Wildlife Ecology
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Lecture – 28
Oil spills

[FL]. Today we begin a new module, which is the ecology of changes. So, we have seen how an ecosystem functions, how different populations and communities interact and so on, but then what happens if you bring in a major change to the ecosystem.

Now, these changes are becoming important day by day because of the disasters that we are observing in the world. So, for instance, if we talk about an oil spill, so if there is a tanker that is carrying oil and it if it spills a large amount of oil on the surface of the oceans, then that is going to have a negative consequence on different components of the ecosystem.

Now, if such a thing happens, how does the ecosystem revert back? Is there some amount of resilience in the system, so that it is able to bring itself back to normal or is it a situation that will become doomed towards the extinction of a number of species. Now, that is an important question these days, because we are observing more and more number of such disturbances.

The disturbances can be of different kinds, there can be disturbances that are abrupt and that are very large in their magnitude such as an oil spill or a forest fire. On the other hand, there can be some other disturbances that take a very long period of time to manifest themselves such as climate change. So, a climate change goes on and on and on for a very long period of time, and that would also result in some amount of changes to different ecosystems.

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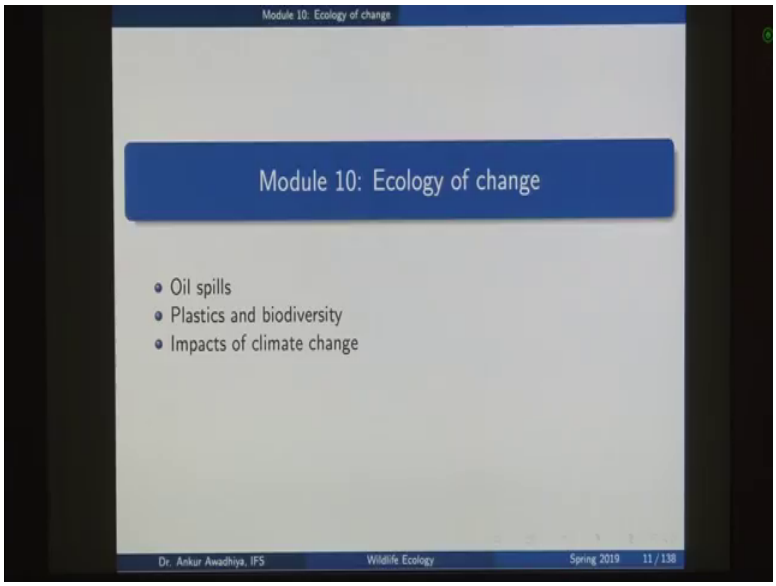

So, in this module, we will be looking at three different case studies about oil spills, plastics, and the impacts of climate change, how they bring out a change in the ecology, and what do we do to bring the system back to normal. So, we begin with the first lecture here which is the oil spills.

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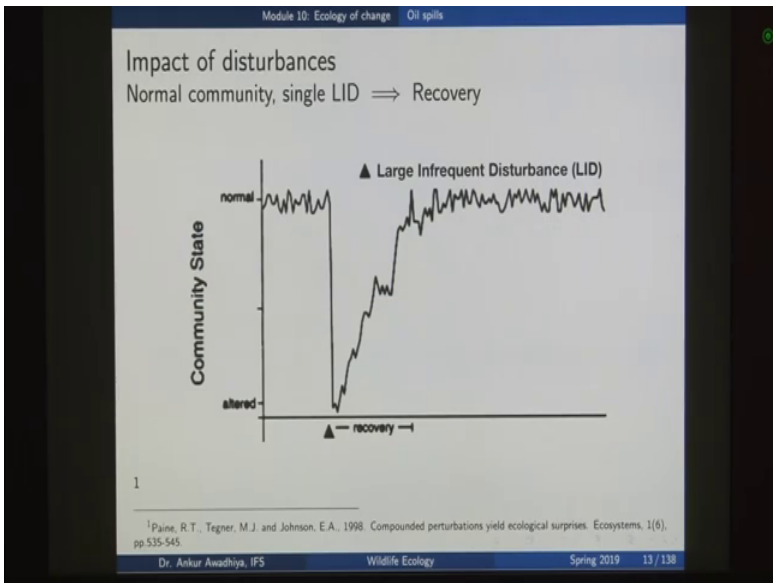

Now, whenever we are talking about any such disturbance, the impact would depend on what was the status of the community before this impact came in and the nature in the frequency and the magnitude of the impact. So, we can classify the situations into three

different categories. The first category is that you have a normal community that is everything is normal, there is no heavy stress on that community, no high pressure of diseases or say no high pressure of habitat degradation and so on. And you bring out a single LID, now LID stands for a Large and Infrequent Disturbance.

So, here we are saying that on the y-axis we have the community state, on the x-axis we have the time. Now, the community state is shown in two forms; one is this altered state, which is at the bottom and the top, top portion is showing you the normal state. Now, in the normal state there would be some amount of fluctuations that we are observing in the community.

Now, where do we see these fluctuations? Because these are the normal variations that we observe, because say a 1 year was slightly dry year or maybe it was a slightly more wet here or probably there were some diseases that cropped up in this community, but then overall it is more or less a normal community. So, these are the variations that we observe in a normal community.

Now, at this time point there was a large and infrequent disturbance, now such a disturbance could be things like forest fire. So, you have this community and there is a forest fire that assume a major portion of this forest, what would happen then? So, when we are seeing a large and infrequent disturbance.

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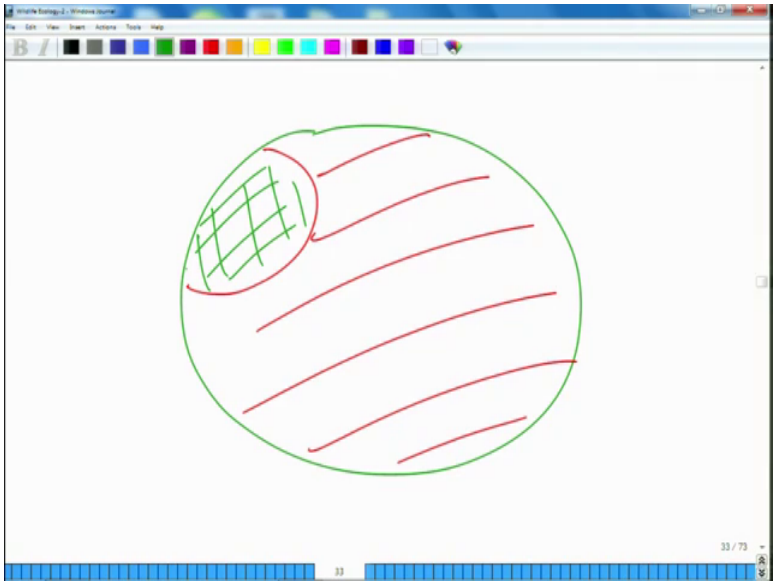

So, probably if this is your forest, you had a forest fire that consumed all of these portions and only a small portion was left. Now, if that is the situation and if this community that was left out if this is a normal community, we would start observing the same scenarios at we had observed in the case of population dynamics.

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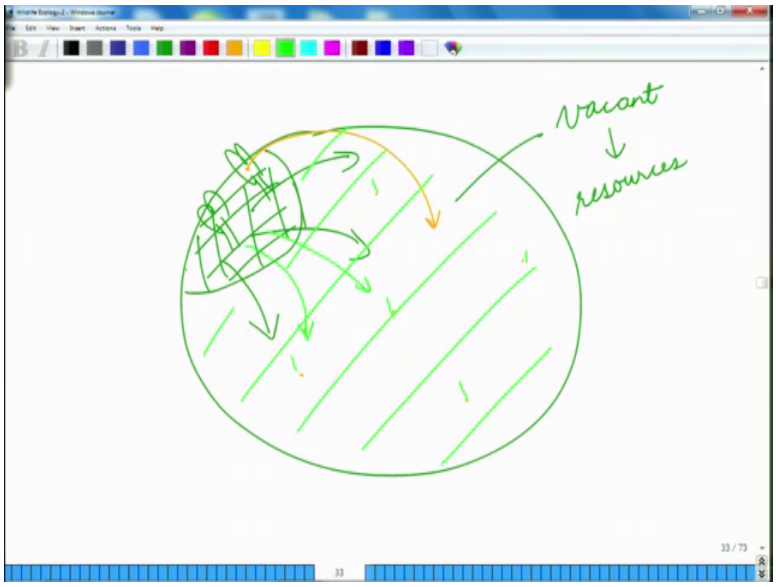

So, in this case this would be equivalent of a situation in which there is an island. And in this island, this much portion is having the organisms and the rest all portion is now clear, it does not have any organisms. So, what would happen then? Then these organisms that are already existing, because they are a part of the normal community they would start dispersing out, because these areas that are now vacant; so this is a vacant area.

So, this vacant area has the resources in the form of minerals. So, because it has minerals when it rains, then would start observing some vegetative growth. There would be some trees that are there in the community and these trees would be giving out seeds. Now, if you have some birds in this area, those birds would be carrying those seeds from this area probably to this area as well or maybe some amount of seeds would come out because of a wind flow or because of a water flow.

So, there are a number of situations at the same time it is also possible that when this area was burned out, there were some seeds or maybe some rootstocks or some tubers that remain below the ground.

Now, if you have these root stocks that have below the ground. So, even if you have a fire on top of this forest, these portions are still alive and so in the next rains, they would start giving out a sprout, so we would start observing sprouts everywhere. And in a very short period of time we would see that there are herbs, there are grasses, there are shrubs and maybe even saplings of the big trees that are now coming up into this area.

Now, once that happens we will also have a situation where, you have ample amount of food that is available to the animals. So the animals that with a part of the community that was left out or that was not consumed by the fire; now those animals would also now come out and they would also start browsing or grazing on to these herbs and shrubs.

Now, once that happens in a short period of time this whole area would start showing up the characteristics of a healthy ecosystem once again, because you would have the plants, you would have the trees, you would have the animals, you would have the birds, the micro organisms the small little degrading organism the or the saprophyte and so on, they will start coming up into this area.

And in a very short period of time, we will have that this community is able to bounce itself back to the normal situation. So, here we have the normal community, you have a big forest fire, but then with time it starts recovering and once it has recovered it becomes a normal community once again. Now, the most important points in this state would be that you have started with a normal community and you only have one disturbance, but then what would happen if you have say a number of disturbances; so in this particular example, when we were talking about a forest fire.

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Now, let us consider another example, where we have this big forest. And in this big forest, there was a forest fire and all these portions were consumed out and only this portion remained. So, now as before all of these areas now behave as freely available areas and then you have the organisms that are now starting to come out.

But then once that is happening once you are observing some regeneration in these areas, let us suppose there is another calamity. So, probably there was a river flowing in this area and this river now floods the area. Now, when it floods this area, probably all of these regions are now inundated and once that happens all these small seedlings and saplings that were coming out, all of those small root portions that were giving out the sprouts. Now, all of them are inundated with water and when they are inundated with water they die out.

So, now we are observing a situation in which there is a community, a healthy community that support one large infrequent disturbance and after that it was trying to come up again, it was trying to show its resilient character, it was trying to come back to the normalcy, but then we observe another disturbance in the form of another large infrequent disturbance.

Now, what would happen that in that situation? So, in that situation the saplings that were coming out are now all dead. So, in this case those seeds or seedlings that were saved from the forest fire are now again dead, what will happen then?

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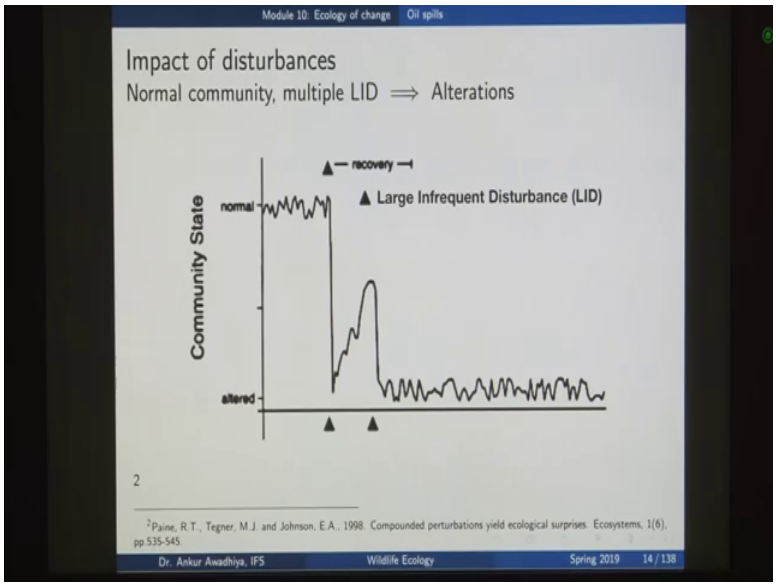

So, this is how we can represent such a scenario, we have a normal community, you have a large infrequent disturbance, now this community is trying to come back to the normalcy. Then you have another large infrequent disturbance and now there are no more living seedlings and saplings in this area, because anything that was saved from the forest fire is now consumed by the floods.

So, once that happens if you have a series of disturbances that come up in a normal community, we will have a situation in which the community after a while will not be able to come back to the normalcy. So, it will behave as an altered community for a very long period of time, because you now no more have any seeds on any rootstocks to bring this community back to normal.

