Course on Integrated Waste Management for a Smart City
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Module-02 Lecture-09
Municipal Solid Waste Characteristics and Quantities

Okay. Hello and welcome back. So we will continue in our second week course that we are in the week two and if you remember from the previous module, we have been looking at the waste properties. So we looked at the moisture content, density and some other physical properties of a certain waste stream. So we will continue looking at some of the other physical properties and we will do some, solve some example problems.

I have some example problems as well as like how I have been telling you in the, if you have, and I hope you should have gone through the previous module. I have been stressing on the fact that this mass and density, they are related and how the data collected related to mass or density is applied. So we will see some of the example problems and how it is being done just to reinforce those ideas.

So let us get started. So if you remember in the previous module we are talking about the mass, volume, density, specific gravity, moisture content. So now we will kind of continue that and another property, another important property is what is known as the porosity. So porosity, if I am pretty sure if you have looked at porosity earlier in a soil mechanics course or any in your high school science classes as well, porosity as we define it, as you can see on this particular slide, it is a very simple way of defining the porosity.

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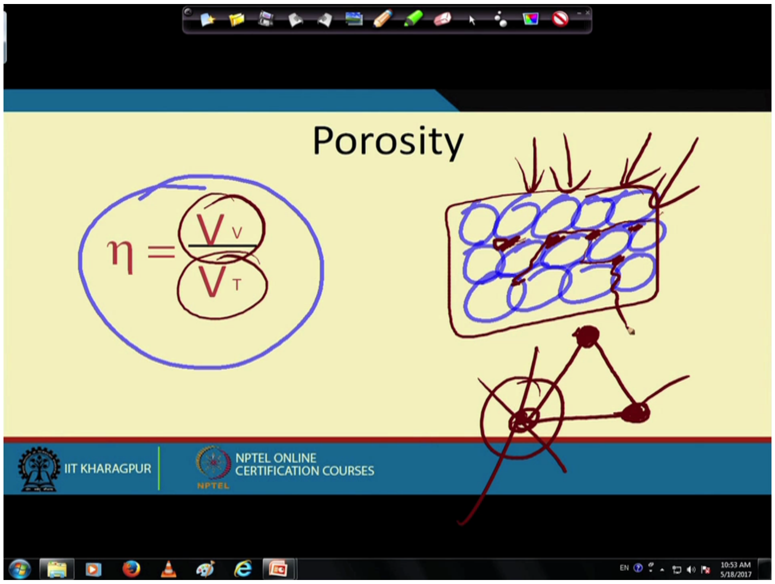

Porosity

$$\eta = \frac{V_V}{V_T}$$

It is essentially volume of voids divided by the total volume. So porosity is whatever is the volume in the void. So if you have, so if you have a several pebbles all put together, so if depending on the size of the pebbles, you can see that when they are stacked together, in between we have some space left. So these are the space in the middle, so these are the void spaces. These are what we call the void space. So this void space, so volume of these void spaces divided by, so that is volume of those void spaces divided by the total volume.

So if you take the total of this, so the total volume is what is in the denominator and the volume of these void spaces is in the numerator. So that is gives us the void, the porosity. Why it is important? Remember when we are talking about the landfill design, if there is a porosity, porosity will have soil air, air will be trapped there. So in case, if you remember from the previous discussion we had that when the waste degrades, methane is produced.

So now this methane if for some reason in the hot and humid kind of weather, very high temperature, waste degradation is an exothermic process as well which releases the heat. So if the temperature goes up, methane being a flammable gas, it does catch fire if the conditions are suitable. And in that case, if you have a big void spaces, that means you have air pockets. And the air pockets means it has oxygen.

So if oxygen is present, methane is burning, so the fire can propagate into the landfill. So that is why, that is another reason why we do the compaction on the landfill. If you saw those pictures where we showed that several compacters are used to compact the garbage, reason for that is of course one of the reason is to increase the strength, stability of the landfill so that this our C and Phi values are good, C and Phi from the soil mechanics are good enough. And then the structure is strong, it will not collapse.

But at the same time, it get rids of these void spaces. These void spaces will be gone. And these void spaces because when you compact it from the top, if you are applying pressure from the top, these void spaces will disappear and then these things will get compressed. And in that case, what you will have is there is a lack of oxygen. So if there is a lack of oxygen, even if the fire get started, remember from your science book that fire triangle where you had, if you have a, just for your recap, we have a fire triangle where one end is something which can burn, the other end is you need to have ignition source and then the other thing is you need to have the air supply. So once the fire triangle is complete, then only the fire can propagate.

Here methane being flammable, say if it will catch fire, it will start burning. But since and garbage can burn, so we do have things which can burn. But since there is no oxygen, because we have compacted the garbage there is no more, no oxygen present and that creates, so the fire will not propagate. So that kind of helps in controlling the fire in a landfill environment. So that is, to do all those calculations, to understand all those factors, you need to know what is the porosity of the garbage and that is important.

And then the other point, say if you want to operate a landfill as a bioreactor landfill, if you are trying to do the air injection into the system, there we need void spaces. When we do the composting for example, composting requires, we need to inject air because composting is an oxidation process. It is aerobic biodegradation kind of stuff. So when you are doing the aerobic system, you need to supply air. And when you are supplying air, the air has to travel in the garbage.

So again if you look at this sketch over there, so if you think about, this is a pile of garbage, if you are trying to inject air here, so if you are trying to inject air, the air has to travel. And for the air to travel, more the void space better it is. So the air can travel and go towards the different parts of the waste. And then your aerobic reactions will be better, things will get degrade, you will have a better compost. And to do that, many times what we do? We add certain things which actually increases the porosity, that is called the bulking agents. You will hear the term bulking agents when we go to the compost chapter as well.

These bulking agents are used which is not being much to the degradation of the garbage but it is actually helping improve the porosity of the waste mix and that porosity helps in air movement in our compost pile. So those are the reason why the porosity is important. And that is porosity is one term which you will be, we will be kind of using it quite like we have to use it in a, many times you will see the porosity being used in the waste calculation. So that is porosity part.

