Soil Science and Technology
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Lecture – 41
Land Degradation and Soil Erosion

Welcome friends to this week 9 lectures of Soil Science and Technology and in this lecture, we will be covering some important aspects like what is soil degradation and what are what is soil erosion; what are the different processes of soil erosion; what is universal soil loss equation and then, we will be discussing about different types of wind erosions as well as tillage erosions. And finally, we will be starting the organic all organic pollutants which are present in the soil.

So, in the first the topic which we will be covering in this lecture is basically Soil Erosion and Land Degradation and in the next topic, the next topic which we will be discussing is basically the universal soil loss equation and after that we will be discussing in details about conservation tillage and then, then the next topic will be wind erosion as well as tillage erosion. And finally, in, you know, in week 9 of lectures, we will be covering the, you know, organic pollutants.

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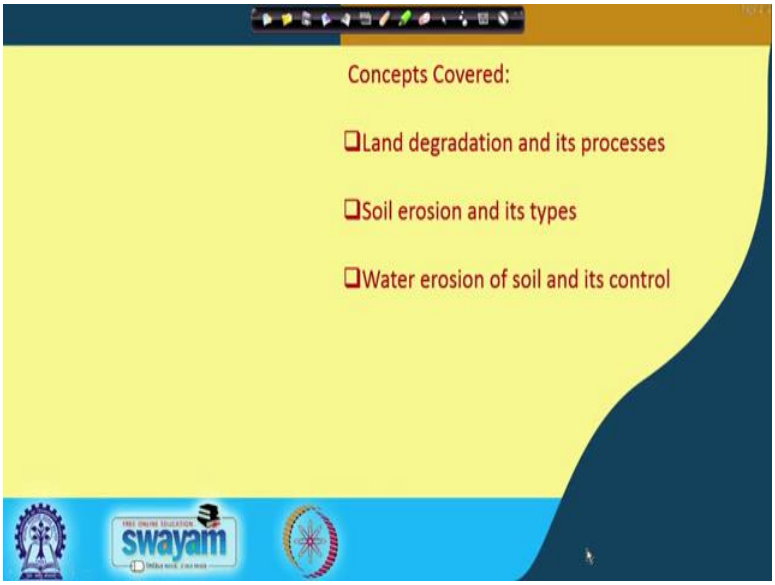

So, let us start with the Soil erosion and land degradation. The basic concepts which we will be covering in this topic is Land degradation and its processes and then, Soil erosion and its different types and then Water erosion of soil and its control.

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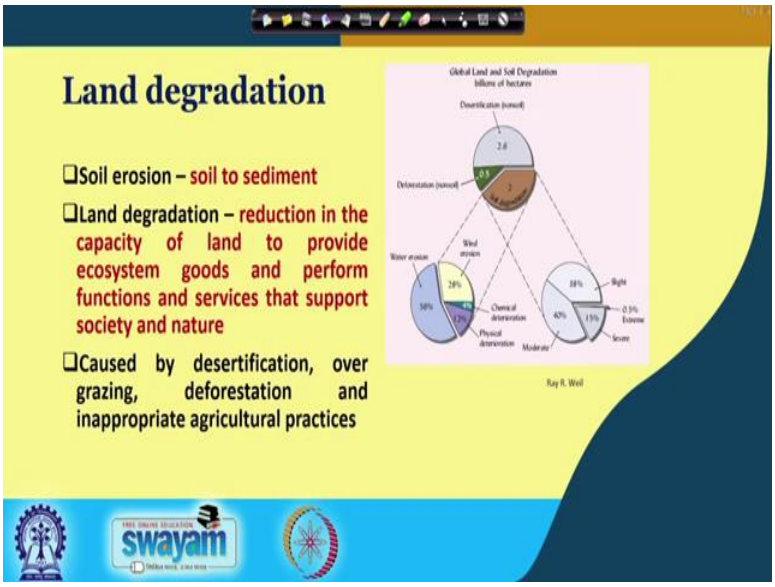

So, what is land degradation? Land degradation, I mean is basically somewhat similar to soil erosion which is basically conversion of soil to sediments. So, you know, land degradation is basically in other words, is the reduction in the capacity of the land to provide the ecosystem goods and, you know, perform functions and services that support society and nature. So, basically this land degradation is caused by desertification, over grazing, deforestation and inappropriate agricultural practices.

So, important are again the desertification is the, you know, conversion of lands to deserts and over grazing by the animals as well as deforestation; that means continuous removal of the forest area or the conversion of the forest area and inappropriate agricultural practices. So, if you see the global, global land and soil degradation; degradation trend in billions of hectares, you will see that the three major factors for global land and soil degradations are nonsoil desertification as well as nonsoil deforestation. And finally, the soil deforestation.

So, you know, the soil degradation can be also, you know, in the billion of hectares and a two billion of hectares land is undergoing soil degradation is affected by soil degradation and this soil degradation is again divided into different causes or causal factors. For

example, you will see that wind erosion accounts for 20 percent of the total soil erosion; chemical deterioration results in 4 percent of the total soil degradation. Physical deterioration accounts for 12 percent of the total soil degradation. Whereas, the water erosion is the major component of soil degradation which accounts for 56 percent of the total, you know, soil degradation.

You know, if you want to see what is the level or what is the scale of these land degradation or soil degradation, you will see that 38 percent of the soil degradation can be termed as slight degradation; whereas, 40 percent are basically moderate and 15 percent are severe and while 0.5 percent, we know, are extreme soil degradation. So obviously, the moderate soil degradation is major component among all these while the extreme soil degradation is only 0.5 percent.

