**Indian Institute of Technology Kanpur**

**National Programme on Technology Enhanced Learning (NPTEL)**

**Course Title**
**Bioenergy**

**Lecture – 19**
**Important Parameter for Selecting Biomass Groups**

**By**
**Prof. Mainak Das**
**Biological Sciences & Bioengineering &**
**Design Programme**
**IIT Kanpur**

Welcome back to the lecture series in by energy so today what we will do from the basic mechanism now we will see the output of it and from there what are the strategies which are being followed.

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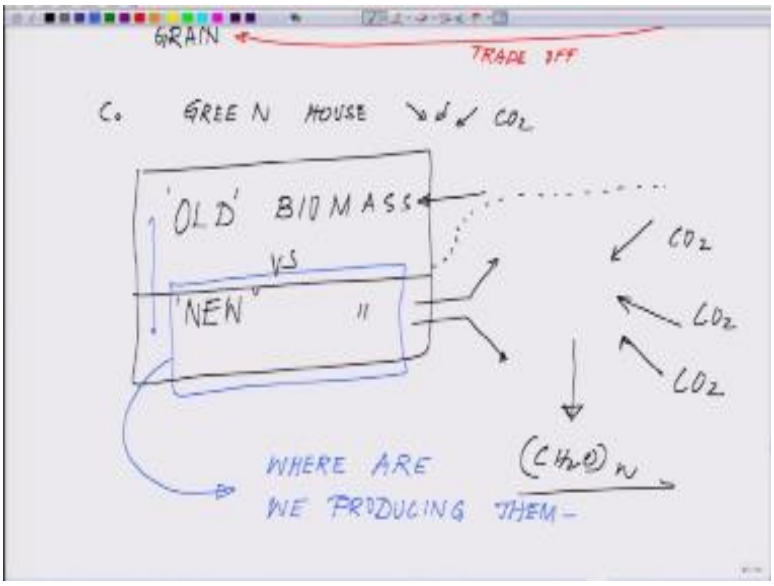


So let us enumerate the features of the crops which will could be used for producing new biomass okay coming back to the slide.

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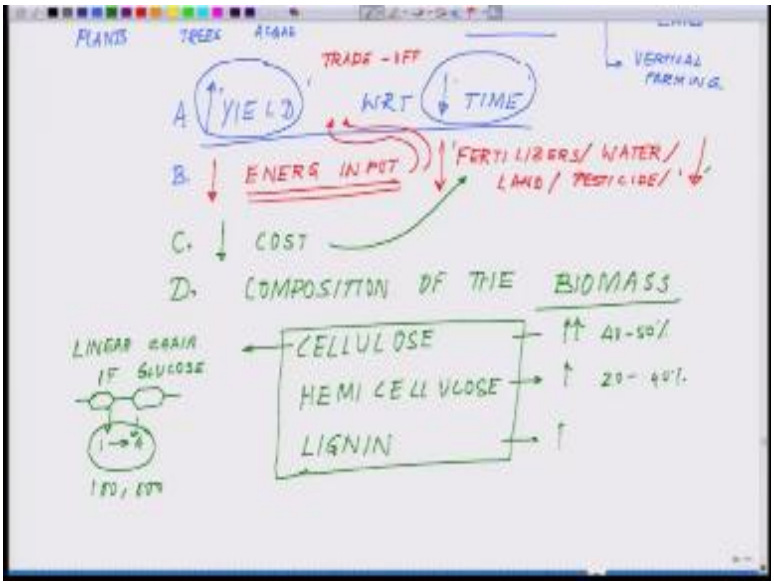


Now we will talk about what all features are we looking forward to so we have two options so if we talk about any kind of energy crops so they could be either grown in the land or in the water so when we talk about crops here I'm talking I include everything okay I am not really no so it includes plant trees algae and several other things okay so land or the water and within the water it could be whether it is a marine salt water which is a huge resource or is it fresh water okay these are the two T similarly for the land utilizing waste and fallow land or resorting to vertical forming okay.

This is the first thing second now among this first what is the yield with respect to time so when we whenever we talk about yield of a crop you can either look what is this much quintal per hectare or likewise that is one aspect but there is another aspect how much time does it take a crop which takes a no 10 months 12 months it is a long period whereas contrary to it cock croft which takes six months or three months is much more faster.