Now, when such a situation happens, we could even say that it would reach a new normal. When we say a new normal, we could say that in place of having tall trees in this area, now you only have those plants that are that grow near the rivers, so that would be a new normalcy or a new stage of succession. But then when we talk about a community that was already in a pre existing normal state, it will not be able to come back to that state for a very long period of time. Now, there can also be a third situation.

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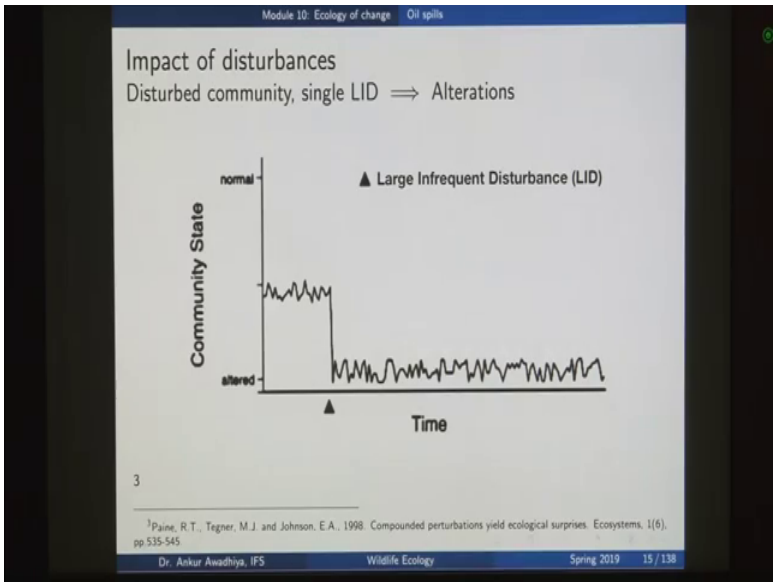

Now, this third situation is when you have a community that is not normal from the beginning. So, it is already suffering from some level of disturbances. So, it is not a completely altered community, it is not a normal community, it is somewhere in between.

Now, a good example would be a forest that has a lot of insect infestation. So, in that case most of the trees are diseased trees and they are not normal trees so to speak or an area that let us say there is a water body. And this water body is getting a number of contaminants in the form of pollutants, because there is a municipal drainage that is draining into this water body.

So, in that case all the organisms or most of the organisms in this water body are now already in a state of stress, they are not a normal community anymore. Now, if that is the situation and if we see a large infrequent disturbance, so in that case the resilient power of the community has already been lost because of the long period in which it was suffering this stress. So, if that is the situation if you have a single large infrequent disturbance it is possible that your community, will not be able to come back to the normalcy for a very long period of time.

Now, a good example in that case would be say an animal community. So, you have a community of animals and those animals are not the normal animals, because they have a very high load of sea parasites. Now, if you have a very high load of parasites or maybe some viral diseases in that community, if there is a large infrequent disturbance, then

because already they are very very stressed. So, their rates of reproduction or the rates of bringing the system back to normalcy is already hampered.

So, in that case if there is a large and frequent disturbance in the form of say a heavy amount of poaching, so these animals that are left out; they are already so disease and so weak that they will not be able to reproduce in a fast enough rate to bring the system to normal. So, this is what we are seeing in this particular instance. Now, we will look at some examples of these large infrequent disturbances.

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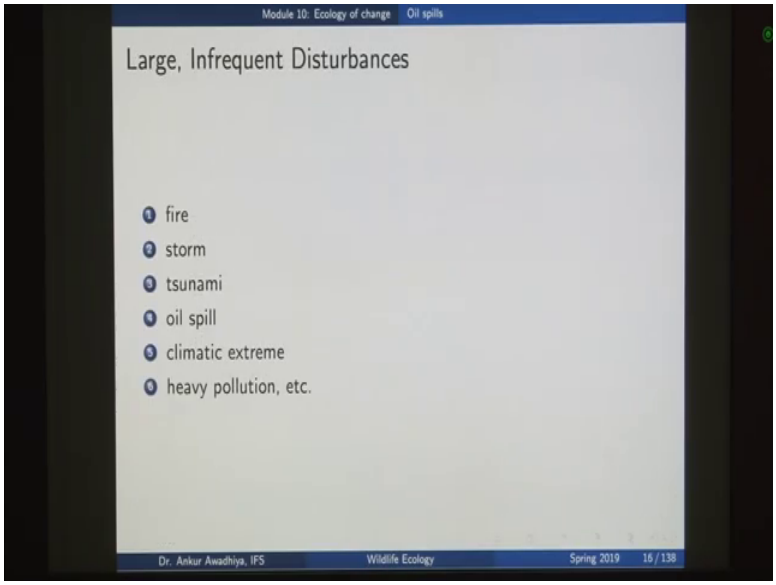

There can be things such as fire. So, there is a forest fire; a forest fire does not happen very frequently except in some specialized forest. So, we can say that it is an infrequent disturbance and it is large because of its large magnitude and the large area that it covers. Another example is a storm, so if you have a storm a very large area would be inundated, a number of trees would get uprooted.

Or a tsunami again in a tsunami there is a large amount of inundation and at the same time there is a heavy mechanical force that is applied by the large volume of water that is coming in and for a very long period of time most of the areas are will suffer from a heavy amount of salinity. Or things like oil spills; oil spills again our large infrequent disturbances because of their large impacts, they cover a very large area and most of their situations and their impacts are very wide and very diverse.

Or climatic extremes, so if you have a situation where your community suffers from a very severe drought. So, a very severe drought or a high amount of flooding would also count as a large infrequent disturbance, because in these situations as well the productivity of the whole community would go down and the impacts would be very severe. Or things like heavy pollution, so if there is an industry that is spewing out, say mercury rich compounds into an ecosystem, so that would again be a large infrequent disturbance.

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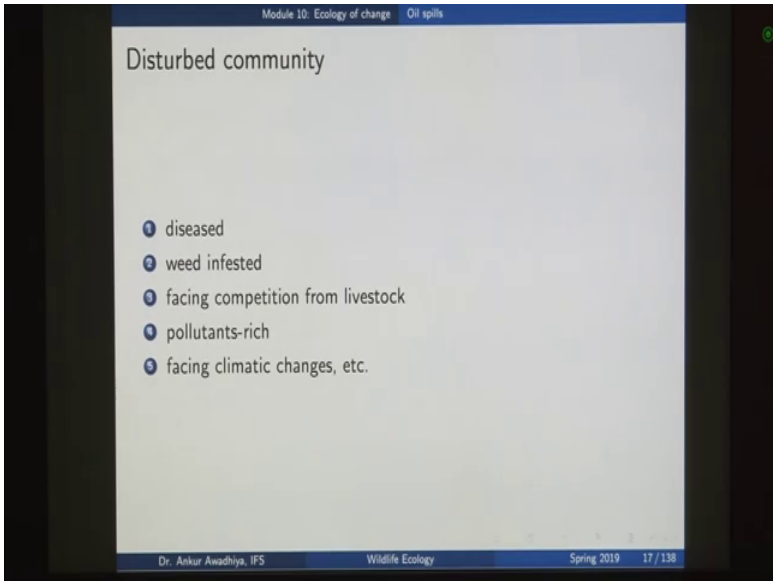

And when we talk about a community that is a disturbed community that is not a novel community, it could be a community that is either diseased it has a heavy load of pathogens or parasites or it is weed infested. So, a good example would be a forest that has a lot of cover of lantana, so because you have so many lantana around.

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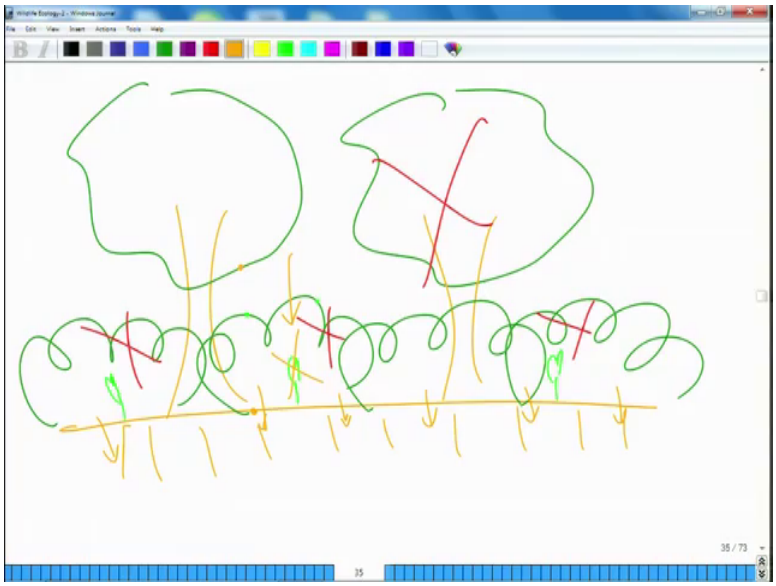

In a normal forest, you would have these trees and these trees would be giving out seeds. Now, once these seeds come to the soil, they start giving out the new regeneration. Now, if you have a scenario in which the whole of the ground cover is now covered with these shrubs of lantana, in that case this the seeds will not be able to reach to the ground, they will remain on top of these lantana bushes, because they are not able to reach to the ground. So, they will not germinate or even if they germinate, so if you have these lantana your seedling will not be able to get sufficient light from above.

So, in that case also the your seedling will not be able to germinate or grow properly or there would be some amount of allelopathy chemicals that this plant would be putting into the soil. Now, allelopathy as we have observed in a previous lecture is a situation in which one organism is trying to hamper the growth or to kill another organism by giving out some chemicals.

Now, lantana also being a member of the verbena sea family is known to give out certain chemicals into the soil, which then hampered the growth or even try to kill other seedlings and saplings, so that the amount of competition that it faces reduces. So, if you have such a forest that already has a heavy growth of lantana and if you now have a forest fire and in that forest fire a number of trees get burnt out.

So in that case the remaining trees, even if you are able to remove all of these lantana and it in that situation even if the seeds of this tree are able to reach to the ground,

because you already have a very heavy dose of the allelopathy chemicals; so, these seeds will not be able to germinate or probably in this case as well you will have the lantana that also has its root stock below the ground and when there is a chance of coming back. So, lantana will be able to out compete your seedlings. So, in that case this forest will not be able to reach back to the normal sea state. So, a heavy amount of weed infestation also counts as a disturbance in the community or facing competition from livestock.

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So, you have a situation where you have a forest and in this forest you say have a few trees and you have a very high amount of competition because of the livestock. So, now in this case even if these trees give out seeds that are able to reach the ground and they are able to give out these seedlings. So, the livestock comes and it eats away the seedlings. So, there is already a very heavy amount of pressure or disturbance in this community.

Now, if you have a forest fire and a few trees are now dead, but then you already have this heavy pressure of livestock. So, in that case whenever a new seedling comes up, the livestock will get it away. So, when that happens then the impact of the large infrequent disturbance such as the forest fire will never be completely removed from the system. So, the system will not be able to come back to normalcy.

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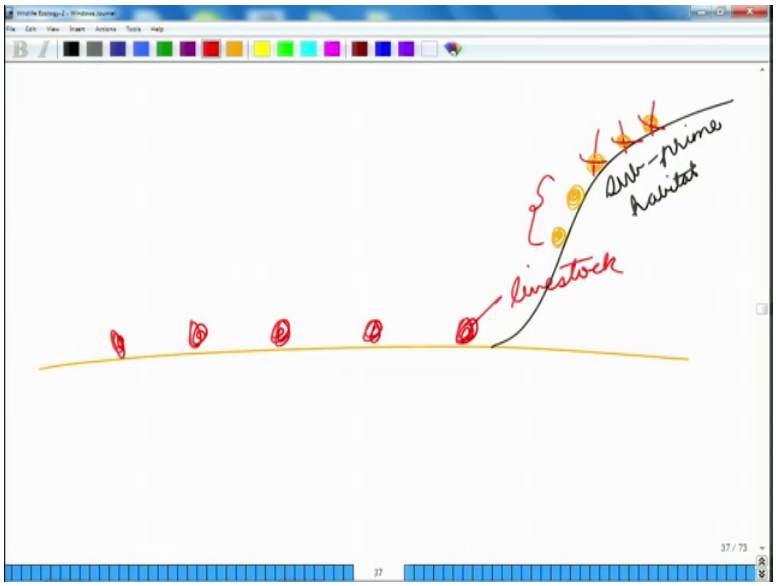

Or a situation in which you have a forest and in this forest you have a number of wild animals. Let us say we are talking about black bucks. Now if you have these black bucks and this area is also suffering from a heavy amount of competition from the livestock, so the red ones are the livestock. Now, because of a heavy pressure of livestock we might observe a situation of habitat displacement, now in the case of habitat displacement as we had seen.

The animals are forced to move into the sub-prime habitats. So, in this situation we will say that the black bucks are forced to move to the subprime habitat say in the hills. Now, in the subprime habitat you do not have sufficient amount of food available to these animals, you do not have sufficient amount of cover available to these animals. Now, these animals are already facing a lot of stress, so in that condition of stress the rate of reproduction would go down.

