Forests and Their Management
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Module - 03
Forest Soils
Lecture – 03
Nutrient Cycles

[FL]. We move forward with our discussion on Forest Soils, and today we will have a look at Nutrient Cycles.

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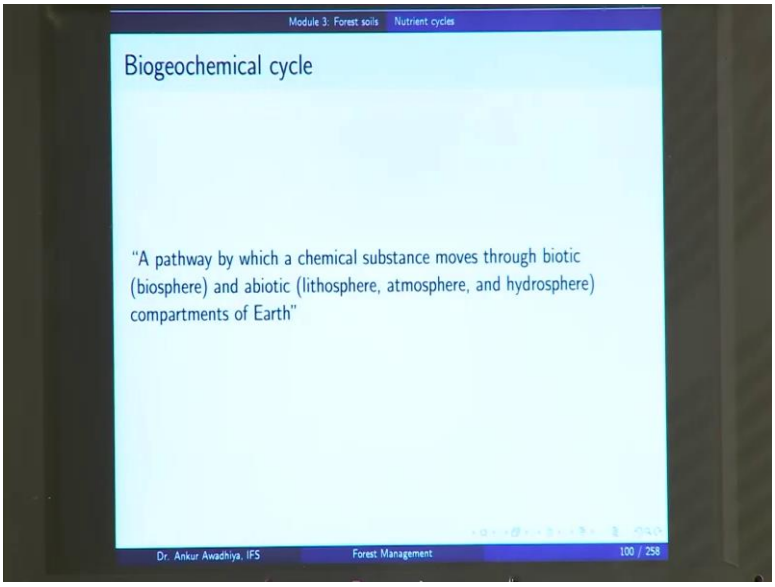

Now, we saw before what a biogeochemical cycle is, and we said that a biogeochemical cycle is "a pathway by which a chemical substance such as a nutrient moves through biotic and abiotic compartments of the earth." Now, biotic compartments are the living compartments such as biosphere, and the abiotic compartments are the nonliving compartments such as lithosphere, atmosphere and hydrosphere. So, in this case what we are saying is that the nutrient or the chemical substance is moving both through the bodies of the living organisms, and it is also moving through the rocks, the soil, the water, and the air.

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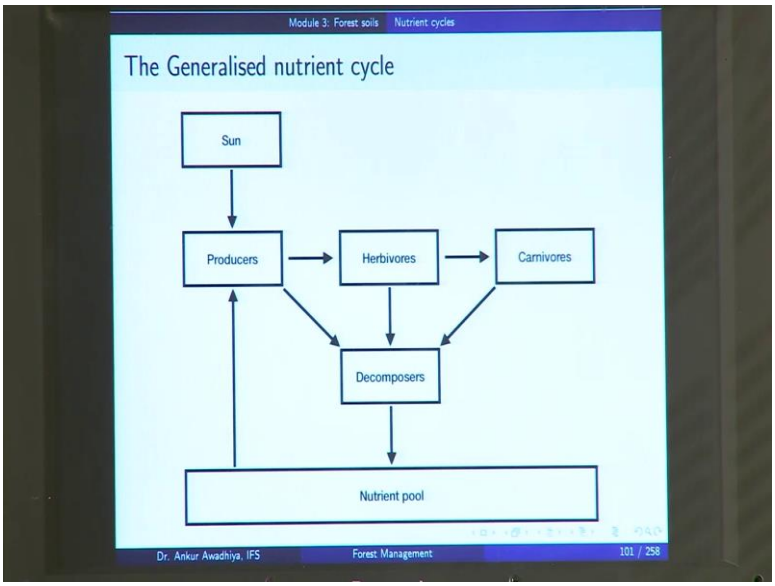

And, a generalized nutrient cycle is represented like this. So, you have the sun that is providing the source of all energy, and here you have the nutrient pool that is there in the atmosphere, lithosphere and hydrosphere in the nonliving components.

Now, the nutrients are moving from these compartments, from these nonliving compartments of the earth, they are taken up by the producers, and they use this energy of the sun to incorporate these nutrients into their own bodies. And, when these producers are eaten up by the herbivores, so typically these producers are plants or they are some other autotrophs that making their own foods. And, when these producers get eaten up by the herbivores, then these nutrients that were there in the bodies of the producers have now moved into the bodies of the herbivores.

When the herbivores in turn get eaten up by the carnivores, then these nutrients move into the bodies of the carnivores. And the producers, the herbivores, and the carnivores, when they die off or when they when they when they when they produce excreta or dung, then all of these are eaten up by the decomposers. So, in that case, the nutrients that within the bodies of the producers, the herbivores, or the carnivores have now reached to the bodies of the decomposers. And then, these decomposers, in turn, break down the bodies and break down these nutrients, and release them in a form that goes back into the nutrient pool.

So, in this case, what is happening is that the nutrients moves through the producers, through this whole biosphere, and then it comes back into the nutrient pool. So, this is a generalized nutrient cycle. So, let us now have a look at some nutrient cycles in greater detail.

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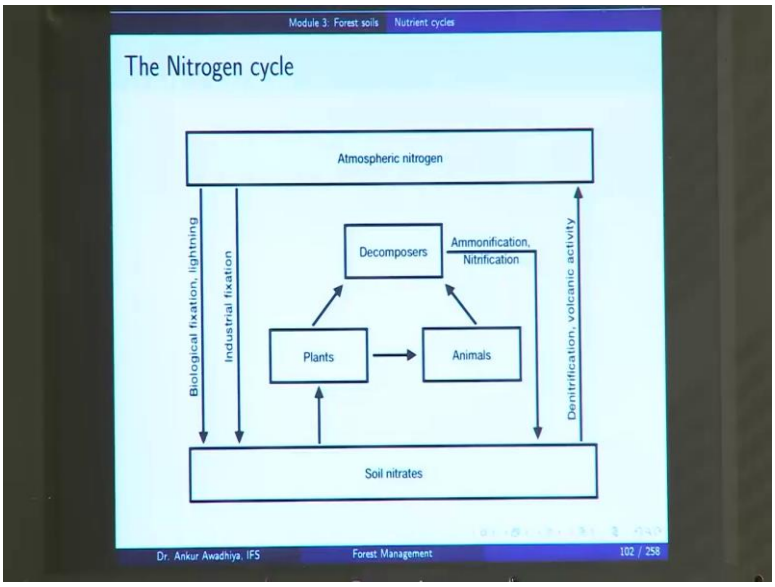

So, let us begin with the nitrogen cycle.

Now, in the case of the nitrogen cycle, you have two major pools that hold up this nitrogen. The first is the atmospheric nitrogen. Now, we all know that as much as 78% of the air is comprised of the nitrogen gas N2. So, most of the nitrogen remains in the form of the nitrogen gas that is present in the atmosphere.

The other nutrient pool is that of the soil nitrates. So, in this case, nitrogen is present in the form of salt, in the form of NO3 minus, and this NO3 minus is present in the form of some salts together with some cations. So, this can be say sodium carbonate NaCO3. It can be sodium nitrate - NaNO3, or it can be calcium nitrate CaNO3 twice or so on.