So in terms of the eel we have to keep in mind what is the time window are we talking about how much time does it take for us to get the complete yield of that crop step 1 okay yield with respect to time step 1 second point be out here if what is the, so of course we'll look for yield with respect to time maximum eels with respect to time with the shortest time okay this is very

critical so there is always a trade-off between these two second thing reduction in energy input to produce what does that mean so this means in order to grow the crops we need fertilizer.

We need water we need land pesticide insecticide and so on and so forth so lesser are their use so your energy input will be less so we have to look for those crossed among that whole series of things what we mentioned earlier the one which consumes least amount of energy okay now points C Point C is we have to look for crop will cost is less in terms up again this is directly linked to because there are crop say for example we talked about sugar cane and all this crops they are very intense they need a lot of fertilization you cannot grow sugar cane every place.

There are several of the crop which are not really domesticated yet but they grow very fast and they could have a very interesting oil production profile so what in other what I wanted to say is like sky's the limit we may need to really go through the genome of different wild species of grasses which we never explored and they grow very fast in a while you have certain very specific features so if you look through like say for example through thousands of years of evolution we have domesticated a handful of plants.

Say for example you have domesticate rice we have domesticated wheat we have domesticated maybe a little bit of a barley and some of these Sargam this Yuma let us but if you look in the wild if you walk through in any Joslyn or anywhere you see there are so many different kinds of grasses and maybe they have not been analyzed we really do not know so what is most important that we have to look into this subject with a very open mind that we should not get tied down okay we only have this handful of crops from there only we have to really there are so many faders we do not even know there are so many faders which are being growing in the wild and which are palatable to the cows and something which we just never really looked into that.

So as more and more we are understanding the genome and other things we simultaneously also have to look for the wide variations of the grasses which are growing in the white they may have they may grow in any fallow land they may grow in waste land without using much of the resources in terms of fertilizer in terms of pesticide and those could be a very profound source for biomass so this is a food for thought to think there are so many species of grass and it is

worth looking at each one of them and if you could do some kind of a breeding studies on them or if we could do some genetic manipulation in them by which we can manipulate some of there are no starch cellulose or Hemi cellulose or you know you can reduce the lignin will come to this part what does what I meant by all that thing okay.

So but just keep it in mind do not kind of a stick your brain with the fact that okay we just have handful of this we have many many more it is just you have to look or to look carefully into the nature we have to explore nature then only will be able to appreciate this okay so this is the second point in terms of the cost because this is very very important always remember that in terms the patrol in terms of the diesel in terms of the coal what all who else we are currently using or even in terms of the nuclear power these we got free of cost because mankind never had to invest a single cent or a dime to produce those Nature has produced them Nature has produced radioactive materials nature has produced coal nature has produced the gas natural gas mankind has only done two things first they discovered that these could be utilized as a feel they are slim ability.

Second thing what mankind has done they bowed whales in order to extract the mount that is the only cost mankind has given but here in the current world we are thinking differently we are now trying to emulate nature itself we wanted to produce fuels for ourselves so this is the different route this is not something so the kana mix come very very clearly that whenever we talk we are flowing in a wave biomass vitamin banner general but the fact is we are entering into a domain whose economics have never been done to the last decimal that exactly.

Because there is a lot of investment what we have to do and it is a socio-economic problem because you cannot use any land as I'm repeatedly telling you this is a big issue many a times many program fails just because you have to compromise with the food production which you cannot do okay so coming back so this is one of the issues which will be very important coming back to the slide in terms of the cost this next point which is critical out here is the composition so composition of the biomass in terms of the composition of the biomass.

We will come here there are several issues linked to it so whenever we talk about the plants let's take a standard example of plants you have cellulose you have hemicelluloses you have a lignin okay so talk about it a little bit okay you have cellulose hemicelluloses and lignin now these three things are present in plant at varying proportions so the most of the plant has the cellulose is at the highest concentration followed by hemicelluloses and the third thing is the lignin after that so in terms of their chemical nature if we talk about.

So they have different kind of chemical nature so cellulose typically cellulose makes forty to fifty percent this is in the woody plant whereas twenty to forty percent is the hemicelluloses rest is all lignin and if we talk about the cellulose is basically a glucose polymers a linear chain of glucose linear chain of glucose so something like this and this chain is attached to each other by if you remember in one of the previous lectures I told you by 1-4glycosidic linkages so they have one four glycoside linkages and average atomic molecular weight is around100,000 okay and they are one of the most prominent component of the plants.