Now, if that is the situation and there you put in a large infrequent disturbance, say you have a spill of a disease or say a heavy amount of poaching or any other such life large infrequent disturbance and you say that a few animals die out. Now, these animals that are remaining, because they are already in your in a stress environment, because they already have a heavy amount of competition because of which they had to suffer from habitat displacement. And they are now in a place, where they are not having sufficient

access to food or water or shelter and so on. So, they will not be able to reproduce at a fast enough rate that they would be able to come back to the normalcy.

So in this situation as well; a heavy amount of competition from the livestock also counts as a significant disturbance to the community which will prevent it from coming back to normalcy. Another disturbance is a rich amount of pollutants that are already there in the system that will also have a very similar impact. So, with a heavy polluted dose a number of members of the community will be facing a huge amount of stress and in that stress they will not be having a high rate of reproduction.

So, in that case if you give a single large infrequent disturbance the community will be doomed or a community that is already facing climatic changes. So, there is a community that say lives in a cold area. Now, because of the climate change there was say a 1 degree rise in the main temperatures and in that case this community is already in a heavy amount of stress. Now, you give it a single large infrequent disturbance a single lid and because this community is already are stressed community, because it is already not in a situation where it has an optimum rate of reproduction or an optimum rate of population growth. So, a single LID will then wipe out this community for a very long period of time.

So, these are the large infrequent disturbances and the disturbances that communities face. Now, we will look at oil spills as a case study of a single large infrequent disturbance, the kinds of impacts that it brings about to the ecosystem and how ecosystems are able to go back or at the same time, how are we as human beings how do we act on these ecosystems in an effort to help them to recuperate back to the normalcy.

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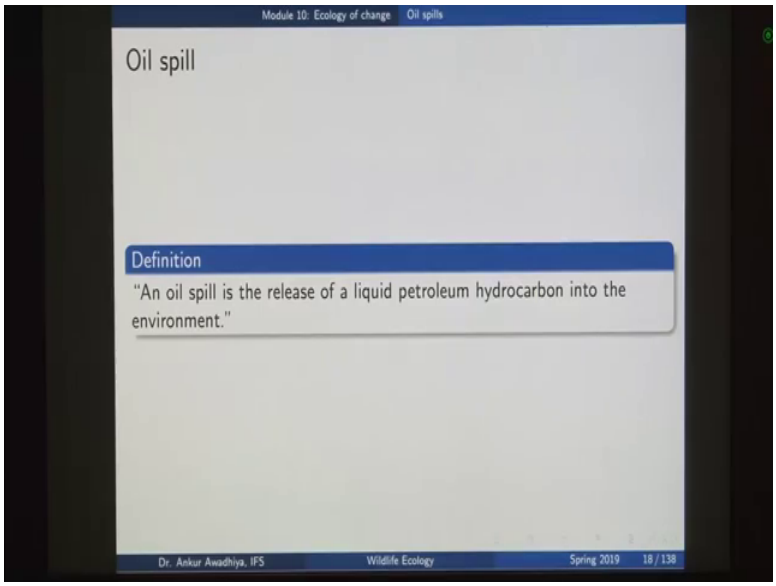

So, we will begin with oil spills now. Now, oil spill is the release of liquid petroleum hydrocarbon into the environment that is the definition, you have liquid petroleum hydrocarbons that gets released to the environment and that is an oil spill.

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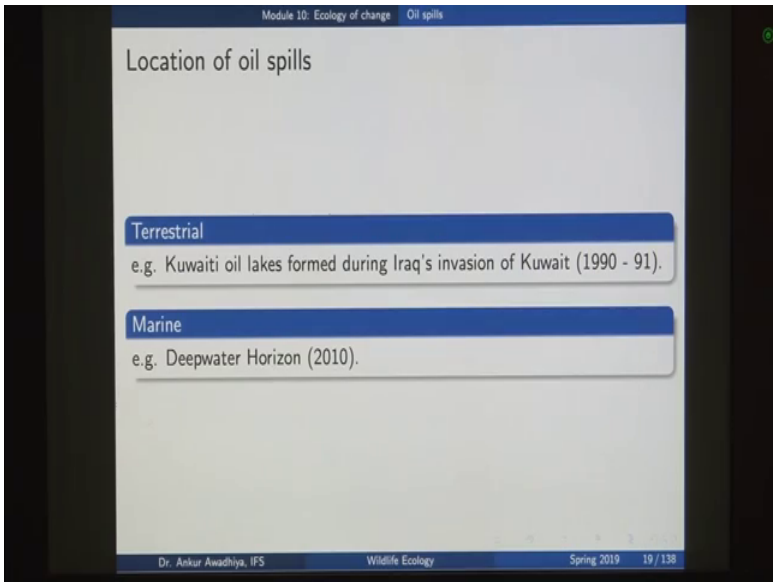

Now, these oil spills can be anywhere. So, you can have a terrestrial oil spill, where the oil spill is coming out on a portion of land a good example is the Kuwaiti oil leaks that were formed during the Iraq's invasion of Kuwait in 1990 – 91.

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So, when we say a terrestrial oil spill, this is how the oil spill looks like. So, you have this area that is predominantly a desert area and then you have an oil spill here. So, all these areas are now filled with oil. So, it becomes a lake of oil, so that is a terrestrial oil spill.

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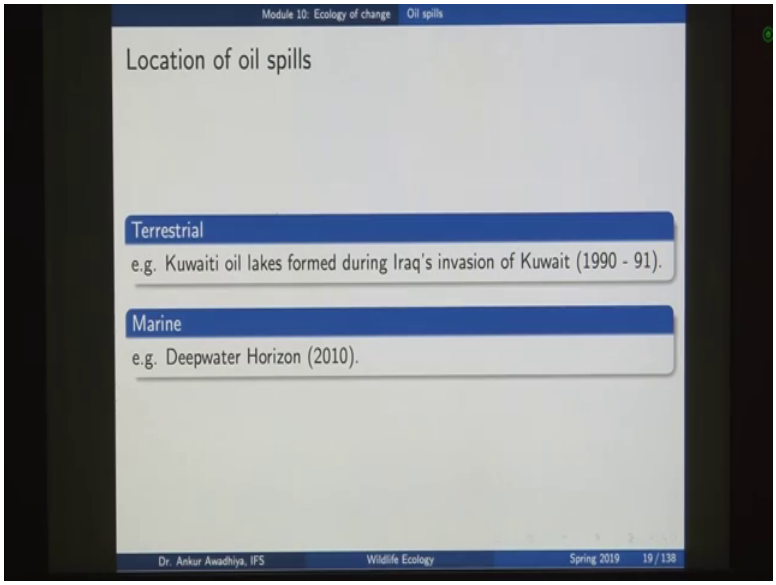

The second is a marine oil spill. So, in the case of a marine oil spill, the liquid petroleum hydrocarbons get released into the marine environment. So, they are released into the seas and the oceans.

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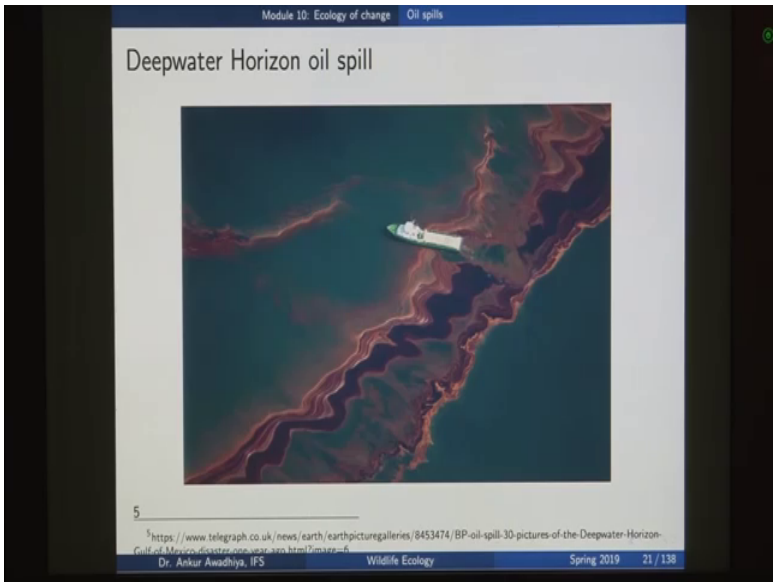

Now, this is an example the deepwater horizon oil spill of 2010. Now, in this case we observe that here you have the ocean and here you have a heavy amount of oil that is there on the surface of the ocean.

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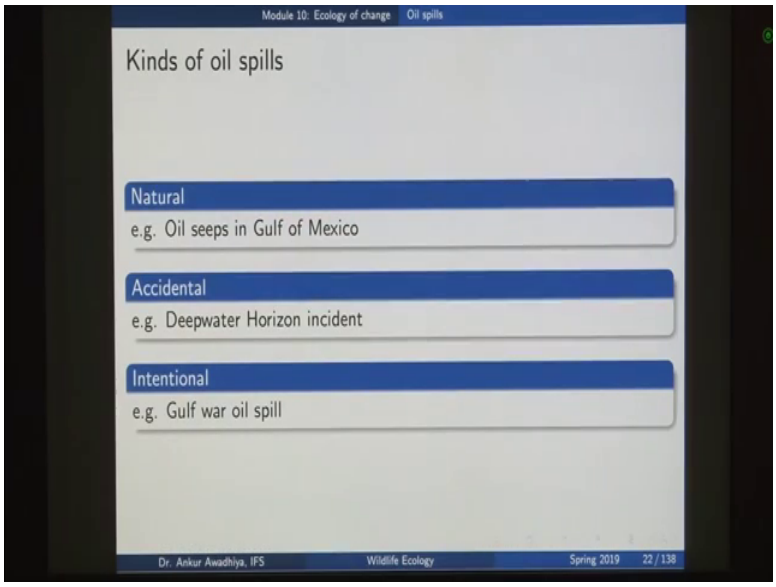

Now, based on their origins they can be classified into national oil spills, accidental oil spills or intentional oil spills. Now, natural oil spills are example is the oil seeps in the Gulf of Mexico.

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Now, in this case what happens is that you have the ocean and in the seabed, there is some amount of natural leakage of these hydrocarbons. So, when that happens some hydrocarbons are coming to the surface. So, this is how it looks like.

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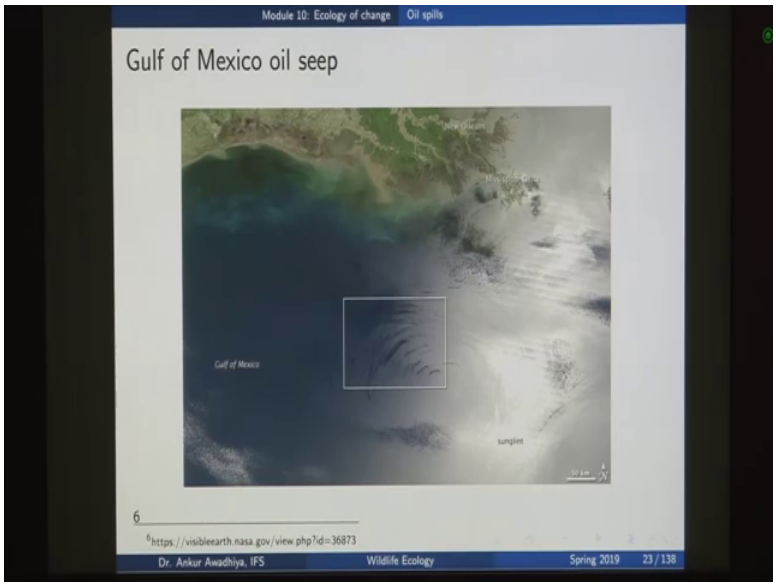

So, this is the gulf of Mexico oil seep and these streaks that we are observing, these are the oil spills that are coming and these are coming out naturally, these are not manmade, these are not intentional, these are not accidental.

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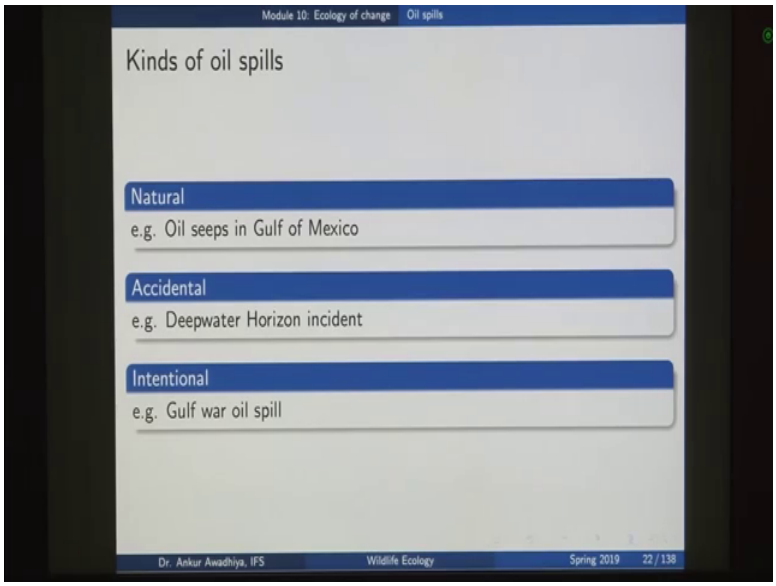

The second kind is an accidental oil spill example the deepwater horizon incident. So, nobody wanted to release this amount of oil, but just because of an accident it got released into the environment. Another example could be a situation in which there is a tanker that is full of oil and it collides with some other tanker or maybe with a rock. So, in that case the tanker capsizes and when it capsizes, it releases all the oil that it had into the environment, so that is an accidental oil spill.