Now, your atmospheric nitrogen is continuously interacting with the soil nitrates. So, for instance, you can have biological fixation, lightning, or industrial fixation, and these 3 processes convert the atmospheric nitrogen into soil nitrates. So, your nitrates, your nitrogen is moving from one pool to another pool whenever there is a nitrogen fixation

by lightning or by industrial fixation or by biological fixation. You will have a situation in which your atmospheric nitrogen is getting converted into soil nitrates.

On the other hand, the soil nitrates can also move back into the atmospheric pool in the form of nitrogen. And, this happens when you have the process of denitrification or for instance the process of volcanic activity. Now, in the case of a volcanic activity, the nitrates that are present in the in the form of rocks they will be heated up to a very large extent and then they will be released back into the atmosphere.

Now, the plants also take up these soil nitrates. So, this was the nonliving component, but then if you talk about the living components, then plants take up these soil nitrates and then they use it to form biomass. So, these nitrates will in turn be used to make say amino acids, which will make up proteins in the plants. And, when these plants get eaten up, then these this nitrogen will get into the bodies of the animals that are eating these plants. And, here again, the animals that are eating these plants are the herbivores. These animals in turn can get eaten up by the carnivores, and the process can go on.

So, you have a primary consumer, which is the herbivore; then you can have a secondary consumer which is a carnivore; but then you can also have a tertiary, a quaternary, a quinary and so on, consumers that in turn are eating up the other consumers. And so, the nitrogen has now reached into the bodies of these animals. And, when these plants or the animals are dying, then the decomposers are converting this nitrogen through the process of ammonification and nitrification. into back into the soil nitrates. So, this is how the nitrogen cycle works. And, in this nitrogen cycle there are a few important steps.

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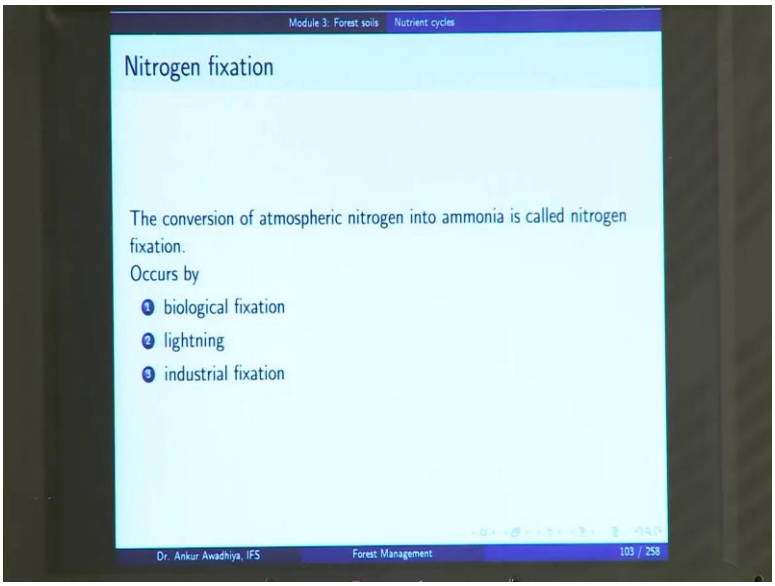

The first important step as we saw is NITROGEN FIXATION. Now, what is nitrogen fixation? The conversion of atmospheric nitrogen into ammonia is called nitrogen fixation. Now, it can be converted into ammonia, or in certain cases, it can directly be converted into the nitrates. And, a nitrogen fixation happens through biological fixation, lightning and industrial fixation. So, these are 3 different ways of nitrogen fixation.

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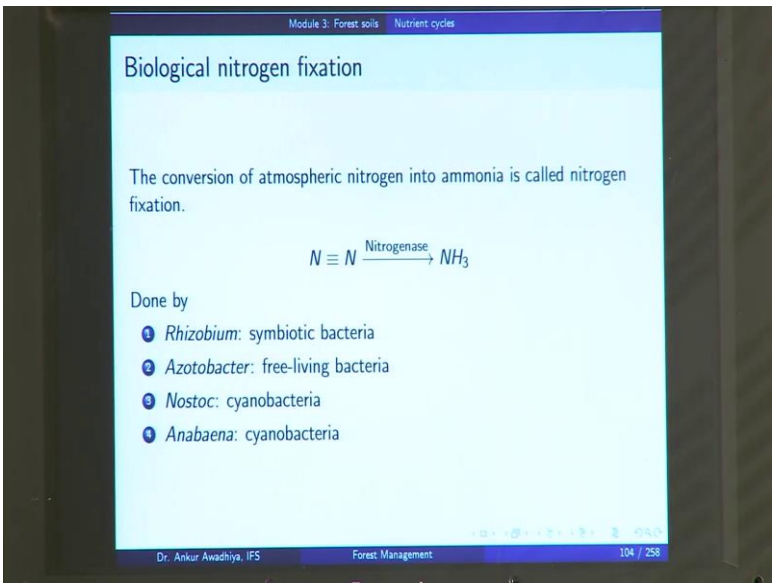

Now, how does biological nitrogen fixation occur? Biological, in the case of biological nitro nitrogen fixation, you have nitrogen gas, and you have the activity of certain

enzymes, such as nitrogenase, which converts it into ammonia. So, this is biological nitrogen fixation. You have certain enzymes that are taking up or that are acting on the nitrogen gas, and that are converting it into ammonia.

Now, this these sorts of enzymes are not found in every organism, they are found in certain nitrogen fixing organisms, and examples include rhizobium. Now, rhizobium is a symbiotic bacteria. Now, what do we mean by symbiosis? A symbiosis is a relationship between two organisms in which both these organisms are helping each other, and primarily through the provisioning of food and shelter.

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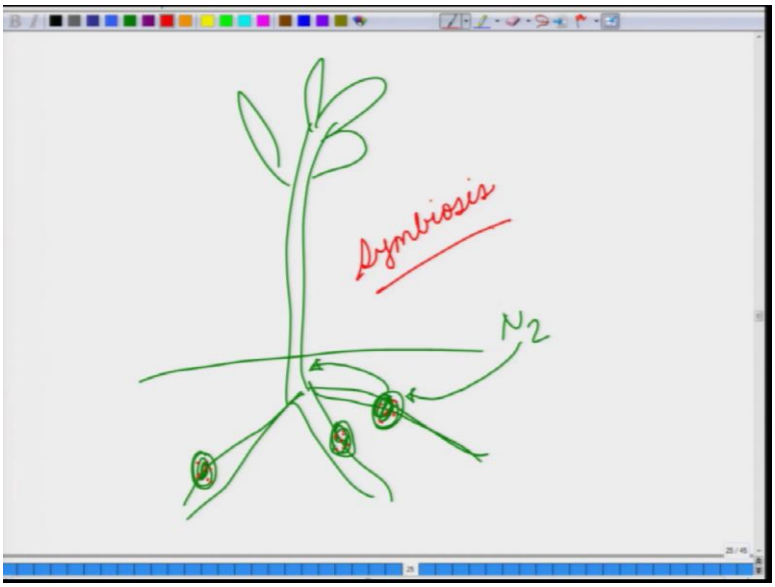

Now, what happens in the case of rhizobium is that, in the case of certain plants, the roots will be having root nodules. So, there will be nodules on these roots, and in these nodules, you will be having these bacteria, which are rhizobium.

