Plastic Waste Management
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Lecture - 32
Biodegradable Plastics

Ok. So, welcome back; we will get into now second video for the week 7 and as we are focusing on green and alternative material. So, in this video the most of the focus will be looking at the biodegradable plastic which kind of we started looking in there towards the end of the previous video.

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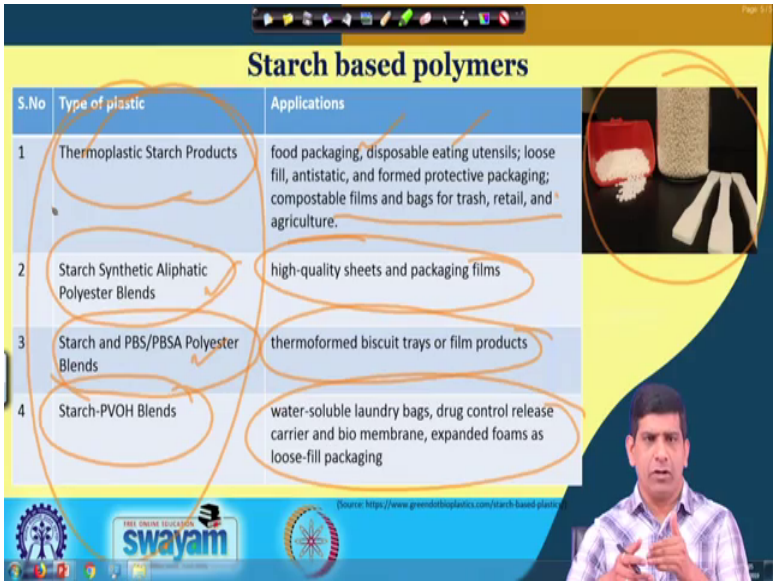

So, there are different types out there as you saw and so, some are here we are looking at some starch based polymers which is used in biodegradable plastic as well. So, as you can see in terms of different example there are some thermoplastic starch products, there are some starch synthetic aliphatic polyester blends so, it is an a mixture of synthetic with polyester with starch; starch with PBS and PBSA polyester blend it, starch with PVOH plan.

And they are used in different applications for food packaging, disposable eating utensils, loose fill, antistatic and form protective packaging, compostable film and retail and for trash bags, for bags for trash use in retail as well as for agricultural application ah. Synthetics this type we have high quality sheets and packaging film. So, here we

have thermoformed biscuit trays or film products for starch and PVOH plant water soluble laundry bag, drug control release carriers bio membrane, loose fill packaging so, as you can see and there are some examples right here in terms of the different product.

So, as you can see there are there are there is so, this bio plastic or bio based plastic where part of the plastic is bio based not in turn not 100 percent as a this is kind of a blend of bio based as well as like a usual it is stuff like polyester and all. So, that is it is there are applications it is not and it is being used already it is being used all rates already being used, but since we use so much of plastic is still there are several plastics are being used which are essentially just the fossil fuel based plastic, but there are alternatives are already been in the market and some of them the with the plastic alternatives thing is that 100 percent biodegradable plastic is still not out there and for many of the applications that plastic is used 100 percent biodegradable plastic is not meeting the same strength and other requirements for that plastic.

So, that is where the research is needed to come up with bio based plastic which can hunt replace traditional plastic and do all the function as the traditional as per traditional plastic does, which kind of sounds sometimes a little bit awkward because the whole reason why this fossil fuel based plastic is so popular because they are non biodegradable and they are they can extend they can last for a long period of time.

So, and now we are trying to make product which is biodegradable, but also do the function and of fossil similar function as fossil fuel based plastics. So, there is always, but since the technology has improved the new and knowledge has come in, we are trying to make something happen, but many of them are still in a blend stage where you have both plastics blended together, but at least part of it is biodegradable so, there is some positive right there.

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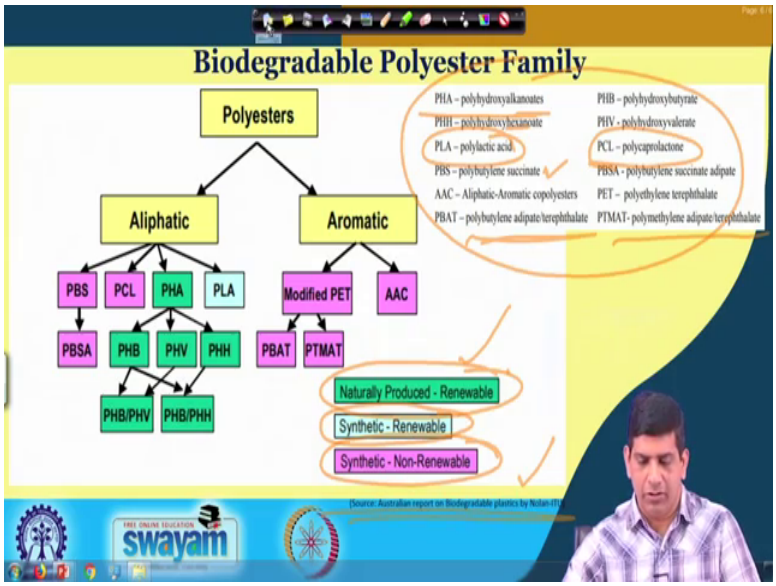

So, there are biodegradable polyester families also there. So, if you look at the polyester there are aliphatic and aromatic there are two different types of polyesters. So, in aliphatic you have different types PBS, PCL, PHA and all those what they mean has been listed right here. So, like a for example, PBS it is a polybutylene succinate, PCL which is your polycaprolactone and again those of you registered for exam or since many all of you I hope that all of you are taking quiz and you should take quiz those of you have registered for this course.

So, I am not we are not going to ask you that what is this, what is that, because that is that will be a little bit unfair to ask, but I do not want to do memorize all these abbreviations here, but just with that when you look at those the names. So, you kind of get an idea of what they are because the names are most of these organic names you can get guess how what kind of structure that a particular like a compound has and also what could be in there so, those things can be guessed based on that.