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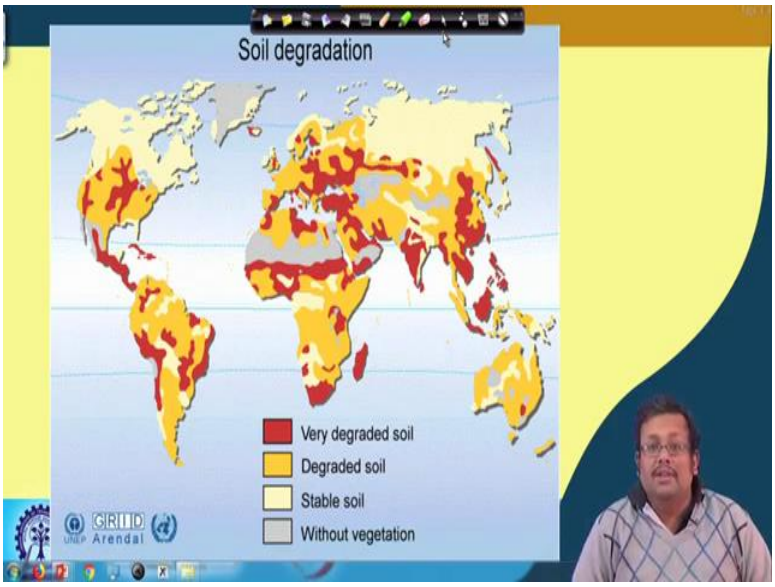

So, let us go ahead and see what are the other traits of soil degradation. So, this shows the basically, you know, world-wide scenario of soil degradation, you can see that the red patches basically shows the very degraded soil and the yellow patches are basically shows the degraded soil; whereas, the white patches are stable soil and the other parts or the this these areas are basically the soils without vegetation. So, basically these are representing different types of desert areas. So, you can see the worldwide scenario of these soil degradation.

Obviously, the very degraded soils are, you know, are ,you know, are distributed throughout the world and as far as the Indian condition is concerned, you know, all the majority of the soil comes under this very degraded soil; specifically, the western as well as, you know, the middle portion of Indian subcontinent. So, that shows the severity of this problem of soil degradation.

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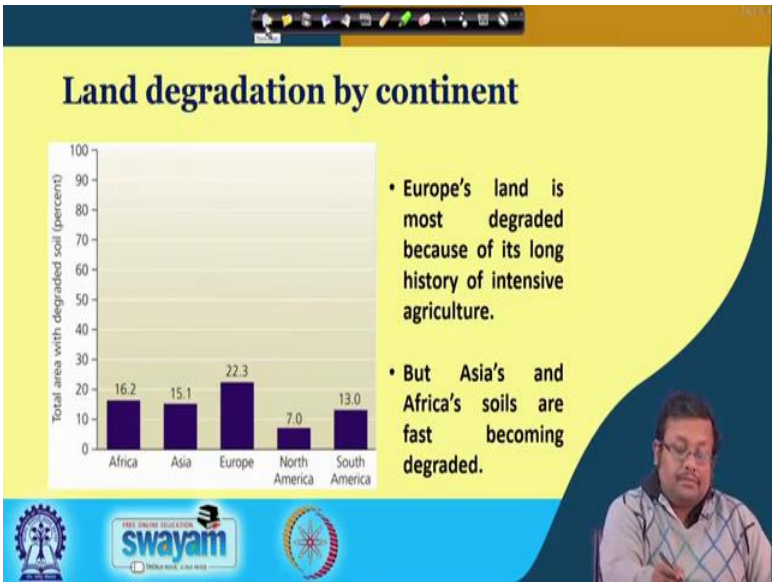

So, let us go ahead and see what is the land degradation by different continents? So, you can see that Europe land is most degraded because it is long history of intensive agriculture. However, Asia's and Africa's soils are fast becoming degraded. So, that shows the importance of controlling the soil degradation specifically in Indian subcontinent.

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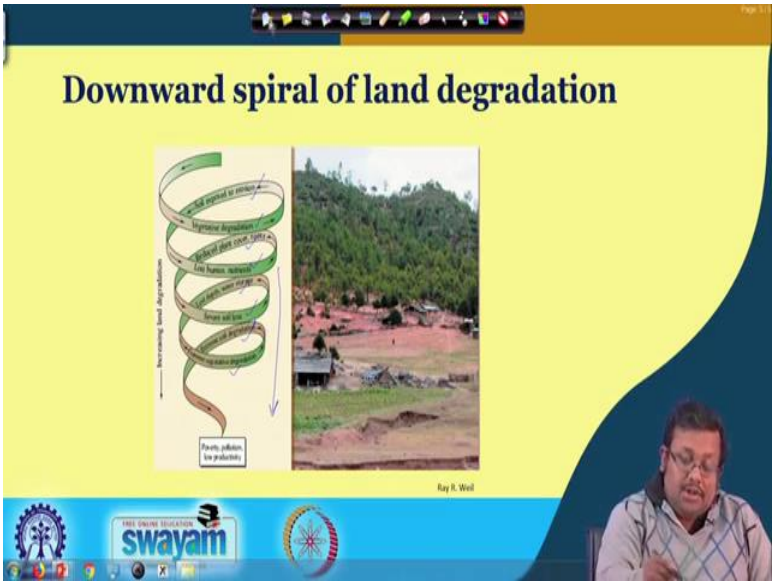

So, if we go ahead and see what is the downward spiral of land degradation; it basically shows different cause and effects of, you know, sequential cause and effects of land degradation. As we can see here, it is a degraded land and where all the vegetation have been ultimately removed which causes different types of soil erosion. So, for example, in this is the downward spiral. So, it is basically goes downward which basically shows the increasing land degradation. And obviously, at the starting point, it starts with vegetative degradation that means, removal of the vegetation and which ultimately causes the soil exposed to erosion.

