Course on Integrated Waste Management for a Smart City
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Module No 07
Lecture 32: Biological Treatment of Waste (Contd.)

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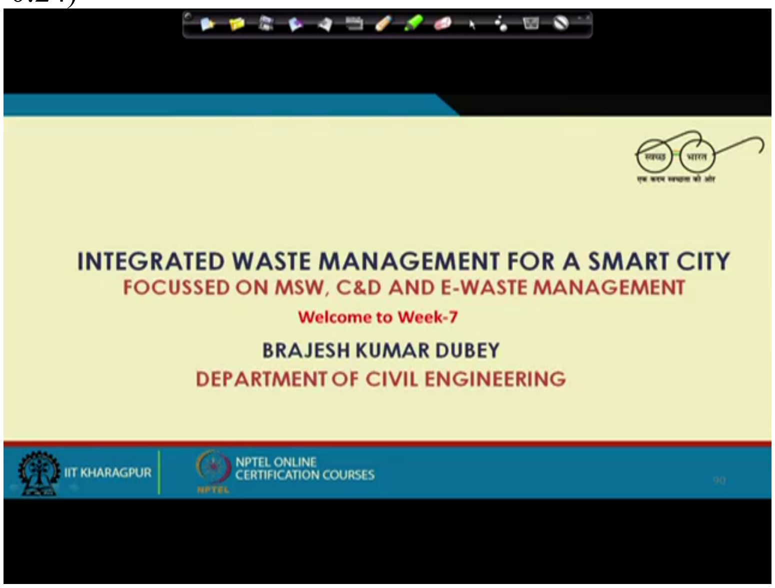

Okay, welcome back. So we will continue our discussion that we were doing in the previous module in terms of composting techniques. We were talking about the aeriatic static pile or before that, we looked at the Windrow. So for aeriatic aerated static pile you can you can use it as I said you can use it as positive pressure or negative pressure and things can get done in 3 to 5 weeks.

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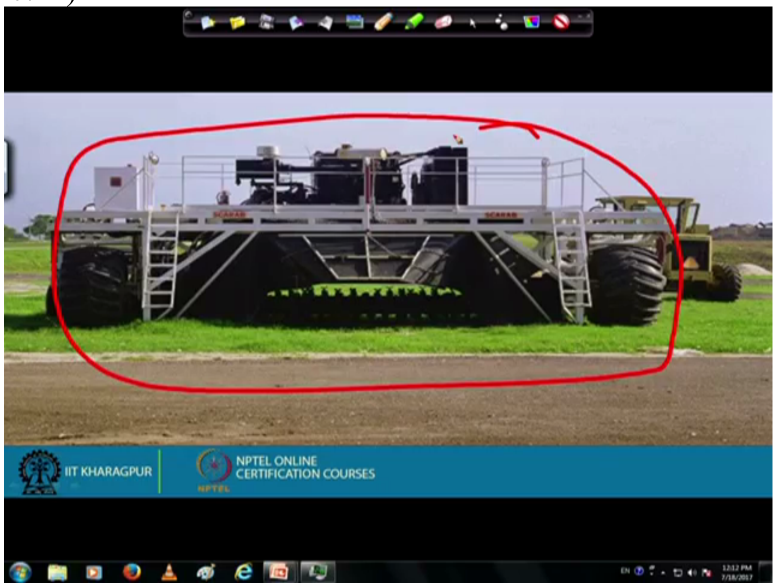

So if both the compost, like winter composting, we also the Turner that I have been trying to explain this to you, this is how it looks like. So this will walk through the garbage pile and then it will does the turning for us. So this is how it will go. There is a, as you can see over here, from this will go and keep on turning the garbage as like for composting process.

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So this is again you can see there is a horizontal reactor. So you put a cover on top and then you will have a Turner coming in and then do the turning from time to time.

You can also have, if you can see it is not very clear because of the black colour of the pie but if you can see over here there is a pipe which is essentially supplying the air or applying the vacuum. You can see on that, so that is right right there. So this, you have this pipe as you can see over here, that pipe is there. So that pipe kind of it is for the air injection going into the system.

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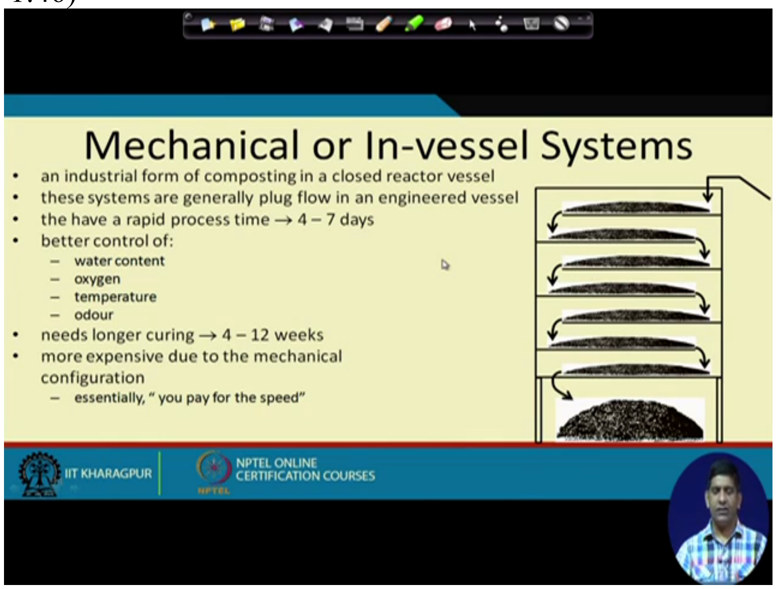

Mechanical or industrial system where you have it is a basically it is a industrial form of composting or a closed reactor vessel. So you have the waste coming in, so this is how the waste is loaded on top. I am sorry. Waste gets loaded on top. So that is where the waste is getting loaded and then we have the different trays. So it is, the system are generally plug flow in an engineered vessel. It is a plug flow reactor.

So the waste will, there will be aeration, the air will be added and then it will keep on shaking and then it will get dumped over here. Then it will dump over here. So it kind of goes back and forth on this and then gets lot of air being mixed to it and then finally in 5 to 7 days, 4 to 7 days, you will have a compost coming out at the bottom. So it is, there here we have a better control of water content.

You can control the oxygen, you can control temperature, you can control smell. So those things are can be done here in a in vessel system. So that is the benefit of doing that. You save a lot of space as well. But the curing, the curing requires longer time because for that all those bacterial population to grow, for those it takes a longer time. You require another 4 to 12 weeks of curing. And that is, it is more expensive due to mechanical configuration essentially you pay for the speed.

So you are, you can get there quicker. So if you have a land issue, you do not have that much of a land, you can get something like this where you get the reaction done very quickly and then that saves you time. So that is really and then you pay for the speed. If you are trying to save the time, you will have to pay for the speed because otherwise like some money has to come from somewhere.

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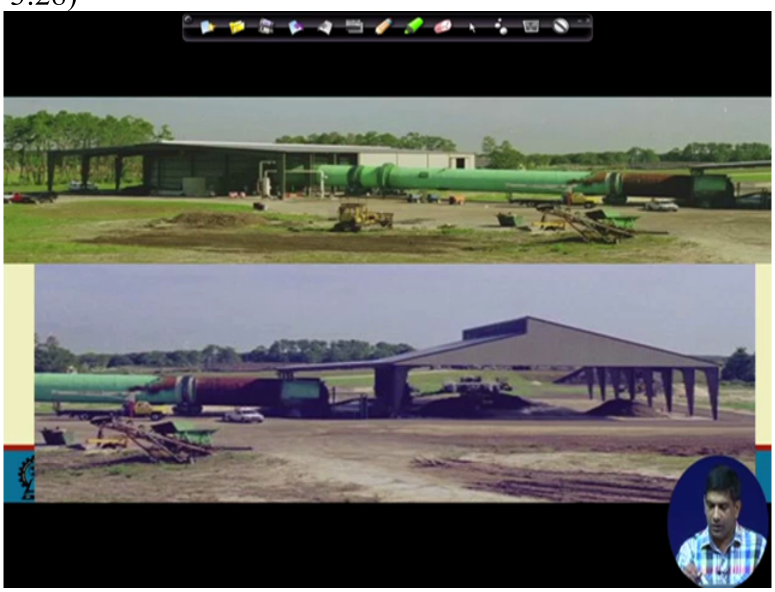

So this is another picture of this is actually I think it was in Germany where this is again a reactor where you have it takes 3 days for the waste to go from the food waste to a compost kind of material. And of course you have to do a longer period of curing. But this reactor is have the waste added to it and then what happens is this keeps on this reactor keeps on rotating. So it will rotate. It rotates, it kind of makes a circle.

And then it will keep mixing the garbage and then the garbage is as it moves over a 3 day period from here to here, it or other way from here to here, and then so it takes some it starts degrading the garbage along the length and after 3 days, you get a humus like material which you will see from the picture over on this side.

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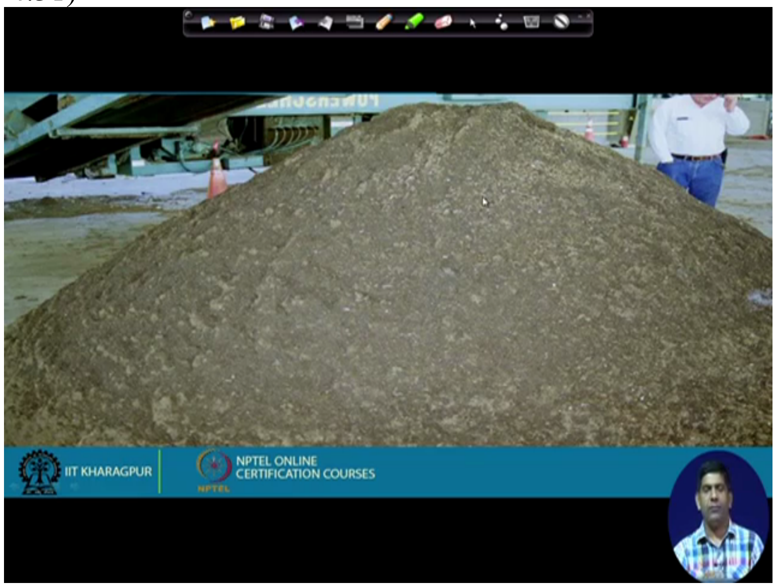

And let us so you get some material like this and then you can cure it for a longer period of time to get the bacterial population grow and all that. So that is how it is done as well.

