Wildlife Ecology
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Lecture - 33
Ecotoxicology and pollution management, Restoration Ecology

[FL]. We carry forward our discussions on applied ecology. And today we will have a look at Ecotoxicology, pollution management and Restoration Ecology.

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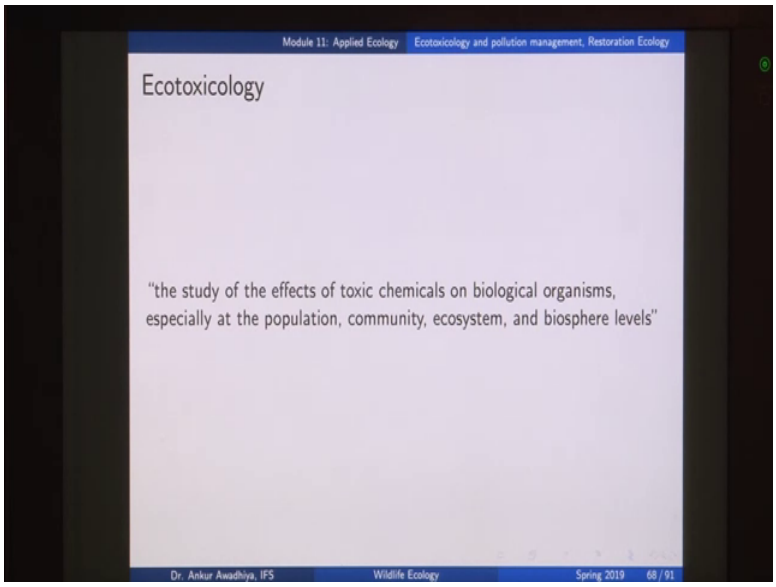

So, eco-toxicology is the study of the effects of toxic chemicals on biological organisms, especially at the population community ecosystem and biosphere levels. So, essentially we are talking about toxicology which is studying the impacts of different toxins or poisonous substances on the ecosystem, so which is why we call it eco-toxicology.

So, generally when we talk about only toxicology; it is concerned with how much amount of a toxic substances required for say a median level of death for of an organism or to kill all the organisms in a particular case; so these are what are studied in toxicology. In the case of eco-toxicology we make it a bit more broader; so we look at the impacts not just on individuals, but also on different populations community ecosystem and biosphere levels.

And at the same time when we talk about eco-toxicology we talk about not all the toxic chemicals, but especially those toxic chemicals that are present in the environmental conditions.

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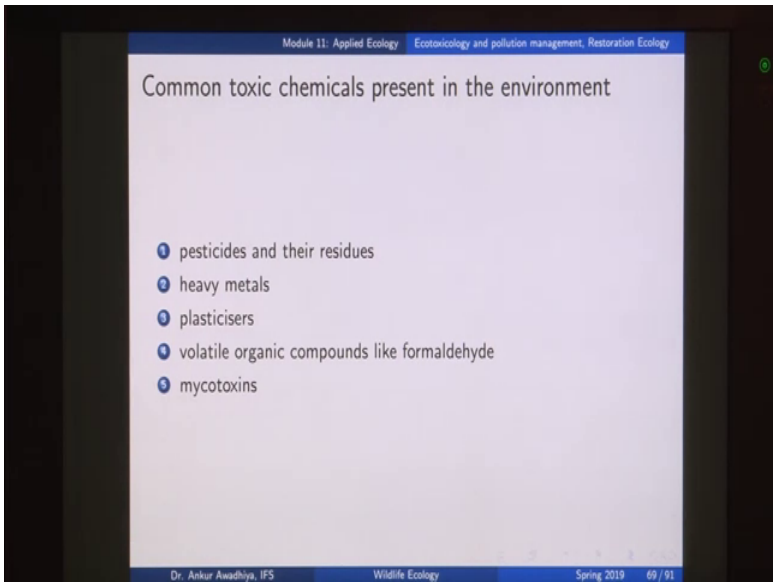

So, some common toxic elements that are present in the environment, they include pesticides and their residues; so for instance if we have DDT and after a while it will get degraded and will have DDE or DDD; so we will consider not just the original pesticides but also all their residues.

Then we have a look at the impact of the heavy metals that are released especially in the mining operations or the impacts of plasticizers. So, plasticizers as we have seen earlier are those chemicals that are added to different plastics to make them more elastic or to make them supple enough so that they can resist some amounts of disturbances, or we locate the impacts of volatile organic compounds, like formaldehyde.

Now, in this case we are looking at those organic compounds that are volatile. So, especially if say you go to a petrol pump and you get the smell of different organic compounds that are there as a part of the petroleum, now some of those might be harmful for health.

So, in this case they are those organic compounds that are volatile because of which they are getting into the air. And we can locate the impacts of those chemicals the toxicity of

those chemicals to the populations, communities, ecosystems or the biosphere levels, or we can locate the impacts of the naturally occurring toxic chemicals, such as micro toxins. Now, micro toxins are those toxic chemicals that are released by different species of fungi.

Now, these are naturally available in the environment, so for instance if you look at ground nuts. And in the rainy season you might have a growth of fungus in those ground nuts, and there could be some ground nuts that taste extremely better. Because there is the presence of a toxin that is known that is aflatoxin. Now, that is a mycotoxins and we also look at the impacts of different national toxins also on the environment.

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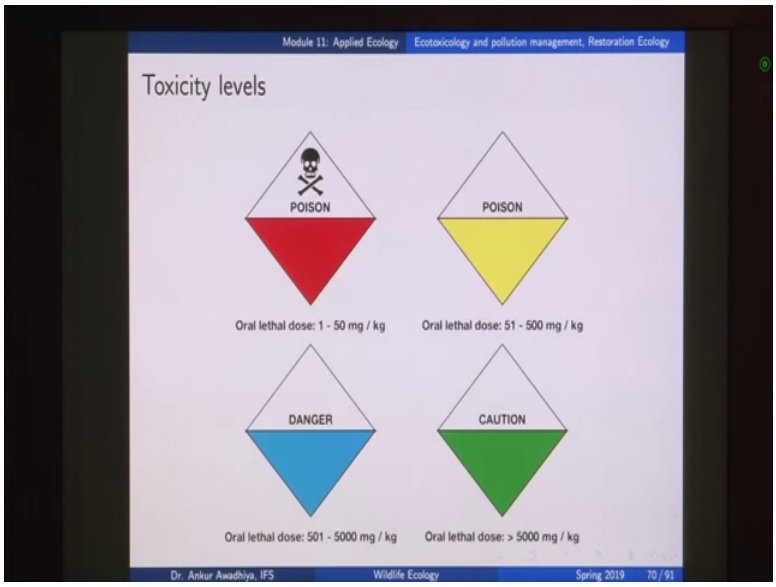

Now, based on the levels of toxicity, a toxin can be classified into these four categories, you could have some that are extremely poisonous. So, in that case the oral lethal dose is 1 to 50 milligrams per kg. Now, when we talk about toxicology or the amounts of toxic chemicals that are required to kill an organism, we generally refer to it as milligrams per kg body weight.

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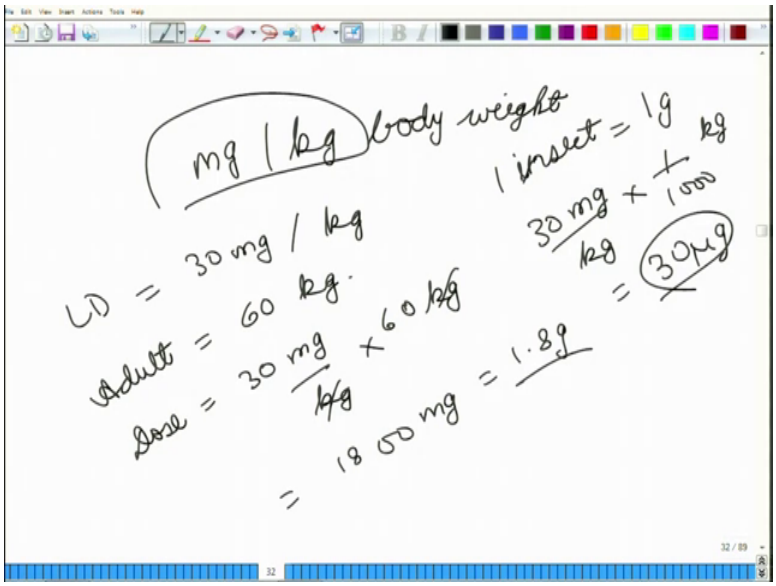

Now, if there is a chemical that is whose lethal dose is say 30 milligrams per kg body weight. And you have an adult individual who is say 60 kgs. So, in that case the lethal dose will be calculated as 30 milligrams per kg into the body weight which is the 60 kg in this case.

So, both of these cancel out and so you get 1800 milligrams or 1.8 grams of this toxic that is required to kill this particular individual. Now, if we look at the toxicity levels of these four different categories. In these extremely poisonous cases you have oral lethal dose that is very less just 1 to 50 milligrams per kg bodyweight is sufficient to kill an organism.

Now, for a number of chemicals when we are talking about say insecticides this dose is going to be very less, because the weights of this insects or the body mass of these insects is also very less. So, when we talk about these poisonous substances, when we are saying that you require say 30 milligrams per kg of body weight, see the weight of 1 insect is only say 1 gram.

So, in that case you will require 30 milligram per kg into 1 by 1000 kg. So, that will be only 30 micrograms of this particular insecticide or this particular toxin will be sufficient to kill 1 organism. So, now in the case of these poisonous substances, you can have a wide range of mortality.

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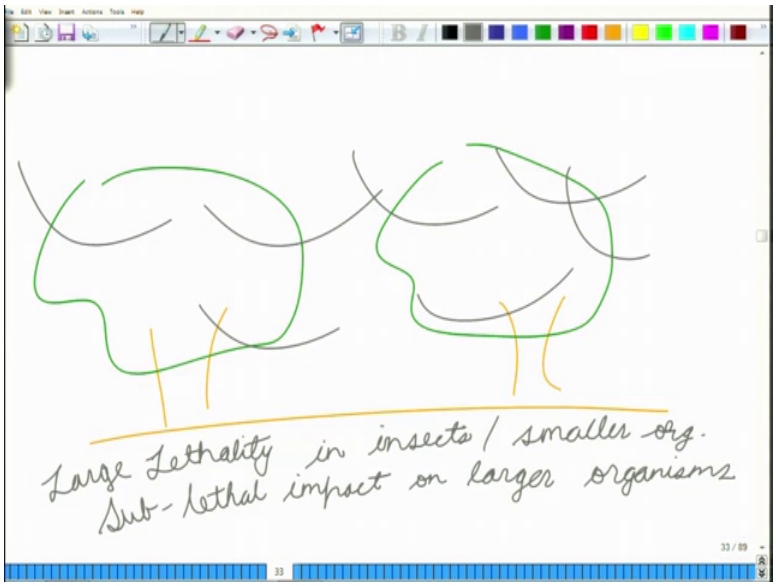

So, for instance; if you have an environment, let us just say talk about a forest region. Now, in this forest area suppose this particular toxin gets released. So, there will be a large amount of mortality in the insects, because in the case of the insects this very small amount of toxin will be sufficient to cross the lethal dosage. So, you will have a lot of lethality or a very large lethality in the insects or the smaller organisms.

But, in the case of the larger organisms or larger animals you will have a sub lethal impact on larger organisms. So, even if you are releasing the same chemical the impacts will differ or depending on what is the species, what is the size of the individual in that species. And also on what are the underlying predisposing factors that that particular individual is having.

So, for instance if you have those organisms that are already diseased in that case probably the amount of lethality will be much greater. Or for those organisms that are not living in burrows, but are living out in the open or are safe flying such as birds. So, birds will have a very great amount of lethality because they are completely exposed to these toxins.

Now, we can have this extremely poisonous once, we can have the moderately poisonous chemicals where the oral, lethal dose is between 51 and 500 milligrams per kg or we can have some dangerous chemicals where the lethal dose is even lesser it is between 500 and 1 milligram that is half a gram to 5 grams per kg or you can have some other

chemicals that have a less amount of toxicity. But still you need to maintain a caution because they still have can have lethality in doses that is greater than 5 grams per kg.

