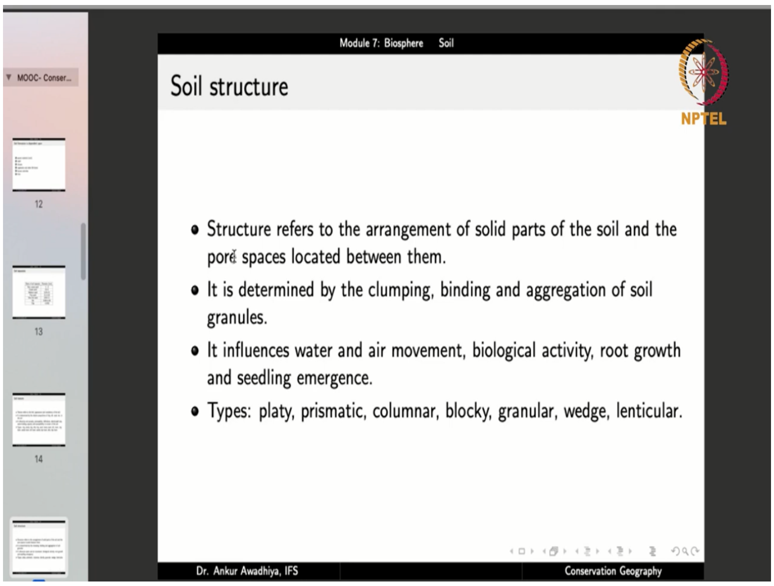

So these are different soil textures. Together with texture, we also have the structure of the soil. Structure refers to the arrangement of the solid parts of the soil and the porous spaces that are located between them. That is, the soil comprises of the soil separates, but how are these soil separates aggregated together? Are the soil separates aggregated into large size aggregates or small size aggregates?

What is the shape of those aggregates? So that determines the structure of the soil. So it is determined by clumping, binding, and aggregation of the soil granules and it influences water and air movement, biological activity, root growth and sealing emergence. Types include platy, prismatic, columnar, blocky, granular, wedge, and lenticular.

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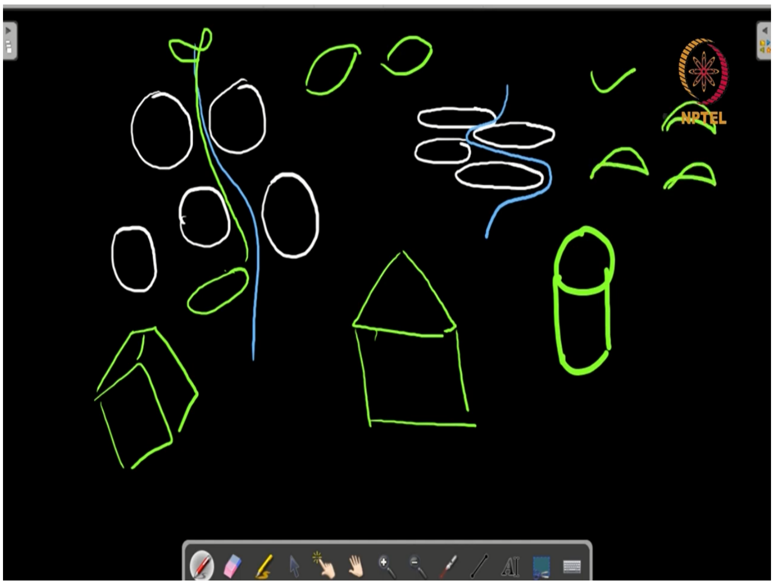

So when we talk about soil structure, we are asking the question, how are the aggregates distributed in the soil? So for instance, if the soil is made up of aggregates that are, say, spherical. So in this case, the aggregates can never fit closely together as compared to aggregates that are, say, in the form of sheets.

Now, in the case of such an arrangement, if water needs to pass, it can very easily pass through this soil, but in this aggregate, the water will take a lot of time because it has to move through all these torturous locations. And so the aggregates determine the properties of the soil. How easy is it for water to move through this soil? Or for instance, if there is a seed germination that is going on, so there is a seed below the soil and it wants to germinate, how easy is it for the young plant to come up?

If the aggregate is a coarse aggregate, the structure is a coarse structure, then the plants can come out very easily. But in the case of such a packed structure, the plant will find it very difficult to come out. And probably, it'll die there. So structure influences water and air movemnt, biological activity, root growth and seedling emergence.

The types include platy, in which case, the aggregates are in the form of plates, something like this. Or we can have prismatic. Now, prismatic would mean that you have the aggregates in the shape of prisms. Something like this. Or we can have columnar, in which case, the aggregates form columns.

Or we can have blocky aggregates or granular aggregates. So this is an example of a granular aggregate. A blocky aggregate would mean creation of block like structures. Wedge shaped structures. Lenticular, which means lens shaped aggregates.

So lens shaped aggregates would be something like or they could be something like this. So all of these different structures can be found in the soil and they determine or influence the properties of the soil.

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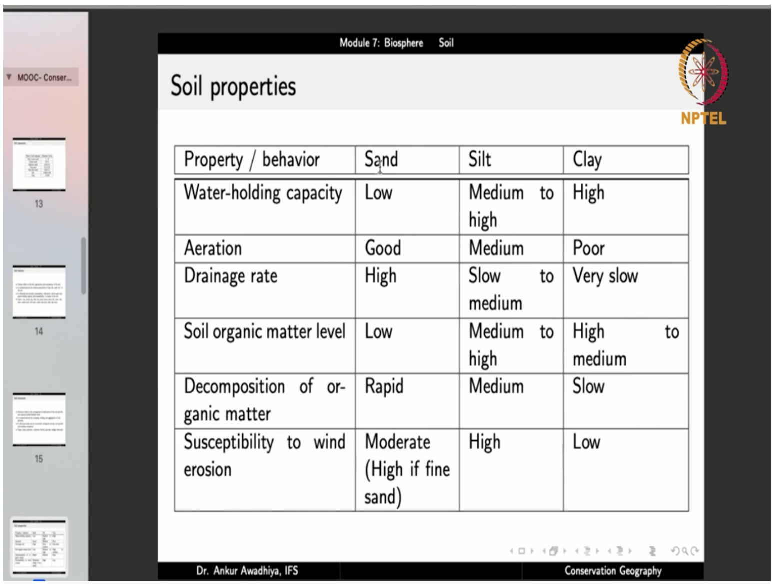
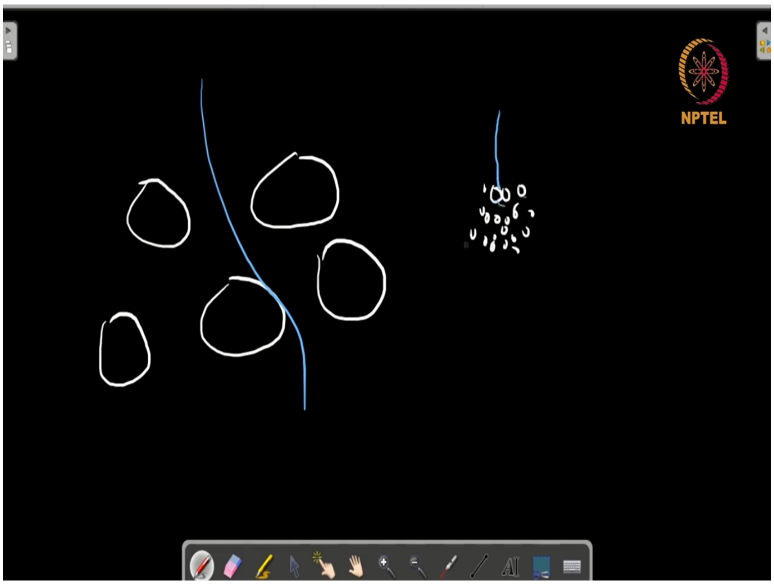


