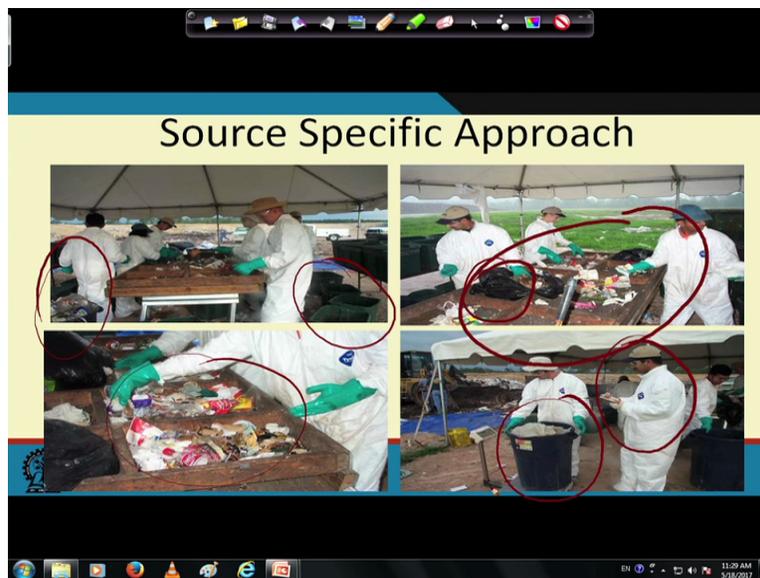


Course on Integrated Waste Management for a Smart City
Professor Brajesh Kumar Dubey
Department of Civil Engineering
Indian Institute of Technology Kharagpur
Module-02 Lecture-10
Municipal Solid Waste Characteristics and Quantities

Okay. So we will get started from where we left in the previous module. So as you can, if you remember we were talking about how those pie charts are developed towards the end of the previous module. And we looked at two different ways of doing it. One is the material flow where what we essentially do is we try to come up with how much of a particular type of product is made and then we estimate its shelf life and then after say three years or four years, the waste, it will come into the waste stream. And that is the one way of doing it.

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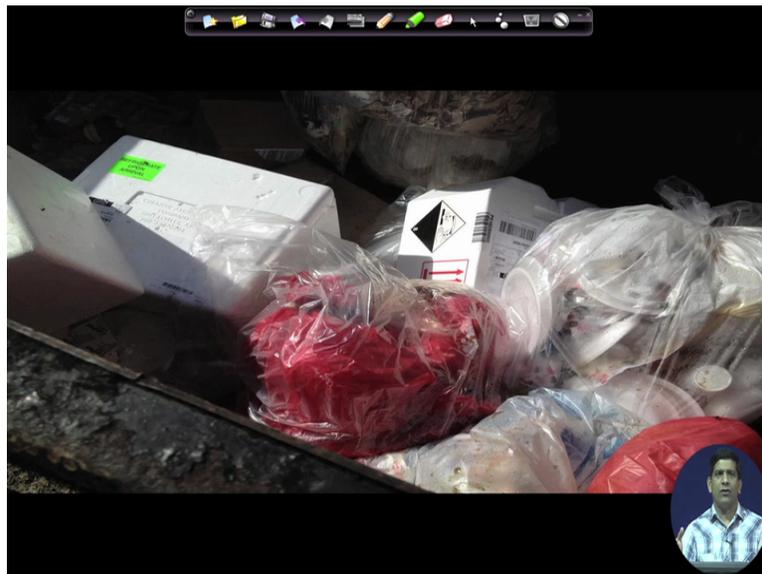
The other way of doing it, what was I was trying to tell you towards the end of the last module is this particular slide you were looking at where we do a source specific approach. And here as you can see we were, group of us were trying to like this is basically myself and some of my students where we are trying to do a waste audit. This is also called waste audit where we took, we had the garbage, we took apart the garbage.

And then as you can see over here, this is, in this particular table we put all those garbage after breaking the those bags. And these are the black bags right there. And then if you can see, the

pictures are not very, very clear but there are lots of bins on this side. And then there are some bins on this side as you can see. And so, we are basically putting it into different bins. And so, here again we are trying to sort through different garbage putting it into different bins.

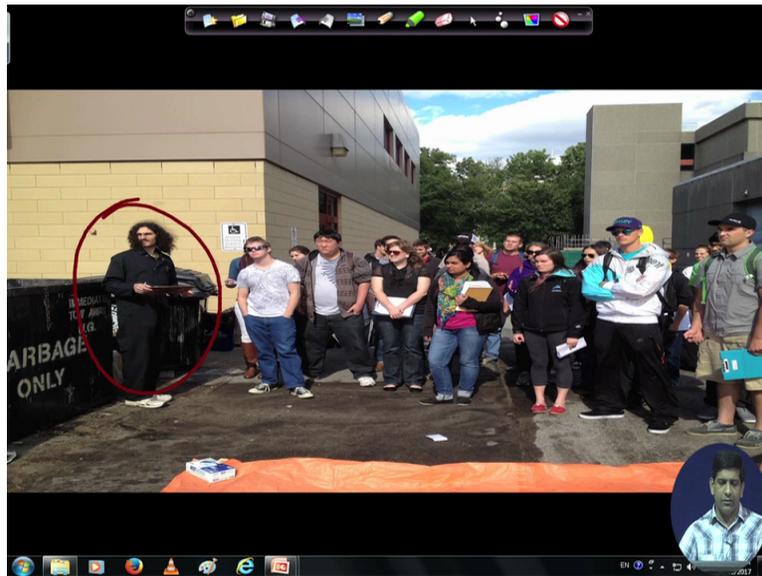
And then we are bringing those bins here and weighing them. So that is myself trying to do the weight. That is how we come up with different waste components, how much is paper, how much is plastic, how much is glass. And using this information, you can prepare those pie charts as we can see. So this was one, it was done several years back and then I will show you some, very recent one where a group of students from my class, I think three years back now and they did a waste audit as well.

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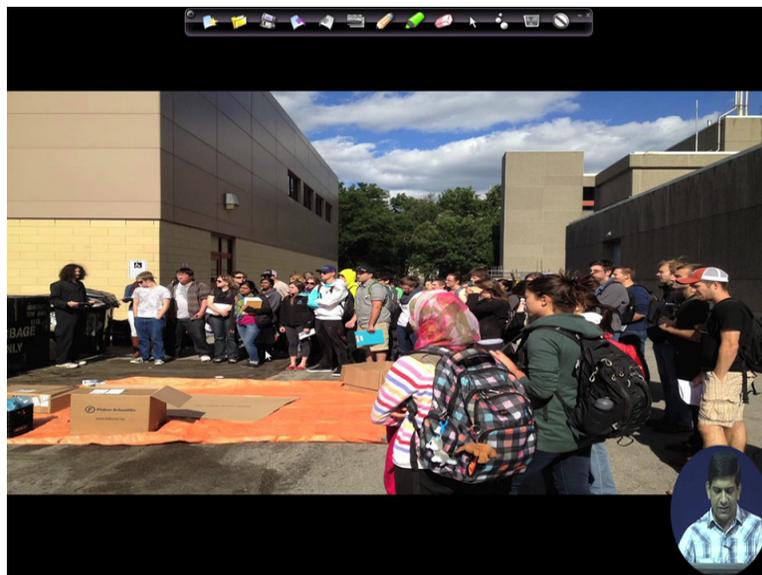


And so this is a kind of lots of pictures. This is just to show you how it is done. And this was done, not done on MSW stream, this was done just for the recycling stream. So we basically looked into the recyclable, these were the recyclable containers where trash cans which takes only the recyclable material at the university setting. So here as you can see, lots of plastics, lots of paper, cardboard; so those are the materials which is present over here.

