Wildlife Conservation
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Lecture – 35
Plastics and biodiversity

[FL] In today's lecture, let us have a look at the impacts of Plastics on biodiversity.

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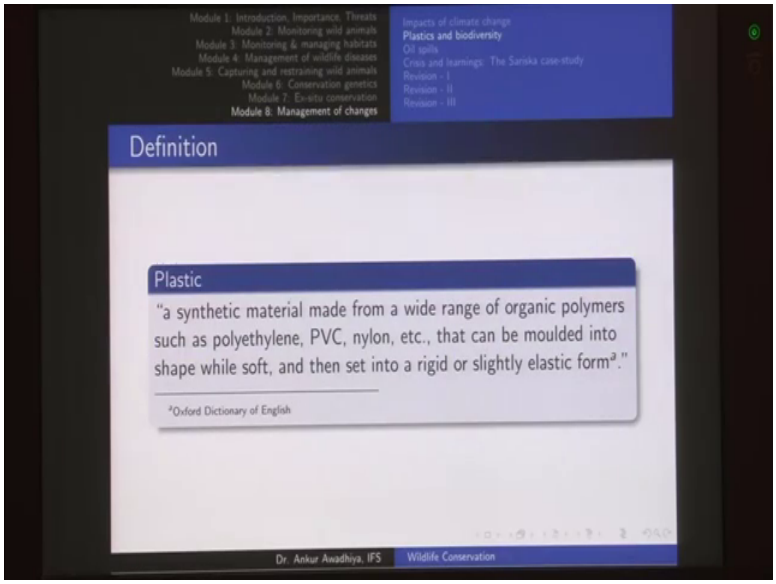

Now, what is a plastic? A plastic is defined as a synthetic material made from a wide range of organic polymers such as polyethylene, PVC, which stands for polyvinyl chloride, nylon, etcetera, that can be moulded into shape while soft, and then set into a rigid or slightly elastic form. So, it is a very wide definition of plastics, but then we can understand plastics by looking all around us.

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So, most of the items that we use these days are plastic materials. So, whether it is a jar that is used for some liquids, whether it is a CD, whether it is a pillbox, whether it is a plastic sheet that is used for wrapping or for or for carrying some stuffs, whether it is our daily used items and so on.

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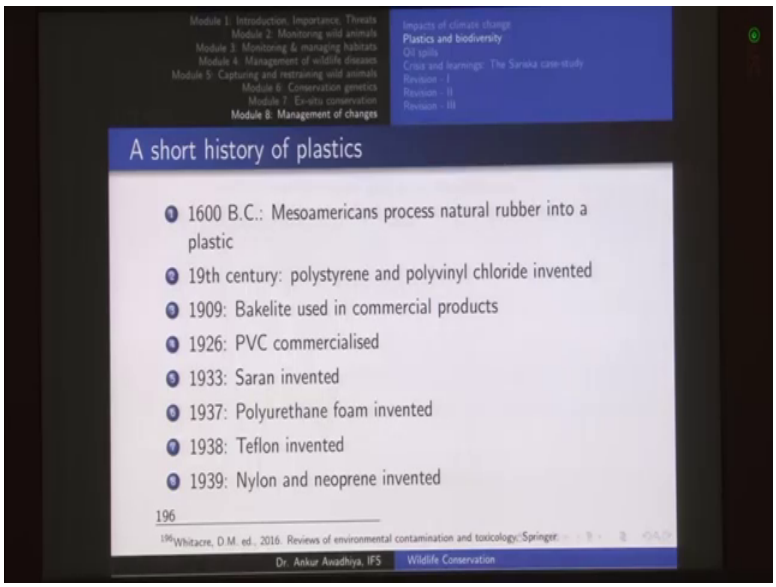

The history of plastics goes back to as back as 1600 B.C. So, plastics are not something that are new; we have had plastics around for a very long period more than 3500 years. So, in 1600 B.C Mesoamericans processed national rubber into a plastic. And this rubber

was processed into a plastic that was made into a ball, and this is a ball that they used to play with.

But, then for a very long period plastics were mostly in the back foot, but they started showing up again in the 19th century, when polystyrene and polyvinyl fluoride were invented. Then in 1909, Bakelite was used in commercial product. Now, Bakelite is a hard plastic that you would have seen in a number of old switches, the black colored switches that we used to have were all made of Bakelite. Then in 1926 polyvinyl chloride was commercialized.

And in 1933 saran was invented. Now, saran is a plastic that we normally use in the form of wraps that is used mostly in the food industry to wrap items. In 1937 polyurethane foam was invented, and this is a foam that is used mostly for insulation properties. In 1938 Teflon was invented, and this is used in most of our non-stick cookware's. In 1939 nylon and neoprene were invented, and they have become very important plastics since then.

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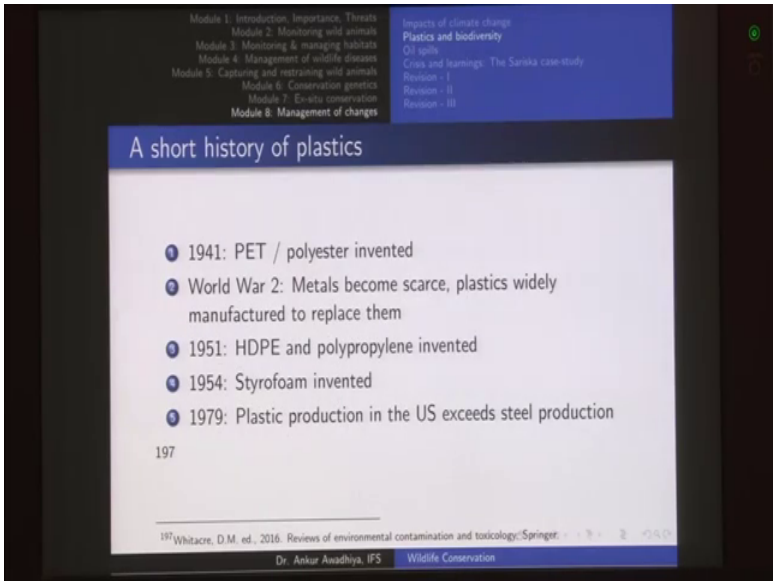

Then in 1941; PET or polyester were invented. Now, PET stands for Polyethylene Terephthalate. And this is the plastic that we use that we see all around us in the form of the plastic bottles that are used for the sealing of water. Now, in 2nd world war metals became scarce, so plastics widely were manufactured to replace them. So, we saw plastics coming even in things like vehicles, automobiles, and so on. In 1951 high

density polyethylene and polypropylene were invented. In 1954 Styrofoam was invented. So, we can see that in most of the first half of the 20th century, it was the plastics age. We were inventing more and more new kinds of plastics. The production also increased so much so that by 1979 the plastic production in the US exceeded the steel production.

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And we have been producing plastics at an ever increasing rate since then. So, this top curve shows us the plastic production in the world, and it has been increasing at 5 percent per annum. Now, what happens to all of these plastics, how much of it is recovered, or how much of it is reused or recycled? So, this is the amount of plastics that are being recovered. So, around this much is prepared, and this much is recovered.

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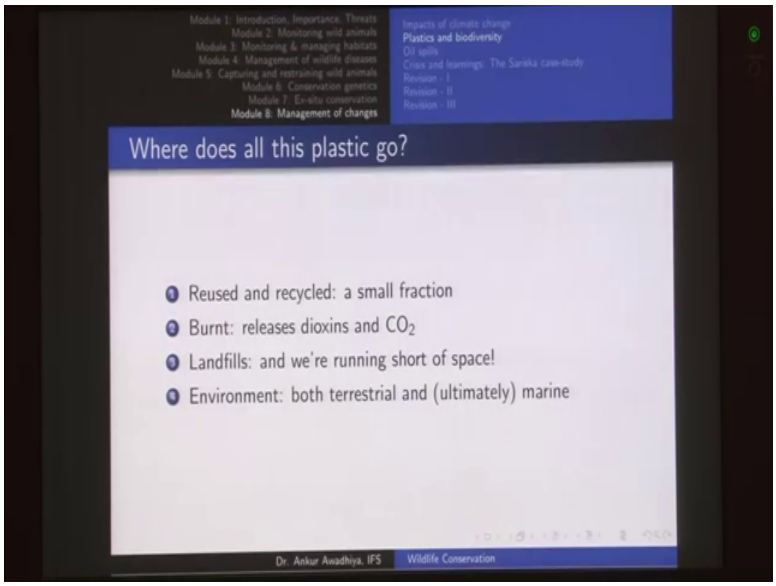

So, we can observe very clearly that there is hardly any amount of plastic that is being reused or recycled, so where does all of this plastic go. Well we have got three different options. One is burning these plastics. Now, when we burn these plastics, we release carbon dioxide, so that is manageable. But, we also release chemicals such as dioxins, which are extremely toxic chemicals.