And third one is an intentional oil spill, in which case human beings intentionally release oil into the environment in order to cause harm to somebody. So, a good example is the case of the Kuwaiti oil spills, in which there were people who spilled out oil into the environment.

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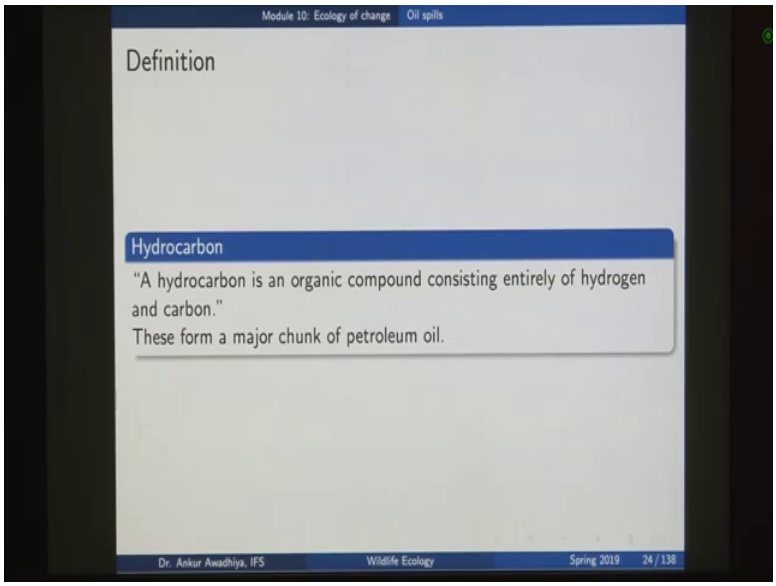

Now, when oil gets released into the environment, we have all these hydrocarbons that come up in the environment. Now, a hydrocarbon is an organic compound that consists entirely of hydrogen and carbon, which is why we have this term hydrocarbon hydrogen plus carbon. So, these are compounds that I made of hydrogen and carbon. And they form a major chunk of the petroleum that is released into the environment.

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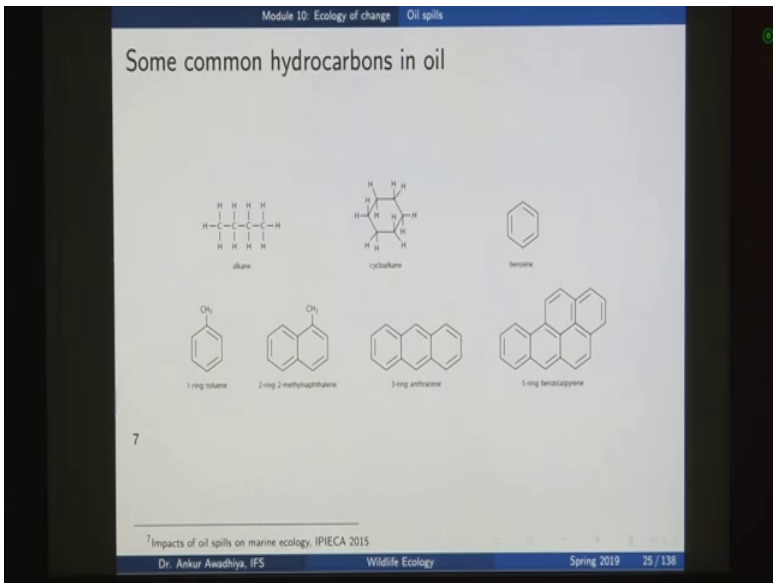

Now, these can be straight cane molecules, this can be cyclical molecules or these can be aromatic hydrocarbons. So, these are some common hydrocarbons that we see in oil and all of these will have different impacts on the ecosystem.

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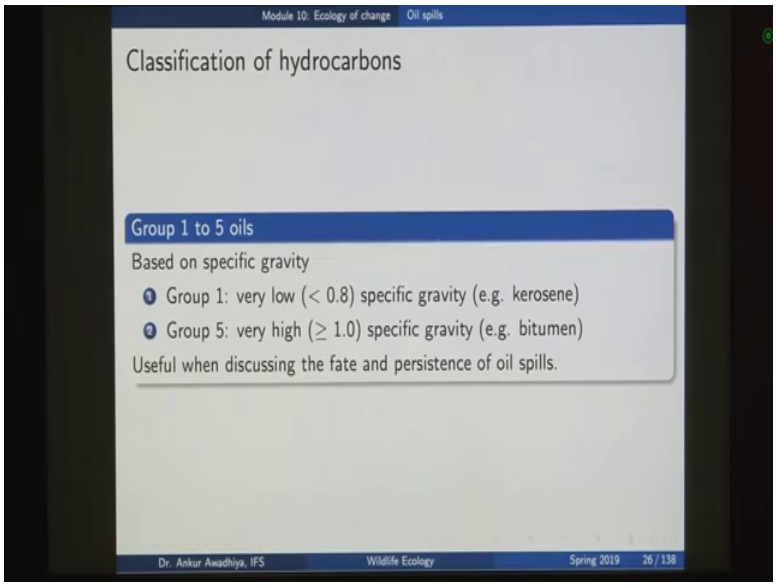

Now, we classify these hydrocarbons on the basis of their specific gravity. Now, group 1 hydrocarbons are those that have a very low specific gravity such as kerosene. Now, it becomes important to classify them on the basis of a specific gravity, because the group 1 hydrocarbons when they are released in a marine environment, they will remain on the top surface of the water. So, they will come to the top surface and they will be exposed to air they will be exposed to the sun; whereas, group 5 hydrocarbons are those that have a very high specific gravity that is greater than 1.

Now, in these situations, because they have a high specific gravity they will sink down to the bottom. Now, why is that important? It is important, because this helps us understand the impact of these hydrocarbons on different ecosystems. So, if there is an oil that comes to the surface, now if it comes to the surface, so birds will get exposed to it or maybe in the mammals that are coming to the surface to breathe. So, examples include whales or dolphins or even reptiles that come to the surface to breathe like turtles, they will all get exposed with this hydrocarbon, because this is on the top surface of the water.

So, any organism that is either reaching the waters from the top for example, birds that are looking out for her for fishes and they will get exposed. On any organism that is

moving from the bottom to the top to have access to the air, it will get exposed. And in the case of group 5 hydrocarbons with high specific gravity, they are coming down to the bottom of the oceans. Now, in the bottom of the oceans you will have a number of benthic communities or bottom dwellers.

Now, those bottom dwellers will then get exposed to the oil, now good examples include things like starfishes or a number of crab species that are living inside the oceans, so they will get exposed. So, this classification is used when discussing the fate and persistence of the oil spills. Fate and persistence, because if you have an oil that is coming to the top. So, on the top it will be oxidized because it is exposed to the air, it will also be acted upon by the UV rays of the sun.

And so the fate will be very different and also the persistence will be very different, because in the case of the hydrocarbons that are coming to the top, after a while they will be removed from the system because of various processes whereas, those hydrocarbons that are coming to the bottom of will probably persist for a very long period of time.

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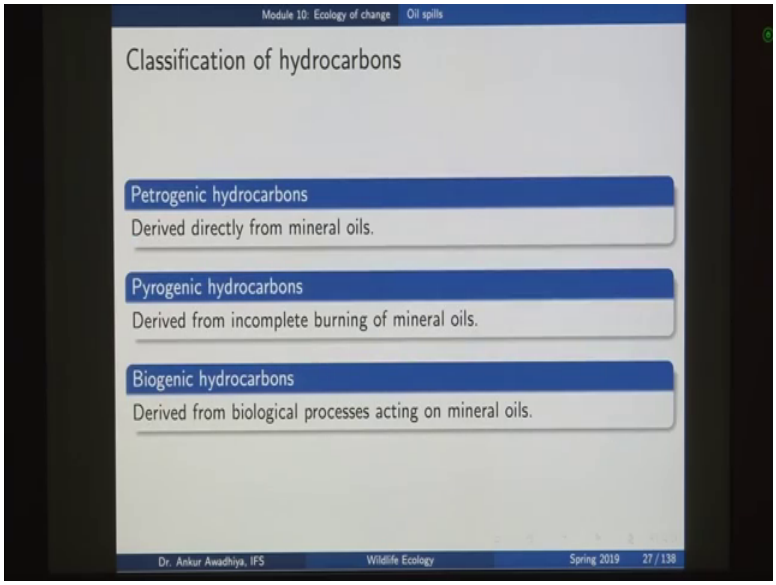

Now, these hydrocarbons are also classified as petrogenic. So, petrogenic is petro is rock, gene is formation; so petrogenic is something that is formed from the rocks or the petroleum. So, these are derived directly from the mineral oils. Now, the second one is pyrogenic these are derived from incomplete burning of mineral oils. So, if you have an oil spill that is coming to the top and it has a petrogenic oil spill you try to burn it off,

and when you are burning it any amount that remains, which is incompletely burnt well we called a pyrogenic hydrocarbon.

Now, the third classification is that of a biogenic hydrocarbon. Now, biogenic hydrocarbons are those that are derived from biological processes acting on the mineral oils. So, if you have some amount of microbial degradation that happens so anything that let us that is left out or that is half acted upon will be termed as a biogenic hydrocarbon.

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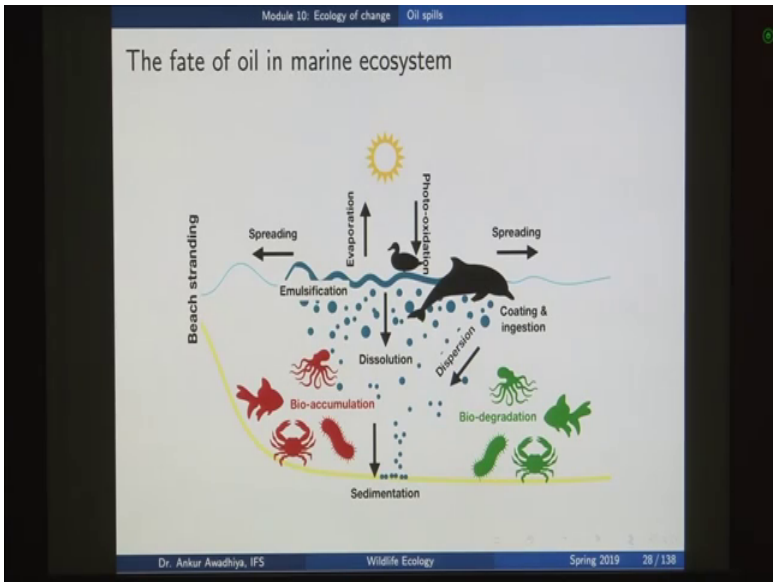

Now, talking about the fate; the fate will be very different depending on the categories of these hydrocarbons. Now, suppose there is an oil spill; now if it is there on the top surface, now here we are talking about the group 1 hydrocarbons. Now, the group 1 hydrocarbons are there on the top and because they have a low specific gravity, they have come to the top and because they also have a low density, so they will also be preferentially evaporated.

So, you have the heat from the sun and these are exposed to the air. So, there would be some amount that would get evaporated and that would be removed from this particular ecosystem. So, it will be carried away with air to some other location. The second thing that happens is photo-oxidation. Now, in the case of photo-oxidation you have photo is light and oxidation is the chemical reaction that occurs because of the oxygen.

Now, these hydrocarbons are exposed to the air and they are also exposed to the sun. So, in that case there would be some degenerative reactions that will happen and they will also remove some part of this oil away from the ecosystem. Now but because these are on the top and you have this water surface, so some amount will also be spread out; so because oil is lighter than water, so it will spread on the surface of the water and a large area will be impacted. So, in the case of group one hydrocarbons there is spreading and it impacts a very large area.

On the other hand, if we talk about the group 5 hydrocarbons, they would settle to the bottom, there would be some amount of sedimentation. And in this case, the impact will be more and more localized to that to that particular area, but then because the group 1 hydrocarbon that had come to the top they are spread to a very large area. So, the impact that they will have on the ecosystem will probably be comparatively much lesser than the impact of these sedimented hydrocarbons, because they are getting concentrated in the locality.

Now, the other things that would happen are things like emulsification. Now, emulsification is the process in which the oil droplets are able to come inside the water. So, in this case the oil is broken down into drops and these drops are then further broken down into very small droplets and these droplets are able to remain suspended in the water, so that is known as emulsification.

On the other hand, we will also have some amount of dissolution. So, if there are some other components of these hydrocarbons and that suppose have an OH group or maybe an acidic group. So, they will be able to dissolve into the waters, so there will be this process of dissolution. And also another process will be that of this coating in injection. So, because you have these hydrocarbons on the surface, if there is a bird that comes to the surface, if there is a dolphin that reaches the surface to get air. So, these animals will be coated with the oil and if this oil is able to reach their mouthparts, so, they will also be eating up some part of oil. So, there will be these processes of coating and ingestion.