PHA which is the polyhydroxylkanoates, now PLA which is very popular polylactic acid which is used a lot and there are others out there as well. So, similarly we have aromatic which has modified PET AAC which is Aliphatic-Aromatic copolyester, then PBAT and PTMAT which is polybutylene adipate terephthalate, then polymethylene adipate terephthalate. So, there are so, here the important thing is that when you look at them anything which is shown in green box they are naturally produced they are enable,

anything which is in the light blue box they are synthetic, but it is still renewable, anything which is in that pink or purple color box with pink slash purple it is non renewable and this came from there is Australian report by on biodegradable plastic than few years back. So, it is basically coming from that and as I said earlier most of these reading reports other stuff is are made available on as a reading material.

So, you can look at if you are interested you can look at it in more detail on those reports as well. And since even if it is say for some reason it is not there in the reading material the details are here you can google it and you will find those reports.

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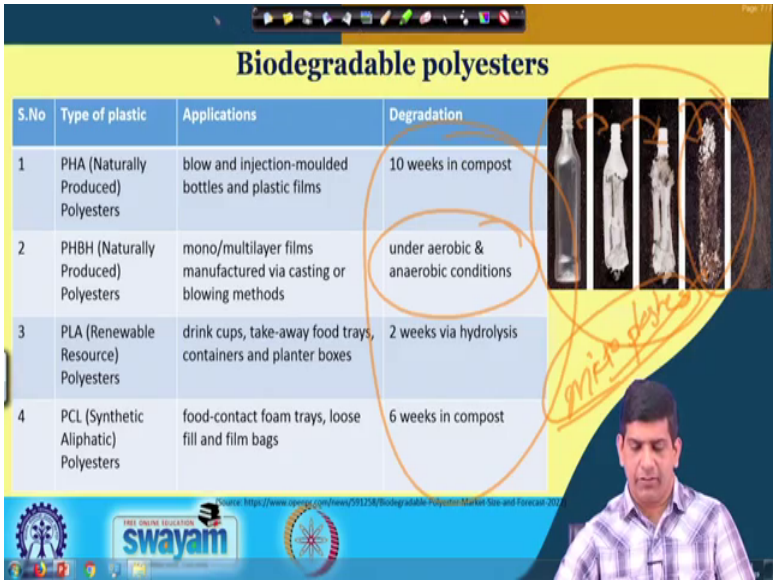

Now, in terms of biodegradable polyesters there are there are p different types of plastic we have a PHA which you saw PHA is a naturally produced poly polyester, PHBH which is not again naturally produced, PLA renewable resource polyester, PCL which is synthetic aliphatic polyester. There are different applications for them it is a blow and injection molded, multi layer films drink cups, takeaway food trays, containers and boxes foot contact form trays loose fills and film bags. And if you do a composting on them excuse me if you look at the composting on them it kind of goes from there are from 2 weeks to 10 weeks for the different types.

So, PHA naturally produced polyester it takes 10 weeks in compost, PLA which is 2 weeks via hydrolysis. So, it is pretty quickly PCL 6 weeks and PHBH can go for under aerobic anaerobic both condition it can degrade so, as you can see in the picture here this

type of like a PLA kind of plastic bottles. So, it will start degrading and then kind of goes and then finally, hit kind of crumbles up and makes into smaller pieces. We need to make sure that these are smaller pieces when it goes it is really kind of degradable it does not create micro plastic, if it creates micro plastic then it becomes a problem.

So, we have to look at that aspect as well it should not create micro plastics, as we talked in the previous I think in the week 4 or week 5 where we were looking at the health impact. So, micro plastics had a lot of negative impact to the environment so, we want to make sure that it does not create micro plastics.

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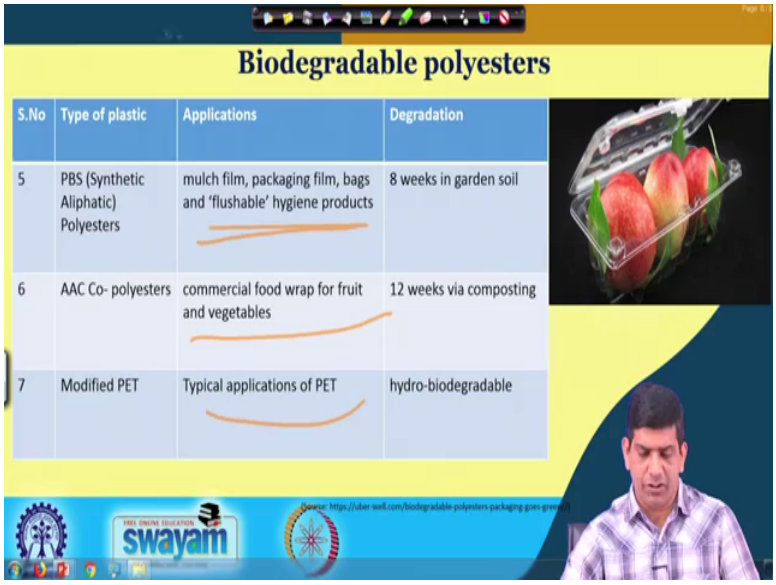

Then there are some others category as well PBS which is and then AAC Co- polyester modified PET and there it is used for mulch film, packaging film ah, you have flushable hygiene product, commercial food wrap, typical application of PET modified PET is also used for that. So, again 8 weeks or 12 weeks it kind of used in those commercial so, that those are used for those kind of application. So, again there are there are biodegradable polymers out there which is used in different application as you can as you saw.