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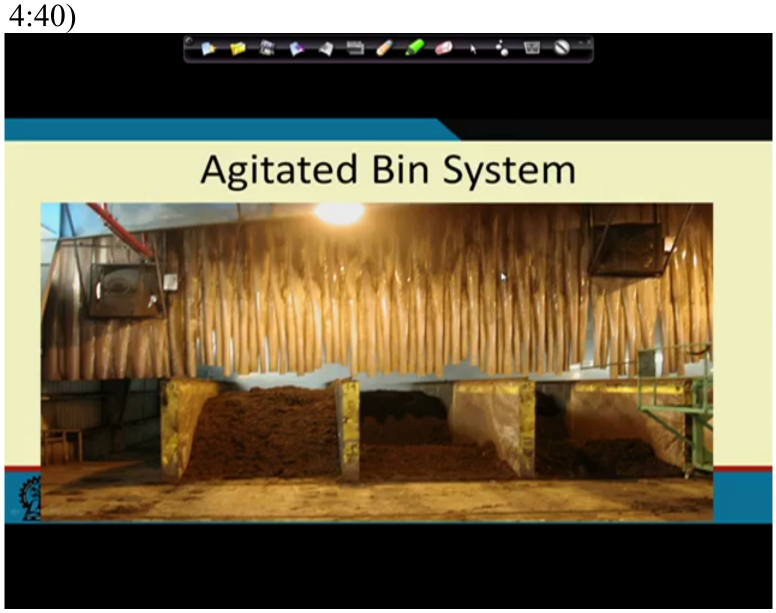

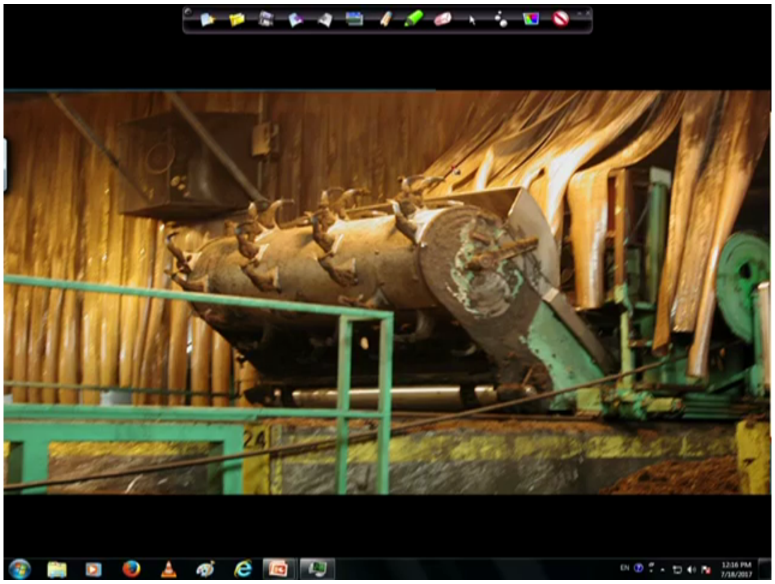

Then there are another agitated bin system where you have a bin where the agitator comes and then it goes like a again agitates that. So that is the picture right there. So this is the agitator which it will come and it will basically turn it. So you see all those arms and twisted arms, so it helps it to mix it.

So that was the mixing is done. So it will go along the length of the trench and do the mixing and come back. So that is what you see over here.

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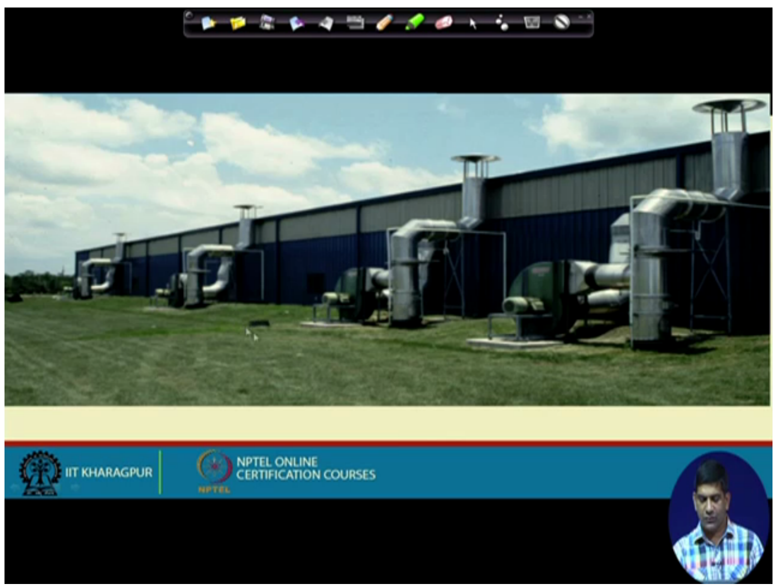

So in terms of the smell, I said smell is there so you apply, you apply certain vacuum into the into the plant as well. You apply the vacuum on the plant when the plant is running. And that keeps the smell a little bit under control. And you, once you apply the vacuum, the stuff that is collected through from the vacuum is passed through certain bio filters. So there are, there will be we can we can install some bio filters on site where we let this gas pass through those bio filters before it gets released into the atmosphere. So that is how that air pollution control system can be controlled.

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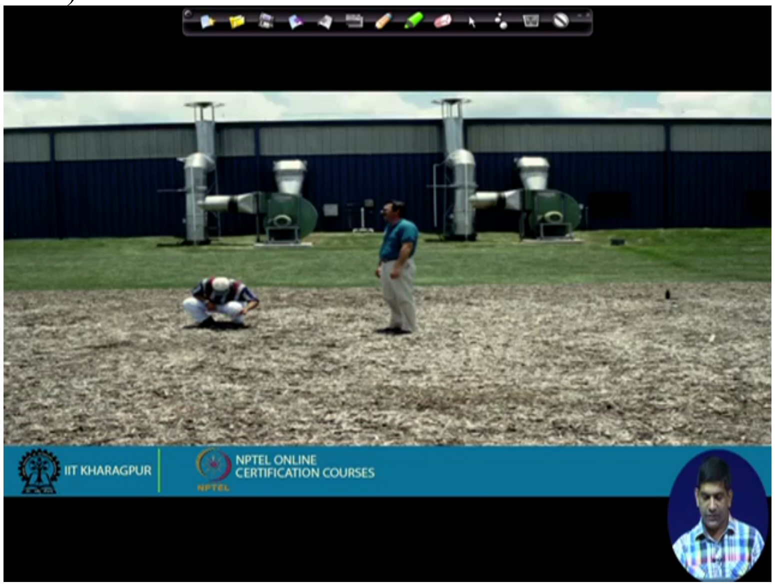

So yes here, you can see this bio filter using woodchips. And we are using the wood chips to make the bio filter and that bio filter we are trying to use ifor the removal of odour, removal of bad smell material in the compost process.

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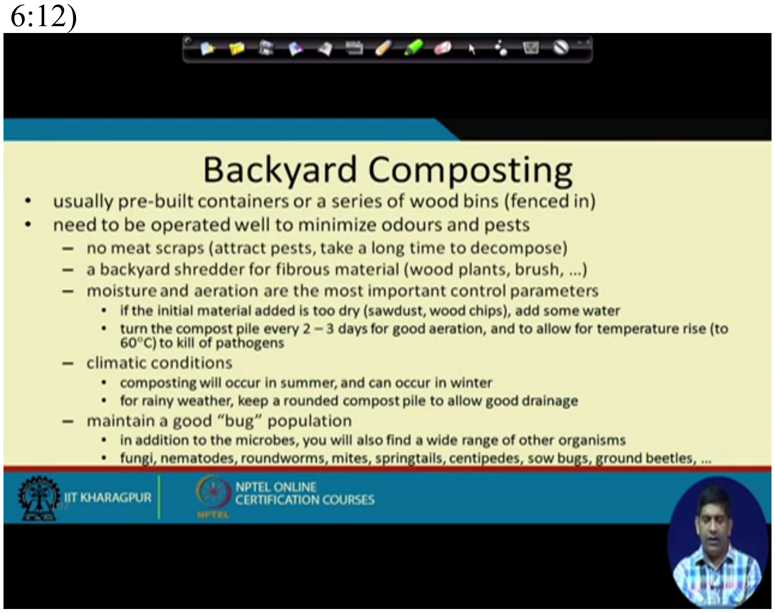

So other example is you can do backyard composting. Usually you can use a prebuilt container or a series of wood bins, again you need to operate it well to minimise the odour. You do not want any odour and you do not want any pest there. Usually for in-house backyard compost, it is advised not to have meat scraps because it attracts pests, takes a long time to decompose.

Backyard shredder for fibrous material will help if you can put one or moisture and aeration are the 2 most important control parameters.

So that is also a you have to initial material added is too dry, then you have to add some water and then turn the waste compost pile every 2 to 3 days for good aeration. And then slow, allow for temperature rise. Temperature again go up to 60 degrees centigrade to kill the pathogens. So climatic condition, composting will occur in summer, it can occur in winter as well because we have seen that happening in winter.

For ready weather, keep it surrounded compost pile to allow good drainage. So we have to otherwise you will have basically lots of leachate being produced. And then maintain a good bug population. That is very important. In addition to the microbes, you will find a wide variety of other organisms, fungi, nematodes, roundworms, mites, Springtail , centipede, so there are lot of other kind of balls are there. So we need to try to have a good population of these different type of bugs and that helps into the composting process.

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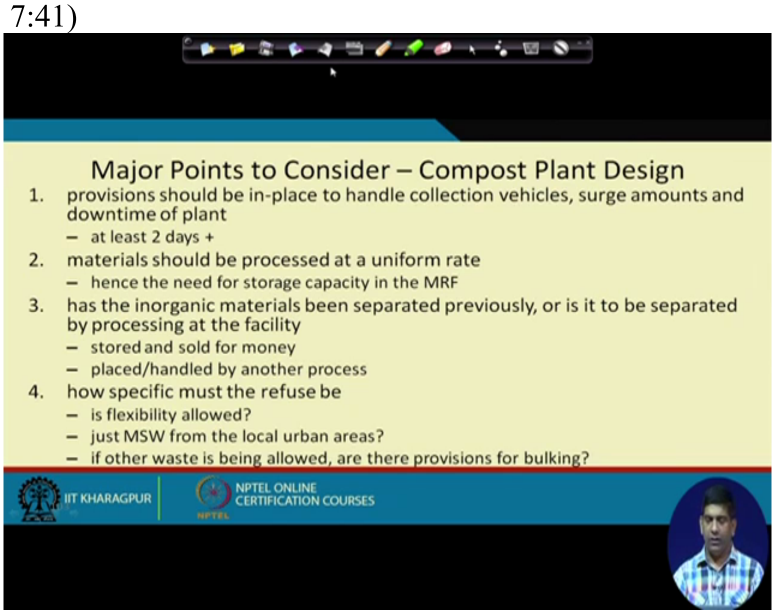

So now if you have to design a compost land, what are the things we need to keep into mind? If you think about what we already discussed, there should be a provision to handle the collection vehicles. These are again, to look at from a very simple, logical way of looking at it. So you have, you are running a compost plant. So you will have the trucks coming in and bringing in the garbage. So there should be a space that those trucks can be handled. So you have to handle the collection vehicles.