Now, what this bacteria is doing is that, because it has this nitrogenous enzyme, so it is fixing up the atmospheric nitrogen. So, the plant by itself was not able to use the atmospheric nitrogen, but now because this nitrogen is being fixed by this rhizobium bacteria. So, it is now being made available to the plants. So, these bacteria are now helping the plants to get their food; to get nutrition.

Now, in turn, what the plants are doing is that they are providing shelter to these bacteria. So, they are providing a shelter that is having adequate conditions for the growth and

propagation of these bacteria. They are also providing some other food materials to the bacteria. So, the bacteria is providing nutrition to the plants, and the plants in turn of a providing nutrition to the bacteria. Now, this kind of a relationship between both these organisms is known as ‘symbiosis.’

So, nitrogen fixation is done by rhizobium which is a symbiotic bacteria. It lives together with those plants that are having root nodules, and typically these are leguminous plants. So, if you talk about things such as pulses or channa or grams. So, these sorts of plants use, which also have bacteria that are doing the nitrogen fixation.

Now, typically these leguminous plants are producing those food materials that are very high in proteins. So, for instance, grams and pulses - we use them as a rich source of protein. Now, proteins in turn are made up of amino acids, and these amino acids have nitrogen in them. So, through this process of nitrogen fixation, we are able to get these proteins in these plants.

Now, another organism that does nitrogen fixation is Azotobacter, which is a free living bacteria. Now, this bacteria is not living in the form of root nodules with another organism; it is free living; it lives on its own. Now, apart from bacteria, you also have the cyanobacteria or the blue green algae, such as Nostoc and Anabaena. Now, both of these are also able to perform the nitrogen fixation.

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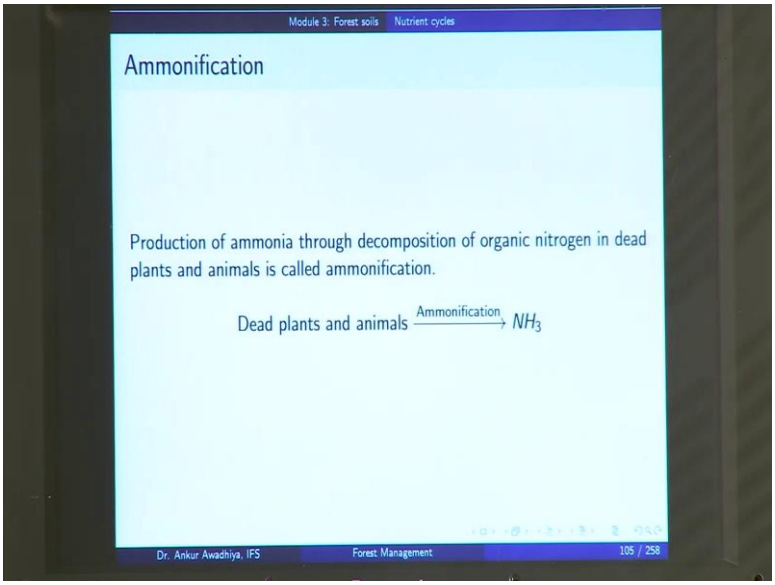

Next, we have ammonification. Now, ammonification is the process of production of ammonia through decomposition of organic nitrogen in dead plants and animals. Now, this is the opposite of nitrogen fixation. In the case of nitrogen fixation, you are producing ammonia, but ammonia for fixation in the biological tissues. In the case of ammonification, you are breaking a biological materials to generate ammonia.

So, what happens in this case is that you have dead plants and animals, and through the process of ammonification the proteins that are there in the bodies of these dead plants and animals and also certain nucleic acids, so all of these are then converted in the process of ammonification into ammonia.

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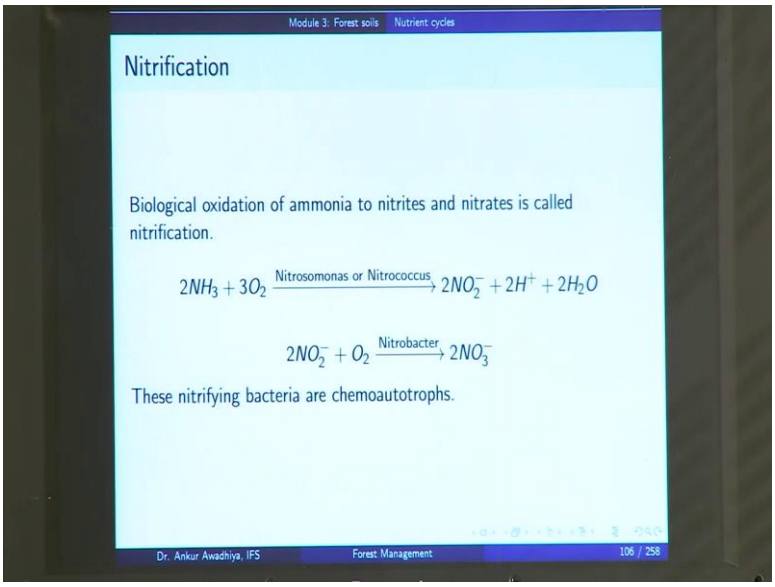

Next, we have the process of nitrification. Now, nitrification is the biological oxidation of ammonia into nitrites and nitrates. Now, as we saw before, the plants are taking up nitrates from the soil. Now, we need to convert ammonia into these nitrates, because typically ammonia is a very toxic compound. You cannot have excess amounts of ammonia, or the plant will die. So now, this ammonia has to be converted into nitrites and nitrates, and the process through which this is done is an oxidation reaction which is known as nitrification.

Now, in the case of nitrification, you have ammonia plus oxygen in the presence of bacteria such as Nitrosomonas or Nitrococcus, it is getting converted into nitrites, and these nitrites are then further oxidized by Nitrobacter, which are another category of

bacteria into nitrates. Now, these nitrifying bacteria that are that are converting ammonia into nitrites and nitrates. These are chemoautotrophs.