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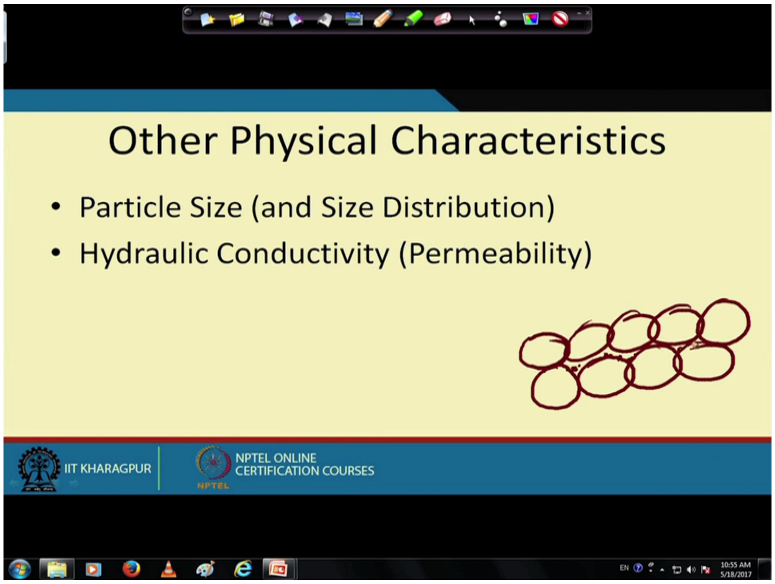

Other Physical Characteristics

- Particle Size (and Size Distribution)
- Hydraulic Conductivity (Permeability)

Now other, there are other physical characteristics, particle size and size distribution. What is the size of the particle? Especially again if you are, if you have a, remember from your soil mechanics class those D60, D10 uniformity coefficient. So all those factors comes into picture here too because we are talking about the stability, we are talking about how the garbage will be compacted.

So if there is, again if you have all big particle sizes, say remember if you, we have seen this example before, if all of them are uniform size, if all of them are the same size, that means I will have a more and more void spaces. But if I have something smaller pieces in between and that will take, that will fill up these void spaces. So that is if I have a uniformly graded soil, uniformly graded waste mix is better for compaction.

So you will have things kind of, but if all of them are of similar size, that becomes a problem in terms of like having a better like compaction or better, you will have lots of void spaces, you will have lots of pore spaces and all that. So that is your particle size is important, particle distribution is important, particle size is also important when we talk about the waste-to-energy plant because uniform the particle size better it is. Otherwise, any any process, they like to have uniform feed.

So even the coal based thermal power plant, if you visit a coal based thermal power plant, they always want to have coal of a particular size. And that size should not change a lot because then your reaction efficiency, everything kind of goes little bit off. So if you have a uniform size, it is always better. So similarly here, we have to do that too.

Hydraulic conductivity or permeability, it is, is the term used to measure how the water will flow, at what rate the water can flow. Remember we talked, we looked at the liner system, typical liner system, the permeability was less than 10 to the power of minus-7 centimeter per second. So even in the case the liner breaks, that soil, the clay soil at the bottom of those liners, they will not let the water pass through at the rate of more than 10 to the power of minus-7 centimeter per second. So that is like a very, very slow movement of water. And that is, we need that to prevent our groundwater contamination. So that is, so those are the terms are important in terms of the hydraulic conductivity and all that.

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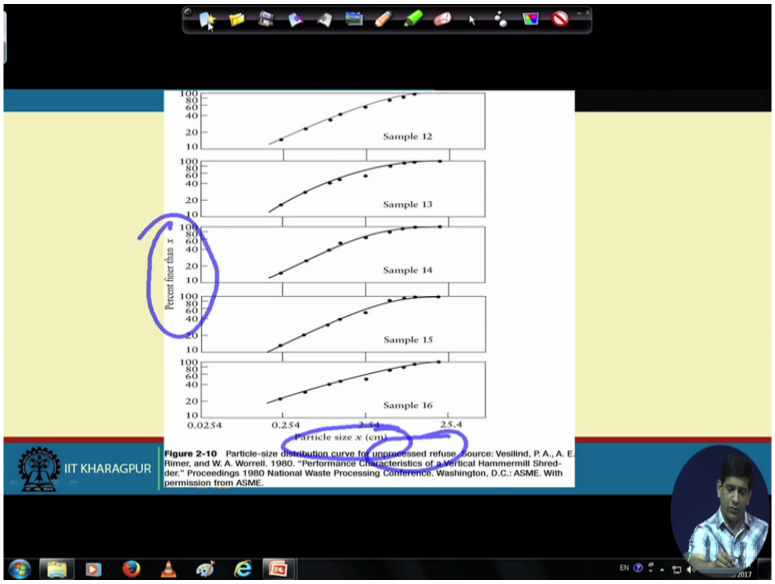

Figure 2-10 Particle-size distribution curve for unprocessed refuse. Source: Vesilind, P. A., A. E. Rimer, and W. A. Worrell. 1980. "Performance Characteristics of a Vertical Hammermill Shredder." Proceedings 1980 National Waste Processing Conference. Washington, D.C.: ASME. With permission from ASME.

There are some examples. Particle size distributions, if you look at different samples, 12, 13, 15, 16 and these are unprocessed refuse. So here as it says, it is unprocessed. It has not been processed, it is an unprocessed refuse and it is coming from one particular book. So here as you can see, the book basically coming from some research project. As you can see over here, different samples and on the y axis, you have the percent finer than x. And on your x axis is the particle size. So for the different samples, there are certain variability. So we do have, we do see certain variability in terms of how the particle size are and that depends on what kind of waste it is, what is the source of waste and all that.

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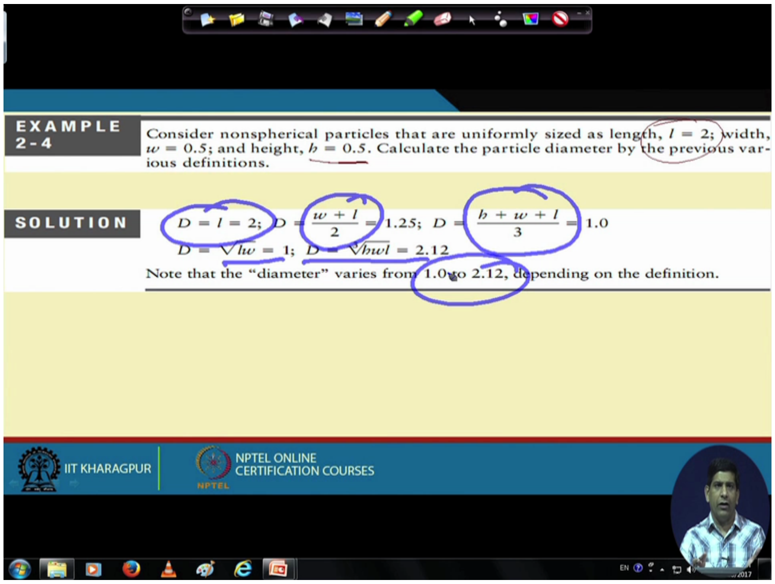

EXAMPLE 2-4 Consider nonspherical particles that are uniformly sized as length, $l = 2$; width, $w = 0.5$; and height, $h = 0.5$. Calculate the particle diameter by the previous various definitions.