There could be surge amounts from time to time because of any particular festival or something happen. You have more waste being produced. So you may have to use those storage space for that. And there could be some downtime for the plant when the plant has some maintenance issue, cannot run, so you may have maybe a week, 10 days of downtime. So you need to keep those waste somewhere.

So you need basically a storage area. You need a storage area for the waste as well. Then material should be processed at a uniform rate. So you need to have a uniform rate. So for that as well, you have to you need some storage capacity in the MRF so that they can put some of those recyclables and other things over there. So has the inorganic material been separated previously so that we can or is it separated by processing at facility, we can look that aspect.

And how specific must the refuse be? Is flexibility allowed? Just MSW from the local urban areas, if other waste is being allowed, are there provisions for bulking agents? All those things are there for consideration.

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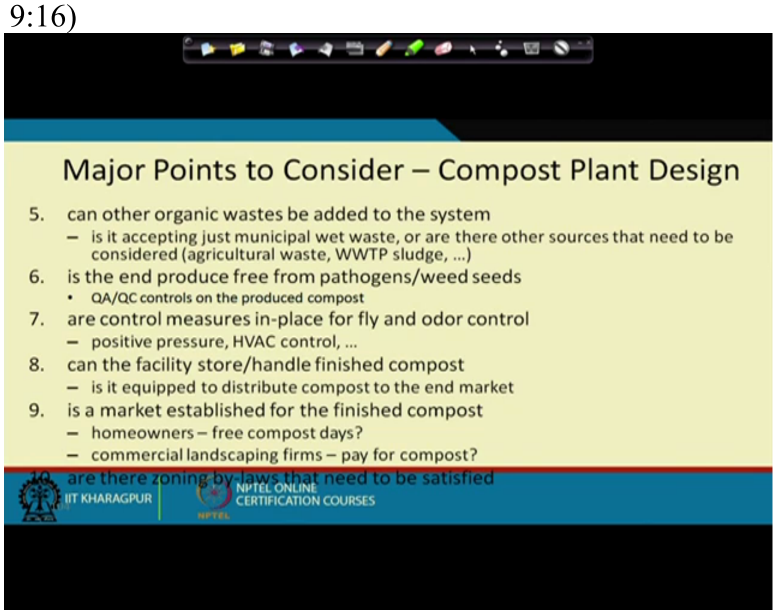

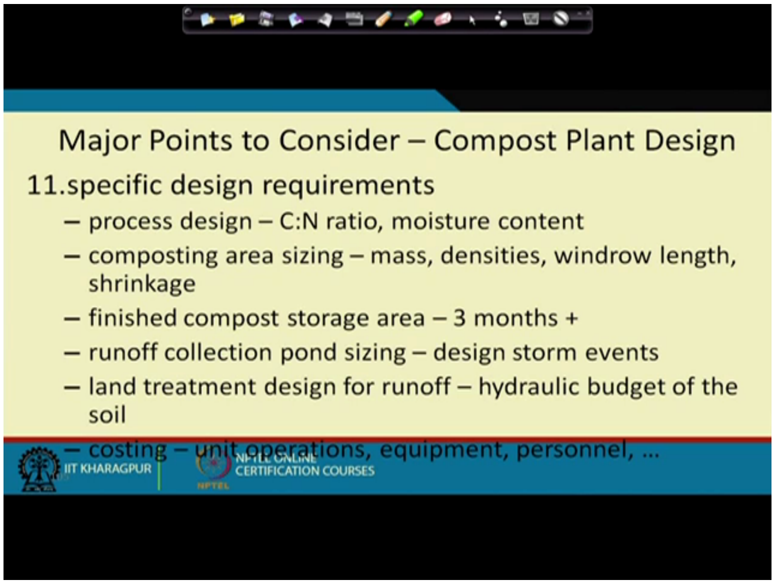

Now major points again and then the organic waste be added to the system, other organic waste? So other than food waste or agricultural, like municipal waste can we add say agricultural waste, for wastewater treatment plant sludge and see the how the compost performance does it goes up or goes down? So it will be a nice thing to check. In the end produce free from pathogens and weed. So we have to look at the pathogen, weeds, we have to have a qualitation, quality control. That is very very important to do a QC, control on the product compost.

And then, are control measures in place for fly ash or odour control like positive pressure, HVAC control, can the facility store handle finished compost? We have to see that. Is it equipped to distribute the compost to the end market? So those like a finished product end market, the end market established for finished compost home homeowners compost. Homeowner, how many compost they will take and what they are doing with those composts, those things also needs to be find out.

So it is it is a have to there is only a limited amount of compost that homeowners can take but there should be commercial plant for compost as well, commercial landscaping firm so they pay for compost and then there could be a commercial facility which is we should be interested in. Present the design requirement. So for process design, we are focused on carbon nitrogen ratio and the moisture content. For the process, that is the 2 thing, we have carbon nitrogen ratio and moisture content.

Then, for the composting area, sizing, you need the mass, densities, windrow length, linkage and all that. So if you want to have that sizing over there. Then finished compost storage area sometimes for 3 months if we have to find out where we have to keep it, so that is the finished compost storage area can be used for that. Then finished collection pond sizing. So we have, so run off collection.

Run off collection from the pond you have to design the storm event because when you have a composts plant, whatever is there an ongoing, through that also becomes part of your leachate so that needs to be treated. So that is run off collection has to be done for for doing the like a analysis or risk analysis of of landfill and leachate and all that. So land treatment design for run-off, we have a hydraulic budget costing, unit operation, equipment, personnel so all these different aspects, many of these aspects are common to even in your structural engineering or geotechnical engineering and other parts of environmental engineering.

But some of them are little bit unique in terms of carbon nitrogen ratio working with like biological or biotechnology people and to kind of try to frame this problem and to solve this problem. So there is a it is a so these are the specific design requirements. So we have , I have tried to give you a overview of how things are done from a compost plant perspective. What are the different components that goes into compost compost plant, so those things have been presented in this particular segment.

Then we will move to the 2nd topic within this organic waste biological bio degradation best in terms of the treatment side. And the 2nd part is to look at the anaerobic digestion. Composting is an aerobic process, anaerobic digestion is an anaerobic process, as the name suggests, it is an anaerobic process.

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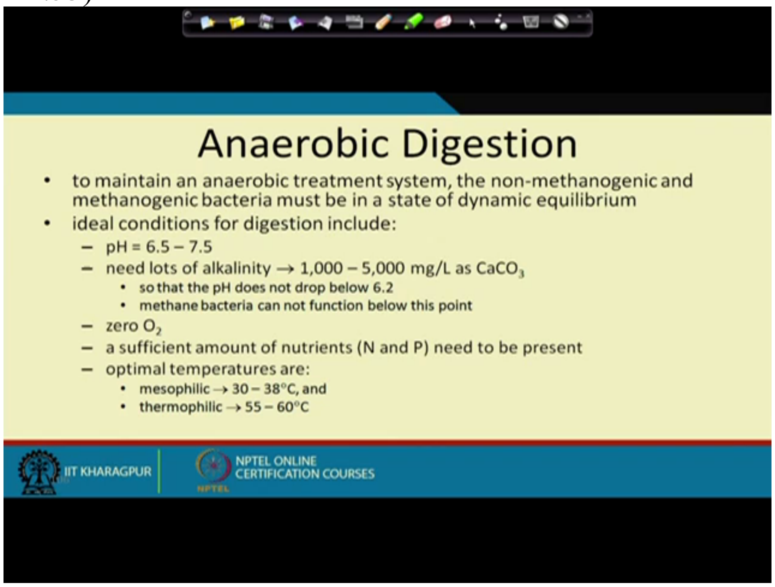

So anaerobic treatment system, we are it is a when this anaerobic system, we have 2 sets of bacteria. One is methanogens, one is non-methanogens.

So what we need to do is, we need to keep a good balance between methanogen activity and non-methanogen activity. So that actually helps into the they should be in a state of dynamic equilibrium because that helps in our process. So ideal condition for digestion include pH of 6.5 to 7.5, needs lots of alkalinity 1000 to 5000 milligrams per litre. Why we need lots of alkalinity? Because we are working with microbes. We do not want too much fluctuation in the temperature.

We want the temperature to be more or less the same so that these microbes are happy and keep on doing their work. So needs alkalinity around 1000 to 5000 milligrams per litre as $CaCO_3$. In terms of this pH, we want the alkalinity why? Because we do not want the pH to go beyond below 6.2 because if it goes below 6.2 that becomes a big headache in terms of operation of this anaerobic digester. And then methane bacteria cannot function below this point.

So we do not want pH to be towards the acidic range. So we have 0 oxygen, sufficient amount of nutrients are there, need to be present. So then we have optimal temperature, mesophilic, thermophilic temperatures are there like and that is 30 to 38 and thermophilic is 55 to 60 degrees. So this is in terms of anaerobic digestion, pH, alkalinity, no oxygen, sufficient amount of nutrient and then you need to maintain certain temperature to do that.

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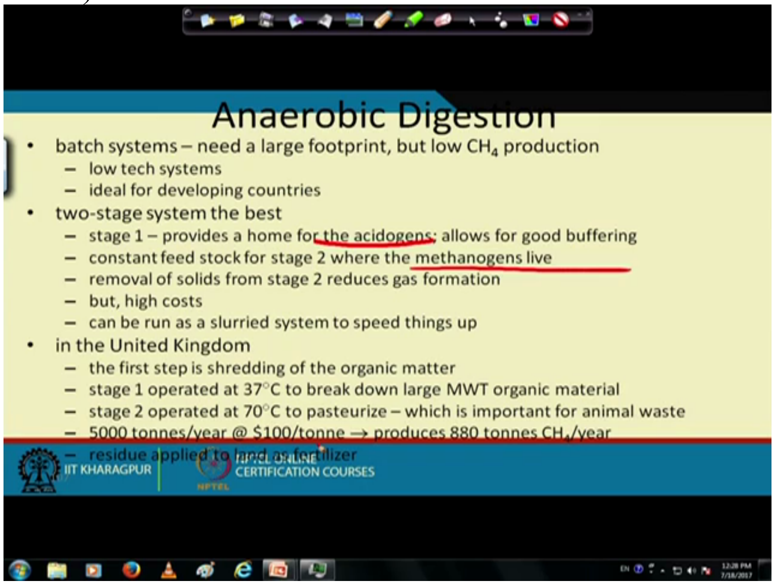

So anaerobic again, it could be batch system, two-stage, single stage, so batch system needs a large foot print but low CH4 production. Low-tech system, ideal for for developing countries. At many places developing countries, it is being used. Two-stage system is the best. Stage 1 is provides a home for the acidogens. So you have 2 stages. 1st stage is acidogenic activity taking place, in the 2nd stage, methanogenic activity taking place.