Then there will be the process of dispersion in which the oil droplets get dispersed out, and if these oils are able to reach to the reaches. So, they will observe the process of beach stranding in which case this oil will quote up portions of the beach and will also have an impact on the terrestrial ecosystem. So, for instance if it covers up the roots of

the mangrove. So, the mangroves might start dying off or if it reaches to the surface, then it will also expose a number of terrestrial organisms to the impact of the oil.

Now, once it is once it has been acted upon or once it has reached the living organisms, now will observe two kinds of impacts. The first impact would be that of a bio-degradation. Now in this case the oil is acted upon by the enzymes that are present in the bodies of the organisms and they are rendered harmless, so that is the process of bio-degradation. So, the oil is degraded into some other chemicals and these chemicals do not now have an impact on the ecosystem, so that is a positive process.

On the other hand, we can also observe the processes of bio-accumulation. Now, because these oils are hydrophobic chemicals, so they might so their chemicals might get absorbed and they might get accumulated in the fatty tissues of these organisms, once that happens we might also observe the process of bio-magnification. So, for instance these chemicals that are present in the oil, they got absorbed in say microbes or say planktons and in that case their bodies now have the chemicals that represent in the oil.

Now, these planktons are then eaten up by the small fishes. So, all of those chemicals now reach the small fishes, but then one fish is going to eat say thousands or even millions of planktons. So, the amount of chemicals that was present in one single plankton that was a very small amount, but then the amount of the chemical that reaches the small fish is much more than was present in the plankton, because it is now getting the chemical from a number of planktons.

Now, when these small fishes are eaten up by the bigger fishes; so the bigger fishes would be eating a number of smaller fishes. So, they would then again magnify the amount of chemicals that are present in their bodies. So, as we move up the food chain will also observe bio-magnification. And the last process is that of sedimentation in which the heavier portions of the released hydrocarbons, they are able to sink to the bottom of the sea floor. Now, all of these processes are going to have some impact on the communities or on the ecosystems.

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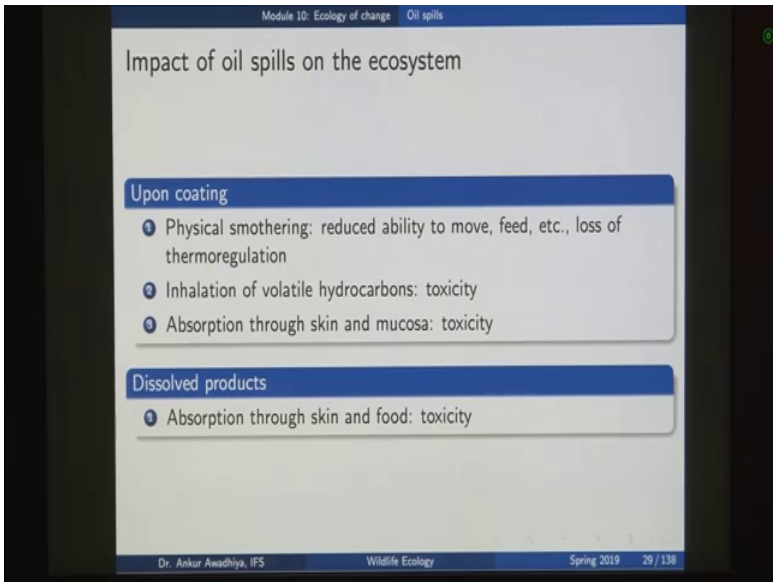

Now, these are the impacts that we might observe, upon coating there might be a physical smothering. Now, physically smothering is a process in which you are physically reducing the ability of the organism to move, to feed, etcetera. Also there would be some amount of loss of thermoregulation, because in the case of birds they have these feathers and the feathers are able to provide thermoregulation.

Now, if the oil coats up the surface of the feathers. So, they will not be able to stand up upright, they will not be able to hold air on the surface of their bodies and in that case they will lose out thermoregulation. So, they will now be exposed to the extremes of temperatures; so they might have die out of hypothermia or hypothermia. So, if they are exposed to cold environments, they will die off of hypothermia; if they are exposed to warm environments, they will die of hypothermia.

The second one is inhalation of the volatile hydrocarbons. So, those hydrocarbons that are volatiles, they will be inhaled, they will reached into the respiratory system, they might result in some amount of toxicity or absorption through the skin and mucosa. So, some of the chemicals will get absorbed into the body and sure they are toxic if impacts. So, this is upon coating if these chemicals get dissolved. So, if they are dissolved, so they will also get absorbed through the skin or through food and be able to show their toxic behaviours.

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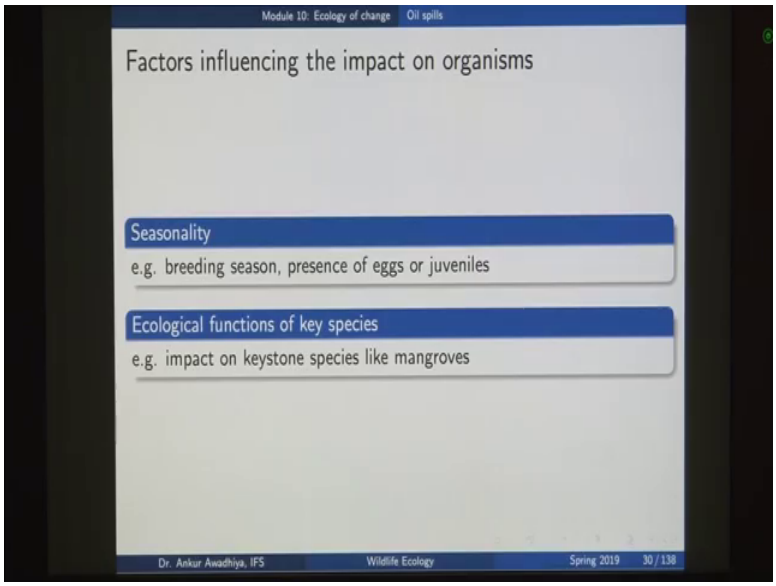

Now, the factors that influence the impact on these hydrocarbons include things like seasonality. So, if you have a community in that is in its breeding season, now if you impact this community in the breeding season, so you are not allowing the young ones to come up or if they are up and there is presence of eggs or juveniles.

Now, when an organism is having the young ones, it is having the off springs. So, typically in those organisms that are that show parental behaviour, the parents are already very much stressed, because they not only have to bring food for themselves, but they also have to procure food for the off springs.

Now, in that case if you have this large infrequent disturbance of oil spill. So, the impact on the community will be very large or if you have eggs or juveniles nearby. So, if you have a juvenile, so a juvenile or a young organism is not able to fend itself off in an optimum manner as compared to the adults. So, in this case the impact of the oil will be much greater. The impact on the organisms will also depend on which organism is impacted.

So, if there is an impact on the keystone species like mangroves, so the impact on the ecosystem will be much greater. So, in the case of mangroves they provide shelter to fishes and they serve as a nursery for fishes and so on. So, if mangroves are impacted, if mangroves die out, the impact on the whole ecosystem will be much greater than otherwise.

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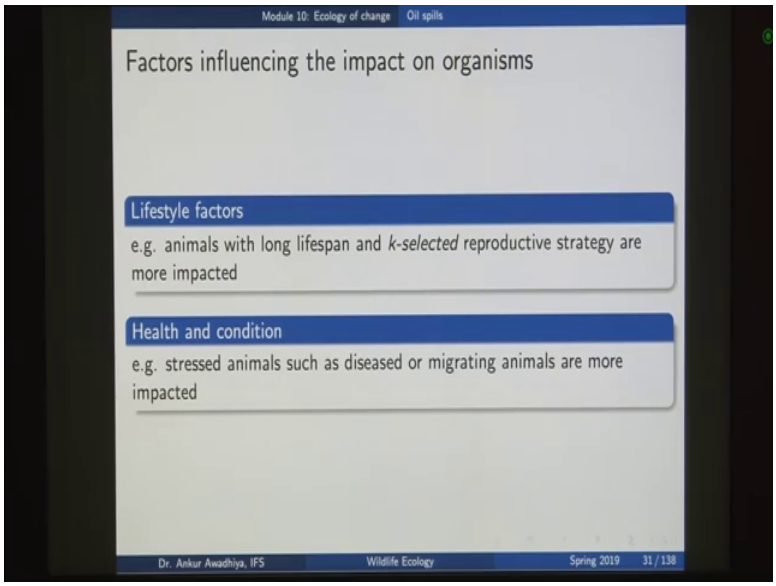

It would also depend on the lifestyle of the organisms. So, those organisms that have a long lifespan and k-selected reproductive strategy will be more impacted. So, we have seen in the population dynamics classes that organisms can have two strategies; one is the k-selected strategy, this is the second one is the r-selected strategy. Now, in the case of a k-selected strategy the organism produces less number of off springs, they take more time to sexual maturity and they involves some amount of parental care.

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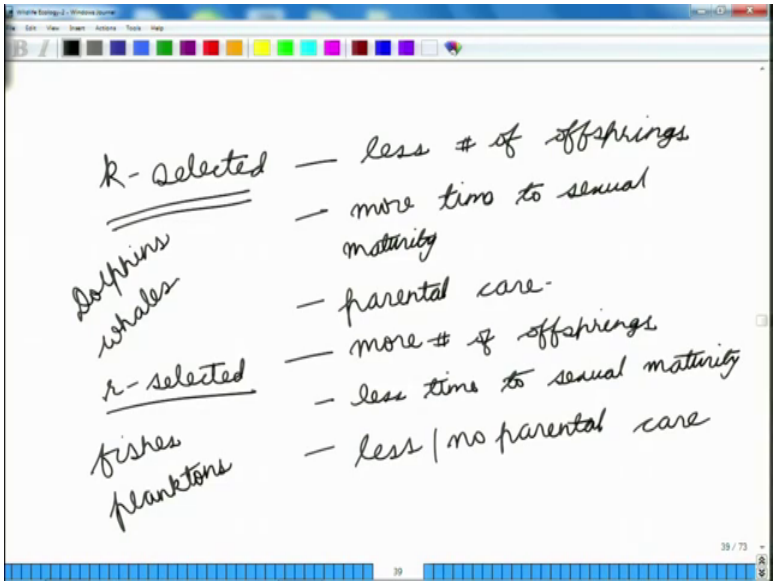

Now, in this case the strategy of the organism is to produce less number of off springs and to devote more time and more attention to those off springs, so that they are able to survive and produce their own off springs. So, it is a method of enhancing fitness of the species by producing less number of off springs and giving them more time and attention. But then because we have less number of off springs, so if those off springs die out, the species does not have another way to produce more number of off springs, because that this species has already selected the k-selected strategy.

Good examples include things like dolphins or in the case of terrestrial ecosystems things like tigers. Now, the impact on dolphins and whales will be much greater, because they are k-selected organisms. Now, the second kind of organisms are the r-selected organisms, which show a very different strategy to increase their fitness. So, they produce more number of off springs, they take less time to sexual maturity and less or no parental care.

Now, examples include fishes. So, in the case of fish two individuals will lay say hundreds or even thousands of eggs, they will take less time to sexually majority say a few months and there will be little or no parental care. So, once these off springs have come out of their eggs, so they are now on their own or other good examples include the planktons. So, the impact on a k-selected organism will be much greater, because it will not be able to come back to the normalcy, because it does not have the capability to produce more number of off springs.

Now, along with the lifestyle factors other factors that play an important role is the health and condition of the organisms. So, if there are organisms that are already stressed, they are already diseased or migrating, so the impact on them will be much greater.

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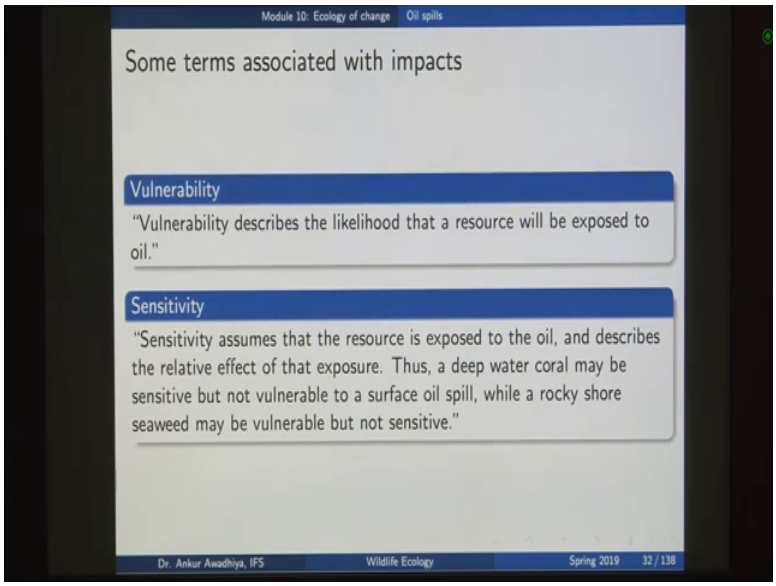

Now, when we talk about the impact, there are these two terms that we should know the first one is vulnerability. Vulnerability describes the likelihood that a resource will be exposed to oil. And sensitivity it says that if our resource is already exposed to the oil, what are the impacts or the effects of that exposure. Now, an example is when we talk about a deep water coral. So, a deep water coral may be sensitive, because if you expose it to the oil, so it might die out very easily, but then it is not vulnerable to a surface oil spill why, because it is not there on the surface, it is there in the deep waters.