So, when the vegetation cover is removed, soil is much more, you know, exposed to erosion specifically, different types of water based erosion and I will talk about those things in the next in a couple of slides. And ultimately, when the soil is exposed to erosion that will that will create the losses of humus and nutrients because of runoff water and as a result of this loss of humus and nutrients, obviously there will be further reduced plant cover and roots because they cannot survive in those nutrient limiting conditions.

So, this reduced plant cover and roots ultimately creates the severe soil loss because there will be further evolve of vegetative cover from the ground and as a result of that there will be loss depth and water storage and, you know, and finally, it will be producing extreme vegetative degradation and extreme soil degradation. So, extreme soil

degradation is basically the final step and obviously, remember that it is all the processes are interrelated and it always starts with the vegetative degradation. So, that is why there is there a always, you know, the worldwide push for afforestation as well as, you know, covering as much as surface area of the soil, as much as soil surface with vegetative cover. So, that shows the importance of different vegetative cover.

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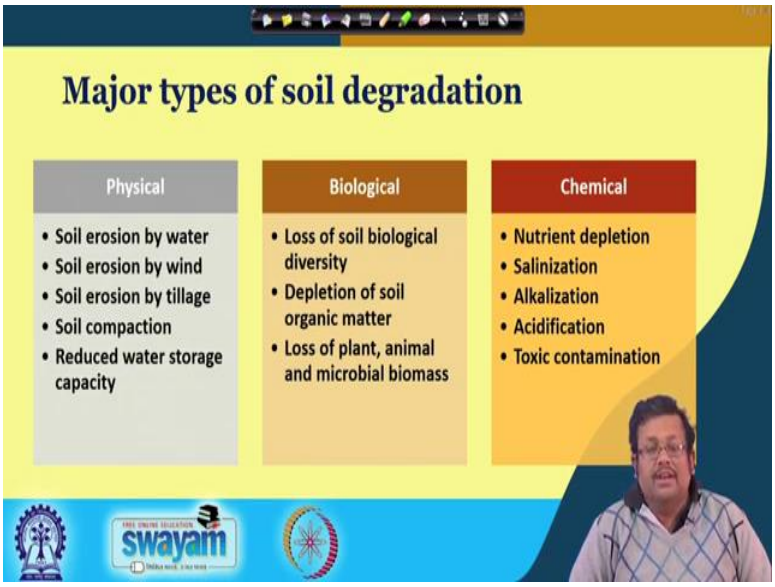

So, let us go ahead and see what are the different major types of soil degradation. We can divide the soil degradation into three types, major types; one is Physical; then, Chemical and Biological. And in the Physical obviously, soil erosion by water is the major component and soil erosion by wind and soil erosion by tillage, soil compaction and reduced water storage capacity; all these are physical forms of soil degradation.

And in term, you know, in the Biological soil degradation basically shows loss of soil biological diversity and the depletion of soil organic matter and loss of plant, animal, microbial biomass and in case of chemical degradation, it shows the nutrient depletions and then, salinization, alkalization, alkalization; then, acidification and finally, toxic contamination.

So, you can see all the physical, chemical and biological processes are responsible for soil degradation and depending on different types of agents of degradation, they are separated into different categories.

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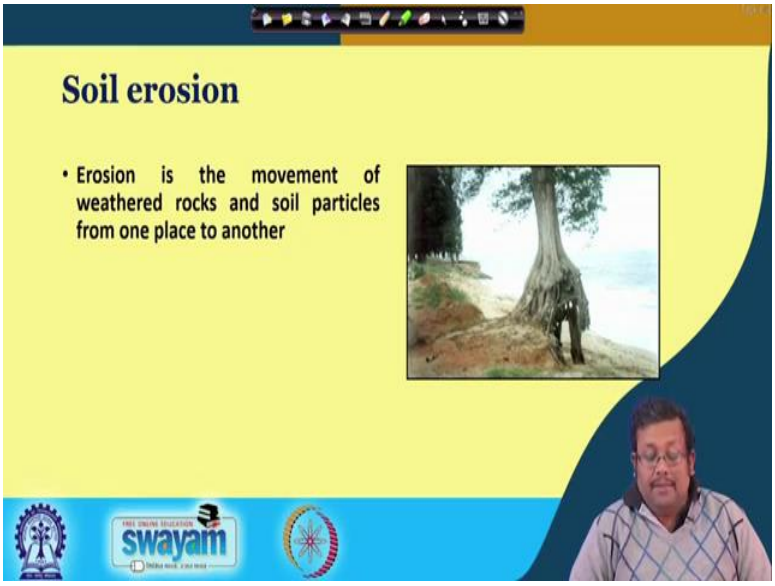

So, well the definition of soil erosion is the movement of weathered rock and soil particles from one place to another. You can see in this picture, the soil underneath the tree has been totally removed as a result of water erosion and this is a physical form of erosion where water, you know, is a major agent for creating the soil erosion.