SOLUTION $D = l = 2$; $D = \frac{w + l}{2} = 1.25$; $D = \frac{h + w + l}{3} = 1.0$

$D = \sqrt{lw} = 1$; $D = \sqrt[3]{hwl} = 2.12$

Note that the "diameter" varies from 1.0 to 2.12, depending on the definition.

And sorry, and for another, let us look at the other example. So let us, we will look at like how to calculate if you take a non-spherical particle which is, for which the length is given to us and width is given to us and the height is given to us, we have to calculate the particle diameter by using definition. There are different definitions for particle diameter. You can take, one definition is where you take the length itself as a particle diameter, that is one definition.

So you can, D is equal to l is equal to so let us say 2. Other definition is where you take the width and length together and take an average of that. Other definition of calculating diameter where you take all the three height, width and length and take the average of that as well. You can also take a square root of the area. Then you can take a cubic of if you calculate the volume. So basically there are different ways of calculating it.

And what we see is that data varies from 1 to 2.2 depending on the definition. So whenever you see a definition with diameter calculated for a non-spherical particle, make sure that you understand how it was calculated. As you can see over here, based on how you go about it and all these approaches are okay. There are people have done these approaches. All these approaches has been used. So you have to understand which approach people have taken so that you can, you should get the background of how it was calculated. So that is important. So this is another kind of example when you are looking at different like properties.

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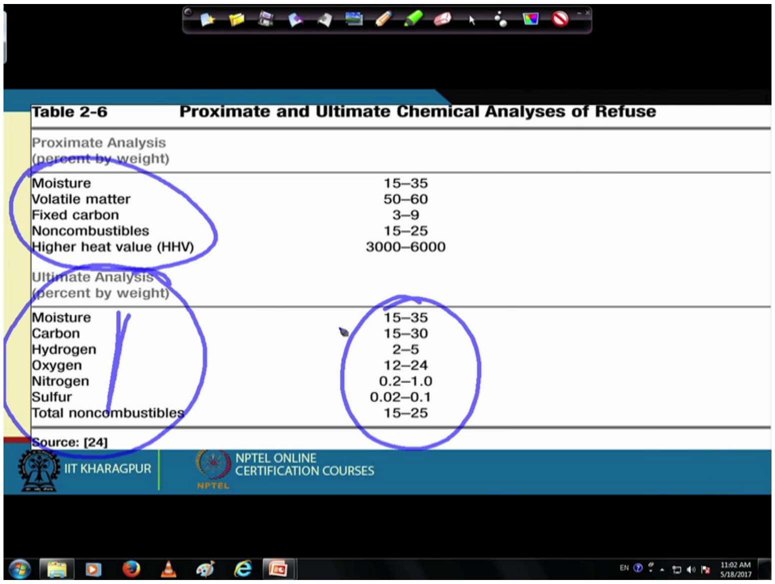

Table 2-6 **Proximate and Ultimate Chemical Analyses of Refuse**

Proximate Analysis (percent by weight)	
Moisture	15–35
Volatile matter	50–60
Fixed carbon	3–9
Noncombustibles	15–25
Higher heat value (HHV)	3000–6000
Ultimate Analysis (percent by weight)	
Moisture	15–35
Carbon	15–30
Hydrogen	2–5
Oxygen	12–24
Nitrogen	0.2–1.0
Sulfur	0.02–0.1
Total noncombustibles	15–25

Source: [24]

Then another area where we talk about the proximate analysis and the ultimate analysis. Proximate analysis, this is a term used where you are looking at certain parameters such as the moisture. As you can see over here, these are the proximate analysis terms we have where we look at the moisture, we look at the volatile matter, we look at the fixed carbon, we look at non-combustible higher heat values. So those are, and these are all percent by weight or depending on the, usually the heat value will be kilocalories per kg.

So moisture, typical moisture, 15 to 35 percent. Volatile matter is 50 to 60 percent. What is a volatile matter? Volatile matter is the matter like the volatile solids which you may have already seen in some other courses. But it is essentially if you take a sample and put it in a crucible, put it in muffle furnace at 550 degree centigrade over a three days period and then you look at what is the mass which has gone, so that mass, the loss of mass is essentially that denotes as the volatile matter present.

Fixed carbon is the amount of, is the type of carbon which will not really react. Then we have some non-combustible and the heat value. So that is, this is known as the proximate analysis. So basically you are getting some idea about the garbage. You are not getting the idea in kind of great great detail. When you try to get the idea in great detail where almost you are taking things all the way to the periodic table level, that is called the next part which is the ultimate analysis.

Here the ultimate analysis part is where we look at the moisture, carbon, hydrogen, oxygen, nitrogen, sulfur and those are your basically the stuff that you see directly on the periodic table and you get the values for these. Why these are, why this is important? Again, as I has been emphasizing from the very beginning of this course, for anything that you do, make sure you understand the significance of that particular task.

Or anything that you read, try to understand what is the significance of this particular topic. So again why this proximate analysis and the ultimate analysis is important from a waste management perspective? How they will be used in waste management perspective? Remember we were talking about we have to find out how much leachate will be produced, we have to look at how much gas will be produced.

So for looking at the how much leachate will be produced, moisture content is important, is not it? We need to know how much is the moisture content because that is one of the source of the leachate production. How much gas will be produced and what rate the gas will be produced and how much the waste will eventually degrade, for that we need to know the volatile solids or the volatile matter.

So those are, so there is always, whatever we are learning in a course, there is always some reason for that. And it is better you understand those reasons and you will have, you will feel more excited about it, you will feel more interested in that particular course and you will not forget the topics quickly and it will get into your head over a long period of time. So that is for the proximate.

Ultimate analysis going all the way to carbon, hydrogen, oxygen, is it needed? Sometime maybe, sometime maybe not depending on what is the requirement. When it is needed, say if you have to calculate the air requirement for the compost plant or you are trying to find out how much gas will be produced in a, from anaerobic digestion or in a landfill. For that, we use a formula to predict the gas, how much gas will be produced or how much air will be required. And when we try to use a formula, we need to know the formula of the garbage that we are supplying.