So, because it is not exposed, so it is not vulnerable; but if you expose it artificially or in certain situations when it gets exposed, it is very much sensitive, so it dies out. On the other hand, a rocky shore seaweed may be vulnerable, but it is not sensitive why? Because you have the seaweed that is there on the surface, it is there on the shores. So, when you have this oil spill it might be able to reach the shores, when it reaches the shores this organism the seaweed it becomes exposed to the oil, so it is vulnerable.

But then it has a very good mucus covering on its surface, which is able to thwart the impacts of the oil. So, even though it is vulnerable it gets exposed to the oil, but then this oil is not able to produce much effect on this organism, so it is not sensitive. So, the organisms that are both vulnerable and sensitive, will have much more amount of impact than those organisms that are either not vulnerable or not sensitive or neither vulnerable

nor sensitive. So, vulnerably and vulnerability and sensitivity play a huge role in determining the impacts on different portions of the ecosystem.

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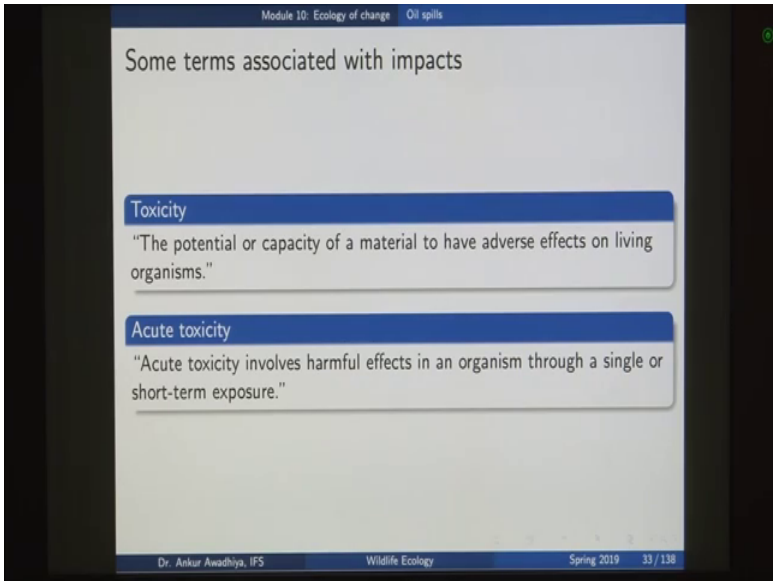

The other terms are toxicity. So, toxicity is the potential or capacity of a material to have adverse effects on living organisms. So, when we say that there could be some toxic components in the oil, it means that there are some components in the oil that will be able to produce adverse impacts or negative impacts on the living organisms.

Now, toxicity is divided into acute toxicity and chronic toxicity. Acute toxicity involves harmful effects on in an organism through a single or a short-term exposure. So, acute toxicity is short-term toxicity, so for instance if you say give cyanide to an organism, the organism will die out, so that is an acute toxicity, because cyanide is able to act very fast.

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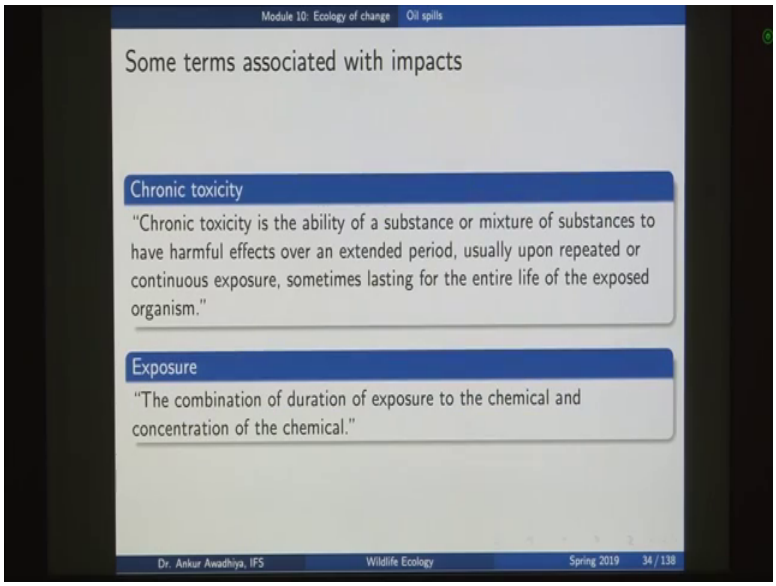

On the other hand, there are things like chronic toxicity. So, chronic toxicity is the ability of a substance or a mixture of substances to have harmful effects over an extended period of time, usually upon repeated or continuous exposure, sometimes lasting for the entire life of the exposed organism.

So, a good example could be some time some types of pollutants; so if you have a heavy amount of air pollution in your area that might be able to produce a negative impact in into your bodies, but then it will take a very long period of time to show its effect. So, it is known as a chronic toxicity or this would include things such as the pesticides.

So, there are pesticides that have a very acute toxicity. So, if somebody is exposed to a pesticide in a huge amount, he or she might die out, but at the same time if we are getting small doses of pesticides because of the food that we are eating every day. So, if those pesticides get accumulated in the body, so over a very long period of time, they will also show their own impacts.

So, for instance you are using pesticides in say rice or wheat and these rice and wheat are not cleaned up properly and the pesticides residues remain in these rice and wheat. So, if you eat these raised in wheat, the pesticide slowly go on accumulating in your body and over a very long period of time, they will show toxicity which will be classified as chronic toxicity.

Now, there is another term, which is exposure. Exposure is the combination of duration of exposure to the chemical and the concentration of the chemical; so the time to which the chemical was exposed to and the concentration of the chemical. Again coming back to the example of the pesticides, if you are having a heavy concentration of pesticide and you expose an organism to that it is a heavy exposure or if you have a slight moderate concentration of the pesticide and you expose the organism for a very long period of time that again would count as a significant exposure to the chemical.

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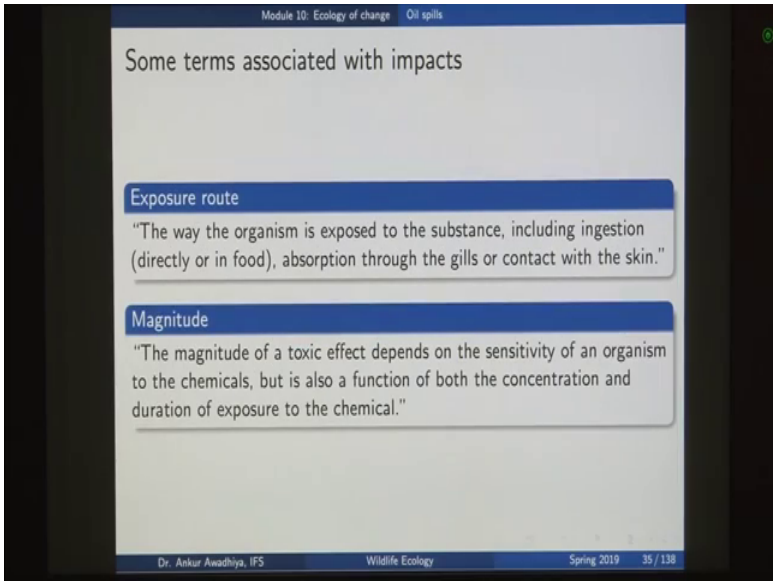

Then we also talked about the exposure routes. So, exposure route is the way the organism is getting exposed to the substance. So, this includes ingestion, so in which the organism is eating the chemical or it is getting absorbed from the surface such as the gills or through contact with the skin, so that is the exposure route. Now, different chemicals get absorbed through different exposure routes and they might be having different impacts on these different organisms that are forming a part of the ecosystem.

The next term is magnitude. The magnitude of a toxic effect depends on the sensitivity of the organism to the chemicals, but it is also a function of both the concentration and duration of the exposure to the chemical. So, the magnitude of the impact would depend on how much sensitive the organism is to the chemicals. So, if you expose corals to the chemical, so they would die out very fast; if you expose the seaweeds to the chemical, they will die out very slowly, because corals are much more sensitive.

So, if an organism is sensitive, the impact will be much greater; also if the organism is not that sensitive, but you are exposing it to a very heavy concentration for a very long period of time, then also the impact will be large or the magnitude will be large.

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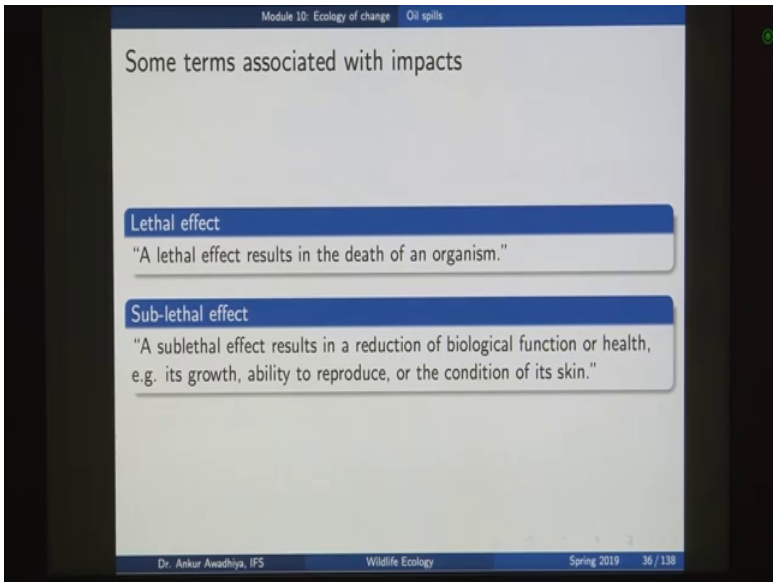

And when these magnitudes are large, they might even result in the lethality to the organism. So, lethality is a term that we use when there is a death of the organism. So, you expose these organisms to the oil and there are some organisms such as dolphins that died out. So, we will say that the oil had a lethal effect on the dolphins.

On the other hand and it might also have a sub-lethal effect in which there is a reduction of biological function or health. So, you expose planktons to these oils and these planktons did not die out, but then their growth rate say reduced. So, in that case we will say that there was a sub-lethal effect on these organisms.

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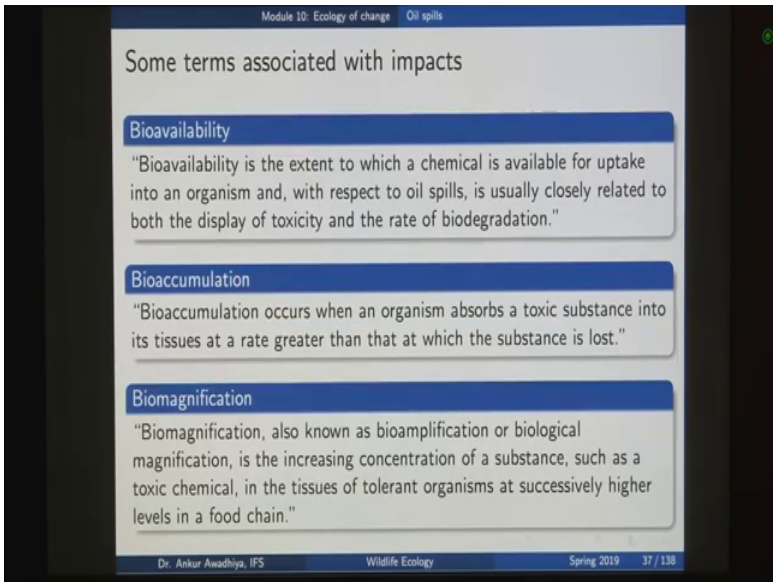

Now, the other terms are bioavailability. Bioavailability is the extent to which a chemical is available for uptake into an organism. Now, with respect to oil spills, it is usually closely related to both the display of toxicity and the rate of biodegradation. Now, bioavailability would say how much toxic is this organ is this chemical and for how long a period is it available to be absorbed by these different organisms. So, if it is a persistent chemical, so it will be bio available for a very long period of time.

Now, the second term is bioaccumulation. Bioaccumulation occurs, when an organism absorbs a toxic substance into its tissues at a rate that is greater than at which the substance is lost.

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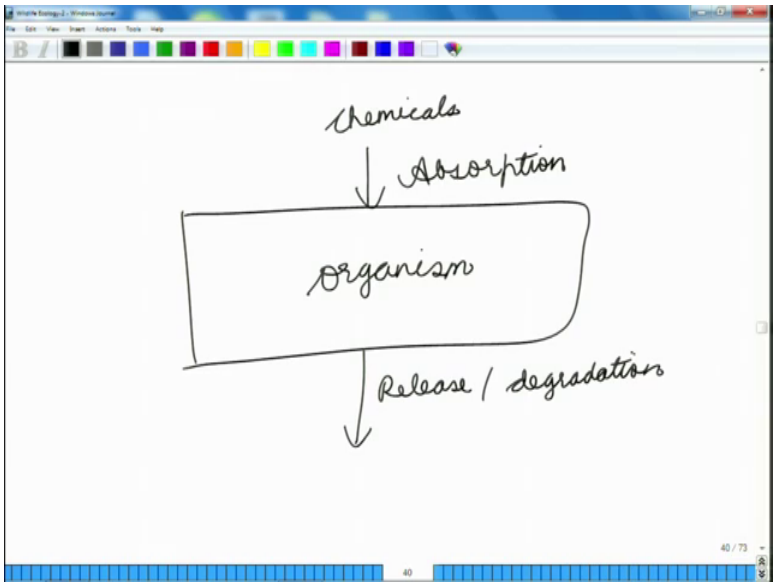

Now, what we are seeing here is that if you have an organism so here you have the organism and this organism is getting exposed to the chemicals that are there in the oil. So, it is absorbing some amount of so this is this process of absorption of chemicals. So, the chemicals are getting absorbed and then these chemicals are also getting released out. So, there is a release or degradation through which these chemicals are getting out of the system that is that they are getting out of the organism.