So stage 1 provides a home for acidogen, it is good, allows for good buffering. Then this constant feedstock goes to stage 2 where methanogens live. So they are live in, acidogens and methanogens, they are living in different tanks. So they don't have to interact with each other and thats, it becomes actually better in terms of managing the composts process. So you have a acidogen which allows that allows for good buffering.

And then you have the feedstock, from stage I going to stage II where the methanogen would leave and they produce methane gas. Then you have removal of solid from stage 2 and reduces gas formation. So remove the solids but high cost cant we run as a like can be run as a slurried system as well. So you can, slurried system to speed things up, again things are expensive but those things can be done. In UK, the 1st step is the shredding of the organic waste.

Then they operate at 37 degrees centigrade to break down the large molecular weight organic material. Then they operate at 70 degrees centigrade to pasteurized which is important for animal residue applied, so that can be used in a, as a fertiliser as well. So 1st stage I, 37 degrees centigrade, we talked about that. Stage II, 70 degrees centigrade. So you have from rather than 5000 tonnes per year, you can go to 1000 tonnes per year or 100 tons per year produces so it should be actually 1000 tonnes per year.

You are producing around 880 tonnes of methane per year. So residue applied to them is the fertilizer. So you have the residual that is coming up that can be used as a fertiliser and then we can, so essentially what it is doing is, you have in the UK what they do? They have the waste coming in, they shred the organic material. They have one stage, 37 degrees centigrade, break down the large molecule to a molecular weight organic material.

Then you have the 2nd stage at 70 degrees centigrade where it helps in pasteurization as well. It will kill all those bacterial that we have on the list and which is important for the animal waste or remember the mad cow disease and other stuff. Then you have around 5000 tons per year is being processed, around 100.per year is the cost, produces 880 tons of methane per year and that methane can be used as a energy source. And the residue can be applied as a fertiliser. So that is how anaerobic system is working in UK.

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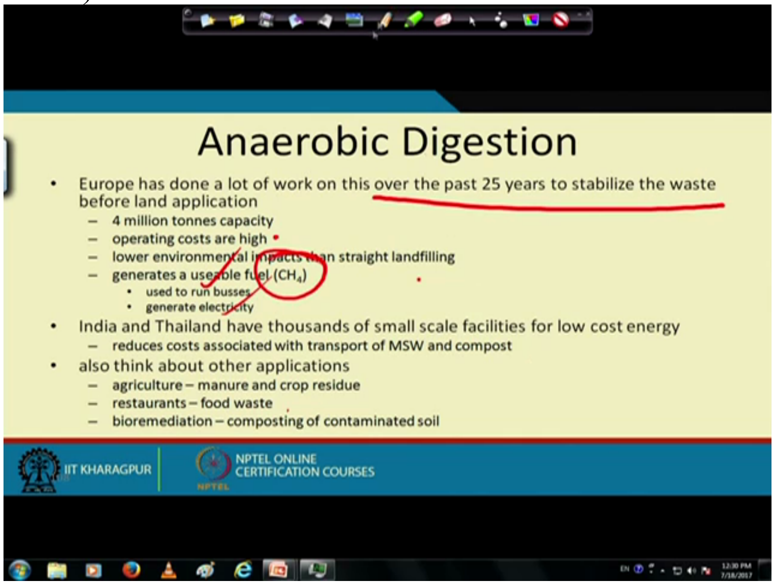

So Europe has done a lot of work on this over the last 25 years, a lot of new technologies have come up in Europe on anaerobic digestion over the last 25 years. They have a 4 million tonne capacity, operating costs are high, lower environmental impact, there is straight landfilling of course, generates a useful fuel, methane is generated. So you can use to run buses. You can generate electricity from that, there is a project now, methane to electricity.

India and Thailand also have thousands of small-scale facility for low-cost energy. Reduces cost associated with transportation of MSW and composts. So you can have a small system where you can have this anaerobic digestion going on which like our gober gas plant and the stuff and all, basic basically there are anaerobic digester but there are other applications in agriculture, like manure and crop residue.

Those can be and food waste, bioremediation, composting of contaminated soil. So all these are part of anaerobic somehow related to anaerobic digestion, some form or another in terms of the basic principle.

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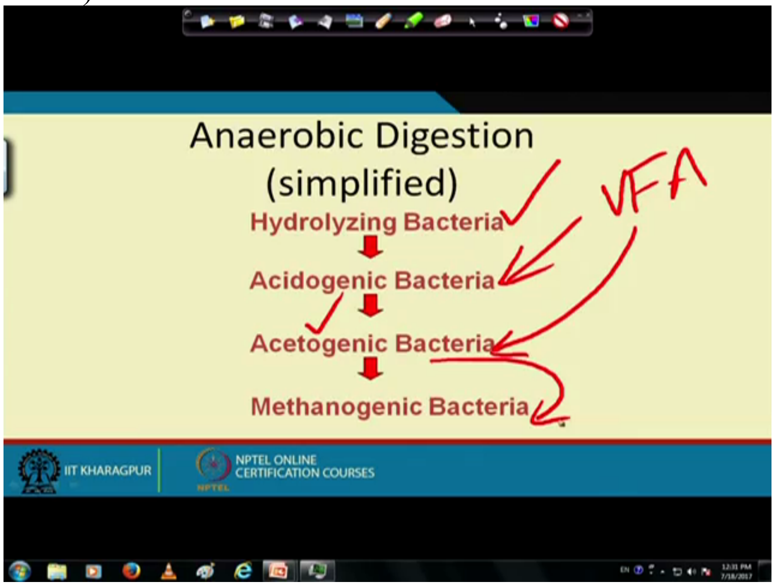

Then in terms of anaerobic digestion, what happens? In a very simplified form, in terms of anaerobic digestion, you are having four steps. The 1st one is your hydrolysed ring bacteria, so the bacteria is getting hydrolysed, bacteria is getting accumulated to the system and it gets hydrolysis, the hydrolysis happens. But hydrolysis, the next step is of course the formation of acidogens or acidogenic bacteria.

We start seeing VFAs acetic acid, forenic, all those acids being formed so that goes in acidogenic bacteria. Then when you have this like VFAs being formed, volatile fatty acids, these VFAs gets converted to acetic acid by this acetogenic bacteria. So the 1st one is the hydrolysed hydrolysing bacteria to do the hydrolysis. Then you have the acidogenic bacteria which produces acids.

But high molecular weight acids, then that gets converted to low molecular weight acids and then you have the acetogenic which is producing the acetic acid. Now then we have the methanogenic bacteria which will go from acetic acid to methane gas. So that is the typical way the landfill gas gets produced. So you have, from acetic acid, the things will go to methane gas. So how it is working? So 1st step, hydrolysing bacteria and in the 2nd step, after hydrolysis, hydrolysing of bacteria, this bacteria starts acting on organic material present and they start they start producing acidogenic acids like VFA, volatile fatty acids and all big molecular weight acids.

And to handle those acids, we have the acidogenic bacteria. And this acidogenic bacteria will convert that to smaller molecular weight acids and then acetogenic bacteria will convert everything to acetic acid. And from acetic acid, methanogens will convert back to methane gas. So this is how system works in terms of and then we have to have different tanks and those kind of stuff to do that.

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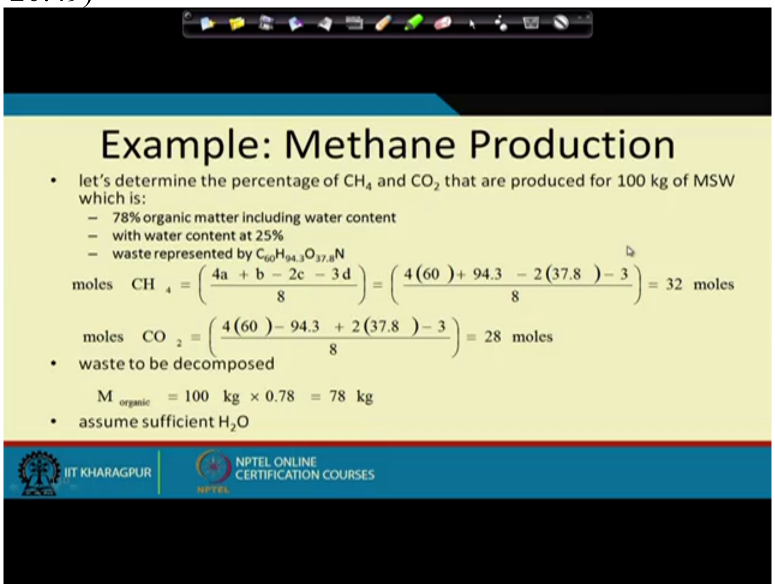

So in terms of the methane production, percentage of CH4, methane produced from 100 kg MSW, so if you have 78 so in this case if you have liked how much methane, how much CO2 produced, so this is the from the anaerobic degradation equation these are the values coming from the anaerobic degradation equation, this 4 plus a plus b minus 2c upon 3d. So one mole of this MSW will produce how much mole of CH4 and how much mole of CO2.

And we found out there will be 32 moles of CH 4 and 28 moles of CO2. So and the waste to be decomposed is 78 percent organic matter. So it is 100 times 0.78 so 78 kg and then they are assuming that sufficient water is present.

So we do the maths and in the same way, mass of molar dry solids, then how much methane will be there, how much CO2 will be there, then other thing is that you look at mass of methane, CO2, ammonia, carbon dioxide and all those things, you get those numbers.

And then you try to compare that number and try to have that number in terms of getting into what we known as like how how much it will be for number of moles that is present. Because here, these numbers are for one mole. So one mole of one mole of waste when it is degrading, producing 34 moles of CH4 and CO2 for this particular equation for this particular waste. But like waste to be decomposed is 78 grams and we know the molecular weight of this, we can calculate.

So we can find out number of moles, number of moles for this particular base that is present. And once we know the number of moles, we can always multiply that with this because one mole will produce this and one mole will produce this much. So if you have say 4 moles or 5 moles you multiply it by 4 multiplied by 5 likewise and then you get your answer for that.