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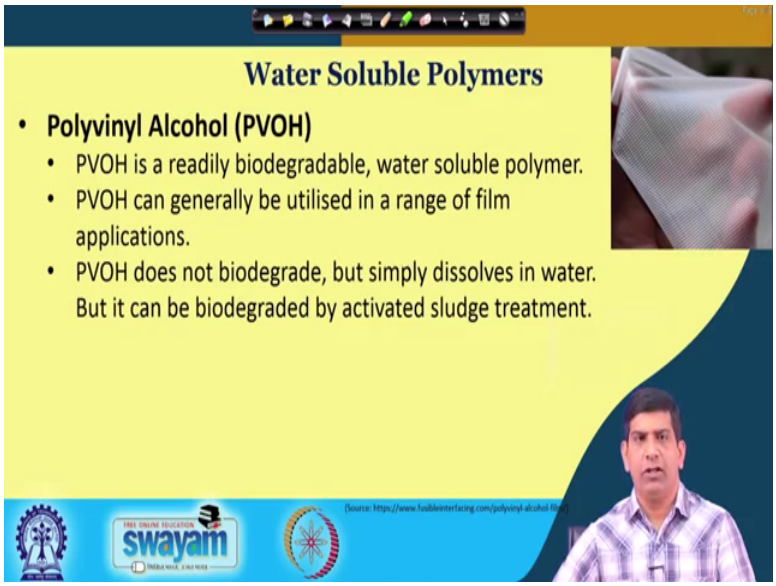

Then there are some call water soluble polymers the PVOH you saw this earlier as well which is Polyvinyl Alcohol, it is readily biodegradable water soluble and it can generally be utilized in a range of film application, as you can see on the right hand side like it is it is kind of a film application, does not biodegrade, but simply dissolves in water it can be biodegraded by activated sludge treatment. So, it does a bio it will dissolve in water and then you can use to put it in the industrial wastewater treatment plant or the wastewater treatment plant and if you like if you have a activated sludge treatment will take care of it is like food degradation.

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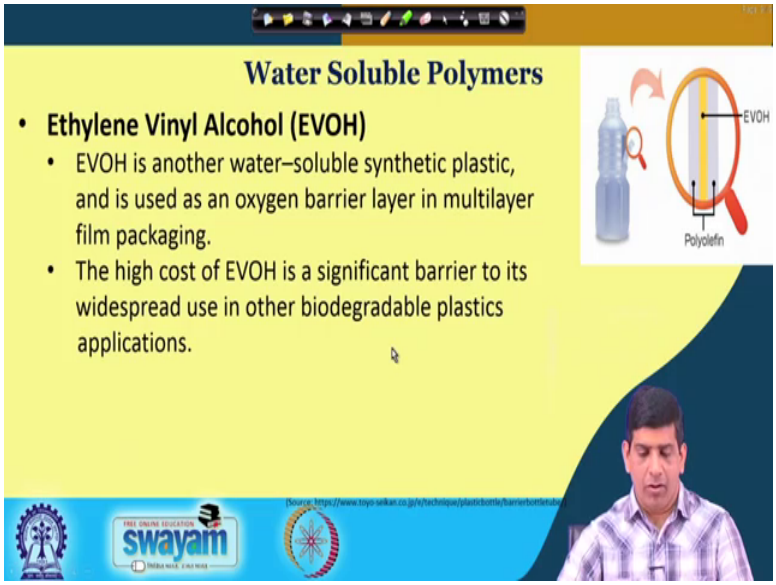

Water soluble polymers is also Ethylene Vinyl Alcohol EVOH earlier we had PVOH this is EVOH which is again another water soluble used as an oxygen barrier layer in multi layer film packaging so many of these films like when you look at your ketchup bottle; ketchup bottles and several other bottles where you have two layers of. So, essentially you have two layers of plastics and in between in between you have a third layer. So, this is your plastic layer, this is your plastic layer and now you have a third layer in between which is so, if you can put it like this.

So, this is the you can see in the middle the pen that we had that I have it is kind of symbolizes the third layer which is your ethylene vinyl alcohol layer. So, that is your; it is an it is a water soluble polymer and what it does it is not let the oxygen it becomes the oxygen barrier layer. So, your whatever is the product inside that particular bottle stays fresh for a longer period of time.

So, it is a high this it is a little bit costly it is a high cost of EVOH is a significant barrier to it is widespread use another biodegradable plastic application, but it is used as a oxygen barrier layer in several containers.

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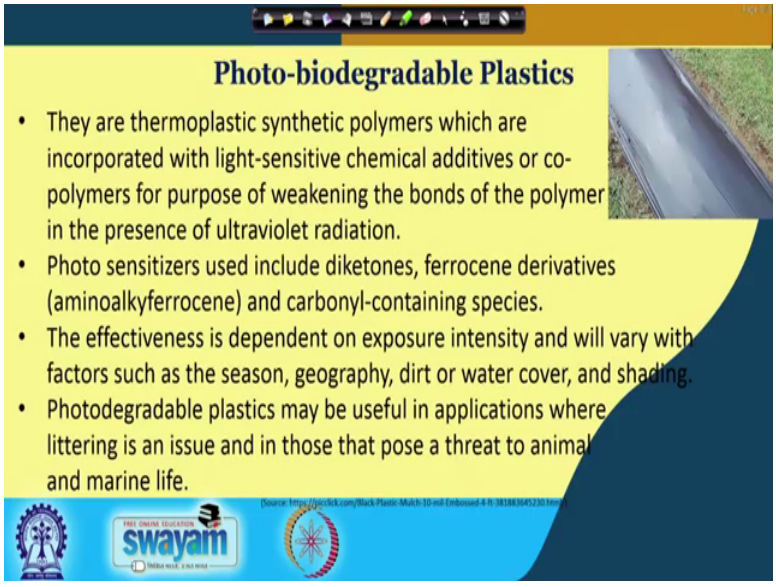

And there are some photo biodegradable plastic which will degrade them when they are exposed to sunlight. So, these are thermoplastic synthetic polymers it is with a light-sensitive chemical additives; so they have some light sensitive chemical additives or

copolymers they got the purpose of this is to weakening the bonds in the presence of ultraviolet radiation.

So, in the; in when it is exposed to sun exposed to UV rays it will start degrading. So, it is they use diketones, ferrocene derivatives like aminoalkyferrocene or carbonyl-containing species and again the effectiveness will depend on exposure intensity vary with factors just siege in geography dirt or water some places in the world we have higher UV content and the others so, that also will play a role. So, photo degradable plastic may be useful in application where littering is an issue.

So, if it is if it is a people are not following the rule and we have a lot of littering of the plastic waste. So, if they are photo biodegradable with the sunlight over some period of time it will degrade and it will go away. So, it will; it will kind of threat to the animal and marine life will go down because it will degrade out based on exposure to UV rays.