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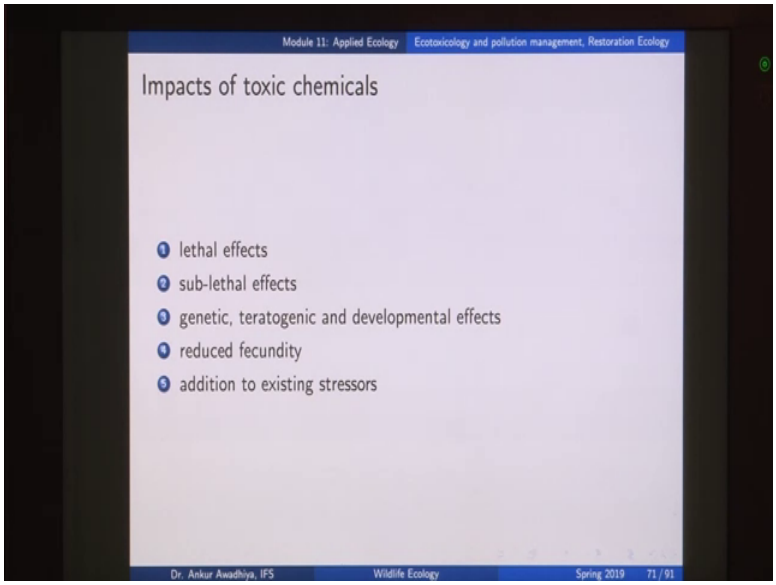

Now, when these chemicals are released into the environment or when they are present in the environment, they can have lethal effects in which the organism dies, they can have sub lethal effects in which the organism continues to live. But is having an impaired bodily function or they can have genetic impacts or they can have teratogenic impacts.

So, teratogenic impacts as we have seen before they are monster causing impact, so, they lead to fetal abnormalities. So, they lead to abnormalities in the unborn off springs or they can lead to developmental impacts to the born off springs and a good example in this case is the number of plasticizers.

So, as we have seen in the case of plastics there is this particular chemical that is known as Bisphenol A or BPA. Now, if you expose tadpoles to this particular chemical it leads to a change in their sex. So, that, that is a particular developmental defect that this chemical is causing, or otherwise it can lead to a reduced fecundity in several animals.

So, when you have a reduced fecundity it means that the animals are not able to produce enough number of off springs; the number of off springs per individual reduces. And so the population growth rate reduces which may further bring a population towards the

blink of extinction. Or you can have the impact of addition to the existing stressors which could be say diseases or parasites or a huge predatory pressure.

So, if you have these toxic chemicals they may add up to those impacts and then together with the other impact they may lead to large scale lethalities in different populations. Now, in a number of situations we have seen that with these toxic chemicals you also see the impacts of bio accumulation and also the impacts of bio magnification.

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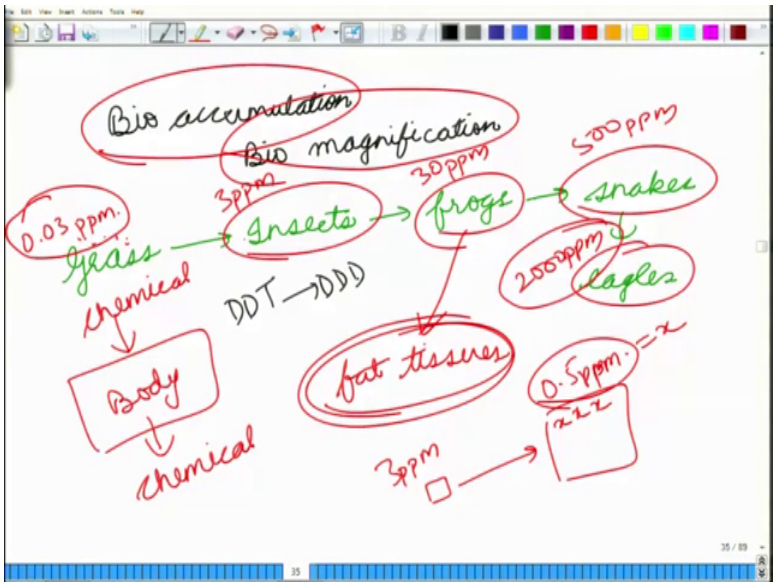

So, we saw this in the case of our energetics classes that if you have grass and on the grass you sprayed certain pesticides. So, grass is eaten by the insects, then these insects are eaten by some frogs, then these frogs are eaten by say some snakes, and then these snakes are say eaten up by eagles. Now, if there are certain chemicals which are there on the surface of the grass and the insects are eating those. So, there would be some amount of lethality in these insects, but then there will also be some insects that have been exposed to these chemicals but are not yet dead.

So, in those insects you will have some chemicals that are inside their bodies. Now, when these insects are eaten up by the frogs, the chemicals reach into the bodies of the frogs. And for certain chemicals especially those chemicals that can reside in the fat tissues of the body, so, if there is a chemical that is say water soluble.

So, in a number of instances that chemical will be removed from the body along with the urine. But, if there is certain chemical that is fat soluble that will go on accumulating in the body. So, you have this body of the organism there is a certain rate at which the chemical is entering into the body and there is a certain rate at which the chemical is getting removed or the chemical is getting destroyed. Now, if the rate of addition is greater than the rate of removal, we say that there is a bio accumulation in that particular organism.

Now when we talk about biomagnifications because as a frog is eating a number of insects; so suppose the insects get this particular 3 ppm of certain toxic chemical, because this toxic chemical was sprayed on the grass. So, it is there on the surface of the grass and the concentration in the grass is let us say 0.03 PPM. So, in that case because the insect is eating a large quantity of grass, so, it is getting much more amount of these chemicals into its body. And then if these chemicals are getting stored in the fat tissues and so there will be by accumulation of these.

Now, if they if you consider a frog a frog is eating a number of insects. So, probably if let us say this frog is eating say 1000 insects. So, the body size of the frog is larger. So, essentially these chemicals are getting diluted, if you consider the chemical in the body of one insect and let us say that it is 3 ppm on an average. Now if there is a frog of a larger size it is eating insect of this size, this was 3 ppm and when it gets into the body of the frog, it will become a reduced concentration.

Let us say it becomes say 0.5 PPM; because it is getting diluted up because the mass of the frog is much larger. But then because this chemical is getting accumulated in the body what is happening is that you have this chemical, let us say that this is in amount x. So, the frog eats one one insects it and it got x amount of this chemical. Then the frog ate another insect it got another x, it go it another insect it got another x.

Now, because it is eating a large number of insects; so the chemicals that were there in small quantities in all of these different insects they are getting more and more accumulated in the body of the frog. And in this case may be on an average or in totality the concentration will be much greater than what is there in the insects. Let us say that in the case of frogs it is suppose 30 ppm; in the case of insects it will be even more because the insects are eating frogs which already have a high concentration of these chemicals;

the frogs already are having 30 ppm of these chemicals. So, probably the concentration in the snakes will be much greater.

Let us say it is 500 PPM. When it reaches into the eagles because the eagles are eating a number of snakes and all the snakes that they are eating are already having the high concentration of these chemicals they are also having the high body mass. So, the total amount of these chemicals in the body of the snakes is also large. Now because the eagle is eating a number of snakes, so the concentration will be even higher. Let us say it will be something like 2000 PPM. So, what we are saying is that as you are moving up in the food chain, there is magnification of the concentration that is present in different organisms at different tropic levels.

Now, if that happens we will see that even though you have a very less concentration of this chemical in the environment; there will be such a high concentration in the case of the top predators that it will start showing up its negative impacts and one negative impact that has been studied in detail is the shell thickness in these eagles.

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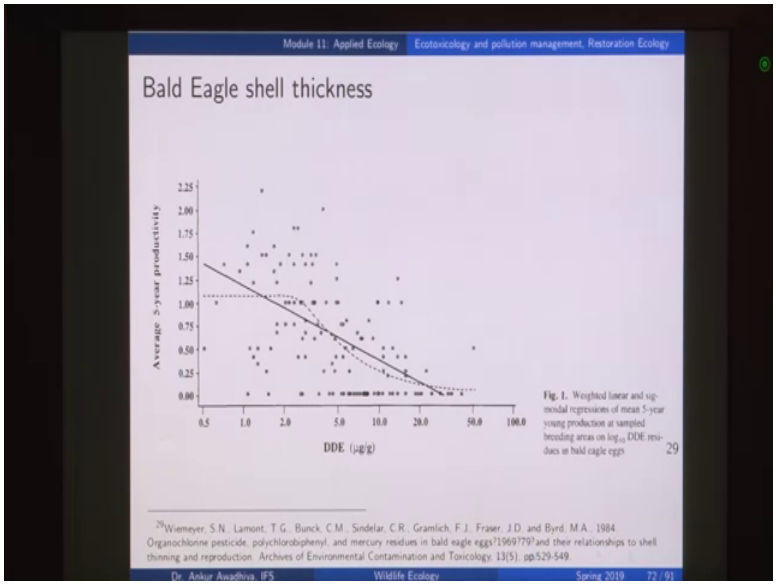

So, this was the Bald Eagle that was considered and it was seen that if you make a correlation between the amount of DDE that is there in the egg shells.

Now, DDE is the residue that comes out of the degradation of DDT. So, you had an insect infestation and to kill off the insects, you sprayed DDT. Now, after a while it is

lost one SCL and it became DDT or it is also known as DDE in certain literature. Now if you look at this DDE concentration and if you look at, the productivity of these bald eagles, we will see that the productivity is let us say 1 every year and after a while it will start decreasing as you increase the DDE concentration and then it will become very less it will become close to 0.

Now, what is happening in this case is that the birds are laying eggs, now because bald eagle is a bird so it is laying an egg. Now the egg is the outer layer of the egg is made up of calcium, it is made up of certain chemicals that are rich in calcium, which are giving it the sturdity.

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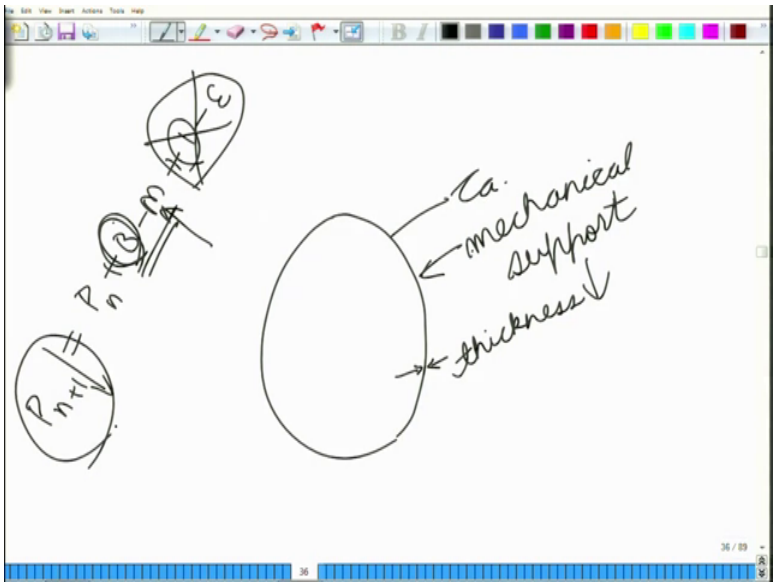

Now, the egg has to be kept at a certain temperature, so that the chick is able to develop inside.

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Now, to keep this egg at the fixed temperature what the birds do, is that they sit on these eggs. Now if you have a bird if you have this egg and you have a bird that is sitting on this egg. So, you have some amount of force that is being applied on this egg; now the egg is able to withstand that force because of this thick shell that it has. So, this shell acts as a mechanical support for these eggs.

Now, when you have a high amount of DDT or DDE in the body of the bird, it hampers with the calcium metabolism in the body. And what happens is that the shell thickness, this reduces. Now if you have an egg that has a very thin shell. So, in a number of situations the bird will not even be able to lay an egg, because it is not able to put a in enough amount of calcium in the eggs. Or in certain situations even if the egg has gone has been laid when the bird sits on it to maintain temperature the egg will break.

Now if you have eggs that are breaking, so we will have a situation in which in this population, there is a very less number of births that are happening because all the eggs are breaking off before the eggs; before the chicks have a chance to mature. So, as we had seen if you talk about a population it is equal to the number of individuals in the last generation plus births minus mortality plus immigration minus immigration.