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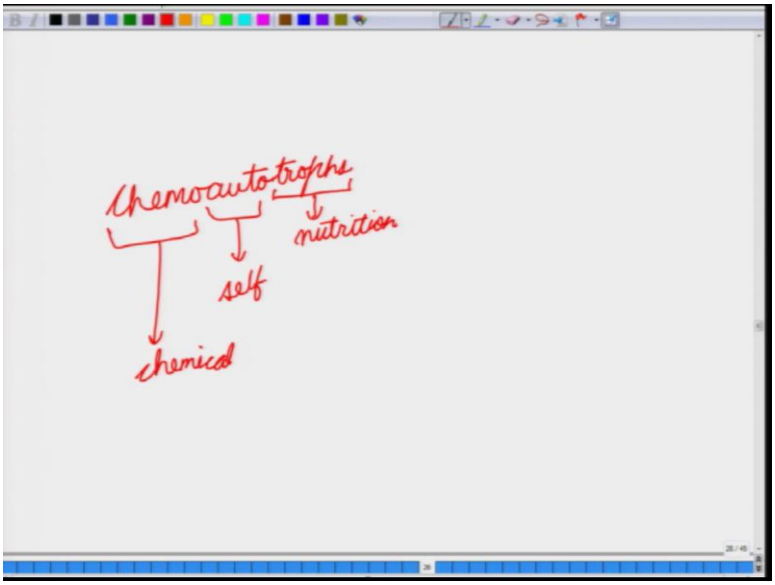

These are chemoautotrophs.

Now, ‘trophy’ is ‘nutrition,’ ‘auto’ is ‘self,’ and ‘chemo’ is ‘through a chemical reaction.’ So, what when we say that these nitrifying bacteria are chemoautotrophs, what we are saying is that these bacteria are using these chemical reactions to produce their own food. So, they are also autotrophs they are doing self-nutrition. But as against the photoautotrophs, such as plants that were using sunlight to produce their food, these plant these organisms are using chemical reactions to make their own food. So, these are chemoautotrophs.

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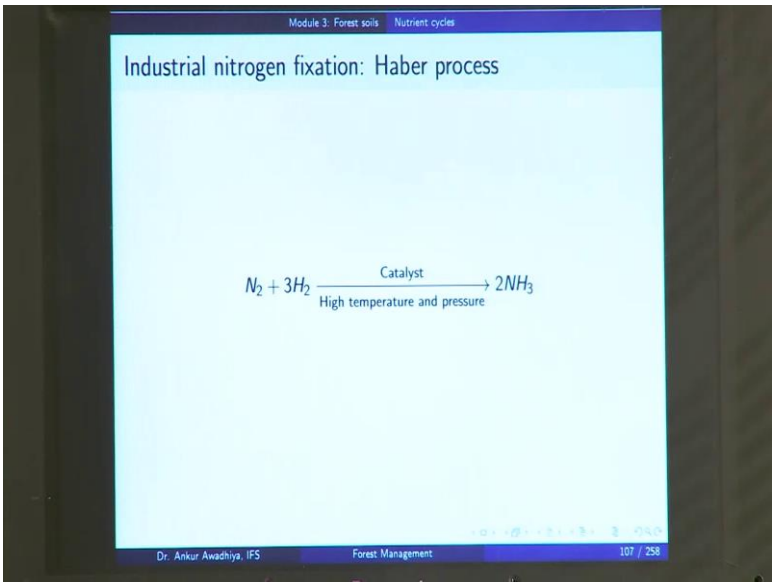

Now, the amount of nitrogen fixation that is being done through natural means - either lightning or through the action of these biological fixation agents is very less. And typically, in the case of agricultural crops, you want to have a situation in which the plants do not have any dearth of the nutrients, specially nitrogen because nitrogen is important for the growth of plants. So, in this case, we have devised certain processes through which we can do the fixation of this nitrogen, artificially. And, this is done on an industrial scale in a process that is known as the industrial nitrogen fixation.

Now, when very common way of doing the industrial nitrogen fixation is through the 'Haber process.' Now, in the Haber process nitrogen and hydrogen are combined together at high temperature and pressure in the presence of a catalyst, and these nitrogen and hydrogen react together to form ammonia. So, this is a process that is not happening naturally, because the high temperatures and pressures that are required and the catalyst that is required, has to be made available artificially. So, this is a process of industrial nitrogen fixation.

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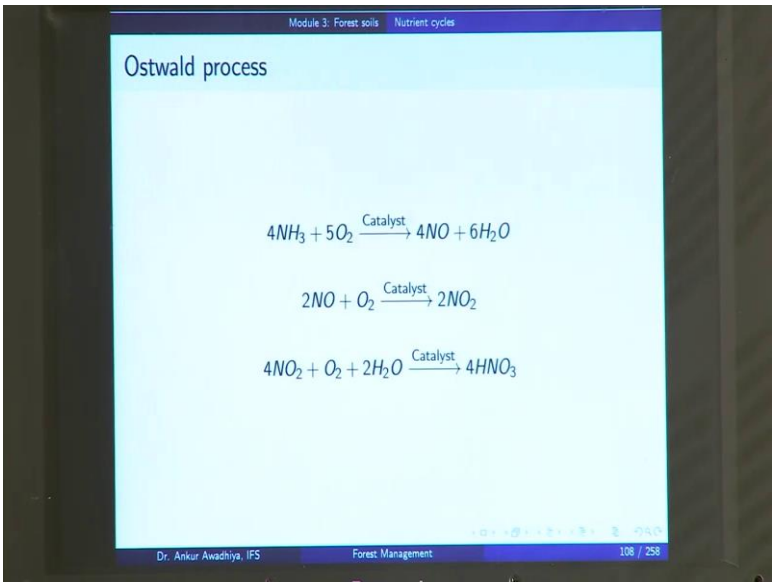

Another way in which industrial nitrogen fixation is done, is through the 'Ostwald process.' Now, in the Ostwald process, you have this ammonia that was built in the Haber's process, you converted into nitrates. So, how is that done? You have ammonia, you have oxygen both of these react in the presence of catalyst to form NO.

So again, we are what we are doing is now the oxidation of ammonia in an artificial environment. So, this NO in that in turn reacts with more amount of oxygen to create NO 2, which in turn reacts with more amount of oxygen and water, in the presence of catalyst, to create the nitric acid. So, what we are doing is that in place of having the biological nitrogen fixation and the processes of nitrification - so in the case of biological nitrogen fixation, we were converting the atmospheric nitrogen into ammonia and then further on through the process of nitrification we were converting or oxidizing this ammonia into nitrates and nitrates.

Now, in the case of the industrial nitrogen fixation, you are using Haber's process to convert atmospheric nitrogen into ammonia. And then, you are using the Ostwald process to convert this ammonia into nitrates, nitrites and nitrates. So, in this way we are able to get a huge quantity of nitrates, which can in turn be used in the fertilizer industry.

Next, we will have a look at the carbon cycle.