So since the garbage is so much heterogeneous, there is always we do not know the formula. So for that, if you know the amount of carbon, hydrogen and oxygen percentagewise or the mass-wise, by doing this ultimate analysis, we can come up with a chemical formula of that particular waste stream and you will see that. We will do those kind of problems in this particular class. I may not do it, I will not do it today but definitely at some point of time in coming modules you will see that. So that is the reason why this proximate analysis and ultimate analysis and these things are important. So that is kind of, I hope that kind of clears up some of the concept there.

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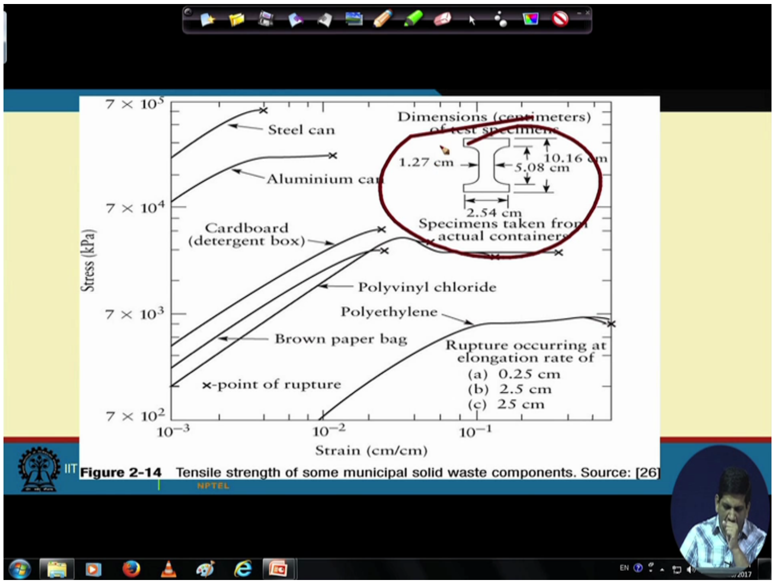

Figure 2-14 Tensile strength of some municipal solid waste components. Source: [26]

And tensile strength of the municipal solid waste component, that is another example where it can be used and why it is important? Again, we are using different types of materials. We want to recycle those materials. We want to look at, make new things out of these materials. Then there are other application, we are going to compact these materials as well. So for that here, if you look at a typical stress strain curve which usually you will see in a like a structural engineering class or strength of mechanics, those kind of class, so here the as usual we put the y axis as the stress and the x axis as strain.

Both y and x axes in the large scale and as you can see from here, we see there is, of course there is a linear term and then we have like a non-linear stuff in there. And for the linear term, stress is proportional to strain as we know and the ratio of that is called Young’s modulus. And but as we go to the non-linear term, that things are a bit different where we have some of the like a failure points are clearly defined. Some places we can see some plastic behavior, so those things are given.

And typically we follow a test specimen, what is called a test coupon. There is a standard way of doing it, so and that kind of what is the test coupon we have used is kind of given over here. So for different, this is kind of standardized now. So for different, even for different waste streams, different type of waste, we always try to use this particular test coupon so that we can compare, we can compare the results. So that is, it is like important from that point of view.

So far we have looked at the waste stream by itself, we have been looking at the waste stream just by itself. We have not looked at if there are certain, usually what will happen, say if you are running a landfill or if running an anaerobic digestion plant or a compost plant or a waste-to-energy plant, you will not have the garbage just coming from one particular location. You will have the garbage coming from variety of locations. So you will have waste coming in.

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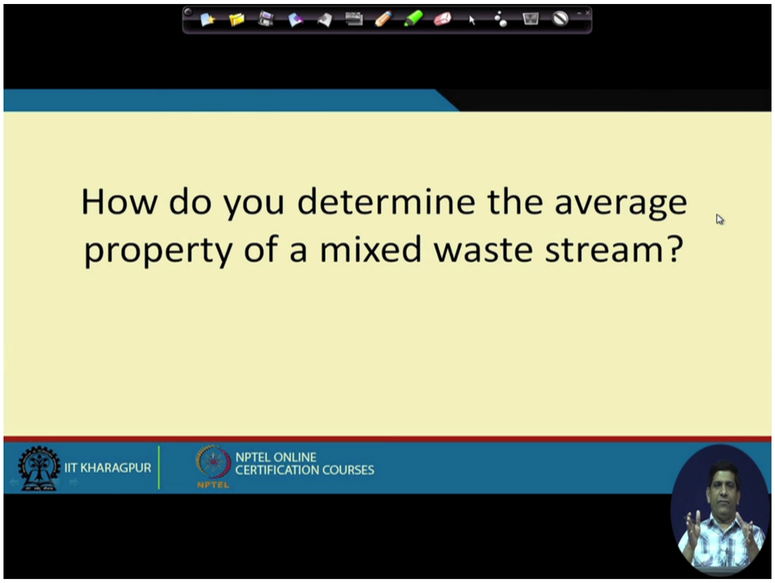

How do you determine the average property of a mixed waste stream?

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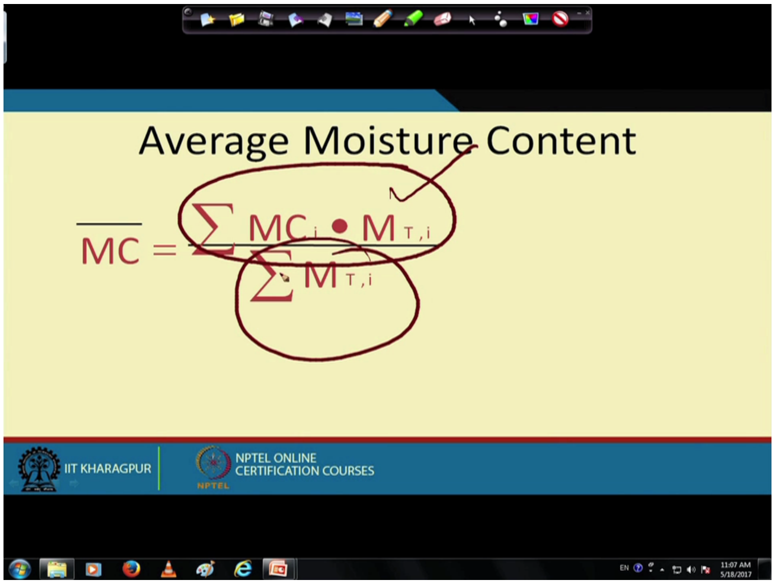

Average Moisture Content

$$\overline{MC} = \frac{\sum MC_i \bullet M_{T,i}}{\sum M_{T,i}}$$

So if you know the individual waste stream properties, how to find a combined waste stream property? Again it is a simple math, weighted average kind of problems. So let us look at some examples just to make things clear for you. So how you determine average property of the mixed waste stream? You can do it, you can do this average moisture content. As you can see here, so what we are looking at here? We, on the top, we have all the moistures from the different waste stream. So moisture content from the waste i multiplied by the mass, total mass of i, that is, what it is giving us? It is giving us the amount of water coming from the individual waste stream.