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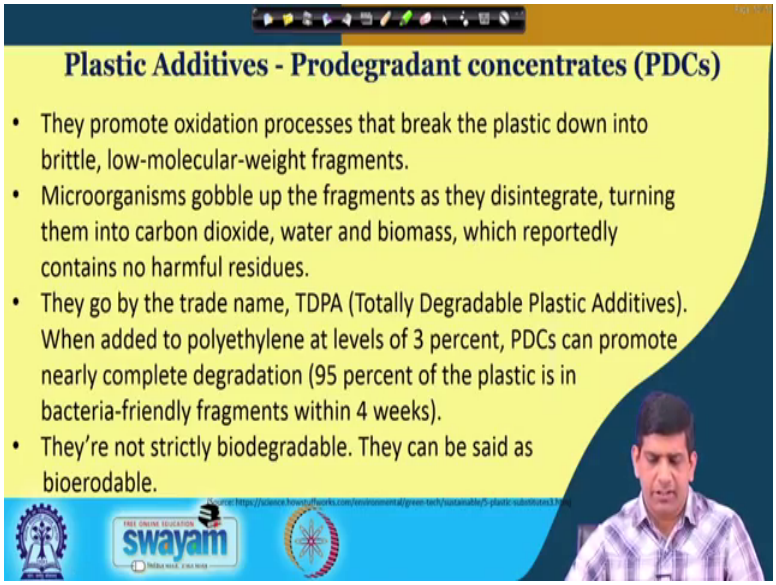

Then there are some; there are some plastic additives which is pro prodegradant concentrates. So, they promote oxidation process that break the plastic down into brittle or low molecular weight fragments. Then microorganisms gobble up the fragments as they disintegrate, turning them into carbon dioxide water and biomass. So, and then which reportedly contains no harmful residue.

So, they go by the trade name of TDPA which is totally degradable plastic additives. So, that is what it is called totally degradable plastic additives and as the name suggests it is supposed to totally degrade and when they are added to polyethylene at the level of around 3 percent, PDCs they can promote nearly complete degradation like 95 percent of the plastic in bacteria friendly fragments within 4 weeks, they are not is strictly biodegradable, but they can be said as bioerodible. So, they are eroded through biological process. So, they are not told like totally like a biodegradable as per the definition of biodegradability, but they are eroded through the bio by the microorganism. So, it can be called as a bioerodible.

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Now in their application they are used in thin plastic shopping bags the manufacturer single use plastic, disposable diapers, trash bags, landfill covers, food containers. So, that is where it can help in degrading those plastic quickly so, that is the point there.

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And there are a lot of other there are a lot of other food products there are a lot of other materials which are also coming up. So, there are some editable edible food packaging is also there which is made from milk protein. So, in this particular video I would like you to you see that there are some of the newer food packaging that is coming in where you actually coming from the milk protein and we are using it as a food packaging plastic which is kind of one of the polymers that is being used.

So, it again it is a bio based polymer it is a like a degradable polymer and it can be eatable poly it is a basically you can eat those packaging. So, I will let you watch this video there is an audio as well. So, I will I will keep quiet in this particular video and then you can just watch it and after that we will have a will discuss it. So, I will get started for you.

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These issues scientists are now developing a biodegradable film made of milk proteins.

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And you can eat it to be.

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Let by Peggy Tomasulo the team at the us department of agriculture developed an environmentally friendly film made of the milk protein casein, these films are up to 500 times better than plastics at keeping oxygen away from food.

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And because they are derived from milk they are biodegradable sustainable and edible. The researchers are presenting their work at the 250 second national meeting of the American chemical society.

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Although the researchers first attempt using pure casein resulted in a strong effective oxygen blocker.

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It was relatively hard to handle and would dissolve in water too quickly.

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So, they made a few improvements, adding citrus pectin into the blend to make the packaging even stronger and more resistant to humidity and high temperatures, the material has a number of unique applications.

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In editions being used as plastic pouches and wraps, this casing coating could be sprayed onto food such as cereal bars or flakes right.

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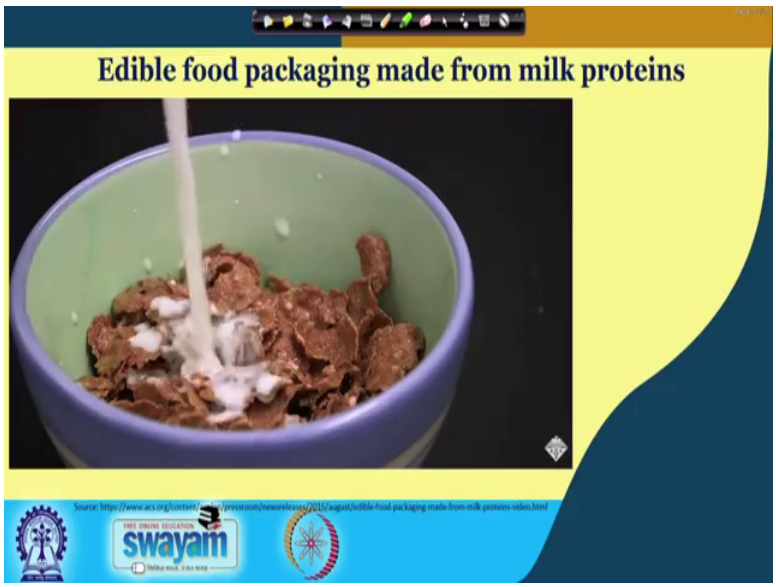

Well, now, cereals keep their crunch and milk to do a sugar coating, instead of all that sugar manufacturers could spray on casein protein coatings to prevent soggy cereal. Co leader of the study Laetitia Bona P says the team is currently testing applications such as single serve edible food wrappers.

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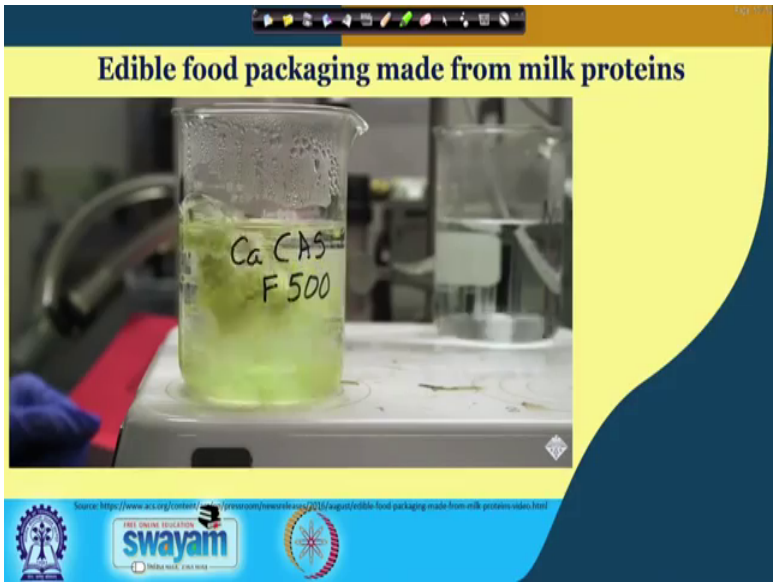

Individual dried soup portions or instant coffee wrapped in the film can be added to hot water where the film readily dissolves eliminating the packaging waste.