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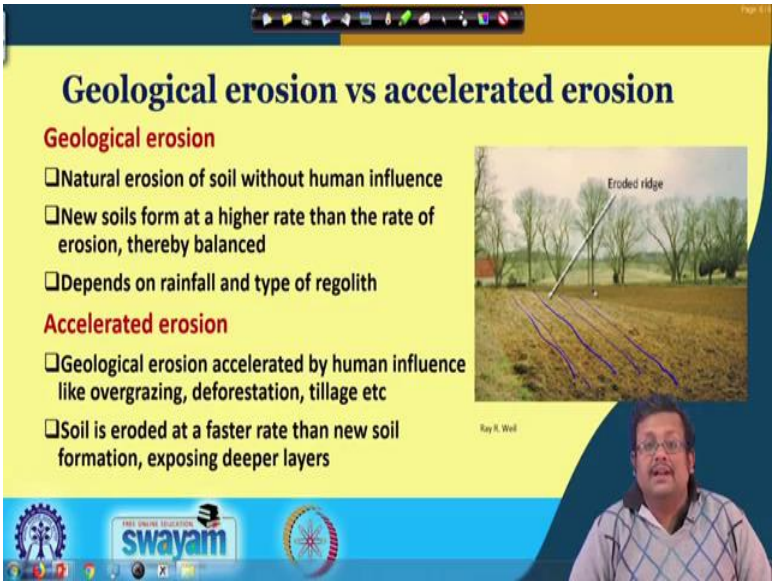

So, what there are two different terms. One is called Geologic erosion; another is accelerated erosion. Now, Geological erosion is basically natural erosion of soil without human influences and in this type of erosion, new soils form at a higher rate than the rate

of erosion. Thereby, there is a maintenance of a balance although all the time and finally, it depends on rainfall and type of regolith. You have already told about the regolith. Regolith is the parent material basically which is present at the bottom layer of soil profile and accelerated erosion, this is kind of human induced kind of erosion.

So, geologic erosion accelerated by human influences like overgrazing, deforestation, tillage etcetera are, you know, they are basically coming under this accelerated erosion and in this type of erosion, soil is eroded at a faster rate than new soil formation, thereby exposing deeper layers; so you can see here in this picture, obviously, this is the tillage mediated erosion or tillage based erosion; so you can see the; we have, you know, as a result of tillage different types of furrow and ridges are developed and in this ridges, soils are, you know, in this ridges, these soils are much more exposed to different types of wind as well as water erosion.

So, thereby, they move away through runoff water. So, this is one example of eroded ridge and, you know, which is an example of accelerated erosion.

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So, let us go ahead and see what are the different impacts of soil erosion. Obviously, there are some on site damages; what are the onsite damages? Like loss of topsoil and associated essential nutrients and organic matter and then, spread of diseases from higher to lower areas and uprooting of trees and seedlings and then, reduce infiltration increase

runoff and further erosion. And finally, overall soil productivity is greatly reduced. So, all these are, you know you know, the outcome of soil erosion.

Obviously, whether is a loss of topsoil, it will obviously, you know, it will obviously, you know, also remove the essential nutrients which is present in the soil as a result of CEC and also which is bound to the organic matter. And spread of disease from higher to lower areas due to the runoff movement of soil from, the movement of soil in runoff from one areas to another areas and then uprooting of the trees and seedlings.

Obviously, they will not anchor further in the soil because of soil has moved away from that place and they reduced to infiltration obviously, due to that, you know, movement of due to the loss of organic matter, there will be reduced infiltration and there will be this increased runoff and further erosion and overall as a result overall soil productivity will be greatly reduced.

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So, what are the different offsite damages? You know, offsite damages are sediments which basically moves from one area to another area and ultimately causes turbidity, eutrophication and raises levels of river causing the flooding. You can see here with the movement of this is basically shows the movement of sediments in the water body and obviously, another effect is windblown particles affects fruits and foliages, increases maintenance and cleaning cost and causes different types of health hazards.

So, windblown particles also very much important for different types of health hazards; especially, the particulate matter which has blown through different wind is causing nowadays greater, you know, grav-e soil, a grave human health hazards particularly in different cities across India.

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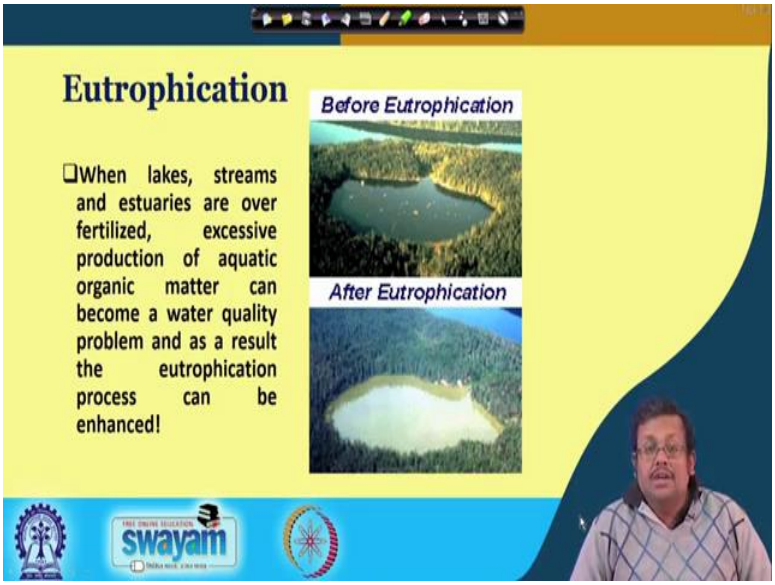

So, let us discuss what is Eutrophication. Obviously, eutrophication is basically a scenario when lake, streams and estuaries are over fertilized and excessive product which over fertilization because comes because of different types of, we know, enrichment; enrichment of different water bodies from the runoff which basically carries soil along with some nutrients. So, when these nutrients enters into the water body, they creates excessive production of aquatic, you know, organic matter and this aquatic organic matter can become a water quality problem because they used up all the dissolve oxygen which is present in the water and as a result the eutrophication process can be enhanced.