Now, there are only two things that are adding to this population; we have the birth and you have the immigration. Now if you consider a bird that is found in the whole of the continent so in that case it is not found anywhere else. So, you are not having any

immigration or emigration in totality. So, essentially the only things that are regulating are the births and the mortality. Now even if you are not having mortality of the birds because of the DDT. But because it is hampering the number of births that these birds can give it will lead to a decline in the population.

Because in this case if the number of births is very close to 0, so for instance here we have average 5 year productivity, it becomes very close to 0. So, there are no births, but the number of deaths or the number of birds that are getting reduced in the population because of mortality that is remaining same. So, even in that case you will have a decrease in the total population of the birds and because of which we actually started seeing a decline in the population.

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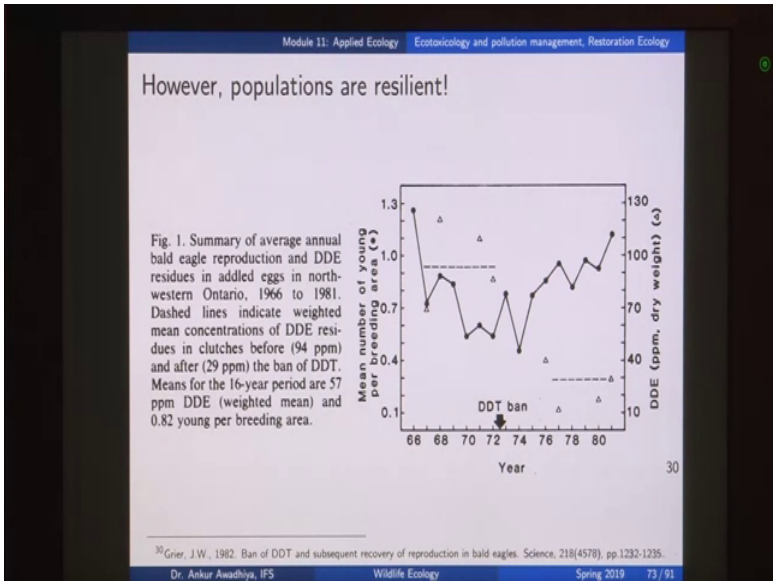

So, if we see here you have the mean number of young per breeding area and the mean number of young per breeding area was close to 1.3, and after a while it started going so low, that it became very close to 0.5. So, you have a very less number of births and the number of deaths, continue to remain as before. Now in the case of these birds it was figured out that the actual reason for this population crashes DDT.

Now, in the US they went for a ban on DDT in the 1972. And here we can see that after a short while, it again started increasing. So, it again these very close to 1.3. So, what we are seeing here is that a number of populations are quite resilient. Especially if the harm

that you have given to the particular population is not very high, now suppose this decline had continued for a very long period of time.

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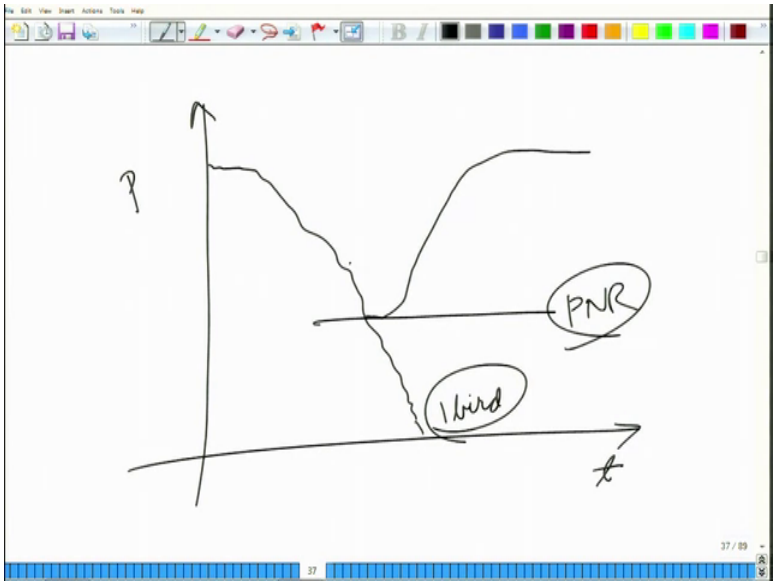

So, if we say that this is the population size and with time t because you have a very less number of birds. So, probably the population started going down.

And let us say you were only left with 1 bird. Now if you only have 1 bird left and there is no other bird for it to mate with; obviously, though this population is going to become extinct. So, you have to put a break on your toxic substances way before it has reached to that stage. So, if you were able to bring it back from this stage, it would again come back to the normal levels, but then there is this point of no return after which if you have given it much more amount of stresses as that have crossed the point of no return in that case the population might become extinct.

So, in this case we are seeing that the population was resilient and so even though you have a very less number of young spirit per breeding area in this area and then it after a while it started increasing again and then the population is stabilized. Now there are two things that you can do; to keep your population resilient or to bring it back to the normal.

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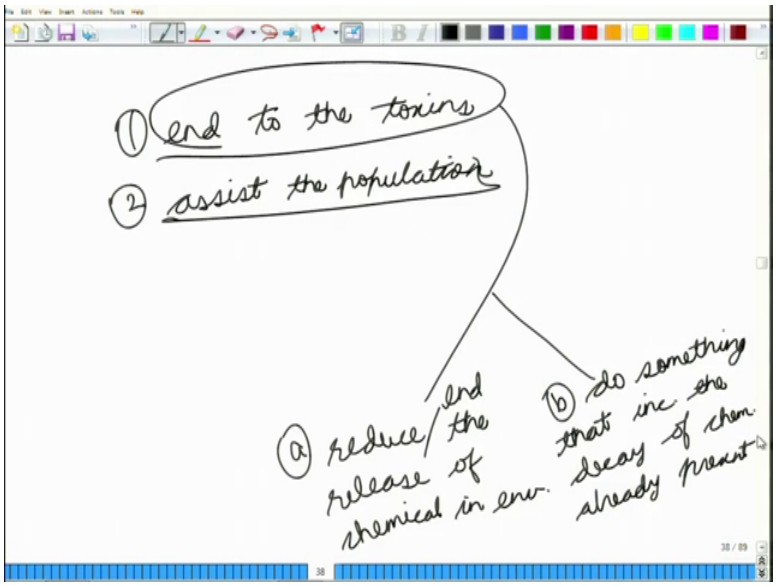

1 is that; you put an end to the toxins and 2 is that; you do something that is able to assist the population.

Now, if you are doing something to assist the population; you could probably take some birds out in an aviary, you could probably go for an ex situ conservation method. In which you keep some birds out and you are giving them certain amount of certain food materials that do not have any amount of d DDT in them. So, in that case you will be able to create an ex situ conservation facility in which these birds are able to breed and after a while you can release them. That is one way that we have seen before.

The other way; is that you need to put an end to these toxins. Now if you want to reduce the concentration of these toxins or if you want to end these toxins again there are two things that you need to do. The first thing is that, you reduce the release you reduce or you end the release of chemical in the environment, which is what we saw in this case there was a ban on DDT. So, this is one thing that is important. The second thing that you can do, to reduce the concentration of these chemicals in the environment is to do something, that increases the decay of chemicals, already present in the environment.

So, there are these two kinds of things that you can do. Now when we are doing such measures we are trying to restore the ecosystem back to the normal step. So, essentially a number of species are resilient.

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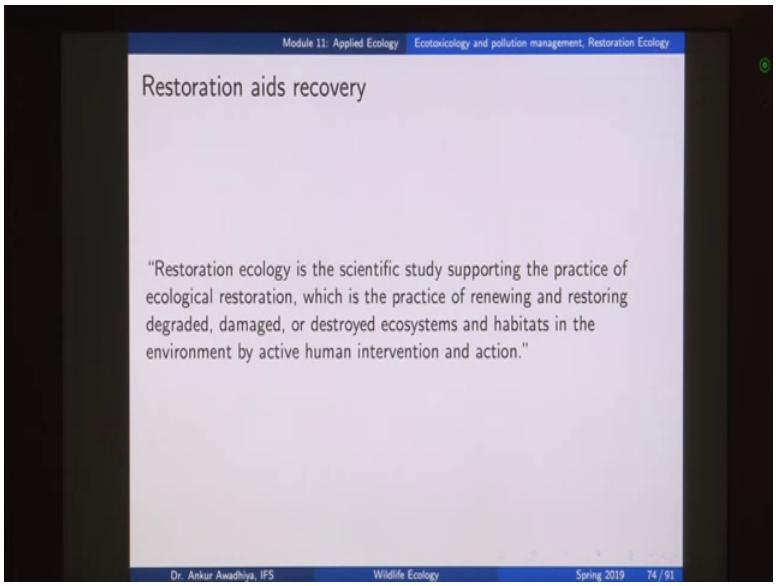

But if you want to recover a number of these populations and communities, if you are doing some restoration work that is going to aid the recovery. Now, restoration ecology is the scientific study supporting the practice of ecological restoration, which is the practice of renewing and restoring, you are renewing and you are restoring degraded, damaged, or destroyed ecosystems and habitats in the environment by active human intervention and action.

So, what we are doing here is that, you already have these ecosystems that are degraded, damaged, or destroyed and you are doing something to this ecosystem so that it is able to come back to the normal state and we will look at a number of such examples in a short while; what are these kinds of interventions.

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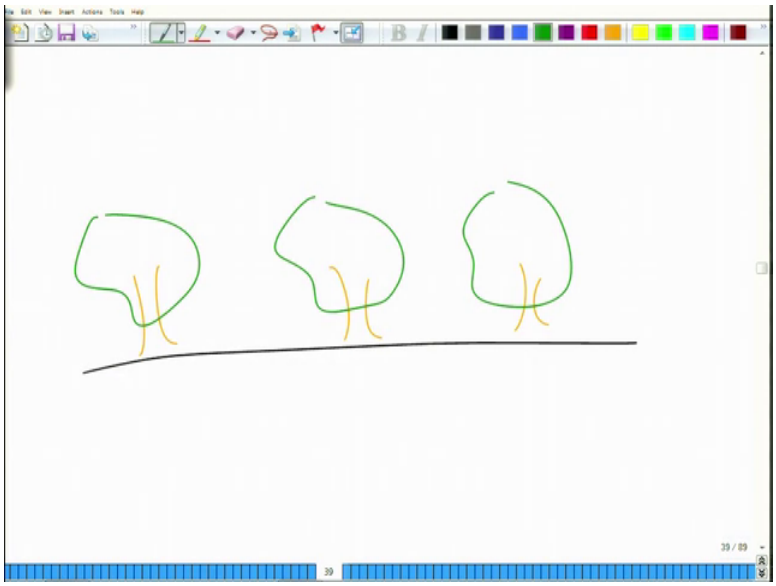

Now to give you a very small example; if there is a forest, so this forest is having a number of trees and then there was a mining activity. Now for mining you need to clear up all the trees, so you remove these trees. Then you perform the mining operation so in the mining operation you created a last sized hole in the earth.

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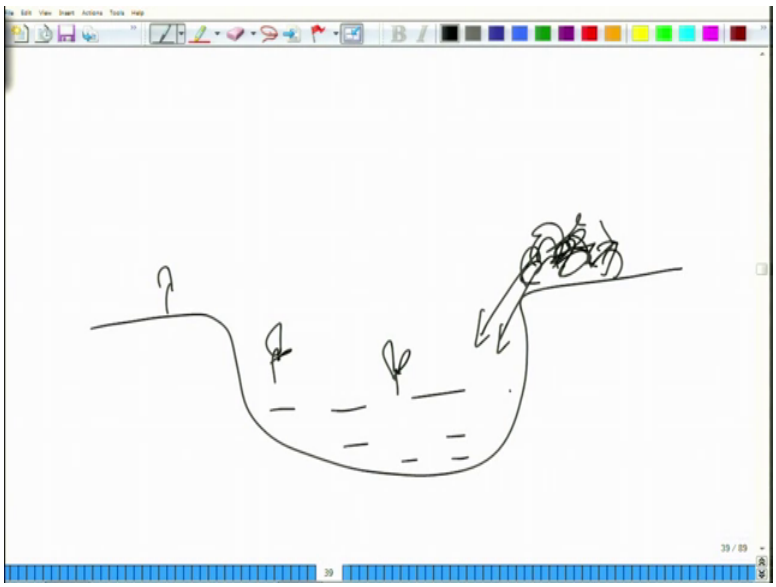

You probably also created a lot of gunk matter that is there in this surrounding. So, now what you have done after at the end of your mining operation, you are left with an area that does not have any trees that has big sized holes and that has a lot of this landfill.