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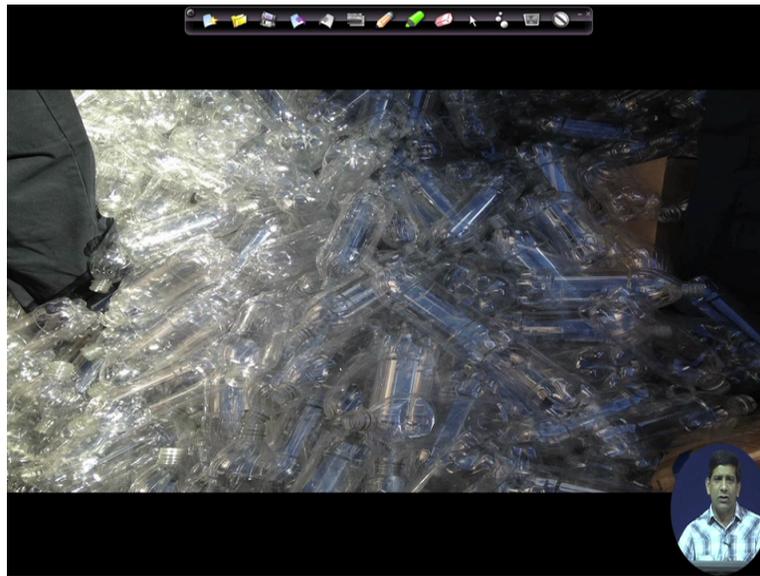


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And these are the students actually from my solid waste class which on that particular year. And this gentleman over here is our campus waste coordinator. So very excited, very enthusiastic person and he was our campus, so this is as you can see the students are there. We have put a sheet of paper, sorry, we have a sheet of plastics, everything laid out. And it is sheet of plastics laid out, we have several like they are taking out the stuff. This cardboard box is, just we want to sort into these cardboard boxes for the different waste stream that is coming in.

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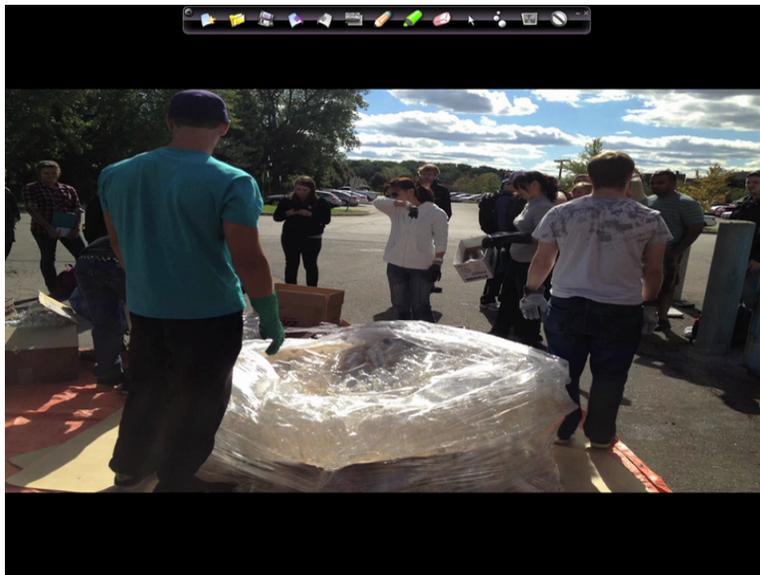
So unfortunate for us, on that particular day one particular lab probably had a bad set of sampling bottles coming in. Maybe this was a discarded set of sampling bottles, so they discarded a lot of sampling bottles in that recycling container. So our data got little bit skewed, so we got very high plastic just, this is and at one point of time, I was thinking that I will not use these slides for this lecture. But that is also, this is also one of the important, so you have to be really careful.

So this was not a good day for doing that waste audit because, just because one particular lab had this huge load of plastic as you can see in this particular picture and this, that led to a data which is, has a biasness. It is not really correct data because this is not a typical sample. This is a very, very special kind of sample you can say where we had lots of plastics showing up in that particular, on that particular day in this trash can which was supposed to be for recyclables.

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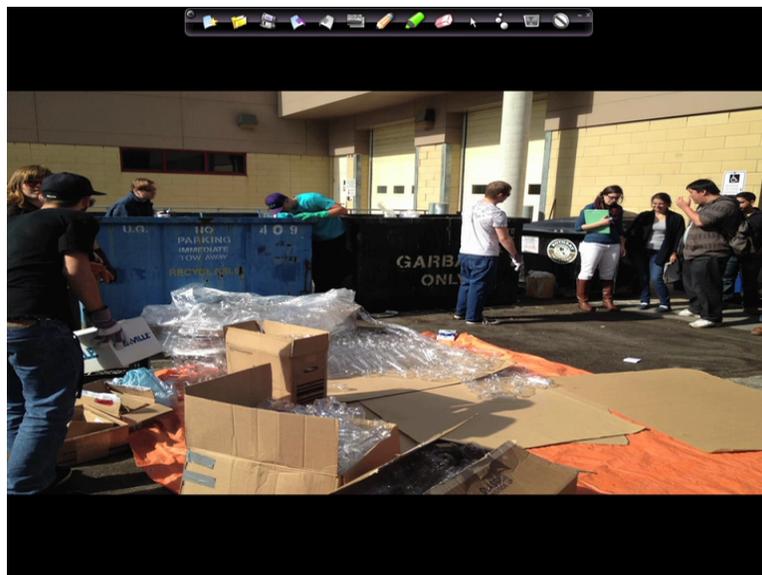
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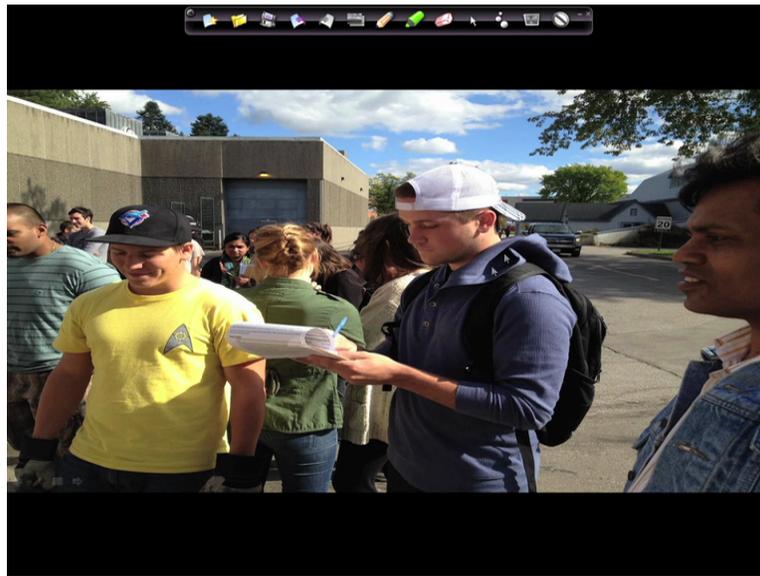
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So the students are taking out, they are taking this stuff away and then they are weighing it. So lots and lots of plastic bottles as you can see, so we weighed them where we sorted them in different categories, plastics, cardboards and other stuff. And these students are taking the note, so basically it is a good exercise although it was not a perfect exercise. But still, it gives a very good idea to the students that how those pie charts are developed.