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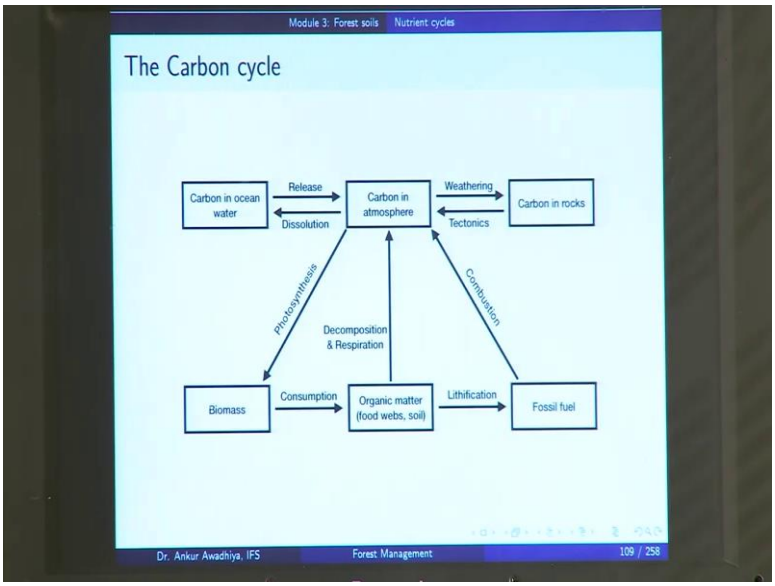

Now, carbon is having a number of reservoirs. So, you have carbon in the atmosphere, in the form of carbon dioxide. You have carbon in the ocean water, which is dissolved in the form of carbonic acid. You have carbon in rocks, primarily in the form of carbonates. And then, you also have carbon in the biomass of different organisms. You also have carbon in the form of fossil fuels, such as coal and petroleum. So, these, so there are different pools, including the biological pool, in which carbon resides on the planet earth, and all of these are interacting with each other.

So, how does this interaction happen? So, you have carbon in the atmosphere, and when there is rain then some amount of this carbon dioxide will get dissolved in the rainwater. And, when this rain water gets to the oceans, you have carbon that is there in the ocean water in the form of dissolved carbon dioxide or in the form of carbonic acid.

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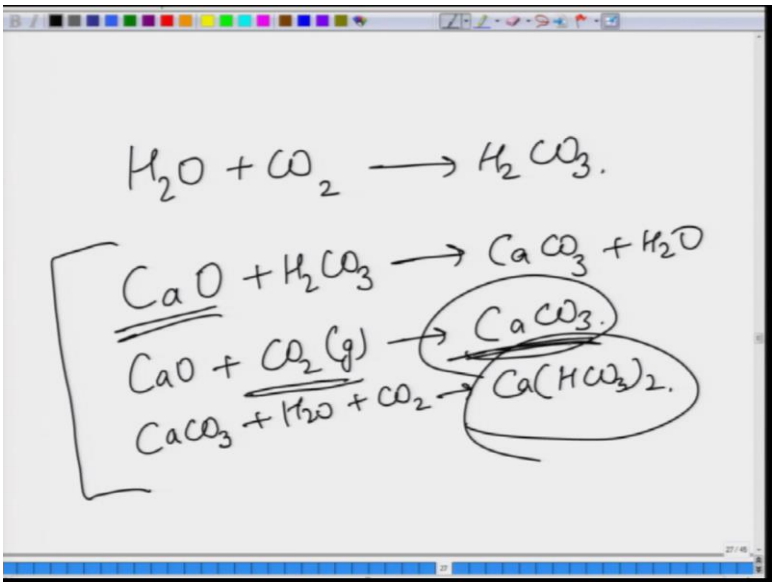

So, here we are talking about H2O that is water plus CO2 is leading to the formation of H2CO3, which is the carbonic acid. So, this carbonic acid is dissolved in the ocean water. But if there is certain increase in temperature, then the amount; then the ability of the seawater to retain this carbon dioxide decreases, and this carbon dioxide gets released back into the atmosphere. So, you have these processes of dissolution and release through which carbon is moving from atmosphere to the ocean waters, and back.

Now, similarly you have carbon in the atmosphere which is interacting with carbon in the rocks. So, you have carbon dioxide in atmosphere, and when there is weathering of rocks then it can enter into the rocks. Now, how does that happen? Suppose, you have a rock that has calcium oxide. This is reacting with H2CO 3 to give you CaCO3 plus H2O or we can also write it as CaO plus CO2. So, this CO2 is coming from the atmosphere, it is in the gaseous form and is it is forming CaCO3. Next, you have CaCO3 which is interacting with H2O and CO2 to give you CaHCO3 twice.

So, you are getting calcium carbonate, you are getting calcium bicarbonate. So, in this way, the carbon that was there in the form of carbon dioxide in the atmosphere, it is leading to the weathering, and in the this process of weathering, it is entering into the rocks. So, this entry into the rocks can be directly from the gaseous stage or through the presence of water. So, typically in a moist state, this weathering is much faster.

Now, weathering as we have seen before is the process in which a rock is getting broken up because of the action of different elements, because of say - physical weathering, in which case there was ah there was a a physical process that was leading through the breakup of rocks, such as increases and decrease in temperature, or say salt crystal growth, or there was frost growth, or there was action of ocean waves. So, that was physical weathering. But then, there is also the there is also the chemical weathering, in which case the rocks are reacting with different chemicals, and in that process, they are breaking now.

Now, what we are seeing here is that - you had a rock that had calcium oxide, and when it reacted with carbon dioxide, it formed calcium carbonate. So, there is a change in the volume, and because of this change in the volume there can be cracks that develop in this rock, which further lead to weathering of this rock. Now, similarly when you have this CaCO3, it further reacts and it forms calcium bicarbonate. Now, this calcium bicarbonate is soluble, now when it is soluble in water.

So, in that case, what will happen is that it will slowly and slowly, it will move out of these rocks. So, you have a rock in which there was a crack that developed because there was certain expansion, and then there was a dissolution; so, material is going away and so now, this crack is deepening even further. So, through the process of chemical weathering, you can have you can have a situation in which the carbon dioxide in the atmosphere is getting into the rocks. Now, this carbon in the rocks can get released back through the process of tectonics. Now, tectonics is the moment of plates that are there in the lithosphere.

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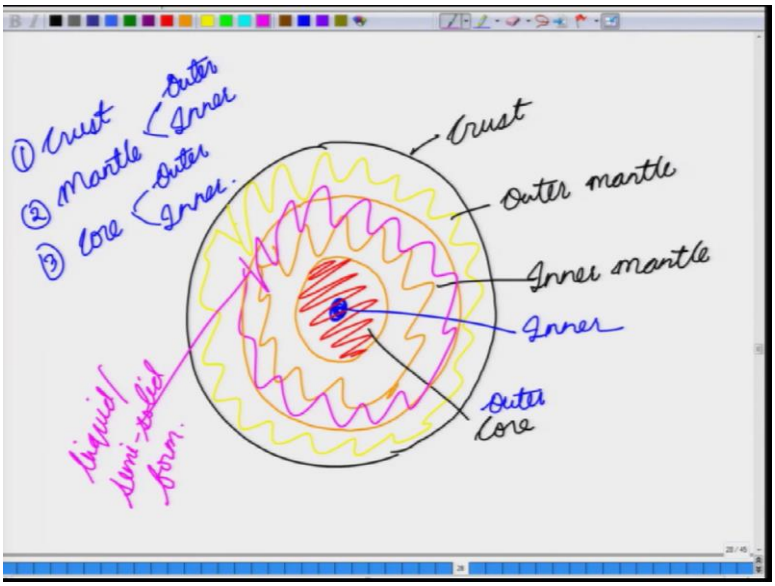

So, typically if we if you look at the structure of earth; so, earth has got 3 different layers.