So, due to the use of all the dissolved oxygen which is present in the water, all the organisms which are aerobic organisms which are present in the water they become dead. So, this is called eutrophication. So, you can see in this picture; obviously, there are two scenarios. One is before eutrophication, you can see a clear water and after eutrophication, you can see algal bloom which occurs due to the high enrichment of nutrient in this water body and as a result of that all the aerobic organisms which are

present in this water get, you know, excrete. So, this is the eutrophication and this is an effect of offsite soil erosion.

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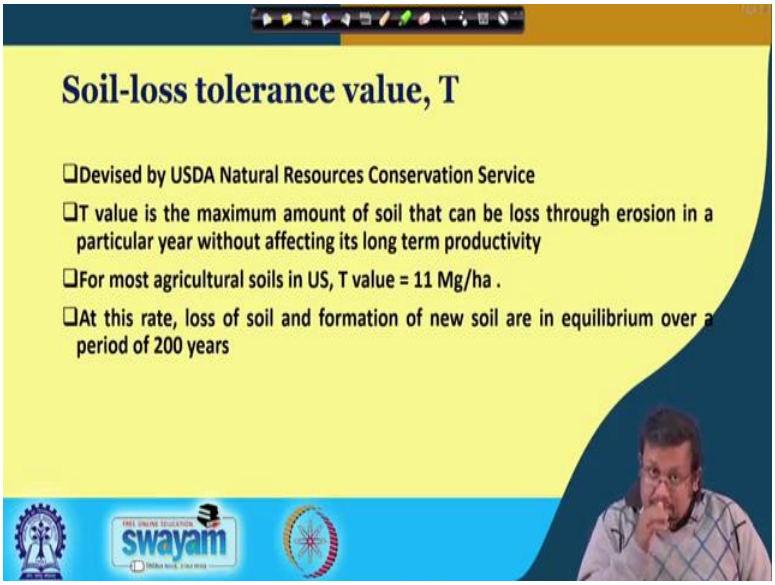

So, what is soil loss tolerance value or T. So, it is the soil loss tolerance value or T is basically devised by USDA or United State Department of Agriculture Natural Resource Conservation Service or NRCS. That the T value is the maximum amount of soil that can be lost through erosion in a particular year without affecting its long term productivity and for most of the agricultural soil in US, the T values is considered as 11 mega gram per hectare or 11 tons per hectare and at this rate loss of soil and formation of new soils are in equilibrium over a period of 200 years. So, this is an important concept that soil loss tolerance values.

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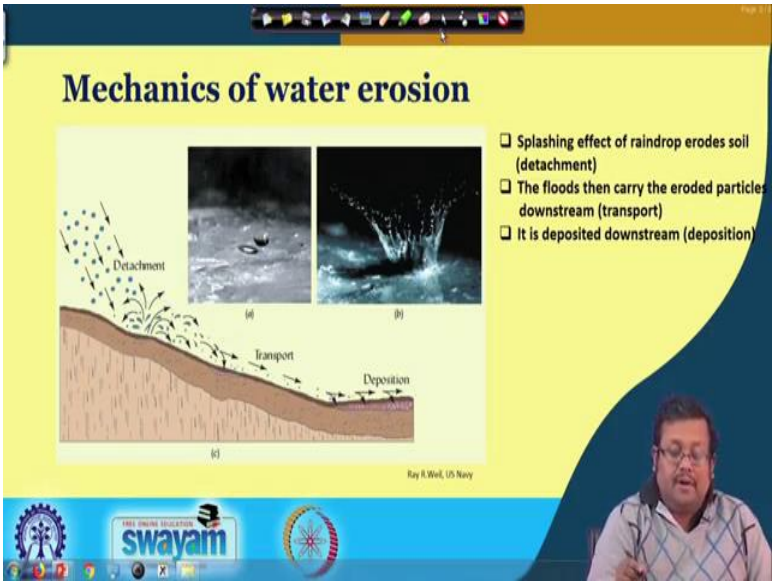

So, let us see what are the different mechanics of water erosion? Since, water erosion is a major causal factor of soil erosion. Let us see what are the mechanics of soil erosion. So, you can see here, there are three major processes of water based erosion, one is called detachment. Then, the second one is called transport and third one is deposition.

So, the first one is detachment which basically shows the splashing effect of rain drops which basically erodes the soil. So, you can see the flashing effect of rain drop. So, it is a falling rain drop and when rain drop falls over the surface, it causes the detachment. So, this is the first maybe, you know, process. The second process is the floods, then the floods, then carry the eroded particle downstream as you can see these eroded particles are detached particle, then carried downstream along with the floodwater and ultimately, it will deposit at the, you know, it will deposit downstream which is called the deposition process. So, basically mechanics of water erosion can be explained in terms of three these three different processes.

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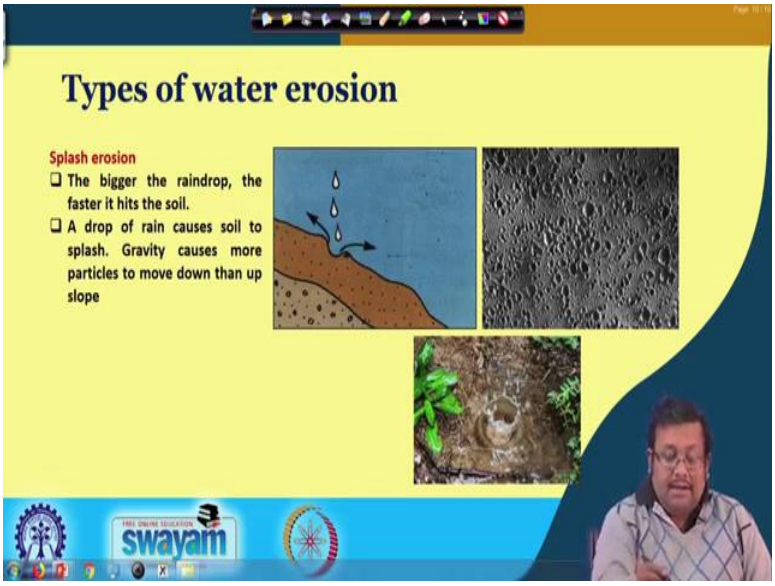

So, what are the different types of water erosion? The first important type of water addition is called Splash erosion and this splash erosion remember that the bigger the raindrop, the faster it hits the soil. So, you can see the raindrops are falling and ultimately, it is hitting the soil and ultimately there is further, you know, detachment of the soil particles.