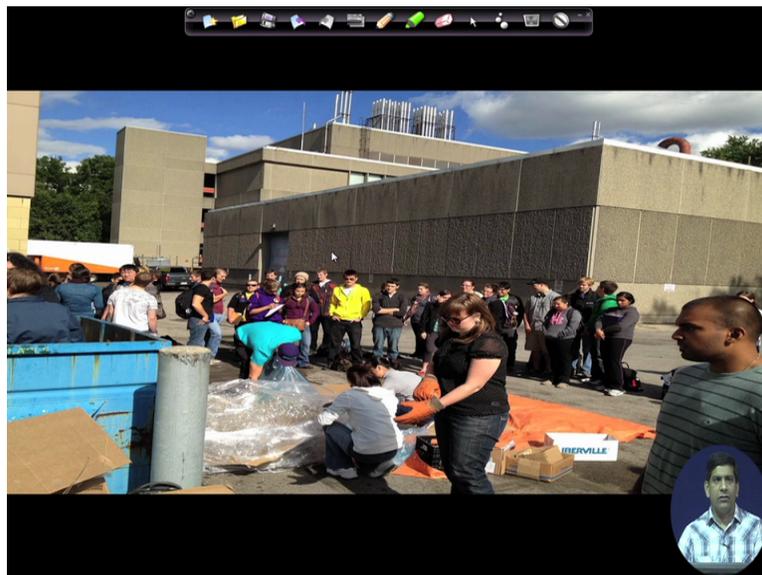
So they go through the process, they understand the process. So that is what is the application and in the engineering education, we need to bring in these kind of applications more and more in our classroom experience or taking students out in the field and have these kind of things going on, so the students will appreciate the effort that goes into making these pie charts. So it is not that, it is not an easy stuff.

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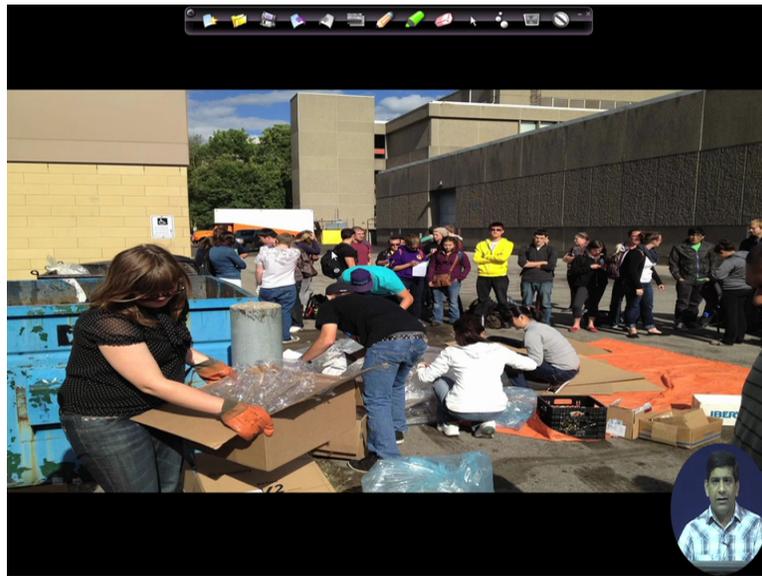


And you can see a scale, so we will weigh things over here in those scales.

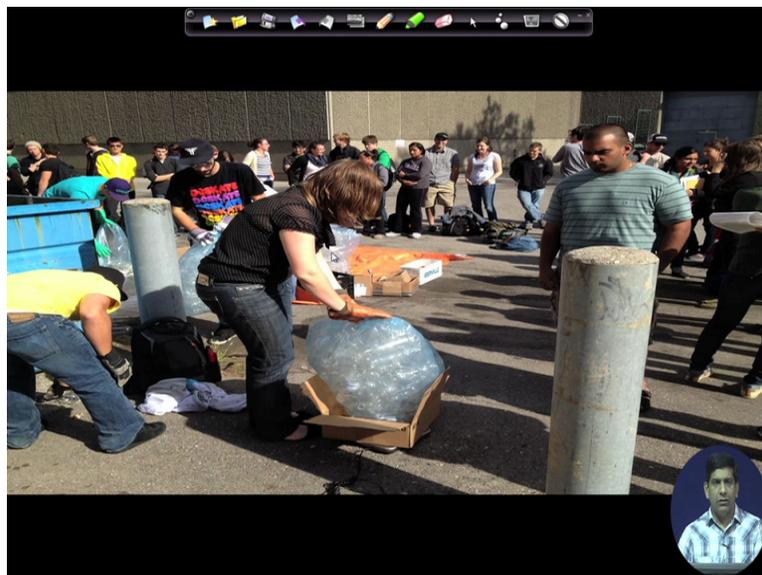
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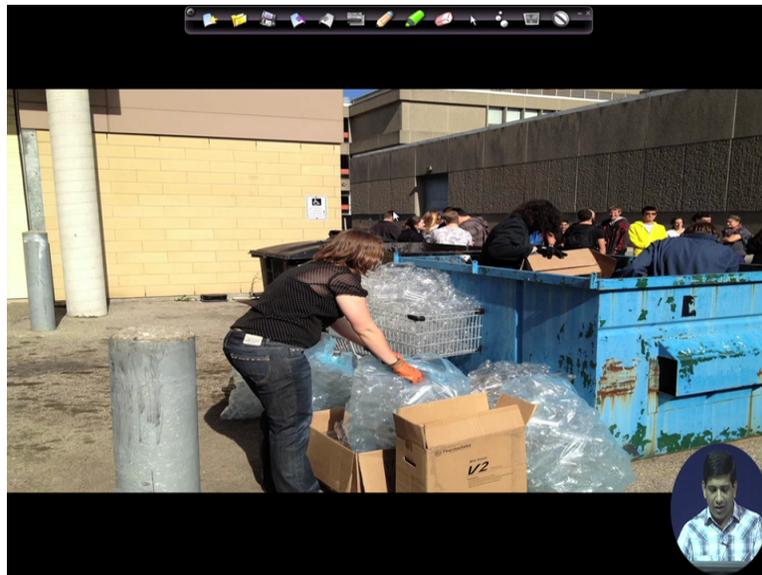
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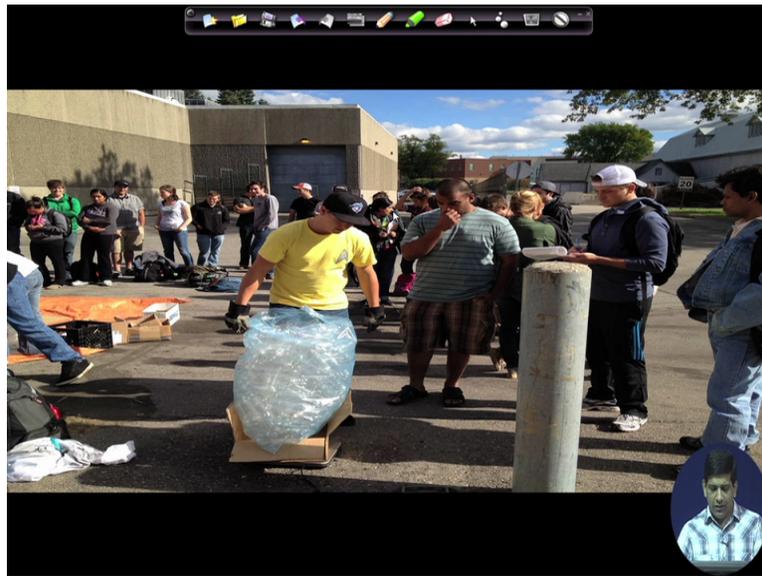
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And then the students are taking the different waste components apart and then they are weighing them. And there are lots of pictures and then lots of plastics. Plastics, and plastics and plastics, so again not a very good day. After weighing them, we are putting it back into the trash, to the recyclable can because our goal was not to recycle it, our goal is to actually find out the pie chart of the different waste components. So this is the students weighing them over there. And we come up, that will lead to a pie chart like the one we saw it earlier. So this is again, it is a source specific approach where you can go ahead and do it.