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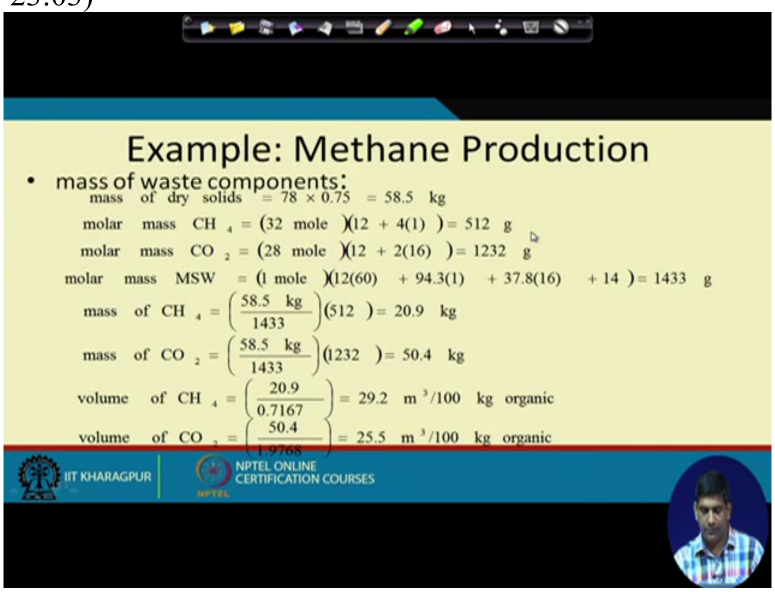

So mass of waste how will you like a example methane production, so mass of waste, weight component, mass of dry solids, we have 78 kg, 75 percent, so this is the dry solids which is present. And from dry solids, it is a molar mass of methane and CO2. So you can you can convert that, like how much for one mole of oxygen, how much mole of methane is required or how much mole of methane is produced.

So in this case actually, it will be methane will be produced and then when oxygen is not supplied here, it is an anaerobic process. So it is the methane and CO2 both will be produced. So if the molar mass is 32 and 28, so multiplied by that, we kind of get the weight of each one of them, molar mass of MSW we can find out, we know the equation. So we can find out how much, what is the molar mass of MSW.

Then we can find out what is the mass of methane, mass of CO2, that is based on how much is the weight coming in in terms of 58.5 kg, total moles of this multiplied by in terms of how much grams and then same thing with the grams, so you get mass of CH 4, mass of CO2. Then from mass, we can convert that volume using the density and all those different factors associated with that. So this is how you can calculate for how much methane will be produced.

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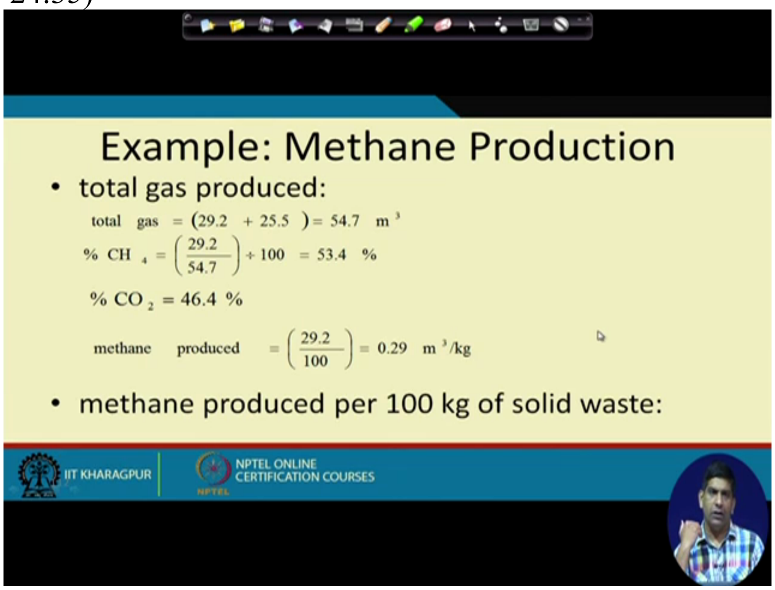

Again, as in the previous quest, in the composting one, we have talked about oxygen being supplied, that is important here, the methane production is important because if you want to do a this anaerobic digester to energy project, if you want to produce energy out of that, you need to have, you need to have an idea how much methane will be produced. So total gas produced in terms of the volume is this much and that comes to methane is around 53.4 percent and CO2 is 46.4 percent.

So we have 53.4 and 46.4 percent of their and methane produced, if you convert that to meter cube per kg, so you have 0.29 metre cube per kilogram of the waste, that is how much methane was produced from that (())(25:17). So that the methane produced per 100 kg of the solid waste.

So that is an example of how much methane is getting produced. So let us look at so we did that yes, we did this part, we did this part, we did this.

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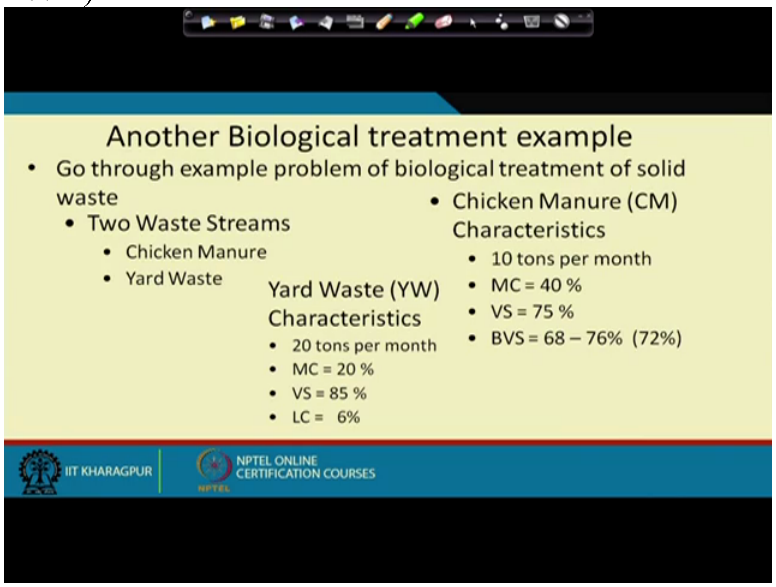

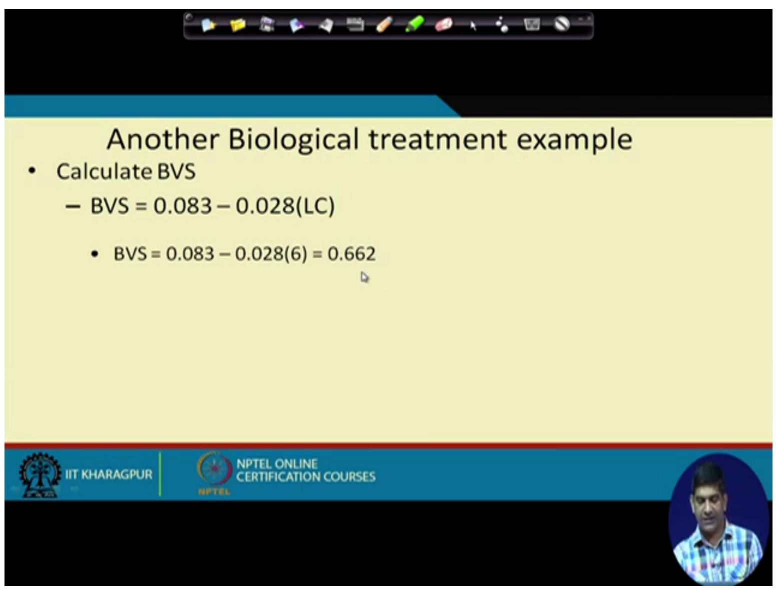

Now we will go to this chapter so where we have another biological treatment example. So we will go through another math problem. So here we have 2 waste streams, chicken manure and yard waste. For both, we have been given the data. So for the chicken manure, the data has been provided, for the yard waste also, data has been provided, so for chicken manual, we have 10 tons per month, yard waste is 20 tons per month, moistur is no e content is there for both. Volatile solid is provided to us.

Then we have linen content in one and we have BVS in the other which is 68 to 76, so we can take the average of those 2 numbers kind of in the middle. So if you, in terms of this particular example, so if we try to do it step-by-step, here BVS if the linen content is known, we can calculate BVS using this equation where BVS is equal to 0.0 Amul number 83 minus 0.028 times LC. LC is the linen content expressed in percentage. So here the linen content is 6 percent.

So we can plug those numbers and we get BVS as 66.2 percent or 0.662. So that is here we had BVS as 72 percent and this the other one is 66.2 percent. So that is the how the BVS numbers you get, you can get it from the linen content, you can also measure it directly using bomb calorimeter and all that like what is the not yes, how much waste will like in terms of BVS fraction, how much waste you will drole of broadband egrade so we can find out from.

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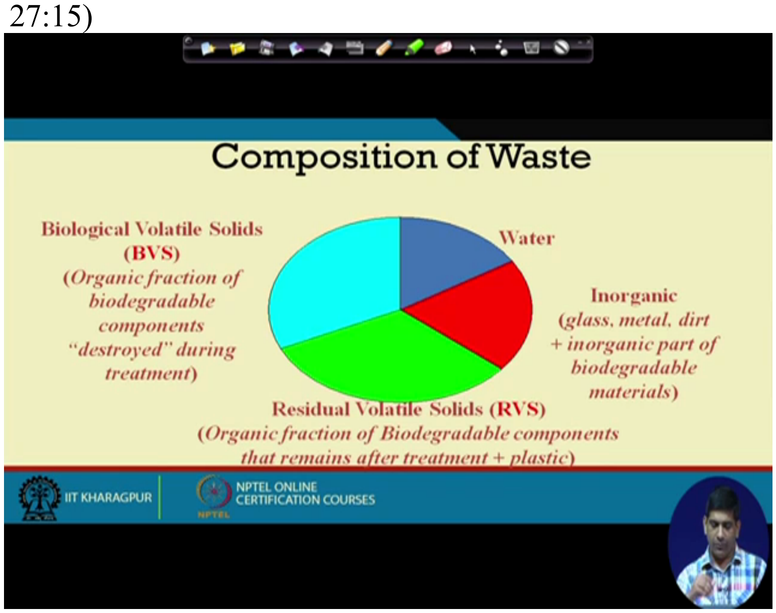

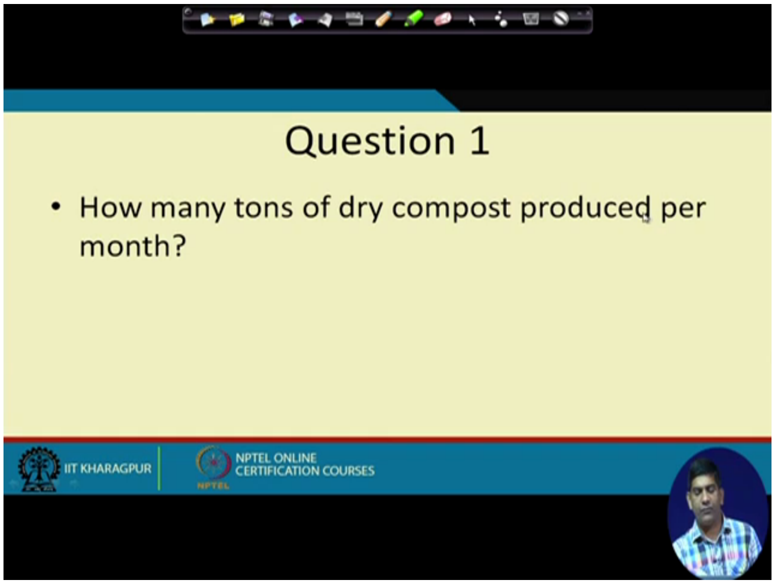

So again looking at the composition of waste, we have this BVS fraction which is going to react. So not the other faction, it is the BVS fraction which is going to react. So this is the fraction which is going to react. So we have to have this formula for those (())(27:28) and then we use our common like equations not that difficult. So how many dry tons? It says the 1st question is how many tons of dry compost will be produced?