Property / behavior	Sand	Silt	Clay
Water-holding capacity	Low	Medium to high	High
Aeration	Good	Medium	Poor
Drainage rate	High	Slow to medium	Very slow
Soil organic matter level	Low	Medium to high	High to medium
Decomposition of organic matter	Rapid	Medium	Slow
Susceptibility to wind erosion	Moderate (High if fine sand)	High	Low



What properties? Properties including the water holding capacity, how much water does the soil hold. So for instance, if we talk about sand, sand has a low water holding capacity. Why? Because sand is made up of coarse particles, large size particles, and these large size particles have lots of pores in between them. And so if you put water, the water will just flow out. But, if the particles are very small in size, in that case they become more densely packed. There is less amount of porous space. And if you try to put water then water will be retained in all of these spaces in the form of capillary water and very less amount of water will be released from the soil.

So essentially, if the soil is a clay soil, it has a high water holding capacity. If it is a sandy soil then it has a low water holding capacity. Silt is in between, medium to high. Aeration, now aeration also depends on the pores. Sand having good amount of pores will have good aeration. Clay having particles that are close together will have poor aeration. Silt will be between.

Drainage rate, again, a very similar thing. How fast does water move through the soil? If it is comprised mostly of sand or comprised of structures that have large sized aggregates, then you have a high drainage rate. In the case of clay, it has a poor drainage rate. Silt is in between. Soil organic matter level, now because clay has large amount of water, so it will also have more amount of organic matter. So soil organic matter is high to medium. In the case of sand, it is low. In the case of silt, it is medium to high.

Decomposition of organic matter, in the case of sand, there is a rapid decomposition. Why? Because there is a very good amount of aeration. In the case of clay, there is a slow decomposition because the aeration is poor and it very easily creates anaerobic conditions in which decomposition is hindered. And silt comes in between. Susceptibility to wind erosion, in the case of sand, it is moderate because the particles are of large weights. They have more mass. But if it is fine sand, then it can very easily get eroded by wind.

So we have looked at the example of sand dunes and in the case of sand dunes, wind access the agent of erosion. Now, in the case of sand dunes, if there is fine sand then the sand dune can very easily get eroded, but if the sand is very coarse sand then wind will have to do a lot more work. In the case of silt, there is a high susceptibility to wind erosion because it has particles of different sizes.

So if you have winds that are of any speed, there will be some particle that can very easily get eroded. In the case of clay, it has a low susceptibility to wind erosion even though it has very fine particles. Why? Because it has a high amount of water holding capacity. So the soil is mostly wet.

Not only is it wet, but it is also high in soil organic matter, which acts as a binding agent and it keeps the soil together. And so the susceptibility to wind erosion is low.

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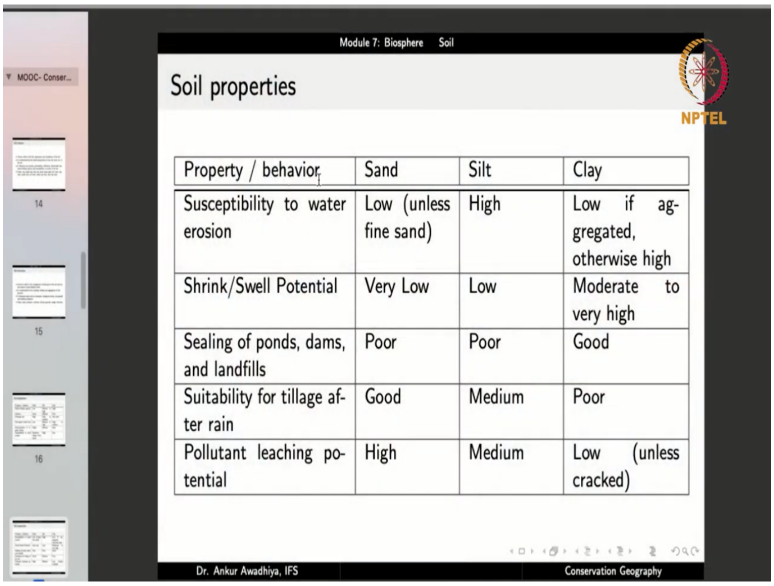

Property / behavior	Sand	Silt	Clay
Susceptibility to water erosion	Low (unless fine sand)	High	Low if aggregated, otherwise high
Shrink/Swell Potential	Very Low	Low	Moderate to very high
Sealing of ponds, dams, and landfills	Poor	Poor	Good
Suitability for tillage after rain	Good	Medium	Poor
Pollutant leaching potential	High	Medium	Low (unless cracked)

If we talk about water erosion, then again, in the case of sand, the susceptibility is low unless it is fine in size. For silt, it is high. In the case of clay, if it is aggregated that is if it has formed a structure by clumping of the soil particles then it has a low susceptibility. Otherwise, it has a high susceptibility because the particles are small in size and they can easily move with water. Now, when we talk about water erosion, we are talking about a situation where a lot of water is there with the soil. And so the soil very easily gets into a suspension mode and so it can very eaily be removed.

Now, this is unlike the case of wind erosion, in which case if the soil is wet then wind finds it difficult to move this soil because of the aggregation effect. But in the case of water erosion, so much amount of water is available that the clumping action of water does not play any role here.

Shrink and swell potential, it is moderate to high in the case of clay because clay is a soil that swells and shrinks. So if you take clay, if you add water, the volume will expand. When it dries, it becomes smaller in size. So it shrinks. Now, this property is very specific to clay and it plays a very big role in the case of agriculture because remember that clay has poor aeration, but because of the shrink and swell potential of clay, it permits it to aerated self.