So, what are the kinds of things that you can do to aid in the restoration? Now if you do not do anything probably in say a 1000 years or say 10000 years nature will reclaim this area by itself. So, probably with the rains all this gunk will start getting inside. So, it will start filling up after a short while and then you will have some plants that will start invading into this area, and after some time you will have the successional processes that start again.

Because again you will have some species that will be more resistant to the impacts of the lizards that are there in the environment plus at the same time, you will also see that when you have these mining gunk then probably with the rains some amount of it is getting into the stream.

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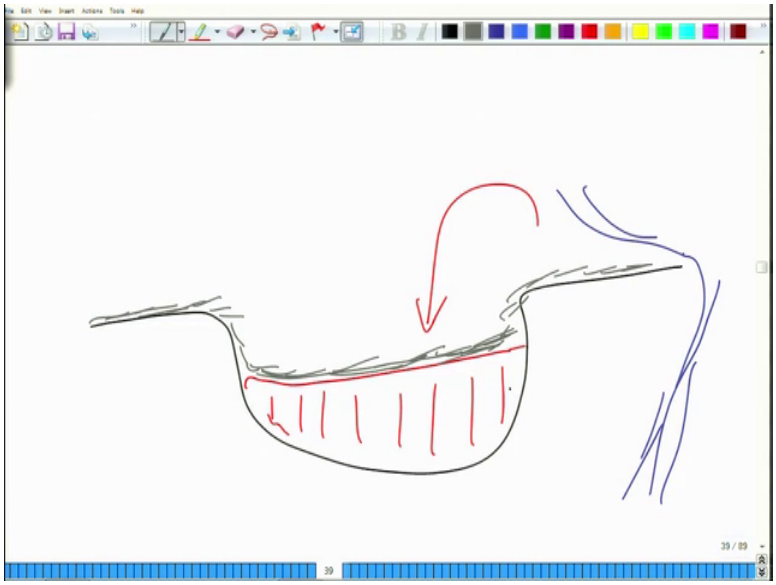

Now, when you have these materials that are getting into the stream; one is that you are getting the sediments, second is that if you probably went for the mining of metals you would also have a high amount of heavy metals that are getting into the water streams. Now heavy metals are extremely toxic and that might lead to the death of a number of organisms.

But then again after some time probably the concentration of heavy metals would reduce with time, because you will not have so much amount of heavy metal that is there in the gunk. And after some time the concentration will reduce enough so that some organisms are able to live there.

But then when we talk about restoration ecology, we are trying to aid this process. So, how can we aid this process? One is that, because you have this gunk that you can get into the reverse if it is left outside, you probably put all this gunk into this hole. So, what will happen is, you now do not have any of these landfills here; plus you also do not have these holes here, because you have filled up the hole. Plus you can also bring some amount of soil from outside.

So, basically you bring some amount of dirt from outside and you create a layer of soil, over all of these areas. Now why would you want to do that? Because in case you have these gunk materials inside they are still having a lot of heavy metals, they are still having a number of chemicals. So, you put a layer of soil on top so that even if there is rainfall in this area, the water is not able to reach to this gunk. So, you essentially create a layer on top of your landfill material so that the water is not able to reach inside.

So, now you have saved your rivers. So, in this case nothing is getting into the rivers, now the river is clean. Plus the other thing is; the other thing is that, even after you have done this, it might take say now because you have already added the soil so probably it will now take in place of 10000; 10000 years, it will probably take 100 years, for nature to reclaim this place. Because after a while some seeds will come into this area, some sports will come into this area; the process of succession will start.

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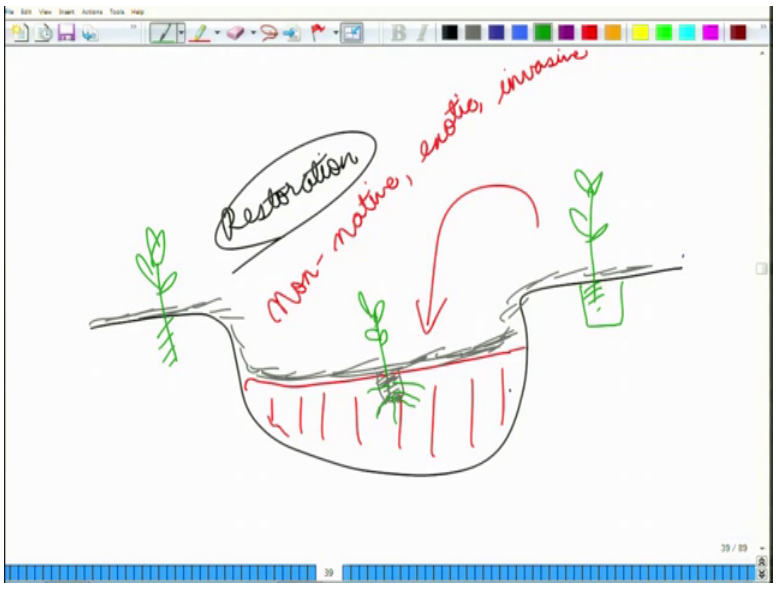

But then you can aid in that process even further by say, planting those particular plants that are already found in this area. So, you are adding those plants, you are bringing those plants and probably even in this gunk area you are planting those plants. And to protect them from the high heavy metals what you do is, that you make a small hole and you fill it up with soil and you put these plants here.

Now what will happen after a short while, is that these plants will give a roots. And these roots will slowly enter into these gunk areas as well, but then because they also have this soil to dilute the impacts of the heavy metals these plants will be able to survive. So, in place of having an area that nature would have reclaimed in say 1000 of years, now you have helped nature to reclaim this area in say a couple of years.

So, that is something that we know that we call as restoration. So, we are restoring this area, so that the systems can get back to normal. Now in this case the restoration will move according to certain principles.

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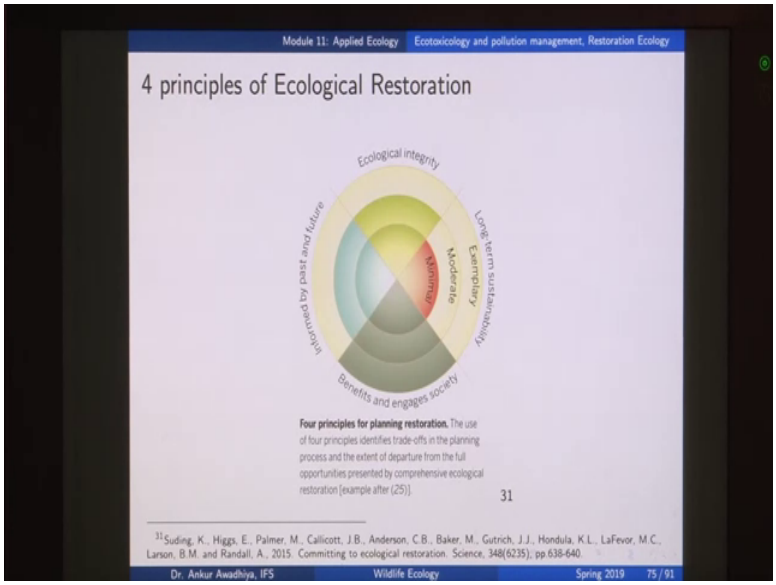

So, we have these four principles of Ecological Restoration. Whenever you are doing any restoration activity, you have to maintain ecological integrity which means that if you are good if you are planting these trees in say a tropical area, you need to have the plants that grow in the tropical area only. You cannot bring in some other invasive species and you are trying because your invasive species will probably establish faster in this area.

Because they have lower nutritional requirements or because they spread very fast, but then what will happen is that if you in place of going for native species.

So, if you go for nonnative, exotic, or invasive species then even though this area will have certain vegetation cover, but then it is also possible that they will spread even further and after a while they will destroy a much larger ecosystem. So, you need to maintain an ecological integrity and all of your operations. Secondly, it has to be informed by past in future. So, basically when we say that we are doing some planning operations here, we need to look into all different case studies that have been done.

So, we need to go for the best practices whenever we are planting any material here. So, for instance you need to know what is the size of the hole that you need to dig, in this area, Do you need to irrigate this area or not? If you want if you need to it you to irrigate this area, how often do you need to irrigate this area and things like that. So, all the past information and what even those information that come up in future they need to be integrated into any of your restoration activities. You just cannot say that I did not have a time to look at this information, and so I did the wrong thing. It has to be well informed.

Then it needs to benefit an engage the society. Because once you have done this plantation, they will also be say some villages that are nearby. So, the people the local people who are there in those villages, they need to get a benefit out of this activity. They need to be actively involved in this activity.

So for instance when you are planting these trees; if you give employment to the local people; if you involve those local peoples; so, they also become stakeholders. What will happen is, because it is their forest they will try not to cut this forest, they would want this forest to grow, because it is after all a result of their own hard work.

So, in all these activities you need to make a point that you are benefiting and you are engaging the local people, you are engaging the society. And at the same time the 4th principle is that it should have a long term sustainability. You cannot go for short term solutions it has to be a long term solution. So, for instance you cannot go for your exotic plants; that is also another example here.

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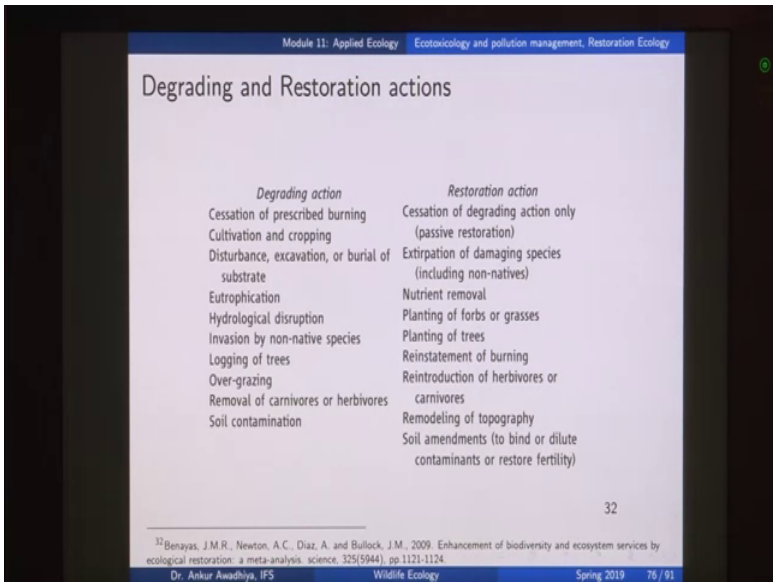

Now, we look at some activities that are degrading and some activities that are restoring activities. Now degrading activities could mean things like, cessation of prescribed burning.

So, you require certain areas to be burnt after every few years or say after every few months, because let us say there are some invasive organisms that have come up into this area and you want to keep their population in check. So, one of those operations could be the burning operations. Now, if there is one particular manager who comes into this area, and says no I am not going to burn this area; so he is actually performing a degrading action by not acting on the prescribed prescriptions.

Another degrading action could be cultivation and cropping in this area, because if you have a very heavy cultivation in an area, you would probably go for a large amount of pesticides, a large amount of fertilizers that could again be degrading to the ecosystem. Or things like disturbance, excavation, or burial of substrate.

So, things like mining operations or things like you dig a hole and you fill it with waste materials, that is included in these things. Another degrading action is eutrophication or hydrological disruption; hydrological disruption means things such as creation of dams. So, if you have a dam you will disrupt the hydrology.