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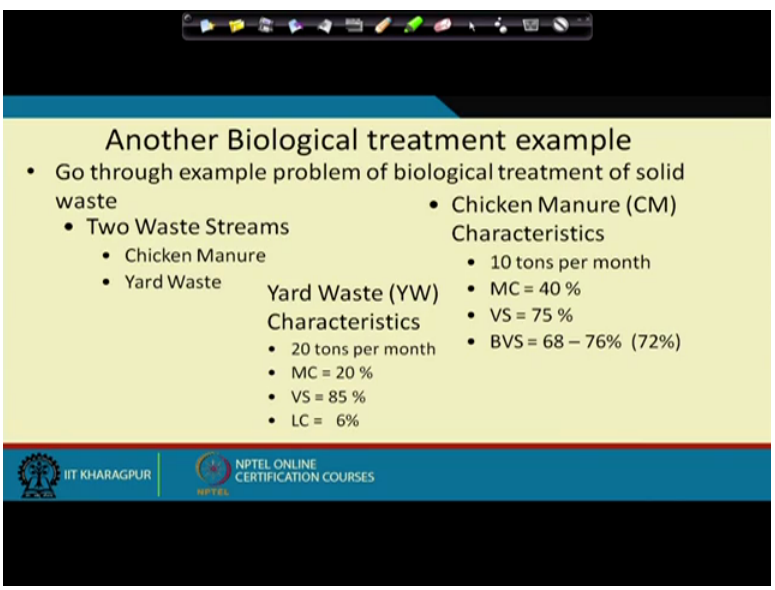

So we have these 2 waste streams, yard waste and chicken manure, they have certain moisture content. There will be certain BVS content.

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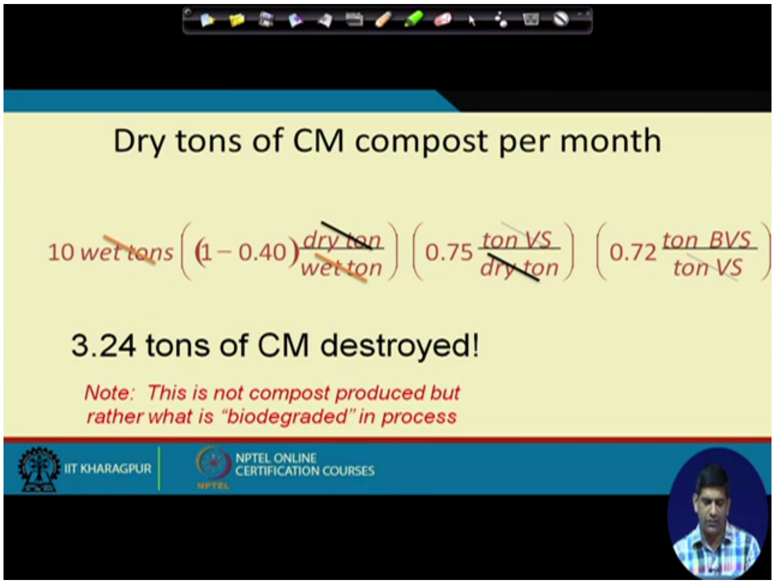

So assuming that the entire BVS like 100 percent efficiency of conversion, we can calculate dry tons of chicken manure compost per month. So we have 10 wet tons, 40 percent is the moisture content, 0.75 percentage is the VS and out of that 0.72 percent is the BVS. So we can find not what is the amount of BVS present and that amount of BVS is what is going to be, will be reacting into the system.

We should not use the like I have the word destroyed, destroyed is basically just to grab your attention. It is basically 3.24 tonnes of chicken manure will get decomposed, they will react and then will get decomposed. So this not the compost produced rather than what is biodegraded in the process. So that is what we have some chicken manure.

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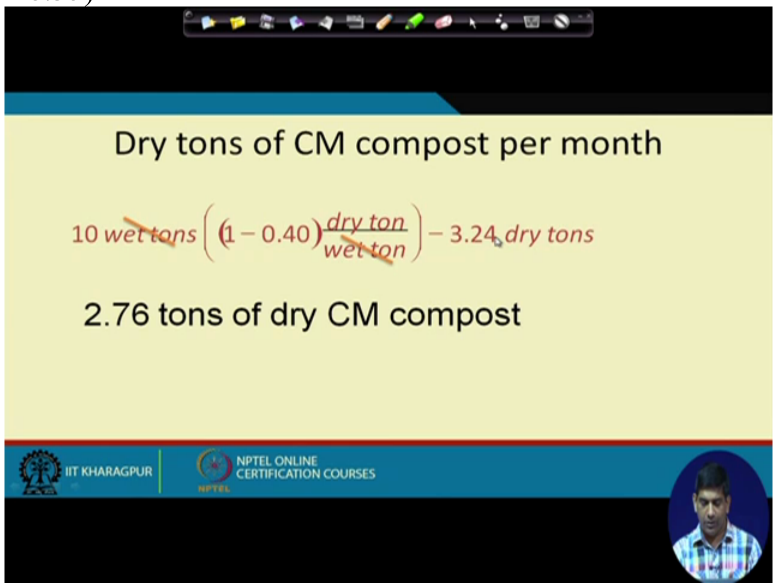

So from chicken manure, in terms of 3.24 tonnes of chicken manure is it is there, that is what it is what is sorry 3.24 tonnes will react and will get converted to compost will actually get out of the system as part of the reaction.

So we have this this wet ton, so amount of this is the total amount of dry ton present, this is the dry ton which will react and go out of the system in the form of gas and other stuff, so the remaining will be your dry chicken manure compost material. So it is around 2.76 tons of dry chicken manure.

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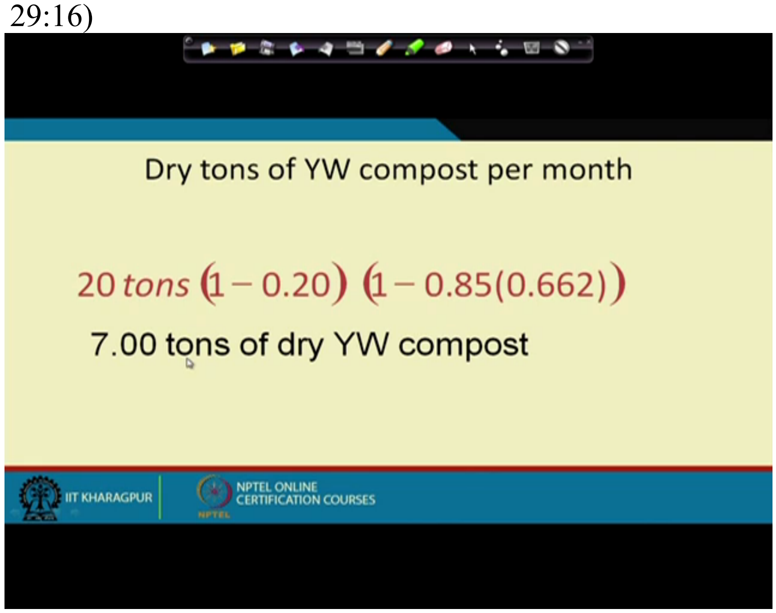

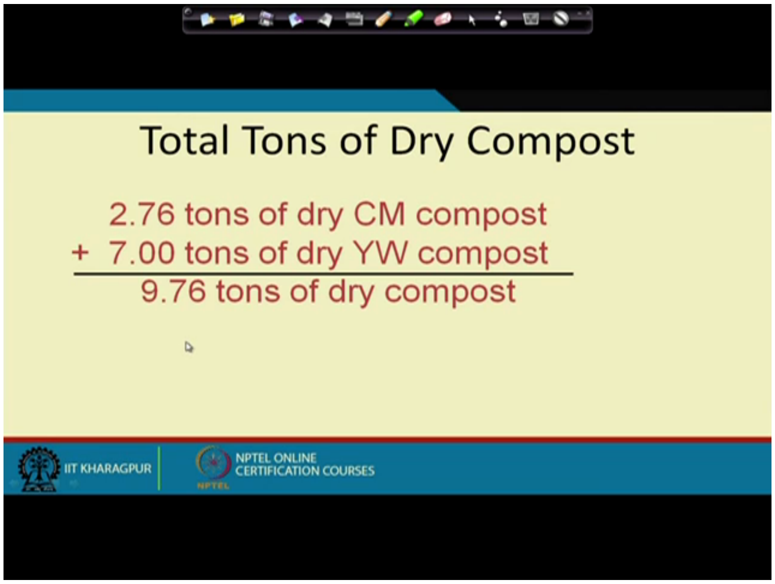

Yard waste, similarly you can do the yard waste calculation, you get 7 tons of dry yard waste compost. So if you add them up, you get 9.76 tons of dry compost produced per month from that facility.

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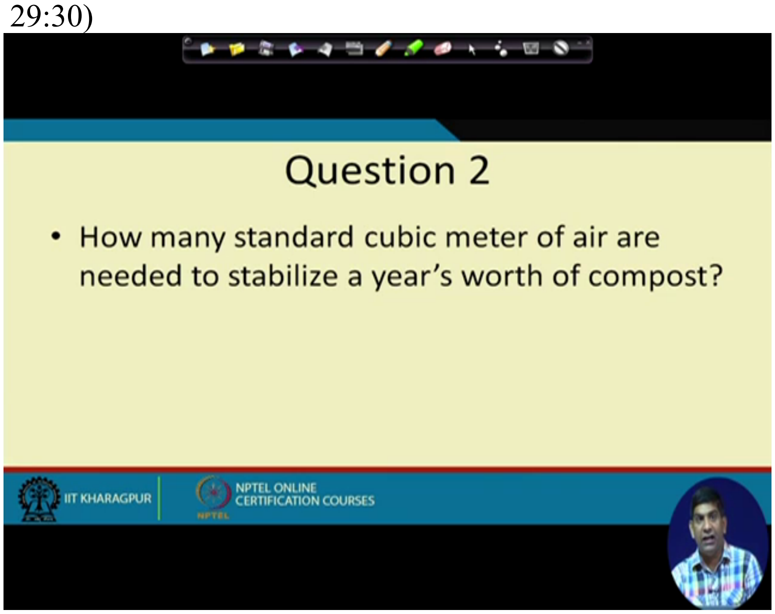

So the other is, other question is how many standard cubic metera of air required to stabilise a years worth of compost? So stabilization means 100% of BVS getting converted to CO2 and water. So then air has 79 percent or nitrogen 21 percent, oxygen, it is only oxygen that is participating. So we have to determine the oxygen, how we do it? We can measure it, we can do some samples in the lab and we can get the data from there.