Now, why would we burn the plastics, burning reduces the volume of plastics that needs to be disposed. And at the same time burning of plastics is also being used in some places for the production of energy, because after all the plastic that we are using these days are coming from petroleum. And so they can be burnt to produce energy.

The second option is landfills. And in the case of landfills, we are running out of them at a very fast pace why? Again you can look back into this curve all of these plastics that were ever prepared most of it have now come into the landfills. And the 3rd option is that we do not do anything. So, if you do not do anything, these plastics will remain in the environment. They would get into the terrestrial environment, and from there they would stay with rainfall, they would ultimately get volt away into the marine environment.

So, when the plastics are there in the environment, they can also pose a risk to our biodiversity. Now, when we are talking about plastics, let us also have a look at the size classification of plastics. So, when we say that we have a plastic that has washed down

into the oceans then, what is the size of this plastic is it a big sized plastic, it a very small sized plastic.

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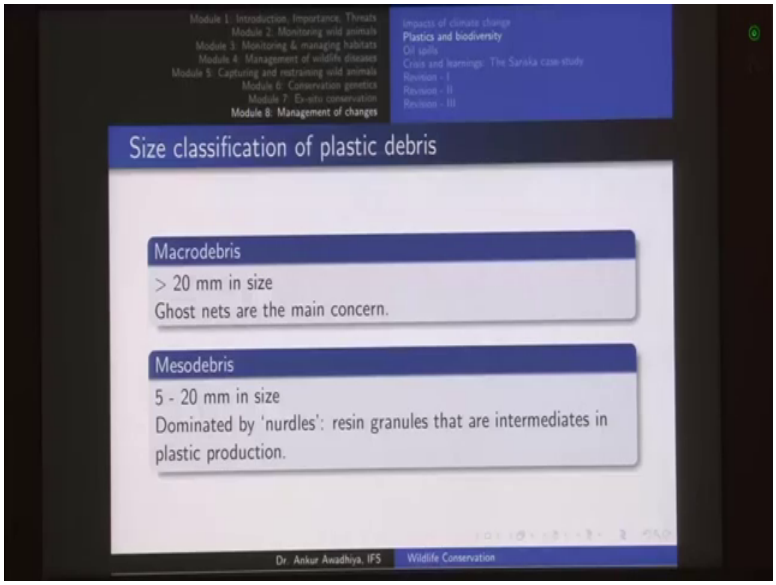

So, in that regard the plastics debris have been classified into three classes. The first is macro debris. So, macro debris consists of those fragments that are greater than 20 millimeter in size or anything that is greater than 2 centimeters in size. So, 2 centimeters and more is macro debris. Macro means, large sized. And in this case, ghost nets are the main concern. Now, what is a ghost net? Suppose we had fishermen or say a fishing boat or a trawler that was using a net for fishing.

Now, these nets also have a limited lifespan. So, after a while these nets would be turned away or maybe they were washed into the oceans, and then these nets start floating here in there. Now, these nets because they were actually designed for catching of animals. So, they are still able to capture animals, but these animals are now not being recovered. So, once an animal gets trapped into a ghost net. So it would be there with the ghost net itself.

So, for instance if there is a reptile that gets trapped suppose, there is a turtle that gets trapped. And this turtle needs to surface out into the oceans to take a breath of air, and then it goes down, and maybe it feeds on something. Now, if it is stuck somewhere, and if it is stuck below the surface of water, it will not be able to come up to catch a gasp of

air. If it is there on the surface, it would not be able to get down and get its food. So, in both these situations this animal is going to die out in some time.

So, ghost nets in the case of macro debris are a main concern for all of us. The second is meso debris, meso is somewhere in between. So, these are things that are greater than 5 millimeters in size, but then less than 2 centimeters in size 5 to 20 millimeters is meso debris. And these are dominated by nurdles. Nurdles are resin granules that are intermediates in the plastic production.

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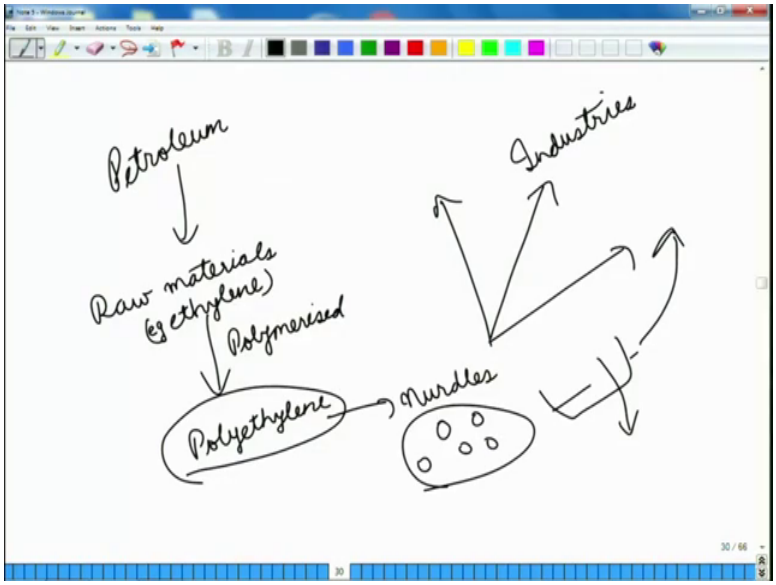

So, what happens is that in the case of plastics, we have petroleum that is then processed to produce a number of raw materials. Now, an example would be ethylene, so now ethylene is the raw material. When this raw material is then polymerized, we get polyethylene. Now, polyethylene itself is a plastic, but then this polyethylene can be used in a number of applications, it can be used to make some polythene bags, it may be used to construct say some scales or rulers that we use it may even be used for the construction of a pen.

So, now when the industry has to transport polyethylene, it does not transport it directly in the form of the finished product. But, then this becomes a raw material for all of these different industries, so it is converted into nurdles. Now, nurdles are small green like pieces in which we have all of this polyethylene that is melted, and then it is formed into the form of a small green.

Now, these nurdles are then transported, and then they can be used in a number of different industries. Now, these nurdles are of the size between 5 to 20 millimeters, so, they become a meso debris. But, then how do they get into the environment, because when these nurdles are being transported, and suppose there is a ship that was transporting these nurdles two different country, which had all these industries that would be using these nurdles. And if there was some accident and these nurdles came out into the ocean, so that would become an issue even when they are being opened up.

So there is a huge stack of nurdles that has now been opened up in the industries to be put up into a machine. In that process, some of these nurdles could come out, and maybe come out as waste products. Now, when the factory floor is being cleaned off, so these nurdles move into the drains and from those drains they could get into the environment. So, there are n number of ways in which these nurdles could get into the environment.

Now, the problem with these nurdles is that because they are dense molecules and they are very small in size, it becomes very difficult for us to pick all of them. So, for instance if there is a polythene bag that is laying somewhere, you could ask a volunteer or you could ask an employee to go then and pick it up, and then throw it somewhere, where it could be safe, but for recycling, but in the case of nurdles, because these are this small sized particles. So, if they are lying there on a sea beach, you cannot just go and look at every grain of sand and decide whether it is a grain of sand or whether it is a grain of nurdle. So, these substances are now concentrating in most of our sea beaches.