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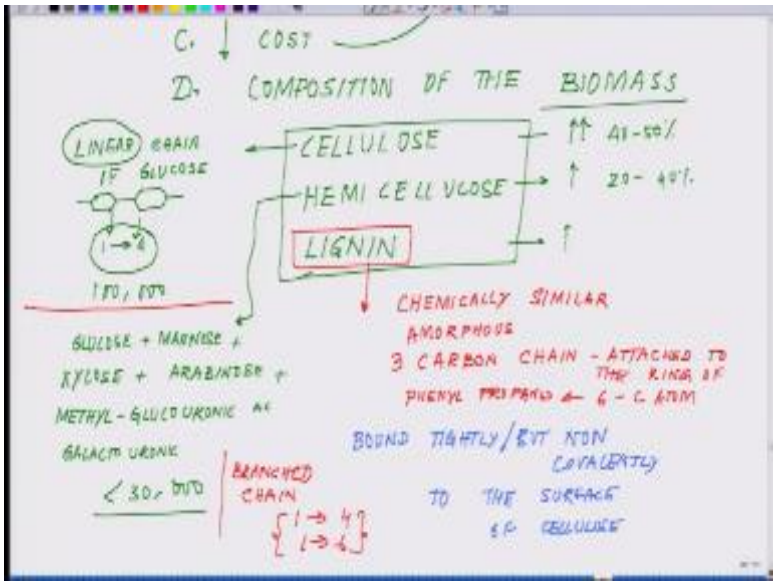


Then comes the hemicelluloses the difference between cellulose and hemicelluloses is this is a very mixed polymer it is made up of glucose mannose and there are a bunch of five carbon

carbohydrates which are present their silos add up the nose then you have methyl glucuronic acid then you have galactic runic acid so average molecule molecular weight is less than 30,000 and instead of linear in the case of cellulose this one is a branched chain so this is the critical difference so very branch chain structure so it will have possibly 14 as well as 16 linkages which I have already discussed you during photosynthesis okay.

And these are these Hemi cellulose are bound tightly but non covalently to the surface of the cellulose tightly but this is very important but non-covalently why this is very important bound tightly but non-covalently to the surface of cellulose the call realize one thing that what are we expecting in the form of high energy we are extracting we are breaking the bond energies. so between two carbon there is energy which is holding them between carbon nitrogen there is energy which is holding this carbon-hydrogen there is energy which is holding next like so on and so forth.

So there is a bond there is a covalent bond some other lip electrostatic bond whatever you know so now the thing is what you are doing essentially was breaking that bond you're breaking then bond and the energy which is released is the one which you are utilizing for XYZ function so in the form of hemi cellulose and cellulose the binding is non covalent so there is no covalent bonding it means if you split them the energy which will be released in much less, so that is why it is very important you should understand what kind of bonding are there and of course it will be easy to break them apart.

Because there is hardly any strong bonding taking place okay so next thing is the lignin the third category in this is the lignin so lignin is very similar to these families but it is chemically similar to cellulose and hemicelluloses kind of a binder chemically similar binder for the cellulose between the cellulose and hemicelluloses and putting it all together it is amorphous and it is made up of three carbon chain free carbon chain this is this part is very critical 3-carbon chain attached to the ring of six carbon atom attached to the ring of six carbon atom and this is called the name for this and it is called fennel proteins. And based on this is a classification.

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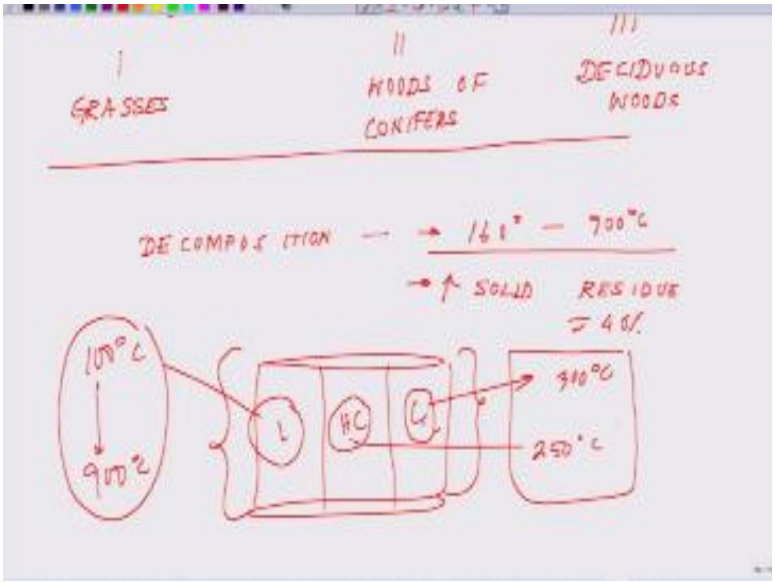


