Wildlife Conservation
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Lecture – 36
Oil Spills

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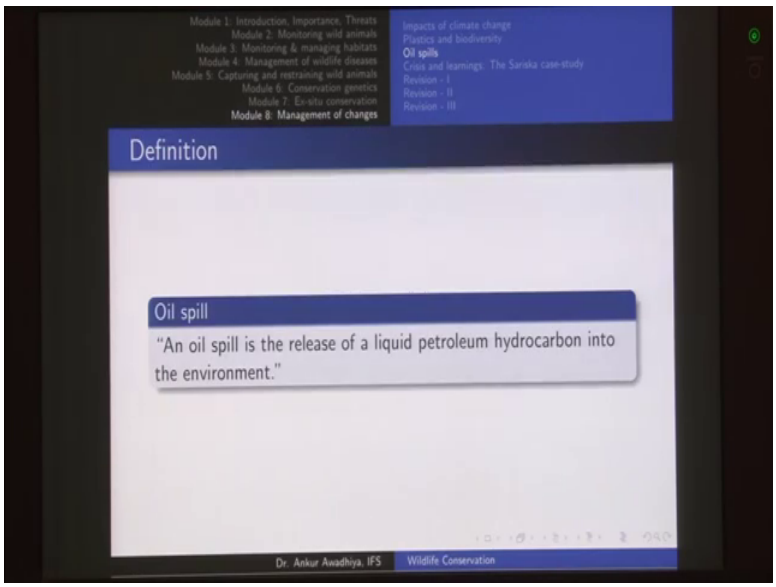

[FL] In today's class, we will have a look at the impacts of oil spills on our biodiversity. So, what is an oil spill? An oil spill is defined as the release of liquid petroleum hydrocarbon into the environment. So, liquid petroleum hydrocarbon is something that comes out from the ground; and if it gets released into the environment, we will call it an oil spill.

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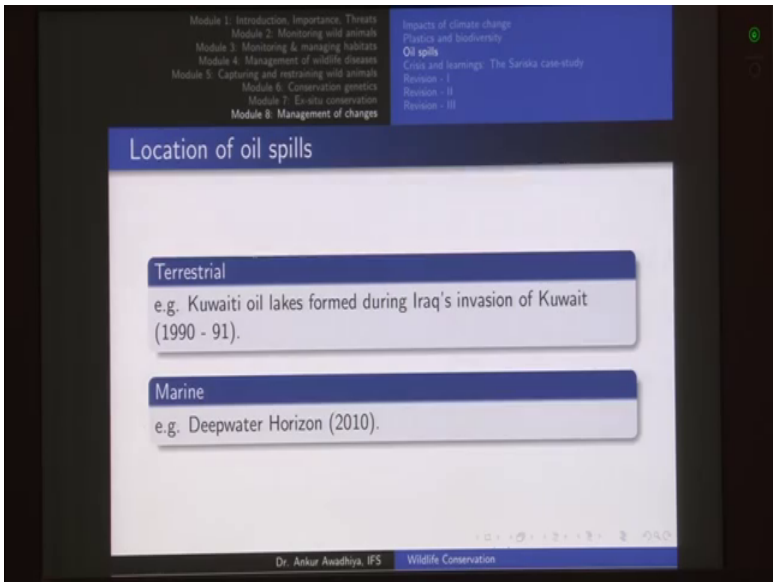

So, this oil spill or the release of this liquid petroleum hydrocarbon can occur on the land or it can occur in water. When it occurs on land, we call it a terrestrial oil spill, such as the Kuwaiti oil lakes that were formed during the Iraq's invasion of Kuwait. So, what happened in this case was that Iraq invaded Kuwait and then when Iraqi's were forced to retreat, so while they were retreating they damaged a number of oil spills. They put some on fire and they also exploded some of these oil wells. So, when that happened quite a lot of oil came out into the environment and formed lakes.

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So, in this case, we are seeing a lake, so all of this is petroleum, and in some part it has a fire. So, we are seeing smoke coming out, and on all of the other areas we are seeing a spill. So, this is a large sized terrestrial spill that was caused during the Iraqi invasion of Kuwait. The second is a marine oil spill which have which occurs in the seas and the ocean. And a very good example from recent past is that of deepwater horizon which was an accident that happened in 2010.

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So, in that case quite a lot of oil came out from the oil rig, and it got spread all over the ocean. So, this thing happened in the Gulf of Mexico.

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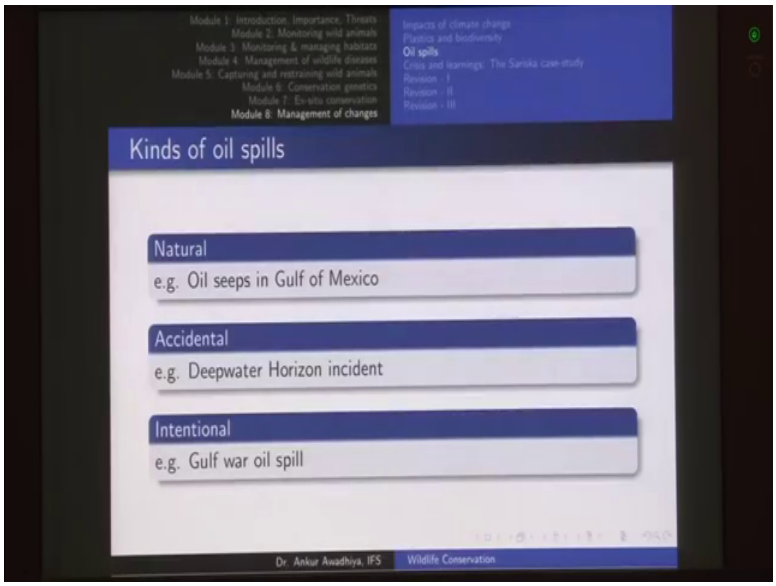

Now, apart from its location, we can classify oil spills as natural accidental or intentional. Now, natural oil spills are those that are occurring naturally, because when we have this petroleum deep inside the earth, there would be some amount of seepage that is going on in a national fashion. So, an example includes the oil spills the oil seeps in the Gulf of Mexico. The second is accidental which occurs, because of an accident such as the deepwater horizon incident. And the third is intentional when there is somebody who wanted to do it voluntarily knowing that there would be an oil spill. And a good example is the Gulf war oil spill that we saw just a while back.

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So, an example of the natural oil seep or the oil spill is this Gulf of Mexico oil seep. So, this is a satellite image. And in this image you can see these streaks that are coming out, because there was a release of oil that was that was happening naturally. Now, based on what is causing it we can have natural accidental or intentional oil spills.

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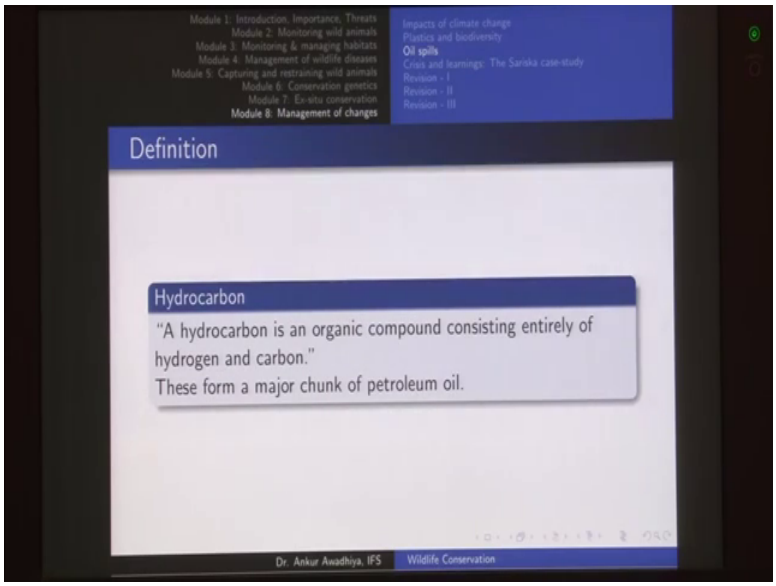

So, what comes out of an oil spill? So, most of the things that come out are hydrocarbons. A hydrocarbon is an organic compound that consists entirely of hydrogen and carbon. And it forms a major chunk of petroleum oil. So, it is a chemical that is made out of only carbon and hydrogen.

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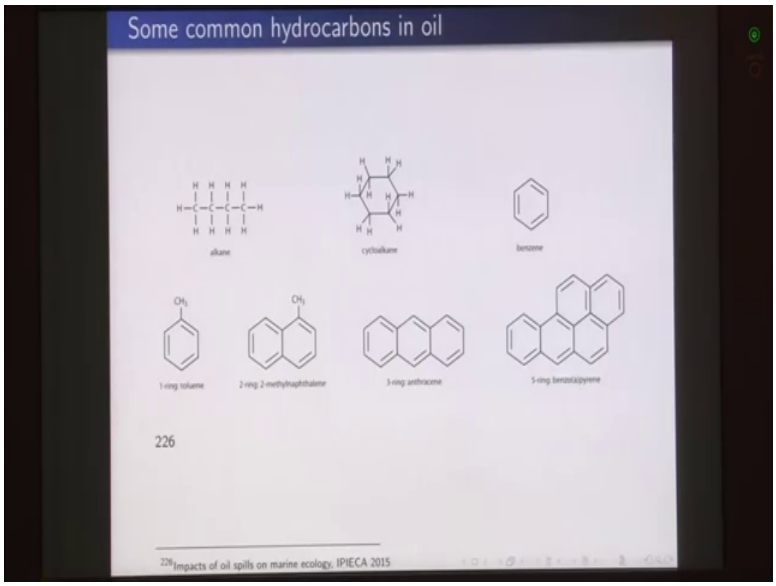

So, examples include alkanes. So, in the case of alkanes we can have things like methane or ethane or propane or butane and so on. We can even have cyclical alkanes which we call as cyclo alkanes. So, this in this case we have 6 carbon molecules, so this is a cyclohexane. We could also find aromatic hydrocarbons such as benzene, so in the case of benzene, this is an aromatic ring. We can also have benzene derivatives such as toluene, and also substances in which we have more of more than one of benzene rings such as naphthalene anthracene or benzopyrene. So, we can have n number of different hydrocarbons that come out into the nature when there is an oil spill.