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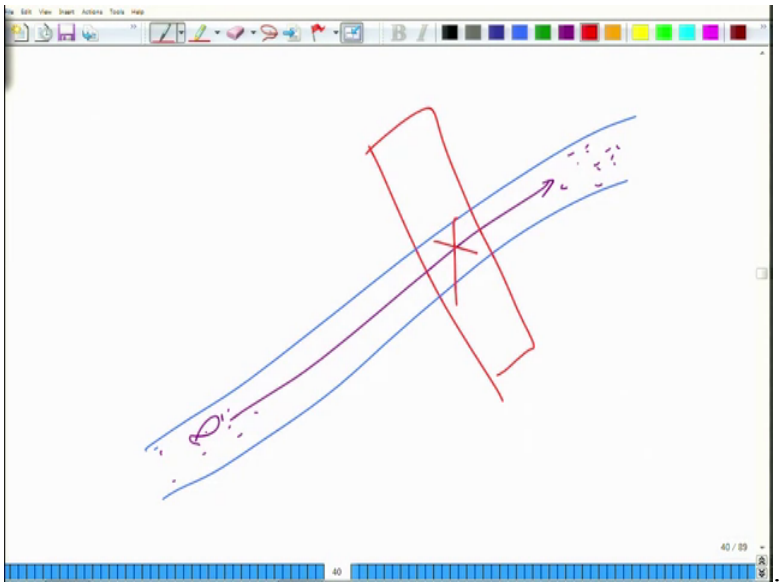

So, if suppose there is this particular stream that is going a very long distance. And there are supposed certain fish species that need to feed in this area and this area or they are going to lay eggs in this area.

So, there is a migration of these animals from one area to the next area. Now suppose you create a dam in this area. So, once you have this dam these fishes will not be able to move, their movement is hindered. Once that happens they will not be able to go out to the other area to lay eggs and in a short while their population will collapse. So, or invasion by nonnative species such as lanthanum or logging of trees that is a deforestation or over grazing which might lead to desertification these are all degrading actions. Or removal of carnivores or herbivores, especially through hunting if you have a forest you do not have any tigers you have posed up all the tigers, the deer population will increase and it will eat up all the forests.

And so your forests will turn from a well functioning ecosystem to a degraded ecosystem or things like soil contamination. So, if you are adding a lot of pesticides or heavy metals into the soil, or if there is say a radioactive fallout, that is contaminating the soil these are all degrading activities. Now we will have a look at some restoring activities cessation of degrading action only. So, this thing is known as passive restoration.

So, in the case of a passive restoration you stop degrading. So, essentially when we talked about the release of DDT, and you have stopped releasing DDT that is a passive

restoration. Because at least you are reducing any further inflow into the system, but you are not removing the things that are already there you are not helping in its degradation. So, this is known as a passive restoration.

Another example is extirpation of damaging a species including nonnatives, such as what we saw in the last lecture in the case of prickly pear or open chia. So, that was a nonnative species that was coming up in a largely in Australia, and you got rid of it. So, that is a restorative action, because in this case the native species will be able to reacquire that particular area, that was earlier that was earlier invaded by the prickly pear.

Or things like nutrient removal, in the case of eutrophication you can have nutrient removal by some way and that would be a restorating activity, because it is reducing the impacts of eutrophication. Or planting of forbs or grasses, or planting of trees or afforestation or reinstatement of burning.

So if you have an area that required a prescribed burning and then you stopped burning that area if you start it again that will again be called a restorative action because you will be able to take control or reintroduction of herbivores or carnivores; so for instance in the case of Sariska tiger reserve we lost all the tigers because of poaching and once that happened the environment started degrading again.

And so we put a control on poaching, we were able to stop poaching and we brought in tigers from other areas. We brought in tigers from Ranthambore into Sariska. So, reintroduction of organisms into an area will also be a restoration action in these organisms can be herbivores or carnivores. In the case of Madhya Pradesh we are shifting bara singers from Ghana to other areas.

So, that is also a restoration action. Or remodeling of topography, remodeling of topography say in the case of mining, you created hills and you created holes. So, you can flatten out the hills and you can fill up the holes that will be a remodeling of topography and that will be a restoration action. Or soil amendments to bind or dilute contaminants or to restore fertility. So, you can amend the soil; so for instance in the case of mining, we saw that we add a layer of soil and that is the restoration activity.

Or in areas that are suffering a heavy amount of erosion you could go for things like geo textiles, to bind the soil or you could dilute up your contaminants by adding more amount of soil, or you could try to restore the fertility, by say planting some specific species, such as if you go for leguminous species the amount of nitrogen will go up.

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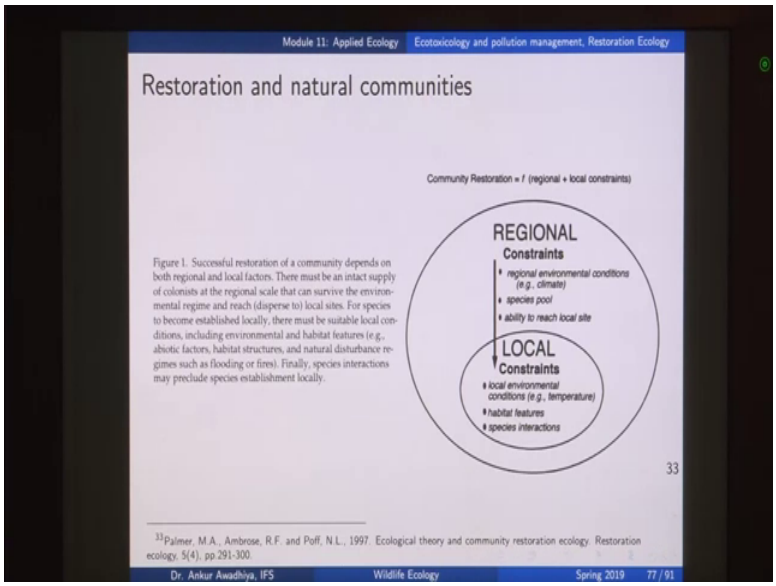

Now, whenever we are talking about restoration of natural communities, we need to keep in mind that the restoration will always be a function of the digital components and the local components. So, if you are trying to do restoration in an area locally you have to make that area good enough. So, you have to remove the constraints and you also need to ensure that from the region the organisms are able to come to your area. So, in this case we can define four different kinds of scenarios.

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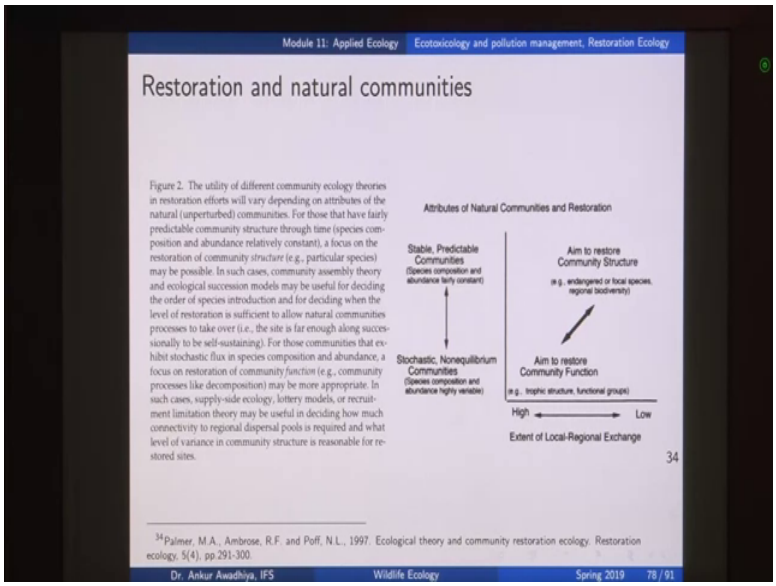

So, you can have the scenario in which in your area you have stable and predictable communities or you can have areas where you have stochastic and non equilibrium communities. So, these are two ways in which you can have the communities. Or when we talk about the regional scale, we can have a high level of exchange or we can have a low level of exchange.

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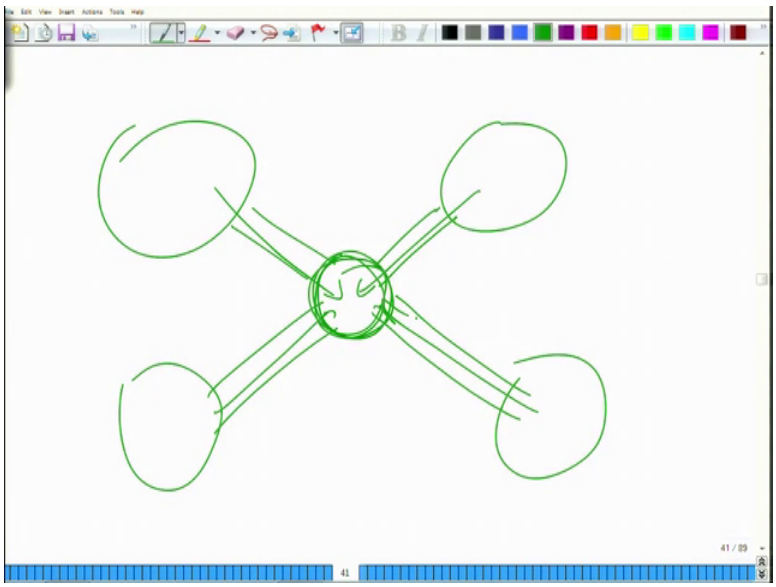

Now, when we say that you have a high level of exchange, it means that suppose this is your forest and then you have this surrounding forest, and in this forest you did some

amount of restoration activity. Now for instance earlier this forest was all invaded with certain exotic species, such as lantana and you perform a restoration action of removal of this lantana ok. So, now the lantana is gone, what next? You need to bring in the organisms from outside.

Now, if there is a good amount of connectivity with the surrounding other forest areas then your animals will migrate by themselves because now there is a niche that is made available after the removal of lantana. But then you can also have a situation in which this area is not connected to the surrounding forest areas in which case you might need to translocate animals into this area from outside.

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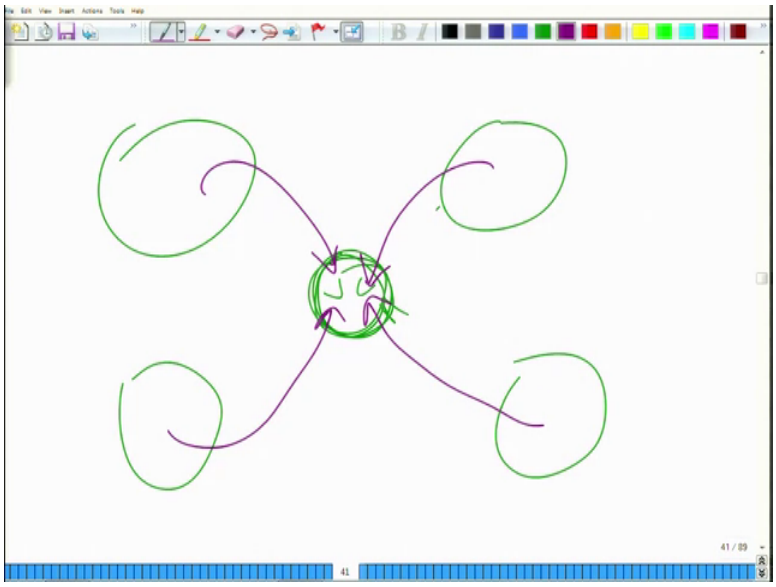

So, you will have to manually bring animals into this area. So, this is what we are talking about here. So, in the case of those areas that have non equilibrium communities. So, these communities have not yet become climax communities, they are still in the process of making. And if there is a high amount of exchange that is possible; so in that case even if this community is not having certain organisms, these organisms will able to come, will be able to come to this area because it is connected.

So, in this case we aim to restore the community function. So, once the function is restored, once you have your weeds that are or the invasive species that have been gotten rid of the rest of the things will be taken care of by nature itself. But then if you have those communities, where you have you already have a climax population. So, in this

case you have a forest that is a climax forest. And this area is not connected to the other areas the connectivity is low.

So, in that case you will have to bring the organisms from outside. So, in that case you not only have to maintain the function, but you also have to restore the community structure, you will have to see to it that the all the trophic levels are now there in the system.