So, in the earth, you have a crust which is the outermost layer, then you have the outer mantle, you have the inner mantle, and then you have the core. And, the core is sometimes also divided into an outer core and an inner core. So, essentially you have 3 layers one is crust, second is mantle, and third is core. Mantle is divided into outer and inner mantle. Core is divided into outer (and inner mantle) and inner core.

Now, what is happening here is that, in the case of mantle, you have; so, as you go down towards the center of the earth the temperature increases, the pressure increases. Now, the crust is the solid part of the earth, but in the mantle, you have a semi solid or a liquid like situation, in which the rocks, because of the high temperature, are in the form of a semi-solid or a liquid state.

And then, if you go towards the core. So, in the outer core you will be having a liquid form; mostly you will have an excess of iron. But, towards the extreme center of the earth this core will be in a solid part, because of very high pressures. But, the point to keep in mind here is that the middle portion is in a liquid or semi-solid form.

Now, if you have a liquid below the surface or the solid surface that is there on the top, it can move. And, when there is this movement this is known as a plate movement or a tectonic moment. So, in certain situations, you can have a case that you have this.

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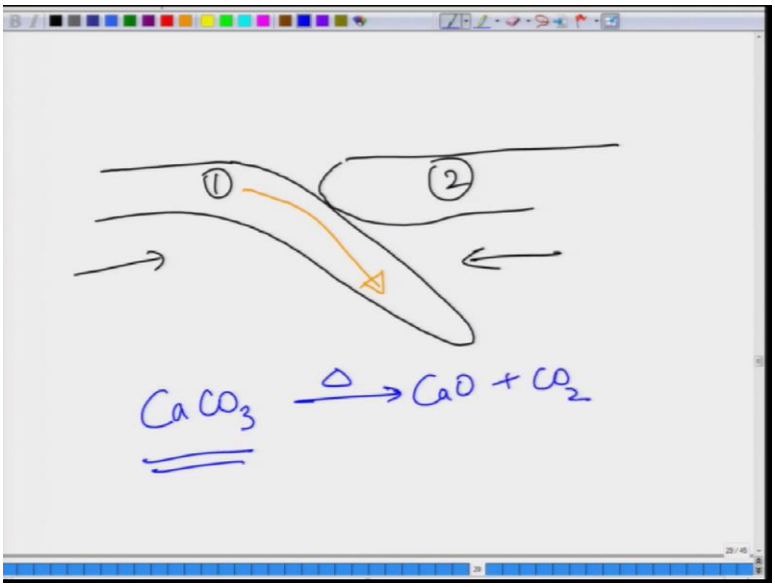

You have this plate, so you have plate 1, you have plate 2, and these plates are moving towards each other. So, in this case, the plate 1 is has bulged towards the center and is now going down. Now, when it is going down it is going into an area that has a greater amount of temperature and pressure. Then, it was having when it was there on the surface. So, you are heating the materials that are there in the crust.

Now, this crust is having rocks, and some of these rocks are also having the calcium carbonate. So, what is happening, in this case, is that you are having calcium carbonate, and you are heating it up because the because of these plate moments one plate is one plate is going down, when it is going down the rocks are also going down into an into a region with high temperatures, and so, you are heating up this calcium carbonate, and this will give you calcium oxide plus CO2, and this CO2 in turn will be released back into the atmosphere.

And we typically see these situations, say in the case of volcanic eruptions. So, in the case of volcanic eruption, you are having the situation in which rocks are very are very much heated up, and you are seeing that carbon dioxide is coming out. So, this is a process in which through these tectonic forces, you can have a situation where the carbon

in the rocks it is released back into the atmosphere. So, these are 3 big pools of carbon. Now, the carbon in the atmosphere can also be taken up by the plants through the process of photosynthesis.

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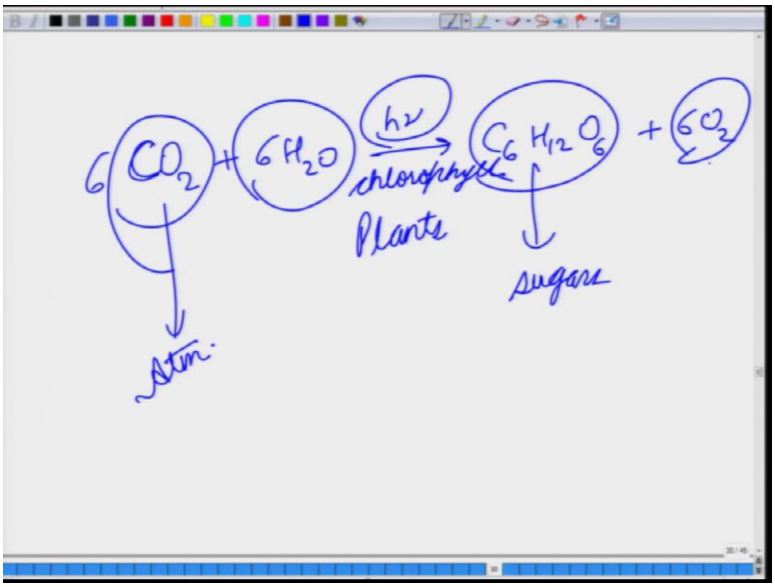

Now, as we saw before in the process of photosynthesis, you have. Now, in the process of photosynthesis, this carbon dioxide which was there in the atmosphere is being taken up by the plants, and they are using light in the process. They are also using water in the process, and this carbon is getting figured in the form of sugars with the release of oxygen. Now, in the process of photosynthesis, the carbon that was present in the atmosphere in the form of carbon dioxide, it has now been converted into biomass in the form of carbohydrates. So, you are now seeing that the carbon is moving from atmosphere to the biomass.

Now, once it has entered into the biomass; it has entered into the biosphere, and now, these plants can be eaten up by animals. They can be eaten up by the herbivores which in turn will be eaten up by the carnivores, and so on, as we saw in the generalized a nutrient cycle. So, once it has entered into the biomass, it gets eaten up through consumption, and it has release into the organic matter. Now, this organic matter or ah may in turn get decomposed through the through decomposers, and the carbon will be released back into the atmosphere.

Now, at the same time, all the living entities are also doing respiration. Now, in the process of respiration, what is happening is that these sugars are getting burnt down, using oxygen in the air and carbon dioxide is released back. Now, respiration is something that is happening in plants and also in animals. The respiration is just the opposite of photosynthesis. So, in the process of respiration, this is what happens. [Slide 29:53]

So, the sugars are burnt in the presence of oxygen in the cells in the mitochondria of the cells, and carbon dioxide and water in turn are released back. Now, through the processes of decomposition, and through the processes of and through the process of respiration, the carbon that was there in the biomass is now getting released back into the carbon pool that is there in the atmosphere.