Coming to that classification go to the next page for this classification of lignin so Chanel propane from failing folk when I am continuing these may have0 1 or 2 methoxy group okay attached to the ring attached to the ring giving rise to three structures 1 2 40 man one two three one two three structures one two and three it's very interesting to note these one kind of logjams are present in the grasses to is present Interviewer: he woods of conifers and third kind of type 3 is present in the deciduous wood okay.

And very interestingly there is another aspect of lignin which is the smallest of all of them lignin when you burn lignin when you are burning the whole thing is decomposition values will come in further detail on this one come where is from $160^0$ to $900^0$ centigrade and it generates a lot of solid residue an approximately 40% solid residue it generates especially during parolees is what is important here.

Now coming back so we talked about you have what is the cellulose what is the hemicelluloses and what is the lignin content so lignin content if the leg me so what you are doing or taking the residue and you go through what will be learning after this will be you go through the parolees is process and breaking them decomposing them now there are specific temperature at which the

bonds breaks say for example 100 degree centigrade $200^0$ centigrade $300^0$ centigrade so lesser temperature the bond breaks listen carefully less of the temperature at which the bond breaks you will be needing lesser energy.

So if something breaks at $50^0$ you hardly almost little higher than room temperature if your room temperature is say 27 or $300^0$ or maybe in a summer $45^0$ okay should $40^0$ fine if something breaks at safety you just have two days the temperature will break so you need very less energy compared to something which breaks at say 100 degree then you have to boil something at 200 you need to give more and more energy but now the problem comes when you have a material which is a mix of something which is burning at 200 something at 300 and another one a component with whose the ranges from at 6,200 to 900.

So now the problem is when you have such material so when the wood is coming just see these pictures will realize say for example you have a piece of wood coming okay so you have three component here say lignin sorry lignin yes hemicelluloses and cellulose and you are processing the whole thing together and if I say the cellulose decomposes that say $300^0$ centigrade just I'm just giving a number for you I mean don't take this number because we will talk later and say this one happens at say you know say around$250^0$ centigrade.

But whereas this one has a range from 100 to 900 now see the situation technically just by 300you should be able to get the necessary decomposition of these two but because they are lignin which is in between it is there you cannot degrade the lignin so what you will be getting out of this will be a product which is not fully decomposed it will have a lot of contaminants of lignin and lignin have burnt lignin or whatever No so keep that in mind these are very basic fundamentals what you have to keep in mind.

So that means you love to have crops which have lesser concentration of lignin but then it has its own set of problems it is not so easy that if I just want I can because these have evolved over the ages and nature has done every molecule so that's why do you thing always say.

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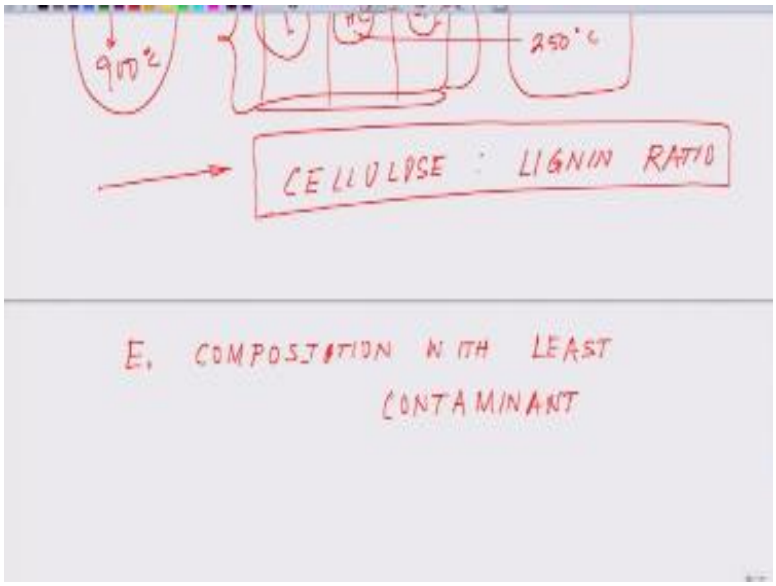


And coming to the site this is being always say it cellulose to lignin ratio is critical cellulose to lignin ratio this ratio determines what will be the efficiency of decomposition and how much energy we really needed to spend on it. So the is very very critical for you paper to understand that cellulose to and lignin ratio will further determine Oh point II will be so that is why I had to go to the contaminant point composition with least contaminant composition with least contaminant see for example some of the species of lot of alkali metals and all those.