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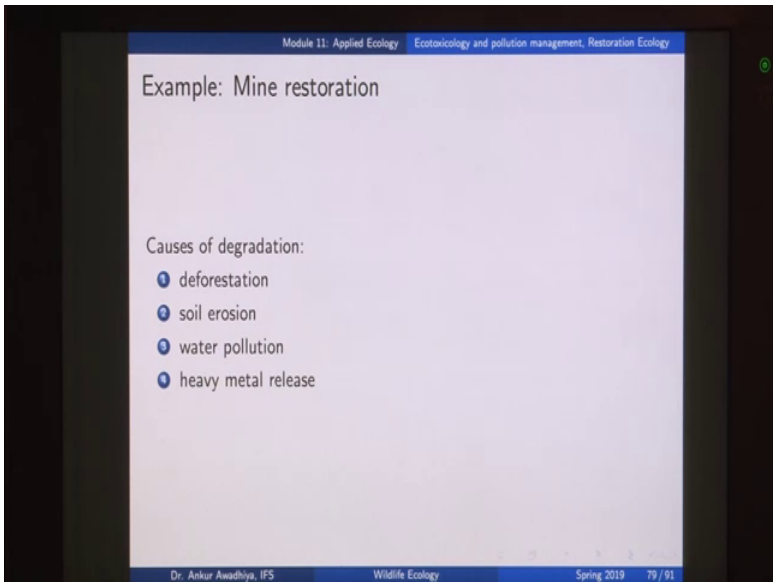

Now, we will look at two case studies one is this mine restoration.

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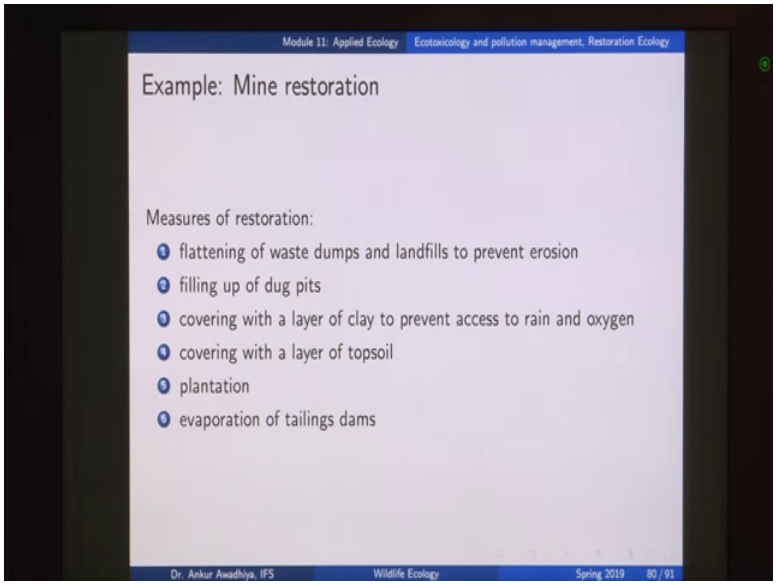

So, if there is a mining activity then there will be a number of degrading activities that are there, deforestation, soil erosion, water pollution and a heavy amount of heavy metal release. In the case of mine restoration, we flatten up the base dumps, we fill up the dug pits and we also flatten the landfills to prevent the erosion.

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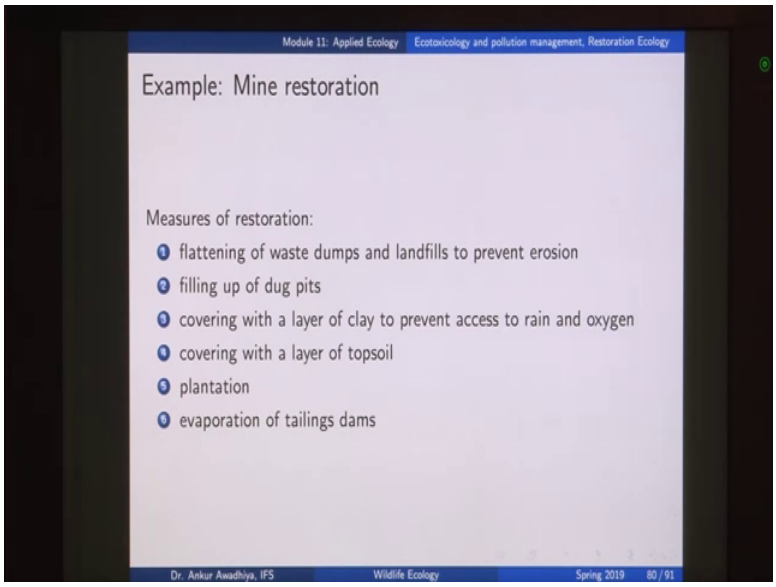

So, in this case if you have this area and here you have a big waste pool. So, if there is any amount of rain; it will be easier for rain to take these sediments away through erosion, but then if you flatten it out; so you put all of this gunk inside.

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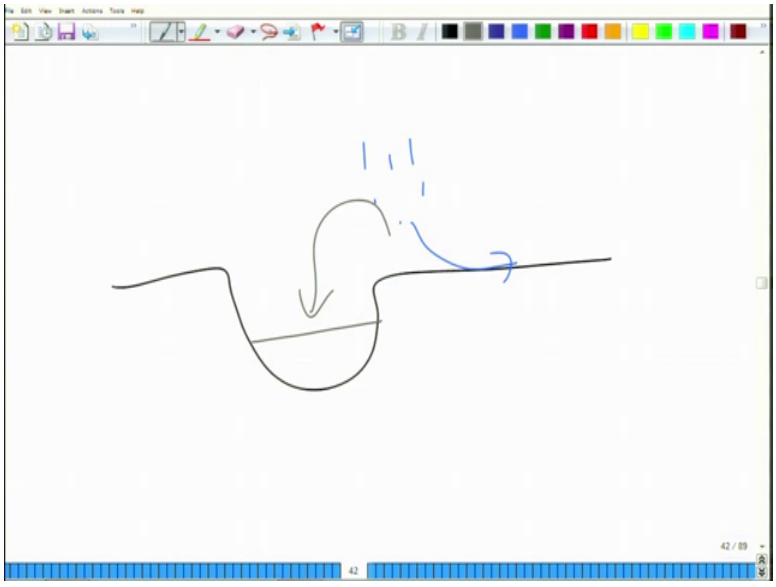

So, in that case all of it comes here and this portion is gone. So, now, the amount of erosion will be much less, or you cover it with a layer of clay, to prevent access to rain and oxygen or you cover it with a layer of topsoil do some transition activities. Or perform some evaporation of the tailings dams. Now what is the tailings dam?

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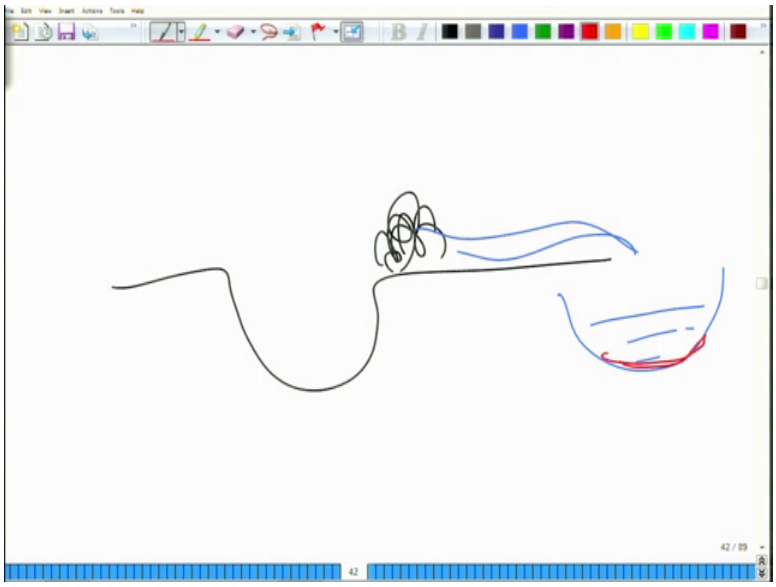

So, essentially earlier when you were doing the mining operation, you were still having this gunk here and then it was giving rise to certain leachates and these leachates were then collected in a lake.

Now, in this lake you should perform evaporation so that all the water is now gone because it is all full of heavy metal chemicals. So, once you have gotten rid of the chemicals all the heavy metals will come to the bottom and then you can scrape and scrape it off and then you can keep it in some other area so that it does not reach into the water table.

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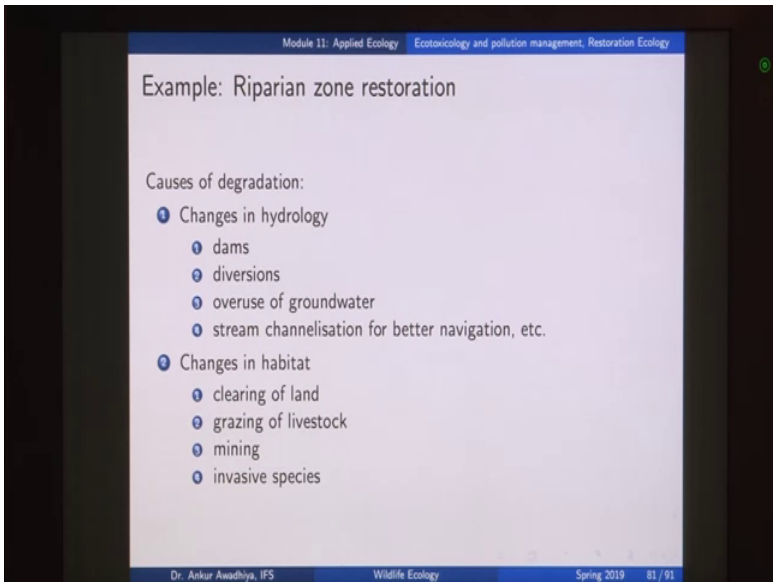

Another example is a Riparian zone restoration. Riparian refers to rivers. So, in a river zone area you can have different kinds of degradation, you can have a changes in hydrology because of dams, diversion or overuse of groundwater or stream channelization for better navigation.

Now, when we say stream channelization what you are doing is that you have this particular area, in which you have this stream and what you do is that you make it a flattened or a streamlined stream.

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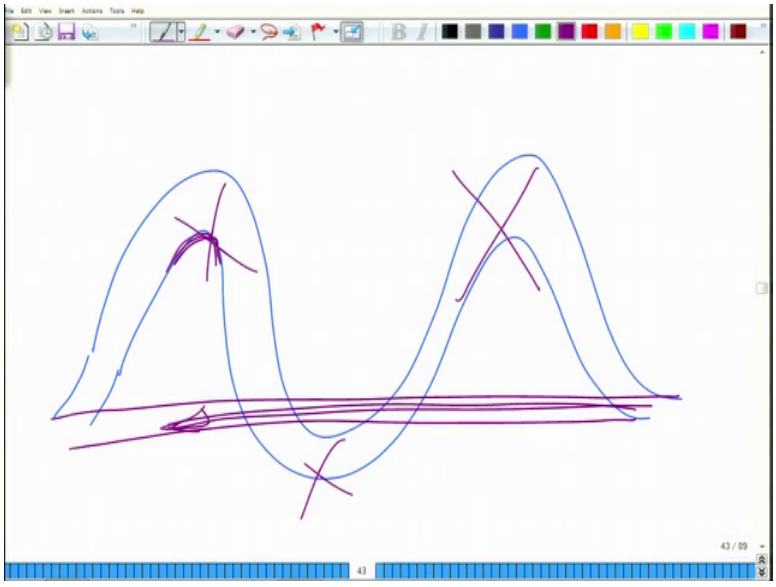

So, you connect these two areas like this. So, now all of these bends are gone and you have a straight channel which you can use for navigation. But then this can also lead to a certain amounts of degradation to the ecology because there could be certain species that are dependent on these bends. Because on these bends you will be having a number of sand banks and there would be certain species that lay their eggs in the sand such as Gadial.

So, if you make the whole stream straight then you do not have any further sand banks and this species might get extinct. So, these are also causes of degradation or you can have changes in habitats, such as clearing of land, grazing of livestock, mining or invasive species. So, these are the kinds of.