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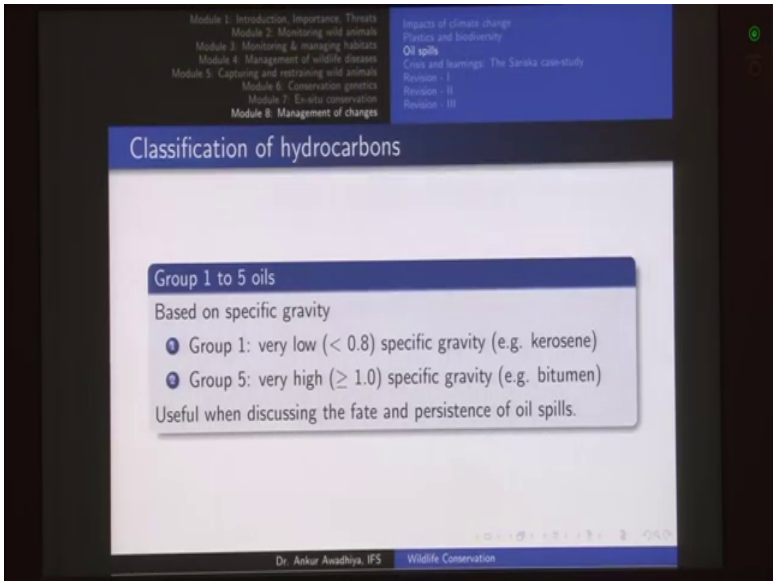

Now, these hydrocarbons can be classified on the basis of their density in which we classify them as group 1 to 5 oils based on their specific gravity. Now, group 1 has a very low specific density that is less than 0.8. Now, these hydrocarbons such as kerosene, because they have a very less density; so, they would come out on the surface of water. They will not sink down one, and two, because they are very small sized molecules. So, they would also be very easily evaporated out into the air. On the other hand, the group 5 hydrocarbons have a very high specific gravity greater than 1 example includes bitumen.

Now, these hydrocarbons are mostly non volatile. And they would seep down when they are exposed to water. So, this classification based on the specific gravity tells us the fate of the hydrocarbon whether it will come to the surface of water, whether it will sink down. And even if it comes to the surface of water is it going to come out into the air as vapors or is it going to stay in the water. And it also tells us about the persistence of oil spills. Persistence because if we have those chemicals that are very small in size, they can be degraded much faster typically as compared to the larger sized hydrocarbons. So, this also tells us about the persistence of hydrocarbons.

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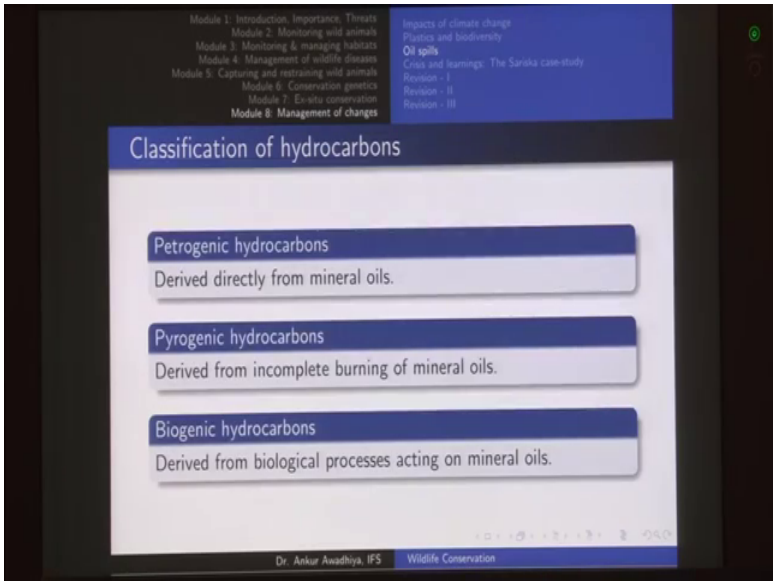

Another classification of hydrocarbons deals with how they are formed. So, the first one is petrogenic hydrocarbons. Petro is rock, genic is formation. So, these are those hydrocarbons that are directly coming out of the rocks or which are there in the petroleum directly. So, these are derived directly from the mineral oils without any

further processing. Now, if there is some processing it could be in the form of fires, so in which case we call it a pyrogenic hydrocarbon.

Now, pyrogenic hydrocarbon is a hydrocarbon that is derived from incomplete burning of mineral oils. So, this is our pure mineral oil, if you burn it and something else comes out, it will be called as pyrogenic hydrocarbon. Third is a biogenic hydrocarbon which is derived from biological processes acting on mineral oils; so, this natural mineral oil if it suffers or if it undergoes any amount of biological changes, then we call it a biogenic hydrocarbon.

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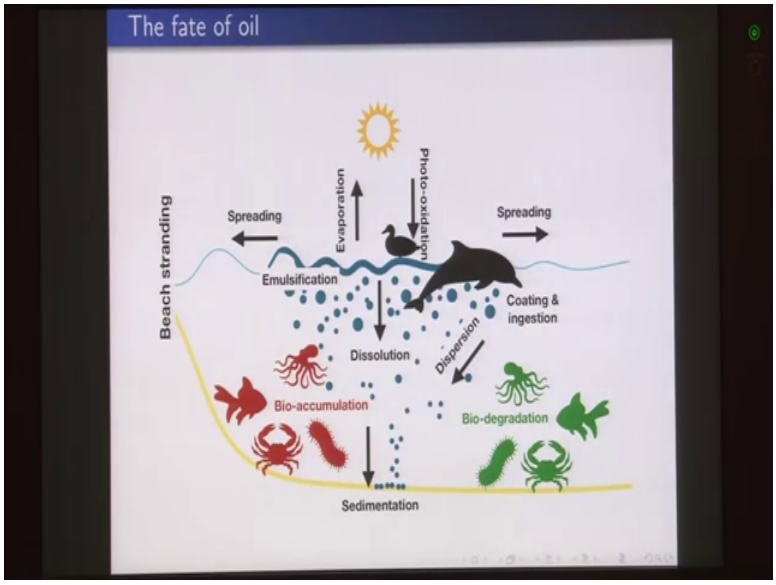

So, considering all of these hydrocarbons, why is it important to know about all of these, because of their impacts on the biodiversity. So, let us look at this image that is telling us the fate of oil. So, there was some oil that was leaked out and it is there on the surface of water. Now, depending on it is density some of it would be evaporated when it is exposed to heat, because of the sun, so some of it will evaporate and get into the air, some of it will remain on the surface, and some of it will sediment down into the ocean floor.

So, this is on the basis of its density. Then if it is there on the surface of water, then it could suffer emulsification. So, in the process of a of emulsification, we have sea waves that have mixing this oil with water that is it is putting it in a very topsy turvy fashion, so that this oil becomes converted into smaller globules, and these globules are then spread

inside the water. So, this is the process of emulsification. Also there could be some substances in the oil that are water soluble. So, typically we could see small amount of say some salts or maybe some other molecules such as some alcoholic compounds in which we have some OH group, so that makes it water soluble. So, in that case that potion will become dissolved.

And the third is dispersion, so after the emulsification all of these could then disperse out in the whole of the ocean. Then the next process that could occur is that of spreading. So, because of this wave action and also, because these oils are lighter than water they would spread out on the surface of the water. So, they would be spreading on both the directions typically on all the directions. And then when after this spreading and these oils are being pushed by wave action onto the beaches, then it may also lead to beach stranding in which these oils have become deposited on the sea beaches.

Now, in all of these circumstances whenever an oil is exposed to air, and whenever it is exposed to light, we could have some photo oxidation reactions that go on which could result in some chemical modifications, such as we could see some oxidation or we could see some (Refer Time: 08:48) in which these larger molecules are broken up into smaller parts. Now, when they are out there on the surface then they then it could also lead to coating and ingestion by a number of other animals.

So, if there is a water bird, then its feathers may get coated with the oil. If there is a marine mammal that is coming out to the surface for a gasp of air, and there is oil on the surface, so this oil may then even coat the body of the animal. So, this is how our biodiversity is getting exposed to these oils. Next when there is dissolution and dispersion of these oils inside the water then also it is possible that our marine animals become exposed to them, because they are eating and drinking this water. Another thing that can happen is that after this oil is getting ingested into the bodies there could be some amount of bio degradation that occurs in the bodies of different marine organisms.

So, these include all the things from our microorganisms to as many as the larger size animals such as the fishes or the crabs or the octopus or even the mammals. So, if there is any amount of bio degradation that is good, because these oils are now getting converted into some substances that are now harmless. But, on the other hand we could also observe bioaccumulation of certain chemicals. So, in this case the toxic chemicals

may go on accumulating in the bodies of these animals typically in the fat tissues, and in that case we will start seeing the impacts of bioaccumulation which would be toxicity, and also the impacts of biomagnification.

So, basically if there is a microbe that has some toxic substances inside it, and this microbe is then eaten up by some say larger microbe, so the concentration of these toxins will go on increasing. When that gets eaten up by a fish ,then that would get even greater concentration of these toxins. And, so the concentration of these toxins will go on increasing at every step of the food chain in a process that we call is bio magnification. So, we would observe bioaccumulation and bio magnification. So, these are typically the fate of oil.