Now, there is also another process that could happen which is the process of lithification. Now, 'lithos' is 'rock,' 'lithification' is the process of 'rock formation.' Now, when you have this organic matter in the form of the bodies of plants and animals, there could be situation in which these bodies are moving into the into the water bodies, they get deposited in the water bodies in the form of sediments.

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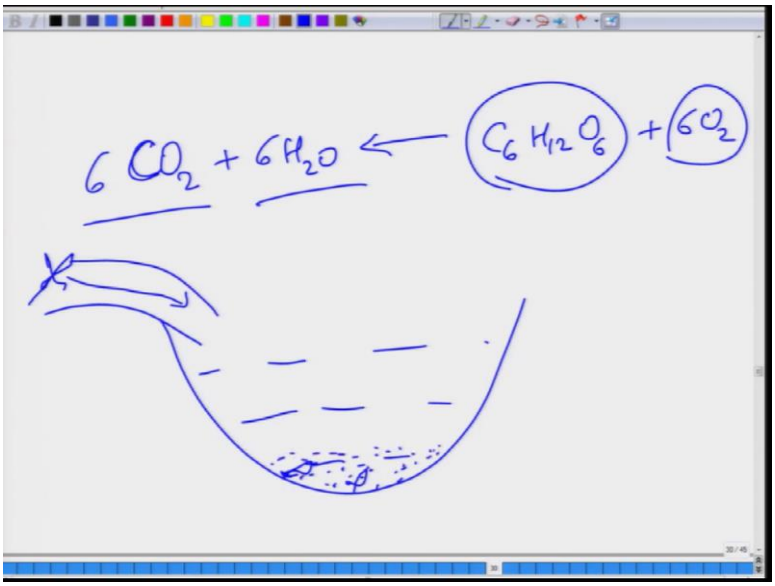

What is happening here is that you have this lake, and this lake is being drained by several streams, and so, if there are plants or parts of the plant, they are moving along with this stream, and then they get to the bottom of this lake. So, they are forming the

sediments on this lake. Now, these sediments, in turn, when these sediments are getting deposited again and again, then because of the because of the pressure that is happening there, so these are getting compressed.

Now, later on it is possible that because of the tectonic forces, all these sediments that were there in the compressed form, they are now getting inside the surface of the earth, where the temperatures are even higher; where the where the pressures are even higher. Now, in the in these circumstances, the organic matter get can get converted into coal or into petroleum. So, coal is the solid portion; petroleum is the liquid portion. Coal is typically formed out of the plant parts; petroleum is typically formed out of both plants and animals.

Now, in this process, what is happening is that the organic matter has been converted into a fossil fuel. Now, this fossil fuel, in turn, can be dug out, and when we use this fossil fuel in our industries and in our vehicles, then when we are burning these fossil fuels, we are we are releasing this carbon back into the atmosphere. So, what you are seeing, in the case of the carbon cycle, is that the carbon that is there in the atmosphere can go into the oceans, come back. It can go into the rocks; it can come back. It can go into the biosphere and come back through the biosphere, or can go into the biosphere get converted into fossil fuels, and then, in turn, it can it can come back into the atmosphere. So, all of these are cyclical processes and this is the carbon cycle.

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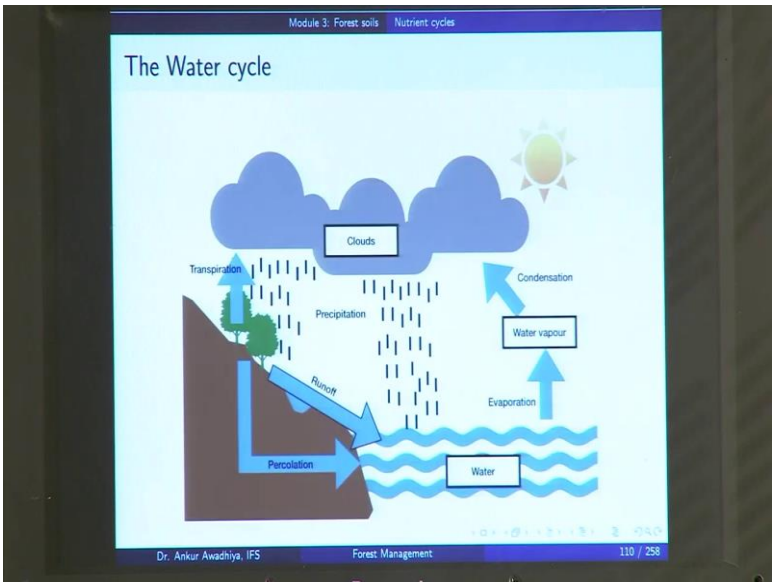

Similarly, we also have the water cycle. Now, in the case of the water cycle, you have water in the hydrosphere - mostly in the form of lakes, rivers and the oceans. And, you and because of the energy of the sun, there is evaporation that is happening, so this water is getting converted into water vapour. Now, once this water has entered into the air, in the form of water vapour, when it rises as you go up the temperature goes down and so, there is condensation happening, which leads to the formation of these clouds.

Now, once you have these clouds, you will you can also have rains and when there is rains this water comes back into the oceans and the hydrosphere. Or, on the other hand it these clouds can move along with the winds, and then they are doing they are giving rains on top of the land. Now, in which case, this water that is falling on the land it can directly move into the back into the oceans, through run-off or it can get absorbed, and then through the process of percolation, and movement it can go back into the oceans.

Now, in the land, you will and also in the water, you will be having a number of plants. But, in the case of land, this water that is getting absorbed by the soil, is also getting released back in into the atmosphere, in the form of water vapour, when the plants are doing transpiration.

Now, some of this water can also get used up in the process of photosynthesis, and then this water is also released back when there is respiration. So, all of this water, if you start at any point, if you start at see the oceans, the water is moving through the atmosphere back into the oceans, or it is moving through the lithosphere, back into the oceans, or it is moving through the biosphere, and then it is coming back to the atmosphere, then it is coming back to the oceans. So, all of these are cyclical processes and this is the water cycle.

Next, we have a look at the phosphorus cycle.