And we had another like there was another time also, so far like if we get a chance later on, if we have time, we will show you some more examples of how this waste audit is done because it is a very important stuff. Because why this waste composition is important? Again, why this pie chart is important? Because that pie chart will tell us what can we do with this garbage.

So if you want to design something, even if you are from a structural engineering class or if you have to design a beam for a building, first of all, you need to know what is the load coming onto beam. So then only, you can go for designing that beam. Similarly here for the waste stream, we need to know what is there in the garbage. Then only we can decide whether to go for composting or anaerobic digestion or waste-to-energy or nothing can be done and things has to go to engineered landfill.

So those things can be decided only after doing a proper waste audit. And when I say proper waste audit, in the Indian context, especially when you are looking at the municipal solid waste, the municipal solid waste that you and I produce at home and what ends up at the dump site as of today is very, very different. Now why it is different? If you think about the waste that you and I produce, we, of course the paper and plastics and other stuff for most of the middle class family and the semi-urban or urban areas, things are being taken up by these kabadiwalas. They will come and buy those newspapers and plastic stuff from us, so that does not go to the (municipal) municipality, municipal solid waste stream because that is already being taken away.

And the rest of the stuff even if they are some paper, there are some plastic which is actually mixed with the other like it is we call it, in a technical term, we call the contaminated waste. So even if recyclables are there but they are already contaminated with the food items, it is a nasty, cannot be recycled, the kabadiwalas will not buy it. So that will go to municipal solid waste but even from the municipal solid waste, from the primary collection when it goes to the secondary collection, we have the rag-pickers or the people who will come there and try to take those stuff out as well.

And then the food waste that we have, we have lots of animals coming into those secondary collection point before things gets into the truck. We have the animals coming in, many times the cows or the deer, sorry, the cows, goats and other animals will come in and they will eat it. So if you do the waste sample and at the household level and you do your design of a compost plant or

anaerobic design plant or you do a design for say bioreactor landfill and estimate how much gas will be produced so that you can make electricity out of that several megawatts or even for your waste-to-energy plant.

If you do all those by taking the samples from individual houses and not control the flow, so you are allowing rag-pickers to come in and you are allowing this cow and other things to come in and to eat and everything. So you are not actually presenting it through picture. And unfortunately, that is the scenario in most of the DPRs like I have been reviewing DPRs for as part of the 'Swachh Bharat Mission' for several ULBs and I do see the problem there.

The waste sample that is collected from certain houses, it is not the waste sample that is ending up in the dump site today because we do not have control in the middle. Our collection system is not, there are people coming in into the collection system and taking out several stuff from the primary collection point, from the secondary collection point. So we need to actually do the sampling, we have to be really like I do not know the better, like, it will depend from side to side.

It will depend on what kind of collection system a particular ULB has, but we need to be really careful. So it is otherwise, we will be having a, we will set up a plant which will not work and then unfortunately the technology which the plant is supposed to use, it gets the bad name. Technology is not bad, if a certain technology is being used in Germany, US or Canada wherever, it is working with the garbage. The problem is we are not giving a proper input to that technology.

And the problem is we did not did the homework properly. So unfortunately, many times what happens is the technology gets a bad name and then it becomes very difficult to bring back and use the same technology again because once you like get a, if somehow you get into the negative news, it is although you may be, it may be very good but if it gets into the negative news, it takes a long time to recover.

Like recently we had the issue of Nestle Maggi where the Maggi got the bad name and it took a while for it to recover. Maggi of course is a different ball game. So it is we cannot compare with the garbage technology but just to give a perspective that anything which gets into a negative press, it gets very difficult to bring it back because people are afraid to try it out. So but we need to be really careful about, so waste composition is the bottom-line.

Before you start designing your ULB's integrated waste management plan, make sure you have really done well in terms of your waste composition pie chart. And this pie chart truly reflects the garbage that you are going to treat. And if you are not doing that job properly, I am sorry, it is going to really, it is not going to work, it will have a problem. It may work but still there will be issues out of that and there will be very good chance that there will be failure. And at that time, it may be too late. So better to do the homework properly. So I think I have stressed upon that enough.

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Characterizing a Waste by Biodegradability

- Biodegradable Components
 - Paper
 - Cardboard
 - Food Waste
 - Yard Waste
 - Wood, Leather, Rubber?

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So let us look at and we will try to characterize the waste. It is the same pie chart, we will try to characterize it in a different way. So here if you want to characterize the waste for biodegradability, now what is the (bio), why we will like to do it? Again, every time I go there and first question I raise is, why? Because why we need to do this biodegradability? Biodegradability, we will do for say if you want to design a compost plant. Compost plant, in Indian context, we have been trying to do compost. There have been some success story, there have been some failures as well.

And there is a reason especially for compost or anaerobic digestion, if we keep the organic separate from non-organics or I would rather say from biodegradable fraction separate from non-biodegradable fraction because plastic is also an organic. If you can keep the biodegradable material separate, your compost will work and anaerobic digestion system will work quite good.

So what are those biodegradable components? Say if I want to, or I am sitting at IIT Kharagpur campus right now and if I want to, if I have been given a charge to find out for say Kharagpur town if we can have a compost plant, so first thing I need to know is in terms of the garbage that is coming to the dump site today and thinking that we are not going to change the collection system or we have collection system will be like that, there would be rag pickers, there would be kabadiwalas.

They will be there because that in formal sector is also part of the solid waste management system, they are not going to go away. If you think that they will, I do not know. But how they will go away? Like there is, we have to have a alternative and why should they go away? Because they are doing a pretty good job in recycling anyway, especially the kabadiwalas. We need to do some skill development for them as part the Skill India or make them, give them some technology so that they can do better, they can become entrepreneur, there could be Startup India and all those things coming in can be used for that. But they are doing a decent job, so I do not see any reason why this, especially the kabadiwalas going away.

The rag-pickers are actually where there are getting lot of human health problem and health issues associated with that. So we need to look at that part. But coming back to that initial original question that I am raising that, if I have to design a compost plant for city, for the town of Kharagpur, first of all, I need to know that amount of garbage that will come to the compost plant, what is the biodegradable fraction? Do they have enough biodegradable fraction to make a good quality, to make a substantial compost so that I can be able to sell those compost?