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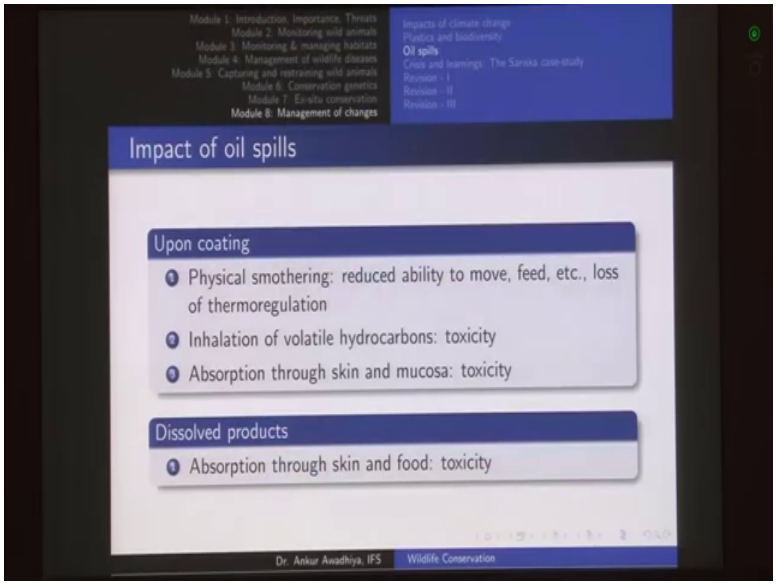

So, what would happen to our animals when they get exposed to oil, so the first thing is that when they are exposed physically in the form of coating, so there could be a physical smothering which is a reduced ability to move feed etcetera and a loss of thermoregulation. So, what we are referring to in this case is that suppose there is an animal that has surfaced. And as soon as this animal surfaces to get some air it is surrounded by oil, and this oil gets into its lungs for instance or this oil completely smothers out its face.

So, in that case this animal is no longer able to breathe properly, because there is oil everywhere it is there in all the orifices of the of the animal, so that could lead to

physical smothering. It not only reduces the ability of the animal to breathe, but maybe also reduces the ability of the animal to feed or the ability of the animal to move around, because it is now everywhere it is covered with oil, and this oil typically has a has a graded viscosity as compared to that of the water around. So, it will not be able to move properly.

Next when it is exposed it, there could be inhalation of the volatile hydrocarbons which would lead to their own toxicities. So, for instance if there is an animal that gets exposed to quite heavy dose of say ethylene, now ethylene is not something that any animal is accustomed to breathing. So, when there is quite a lot of ethylene, then there could be some amount of toxicity that this animal gets also, because these oils also consist of a number of other substances other than hydrocarbons which could be even more toxic to the animals. Then there could be an absorption through the skin and the mucosa, So, there could be some amount of chemicals that get absorbed right through the skin. So, this animal came out and came out of the water it was covered with oil and then there could be some chemicals that directly get absorbed through the skin. So, that would also result in some other forms of toxicity.

Next, in the case of the dissolved products, we could have an absorption through the skin and also through the food. So, there would be some amount of toxicity that is involved here as well. So, we what we are seeing here is that we will observe three kinds of impacts. One is physical impacts such as smothering of the animals; two is that when the animal is covered with oil everywhere, so there would be a loss of thermoregulation. So, for instance, in the case of birds the birds have feathers and these feathers provide thermoregulation. So, they keep these birds warm.

Now, if there is oil everywhere, so the amount of thermal regulation that is provided to the birds would typically reduce, because these feathers will now no longer be in the correct orientation. They would be sticking around, and probably they would in place of forming a fluffy layer all around, they would just stick around, and make a very thin layer. So, there would be a loss of thermal regulation. And third thing would be toxicity it could be, because these oils are getting inhaled they are getting eaten or they are getting absorbed through the skin. So, all these three ways are possible.

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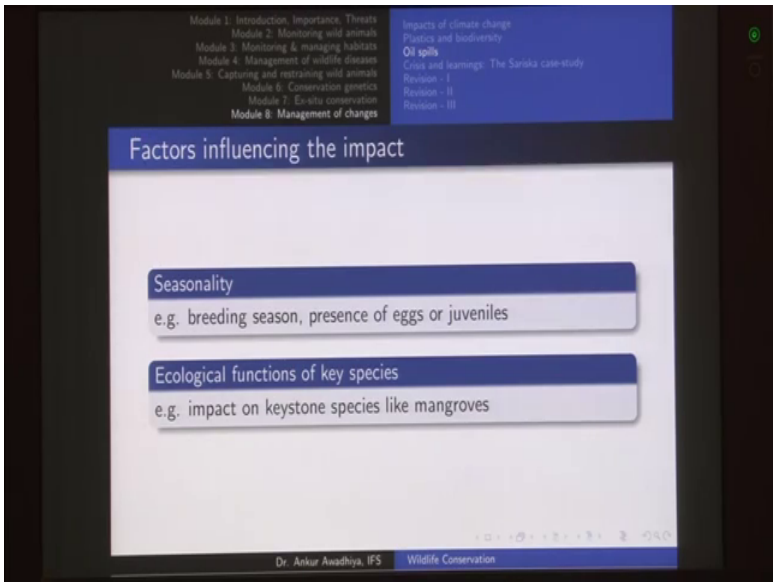

Now, not every animal would be influenced to the same degree. So, there are a number of factors that influence the impact. Now, this is important, because when we talk about biodiversity, there are some organisms that will be at the brunt in a more bigger fashion as compared to some other organisms. Now, what are the factors that influence the impact of these oils, the first is seasonality.

So, for instance, if there is an organism that is in the breeding season, if it has eggs, if it has juveniles around, so these eggs or juveniles are suffering from the impacts of these oils much more as compared to the adult organisms, because they are much more susceptible. So, seasonality could influence the impact. So, if there is if there is a bird that is there in its that has its juveniles, it will suffer with a impact much more than another bird that is out of its breeding season, and does not have any juveniles around. Then the ecological functions of key species would be a major factor influencing the impact.

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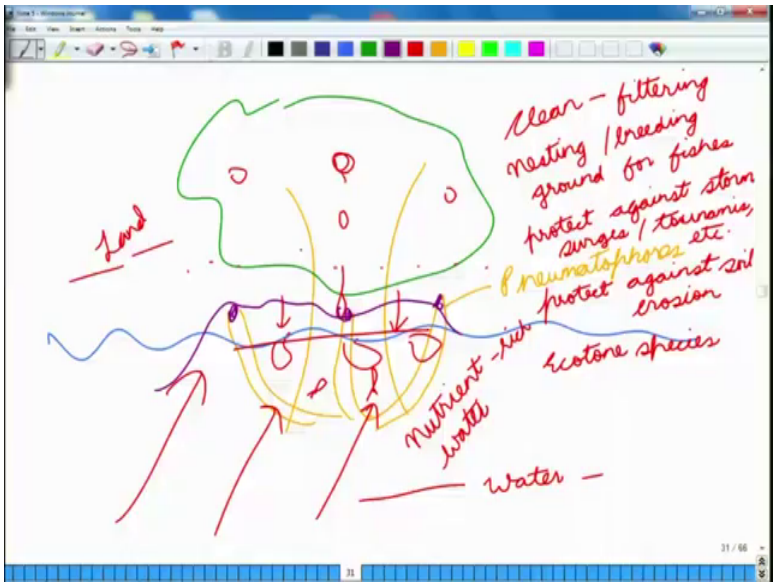

So, for instance, if there is an impact on a keystone species such as mangroves, so in the case of mangroves, so we will have a mangrove say this is the water level here we have the mangrove tree, and it gives out a number of roots out into the air. So, these are for breathing, and we call these as pneumatophores. The mangroves play a very important role in the ecosystem, because they clean the water that is coming up, so essentially, so if there is any debris that comes to this area, it gets stuck there and so it provides some amount of filtering to this area. Then it also provides a nesting or breeding ground for fishes, because if there is a fish that is that has come inside this area, so it is very much protected from any of the predators.

So, there are a number of a fishes that lay eggs inside these roots of of mangroves. And they have their juveniles that are swimming around in the protection of all of these mangrove roots that is another way in which these mangroves play a very important role in the ecosystem. Then third they also protect against storm surges or tsunamis etcetera. So, essentially if there is a big storm that is coming in, so mangroves act as protective barriers. They also protect against soil erosion, because any soil that was there on that side it gets stuck with the roots of the mangroves. And so it is not able to get outside and also they act as very important ecotone species.

Now, ecotone because here we have water everywhere, and here we have land everywhere. So, these are species that are right there on the edge. So, they also have

some other impacts as ecotone species. They also act as a very good nesting ground for birds so, if there are birds that are residing here on the top of the mangroves, and these birds go out for fishing deep into the oceans. And then when they come back they would sit on these trees and maybe drop their (Refer Time: 17:33) down into the water, so that would act as very high amount of nutrient rich water. So, it would provide nutrient rich water which would in effect lead to the growth of a number of seaweeds or planktons into this area which would then sustain the food chain of this area.

So, mangroves are very important keystone species in this habitat. Now, what happens is that if we get these oils, and these oils come here and they smother out all of these pneumatophores. So, typically we would observe that these mangroves would start dying. And when these mangroves die, because they are keystone species, so a number of other animals would be impacted, such as all of these birds, all of these birds all of these fishes, the crabs that live inside the planktons that live here, the seaweeds that live here.

And then we would also observe an impact that is much wider, because when you have an impact on the seaweeds, when you have an impact on the planktons, then you are essentially you are hitting at the very bottom of the food chain. So, when these animals are getting impacted a number of other animals will also be impacted in the form of trophic cascades. So, this is also a very important factor that influences the impact. So, one is seasonality whether your animal is in a breeding season, and second is that if there is any keystone species, that is getting impacted.