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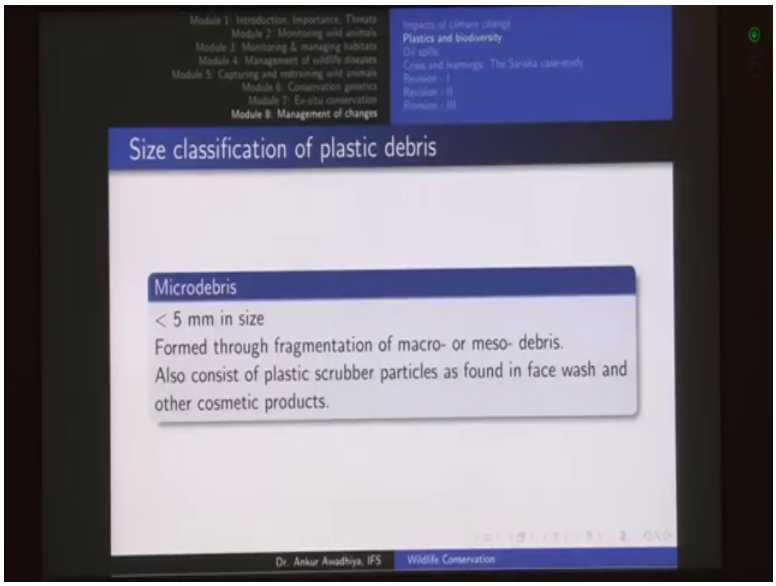

The 3rd substance or the 3rd classification is that of micro debris. Now, micro debris are those that are less than 5 millimeters in size. And they are formed primarily through the fragmentation of macro and meso debris. They also consist of plastic scrubber particles as are found in face wash and other cosmetic products. So, cosmetic products have a lot of plastics that form micro debris, and they could also be formed because of fragmentation of the macro or the meso debris.

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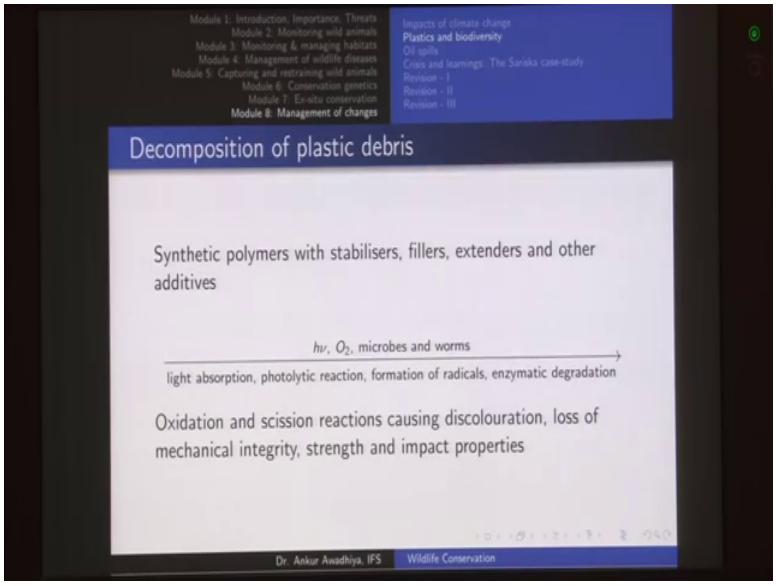

Now, how does this decomposition occur? Now, if we consider any synthetic plastic, we would be having polymers together with some stabilizers, some fillers, some extenders, and some other additives. So, in the case of any plastic material, so if we even consider this pen. So this pen would be consisting of a predominant plastic say polyethylene. And together with that polyethylene there would be some plasticizer, there would be say some fillers that give it this color, there would be some colorant molecules, and so on.

So, when we consider all of these together, and when these come out into the environment, there is an action of light especially the UV light that comes out from the sun. We have oxygen that is there in the environment, we have microbes and worms that are there in the environment, which are producing n number of enzymes.

And all of these would result in a number of reactions such as light absorption. Photo lytic reaction in which there is light, which is causing a lysis, lysis is a break now. We could have formation of free radicals because of this oxygen, we could have some amount of enzymatic degradation for some plastics. And all of these together result in oxidation and scission reactions. Scission means cutting as in the case of scissors. So, oxidation and scission reactions that cause discoloration.

So, for instance if you take plastic bottle, and leave it out in the sun in a very short period of time, it would seize to be transparent. And it would start looking very brittle, so that is because of all of these reactions. So, they lead to discoloration, loss of mechanical integrity, strength and impact properties. So, when all of these occur, so this large bottle of plastic or this pen would after a while start decomposing, so it will from this big with pen, it will decompose into smaller parts. Then those smaller parts would again be decompose and then they become from macro debris to meso debris to micro debris.

Now, of all the plastics that are released into the environment most of them which are not there in the landfill, we will ultimately find their way into the oceans why, because if there is any plastic say a plastic bag that is lying around, if there is rain, then it would get then it would flow along with the water into the nearest drain from that drain, it would get into some regulate from that regulate, it will get into some river. And from that river, it will ultimately get into the oceans. Also quite a number of plastics are directly released into the oceans, during the process of transportation through ships.

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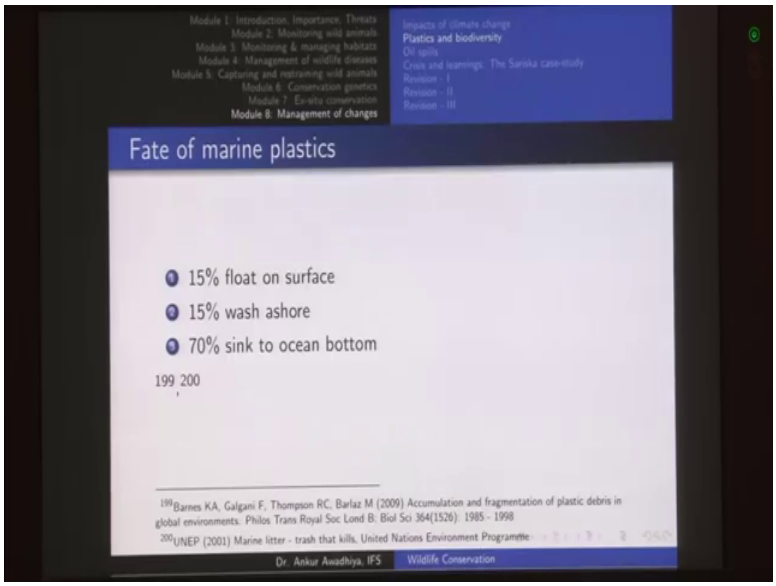

So, when these plastics reach oceans, what happens to them? So, as much as 70 percent would sink into the ocean bottom. So, it would comprise all of those things that are heavier in density than water, but of the rest 30 percent. 15 percent will float on the surface, and 15 percent will then wash ashore. So, they will come onto our beaches through the action of waves.

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So, this is how it looks like. So, these are floating debris, so these have lighter densities. And in most of these objects, we have some amount of air that is trapped. So, there is this

bottle that has air inside and this bottle is capped. So, it cannot drown down into the ocean floor.

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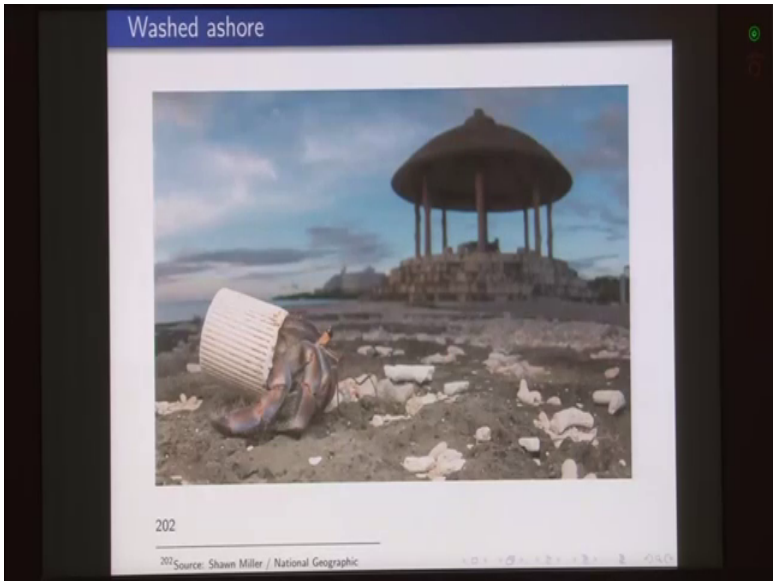

There would be some that would be washed ashore. So, this is sea beach, and we are seeing that this cap of some bottle, it has now washed ashore from the oceans.