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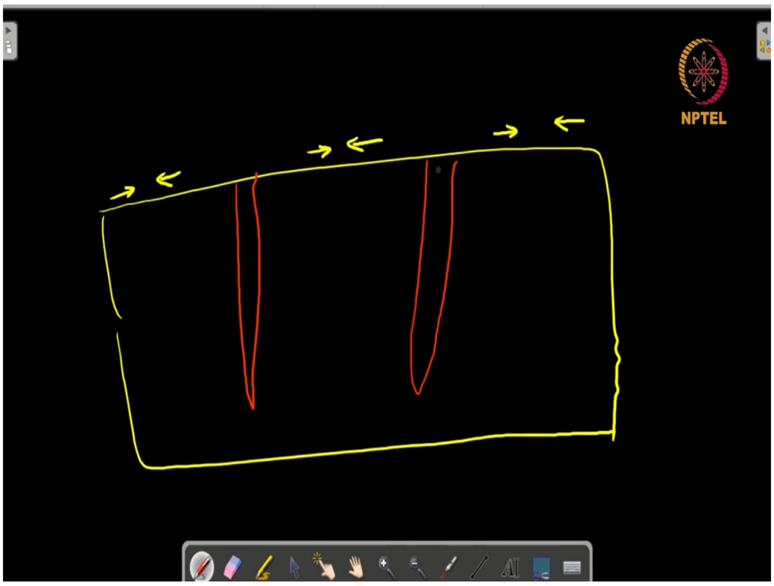

That is, in the summer season, what will happen is you have clay and if you look at the clay when it dries, it will shrink. So when it shrinks, then different portions are moving towards each other. When that happens, the regions in between, they develop cracks. And through these cracks, air can reach inside.

So the cracks play a very important role to aerate the soil. So the shrink and swell potential is moderate to very high in the case of clay, low in the case of silt, and sand hardly has any shrink and swell potential. Then if we talk about the sealing potential for ponds, dams, and landfills, clay is used as a very good sealant. Because of its small sized particles, it can fill in all the gaps and all the pores that are there at the bottom of the pond, which makes the bottom of the pond a watertight structure and it retains water.

Now this is possible because the clay has very fine particle size. So the sealing potential of clay is good. But for sand and silt, it is poor. Suitability for tillage after rain, so after it has rained, clay becomes swelled. It becomes sticky.

So once it has rained, it is very difficult to till the clay. It is very easy to till sand because sand does not retain water. It does not swell. It does not become sticky. Silt comes in between.

Pollutant leaching potential, if sand has any pollutant with it, the moment you get water, water moves through the sand and it takes the pollutant and the pollutant leeches away into the water body. So it has a high pollutant leaching potential. Clay has a low pollutant leaching potential because it just does not permit water to pass that easily except when it is cracked because of shrinkage. Silt comes in between.

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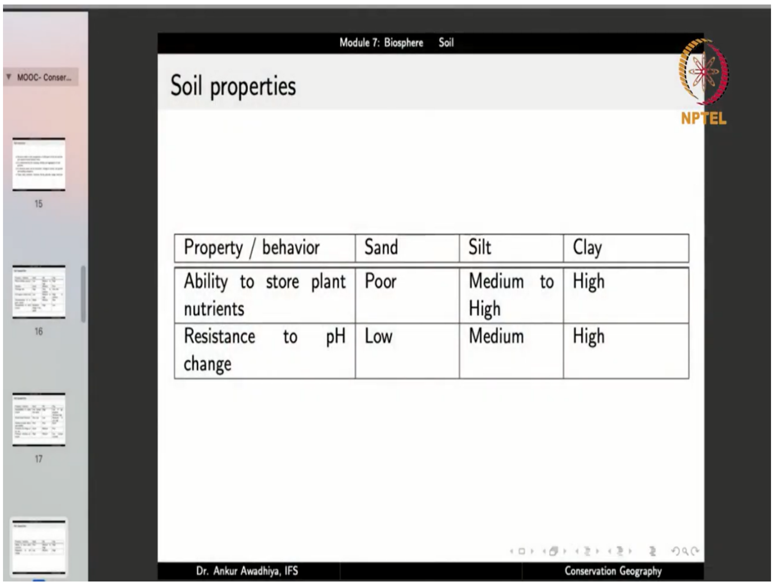

Ability to store plant nutrients is high in the case of clay, not only because it has very small size particles, but at the same time because it also has a lot of organic matter. Sand has a poor ability to store plant nutrients. Silt comes in between. Resistance to pH change, in case of clay, it has a high resistance to pH change. Why? Because it has a lot of organic matter and this organic matter acts as a buffer. So it does not permit the acidity or the alkalinity of the soil to change very easily. Now, because sand has very less amount of organic matter, so there is very low resistance to pH changes.

Silt comes in between. So here, we're observing that the composition of the soil in terms of what fractions are present in the soil, what fractions dominate in the soil, they determine to a large extent, the properties of the soil.

Now, when we talk about structures, then structures also play a role here. So in the case of clay, if you have a clay soil with a coarse structure, with a granular structure, then it will behave like sand for some of the properties, not all. So the structure and the composition of the soil plays a big role in determining the properties of the soil.

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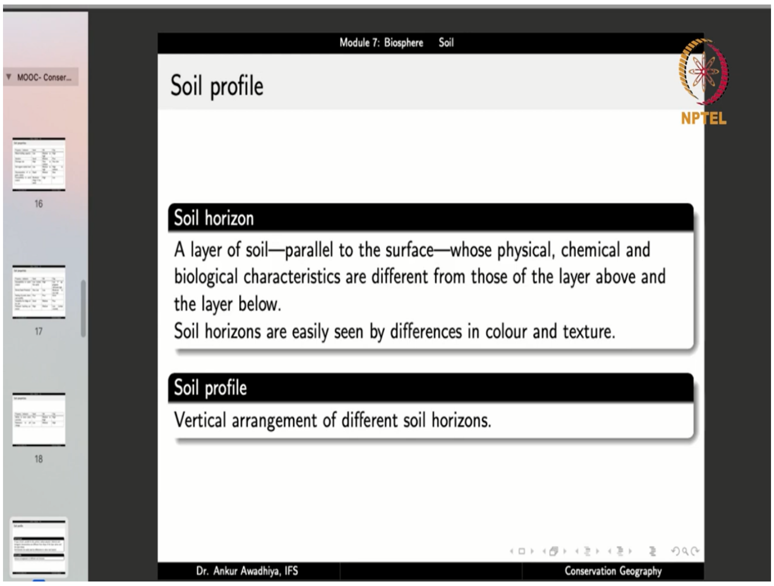

And in this context, let us also talk about the soil profile. Here, we can define soil horizons, which is a layer of soil which is parallel to the surface whose physical, chemical, and biological characteristics are different from those of the layer above and the layer below.