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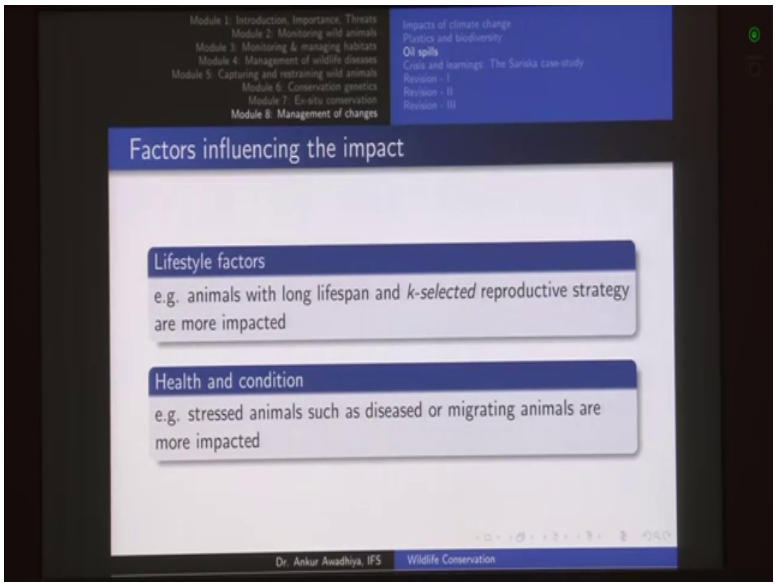

Third is the lifestyle factors. So, for instance, there are some animals with long life span and they are k-selected reproductive strategy, and they are more impacted.

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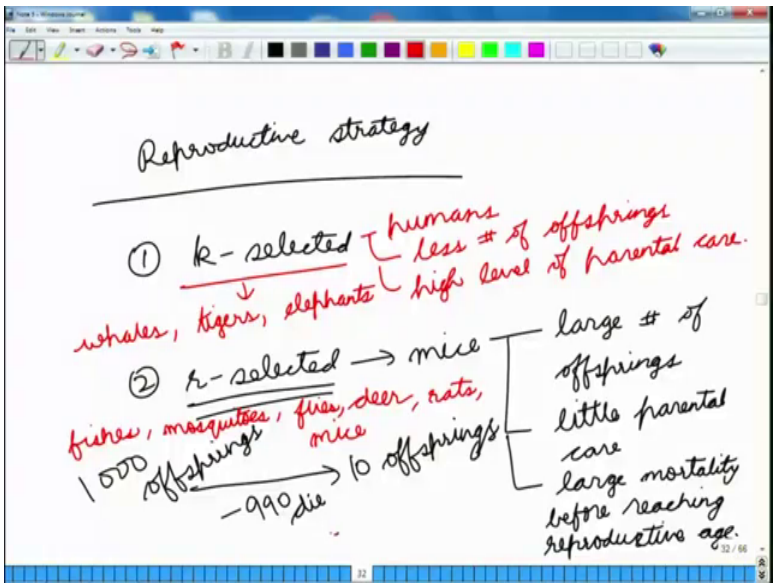

Now, what do we mean by this? When we talk about the reproductive strategy, we have two kinds of reproductive strategies; one is called k-selected, and the second is called r-selected. Now, r-selected is easy to remember by considering say your mice. Now, what happens in the case of mice, if you have a pair of mice that, will lead to a very large number of offspring's. Now, this large number of offspring will have some amount of

parental care, but the amount of parental care would be little. And third is that there is a large mortality before reaching reproductive age.

So, essentially what these animals are doing any animal that is r-selected is that it would give rise to say 1000 offspring's. Now, of this 1000 offspring's as many as say 990 died. And so you are left with 10 offspring's that reach maturity. What these animals are doing is that because there is competition, because they know that a number of offspring's would die. They would prepare a large number of offspring's devote very little amount of time and attention and parental care, so that a large number of offspring's are going to die in any case.

So, a very small number of offspring that remain they would act as another very large (Refer Time: 21:07) for more number of offspring's in the next season. So, in this case even if there is a huge impact on the offspring's, even if a few offspring's remain for the next generation, they would be able to repopulate this area again. Now, k- selected species a good example is humans. So, now, in the case of humans we would have a very less number of offspring's, and a very high level of parental care.

So, essentially what we are seeing is that, in the case of k selected reproductive strategy the strategy of the animal is to have a very few number of offspring say one or two offspring's give all the time and attention and effort, so that these two offspring's are able to survive to the next generation, whereas in the case of k- selected species the strategy is that you have n number of offspring's of very large number of offspring's. Do not give them any time and attention, because you are putting all of your energy in place of giving them time and attention. You are putting all of your strategy into having more and more number of offspring.

So, in that case the even if a number of offspring's die out your species will be able to propagate to the next level now. Good examples from the case of wildlife would be that in the case of k-selected species we have things like whales. So, we would typically have (Refer Time: 22:39) calf with every mother. We would have species like tigers we would have species like elephants. In the case of r-selected species we would have things like fishes.

So, a pair of fish would typically give rise to say 1000 eggs or things like mosquitoes. So, one pair would give rise to excess of 400 eggs, flies or say deer. So, deer a

population also grows up very fast or rats or mice and so on. Now, this reproductive strategy becomes very crucial, when we are considering the impacts of oil on these species, because as we saw in the case of r-selected species you have a large number of organisms. And even if you kill off a very substantial proportion even if you kill off say as many as 90 percent or 95 percent or even 99 percent of the animals that are there whatever animals remain they will breed profusely once the impacts of oil are gone, and so they would be able to recover back.

But, in the case of k-selected species, because they are having a very few number of offspring, and their strategy is to take care of their offspring's. So, if the offspring's die off, because of the impacts of oils oil spills, these species will not be able to recover back, because they have a very slow rate of reproduction, so that would also impact the influence the impact of the oil spill. So, these are the lifestyle factors. Animals with long life span, and k-selected reproductive strategy are more impacted, because they have very few number of offspring's.

Then the next thing is health and conditions. So, if there is an animal that is already stressed because of a disease or if there are animals that are migrating, now in the case of migrating animals they typically do not have access to a huge amount of food. So, they are already their bodies are already stressed. So, you give them one more factor you give them some more amount of oil and they will perish.

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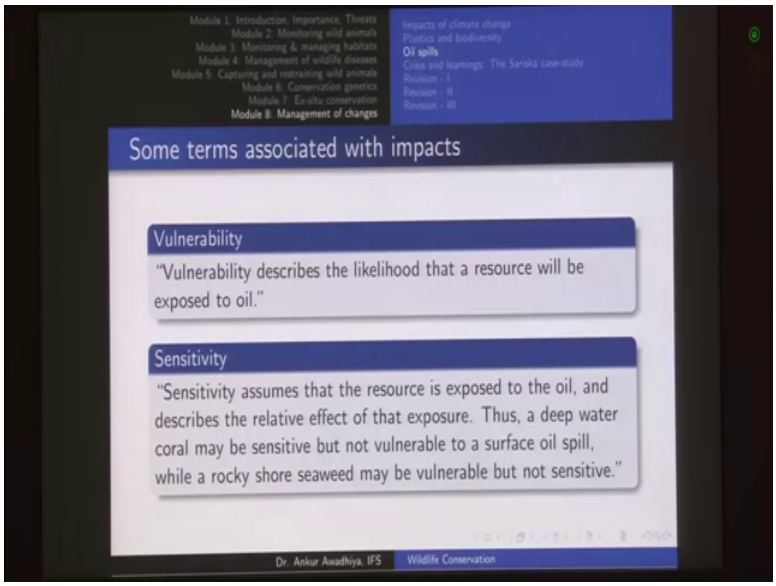

Now, in this context two terms are very important. One is vulnerability, one is sensitivity. Now, vulnerability is the likelihood that your animals or your resource will be exposed to oil. And sensitivity ask the question that if your animal is exposed to oil, will it have an impact of oil on it or not. What is the relative effect of that exposure to oil?

So, for instance when we saw this slide, so in this slide anything that is coming on the top, so any of these water birds are extremely vulnerable, because if there is any oil spills, they would come into contact with it. If there are any mammals that are residing here or if there are any reptiles that have to come out on the surface, so they would be very much vulnerable to these oils, whereas these crabs that are residing at the bottom of the sea floor they will not be that much vulnerable, because they are not getting exposed to the oil.

Now, when we talk about sensitivity it is possible that there is this particular bird, which when it is exposed to oil, it is able to resist its impacts. But, then if we consider this crab, if you give it a very small amount of oil, it might die. So, there we are talking about sensitivity. So, sensitivity assumes that the resource is exposed to the oil, and describe the relative effect of that exposure. So, a deep water coral may be sensitive, but not vulnerable.

So, it is sensitive, because you give it some amount of oil, and it will die. But, it is not vulnerable, because all the oil comes to the surface. It does not reach these deep water corals whereas, a rocky shore seaweed may be vulnerable, but not sensitive. Now, it is vulnerable, because it is there on the surface and, so it is exposed to the oil, but it is not that much sensitive, because it has a protective layer of mucosa around a mucous layer on the top. So, it is not very much sensitive.