And what is there in the bottom? Bottom is the total mass. So as we know, the moisture content is what? Total amount of water present divided by the total mass. So that is kind of give us the moisture content. So, same thing has been done over here. There is nothing kind of a rocket science on this particular aspect.

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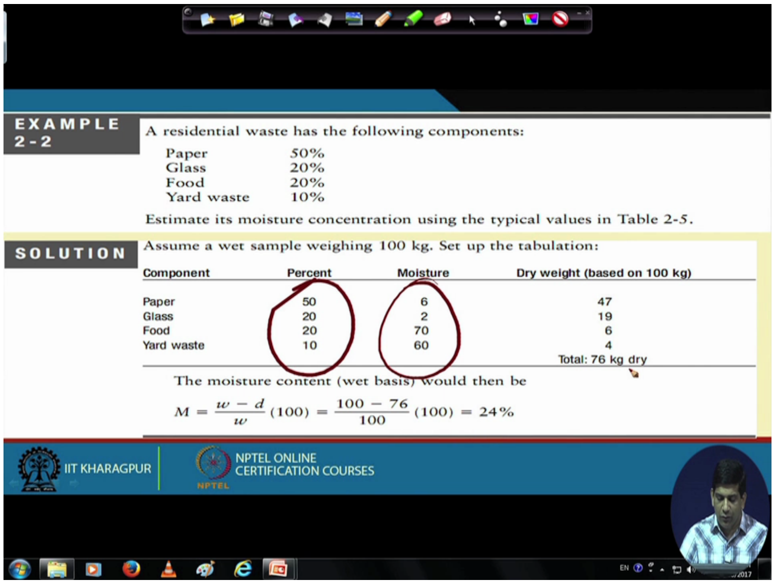

EXAMPLE 2-2

A residential waste has the following components:

Paper	50%
Glass	20%
Food	20%
Yard waste	10%

Estimate its moisture concentration using the typical values in Table 2-5.

SOLUTION

Assume a wet sample weighing 100 kg. Set up the tabulation:

Component	Percent	Moisture	Dry weight (based on 100 kg)
Paper	50	6	47
Glass	20	2	19
Food	20	70	6
Yard waste	10	60	4
			Total: 76 kg dry

The moisture content (wet basis) would then be

$$M = \frac{w - d}{w}(100) = \frac{100 - 76}{100}(100) = 24\%$$

If you look at one example where you have the residential waste has the following components: Paper is this much, glass this, food this, yard waste this much. And if you have to estimate the moisture content using the typical values which is provided in the table over here. So these are my different waste components. I have, these are my waste components. Let me get that. These are my waste component. This is the typical moisture content. So one way we can do is since we know the moisture content, we can calculate what is the dry weight based on 100 gram, 100 kg sorry.

So if 6 percent is the moisture, 50 percent is the paper. So out of, based on 100 kilogram of the total weight, we will have around 47 kilogram of dry paper. Similarly for your glass and similarly for food waste and yard waste. So that is, if you know that, we can calculate. So 76, out of 100 kg, 76 kg is dry. So that means 24 kg is the moisture. So the moisture content, since it is we are working with the 100 kg, moisture content becomes 24 percent. So same thing has been done over here where you can see that it is w minus- d divided by w. So w is, weight is total is 100, 76 is a dry, divided by 100 and then you multiply it by 100 to get the percent, it is around 24 percent. So that is the amount of like a moisture content for this particular waste stream.

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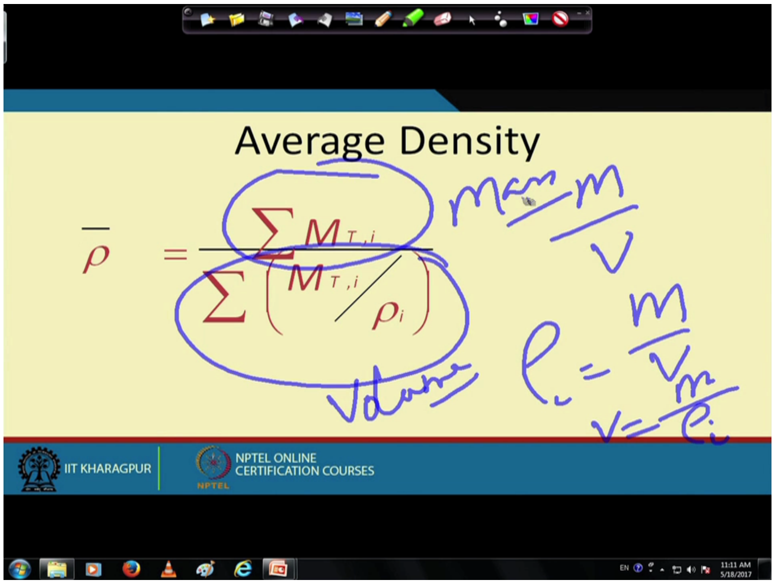

Average Density

$$\bar{\rho} = \frac{\sum M_{T,i}}{\sum \left(M_{T,i} / \rho_i \right)}$$

So average density, density is what? Density is mass upon volume. So we have to, density again, we cannot take a weighted average of density. The question is, why? And try to understand that why I am telling that because density is not an independent parameter. Density is a dependent parameter. Now when I say independent parameter and a dependent parameter, what does that mean? Dependent parameter means density depends on both mass as well as volume.

Mass by itself is independent parameter, volume by itself is an independent parameter but density depends on both mass upon volume. So that is why it is a, when we do the average density, we cannot just take the weighted average because the mass and when we mix two things together, the volume will change and so as the mass and they may not change in a certain ratio. So we have to look at them in a separate way.

So in terms of the average density, what we do is we take the total mass on top. So as you can see over here, we take the total mass on top and then we take the total volume. So that is the density is mass upon volume. So we take the total mass on top divided by the total volume. Now what the total, for the total volume, how we will do it? Volume is if you look, if you remember density was mass upon volume, so we can, so that means volume is equal to mass upon density. So that is what you see over here at the bottom.