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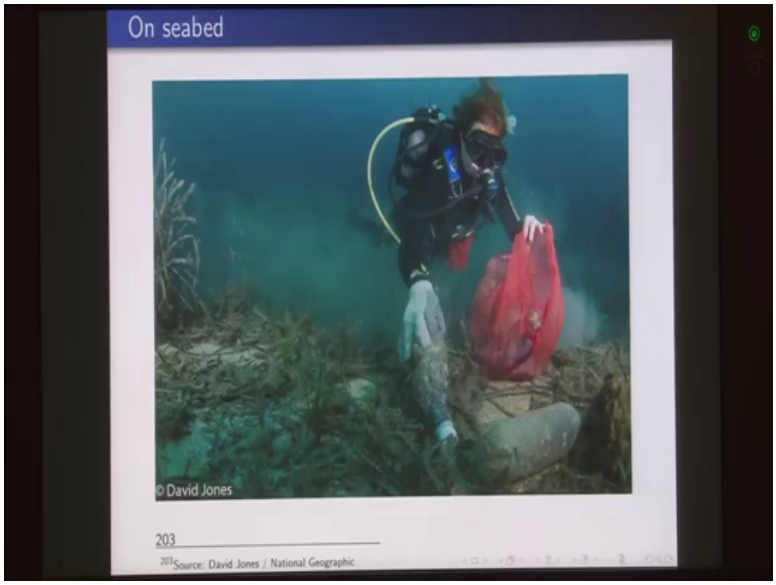

Or it could sink down into the seabed. So, especially if you have a bottle that got filled up with water or with sand, then it would sink down into the seabed. So, even when you go for a diving, you could find plastics even on the seabed.

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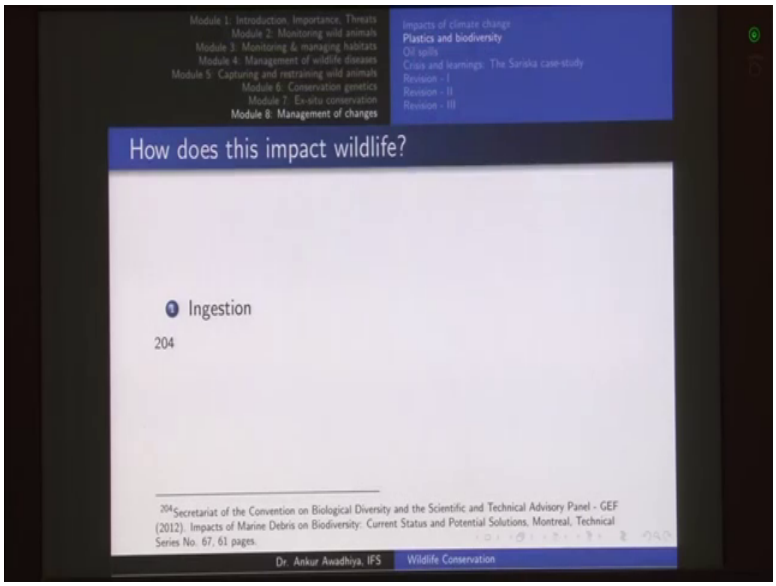

Now, what is the impact of these plastics on the wildlife, why should we be concerned? So, the impact consists of a number of things, so let us begin with ingestion.

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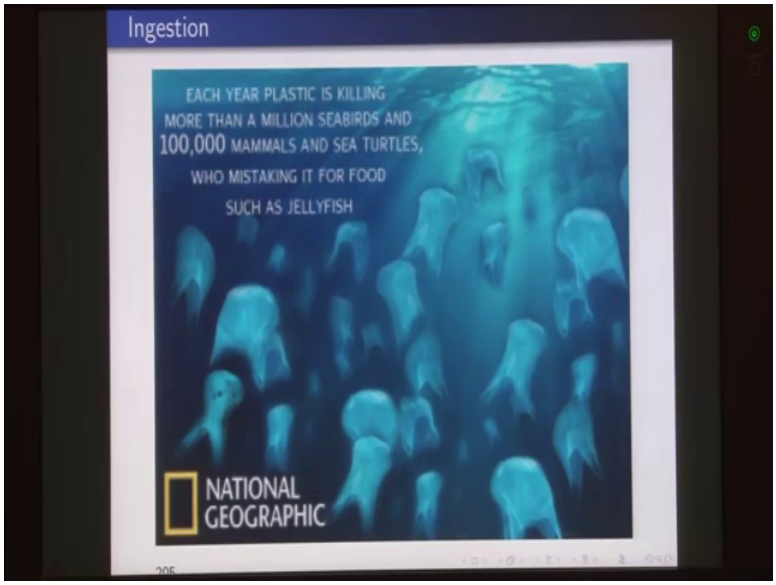

Ingestion means, that the animals could eat up these plastics. So, this is one picture from national geographic, what they are showing is that these are all polythene bags, plastic bags. And if you put them into water, they look they appear like a jellyfish to most of the animals. Now, if there is a turtle that misidentifies this plastic bag for a jellyfish goes and eats it, what happens? For one this plastic will not be digested easily by the enzymes that

are present in the elementary canal of the turtle. In most of the situations, these plastics would just get inside and block the elementary canal.

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So, this is another picture from Smithsonian in which they are showing this albatross chicken. So, albatross is a very large size bird and it is a very long lived bird. This bird lives for as much as 60 plus years. Now, this is chick of the same species. Now, in this in the case of this bird there is a nest, and then the parents go out into the oceans for very long distances as many as 10 of kilometers they would go out. And then they would pick up fish, then bring them back, and then feed it to the chick. Now, all these plastics mostly in the form of caps of pens or some other items, they would be floating on the surface of the ocean.

So, the birds misidentify them for fishes. So, the parents bring all these small pieces of plastics right from the oceans, and then feed it to the chick. Now, this chick was fed with so much amount of plastics that all of it is elementary can almost blocked, all of it is gizzard intestines etcetera were blocked. Once that happens this chicken is no longer able to feed on any more food. And so ultimately this chick would die out of starvation. Now, just consider a bird that would have lived for more than 60 years in natural circumstances has died out, before even it has reached the age of 1 year. So, this is something that is very crucial, when we are considering the impacts of plastics on wild life.

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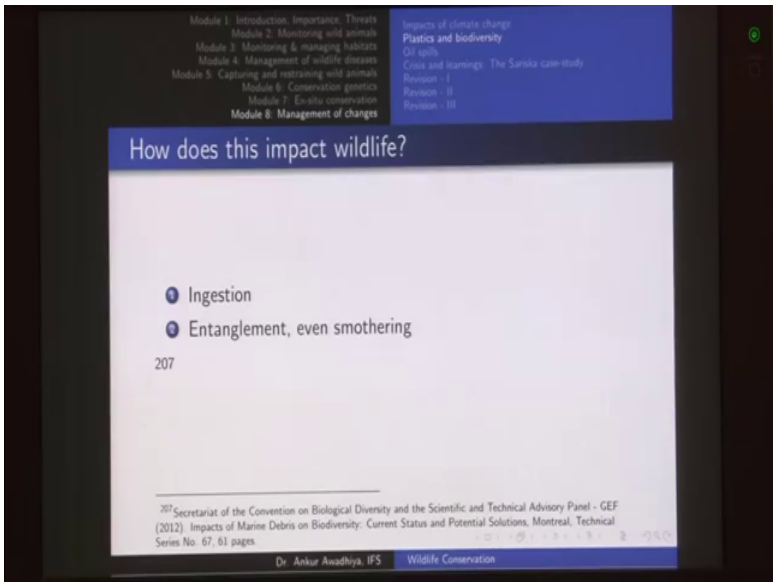

Second thing that could happen is entanglement or even smothering.