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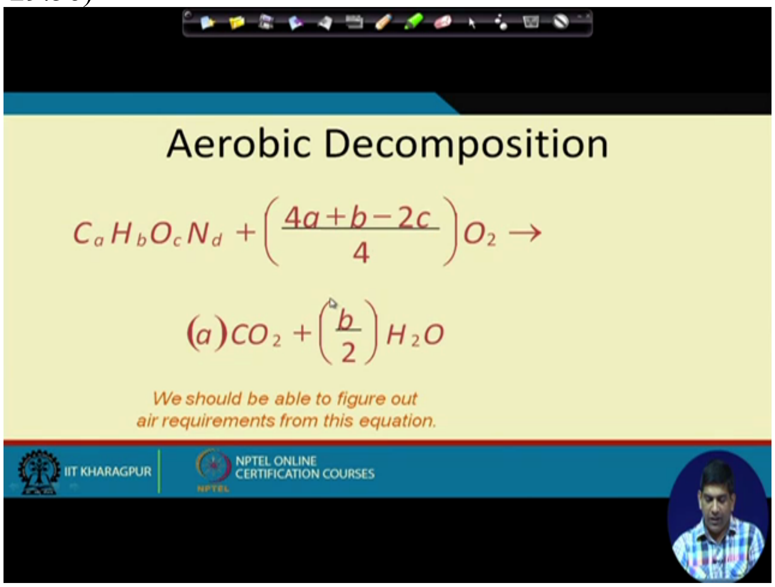

So in terms of aerobic decomposition we have looked at this earlier, the CO2 is produced, so this if you know the formula, you know how much oxygen is required, you can know how much CO2 is produced.

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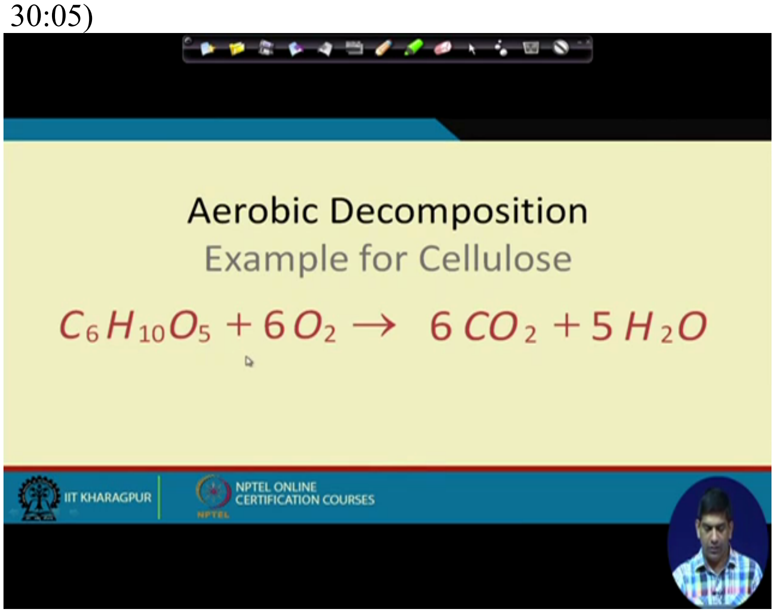

And for so this is a simple format so where you have the simple organic material with oxygen, it is producing 6 CO2 and 5 water.

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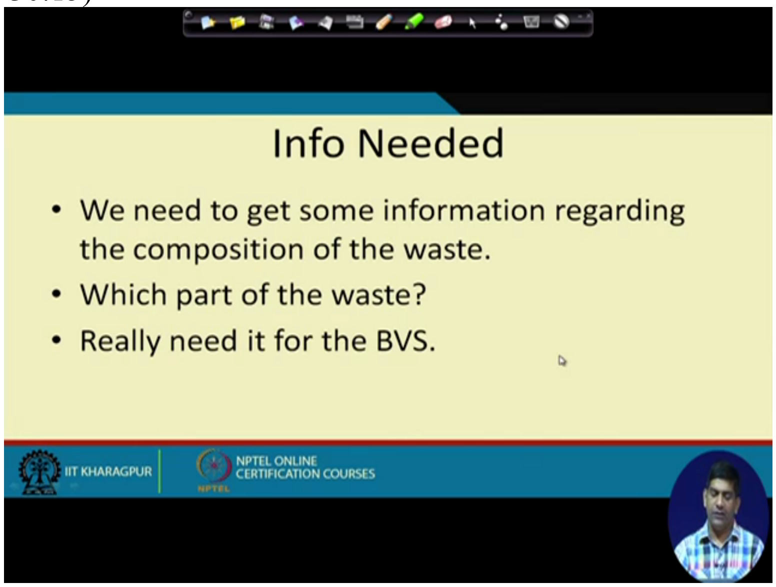

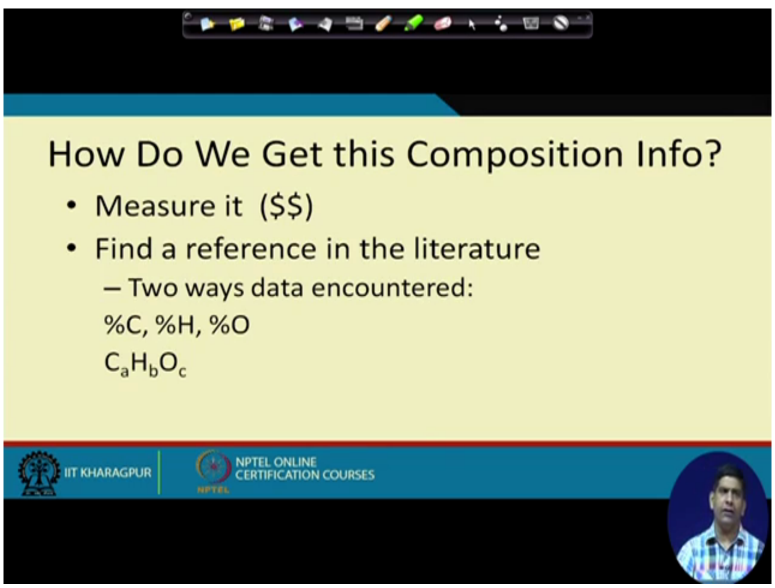

So what we need to get information is we need to get information regarding the composition of the waste and then which part of the waste? It is the BVS part of the waste. That is what we need to get the composition. We came to measure, we can measure it but that is costly. It requires money to measure that or we can find a reference in the literature, 2 ways you can encounter the data, you can have percentage carbon, nitrogen, oxygen or you can get the formula directly. So either way, you can get the data and use it in your problem.

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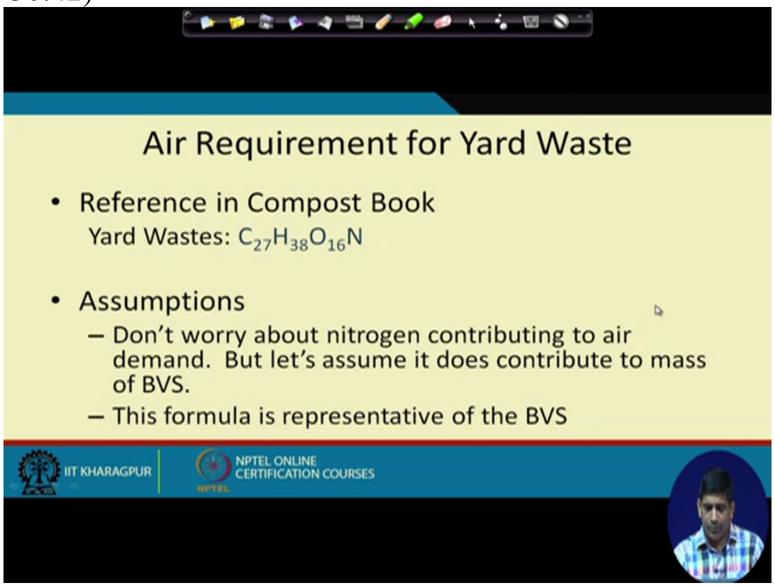

So air requirement for the yard waste reference in the compost book, yard waste we found some formula, so we can go ahead and use the same formula if the time and money, if resource is limited. So here it is essentially carbon, hydrogen, oxygen which is contributing to the air demand and nitrogen, it is not contributing. Let us assume that it does contribute to mass of BVS but does not contribute to the air demand. And then the formula is representative of the BVS so that is the formula which is out there.

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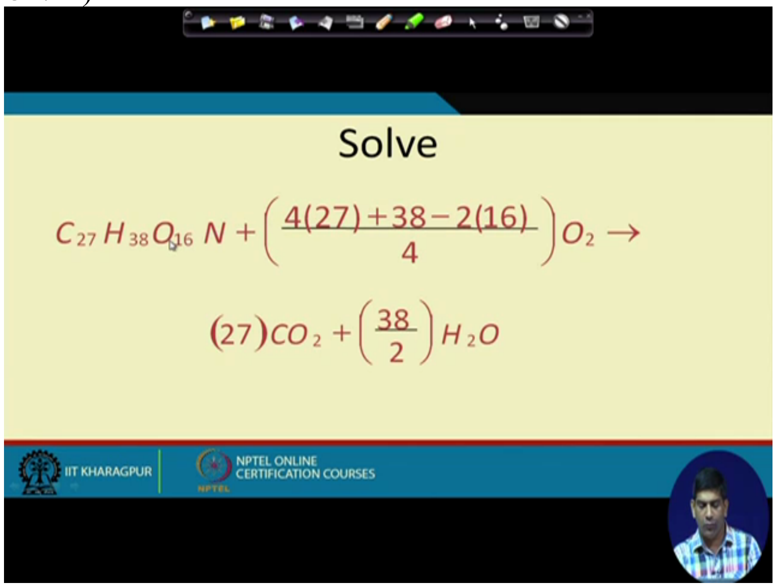

So if you have this formula in terms of how much moles of oxygen will be required for 1 mole of this to produce methane or produce CO2, so if you plug in those numbers you get 28.5 kg mole of oxygen per kg mole of this particular waste material. That is what is needed. So then how do we get the air requirement? If we know the how much kg mole of oxygen is required we can convert that in volume and then we can use that number.