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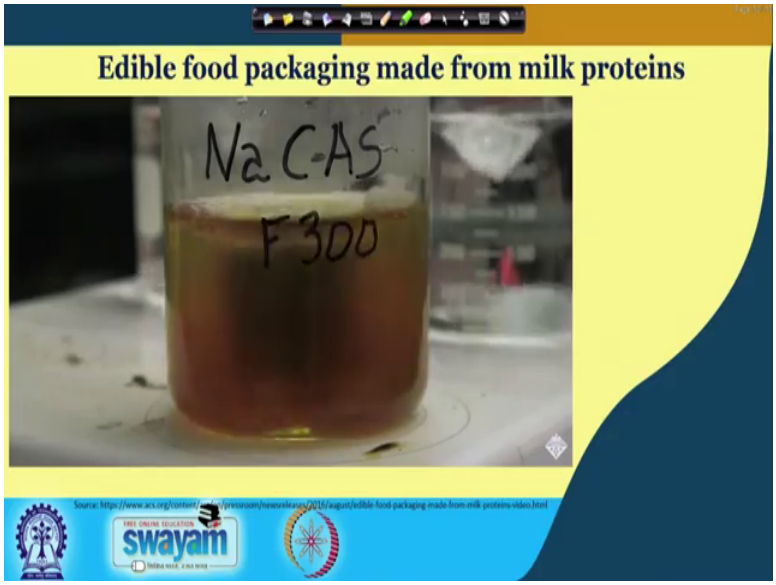

Because single serve pouches would need to say sanitary on store shelves, they would have to be encased in a larger plastic or cardboard container to prevent them from getting wet or dirty, Tomasulo and her team hopes it.

So, as yourself it is it was like it is mostly like a based on milk protein and you saw that how easily it was like did got dissolved and then it can be like degraded, it is most and

you saw one gentleman one like a boy eating one of those plastic as well. So, there are there are products out there which is claiming to be eatable food packaging.

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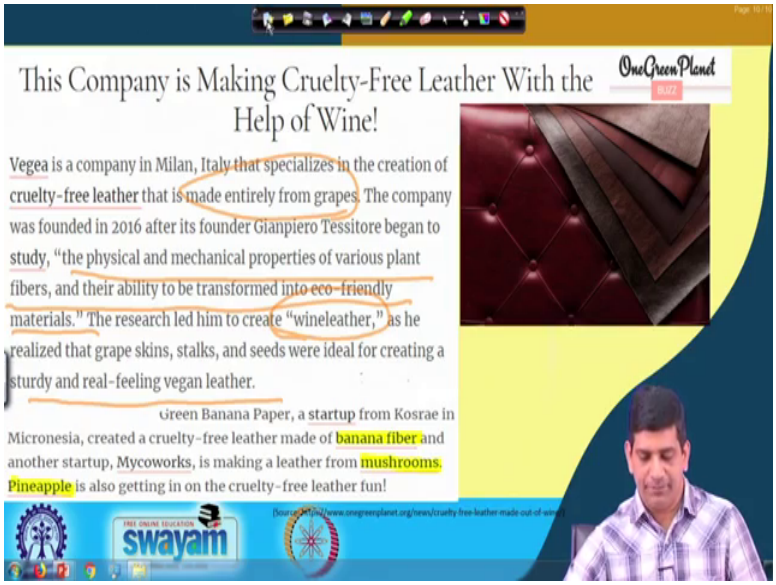

There is also some cutlery sets are coming up where cutlery sets even plates are coming up which is eatable plates. So, you eat some if you take a snacks and after that you eat the plate itself. So, those products are also coming up mostly we see from the European market those things are being showing up. So, this is a becoming it is; those are becoming a little bit popular they are not in a big scale is still, but it is becoming popular in terms of like a alternative to plastic packaging alternative to plastic especially in food and related sector where you can use these as part of because you can eat that too. So, you can eat whatever is the for inside, but at the same time it the package packaging as well so that would that is like a it looks cool as to.

So, going a little bit further there was so much like a in terms of some of the like a leather kind of stuff, this is one company in Milan, Italy it is a which is like a Vegea if I am spelling it correctly because maybe it is Italian name. It specializes in creation of cruelty free leather as you know leather is it is most of the leather is coming from animal bodies. So, your leather shoes or leather bags or leather purse or leather jacket they all coming from some animal. So, here they are looking at try to make entirely this leather from grapes. So, you can use grapes which is entirely made from grapes. So, that is you can use grapes to make leather, the company has was founded just like more than just

more than 2 years ago in 2016 after became to study the physical and mechanical properties of various plant fibers and their ability to be transformed into eco friendly material.

So, he went a;his research made something what is called “wine leather” so, because as you know grapes it is a wine. So, it is realized that grape skins it stocks and seeds where ideal for creating a sturdy and real feeling vegan later so, you have now vegan leather. So, and then there are other so, that is they are using grapes to make as eco friendly leather it is called “wine leather” because it is coming from the wineries with the grape skin, stalks and as well as seeds.

Then another one is the green banana paper I start up from Micronesia created a cruelty free leather made from banana fiber and another start of Mycoworks is making leather from mushrooms and pineapple is also getting into the cruelty free leather fund.

So, a lot of as long as we use kind of voiced product from these it is ok, but if we say if we start using banana as a fruit banana and trying to use it for this then we are competing with food sources. We need to eat the first preference is to eat the banana and not to make leather out of that, but we are not using the banana fruit here it is actually the banana it is made from the banana fiber. So, it is you can take from the kind of banana skin and other things from the banana plants that can be used for making those leather. So, that is that is fine that can be it is a like a good initiative.