Now, they are getting released, because they are getting processed by the livers of the organism or by the kidneys of the organism and these are actively being thrown out of the body, because these are not good chemicals for the body, so the body is trying to throw them out. Now, if the amount or the rate of absorption is greater than the rate at which these chemicals are getting out of the body, then we will see that there is some amount of accumulation in the body.

So, for instance you took in say 100 grams of a chemical and you were able to release only 90 grams of the chemical. So, 10 grams of this chemical now become accumulated into your body, so that is known as bioaccumulation, when the rate of absorption is greater than the rate of degradation or the rate of release. Now, typically this happens in the case of those chemicals that decide in the fatty tissues. So, in the case of hydrophobic chemicals, they will reside in the fatty tissues and then it becomes very difficult to throw them out of the body systems.

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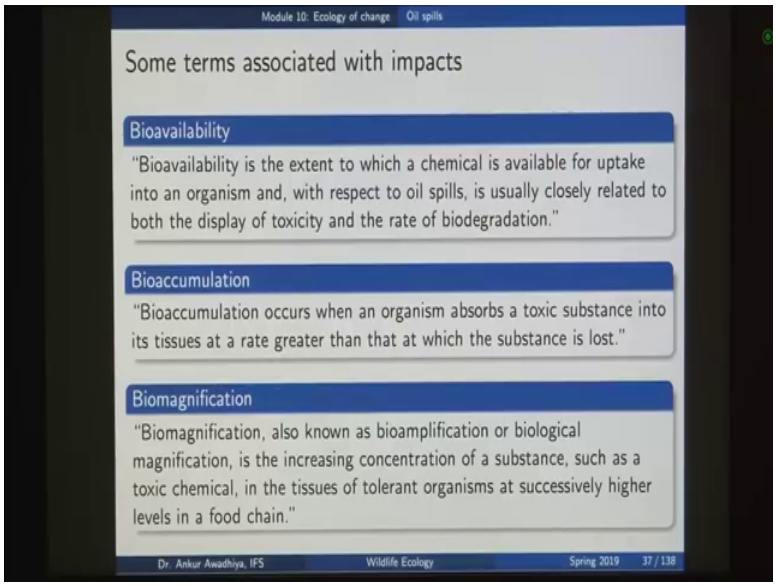

Now, another term is that of bio magnification or bio amplification. So, in the case of bio magnification, there is an increased concentration of this of the substance such as the toxic chemical in the tissues of the organisms at successively higher levels in the food chain.

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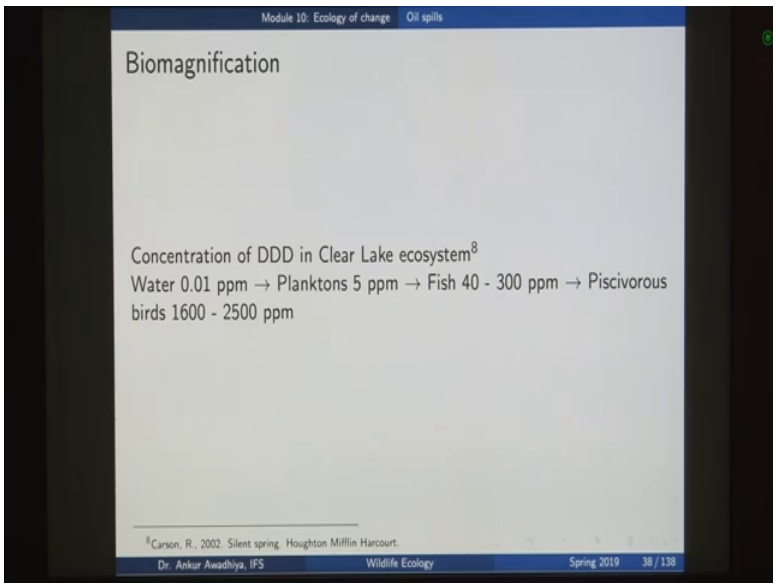

And a good example is provided by the concentration of DDD in the clear lake ecosystem. Now, DDD is a chemical that was used before DDT was invented or was used in a large measure. So, in the case of this clear lake ecosystem, there was a spray of

DDD to control certain organisms. And when this spray was done, the concentration of the chemical in the water was 0.01 parts per million. There was a very low concentration of this chemical in the waters, but then if we look at the planktons that were there in the system, they were able to accumulate this chemical to a larger concentration of 5 parts per million.

Now, why was that, because the planktons were able to absorb this chemical, but they were not able to release this chemical out of their bodies. So, there was bioaccumulation in this case, so even though you have a very low concentration in water, the amount that is there in the planktons is much larger. Now, if we looked at the fishes, they had a concentration between 40 and 300 parts per million. So, from 5 parts per million you have 40 to 300 parts per million.

Now, why is that so, again because one fish will be eating a number of planktons and all of those chemicals all the DDD that was present in these planktons that is now reaching into the bodies of the fishes. And there is bioaccumulation at the level of the fishes as well, so the amount of DDD that these fishes are getting into their body, they are not able to release all of that out from their own bodies. So, the chemical gets concentrated in their bodies. So, from 5 ppm it reaches, 300 ppm.

Now, if you look at the birds, the birds had an even higher concentration; 1600 to 2500 parts per million. Now, we could say that such a low concentration 0.01 parts per million in water may not have a very high impact on a number of organisms, but it is a very low concentration, but then because this chemical gets accumulated in the bodies and because it gets magnified through the food chain. So, if you have such a heavy concentration of the chemicals 2500 ppm of DDD in your body that will have a negative influence on the organism.

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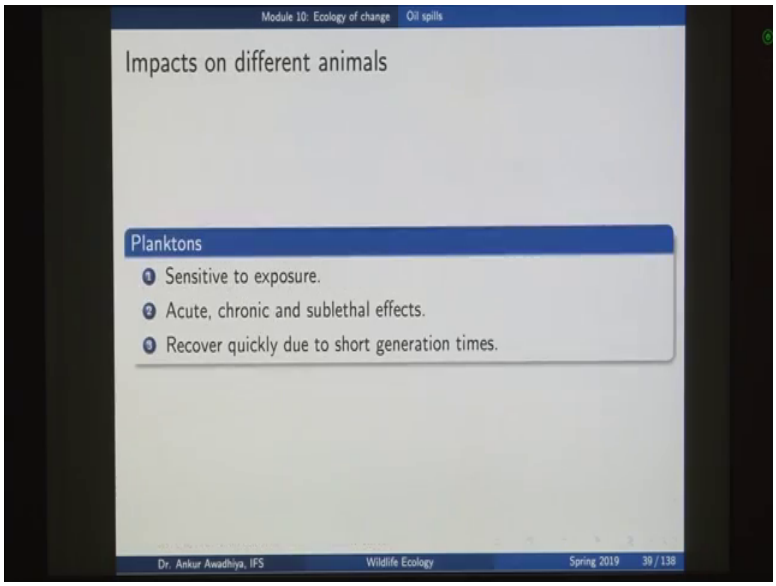

Now, if we look at the impacts on different animals. So, we have so far looked at the impacts theoretically, whether it is a k-selected or an r-selected species, it would have a differential impact. Whether it has a juvenile or whether it has an adult feel, it will have a differential impact, but then what are the actual impacts that we observe in different organism.

In the case of planktons, they are sensitive to exposure. So, if you expose the planktons, they will die out. There is acute, chronic and sub-lethal effects but then they are able to recover quickly because of their short generation times, because they are r-selected.

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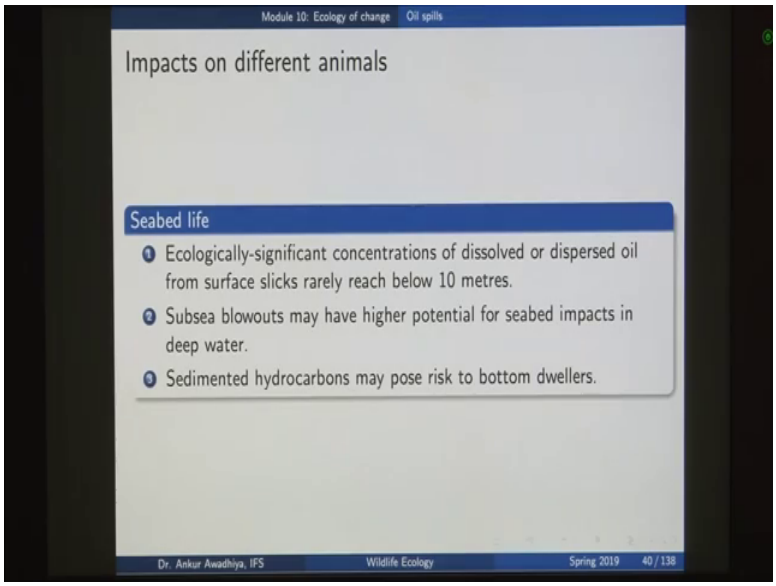

In the case of seabed life, you have ecologically-significant concentrations of dissolved or dispersed oil from surface slicks rarely reaches below the 10 meters. So, in this case they are less vulnerable, they are not that much exposed to the oil except in the case of subsea releases or subsea blowouts that have a larger potential. And the sedimented hydrocarbons may also pose a risk to the bottom dwellers, but then because the vulnerability is less.

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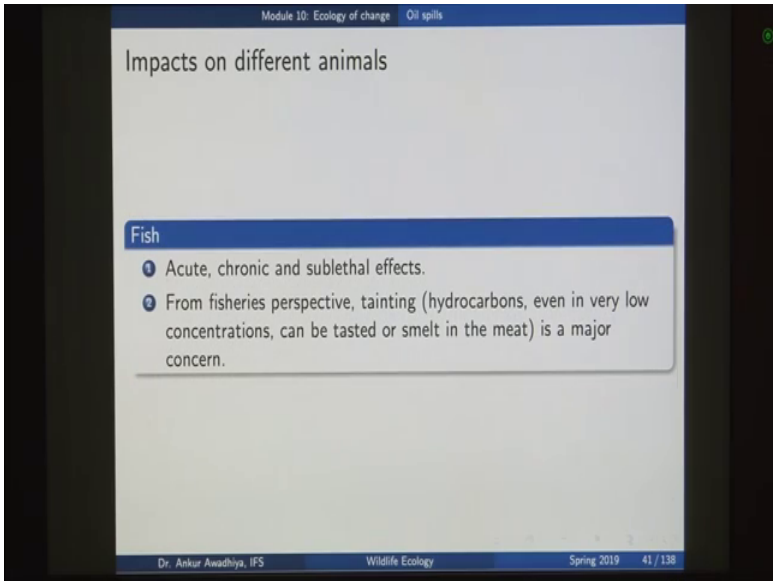

So, there is a less impact that has been noted in the ecosystems. In the case of fishes, there is an acute, chronic and sublethal effect. So, the fishes do not die out, because they do not have to come to the surface often, but there is a sub lethal effect. And in the case of the fishery industry, it causes a huge impact because of the process of tainting. So, in the case of tainting, because you have a very low amount of hydrocarbons in the system, people are able to smell it in the meat of the fish, so they do not like that particular fish.

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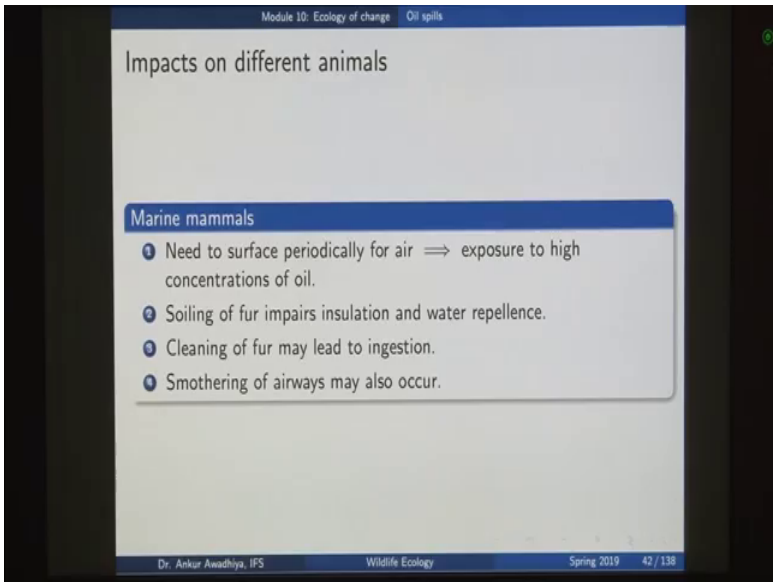

In the case of marine mammals, the effect is much more, because they need to surface periodically for air and so they are exposed to high concentrations of oil. And in this case, if there is soiling of fur, then it impairs the insulation and water repellence, the cleaning of fur by licking it, may lead to ingestion or there could be a smothering of airways if the oil reaches into the air ways. So, the impacts are much greater in the case of the marine mammals.