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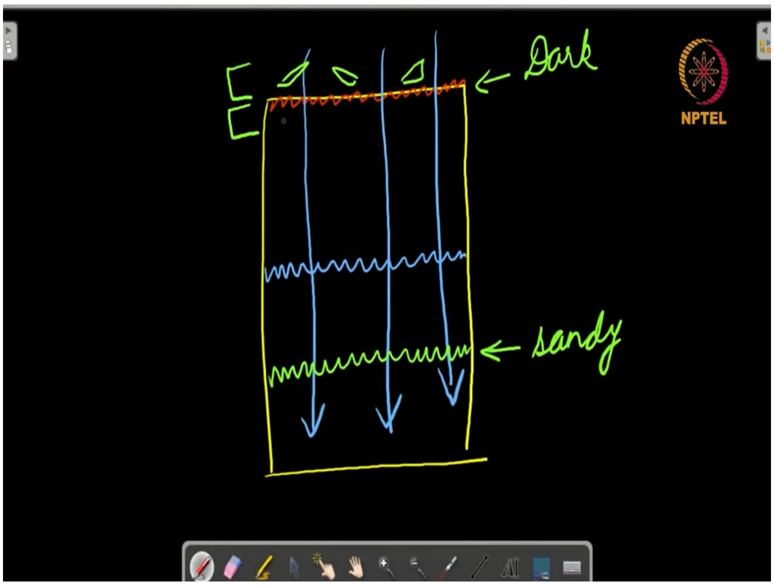

So essentially, what we are saying here is that if you consider a sample of soil that has just been dug out, so we have taken a core of soil from the Earth. Now in this case, all the soil that is there on the top, it has been exposed to very similar conditions. It is directly in contact with air, probably all of it is getting heated by the Sun and so on.

Whereas, a layer which is inside has probably less amount of exposure to air. Similarly, whenever water moves through the soil, it moves through gravity. So it moves from top to bottom. Once that happens, then some of the constituents of the soil may get leached away, which means that water takes them away.

Now, once water takes them away, they have to be deposited somewhere. So it is possible that some of those leachants are deposited here. So essentially, soil comes in the form of layers and these layers are parallel to the surface. And the properties of these layers are determined by the layers above and their position in the soil.

So this is what soil horizon talks about. Soil horizon is a layer of soil parallel to the surface whose physical chemical and biological characteristics are different from those of the layer above and the layer below. And soil horizons are easily seen by differences in color and texture.

So it is possible that on the top, you have a dark colored soil. Why dark colored? Because this will have a lot of humus. Whenever you have any leaves that fall to this area, they get converted into humus and they form a dark colored soil. Whereas towards the bottom, you will probably have a very sandy soil, light colored soil.

So these layers, these horizons can be identified by differences in color and texture, and also by differences in their physical and chemical properties. And soil profile refers to the vertical arrangement of these soil horizons, how are they arranged.

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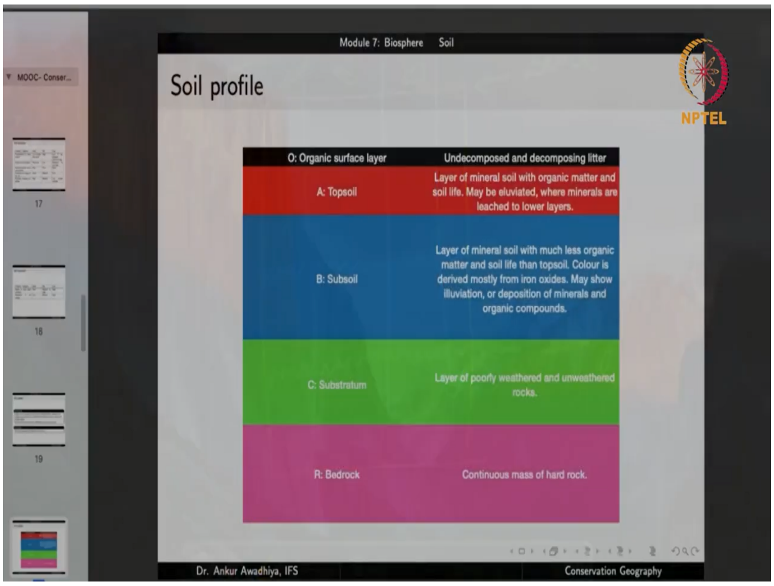

And typically, we find these soil horizons. The top layer is the organic surface layer. It is comprised of undecomposed and decomposing litter. So when we talk about the soil, this layer is the O horizon, the organic horizon. It comprises of undecomposed matter and decomposing matter in different stages of decomposition.

After that, we have topsoil. Top soil is a layer of mineral soil with organic matter and soil life. It may be eluviated where metals are released to the lower layers. Typically, this is the most important layer of the soil when we talk about things such as forestry or agriculture because this is the layer that the plant roots come most in contact with. And this is the layer which, if it is fertile, then it will help the plants to grow very fast.

So top soil is the mineral layer. So as against the organic layer, this is now a layer of mineral soil, but it also has organic matter which is coming from the O horizon, and it also has soil life. So it has a lot many insects, it has earthworms, it has fungus. So there are various kinds of biotech organisms that are there in this layer.

But this layer may be eluviated where minerals are least to the lower layers. Why? Because when you have rainfall then this layer can lose certain minerals, which then move downwards.

After top soil, we have the sub soil. It is a layer of mineral soil with much less organic matter and soil life than the top soil. So on the top, we have the organic surface layer and any organic matter is moving from top to bottom. So here we will have the maximum amount of organic matter, and as we go down, we will have less and less amount of organic matter.

In the case of sub soil, we have more minerals and less organic matter and soil life. Color is derived mostly from iron oxides and it may show eluviation or deposition of minerals and organic compounds. So the things that were removed from the top soil may get deposited in the subsoil.

Below the subsoil we have the substratum, which is a layer of poorly weathered and unweathered rocks. So this comprises of those rocks that are in various stages of being weathered or being worn out. So when we talk about the substratum, it will comprise of different sized fragments of rocks. Some big sized fragments, some smaller sized fragments. And there is very little, if any, soil life or organic matter in this layer.

And below the substratum, we have the bedrock, which is a continuous mass of hard rock. So this is a typical soil profile, but different soils may have some one or more of these layers missing, which brings us to the classification of soils.

All the soils are not the same. Soils are different and if you can identify the kind of soil, it can help you in planning certain activities. So certain soils are good for forests, certain soils are good for grasslands. Certain soils are very poor. So we can classify soils to understand their properties, to understand the characteristics.

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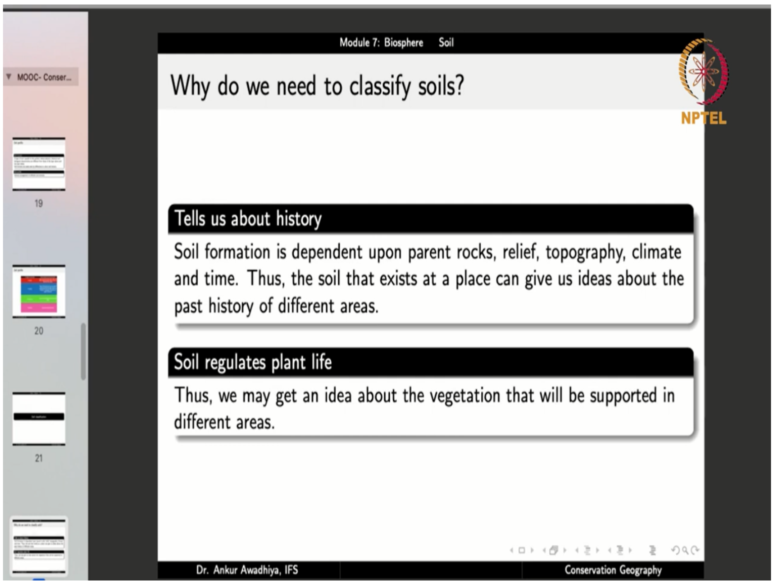

So why do we need to classify soils? One, because they tell us about the history of the soil. How did this soil come into existence? Now, soil formation is dependent upon the parent rocks, relief, topography, climate, and time. And so the soil that exists at a place can give us an idea about the past history of this area.