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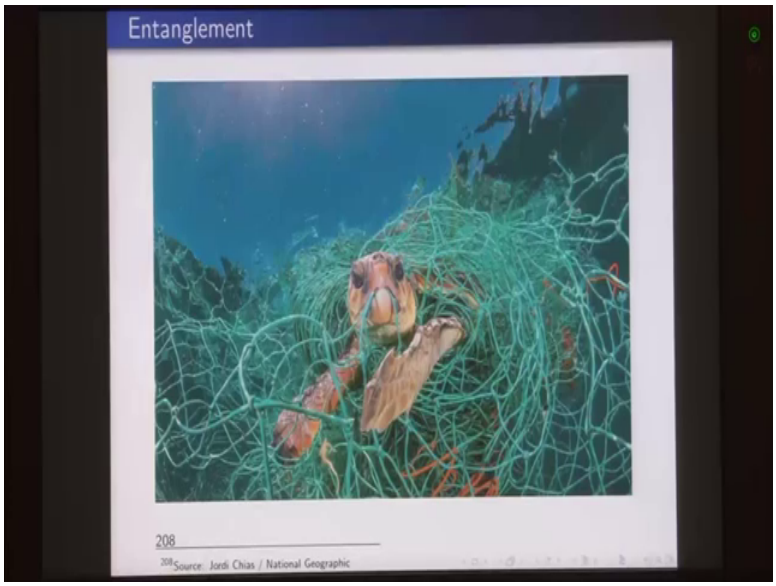

This is anyway that we also saw in one of our earlier lectures. So, here we have this turtle, and this turtle is now entangled into this net; so when this turtle is entangled, and now it is not able to come outside. So, it would not be able to go dive down to feed itself or even if this turtle has moved down and would not be able to come up. So, it is going to die in a short period, well thankfully this particular animal was saved, but then this animal died.

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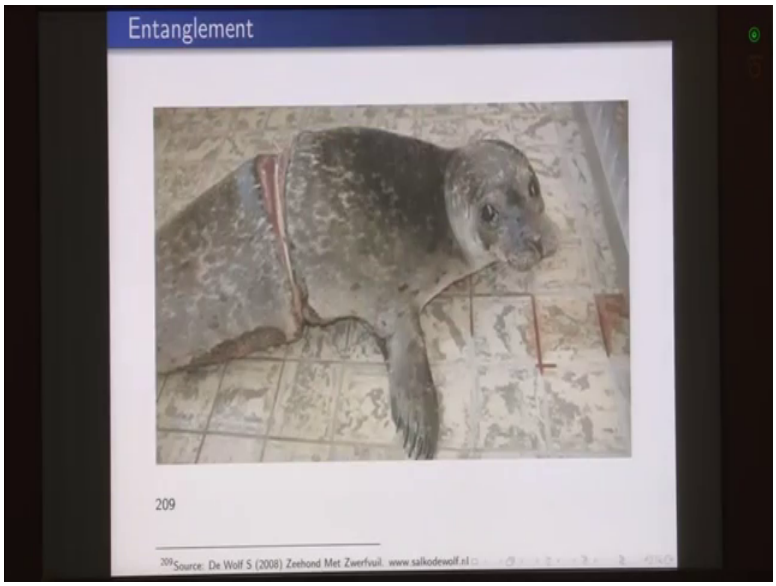

So, this is a seal which had this plastic ring across it is tummy, and then it was outgrowing this plastic ring. And so this plastic ring was actually making an (Refer Time: 17:31) all through its flesh. So, this is another example of entanglement. So, it is an extremely serious situation.

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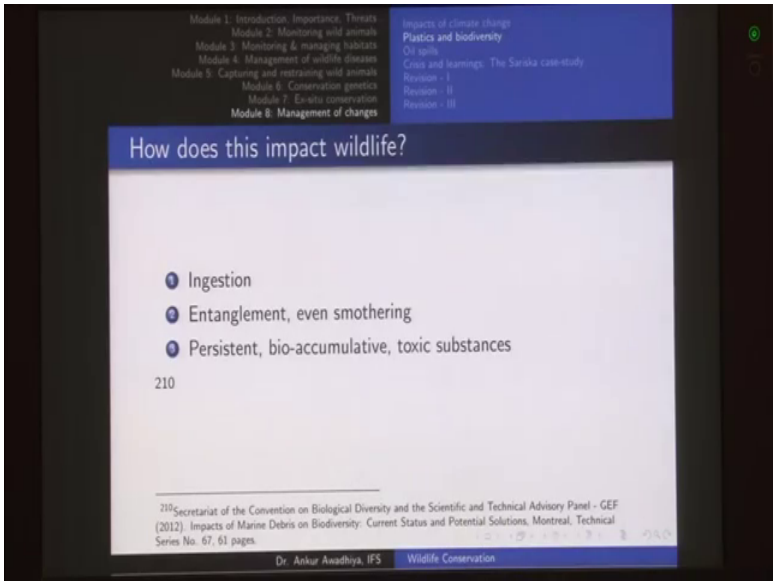

Also a number of plastics comprised of many persistent bio-accumulative and toxic substances. Because, when we are talking about any plastic, so when we are talking

about say this pen, so we are only concerned with the life of this pen, the appearance of this pen may be the weight of this pen, and so on.

But, we hardly consider what all things have gone inside this material, what was the plasticizer used for this pen, what was the filler material used for this pen, what was the colorant that was used on this pen, and whether this colorant or this plasticizer or this editor, whether any of these have any negative impacts on wildlife or not because ultimately after this pen is used after its usable life, it is going to find a way in a dustbin, and ultimately it will go to the environment. So, when we are designing anything are we taking into consideration, whether these things are going to help the environment or whether they are going to harm the environment?

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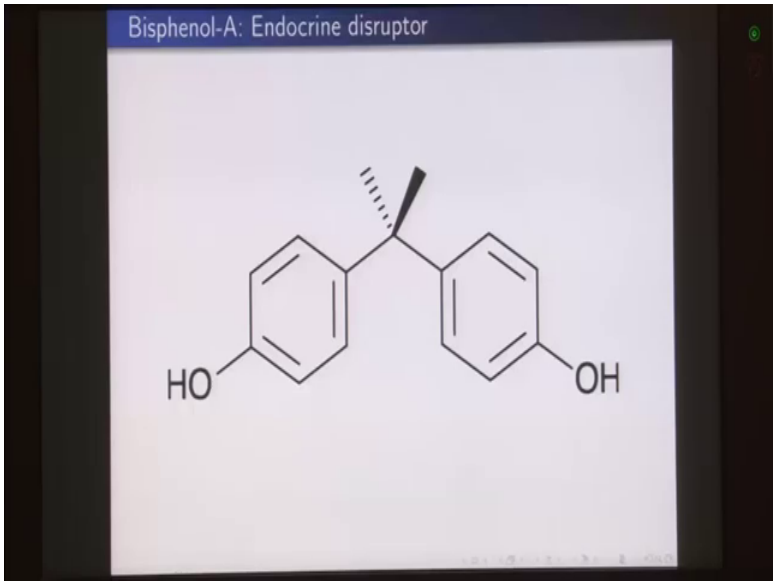

Now, some substances that are more pertinent here are things like Bisphenol-A. Now, Bisphenol-A is an endocrine disrupter, so essentially it mimics some of the hormones in the body. And for instance if you take a bowl, and you keep some tadpoles or the young ones of frogs into it, and if you add some Bisphenol-A, you would observe a drastic change in their sex composition.

So, they would change in their sex, because it very closely mimics the sex hormones. Now, where do we get Bisphenol-A, well we get Bisphenol-A most of our plastic bottles. So, if we consider this bottle of plastic, Bisphenol-A would be one of the plasticizers that

would be added here. We normally use it for drinking water, but then this could be a very potent toxin, especially when you are giving it to the wildlife.