The next thing is, is there a market to sell those compost? And if the market is not there and say if I have to take this (comp), if I am making the compost at Kharagpur town and then I have to take this compost 100 kilometers, 200 kilometers to sell it, we should take into account the transportation cost. That is, because that is also part of the cost. And the economics may not work because the fertilizer industry is there, there is we have the competition with them.

Of course, the government is coming up with the subsidy where they are trying to force this fertilizer company to use part of the compost. And to make that, we need to have a source separated organic fraction because if it gets mixed with other fractions in there, the compost

quality may not meet the compost standards. So those things we need to really think about. It is not that we want to make a compost, let us go ahead and set up a compost plant.

Unfortunately many times we do that and that is not the way to, that it is better to do things properly rather than doing things like in haste. There is a saying in Hindi that 'Jaldi kijiye jaldabazi mat kijiye'. So like we have to do it, things in a quicker way because we are already too late in terms of waste management system in the country. But at the same time, we do not want to do it in a hasty way.

So we do not want to do it in a hasty way and after five years again we come up with the same problem that we have been doing for last say 40, 50 or whenever we have started working on solid waste management system, at least from 2000 onwards when we have the first waste management rules. So to set up, before we go for the compost plant, we need to, have to know what is the biodegradable fraction.

And for these biodegradable components, what are those biodegradable components in a waste stream? So typically when we talk about the biodegradable component, we are looking at the paper, cardboard, food waste, yard waste. So these are the major ones. From Indian context, most of the papers are, if it is taken away by the rag-pickers, it is not available. Cardboard could be also taken up, so it may not be available.

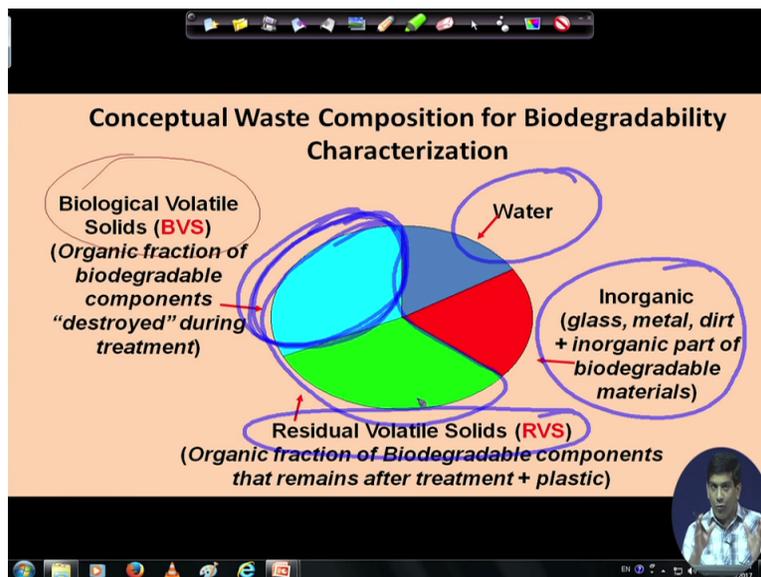
So what we have essentially is the food waste and yard waste. Food waste, what happens? From our house food waste starts traveling but at the secondary collection point, part of its gets eaten up by cows, goats and other stuff. So whatever food waste you have, you think that you are getting, actually you are not getting that food waste at when it comes to the compost plant because things are getting eaten away.

And if your collection system is not proper, if the waste is just sitting there for say 2 to 3 days, food waste will degrade. So part of the food waste has already degraded before it came to your compost plant. So we have to take those things into account. They are, they may seem trivial but they are not because when you look at in totality, when you try the things, if you look at how much you are actually losing, that may result in your plan being from a making profit plan to a making loss plan because there is always a lot of competition. So it is your profit margin is not high.

And we cannot run any system on subsidy for a long period of time. Government is providing some subsidy for compost right now but how long government will be able to provide subsidy? And why should government provide subsidy to any business at all? Like at the some point of time, the business has to stand on its own. So it is, there is I do not, at least in my view, we should have a plan for subsidy only for a certain period of time just to help this industry setup and then the industry should be able to run by itself. So the economics has to work for that particular.

So again for food waste, what you are getting at the site is not the amount that is getting from the house. Yard waste is whatever that you have any like wooden stuff, leaves and those kind of things, that is what the yard waste. And again part of it could be eaten up by the cow, by the animals along the way as well. So those things has to be taken into consideration. And wood, leather and rubber, in theory they can degrade but in practice they do not really degrade that much because it takes a long period of time for them to degrade. So essentially we are looking at these four: paper, cardboard, food waste and yard waste. So yard waste is leaves and other stuff, that is what there in a like a compost or and from a biodegradable perspective.

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So to do that, we can explain, we can put the same thing, same pie chart now in the form of what is known as the biodegradability characterization. Again this pie chart is important. You need to have this kind of characterization before you start thinking about compost plant, anaerobic

digestion plant or even for landfill gas to energy kind of system, biomethanation system. So what we are looking at this pie chart? Rather than putting into paper, plastic, moisture content and other stuff, we have put what is known as here if you look at the terms here, we are calling it biological volatile solids. One term, we are calling it biological volatile solids. We have other term which is known as the residual volatile solids.

Then we have some inorganic material, then the moisture is there. So let us look at each one of them. What is the biological volatile solids? Biological volatile solids is the organic fraction, it is the organic fraction of the biodegradable component which will get destroyed during treatment. So what when we say destroyed during treatment, what do we mean by that? It is essentially that particular fraction. So this pie chart over here, this part of the pie is what we will, it will actually react in the system.

So when you put your waste stream in the compost pile whether it is agitated pile, the different types of composting, we will talk about that when we go to the compost chapter. But when we look at this compost pile, this is the fraction which will actually react. Rest of it will go into the system and will actually come out of the system. So you do not, so this is the fraction which will react.

So when we talk about how much oxygen needs to be supplied is basically how much oxygen this particular fraction of the pie requires for the aerobic degradation in a compost plant. And then the green part at the bottom is what is known as the residual volatile solid. So this is also an organic, it is an organic fraction but it does not degrade because see, it is a biological reaction.

The biological reaction works based on the microbes who, microbes are present, what types of microbes present. So microbes has a certain limitations as well, certain very high molecular weight compounds, very like a lot of bonds and lot of like if it is a highly stable or certain compounds those microbes cannot degrade. So although it is there but it will not degrade.