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So, there are a lot of things are happening in the world and these are some examples again as I keep on telling you there is not a standard textbook on this particular course there is this is a there is no this is a brand new course. So, that is why he we have tried to put together a lot of information from different sources and we are discussing those, we are presenting it to you, we are just telling you what it is, we are not we are not here to make any opinion about one versus the other. These are the facts and you can make your own opinion which one is good which one is bad we are showing you pros and cons of everything and of course, it; the one of the major goal of it is to make you aware of plastic waste management issues alternatives to plastic. So, that we can as a society we can make a decision of how to manage this plastic waste and what are the alternatives that can be used.

So, now another use that is chicken many like the chicken is one of the staple food now, in everywhere in the world you find a lot of chicken being used a huge poultry industry around the world. So, the chicken feathers that is can be a Spanish company is using is looking to use chicken feathers as a form of plastic to use that is that is sounds again pretty cool. So, it is a they said it will be a strong plastic most of the waste for the chicken feather is a profitable material due to it is high carotene content feathers are likely to produce plastics that stronger and more tear resistant compared to those using modified starch or plant proteins for examples it will be a better than other bio based plastic.

So, and so they have a project KARMA2020, which is looking to how to transform unwanted feathers into biodegradable plastic how so, there are challenges of course, to use as a raw material ah. They have also created samples of feather based material could be used for packaging using a poses where heated material is injected into mold and shape it then they are working on scaling up. So, there is some research going on also looking how to make food packaging from feather and also other application like slow release of fertilizers, compostable composite materials, flame retardant coatings.

So, they are looking at economic technical feasibility of all that. So, that is another some interesting stuff going on, again as I keep on telling you if you find some interesting stuff I strongly encourage you to go on Google and search for all these different topics because this field is. So, dynamic the moment we said put together these slides there might be some more reports out there which we may have missed it we are also trying to

keep an eye on that, but if you find something new please post it on the discussion forum. It would be helpful for each one of us including our like team out like my team, including myself which who are working on putting together, who worked on put together on this particular course. So, chicken feathers from there to plastic, we looked at grapes skin to plastic ah, banana fibers to plastic, even pineapples, mushrooms to plastic so there are lots of things are going on.

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Mushroom roots with Mycelium mushroom routes finally, let us same stuff that Quorn is made from a packaging is literally grown it is a ecovative design gather agricultural waste mix it with the mycelium in molds and then the packaging quite literally grows. So, you can make pack packaging product from mushroom roots so, that is also being looked into.

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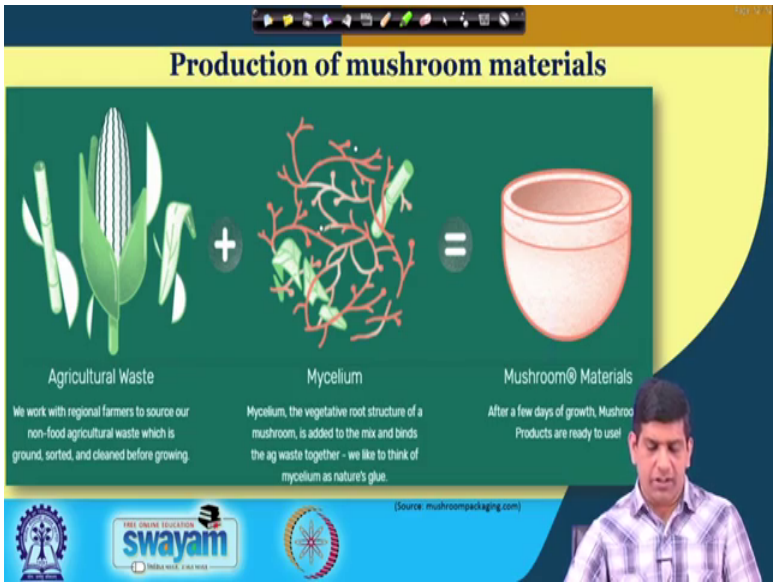

So, you can agricultural waste and then you put mycelium and then you get after a few days of growth mushroom products are ready to be used.

So, it is we work here they work with the regional farmers to source our non food agricultural waste which is sorted, grouted, sorted, ground and clean before growing, then you have mycelium the vegetative root structure of a mushroom is added to the mix and binds the agricultural waste together which essentially mycelium is like a nature's glue and then you have mushroom materials which can be molded into different products so, that is also it is getting popular.

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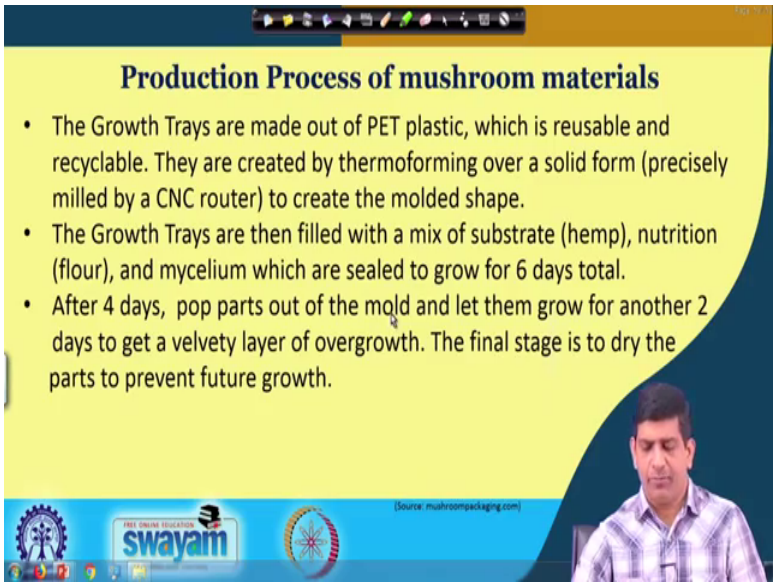

So, in terms of mushroom material the growth trays are made of PET plastic, which is reusable and recyclable. They created thermoforming over a solid form you can precisely mill by a CNC router to create a mold molded shape. The growth trees and then filled with a mix of substrate which is hemp, nutrition flour, mycelium which is sealed to grow for 6 days total. After 4 days, pop parts out of the mold and let them grow for another 2 days to get a velvety layer of overgrowth. The final stage is to dry parts dry the plant parts to prevent future growth so that is where you make this mushroom materials.