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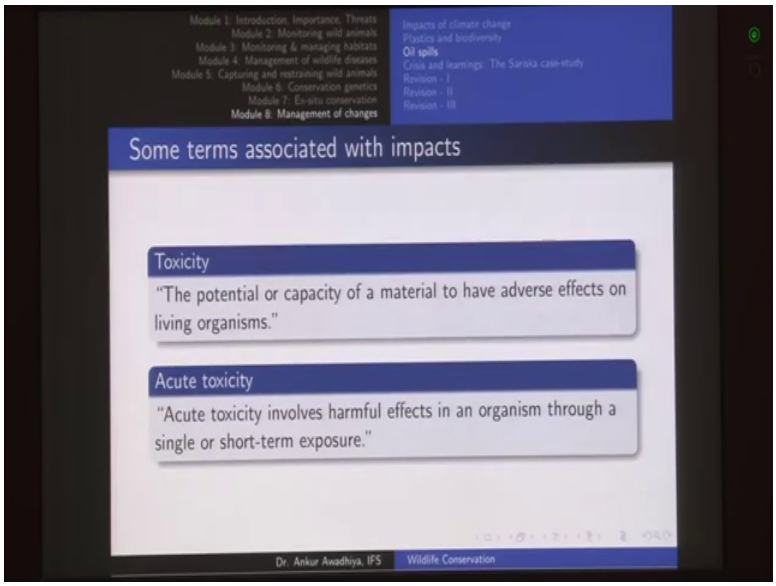

Now, other impact other terms that are associated with impacts are toxicity. So, toxicity is the potential or capacity of a material to have adverse effects on the living organisms, so that is toxicity. Now, this toxicity could be acute toxicity or chronic toxicity. Now, acute toxicity is something that happens in a very short duration. So, you expose something to oil and it dies off, say in a few minutes or a few hours or maybe in a few days, so that is acute toxicity it involves harmful effects in an organism through a single or a short term exposure.

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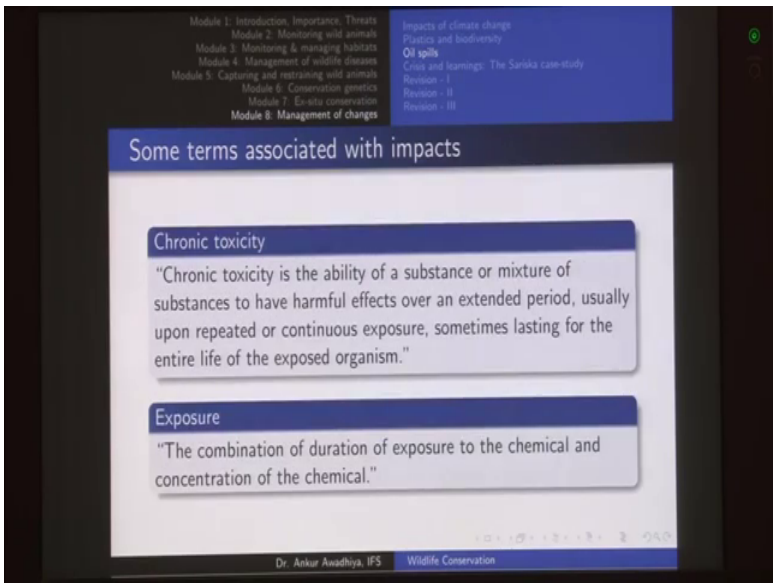

The next thing is a chronic toxicity which occurs in a very long period of time. So, chronic toxicity is the ability of the substance or mixture of substances to have harmful effects over an extended period. So, the only difference is that of time whether it is short acting or long acting usually upon repeated or continuous exposure sometimes lasting for the entire life of the exposed organism. So, typically if you have a very low concentration of your oils or oil derived substances, but your animals are getting exposed to it day in and day out that would lead to some amount of chronic toxicity.

Now, exposure is another term. It is a combination of the duration of exposure to the chemical and the concentration of the chemical. So, basically if you have a very low concentration of chemical, but you expose your organism for a long period of time, so it would lead to a greater amount of exposure or if you have a very short duration to be for which your animal is exposed to the substance, but it is exposed in a very high concentration, so that would also excess the bit the impacts of that substance. So, a combination of both of these that duration and the concentration goes by the term of exposure.

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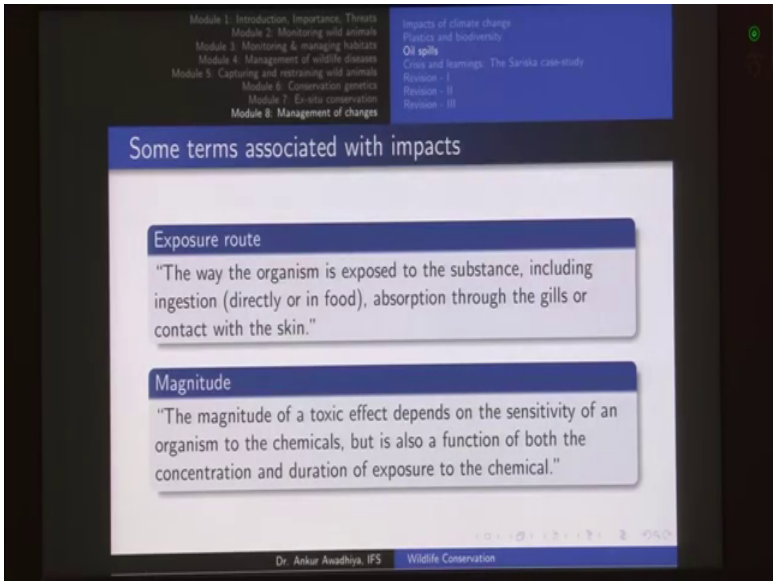

Now, this exposure could occur through various routes. So, this exposure could be through ingestion, when the animal is eating this substance or it could be through absorption through the gills or contact with the skin or maybe it could be through inhalation route in which this animal is breathing in the substance. Now, magnitude of a

toxic effect depends on the sensitivity of the organism to chemicals, and is also a function of the concentration and duration of exposure to the chemical. So, essentially here you are asking three things.

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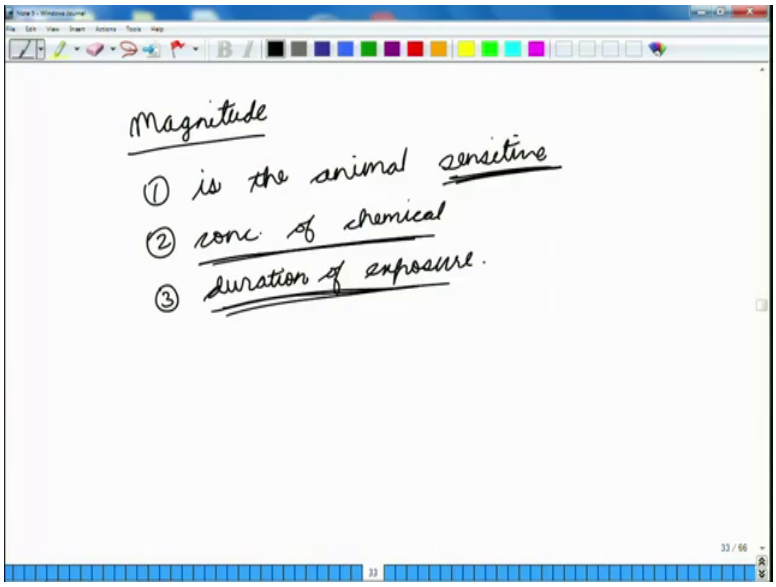

So, when you have magnitude, you are asking three things is the animals sensitive or is it able to throughout back the effects of the chemical. Second the concentration of chemical. And third is the duration of exposure. Now, if an animal is very much sensitive. So, even if your concentration is less, and your duration is less, it would die off, so the magnitude would be high. Now, if your animal is not that sensitive, but the concentration is very high or the duration is very high that would also result in the death or a very huge impact on the animal. So, magnitude is a function of all three of these.

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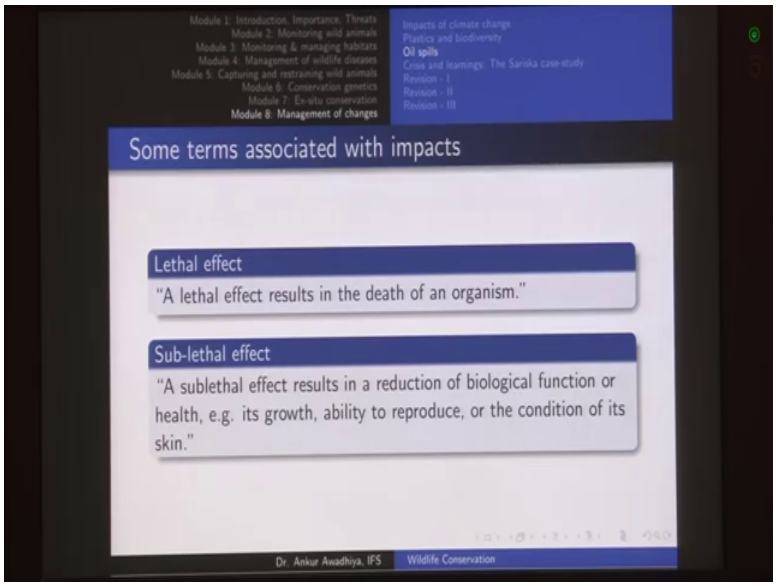

Now, the impact could be lethal or sub lethal. Now, lethal is something in which the animal dies, sub lethal is something in which the animal does not die, but there is a reduction of biological function or the health. So, basically if you are giving some chemical in a very low dose, then typically the growth of the animal might be reduced or its ability to reproduce might go down or the condition of its skin may go down; so, for instance in the case of birds when they are exposed with oil, their amount of thermal regulation goes down.

So, in that case they are not able to function as efficiently as they would have in place of when they were not exposed to the oil, so that would be a sub lethal impact, but lethal impact would be if you expose say a fish to these oils, and these fishes die off that would be a lethal impact. Now, there would be a different impact on different organisms.