So that is organic fraction of biodegradable component that remains after treatment. It will not really degrade. It is kind of similar to BOD and COD. Remember if you had, in your class BOD is the (biologic) biochemical oxygen demand where you always, most of the time almost, most of the time your BOD numbers are much less than the COD numbers because BOD is based on the microbial activity. COD is the chemical oxygen demand, very based on the chemistry. So you

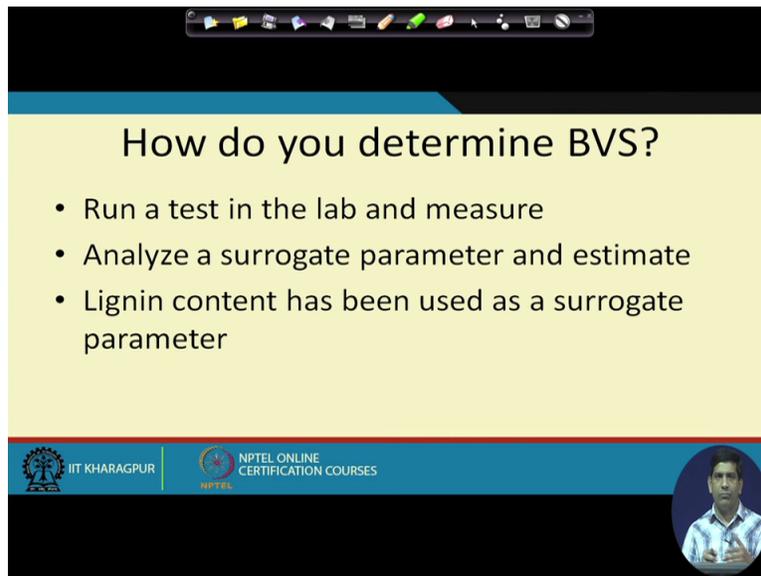
are using potassium dichromate to basically oxidize everything which could be potentially oxidized. So similarly here there are certain organic fraction which will not react by these microorganisms. So they will be there even after that the treatment has been done.

So that is our the biological volatile solids, very important. Residual volatile solids, together they are, together these two light blue and the green part is what is known as the VS, volatile solids which we talked about earlier. So that is why, remember we talked about that volatile solids is an important parameter we need to know but here it is why we need to know.

Moisture, moisture is needed for microbial activity, so moisture is present. Inorganic fraction, at least we need to know what is the fraction which will not react at all. So these are your glass, metals, dirt, inorganic part of the biodegradable materials, so they will not react. So these are, so these we need to have a pie chart like this.

Say, if you are in charge or if you are working in a waste management area today or if you, wherever you will be working in waste management area, if you have been asked to say design a compost plant, design anaerobic digester or looking for gas from the landfill, you should have a pie chart like this in front of you before you start designing your system. And you need to develop this kind of pie charts by doing the sampling and other stuff because that will be a correct approach of doing it, rather than, so to do things in a more perfect way so that you can do things correctly. So that is conceptual waste for the biodegradable characterization and we will look at the other characterization as well.

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How do you determine BVS?

- Run a test in the lab and measure
- Analyze a surrogate parameter and estimate
- Lignin content has been used as a surrogate parameter

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So that is, so how you determine BVS? What we, how we do it? We can run a test in the lab and measure it. We can run a test and see how much got degraded, and then we can do that. We can analyze a surrogate parameter. Surrogate is a term where we, it is essentially rather than using the biological fraction directly, we are actually doing it by measuring something else. And that something else is called, it is what we most of the time we use is lignin content. What is lignin content? Lignin is a compound which you may be, you may have heard about. Lignin is very hard to degrade. So if you know the, although it is organic but it does not degrade. It will be like part of your RBS.

And it does degrade theoretically but it takes long time to degrade. So higher the lignin content, it is hard to degrade, means what? Higher the lignin content, lower the biological volatile solids, is not it? And we will, I think we will see it in the next slide or so. So we use lignin content as a surrogate parameter because we can analyze for lignin in using analytical instruments and that uses a surrogate parameter.

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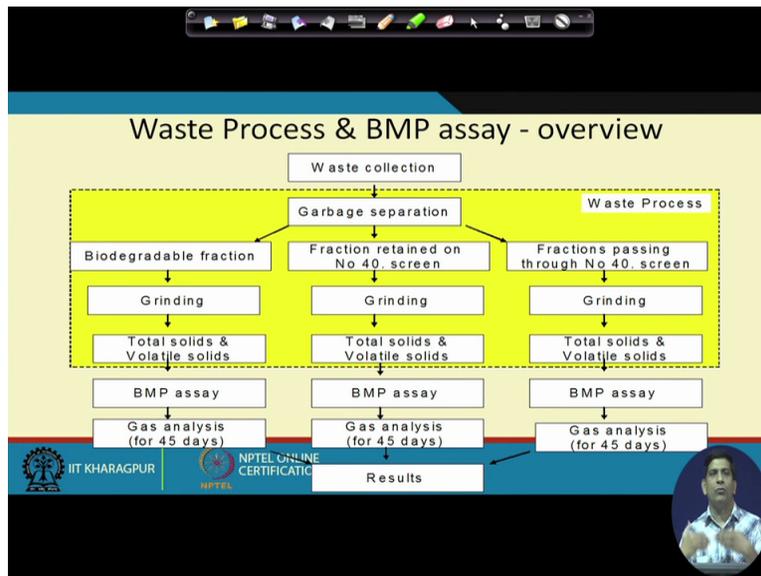
$$BF = \frac{BVS}{VS} = \frac{0.83 - 0.028(LC)}{VS}$$

LC = Lignin Content (%)

And then we can calculate this BVS. BVS upon VS which is also known as the biodegradable fraction. This BF, BF is known as the biodegradable fraction and BVS is the biological volatile solids. VS is the volatile solids. So this can be estimated by this particular formula and it is empirical formula, which has been developed based on research done earlier.

So here it is 0.83 minus- 0.028 times LC. Now what is LC? LC is the lignin content expressed in percentage. So you need to be careful. So you need to remember that it is always lignin content in percentage. So 0.83 minus- 0.028 times the times the lignin content which is the lignin content is expressed as percent. So as you can see from this formula, as you have more and more lignin, that means less and less biodegradable fraction because it is a negative term here. So it is more the lignin, (high) it cannot be degraded. So that is gives you an idea about, so using lignin content, we can find out the biodegradable fraction.

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Then other way of doing it is you can do a BMP test what is known as the biochemical methane potential test. What is the biochemical methane potential? Biochemical methane potential is as you take the sample, you bring the sample to the lab, you do some sampling of this solid waste and bring it to the lab, separate into different fractions and process it. Then you put it in those, what is what we know as the BMP bottles and then you have the reaction going on. You put some bacteria in there, the bacteria will start degrading it and we do it in anaerobic system.

In anaerobic system, we will have methane being produced. So this methane, we will measure how much methane is produced and based on the methane production, we can estimate what would be, what is the biodegradable fraction. So I will walk you through how it is done and that will make you little bit clear. So in next 3-4 slides, we will explain that and how this BMP test is done. So this is, if you look at this particular slide, this kind of gives us the big picture overview.

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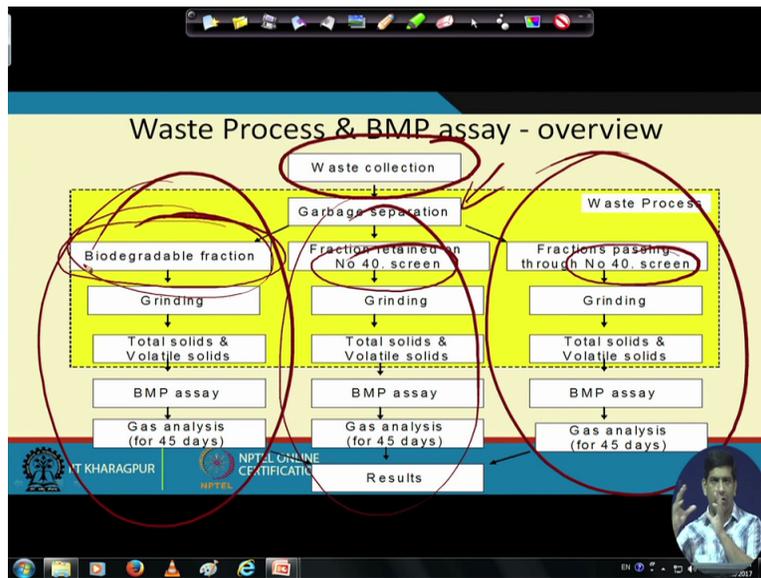


So we collect the garbage, so you collect the sample and this is how the sample is collected. So here you can see from and we will come back to that slide in a minute. So here the, this is from existing landfill, so we were actually drilling the landfill. So as you can see we are doing some drilling over landfill and then collecting the samples from these places.