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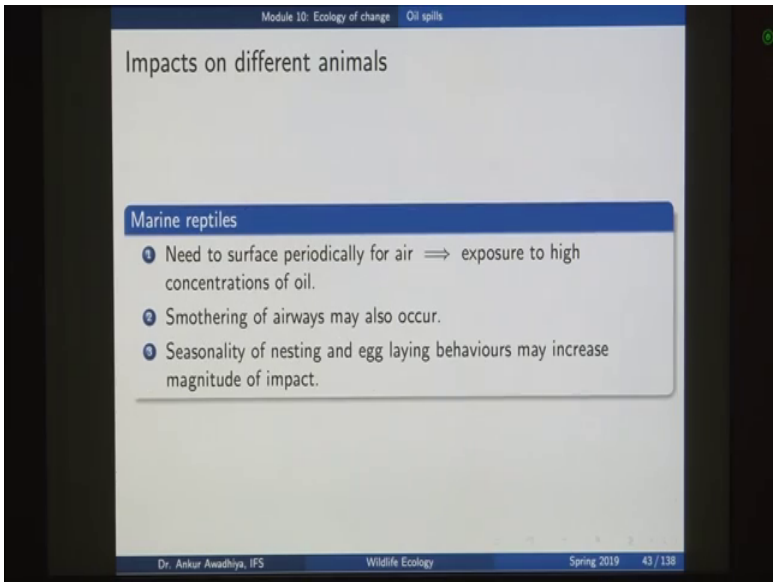

Also in the case of marine reptiles, they also need to surface periodically for air, they are also exposed to very high concentrations of oil and here although there is a large skilled lethality that is observed because of smothering and especially if there is a seasonality of nesting and egg laying behaviour. So, if these animals are there in the egg laying stage, so in that case the impact will be much greater.

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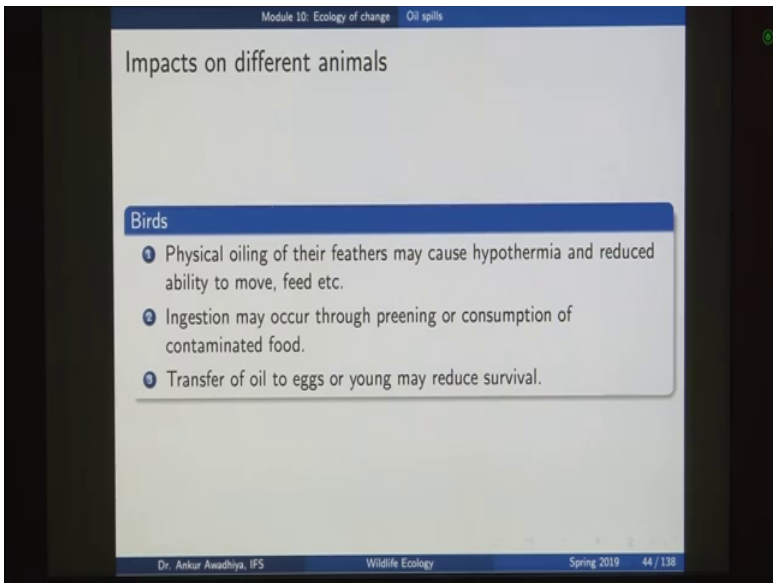

In the case of birds, for those birds that are coming down to look for fishes, they are also exposed to very high concentrations of oil and in this case also if there is physical oiling

that causes hypothermia reduced ability to move, reduce ability to feed, there could be ingestion; if they are preening or if they are they are feeding on this contaminated food because of the process of bio magnification. And there is transfer of oil to eggs and young ones, if there is such a transfer, then it also reduces the amount of survival, because if there is oil on the body of the bird and if it goes and sits on the eggs, then it might cover the egg and in that process the egg will not be able to get oxygen for the development chick.

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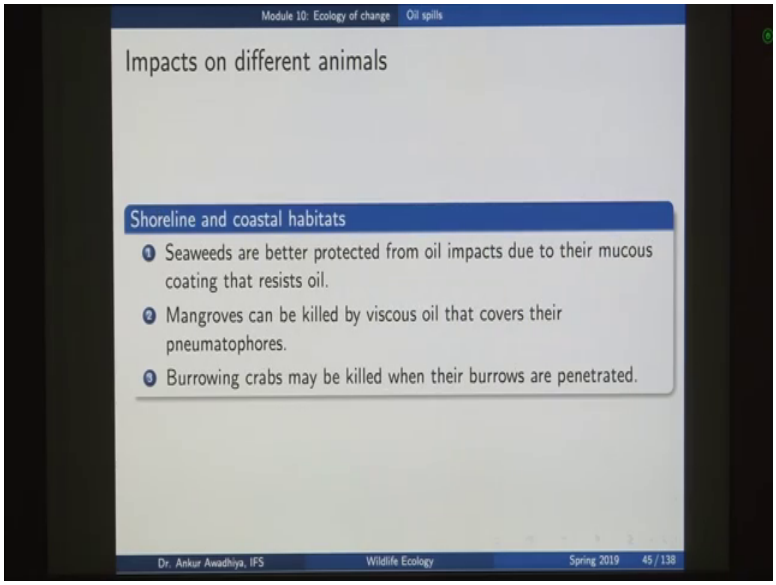

In the case of shoreline and coastal habitats, the seaweeds are much better protected from oils because of the mucus coating that is the soil. So, the sensitivity is less, but mangroves get killed very easily, because there are new metaphors or the roots that bring in air they get clumped. Burrowing crabs may be killed if their burrows get inundated with oil.

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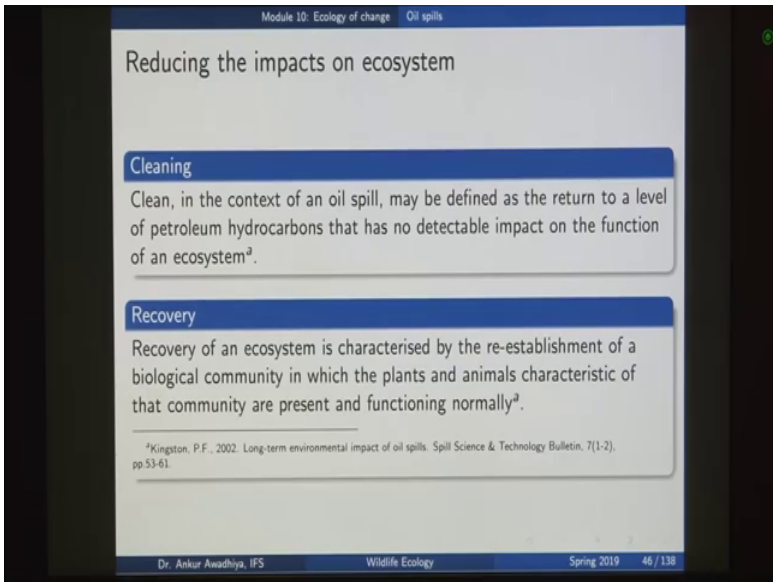

And because of these large impacts on different organisms of the ecosystem, the cleaning and recovery becomes very important. So, cleaning and recovery is a process through which we are here we are trying to help the ecosystem to come back to its normal stage. So, there is this large infrequent disturbance, which brought the ecosystem down, so we are trying to bring it back to the normal state.

Now, cleaning in this context refers to a level of a return to a level of petroleum hydrocarbons that has no detectable impact on the function of the ecosystem. So, you are trying to reduce the amount of oil that is present in the ecosystem. And recovery is the reestablishment of the biological community in which the plants and animals, characteristic of that community are present and are functioning normally. So, we are trying to reduce the amount of oil and you are also trying to help the ecosystem come back to its normalcy.

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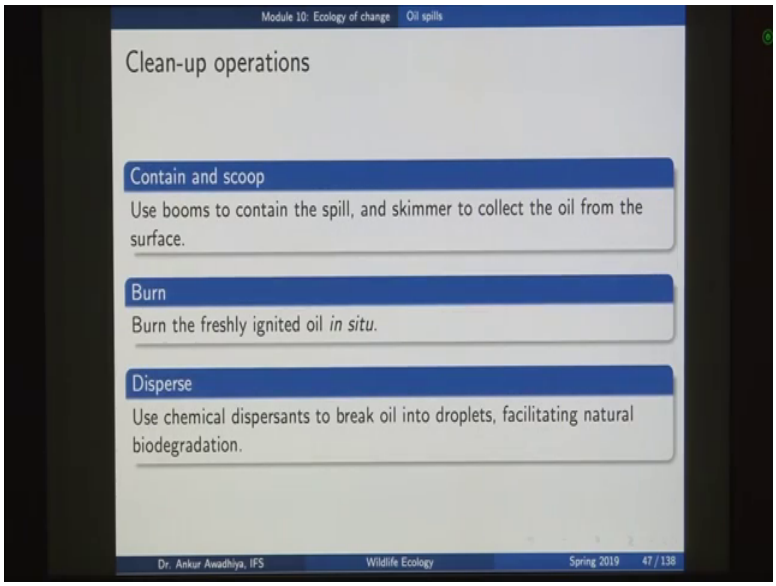

So, cleaning operations include containing scooping operations in which the oil is physically removed or you can burn the oil or you can disperse the oil using detergents.

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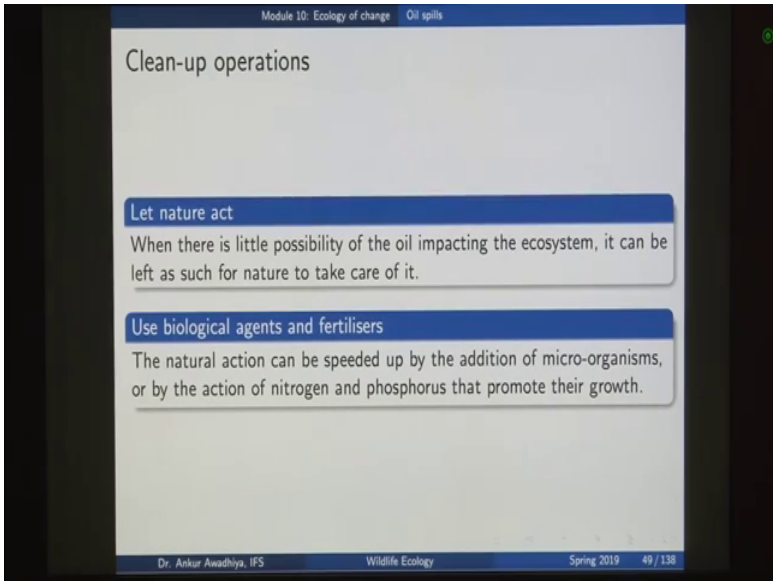

Or you can just let nature act, because you already haves so many natural processes photo oxidation, dispersion and so on that will reduce the amount of oil that is present in the ecosystem or you can make use of biological agents and fertilizers so in which case you try to increase the microbial community that is there, so that it kills off the oil.

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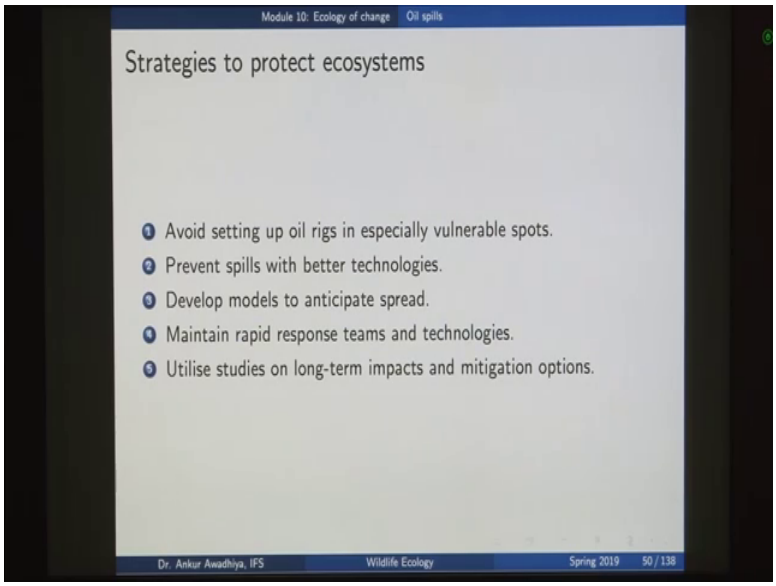

But then the most prudent strategies are to avoid sitting above oil rigs and vulnerable spots. Prevent spills with better technologies develop models to anticipate spread, so that you are able to concentrate your effort to those areas that will be more susceptible. Maintain rapid response teams and technologies and utilize studies on long-term impacts and mitigation options in all of your oil operations. So that is all for today; today we looked at the impact that large infrequent disturbances can have on the ecosystems and then we looked at the oil spills in a much greater detail as a case study.

So, thank you for your attention. [FL].