So for instance, if you go to an area and you find certain minerals that are very much found in a particular soil, say your soil has a lot of placer cold deposits. So this can give you an idea that okay the soil has come from an area where the rocks were cold. Now similarly, we can look at the mineral composition to understand what are the rocks that were the parent material for this soil. How did the soil come into existence?

What were the weathering agents? Was it weathered by air? Was it weathered by water? And what was the morphology or the geomorphology of the area because depending on the geomorphology, different agents of weathering would play a very different role. We can get an idea about whether this area had life or not.

So soil tells us about the history of the area and soil also regulates plant life. So we get a good idea about the vegetation that will be supported in different areas, the kind of biodiversity that different soils will be able to support. Now this is why we classify soils.

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Now we can classify soils in various ways. The early classification, especially from the point of view of a farming community would we be to classify soils on the basis of fertility. Is it a fertile soil or is it a sterile soil? Fertile soils in India are known as Urvara soils, and the sterile soils are known as Usara soils.

Now, a soil can be Urvar or Usara because of several different reasons, probably it has a mineral that is absent, or probably, it has too much of salt or probably it has very high pH or very low pH. So there are n number of things that can make a soil fertile or infertile. So this early classification, it just gives an idea about the fertility, it does not tell us why a soil is fertile or infertile. It does not tell us about how this soil came into existence, but this was the early classification of soils.

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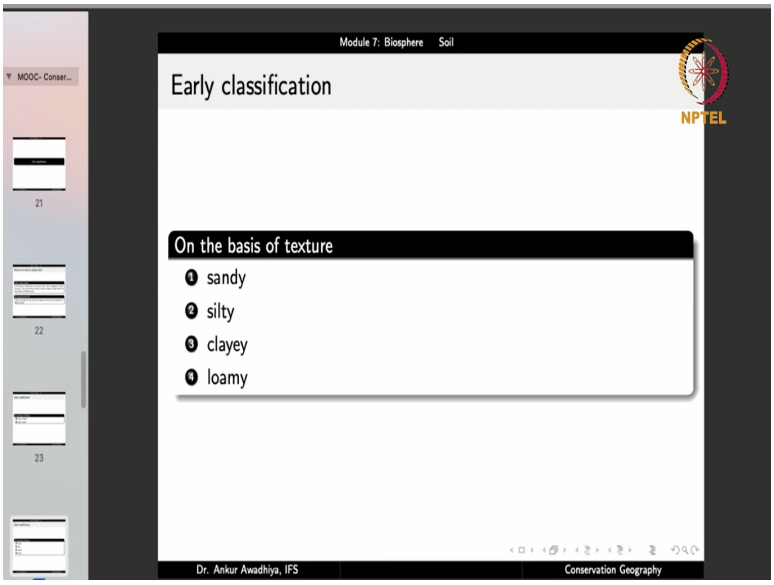

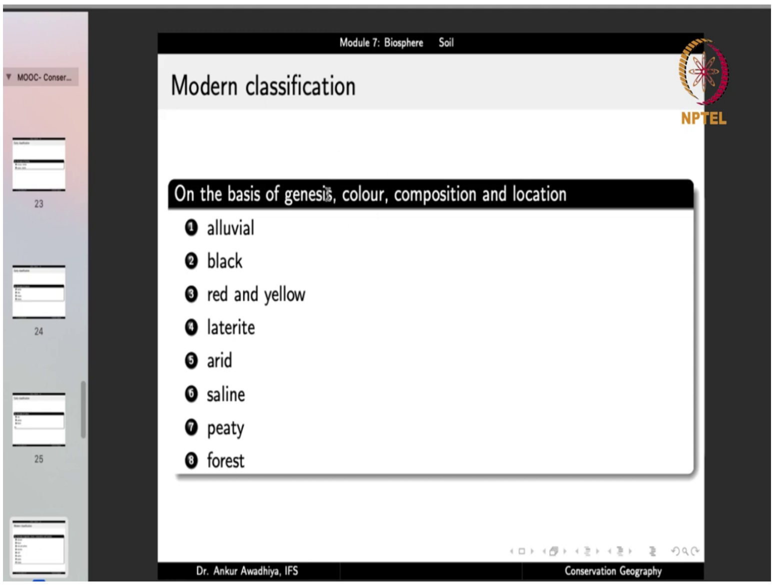

Next we move into texture. So soils can be classified into sandy soils, which have a predominance of sand, silty soils, clay soils, or loamy soils. Now, loamy soils have a roughly equal proportion of sand, silt, and clay. So this was a classification based on texture. Now, classification on the basis of fertility or classification on the basis of texture is easy to do. So which is why these are early modes of classification. Yet another early mode of classification is classification on the basis of color. Is it a red colored soil, is it a yellow colored soil, is it a black colored soil? And so on.

But now, the modern classification compiles all of this information together. And now we classify soils on the basis of their genesis, which is how they came into existence, their history, the color, the composition, and the location. So now when you classify soil into one of these eight categories, alluvial, black, red and yellow, laterite, arid, saline, peaty, and forest.

Now, when you classify soil into one of these categories, you can get an idea about the genesis, the color, the composition, and the location of the soil.

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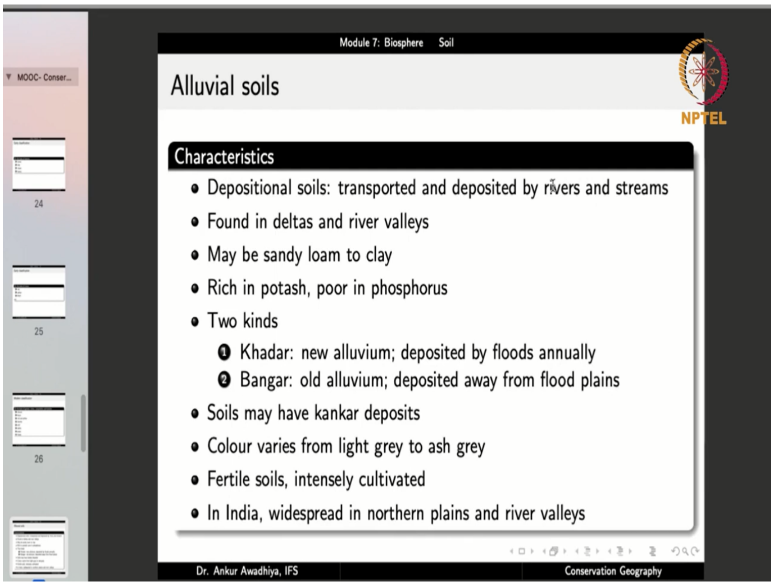

So let us now understand this classification. The first is alluvial soils. Now, alluvial soils are depositional soils. They are transported and deposited by rivers and streams. And so they are found in deltas and river valleys. So when we talked about the northern plains of India, we said that they are comprised out of the alluvial soils that were deposited by the various rivers in this area. Indus and its tributaries, Ganga and its tributaries, Bramhaputra and its tributaries.