So, finally, a drop of rain causes some soil to splash and gravity causes more particles to move down then upslope. So, as a result of this splash erosion, the bigger part, you know the you know, the soil basically splash away and ultimately, they, you know, all the bigger clods they break down and the individual soil particles move away with the floodwater from one place to another place; so this is the splash erosion.

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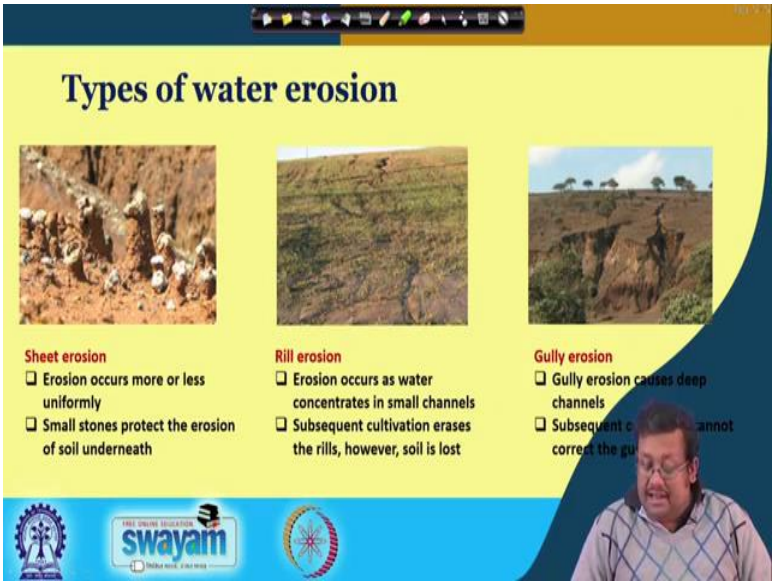

And let us see what are the other three types of erosion; the other one is a sheet erosion, where erosion occurs more or less uniformly and small stones protects the erosion of the soil and then, it as you can see here. Here basically this was sheet erosion a sheet of, you know, it will look like that a sheet of soil is move away due to the erosion and as a result of that those, small stones protect the erosion of the soil underneath and the another type of erosion is called rill erosion and this erosion occurs as water concentrates in small channels.

So, you can see these are the very small channels through which water concentrates and as a result erosion occurs in this channel and subsequent cultivation erases this rill. However, the soil is lost. So, you know, these rills can be, you know, these rills can be erased using the subsequent cultivation in this field. However, the soil will be permanently lost here and gully erosion basically is an extreme form of soil erosion and in this type of erosion, you know, gully, you know, it causes deep channels and subsequent cultivation cannot correct the gully.

So, this is very important and this is the difference between the rill erosion and gully erosion. Again, in case of gully erosion, there is a there a basically the formation of small channels and this gully erosion can be, you know, these rills can be erased using the subsequent cultivation; however, the soil is permanently lost. However, in case of gully

erosion, there is a deep channels and these, you know, cultivate, you know, subsequent cultivation cannot correct the gullies.

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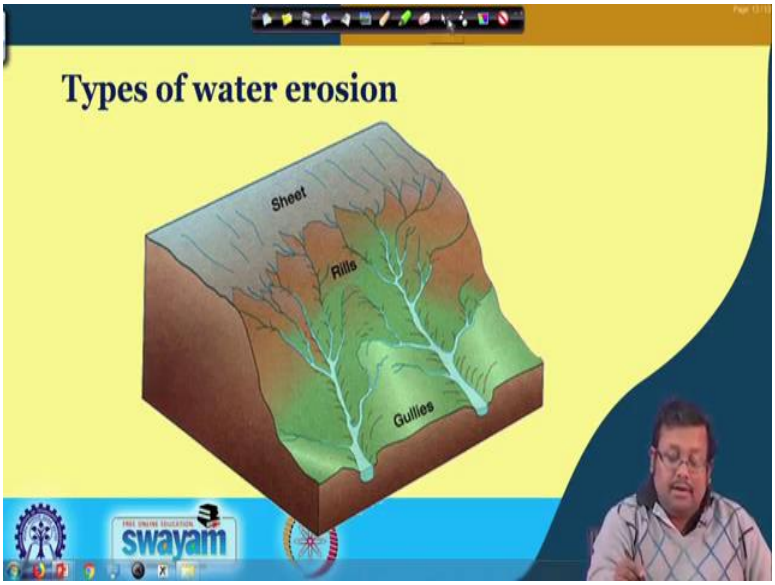

So, if you see what are the different slopes which are responsible for, you know, different soil erosion or in other words, which soil erosion occurs at what slopes. So, you can see at the top at the top there is obviously, sheet erosion followed by rill erosion and in the lower depths obviously, there will be formation of the gullies. So, it depends on the slope these, you know, this erosion also varies from or in other words these three different erosion like sheet, rills and gullies depends on the slope of the land. And these gullies erosion basically occurs in the downstream areas.