So mass upon density for each one of the waste components and summation of that gives us the total volume. And on top, we get the total volume of the moisture present. So total volume of moisture divided by the total volume gives us the sorry, we get the total volume of here, we get the total volume here and we get the total mass on top. So as we know, mass upon volume gives us the density. So that is how you can calculate average density. So those are pretty like a simple but straightforward stuff. So that is how you can do in terms of like average of two different waste stream.

Now we will start looking at, so we have kind of, in terms of the physical properties if you remember from the previous module, we were talking about that we will look at the physical property, we look at the chemical property, we look at the component composition. So with that particular just, with this particular slide that we just finished, we kind of finished the part of the physical property.

Of course, we will have several math problem for you to work on and there will be some assignments as usually happens in this kind of course. So we will have the assignments and other things coming in as well. But in terms of component composition, we will start looking at from the, after since we finish the physical part, we will start looking at from the chemical perspective.

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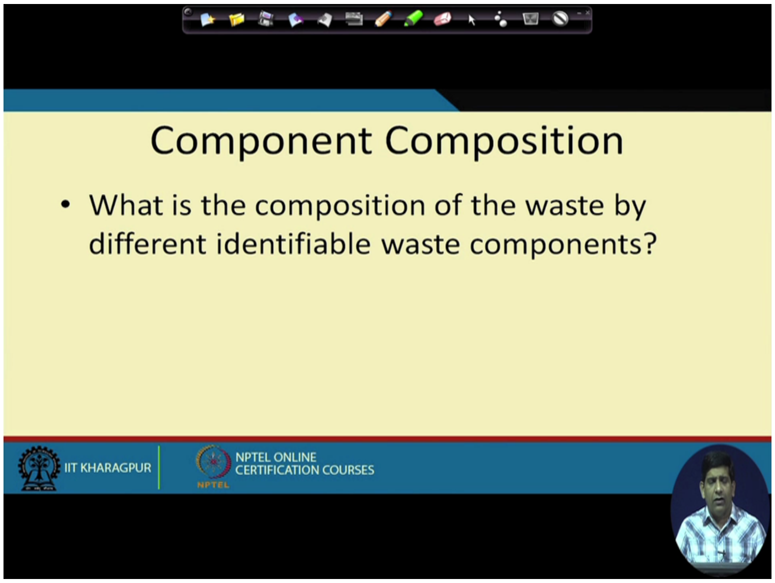

Component Composition

- What is the composition of the waste by different identifiable waste components?

Now what is the composition of the waste? Or from the, also from the component like what are the different waste streams present in a typical MSW waste, municipal solid waste? So composition of the waste by different identifiable waste components, so what are, what we are talking about here? Let us look at some examples that will make it clear.

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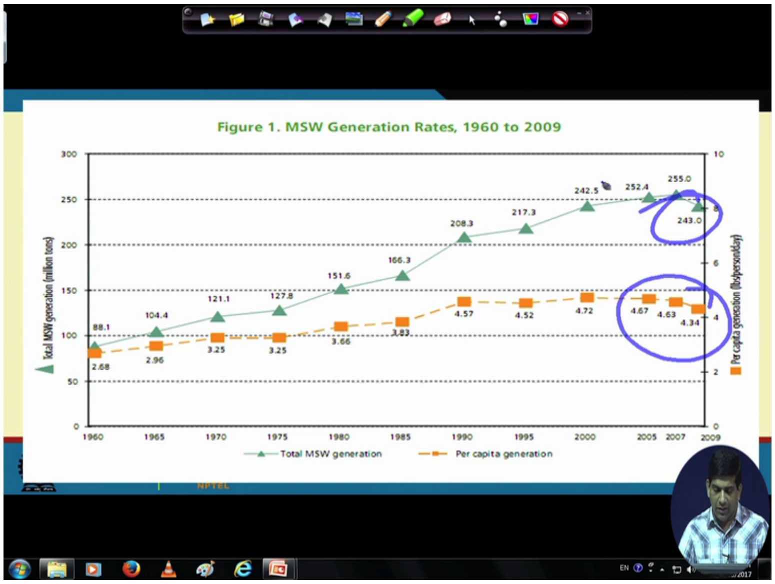
Figure 1. MSW Generation Rates, 1960 to 2009

So if you look at the MSW generation rate, it is like a per capita generation has kind of, and again this is the US EPA data. From an Indian data, unfortunately we would like to have data like that. That would be really cool to have a data. And to collect it, we should start kind of collecting data now so that maybe after 30 some years, we can have some nice graphs like this what we see in front of us. So here what historically based on the data collected in the United States, what they have seen that this orange dotted line and the orange boxes are for per capita generation in the household.

And the triangles are total waste generation in million tons. So if you look at that orange one, it is, we see that there was a trend of waste generation going up. But now there is a tendency of waste generation either coming down a little bit. And for that, we do not know what is the reason. Of course, it is maybe more awareness. People are more aware now because of all the things that that gets highlighted in different media.

And so that is, that could be the reason of people are becoming little bit more waste, less wasteful and probably recycling and doing those kind of things a little bit more. But this will be informal recycling because here MSW generation rate means whatever is the waste going into the dumpster and that includes the recycling can as well. So but, that could be one reason people are being less wasteful.

And the other reason is if you look at over the last 10, 15 years, the type of packaging material and the amount, although the amount of packaging material may have gone up but the type of packaging material and the weight of those packaging material, this is all based on million tons, which is a based on the weight. So the weight of the packaging material is actually, we see that weight of the packaging material is going down. So although, so since the weight of the packaging material going down, ultimate, the overall weight will go down. So that could be, some of the impact over here is because of those kind of things happening over there. Same thing over here as well.

And then overall, like if your accumulative is what you are seeing in the green line with a green circle, green sorry, green triangles and you see that the waste has been increasing but it is kind of decreased a little bit in the last decade. So that is kind of gives you some examples along in terms of the MSW generation rate.