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Application of mushroom materials as you can see in different things as a packaging material as we can use as protection for like breakage. So, those material can be used rather than using the Styrofoam, these materials can be used which are essentially biodegradable. So, they look very much similar to a styrofoam which we used quite a bit any packaging lot of styrofoam, but then they do not degrade when they burn they create a lot of air pollution issues.

So, rather this material which we much is environmental friendly can biodegrade and those issues are not there as well. So, as you can see lot of packaging is being done especially for medicines also for this is your Canadian maple syrup which very popular in Canada and then you can use it for other applications as well a candles and all those kind of stuff anything breakable you can just put a packaging around it.

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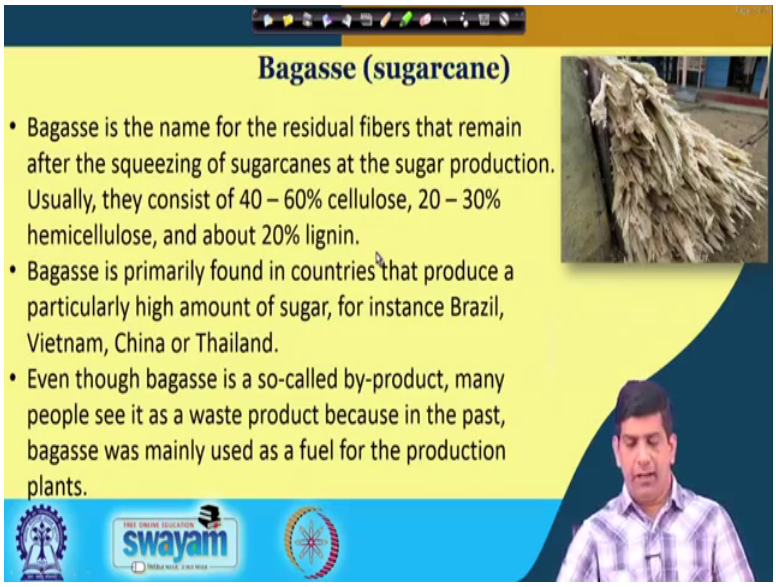

Then bagasse which is sugarcane after the sugarcane juice again very popular we see a lot of that in India especially during this summer months in during a summer when they after we get this sugarcane it starts coming in the winter towards the end of after Diwali. Diwali is when you first see it like a great new when you produce of sugarcane and then since then up to all the way up to the summer vacation sugarcane is available during the summer vacation as well and every time you drink a glass of sugarcane juice you see all those pulp that is coming out and then they are just kept there many times they are just dumped somewhere where I have seen in the city of Kharagpur in the town of Kharagpur

getting dumped some places it can be dried they have good calorific value and can be used as an energy source as well, but most of the most of the time it is just dumped on a side of the road or maybe in a landfill.

So, here I; they have usually 40 to 60 percent cellulose, 20 to 30 percent hemicellulose, about 20 percent lignin. So, it is a mostly cellulose and hemicellulose and they produce a high amount of sugar like Brazil, Vietnam, China, Thailand also in India we see a lot of bagasse. And bagasse is so-called a by-product many people see is a waste product because in the past bagasse are mainly used as a fuel for the production plant. So, now, with that not used that much for the fuel it is considered as a waste, but it is not waste because it can be used for different application.

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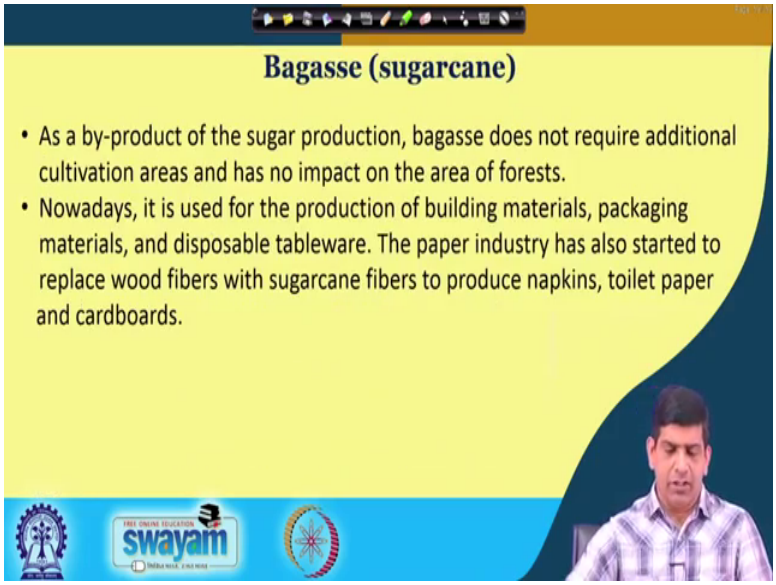

So, as a by-product of sugar production bagasse does not require additional cultivation area. So, there is no impact on forest it is used for production of building materials, packaging material and disposable table tableware. The paper industries also started to use replace wood fibers with sugar cane fibers to produce napkins, toilet paper and cardboard so that is where the bagasse sugarcane is being used.

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So, this is in the; it is being converted into several packaging material this is. So, here has see these eco-friendly containers made from sugarcane or as stronger than or as stronger than plastic. So, cutlery cups and plates that we want in so, here in it this is coming from our own country. So, in India many startups are finding alternatives to plastics. So, bagasse is being used in terms of extracting sugar after extracting the sugarcane juice can be used to make disposable cutlery and container.

Pappco is a greenware manufacturer is tapping into this market and creating awareness with good results as you can see all sorts of things that we use like fork, spoon, different types of a spoon, even your knife, different packaging, your plates, different sizes of plates, different types, different size and shapes of containers. So, it is pretty much everything that you will use for your kind of packaging material including this multi like a plate with so many divisions. So, you can put different food items at different places this is very popular plate used in many places.