That is myself trying to, collecting samples from a waste landfill site and here what we are trying to do is we are actually trying to find out how much of the biodegradable material left at this landfill and if we can set up a gas collection system, whether there will be enough gas produced so that in the next door, they were trying to build asphalt plant so that whether we can supply energy from this landfill to the asphalt plant.

That is what the reason for this analysis but so this is how you collect the sample. This is one way of collecting sample. If you are doing it in existing landfill, if you have a raw sample like we want to have a municipal solid waste just collected from a landfill site or from the individual household primary collection or secondary collection, we can use that as well. So once the waste is collected, you bring it to the lab. And then here the waste is collected, you bring it to the lab and what you do it?

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After bringing to the lab, here your waste is, collection is done. You bring it to the lab, then you separate the garbage, and you can do a garbage separation. And how it appears? Now we take a biodegradable fraction. How we take the degradable fraction, we will look at it. We will look at paper, those 3-4, paper, cardboard, food waste, yard waste; we separate them and we put it and I will show you in the slide right now. And that becomes our biodegradable fraction. We grind it, we measure the total solid, we measure volatile solid, we do the BMP assay, we analyze the gas over 45 days period.

Anything which is, then we also do the sieve analysis. Anything which is retained on No. 40 screen and which also passes through 40 screen, we take them, we take both, grind them as well. We do the total solid BMP assay on them. Why we do this? Because these fractions is, there may be certain organic material present in these fractions which cannot be captured directly here in the biodegradable fraction because of particle has already like gone into small pieces. These two are more common when we are actually trying to take the garbage coming out of the landfill. If we have, if it is a fresh garbage, most of it will be on this side.

But many times we are actually doing this BMP test on semi-decomposed garbage as well where we have to do all those three parameters. So once, how these are done? You saw the picture of how the waste is collected.

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Waste Sample Processing



Waste sample for manual sort

Fractions retained on ASTM No. 40 screen

Fractions passing through ASTM No. 40 screen

Dried waste samples are placed in a shaker and separated by size.

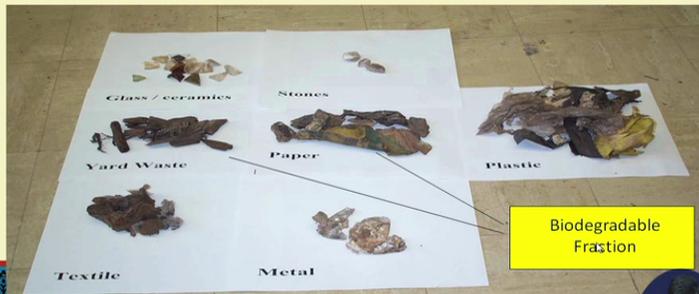
Waste sample fraction retained on No. 40 screen is collected and assigned as "R" sample and other fraction passed through No. 40 screen is classified as "P" sample

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After waste collection, this is the waste, how the sample is processed. So we will dry the sample here. So we will put it in oven, it is putted in oven and we are drying the sample. After drying the sample, we like shake it. This is the No. 40 screen. Whatever is passing through 40 and whatever is retained on 40, we take both. And then we do, we grind all these the samples over there, I will show you.

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Waste components manually separated



Glass / ceramics

Stones

Yard Waste

Paper

Plastic

Textile

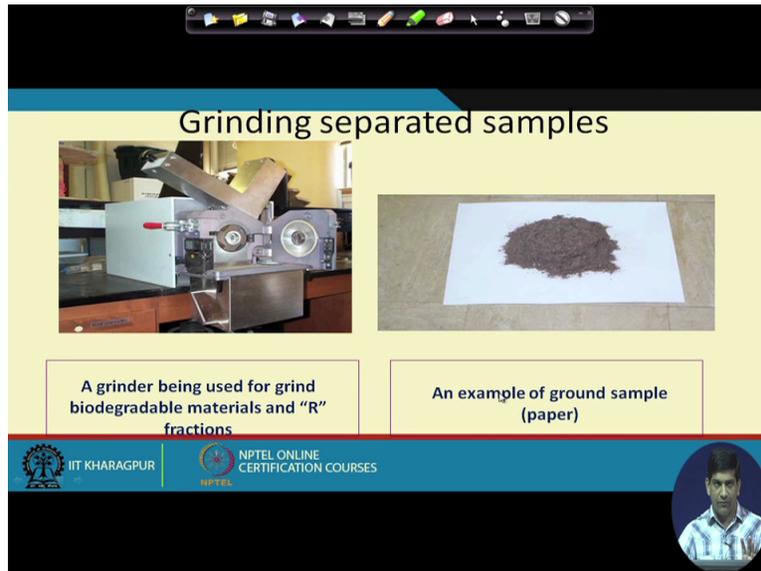
Metal

Biodegradable Fraction

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This is the waste manually separated. So this is your yard waste, paper. This is a biodegradable fraction. Plastics, metals, we do not take them into account. So only biodegradable fraction for the first part.

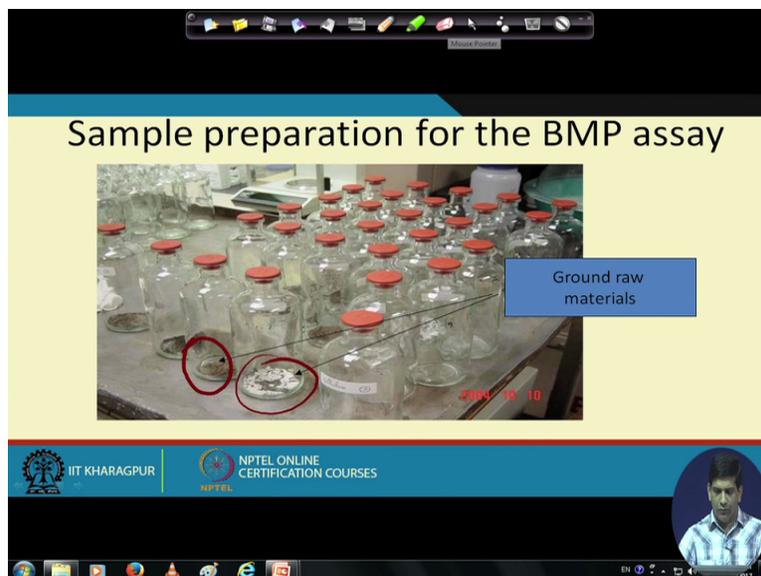
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The slide is titled "Grinding separated samples". It features two photographs: on the left, a mechanical grinder in a laboratory setting; on the right, a pile of dark brown, finely ground material on a white sheet of paper. Below the images are two text boxes: "A grinder being used for grind biodegradable materials and 'R' fractions" and "An example of ground sample (paper)". The slide footer includes the IIT Kharagpur and NPTEL logos, and a small circular video feed of the presenter.