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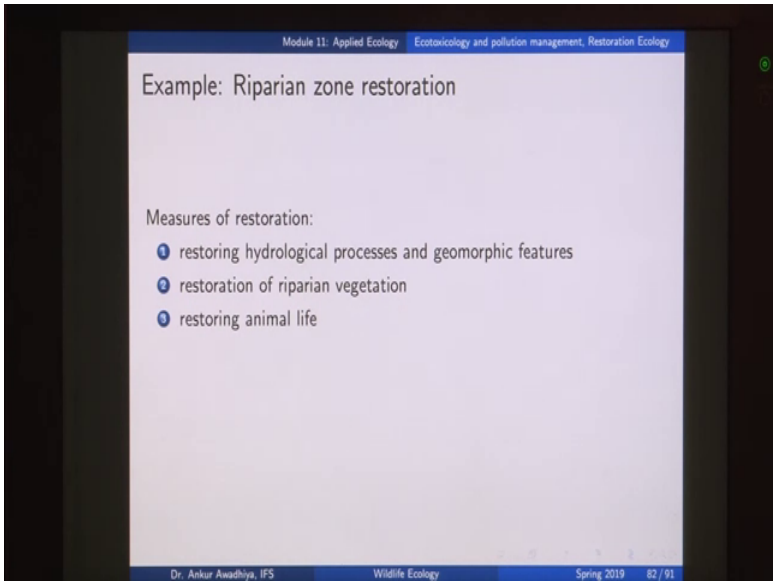

Now, if there are these degrading activities you can go for certain restorations, now these could involve restoring the hydrological processes and geomorphic features.

So, if you have straightened up a stream you could make it bent again, if you have a dam you can create some revenue so that the animals are able to cross the dam or you could go for restoration of the riparian vegetation which is the natural vegetation which is found on these river banks. Or you could go for a restoration of the animal life. Now these are some common ways in which we perform these restoration activities.

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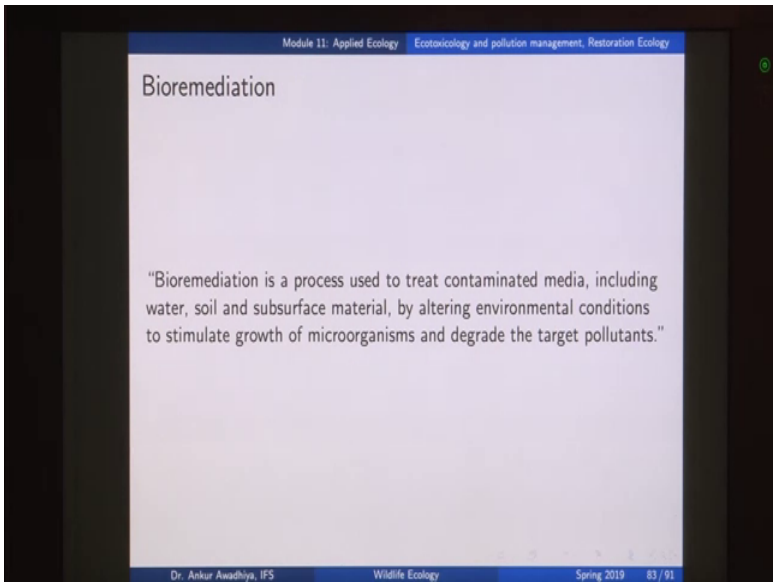

Now, one other thing that has come up these days is known as Bioremediation. So, "Bioremediation is a process that is used to treat contaminated media, including water, soil and subsurface material, by altering environmental conditions to stimulate the growth of microorganisms and degrade the target pollutants".

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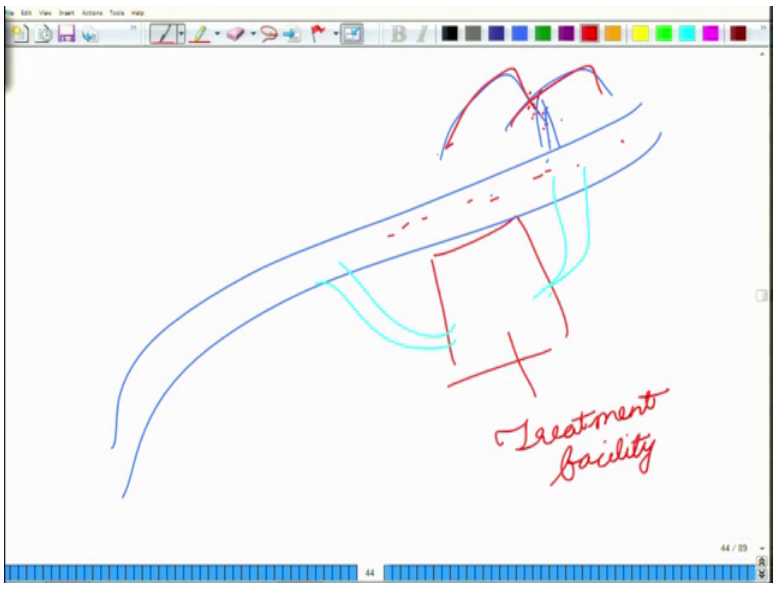

So, essentially what we are saying is that you have a particular stream and in this stream suppose there is some heavy metal that is coming from a nearby hill. So, you have this

hills and because they are rich in heavy metals there is in stream that is bringing these heavy metals into your river.

Now, to perform the restoration you could either go for say making of a big water treatment facility. So, in that case you divert all this water into your facility you get it treated and then you release it back here. So, that from this point onwards you do not have any of the heavy metals that are there in the stream. That is one way out, by putting up a treatment facility.

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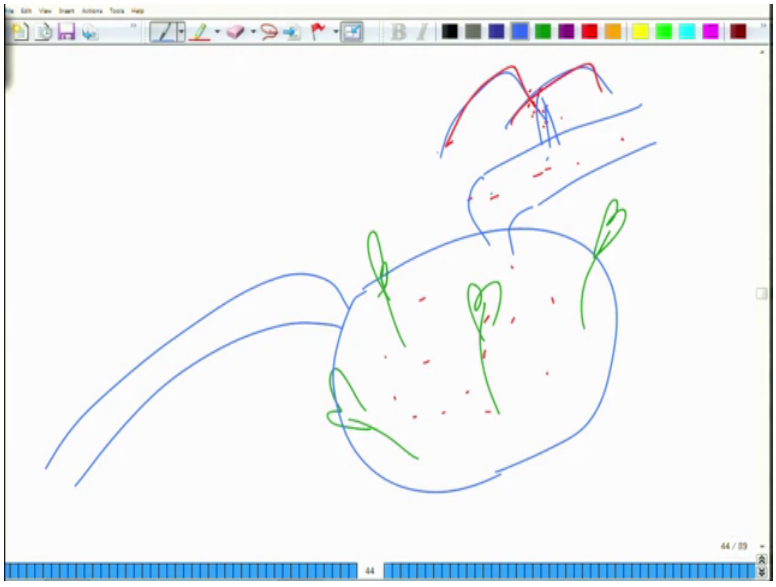

Or the other way is to go by bioremediation; now in the case of bioremediation what you could do is that in place of setting up this facility, you could just divert the water so that this area or you create a large size wet line and you divert the river into this area. And probably so it becomes like this so all your heavy metals are now coming into this area and then you are growing certain plants in this area that are able to absorb these heavy metals. And then from time to time you can take these plants out, you can cut them, you can burn them, and you can extract these heavy metals and remove them from this from the system.

So, you are having this water that is coming here and then the clean water is then let again into the stream; so that is another way. So, if you go for these biological measures this is known as bioremediation.

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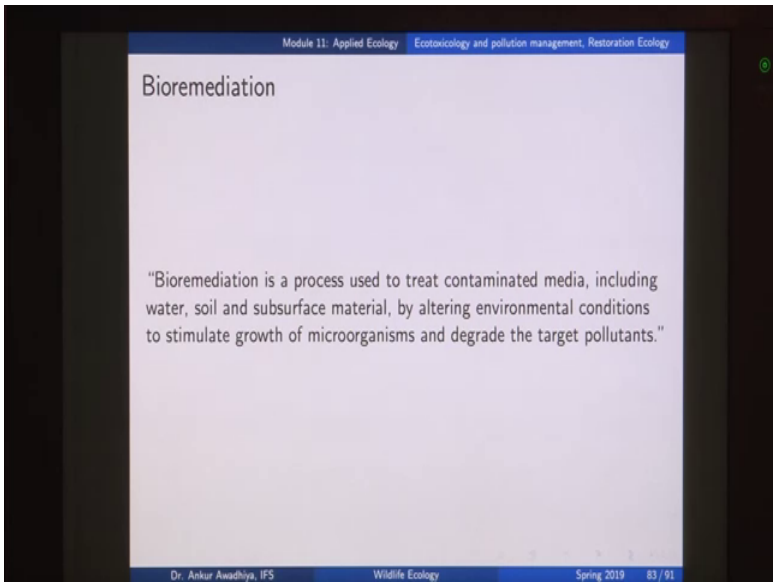

And in this case you can make use of number of microorganisms that are degrading your pollutants or you can make use of certain plants that are absorbing these pollutants.

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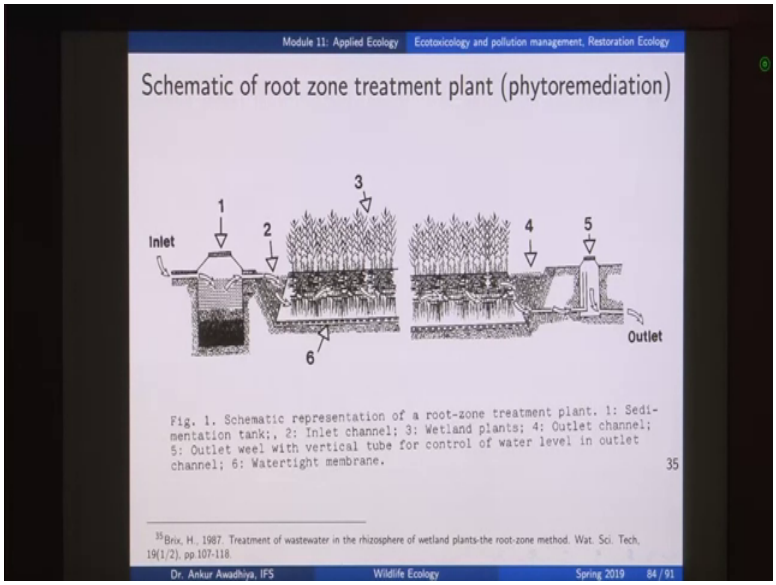

And one good example of such plants is the plant known as phragmites. Now, phragmites is a plant that is a wetland plant and in the case of your sewage disposal, it is extensively made use of in the case of root zone treatment method. Now in the case of root zone treatment method, what you have is that you have this inlet tank, now in this

tank you put in all your sewage and there is some amount of sedimentation that happens in this tank.

So, all the solid matter they come down and whatever remains on the top now this is extremely polluted water, this is your black water that is having a very high amount of organic materials and that is also having a very high amount of microorganisms. So, after the sedimentation tank this top water is then put into these layers and in this area you have some amount of soil and you are having these plants which are phragmites plants.

And you create this area in such a manner; so on the bottom you have an impervious membrane you generally make use of plastic or concrete so that the water is not able to seep down into the water table; so the water has to go like this only. Now if the water goes like this and this is generally put on a slope so, that the water naturally flows down and in this case you have these plants and this water is stretching all the roots. So, it is stretching the zone of the roots of these plants and in this zone you have a number of redox reactions that occur.

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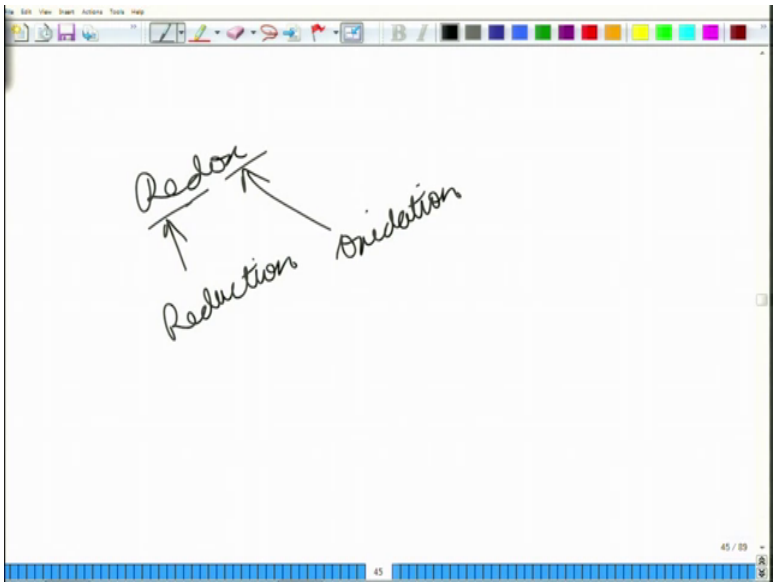

Now, redox reaction you have, redox it means reduction. So, you have red plus o x which is oxidation.