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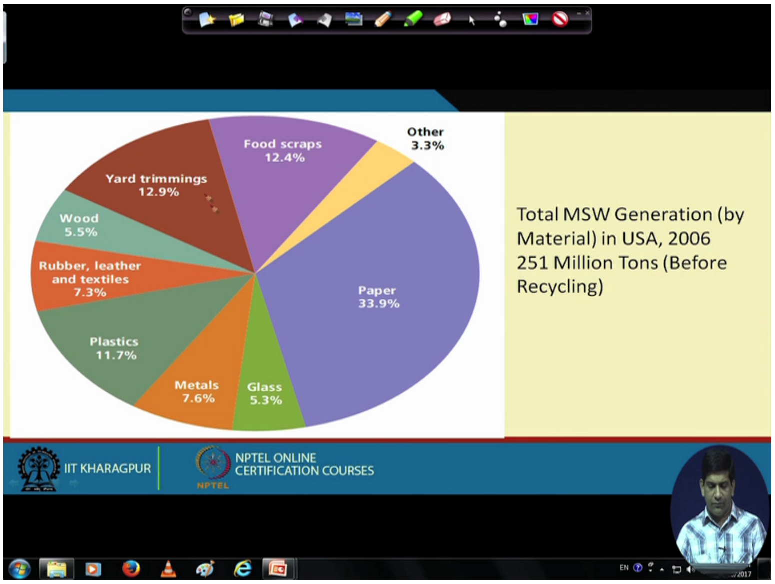

Total MSW Generation (by Material) in USA, 2006
251 Million Tons (Before Recycling)

So being said that, then we have different types of in terms of the waste composition, like different pie charts are out there, we will look at how these pie charts are produced. But as you can see typically again this is from the United States, from the US EPA. The paper seems to be a very high component of the garbage and this paper is essentially office paper. And those are the kind of paper, newspaper, office paper, those are the kind of papers which you will see. There are some food scraps, some yard trimmings, wood, rubber, textile, plastics, metals and glass.

So these are and some of those kind of MSW generation by material in US. But how these pie charts are developed? So how this, and we will talk about that. How we get this kind of pie charts? If I want to get a pie chart made for a particular town, how I can go about it and do it? So that is kind of important in terms of looking at these pie charts.

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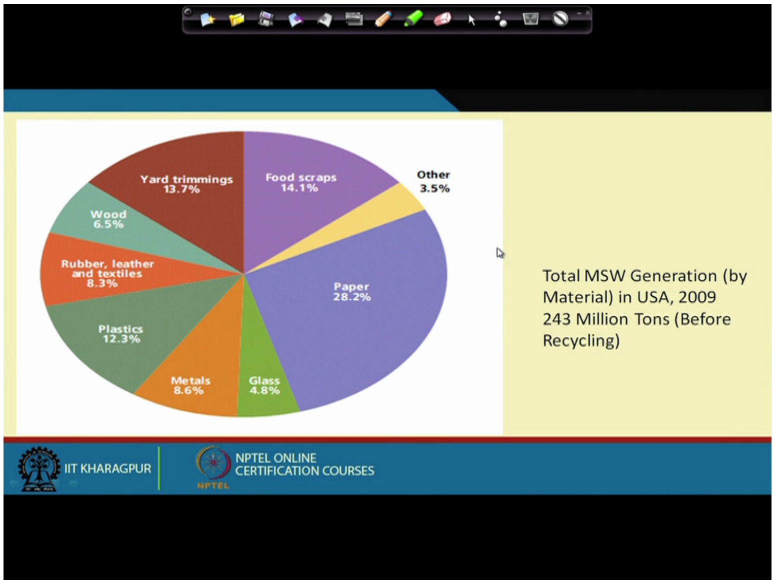

Total MSW Generation (by Material) in USA, 2009 243 Million Tons (Before Recycling)

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So let us look at how this is, so this is another example. Same thing and 2009, nothing much difference here.

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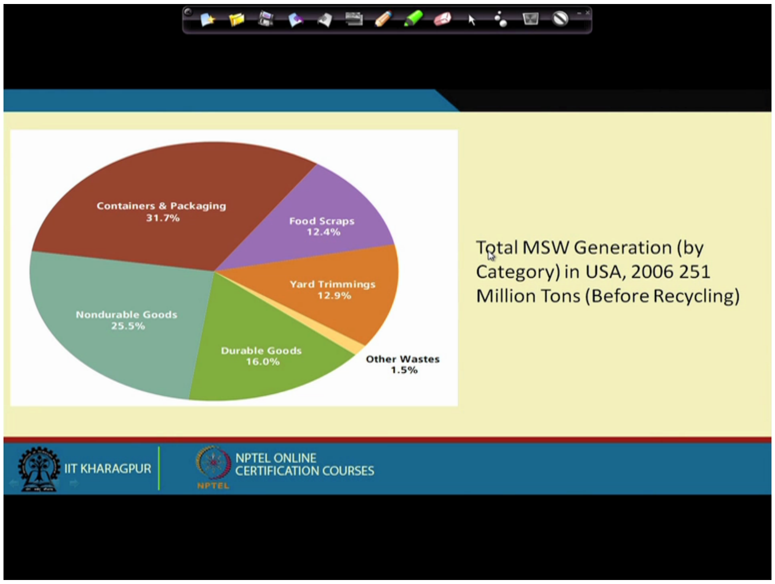

Total MSW Generation (by Category) in USA, 2006 251 Million Tons (Before Recycling)

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And USA, 2006, this is before recycling in terms of the different categories, container and packaging, non-durable goods, durable goods, food scraps, yard trimmings. So this is in million tons, it is before recycling.

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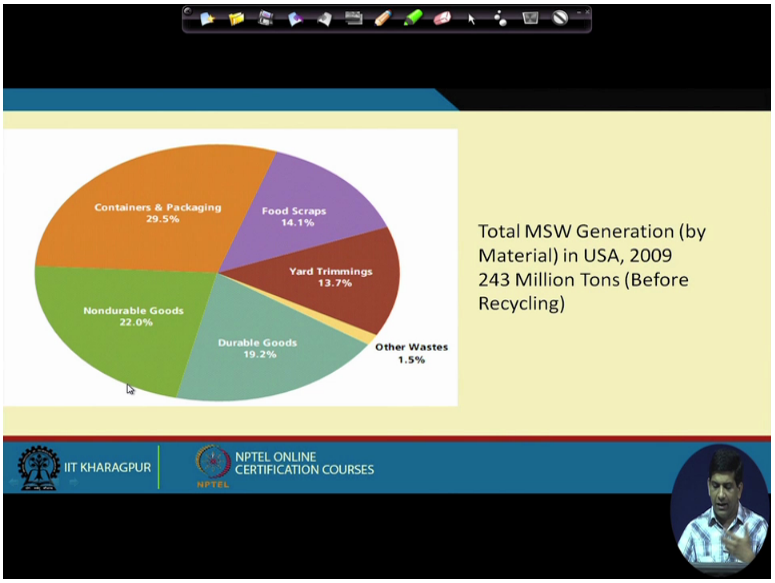

Total MSW Generation (by Material) in USA, 2009
243 Million Tons (Before Recycling)

Then this is again before recycling, you see lot of material that is going into the waste stream.