Then you grind it using a grinder and then you have the ground of sample. This is a like example of the ground of sample.

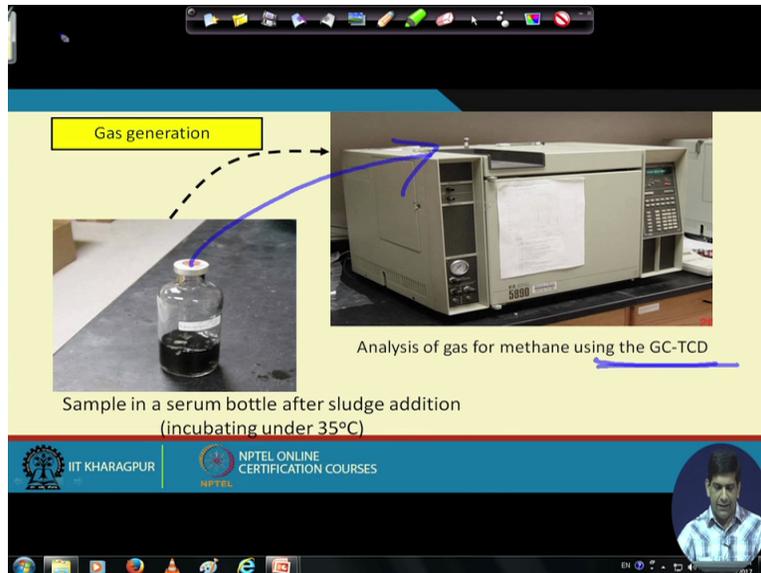
(Refer Slide Time: 31:01)



The slide is titled "Sample preparation for the BMP assay". It shows a photograph of a laboratory bench with many glass bottles, each with a red cap. Two bottles in the foreground are circled in red. A blue text box on the right says "Ground raw materials". The slide footer includes the IIT Kharagpur and NPTEL logos, and a small circular video feed of the presenter.

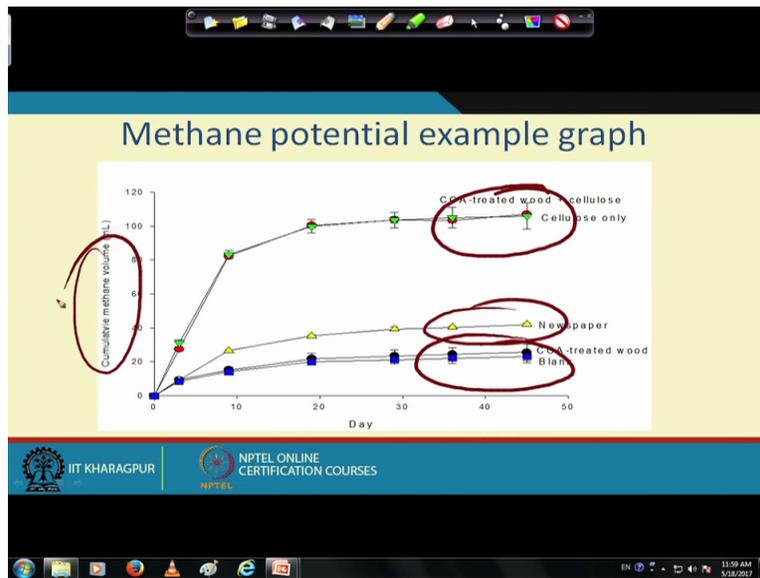
Then you put it into BMP bottle, so this is your samples over there. As you can see this is a sample over there. And this sample as you can, and here we have this white white powder that you see is the glucose. So that uses a positive control. So we have sample, we will add some inoculum. We will add some bacteria to it and let it, get the reaction going on over a period of time.

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And so this is the with the inoculum, as you can see over here with the inoculum. So serum bottle, we incubate at 35 degree centigrade. So as the gas is produced, we analyze this gas using GC-TCD. So that is like we use the GC-TCD to analyze the gas which and then the gas, we take the sample from here, inject into here. And then we analyze the gas and that process is done over a 45 day period, typically 45 day period. Why 45 days? You will see in the graph when we show you.

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It is after 45 days, things starts flattening out. So if you see this picture, it starts, this started actually getting straight. So no more and this is cumulative, this is cumulative graph. As you can see, cumulative methane volume. So what it shows? That after 40-45 days, there is no more further gas production. Whatever gas could be produced is already produced. So then, we can stop and then we can find out how much gas was produced per unit of that particular material and that way we can know what is the biodegradable fraction of that.

So this is, but it is a time consuming process of course. It takes time, it takes money and so but many times it is needed. It is actually, it will save you money later on. So many times what we try to do is to have, to save our project cost, we try to avoid doing this test at the beginning but later on we ended up designing a system which does not work. So we need to be rather do it properly from the beginning.

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Component	Percent of MSW	Percent of each component that is biodegradable
Paper and paperboard	37.6	0.50
Glass	6.6	0
Ferrous metals	5.7	0
Aluminum	1.3	0
Other nonferrous metals	0.6	0
Plastics	9.9	0
Rubber and leather	3.0	0.5
Textiles	3.8	0.5
Wood	5.3	0.7
Other materials	1.8	0.5
Food waste	10.1	0.82
Yard trimmings	12.8	0.72
Miscellaneous inorganic	1.5	0.8
Total	100	

Source: [20, 28]

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Here are some examples of the different biodegradable fraction which is paper and cardboard. As you can see, you will see the food waste. If you have the food waste, here the percentage of MSW, biodegradable fractions of MSW around 10.1 percent. Paper and paperboard is actually the, this is the percent. This is actually percentage of MSW. In a typical MSW, this is how much they are.

And again this data is, as most of these books are written in western countries, this is the typical waste composition from a western country. If you think about India, we will have more food waste. We will not have this much paper and cardboard because our kabadiwala does a very decent job in India.

So you will not see this much paper and these things coming up. But this is a typical MSW, from say US MSW and this is, important thing for present discussion is how much or percent here actually. So nearly 50 percent of the paper and cardboard is biodegradable. 82 percent of food waste is biodegradable. 72 percent of the yard trimmings are biodegradable. So even not 100 percent of the food waste, around 17-18 percent of the food waste is not biodegradable. So that is also, it is just to illustrate those points.

So let us, so that is kind of gives you that example and let us kind of stop over here. Then we will try to look at from a thermal characterization of the waste. So what we have tried to cover in this particular module is in terms of the waste complement system, integrated waste management

system and then we looked at the (bio) biodegradability kind of characterization. Next, we will kind of continue this and we will look at the thermal characterization and then some other analysis part of that as well, how things are analyzed, some of the statistics involved with that, some more examples would be done.

So I hope you are enjoying this course and this, I think this video completes the second week of the material. Again you will have the quiz, every week we will have quiz. And but the discussion boards are there. I will look forward to receiving your suggestions, questions. If you have any suggestions on the course material, you are more than welcome to do that as well. And I hope we will make it more enjoyable over the coming weeks. Okay. Thank you and enjoy the course.