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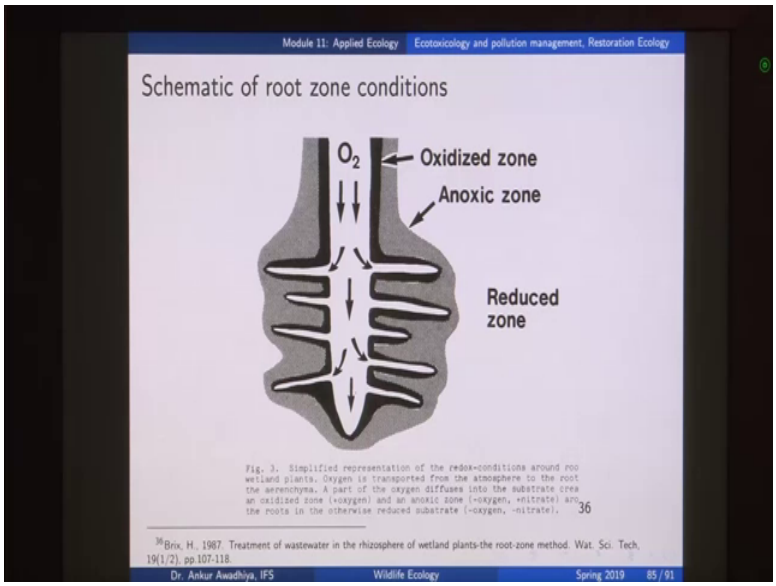

Now, what is happening in this case is that you have this upper zone that is oxidized, you have the bottom zone, which is a reduced zone. So, whatever are the chemicals that are there they will be acted upon, they will either be oxidized they will either or they will be reduced plus there will be a heavy amount of microorganisms that will be growing in this area.

Because the roots are providing shelter to the microorganisms and when you are bringing in your sewage water; it is also having a number of organic chemicals that these microorganisms can use for food. So, in this case you in a concentrated manner you are performing a treatment of the sewage water and once that has happened; so, it will reach into the second chamber in which you can control the level of water and then it will move out into our an outlet, and this outlet water this can be used either for irrigating of your different plants. So, you can use it in agricultural purposes or horticultural purposes or maybe you can release it, now back into the streams.

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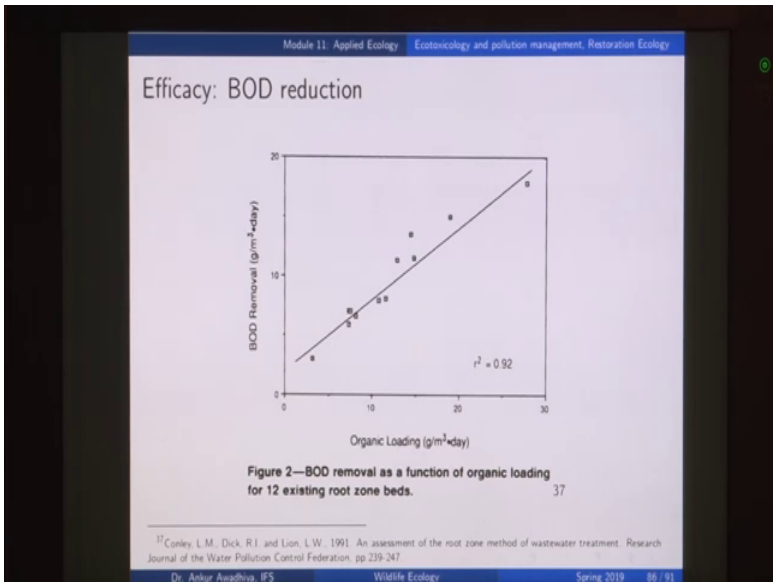

And these kinds of systems, these kinds of bioremediation of phytoremediation systems they have a very good amount of efficacy.

So, this curve is showing us the amount of organic loading and the amount of BOD removal. And we see that even at a very high amount of organic loading, so if you are giving it to say 30 grams per cubic meter per day as much as 20 grams per cubic meter per day is getting removed by this system.

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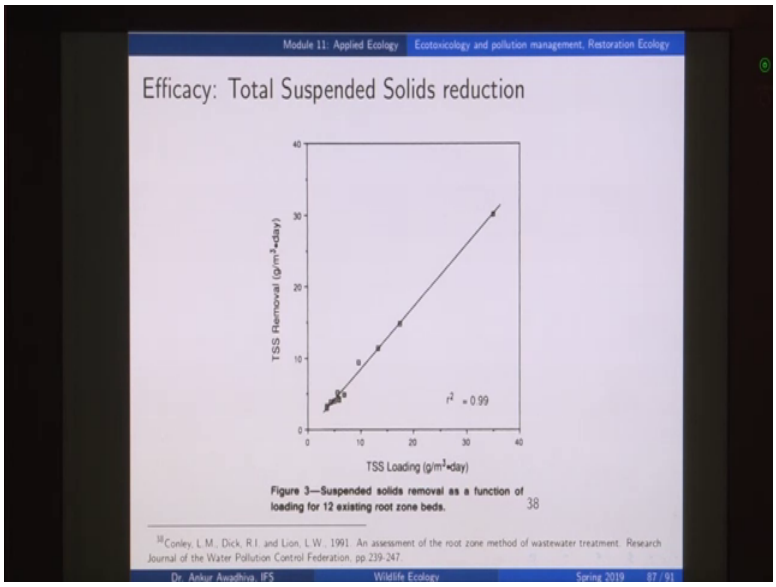

So, by having a bit larger system probably you can remove it even further. And similarly if you look at the Total Suspended Solids or the TSS it is able to remove it to quite an extent. So, if you are giving it say 35 grams per meter cube per day of total suspended solutes. So, in that case out of this 35; it is able to remove 30. So, whatever comes out is a very clean source of water and probably you can treat it further if needed be or you can use it for agricultural or horticultural purposes. Now that is about bioremediation.

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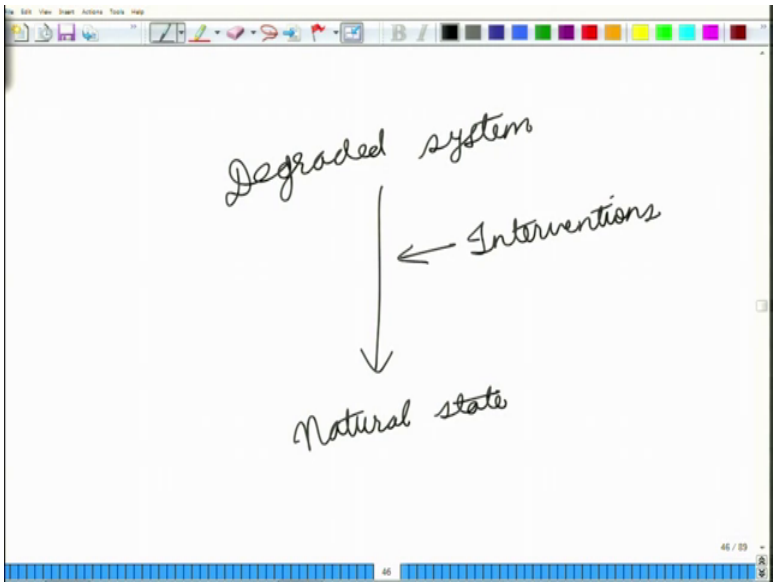

Now, when we talk about restoration of a system, what we are trying to do is that we have a degraded system, and we are trying to bring it back to the natural state, by putting in certain interventions. And these interventions have to be guided by science these interventions have to be guided by the use of social beneficence so that everybody gets a benefit and these also have to be guided by the technologies that are available. But then when we move into restoration; we also need to keep in mind that there is a limit to what we can restore.

So, one thing is that we cannot restore if there is a system that has become extremely bad. So, for instance you added so much amount of pesticides, that now your system does not have enough number of organisms. So, it will never be able to bounce back. So, one thing is that you have to put your step down before you have crossed a critical threshold. The second is that you should not take it to a logical extreme; so this was a

paper that was published in nature and in this case the authors talked about Re wilding of North America.

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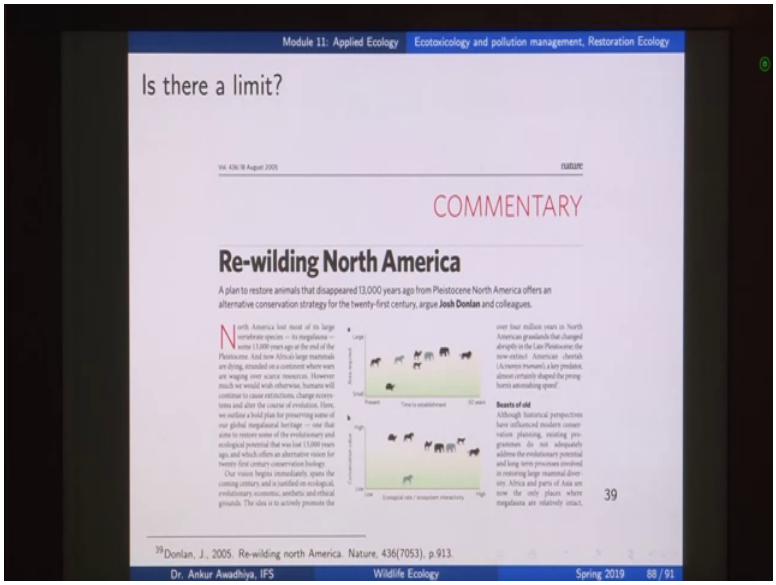

So, they said that in the other continents we have all these different animals and we had these large megafauna even in North America in the very old times, but then when human beings came into the system they killed off all of these.

So, now let us bring everything back into the system. Now while it might look like you are you are changing those system into a natural state and while you are saying that the current system is a degraded system, but then why we are saying that that you need to be a very of it, is that even in this degraded system if your degree the system has continued for a very long period of time. Then probably that has become a norm for the species that are now present in your system.

So, for instance if you have our forest and you are having lantana, and these forests with lantana are say allowed to continue for say 200, 300 more years. So, in that case there would be a number of bird species that would become more and more dependent on this lantana as a food source. Now later on, if you try to remove lantana you will also be getting rid of all those bird species. Because they had the source of food they change their niche and they are now using this lanthanides food whereas, their ancestors were not using it as food. But if your system changes so that your degraded system has

become a norm. So, you need to keep a check on the amount of interventions that you are ready to do.

So, in this case if we talk about rewinding of an area by bringing in those animals that were say extinct long back in those particular areas, that might not be a very good proposition. So, essentially this paper was highly criticized later on.

So, in this particular lecture we looked at restoration ecology. So, we began with what are pesticides, what are the kinds of impacts that they are doing and we also looked at different kinds of restoration activities that we do in certain environments. We looked at the case studies of a mining area in case studies of a stream area which has been degraded, what are the kinds of restoration activities we will bring there.

And then we also looked at the process of bioremediation. Now there are two three things that you need to keep in mind; one is that restoration is a process which is aiding the natural process, if you do not do any restoration, nature will take care of itself, but it will take a very long period of time. Now the amount of disturbances that we are bringing in are very vast and the amount of disturbances are coming in at a very fast pace.

So, you cannot have a system where you bring in disturbances very fast and then you allow nature to take care of it in a very long period of time. So, if there are fast disturbances, you should have a system that permits it itself to get restored in a short period of time. So, that your disturbances are equalized by the amount of restoration. So, manual restoration becomes necessary because we do not have so much amount of time. If we leave the degraded areas as such it is possible that they will become further degraded or it is possible that they leach out a number of heavy metals or the contaminants that will harm the larger ecosystem.

So, we need to go for these restoration activities. Now whenever you are doing a restoration activity that has to be guided by the science and technology, that has to be guided by your previous learning's, that has to be guided taking into account the future uses, that has to be guided taking into account the ecology of that place and that has to be guided taking into account the aspirations of the local people; they also have to be involved, they also should get a benefit out of it.

And whenever you have a system that is getting degraded it is always prudent to stop degradation as soon as possible so that the system is still in a position that it is resilient. If you cross the amplitude then probably your system will not be able to come back to normal and that being said if your system has changed into another system, then probably it makes much more sense to let that system remain as such. Because now the organisms have become more and more adapted to it; so that is all for today.

Thank you for your attention. [FL]