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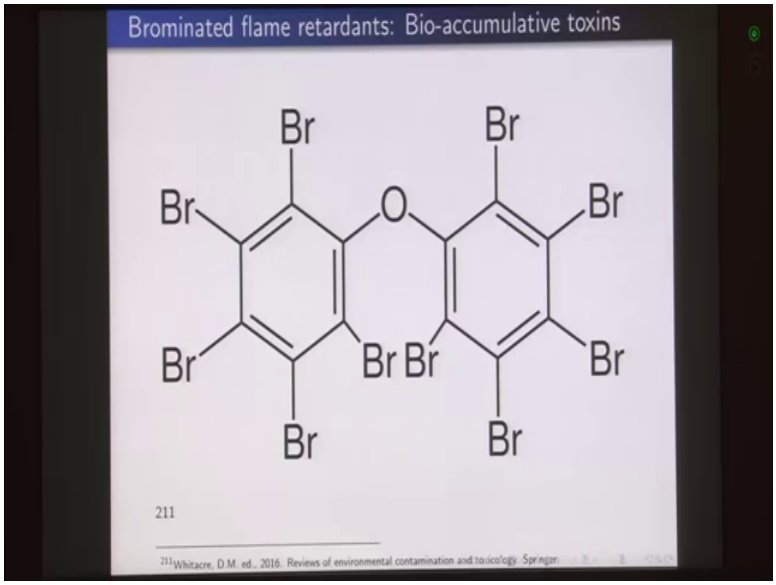

Other things include brominated flame retardants or BFRs. So, these are also toxins, and they are bio-accumulative toxins. What it means is that these toxins are fat soluble, so they go and reside themselves in the fat tissues of the animal. Now, if there is anything that is water soluble, so the animal is eating that thing, for drinking that thing, and then it will come out in the form of urine, when the kidneys have processed that particular chemical.

But, in the case of bio-accumulative toxins, these toxins go and then they reside in all the fat tissues of the body. So, when that happens and when there is another animal that is feeding on this animal as a predator; so all of these would move along with the fat tissues into the body of the predator and so on. So, they go on accumulating in the bodies, and they also go on magnifying in their concentration as we move up the food chain.

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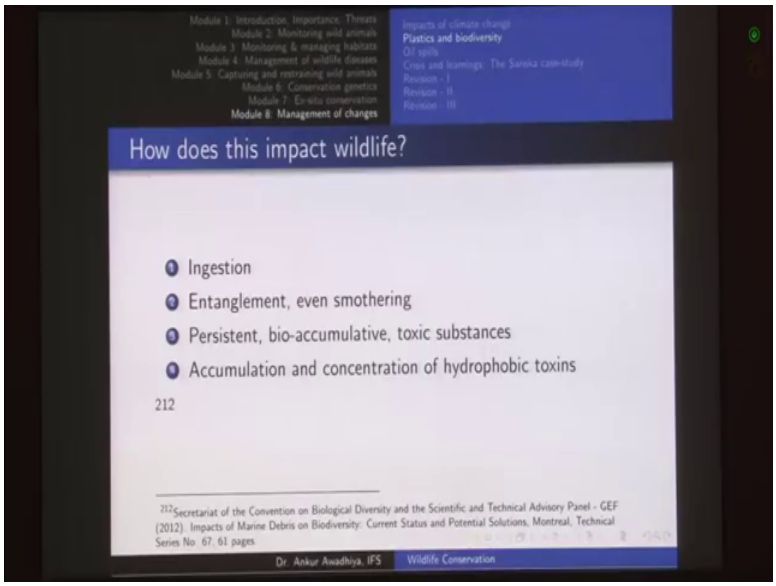

Another impact is that of accumulation and concentration of hydrophobic toxins.

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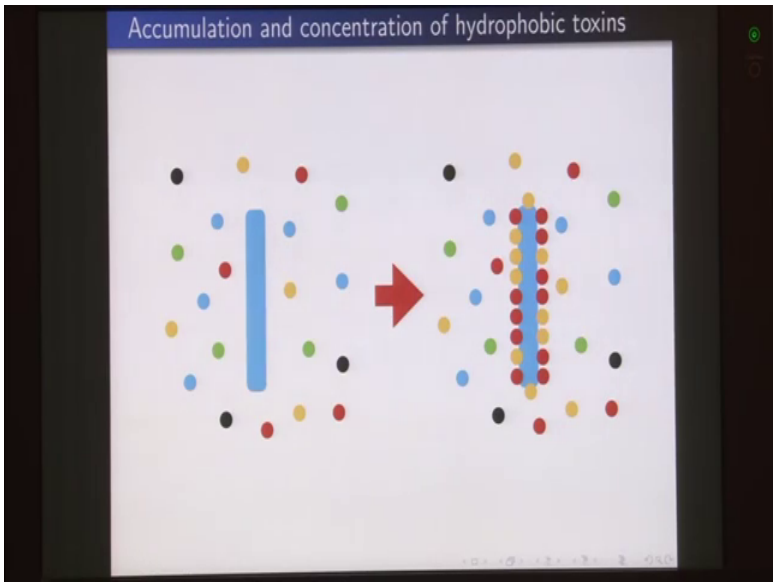

Now, it turns out that most of the toxins that we find in our natural environments, and mostly those that are human generated are hydrophobic molecules. So, in the first instance what we are seeing is that in the water, we had some concentration of hydrophobic substances that were just floating around in the form of droplets. Now, if you put a piece of plastic here, in a plastic is mostly a hydrophobic substance. So, it repels water because of which it does not wet itself.

So, when you put this piece of plastic, most of these hydrophobic substances would move towards this plastic, and would stick on its surface. So, essentially the concentration of these toxins that were there in the water has now increased very much, when we talk about the surface concentration of these toxins on these plastics. And now if there is any animal that eats this plastic by misidentifying it for food, then it would get a very heavy dose of these chemicals into its body.

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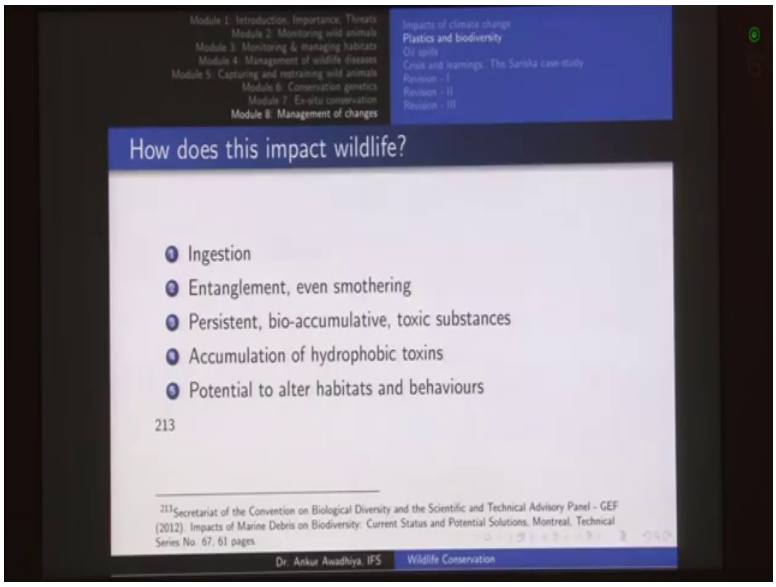

Next impact is the potential to alter the habitats and also the behaviors of the animals.

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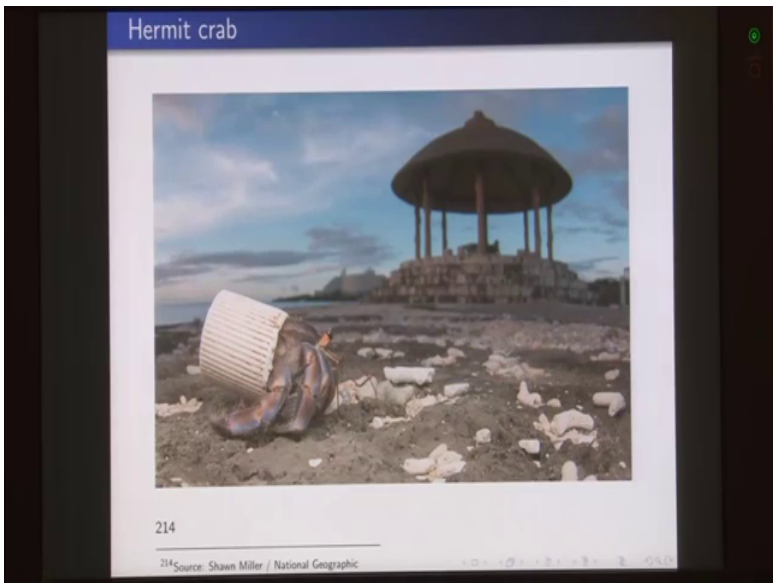

So, for instance this image that we saw a short while back. So, here we have this cap this bottle cap that has come and washed onto the shore of sea. Now, in this case what we are observing here is a hermit crab. Now, a hermit crab uses the shells of other animals as a protective covering. Now, it found out this cap and it thought that this is the shell of some animal, and so it has now started using this cap as its shell as a protection. Now, this is not a behavior that is observed in nature. So, this is an altered behavior, this is an altered behavior in an altered habitat, which is not a natural phenomena.