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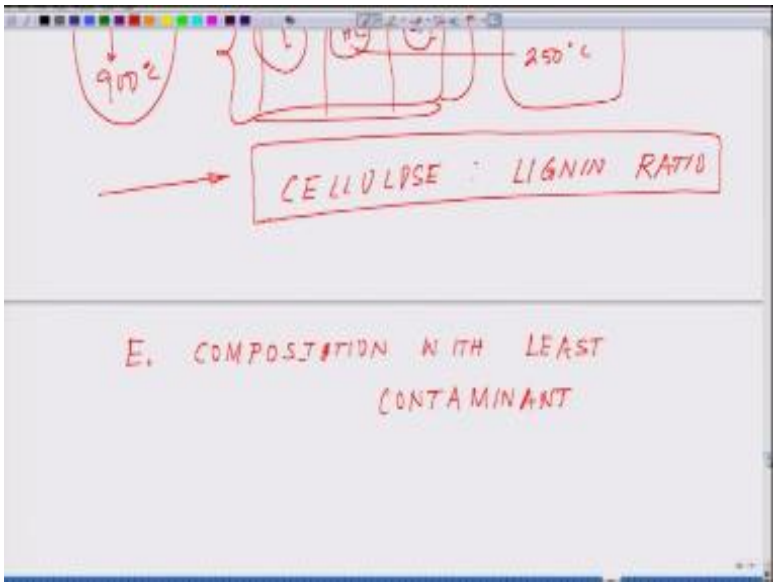


So and they are they have lot of issues with it and F we have already talked about.

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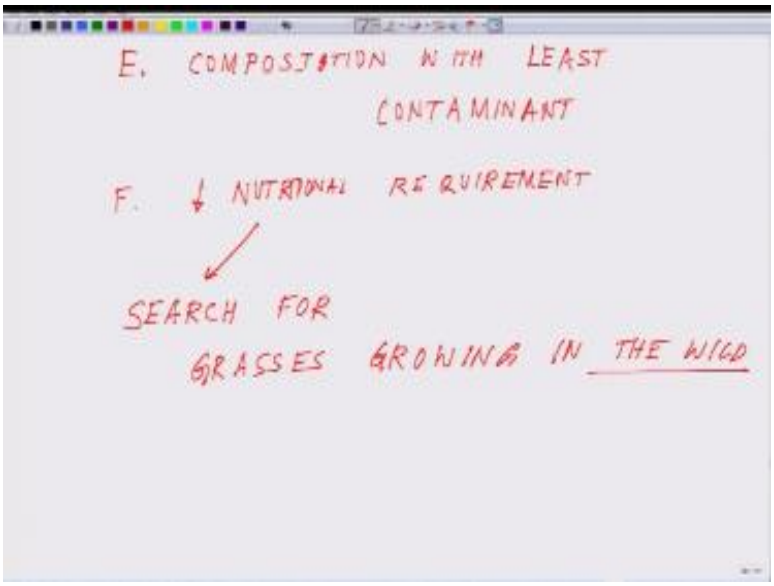


They should have low these crops should have low nutritional requirements we have already talked about it nutritional requirements. So that is why we may always look for search for grasses growing in the wild there are lot of glasses which are going in the wild with least care they hardly have any nutritional requirements and they grow so if we could add out some of them and try to grow them in fallow land wasteland and you know transform them for energy production or there are a lot of bio waste which we could do like you know the banana pill it is a waste could we utilize it there are so many so many crop residue.

So many fruit residues you know when you eat orange the pill orange pills okay the mango you remove the cover could you use them these are the territories or say for example jack fruit it has a huge thick covering and one exploded so these are the kind of thing show we Indians have to think that how you can really make a difference there is so many ways but only you need to know how to process them will come to that now having said this let enumerate after this coming back to the slide let us enumerate after what we have talked about this the factors determining the conversion process okay so we have talked about how we are going to select the crop now we will talk about the factors determining the conversion process okay so we will resume from here in the next class okay thank you.

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