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So, how to control the gully erosion? Now, one of the way of controlling the gully erosion is the check dams. So, these check dams is basically a small sometime temporary dam constructed across swales, you know, drainage ditch or water ways to counteract erosion by reducing the water flow velocities. So, this is the general outline of a check dam. You can see there is a lower spillway at the centre and there is a splash apron just at the bottom of the check dam and these dam basically anchored into the gully walls.

So, you can see this is a properly constructed gully walls and these check dams are basically made to reduce the velocity of the water flow. So, that it causes low amount of or lesser amount of soil erosion. So, this is one of the most effective way of controlling these gully erosion.

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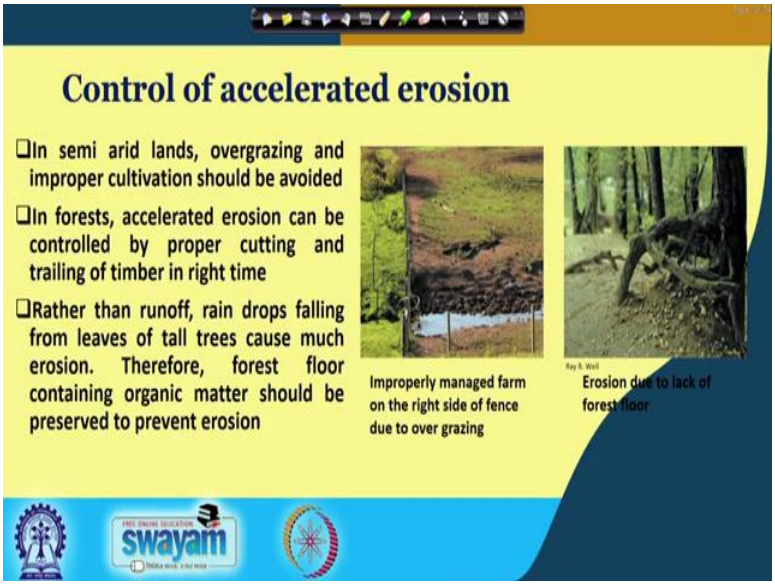

Another one is, you know, let us, you know, control of accelerated erosion. Now, in semi arid lands, over grazing and improper cultivation should be avoided; obviously, you can see improper managed farm on the right side of the fence due to overgrazing you can see. All the soils are mostly, you know, mostly all the soils are bare and as a result there is a high amount of high amount of soil erosion and in forest, accelerated erosion can be controlled by proper cutting and trailing of timber in right time and rather than runoff raindrops falling from leaves of trees because much erosion.

So, forest floor containing organic matter should preserve the should be preserved to prevent erosion. So, you can see erosion due to lack of forest road and that is it is very important to cover, you know, the forest floor, you know you know, the cover the forest floor should be, you know, you should contain more amount of organic matter to prevent the soil erosion.

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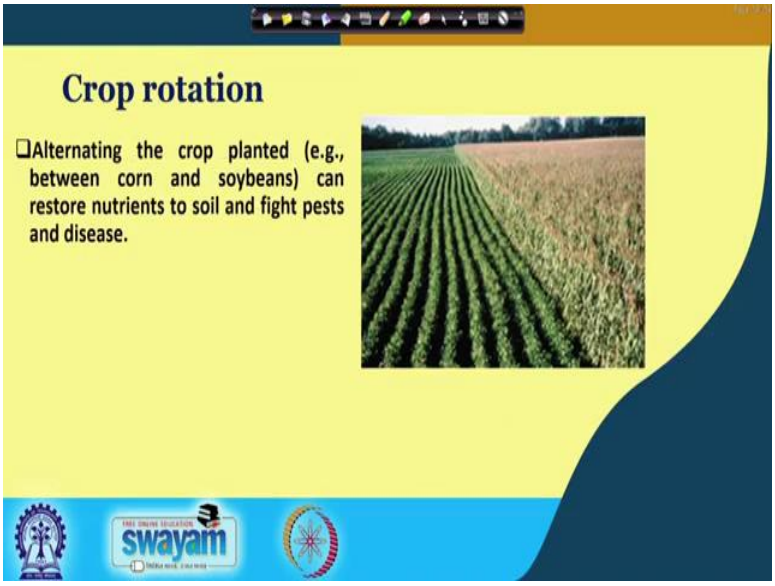

Now, crop rotation is very important way of controlling the erosion and it is basically alternating the crop planted. Basically here you can see it is a bit, you know, crop rotation, you know, between corn and soybean and it can restore the nutrients to soil and fight pests and disease. So, basically alternating the crop planted is an example of crop rotation.

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And contour farming, this is an example of contour farming is basically planting along the contour lines of slopes which basically helps reduce erosion on hillsides.

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Intercropping; Intercropping is basically mixing crops such as in strip cropping which basically you can provide nutrients and reducing erosion as you can see here, you know, mixing crops in the strips. They are growing different types of crops in different strips and ultimately, you know, it can help in reducing the soil erosion.