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Similarly, in this image we are observing a seahorse that is using an ear bud. Now, again an ear bud is not a natural component in the habitat of a seahorse. And when it has altered this habited, now it is also altering the behavior of the seahorse.

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Similarly, the case of these hyenas: so these hyenas which are very crucial part of the ecosystem, because they get rid of all the dead and decaying animals that are there in the forest. Now, these animals are now feeding on this trash dump, and so this is also an altered behavior.

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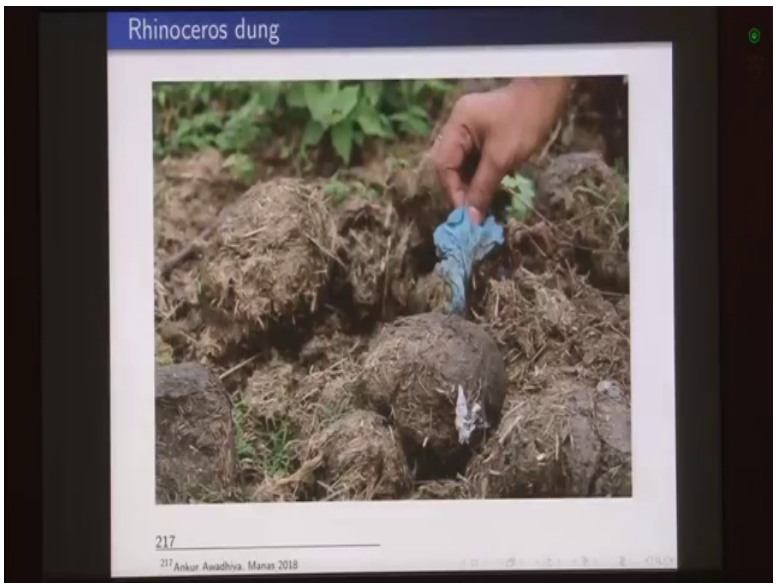

This image in one of our previous lectures; so what we are seeing here is that even in the manas tiger reserve, which is a protected area, and which has one of the greatest amounts of protections that is available for wildlife, we are observing that plastics have made their

way even inside our tiger reserves. So, this is rhinoceros dung, and we are finding plastic bags even in its dung.

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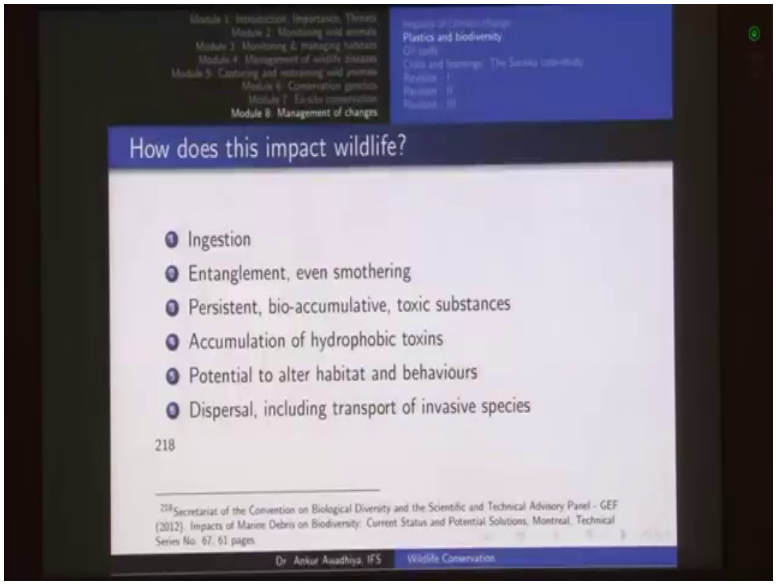

So, this is about the potential to alter the habit and behaviors. One of the thing that plastics would do is to aid in the dispersal of animals; so including transport of invasive species. So, now dispersal is a phenomenon in which species or some individuals of a species move from place a to place b. Now, this is being facilitated by plastics.

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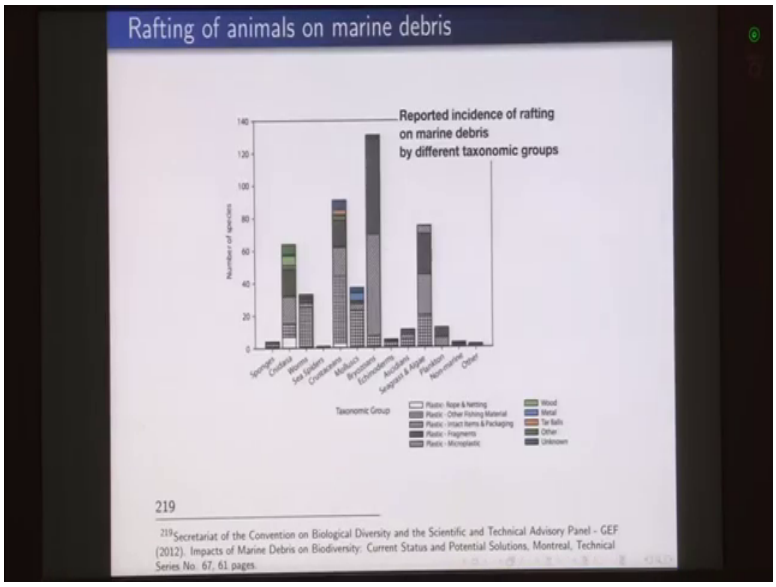

So, for instance this figure tells us different kinds of animals different types of animals, and here we are seeing the number of species that are moving from place a to place b. Now, in all of these bars, we have different-different substances that are being used to raft from one place to another place. The green is wood, blue is metal, the orange one is tar bars, dark green other, dark blue is unknown, but rest of these are plastics.

So, now for instance if we look at worms: there is only this small portion that would have moved if we only had natural substances, but all of these others were able to move because of plastics. Similarly, in the case of these bryozoans, so all of these have moved because of plastics. And only this much amount was naturally possible, if we did not have plastics in the environment. So, we see a very heavy movement of animals and a number of these animals could even be invasive species. So, they would then harm the other habitat.

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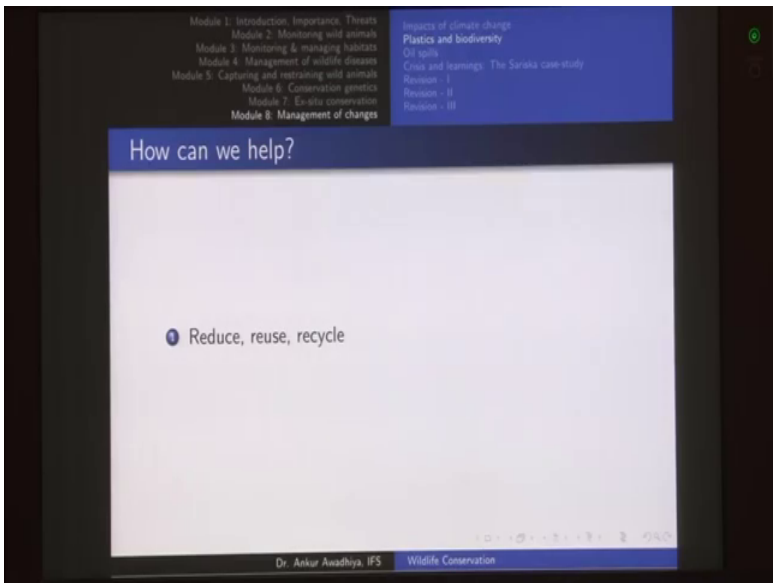

So, how can we help, how do we reduce this menace of plastics? Well for one we could go for a reduce, reuse, and recycle, the three R's. We reduce the amounts of plastics that we use. So, for instance in place of going for a plastic bag, we could go for say a paper bag to reduce the amounts of plastics that we are using. We could go for a reuse of plastics. So for instance: if you have a bottle of water that you had purchased somewhere, you can use that same bottle for some other purposes, maybe even for carrying water for some time.