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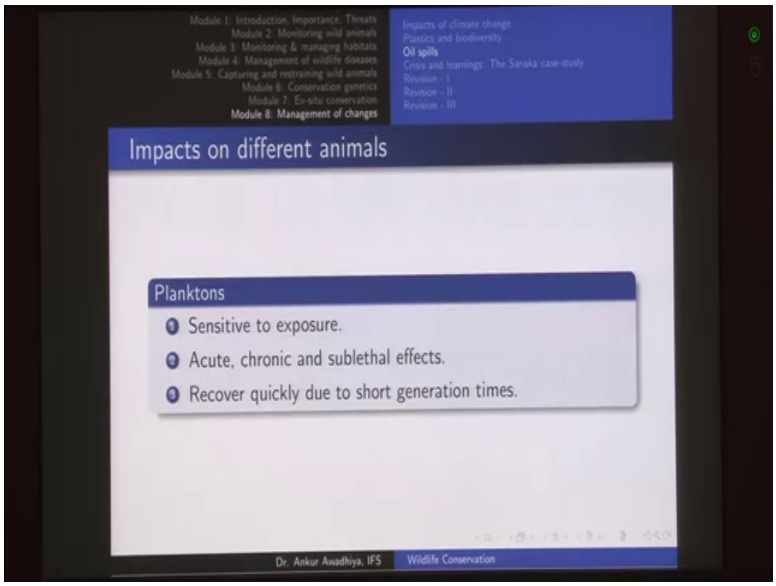

So, for instance in the case of planktons. Planktons are highly sensitive to exposure you give a small amount of oil and the planktons would die off. It would acute impacts chronic impacts sub lethal impact, so lethal impacts you could have anything. So, it might occur very fast it might occur on a long period of time, but planktons are able to recover quickly.

So, in most of the times we say the impacts they tend to become sub lethal, because even if a number of planktons die off, there would be a huge amount of reproduction in the next generation, and so it will be able to recover quickly, and in short generation times, because planktons are r- selected I mean this term is not typically used for plants, but then we can make an analogy that these planktons give off a large number of offspring's. So, they are able to recover fast.

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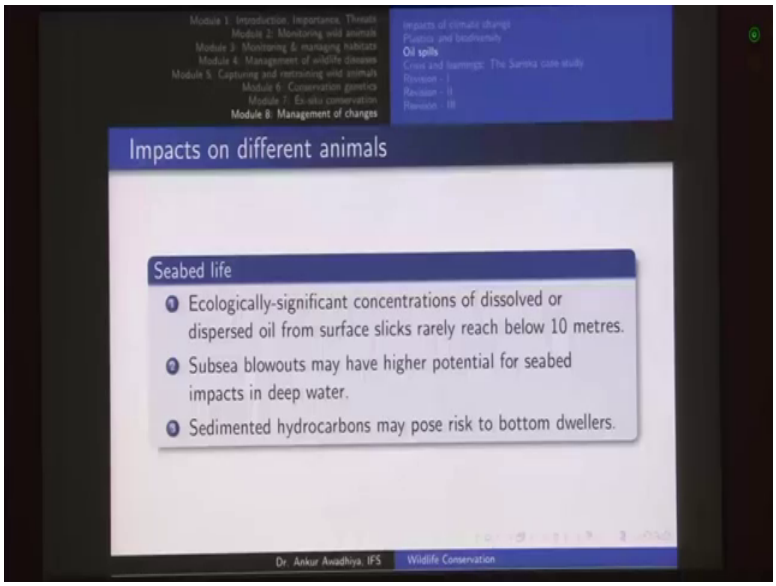

Next if you talk about the sea bed life so, animals that are living on the sea bed. So, ecologically significant concentrations of dissolved or dispersed oil from the surface slicks rarely reach below 10 meters. So, in our earlier image we saw that if we have these chemicals, these oils on the top a very small concentration is able to come down. So, in that case their exposure to these chemicals which is very less.

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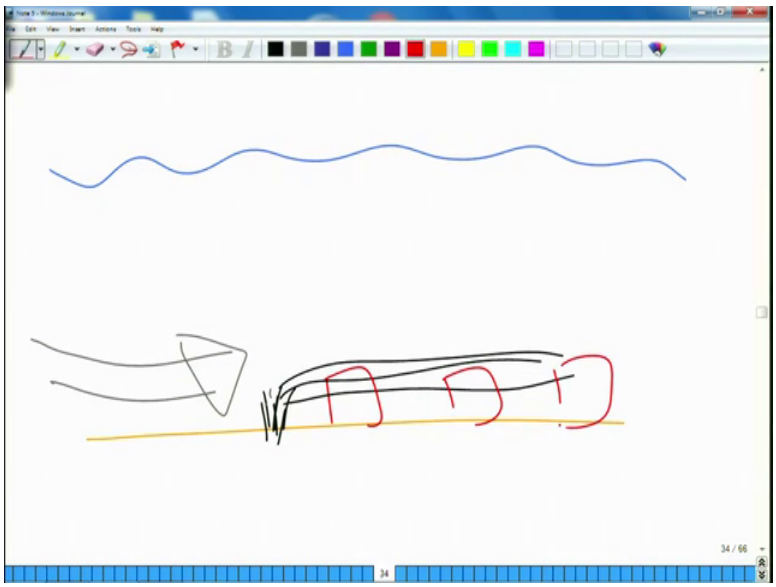

But, if you have a subsea blowout, now subsea blowout means that if you have this ocean, and here you have the land, and then there is some amount of oil that is leaking

out from here, and maybe there is an ocean current that is going in this direction, so it is leading to this oil getting to this direction. So, in this case all the animals that were here in the seabed would be exposed. So, subsea blowouts may have a higher potential for seabed impacts in deep water. And also the sedimented hydrocarbons may pose a risk to the bottom dwellers, but typically this layer, this is less and typically we know very little about these impacts.

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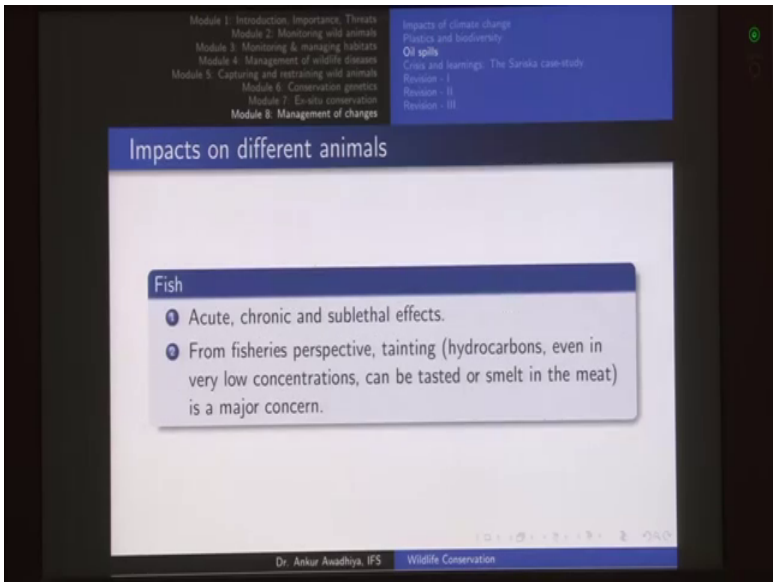

Next, in the case of fishes, we may have acute chronic and sub lethal effects. And from the fisheries perspective we tainting of the fishes becomes a major concern. Now, what is tenting, if you go to petrol station, you would get a smell of the petrol. Now, if you have fishes, and these hydrocarbons they get accumulated in the bodies of the fishes, then when you eat a fish, you would get the same smell. So, hydrocarbons even in very low concentrations can be tasted or smelled in the meat of the fish. So, tainting becomes a major concern for the fisheries industry, but other than that the impacts could be acute chronic and sub lethal.

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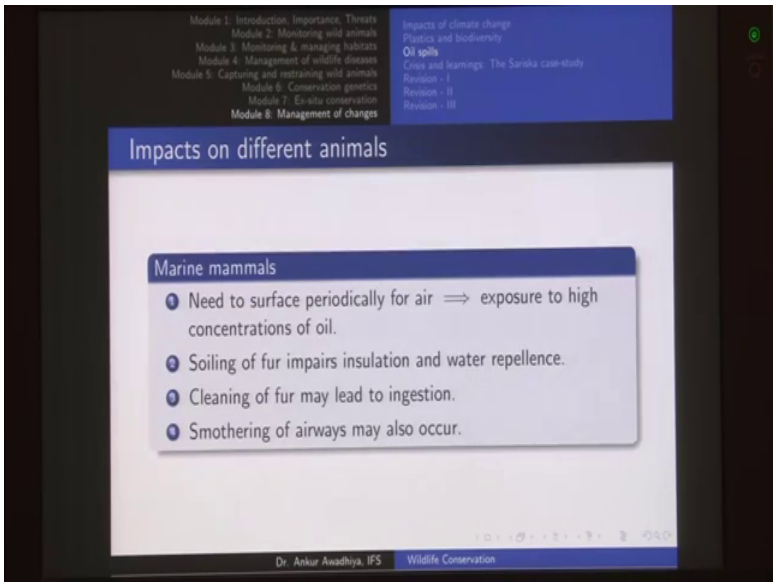

In the case of marine mammals, we have typically a large amount of exposure because they these animals need to surface periodically for air. So, they are exposed to high concentrations of oil. Now, when these animals are exposed, then there could be a soiling of fur which impacts the insulation, and the water repellents of the skin. Then cleaning of fur when these animals typically lick their fur to clean off the oil that is present there, then in that process they may also be eating up this oil. So, it may also lead to ingestion. Then there could also be the smothering of the airways in which the animal is no longer able to breathe.