Now, all of these rivers were carrying sediments, and once they moved out of the mountainous areas and they shifted to the plain areas, their speed reduced. They were not able to transport as well. And so they shed their sediments.

Now, these sediments form the alluvial soil. So this soil is found in deltas such as the Sundarban delta, and in river valleys such as our northern plains.This soil may be sandy loam to clay. So very near to the foothills, the soil will be more coarser because when the speed reduces, the first thing that the river would shed would be the coarser particles because they require too much amount of energy to transport.

And once the river has reached into the plain area, it now no longer has that amount of kinetic energy. But then, at a distance from the foothills, you will find more of clay soil. So the soil may be sandy loam to clay. It is rich in potash and poor in phosphorus. We have two different kinds of alluvium. We have Khadar, which is new alluvium deposited by floods annually, and we have Bangar, which is the old alluvium and has been deposited away from the flood plains. The soil may have Kankar deposits. Kankar refers to calcium carbonate, which is in the form of aggregates.

The color varies from light gray to ash gray. These are fertile soils, intensely cultivated because of which our northern plains have become the breadbasket of the country. And in India, they are widespread in northern plains and the river valleys.

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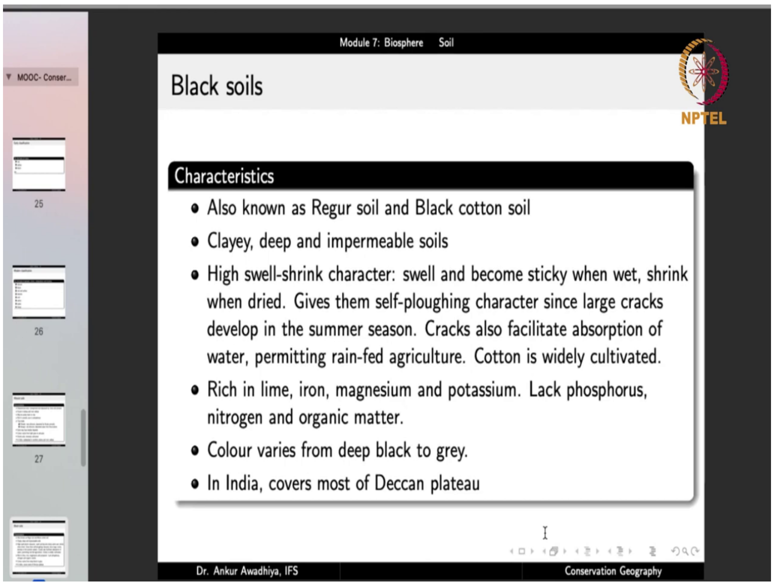

Another soil is black soil, also known as Regur soil or black cotton soil, because it is used for cotton cultivation. These are clay soils, too much of clay. So when you see clay, now, you can think about the various characteristics that clay would be giving to these soils. They are deep soils. They are impermeable soils, because clay does not allow water to pass that easily.

They have a high swell and shrink character given by the clay. This swell end become sticky when wet, they shrink when dry, gives them a self ploughing character because large cracks develop in the summer season, facilitate absorption of water, permitting rainfit agriculture and cotton is widely cultivated. This soil is rich in lime, iron, magnesium, and potassium, lacks phosphorus, nitrogen and organic matter.

So basically, if you want to use this soil for cultivation, you need to add phosphorus, nitrogen, and organic matter, because the soil is poor in that. The color varies from deep black to gray. And in India, it covers most of the Deccan plateu. Now, when you say that it covers most of the Deccan Plateau, you can get an idea about the origin of the soil.

Most of this soil has originated from igneous rocks because igneous rocks are the ones that cover most of the Deccan plateu, especially the flood basalt provinces. So this is the origin of the black soils.

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Next, we have red and yellow soils. They develop in low rainfall areas with crystalline igneous rock bed. They have red color because of iron, and when they are hydrated, they appear yellow in color, which is why they are called red and yellow soils. Fine grained soils are fertile whereas coarse grained soils are poor in fertility. So they can be either fine grained or coarse grained. They are deficient in nitrogen, phosphorus, and humus. So essentially, mostly, they are infertile, commonly found in the eastern part of the Deccan plateu. So they can be put to agricultural use by fulfilling all of these deficiencies.

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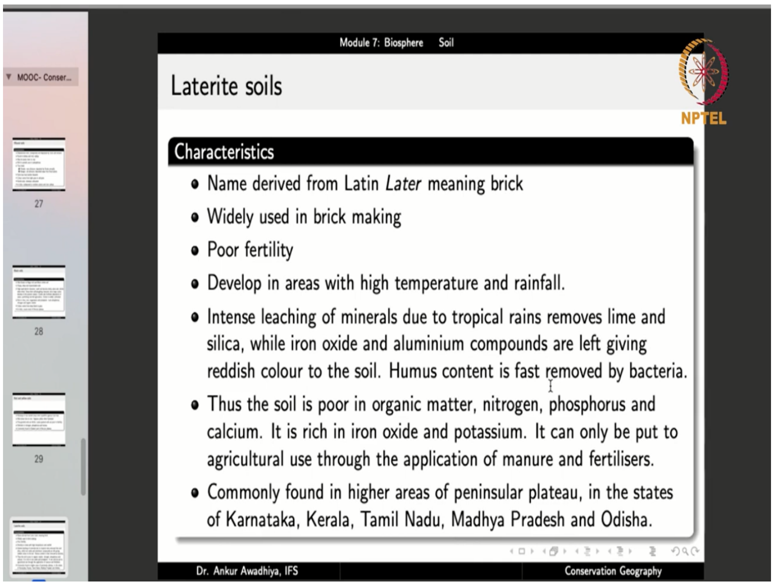

Next we have laterite soils. The name is derived from Latin later, which means brick. So they were used for brick making. So they're not good for most of other purposes, which means that they have poor fertility. The develop in areas with high temperature and rainfall, which leads to intense leaking of materials due to tropical rains, which removes lime, silica whereas iron oxide and aluminum compounds are left behind giving the reddish color.

So these are red in color because of iron oxides. Humus content is fast removed by bacteria because they are found in areas with high temperature and rainfall. So any humus is very quickly degraded. So they are poor in humus. So they are poor in organic matter, nitrogen, phosphorus, and calcium.