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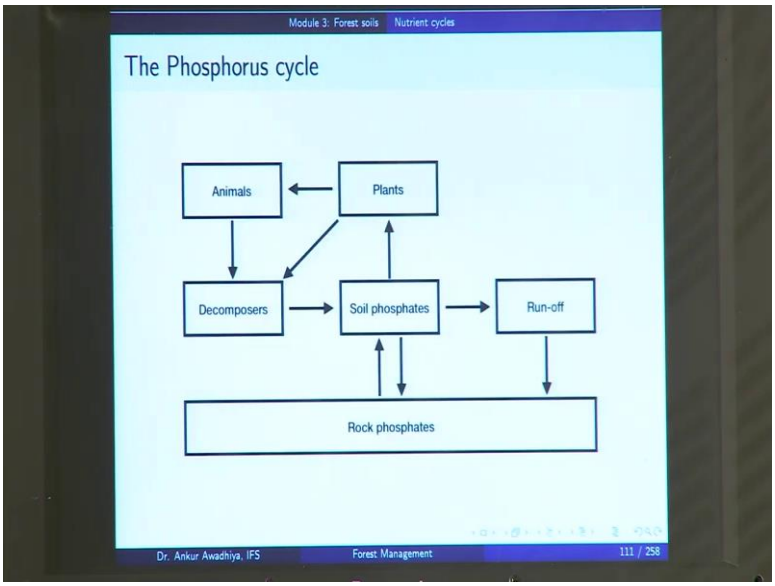

Now, in the case of phosphorus cycle, you have rock phosphates. So, you have phosphates the that that is present in the form of minerals in different rocks. Now, there is a one to one correspondence between rock phosphates and the soil phosphates. So, these rock phosphates can get released and come into the soil phosphates, or these soil phosphates can get deposited in the form of rock phosphates.

Now, once the phosphates have reached into the soil, they can be taken up by the plants, which in turn can be eaten by animals, and through decomposers, it comes back to the soil phosphates. Or, these plants when they die, they can they can directly get decomposed and they come back into the soil phosphates.

Now, the soil phosphates, in turn, can be removed through the process of run-off. So, there can be water erosion in an area, or there can be weathering, and with the weathering, the water is also leaking away the phosphates, and so, this these phosphates are getting a run-off. And then, they reach into the oceans or to other water bodies, where they get precipitated and then later on, they form the rocks.

So, these phosphates, the rock phosphates are moving through the soil phosphates, through the plants and decomposers, back into the soil phosphates and getting back here. Or, they are moving like this, coming through the run-off; coming back here or they are moving into the soil phosphates in back, or they are moving like this through animals back, or they are moving through animals through the runoff back into the soil

phosphates. So, all of these are cyclical processes through which phosphorus is moving between the lithosphere, the hydrosphere and the biosphere.

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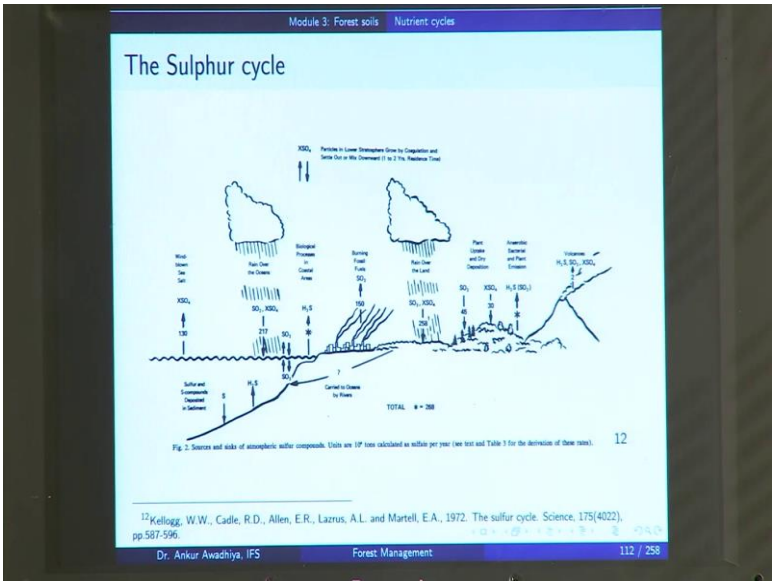

Now, similarly we also have the sulfur cycle. Now, sulfur, now in this case, what we are seeing is that sulfur is present in the air, sulfur is present in water, sulfur is present in land and sulfur is also present in the biota. And, there are a number of processes through which this sulfur is moving from one place to another place.

So, for instance, if there is sulfur in the rocks and when there is a volcanic eruption, this is getting converted into hydrogen sulfide, sulfur dioxide, and different sulfates, and is getting released into the atmosphere. If there is and then the, these sulfates, in turn, are getting precipitated in the form of particles. And, when there is rainfall, then these are coming back into the soil, or when there is rainfall over the ocean, then these are coming into the oceans.

Now, in the oceans, this sulfur can get deposited in the form of nodules or in the form of different salts. Now, at the bottom of this of the sea floor, if there is any decomposition, this sulfur can then be released back in the form of hydrogen sulfide, which will in turn come back into the air. Or, you can have a situation where the sulfur in the water is moving because of the action of wind and the waves, and it is getting in into the air in the form of particles.

At the same time, this sulfur when it is raining on the land or in the water, this can be taken up by the plants and these plants will, in turn, fix it in the biomass. And, then this sulfur will move through the animals, and then back through the decomposers into the soil, or when we are having say fossil fuels like coal. You are also having sulfur there and when these are getting burnt then sulfur dioxide, is getting released back. Or, for instance, when you are making certain chemicals - you are using sulfur as one of the reagents, and in that case also different salts or different compounds of sulfur, and get released back into the atmosphere.

So, here again, what we are seeing is that there is a there is a constant motion between the lithosphere, the hydrosphere, the atmosphere and the biosphere, and the sulfur is moving through all of these. So, there are different cyclical processes through which these different nutrients are moving from one compartment of the earth to another compartment. So, you have the biotic compartments that is comprised of the plants, the animals, these animals can be herbivores or carnivores. So, in which case, we call them primary consumers, or secondary, tertiary, or quaternary, and so on consumers, or there are plants which are the producers.

So this, all these nutrients are moving through these biotic components of plants and animals. These are also moving through the abiotic compartments, which is the lithosphere or the solid part of the earth, the atmosphere or the air, and the hydrosphere. And, there is a constant movement of all these nutrients through all of these. So, because of these different processes, the amount of nutrients are always made available to the plants.

So, let us for a moment, consider what will happen if one of these processes or these cycles gets broken.

So, for instance, you have a nutrient that is present in the soil. The plants take up this nutrient. They make it available to the animals, and through decomposition, these nutrients are getting released back into the soil. But then, we are also having the rainfall that is happening in this area. So, the rains are also taking these nutrients away from the soil through the process of through the processes of erosion and weathering. So, these nutrients are getting dissolved in the water, and then they are reaching the seas and the oceans.

Now, once you have your nutrients away from the soil, if you did not have the processes of say tectonic movements, if those nutrients could not again back be converted into rocks and then into the soil, and brought back again, then the life would stop because all these nutrients, but after a while move away from the soil and into the water.

So, it is important to understand these different cycles, because they give us an understanding of what are the sources from which we are getting nutrients. And, if one of one or more of these sources are not happening, are not providing nutrients to at a at a sufficient rate, then probably we will have to go to some other location, where these nutrients are found and bring those nutrients back, and provide them to the plants. So, that is all for today.

Thank you for your attention [FL].