So, we can have any amount of impacts on these marine mammals, typically the impact is very large, because these are typically exposed to very high concentrations of oil, when they are coming out to the surface of the ocean for breathing. Similarly, in the case of marine reptiles these also need to surface periodically for air. So, things such as turtles; so, when turtles come out on the top, they are also exposed to very high concentrations of oil. And in this case also we observe smothering of airways, and also if there is a time in which these animals are nesting or egg laying, so these behaviors may also be impacted. And these periods may also increase the magnitude of the impact on these animals.

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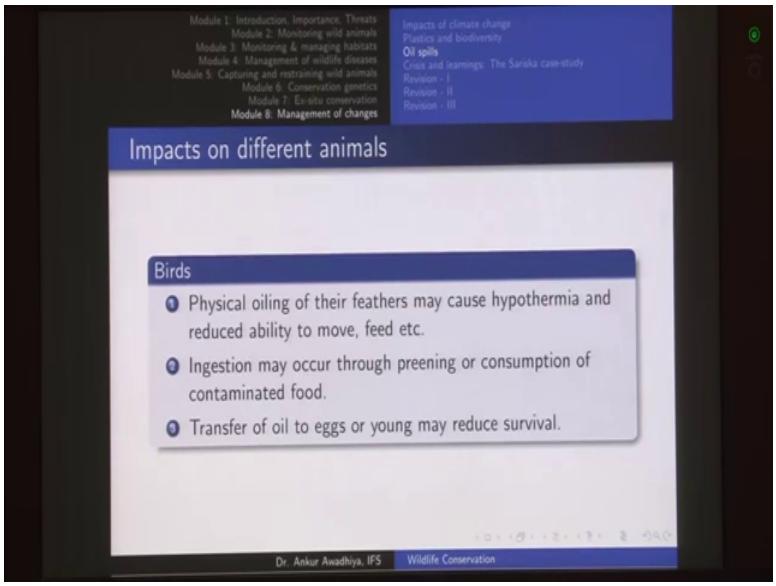

Now, in the case of birds there are a number of birds that feed on fishes in the oceans. So, these birds would go out into the oceans. And when they see a fish, they would come down and catch that fish. Now, in the case of these birds when they have when they are coming down, this may also lead to the physical oiling of their feathers, when they come to the surface of the ocean.

And the oiling of this feathers will lead to hypothermia, and reduce ability to move and feed etcetera, because these feathers will then together and, so the amount of insulation that they are able to provide would reduce, and also they will not be able to fly properly. Now, when they try to clean off their feathers through the process of preening this will also lead to ingestion of the oils. Also ingestion of oils would come through contaminated food such as the fishes. So, the fish has got exposed to the oil the fishes had these chemicals in their body, and when these fishes are being fed upon by the birds, so the birds also get these chemicals. Now, transfer of oil to eggs and young ones will also reduce the survival of the young ones.

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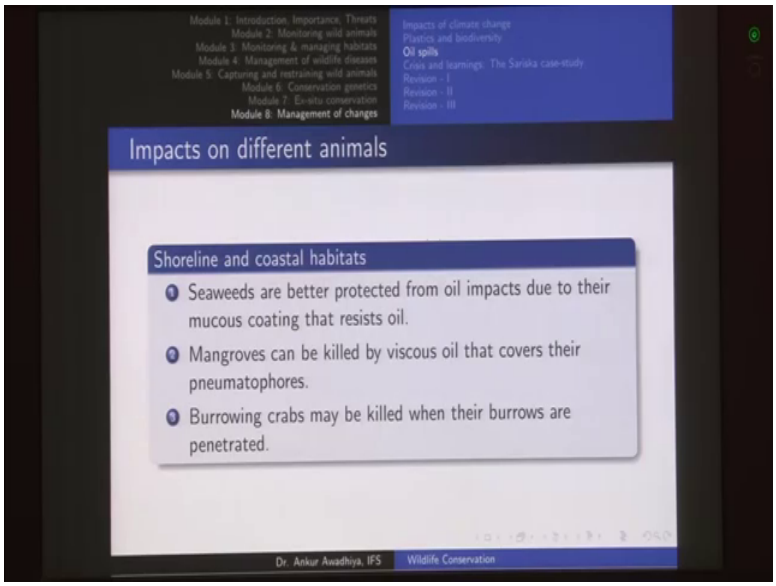

Now, in the case of shoreline, and coastal habitats we would have very different kinds of impacts. Seaweeds are better protected from oil impacts due to their mucus coating that resists the oil. But, other species such as mangroves can be killed by the viscous oil, when it comes into the pneumatophores. Now, pneumatophores as we saw before are those roots that come out of the surface of the water for them to breathe. Now, burrowing crabs may also be killed when their burrows are penetrated when the oil reaches to the seacoast.

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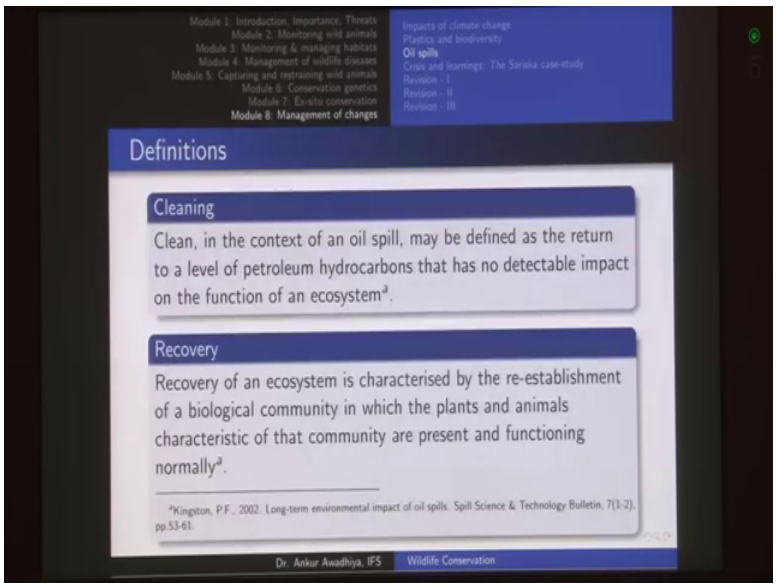

Now, once you have an oil spill into your area, then this is a very emergency situation and requires a lot of cleaning. Now, cleaning is a process in which we try to return to a level of petroleum hydrocarbons that does not have a detectable impact on the function of an ecosystem. So, in cleaning process we are trying to reduce or remove these hydrocarbons that are present there in the habitat.

Now, once you remove these hydrocarbons we would typically expect a recovery of the ecosystem. Now, recovery is characterized by the re-establishment of a biological community in which the plants and animals characteristic of that community are present and functioning normally. So, what happens is that if you have oils, so oil kills off a number of animals, it reduces the ability of a number of animals, and it will continue to reduce this ability, because oils typically persist in the ecosystem.

So, our aim as managers is to go to those areas and clean off this oil. So, we try to reduce their concentrations in the ecosystem once that has been reduced then typically this ecosystem will recover back, because the animals will regain their ability, and also because in the next generation will have more number of animals that would typically reduce the impact of the oil that was seen in the ecosystem.

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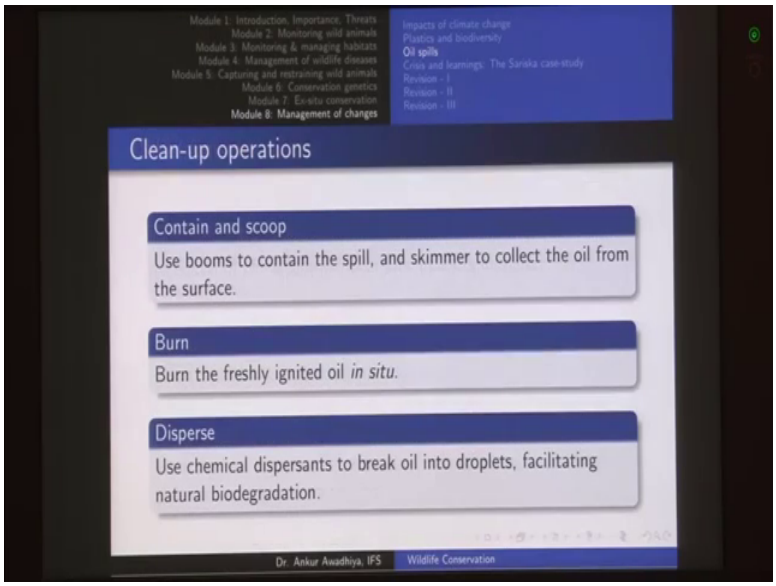

Now, how do we perform this clean-up operation? So, there are three methods one is contain and scoop. So, in this method we use booms to contain the spill and a skimmer to collect the oil from the surface.

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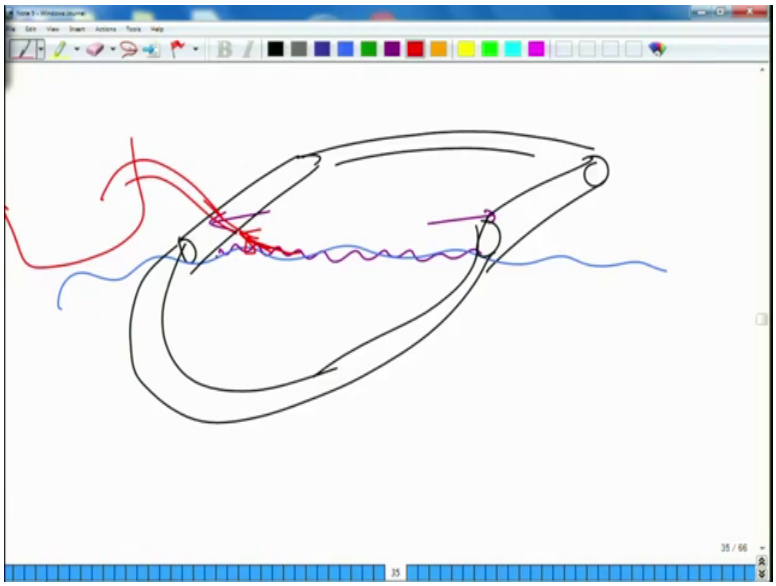

So, what is happening in this case is that you have your surface of water. And in the surface of water you have this amount of oil if you do nothing then this oil will go on spreading to larger areas. So, we put booms, now booms are structures that float on the surface of water, and they are able to contain this oil into this smaller area. Once this oil has been contained, so you have constructed a boom fencing all around this oil once that has been done and your oil has been contained. Next you will bring in a skimmer, so that will have a ship that has some apparatus to take off this oil from the surface of the water.