They are rich in iron oxide, and potassium, and can be put to agricultural use through application of manure and fertilizer that is by fulfilling the deficiencies. They are commonly found in higher areas of peninsular plateu in the states of Karnataka, Kerala, Tamil Nadu, Madhya Pradesh and Odisha, that is all areas that have high temperature and rainfall.

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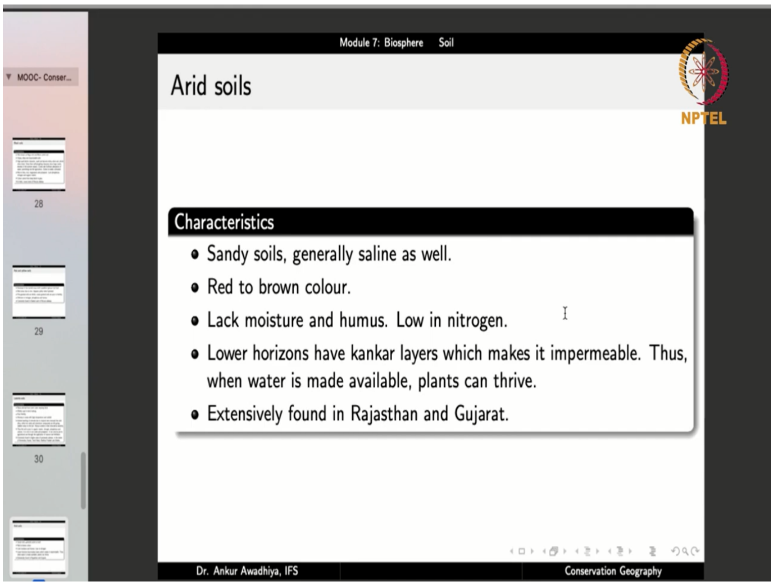

We have arid soils, which is dry soils. Think about desert and you understand the arid soils. They are sandy soils, generally saline as well, which means that they have high amounts of salt. Red to brown in color. Lack moisture, lack humus, low in nitrogen. Lower layers have Kankar layers, which is calcium carbonate, which makes it impermeable. So when water is made available, plants can thrive because of this layer of Kankar nodules. But if these soils are heavily ploughed, and this Kankar layer is broken, then all the water will be really quickly drained off, and you can not perform any agriculture here.

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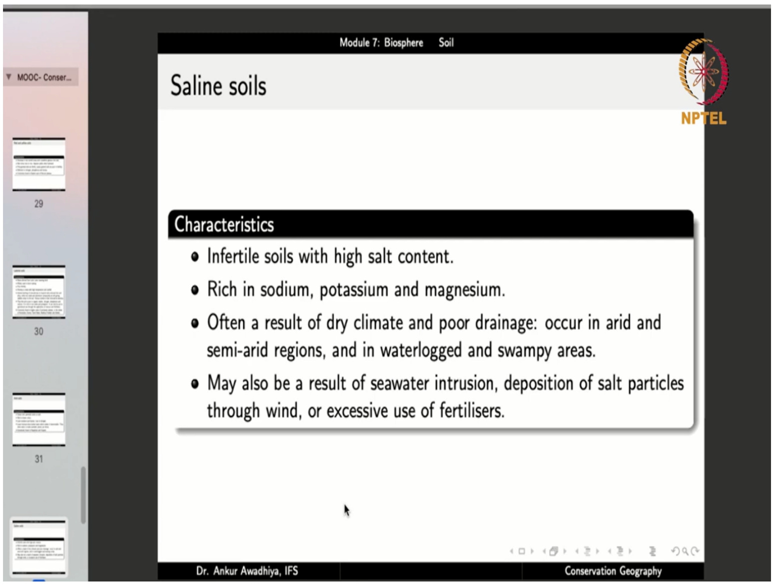

In India, they are found in Rajastan and Gujarat. We have saline soils which are infertile soils with high salt content. Most of the plants just die in the saline soils. They are rich in sodium, potassium, and magnesium. Often a result of dry climate and poor drainage, they occur in arid and semi arid regions, and in waterlogged in swampy areas.

So basically, if you have an area where you get water from the rivers, but this water has been brought artificially and evaporates, so the salts that are there in the water they get accumulated in the soil. And with time, this soil will become more and more salty. It can also become salty if people apply too much of fertilizers, especially the chemical fertilizers. And once the soil is very salty, then plants are unable to absorb moisture because the osmolarity goes heavier.

And so they are very poor in fertility. They may also be a result of seawater intrusion, deposition of salt particles through wind or excessive use of fertilizers.

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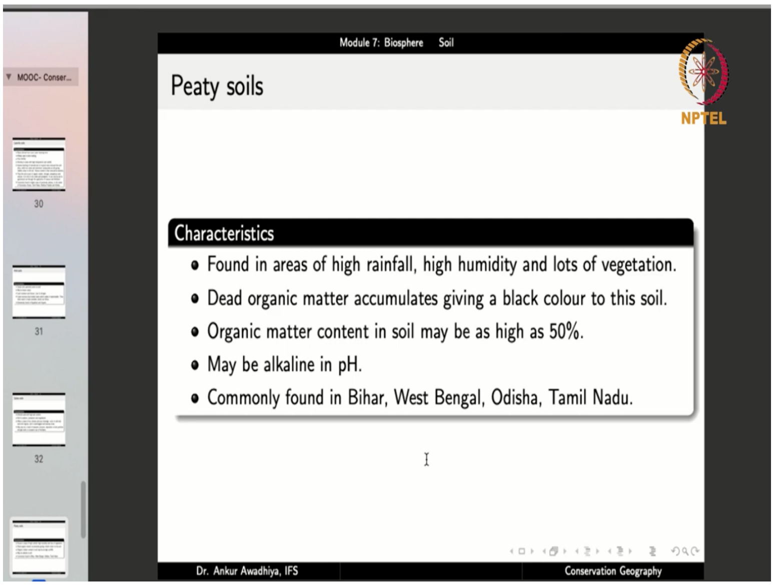

We have peaty soils, which are very high in organic carbon. Just think about lots of organic carbon. So they are found in areas of high rainfall, high humidity, lots of vegetation. Dead organic matter accumulates, giving a black color to this soil. Too much of humus. Organic matters may be as high as 50%, maybe alkaline in pH, commonly found in areas like Bihar, West Bengal, Odisha, and Tamil nadu.