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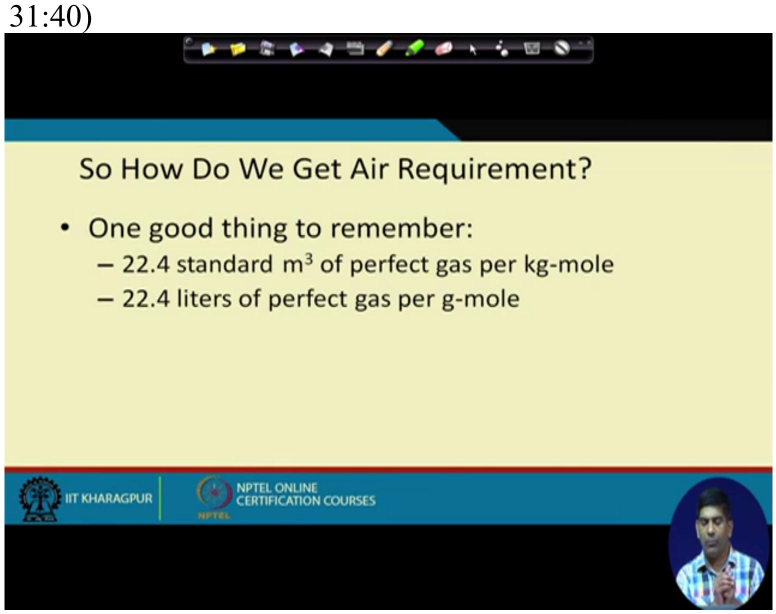

So one good thing which you can also remember that is 22.4 standard metre cube of perfect gas is equal to per kg mole or 22.4 litres is equal to 1 gram mole. So that is a, based on that, you can do the conversion as well.

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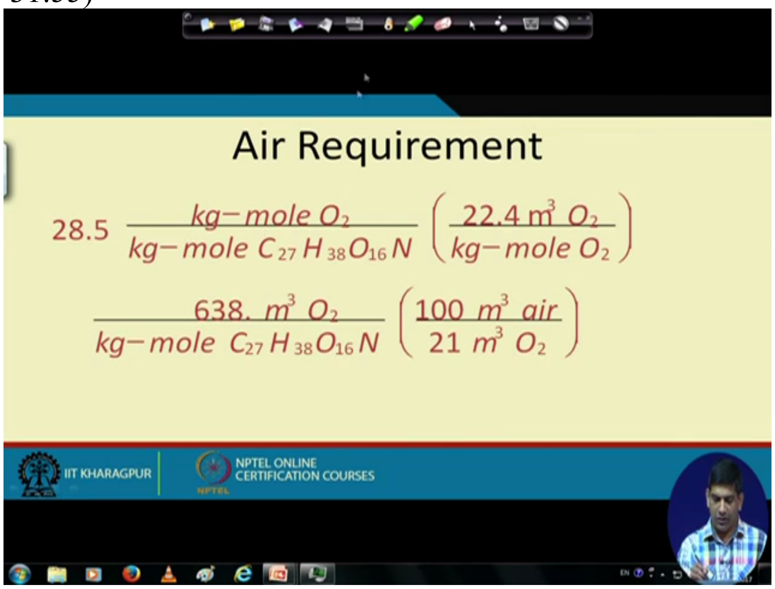

So you had 28.5 kg mole of oxygen required per kg mole of the material that we talked about earlier. So this is what we had in terms of the calculation we did, now per 1 kg mole has 22.4 metre cube of oxygen, so you convert that, so you get 638 metre cube of oxygen per kg mole of this. So this is oxygen, what we will be supplying is air. So if you want to convert that to air, so 100 metre cube of air per 21 metre cube of oxygen. So based on that, you can get what is the air requirement. So this is how it is done. So you can convert things from the BVS.

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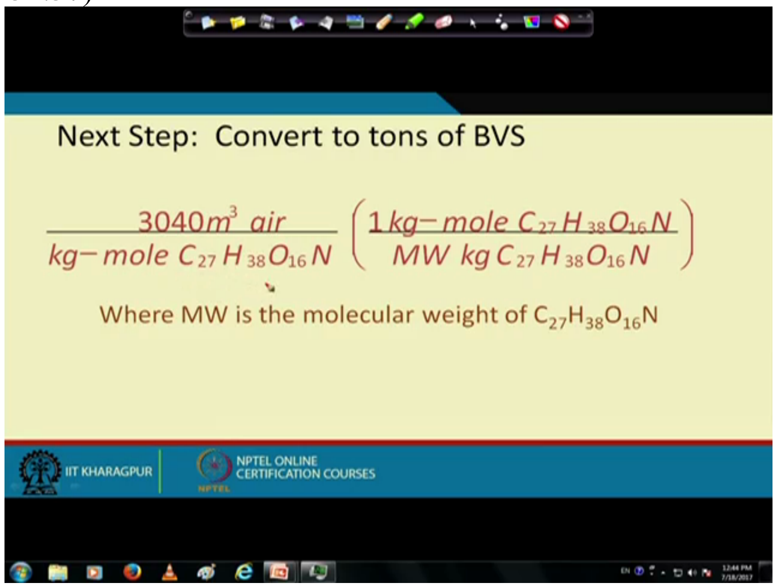

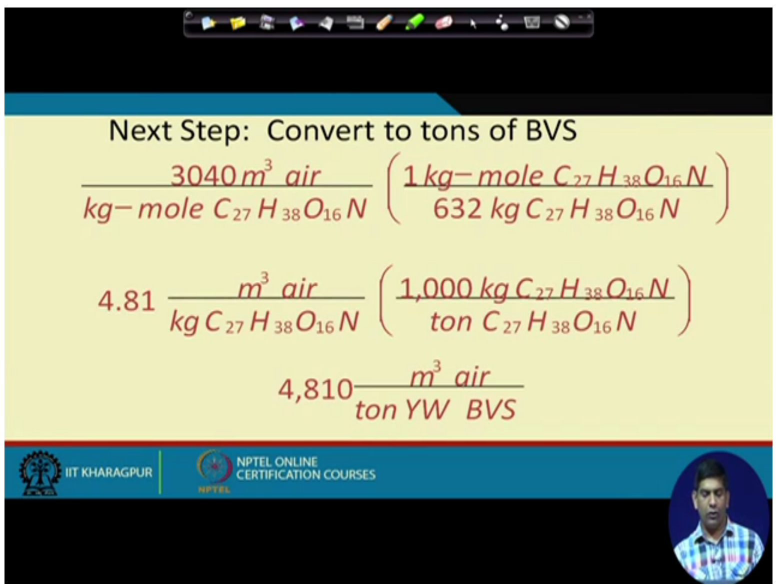

So this much air is required per kg mole. Now what is like how much kg mole of this per molecular weights, you can calculate the molecular weight of this particular compound. So if you do the maths, for molecular weight, you get around 632 kg of this per kg mole of that.

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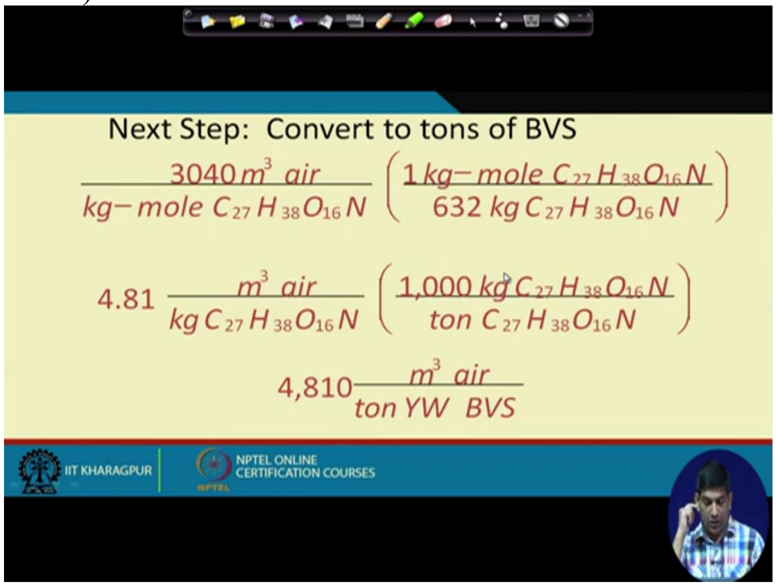

So once we figure fit this number here, so this much metre cube of air per kg mole. 1 kg mole is this much kg. So when we factor that one in, so we get 4.81 metre cube of air per kg. Then we have 1000 kg of because we were working with 1 ton, so we get around 4810 metre cube of air. So that is the metre cube of air that is required for 1 ton of yard waste. So this is how you get your air requirement.

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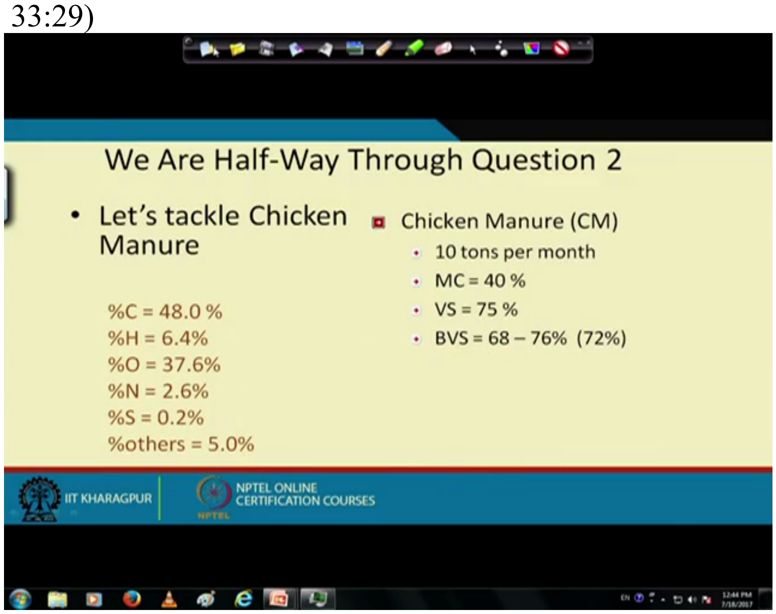

And there is another we are done with half way. Let us kind of for the interest of time we need to I think stop here and then this chicken manure we will do in the next video and then we will do the summarise it in the next video as we make progress.

So what we have covered in this module, we have looked at some of the anaerobic digestion issues initially and then we again got into doing some problems for compost, so we will we are doing some problems in composting. We will continue this is a bigger, this is actually a big problem on composting. We will continue this problem in the next video. I do not want to rush it through because there are some important concepts that I want you to cover, I want but you go ahead like if you have this material available in the PDF format, go ahead and look at it so that you can as a reading material, you may already have this PDF.

So go ahead and look that and you can look at, look through the problem so the next time when you see the video, you have already gone through it once. So let us stop here and this is a this is the 2nd video of week 7. So we will continue the discussion, so once we finish this biological treatment, we will go into the thermal treatment and maybe in video video or half later, we will start talking about the thermal. So with this, let us conclude this video and I will see you again in the next video. Thank you.