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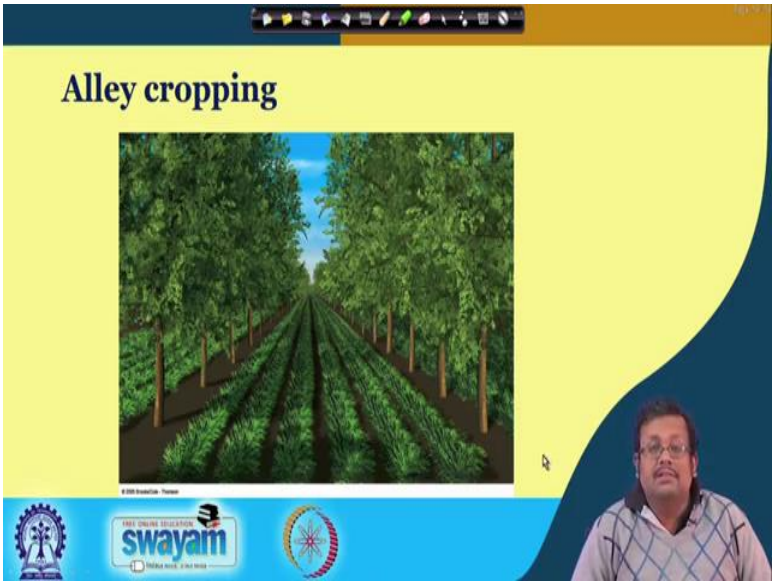

Alley cropping, you can see the growing the crops in alleys alternate alleys the big trees as well as the and the other crops in the alleys. So, this is an example of alley cropping and it helps in reducing the soil erosion.

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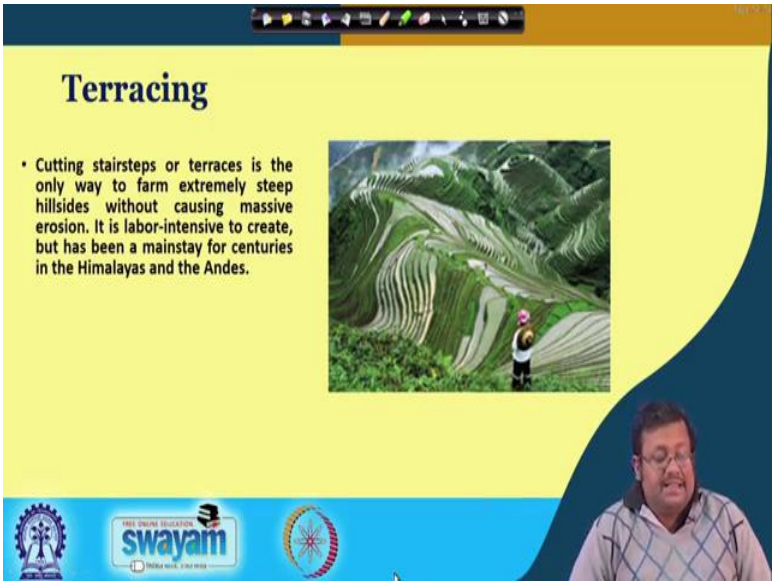

Terracing; Terracing is basically cutting the stair steps or terraces in the, you know, this is the, you know, across the hills. So, this is the only way to farm in extremely steep hills, you know, hills hillsides without causing massive erosion and it is very labour intensive remember to create, but it has been a mainstay for centuries in the Himalayas as well as Andes. So, if you visit the Himalayan regions, you will see extensively these terracing cultivation process; specifically, for rice cultivation and this is one of the major way of fighting against the soil erosion in this extremely hilly areas.

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And conservation tillage, we will be discussing in details about the conservation tillage. There are no tillage and reduced tillage farming which basically leaves old crops residues on the ground instead of ploughing it into the soil and this covers the soil keeping in place.

So, here you can see corns are growing up, these are the corn plants which are growing up of a cover crop. So, growing out of a cover crop; so this is an example of conservation tillage.

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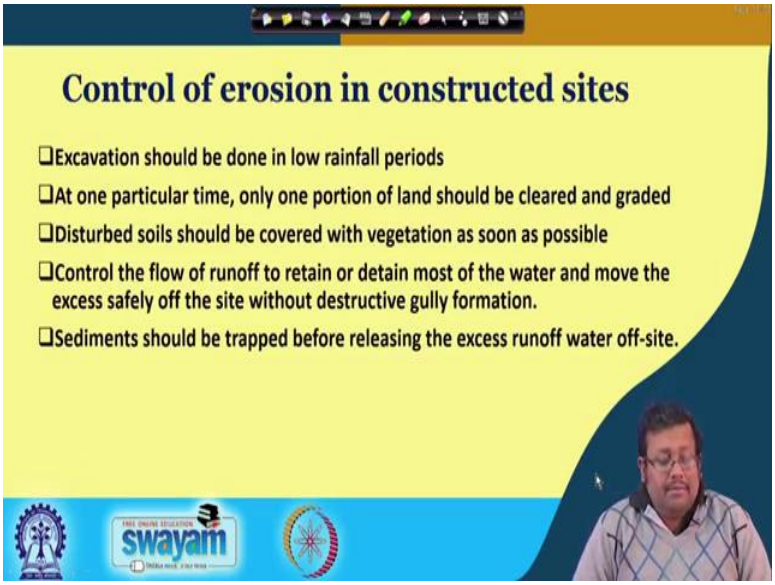

And let us see what are the control of erosion in constructed sites. And in the constructed site obviously, there is another, you know, huge amount of soil get lost. So, excavation should be done in low rainfall periods and then at one particular time only one portion of the land should be cleared and graded and you can see disturbed soil should be covered with vegetation as soon as possible. Finally, control; we have to control the flow of runoff to retain or detain most of the water and move the excess safely off the site without destructive gulley formation and finally, sediment should be trapped before releasing it into the excess runoff water outside.

So, guys let us wrap up here. We know, let us stop here and we will start from the next slide, in the next lecture and we will be trying to finish this soil degradation in the next lecture and we have learned several new things in this lecture. What are the different mechanics of water erosion and how, you know, what are the different types of water

erosion and what are the different ways of controlling this water erosion. And in the next lecture, we will be discussing about the discussing about the other aspects of soil erosion and then, we will be starting the universal soil loss equation.

Thank you and let us meet in the next lecture. Bye.