So, it tries to skim off all of this oil from the surface of the water, so that is the first strategy. Contain and scoop away all the oil from the water surface. The second is to burn. So, if you have an oil that has freshly been released into the environment, you can just go there and burn it off, so that would also reduce the concentration, but then it would also result in the formation of some pyrogenic hydrocarbons. As we saw before if there is any amount of influence of fire we will get some other hydrocarbons. The third clean-up operation is that of dispersing. So, we use chemical dispersants to break the oil into droplets, and facilitate national bio degradation.

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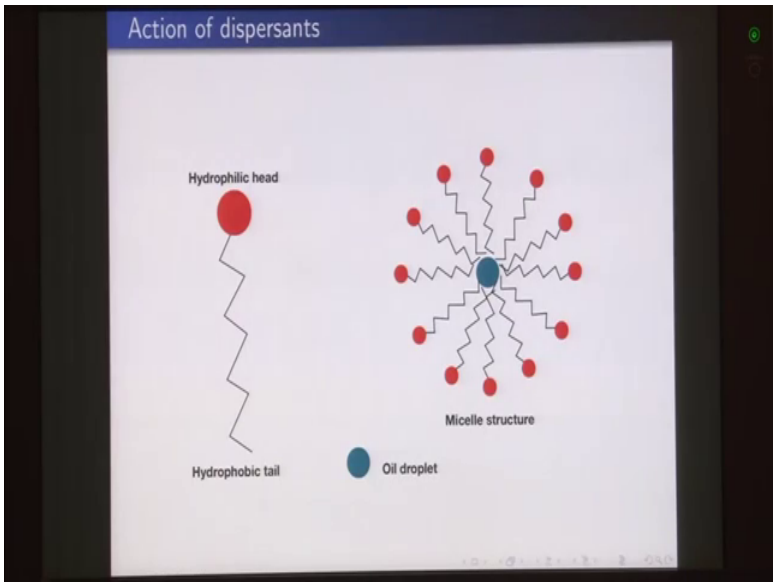

So, typically this these dispersants act as detergents. So, like detergents they have a hydrophilic head and a hydrophobic tail. So, if you have an oil droplet, so these dispersants would cover it from all the sides, and then it would lead to breakage of these oil droplets into smaller pieces. So, they become, so small that they are dispersed out. So, in this case the oil remains in the ecosystem, but its concentration reduces, because in place of being concentrated in a small area it has, now dispersed into a very large area. So, the concentration reduces to such an to such a level that typically our impacts on the ecosystem get reduced. But, here it is important to note that a number of these dispersants, because they are detergent like molecules, and because they are artificial chemicals they might also have a negative impact on the ecosystem.

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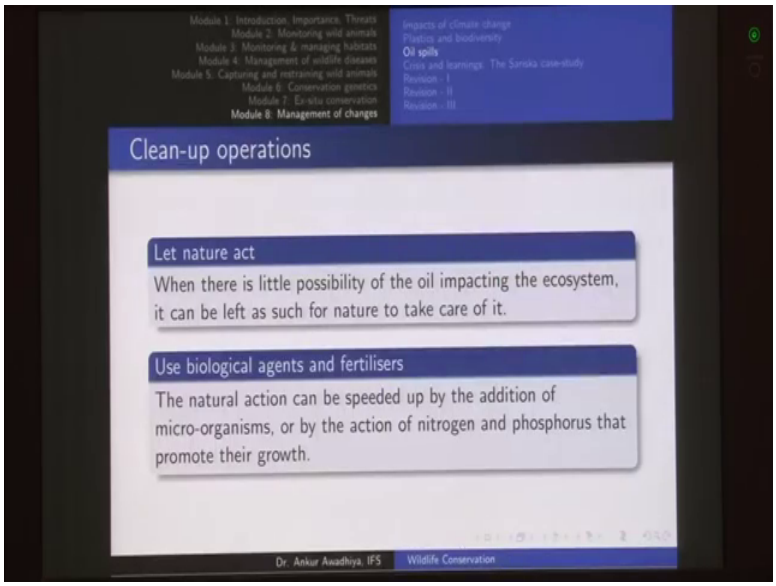

Now, these clean-up operations can be done in two ways. So, when you are letting the nature act. So, if you have a very small amount of oil spill, you can just let nature take care of it. So, when there is a little possibility that the oil will impact the ecosystem, it can be left as such for nature to take care of it. And also you can facilitate this process by adding some biological agents and fertilizers.

So, for instance, if you think that there are some microorganisms, that would be able to break down this oil. So, we can add those microorganisms or increase their numbers in this area by adding some fertilizers such as nitrogen and phosphorus. So, when you have more of these microorganisms more amount of oil will be degraded faster.

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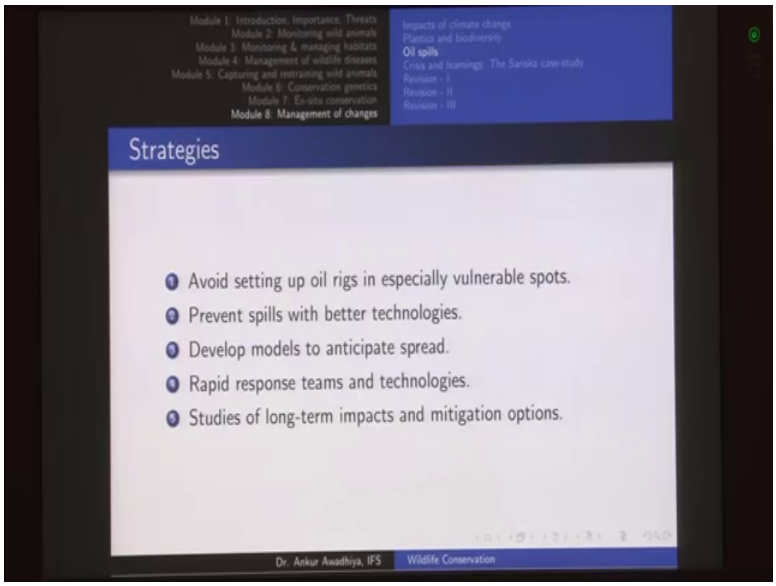

Other strategies that need to be kept in mind are the 1 avoid setting up oil rigs in especially vulnerable spots. So, for instance if you have a nesting beach where turtles are coming, do not set up an oil rig very close to it, because if an accident happens, there would be a huge impact. Prevent spills with better technologies. So, we can have some failsafe mechanisms. So, the older oil spills will need to be put up with these newer technologies. Next develop models to anticipate the spread.

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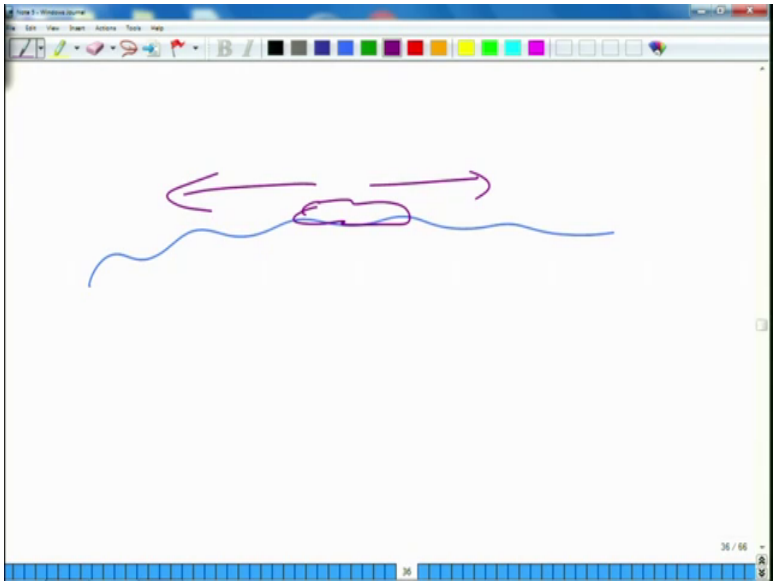

So, in this case, what we are saying is that if you have your ocean, and if there is an oil slick here, if this oil slick is going to move in this direction or in this direction. So, if you can anticipate these spreads, if you can anticipate it by knowing say the direction and speed of the water currents or the direction in speed of the surface winds, then we will by anticipating the spread we can then channelize our operations in a way that we are able to cope up with this situation much faster.

Then we also require rapid response teams and technologies and these rapid response teams need to have a number of drills, so that they practice it again and again, so that whenever an oil spill happens, they are able to clean it up very fast. And also we need to develop new and new technologies such as a better skimmers and also such as better dispersants. So, these dispersants should be able to break up the oil dispersed oil without causing any negative impact on the ecosystem.

And also studies of long term impacts, and other mitigation options are essential, so that we are able to deal with this problem in a better manner. So, in this lecture, we looked at oil spills, what are those the different kinds of oil spills, the fate of those chemicals that come out, what are those chemicals their fate, and also their impacts on the ecosystem their impacts on different species, and also how do we take care of these in our ecosystem. So, that is all for today.

Thank you for your attention. [FL].