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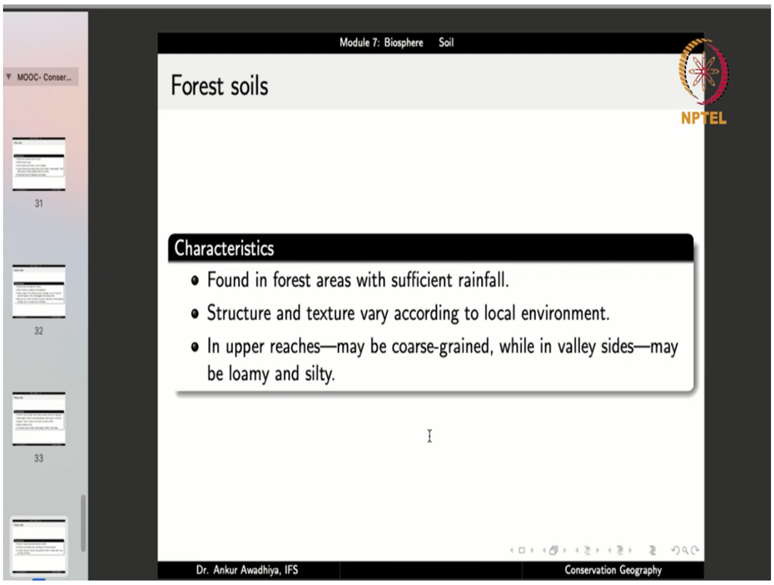

Then we have forest soils found in forest areas with sufficient rainfall. Structure, and texture vary a lot because these are forest soils, so you will not find a very consistent structure and texture, which is why they have not been put into agricultural use. They're typically not very fertile. In upper regions, they may be coarse grained whereas in the valley sides they may be loamy and silty.

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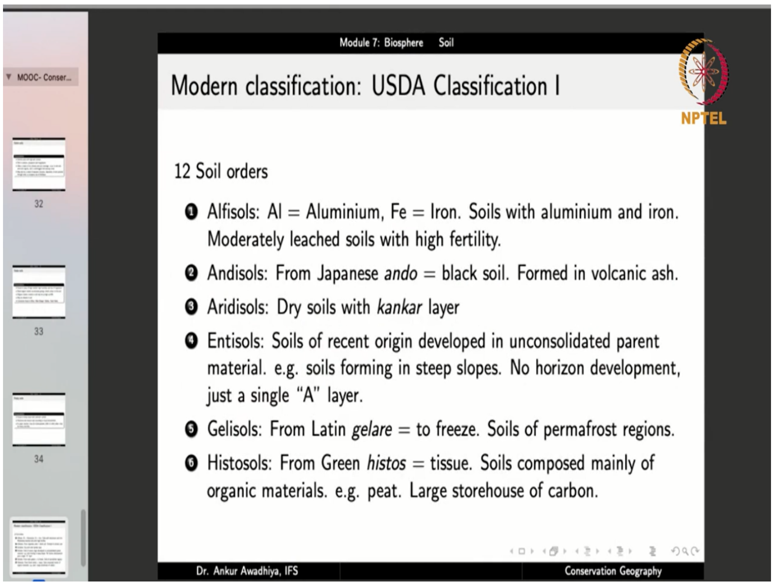

So basically, the composition, the structure, the texture, the fertility, everything is variable in the case of forest soils. Now, apart from this classification, we also have the modern classification by the US Department of Agriculture, which divides soil into 12 orders.

So here, we have Alfisols which are soils that are rich in aluminum and iron, Andisols which are soils of volcanic ash, Airidisols, which are soils of desert areas, that is our arid soils, entisols, which are soils of recent origin, such as those found in steep slopes. And the steep slopes, because the soils did not have a lot of time to accumulate, so there is no horizon development.

Gelisols, which are the soils of permafrost areas. Histosols, which are very much like our peaty soils. They are a large storehouse of carbon.

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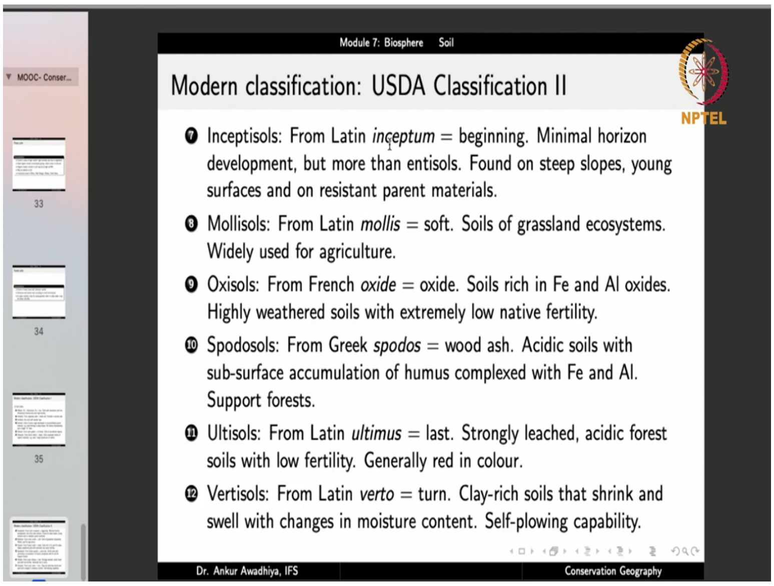

Inseptisos, which are very beginning soils, minimum horizon development but more than entisols. Mollisols, which is a soft soil which is found in grassland areas. Typically, a majority of them have been shifted into agricultural use. Oxisol, which is rich in oxides. Spodosols, which is a soil with wood ash color. So these are acidic soils with subsurface accumulation of humus and placed with iron and alluvium. They support forest.

Ultisols, which are last soils which means that they are strongly leached. They are soils with low fertility, generally red in color. Vertisols, which means clay rich soil, similar to our black soils. So they are clay rich soils that shrink and swell with a self plowing capability.

So we have different kinds of soils. Soils play a very important role in supporting forest and in supporting biodiversity.

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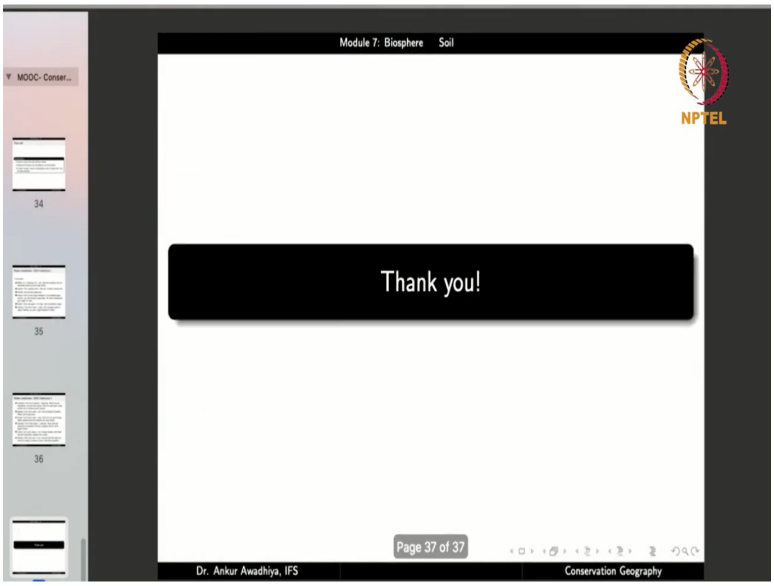

So that is all for today. Thank you for your attention. Jai Hind!