So, this kind of things are also can be used made from bagasse so, it is a biodegradable material as it says for nearly 40 percent cellulose, 20 percent hemicelluloses, and 20 percent lignin, 40 to 60 percent then on 20 percent lignin rest is hemicellulose. So, it is can biodegrade by up lignin will be a little bit hard, but other than lignin things does cellulose and hemicellulose do biodegrade quite easily. So, it can be used for all these different applications so, that is really rather than sending it to the landfill.

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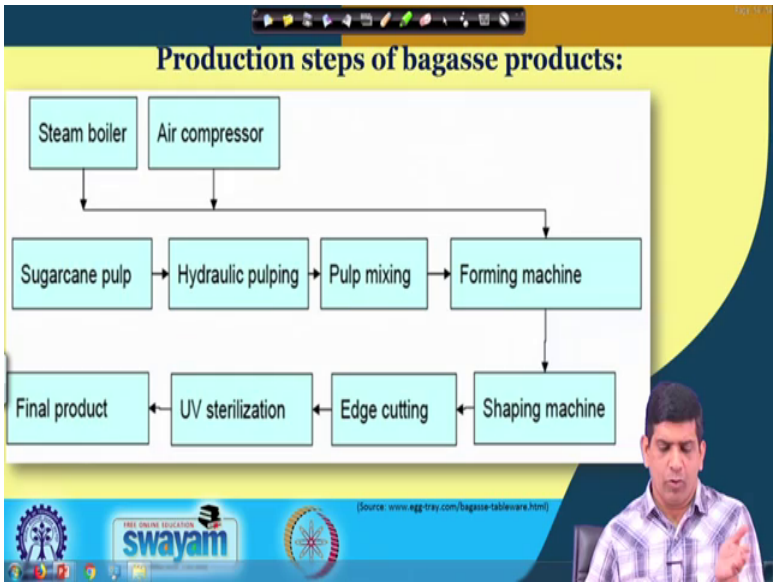

So, whenever we do this kind of stuff it is not only we are using a waste material well and make a product it also that we are preventing that waste material from going to a dump site or a landfill. So, that also helps from a lands landfill management point of view, landfill is space point of view, and the amount of methane gas that could have generated because of this at that landfill site so, all this a there is a benefit everywhere.

So, in terms of production you will have this is that they are talking about a steam boiler, air compressor, you have a sugarcane pulp, going for hydraulic pumping ah, then we have pulp mixing, we have forming machine, final shaping machine, edge cutting, UV sterilization and then you have a final product which you just saw in the previous video sorry previous slide where oops sorry. So, where this was being different plates and other stuff, that is being made from this bagasse products.

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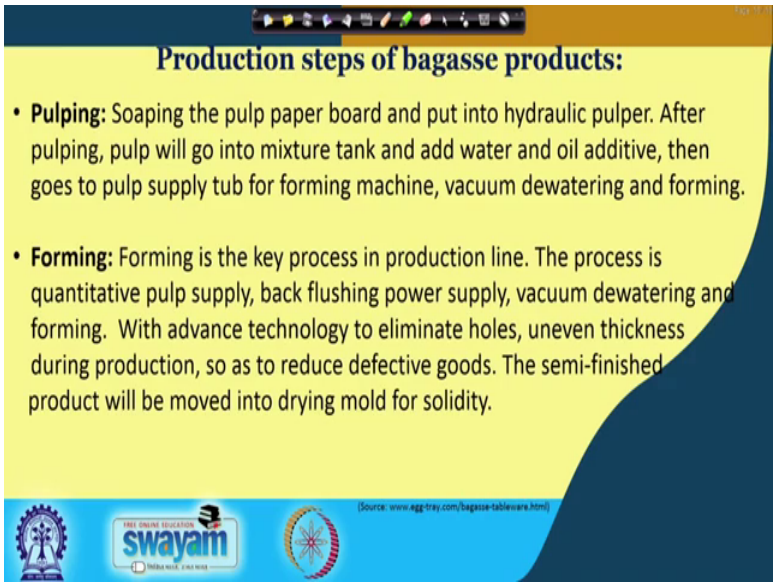

So, production is tips I just saw pulping, forming, pulping is a scalping the pulp paper board and put it into a hydraulic pulper. After pulping pulp will go into the mixture tank and add water and oil additives, then goes to pulp supply tub and forming machine, vacuum dewatering.

So, let us since we will go into this detail into the next video because we will go into each one of them is a little bit in detail. So, let us stop here for this particular video. So, what we have been looking at so, far is different types of biodegradable plastic like a bioplastic biodegradable plastic. We saw that there are so many ventures are coming out in across the world including in India where people are looking at different types of waste product which is a biodegradable waste product and try to make materials similar to plastic and which can make those product which can be used instead of using that is those single use plastic product. So, that is always better because these are going to like help in into the in terms of environmental performance.

So, that is will this; that is what the whole essence of this particular week is looking at greener material alternative to plastic. So, many are out there since these are newer products they economically they are most of them are costlier than the single use plastic, because single use plastic the whole industry has matured quite a bit. So, there is there is they can they have lower prices the prices have gone down on regular plastic products, the alternatives it takes time once the volume goes up for them and also the initial cost in

terms of the research and setting up of the plant that makes the cost of the product a bit higher on right now.

So, from a government point of view, from a policy point of view, what we should get is, we should get some sort of incentive to these companies who are coming up with alternatives to traditional plastic for the betterment of environment, they should get some sort of incentive from the government whatever the government thinks is proper to make these companies kind of a viable economically viable for first maybe a decade or so.

So that they make these products mature, the prices comes down and then they will be economically competitive, otherwise that is one way other way is you put legislation. So, you put a lot of fine on the traditional plastic stuff, but again that is going to help only to put some money into the government, but that money has to be channeled to these startups to this a smaller company so that they can we need to help them out. So, to come up with a newer product safer product which can be can replace our traditional plastic.

So, will continue this discussion; especially this that bagasse product we will go in more detail in the next video. So, again thank you for taking this course and I hope you are enjoying it. We are already kind of in 7th week we are going towards the middle of 7th week in the next video and then after that only a week and a half will be left. So, I hope it was a good decision for you to take this course and again any constructive feedback any concern put it on the discussion forum and you should also be ready with your questions in the live session which will is going to happen in this course as well.

So, thank you and see you again in the next video.