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And the third one is recycling, so this is an image of a recycling plant. So, you can take all of these plastics, then convert them into these big bales. And then these big bales can then later on be subjected to heat, so that they melt again. And then they are converted into some other plastics.

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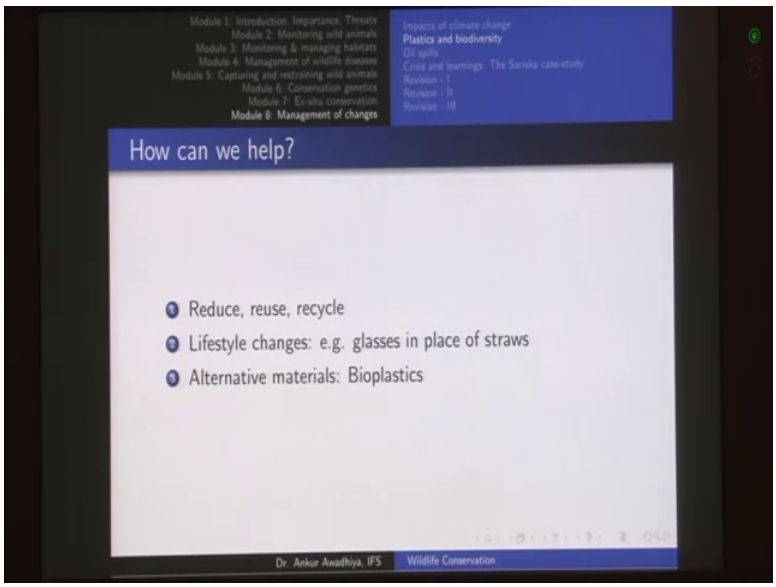

The 2nd way in which we could help is through life lifestyle changes. So, for instance if you are having a cold drink, go for a glass of holding in place of using straws with your

bottle, so these small lifestyle changes will also help us to reduce the amount of plastics that we are using.

The next is to go for alternative materials such as bio plastics. Now, bio plastics are bio-degradable plastics. So, in place of our normal petroleum based plastics that are made using petroleum, which are extremely hydrophobic materials, and which do not degrade, once they have been used. Bio-degradable plastics are those plastics that are made from some biological materials such as carbohydrates or say proteins. And then they have all the properties of a plastic, but an added property is that they are bio-degradable.

So, even if some animal eats them up, so because they are made out of carbohydrates, if some animal eats it, the enzymes inside the body would be able to degrade this material. And just provide it with energy just like any other food item. These plastics are not going to choke the elementary canal of the animals, if they are eaten. Similarly, if these plastics are just left out in open in the trash, so what would happen is that some animals would come and feed it. If some animals do not feed on it, then we would in a very short time, we would start seeing the impacts of bacteria and fungi and microorganisms in which case they would be able to degrade this plastic into say carbon dioxide in water.

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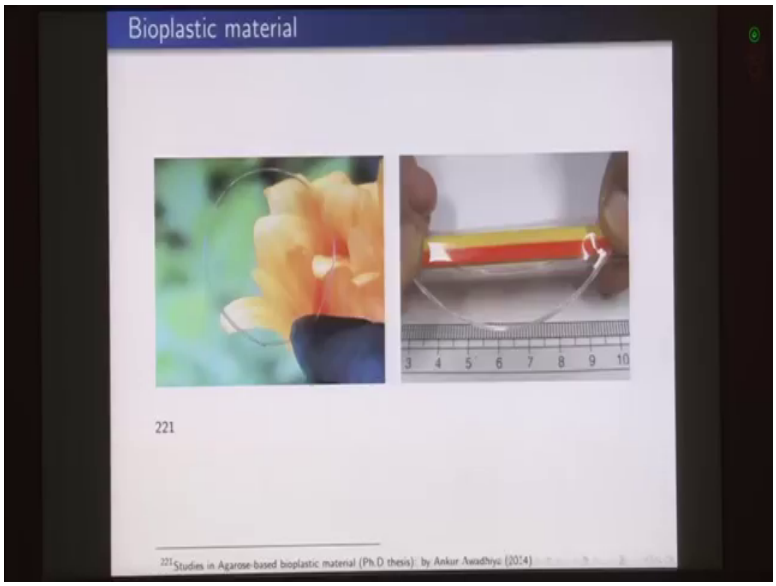

So, one such bio plastic material that we made at IIT, Kanpur is this. So, this is an agarose based bio plastic material, and it is properties that those are very similar to the data of polyethylene. So, here we see that this is a circular piece of plastic, and it is

completely transparent just as we have our transparent polythene sheets. Then it is flexible. So, we have rolled it up on a pencil, so this is a flexible plastic.

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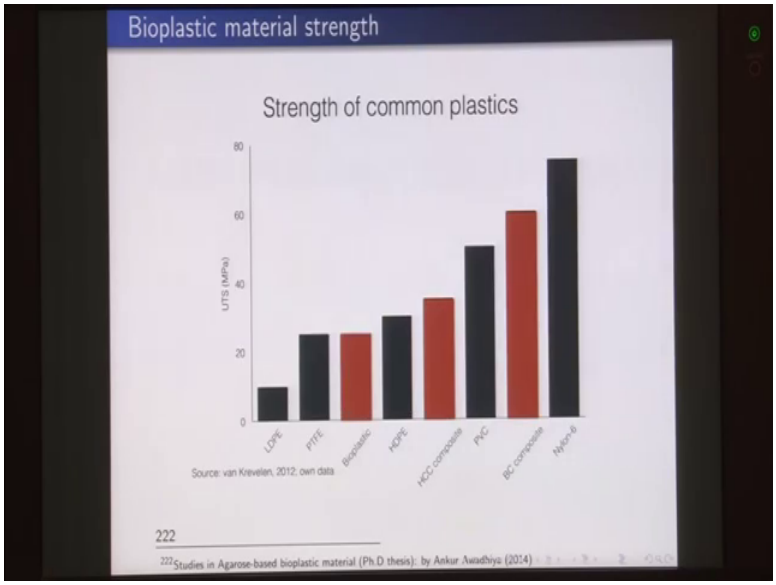

Even more importantly, when we look at its mechanical properties, so such as strength, so the problem with a number of bio plastics is that they do not have appreciable amount of strength. So, for instance you would have read about cases in which people tried to make spoons out of bio bio-degradable plastics, say spoons out of carbohydrate materials. So those are fine, but they are very hard and brittle.

In the case of these plastics, they are not only flexible, but they also have a very good amount of strength. So, we have represented our bio plastic in red. So, as you can see, this is our low density polyethylene that is used in the making of a number of polythene bags. And if we consider our bio plastic, our strength is close to around two and a half times that of the LDPE.

So, right away it has a very high amount of strength, but then we can then composite this material with cellulose and which bacterial cellulose to increase its strength even further. So, as such this bio plastic has as a strength that is comparable to PTFE or to high density polyethylene. With an HCC composite, it increases its strength, so that it surpasses the high density polyethylene. And this bacterial cellulose composite, it increases its strength. So that it is able to surpass all of these even PVC. And it has

reached a strengths that is now close to that of nylon, which is one of the very strongest fibers of label, the strongest plastics of label.

So, the bio plastic is having the properties that are the best of both the worlds. So, they have all the plastic like properties, they have various high amount of strength, they have flexibility, they are transparent. So you can print a number of things, but at the same time they are also biodegradable. So, things such as these alternatives need to be explored as much as possible.

So, in this lecture, we looked at what plastics are, what is the history of plastics, what are the kinds of plastics that we are using, then what happens when these plastics get into the environment, what happens when these plastics are burnt when, what happens when these plastics are put into landfills, and when they come out into the environment how do these plastics degrade from macro degrees to meso debris to micro debris, so what does the process that is followed here.

And then what are the impacts of plastics on our biodiversity. So, what happens when animals eat these plastics, what happens when animals get entangled into these plastics, how these plastics are bringing in more toxic substances even bio-accumulative toxins into the animals, how these plastics are increasing the concentration of toxins that is that are available in the environment and things like that. And then we went into considering what can we do to reduce this menace.

So, we looked at the three R's reduce, reuse, and recycle. We looked at lifestyle changes we also looked at things like looking at new newer materials such as biodegradable plastics or bio plastics, so that is all for today.

Thank you for your attention [FL].