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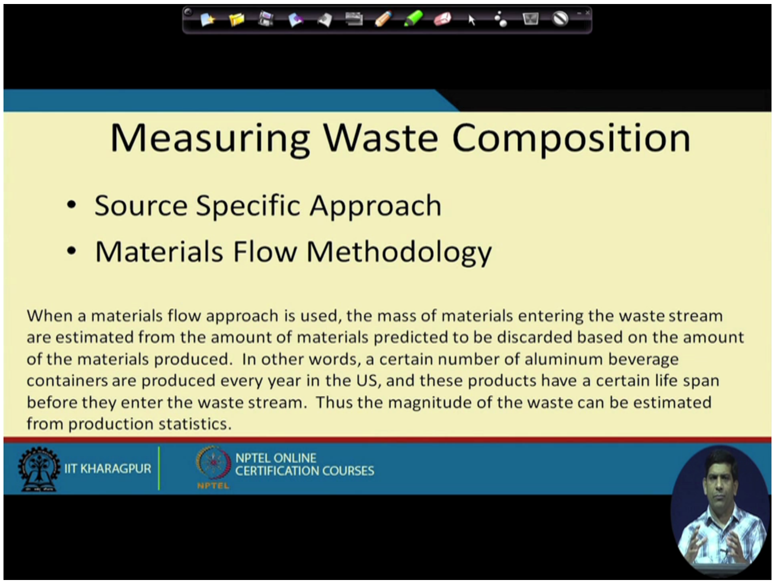

Measuring Waste Composition

- Source Specific Approach
- Materials Flow Methodology

When a materials flow approach is used, the mass of materials entering the waste stream are estimated from the amount of materials predicted to be discarded based on the amount of the materials produced. In other words, a certain number of aluminum beverage containers are produced every year in the US, and these products have a certain life span before they enter the waste stream. Thus the magnitude of the waste can be estimated from production statistics.

But how we get those pie charts? Because those pie charts are very, very important. If I have to, I have to know what kind of garbage I am getting in and based on those pie charts, I can make a decision whether I should go for a waste-to-energy plant or go for biomethanation or should I go for landfill and what not. But that pie chart is important to give us an idea about how the waste, what is the, how the waste is generated.

So how we do that? There are two approaches we use. One is called source specific approach; other one is called the material flow methodology. So what is a source specific? We will look at the material flow first and then we will go to the source specific. So material flow approach is essentially you do, kind of do a mass balance. You look at the all the mass of material entering the waste stream. So estimated from the amount of and how we estimate that? Based on how much of that material got sold off, what was its shelf life or the useful life and then assuming that in that useful life, this material will come into the waste stream.

If you do an example, say laptop for example. So you bought a laptop and for a typical laptop of that particular type, typical age is say 3 years or 4 years. So after whatever you bought this year, after four years we will start considering it as a part of the electronic waste stream. So that is one way of doing it. That is called source, sorry, material flow methodology, where you look at the amount of material that is going around. So it is, so there is, you can estimate the amount of materials predicted to be discounted on the amount of the material produced.

In other words, certain number of aluminum, beverage contents are produced every year in US. These products have a very certain lifespan before they enter the waste stream. Once they enter the waste stream, we can, so based on their lifespan, based on how much they are produced, we can calculate whether it will enter the waste stream or at what particular time. So the magnitude of the waste can be estimated by the production statistics. Of course, there is drawbacks to that.

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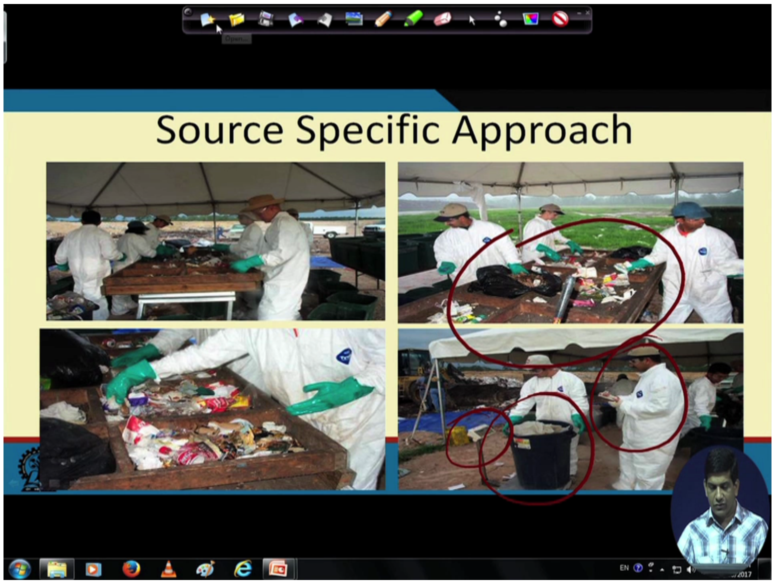

Source Specific Approach

Source specific approach, as you can see on this picture here where myself and some of my students and other people are, we are trying to do some, we are trying to do a waste audit. We call this a waste audit and where we are taking the garbage? As you can see over here, we are taking it apart. After taking the garbage stuff, we are trying, we are taking it apart and then we are collecting it into different bins and weighing those bins.

And then, we are collecting the weight, that is myself taking the data over there. So this is myself and with some of other colleagues and other students. We had tried to do that like a waste composition study. So this is kind of interesting. So that was, that is another approach that you can use. And let us stop here and we will look at another example of how the waste audit was done in one of my class earlier. So again this is, that will be pretty quick.

And so let us stop and again, so what we have done in this module? We started with the porosity, we started with looking at the moisture content, looking at porosity, moisture content and we looked at how if you have the two different waste streams, if they mix together how to calculate their average properties. Then we also looked at that how about in terms of the component composition, how the waste pie charts are developed, how these pie charts are made.

And at the same time, this like there are two approaches, the source specific approach and the material flow methodology; we talked about the material flow methodology. Regarding the source specific approach, we saw a couple of slides and then we will see some more in, after in the next module. So again, I hope that you are enjoying this course. If you have any questions, feel free to post it on the discussion board. We will be happy to answer. We are keeping an eye on discussion board. Our usual, we try to have a turnaround time of around less than 24 hours there. Okay. So thank you and keep enjoying this course.