Urban Services Planning
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Lecture 18
Waste Quantification and Characteristics

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Welcome back in lecture 18, we will talk about waste quantification and characteristics. The different concepts that we will cover on waste quantification, waste traffic count, percentage of waste collected in Indian cities, sampling strategy and waste characteristics.

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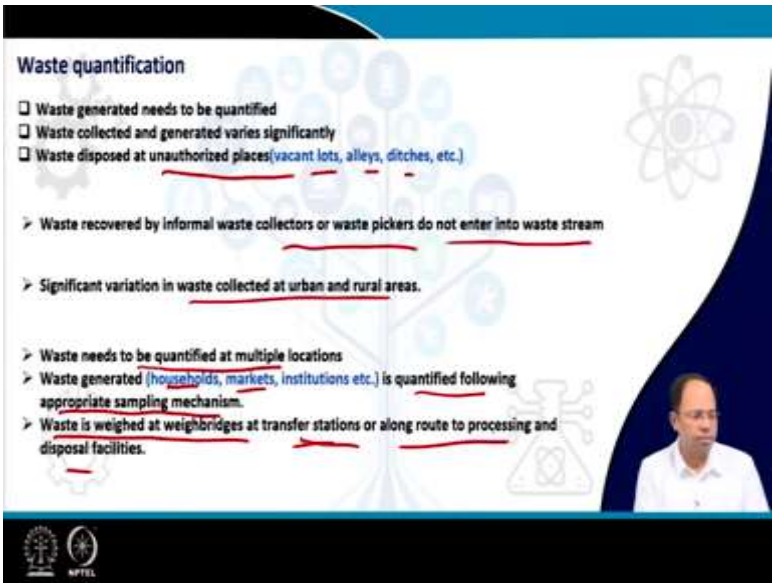

So when we talk about waste quantification in the earlier lectures, we have also discussed this that once the waste is segregated and all we really and we need to quantified it, either it is segregated or it is not we need to first determine based on data that how much amount of waste is being generated and waste because, if I do not know how much amount of waste is generated, then I will not be able to design programs for each collection and also for its further processing and treatment or even disposal.

So quantification is a prerequisite of any kind of waste management. So waste collected and generated also very significantly happens in most Indian cities, not 100 percent waste is collected. So some cities claim that 100 percent waste is being collected but even so there would be certain percentage which is lost along the way because of many reasons.

And so there needs to this needs to be addressed that how much amount of waste is being generated and how much is being collected, because the gap is what we have to bridge and that means those waste is actually mixing into the other activities of urban areas. For example, either people are throwing them into the fields or they are throwing them into the garbage and it hampers other activities with our urban areas.

So waste disposed at unauthorized places vacant lots, alleys, ditches. So always this happens, there is no way until unless people are aware or people are themselves concerned this cannot be stopped, waste recovered by informal waste collectors or waste pickers people who are coming to your house buying the papers so that I am taking them to the scrap dealers.

This kind of and plastics and other things are directly being sold from the house to this waste collectors or waste pickers and this garbage do not enter into the waste stream that means the municipality is not handling this garbage. So this is handled separately. So this is not part of MSW.

Then significant variation in waste collected at urban and rural areas, that means based on the waste collection system that is designed in urban areas and just semi-rural or rural areas just outside the urban area, they will not have that kind of systems design. So automatically the waste collection processes are totally different, they are in rural areas door to door collection usually is not seen and we see that people dump their garbage somewhere and sometimes it is collected via some tractor trailers or some vehicle. So obviously the quantity of is that is collected value is much less.

So the second thing is which needs to be that means first of all, waste is generated in the urban areas, some part of it is collected, the rest is not collected. Next is waste needs to be quantified at multiple locations. It is not only quantifying the interface that is shared in urban areas are collected in urban areas but also quantifying it at different locations of the city what kind of waste is generated because this may vary as per location to location.

For example, like households' areas which have got lots of residences, they will generate a certain type of waste and a certain quantity of waste. Whereas area with a market area or a commercial area, they will generate another kind of waste. So waste generated is quantified for each of these areas or each of these generators following appropriate sampling mechanism. That means we have to have a sampling approach to determine who we should survey or whom we should go and for whose waste we should measure and in what way we should measure it.

So that is the sampling mechanism has to be followed. And other way we waste could be also weighed at weigh bridges at transfer stations or along route to processing and disposal facilities that was before the waste enters into a processing and disposal facility. We can measure the amount of the number of vehicles that are entering that facility or quantity of or the weight of that particular vehicle so that we can take out the weight of the chasing and then the rest of the weight is the weight of the waste that is being going into this particular facility.

So weight state transfer stations could be measured or waste at disposal facilities could be measured. And this helps us to estimate how much amount of waste is being collected but not generated.

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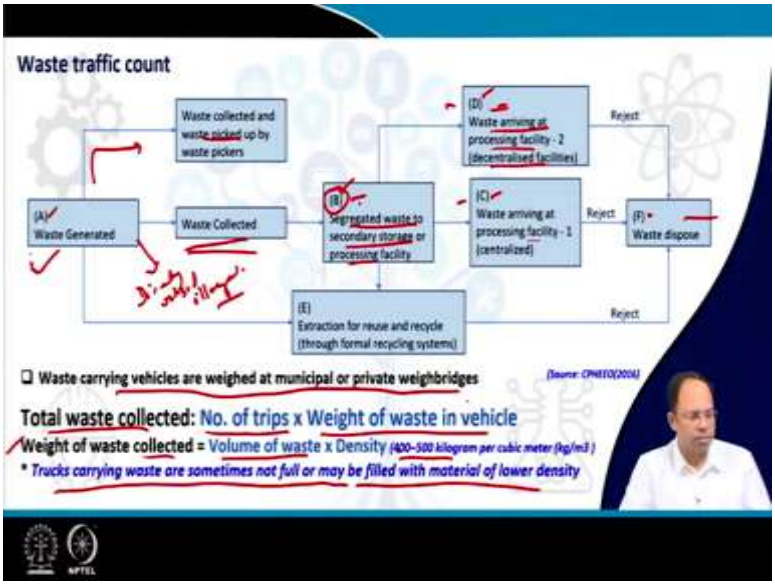

So this figure actually shows that this at each of this stage is that A, B, C, D, we have to you know measure the quantity of waste for example at B like for example waste is generated, so this is a generator. So from there some waste goes to the waste picked up by waste pickers. So these are people directly coming to your house buying some waste problem. So this waste is not entering into the municipal sphere, the waste which is collected now some people may throw some waste directly outside.

So this is illegal but the rest is collected. So an even collection means after the collection, it is it this waste could be taken to a segregated to a secondary storage or a processing facility that is somewhere in the neighborhood it is coming it is being stored for further transfer or to a processing center where some sort of sorting and risk taking out of recyclable materials can happen at a local level of course.

So this is where we can measure the waste, but here the waste is coming in using maybe wheelbarrows, if it is door to door collection using some tractor trailers, where if it is not community bin level collection so this is where we can measure it then from here the waste goes into this recycling either it can go into this waste facility processing facility, which could be a decentralized facility or it could be a centralized processing facility.

There could be multiple many number of these facilities and at each facility we can measure how much waste is arriving. So based on that I can determine that okay, what sort of treatment needs to be given like for example, if it is a decentralized composting facility,

based on the quantity of waste that is coming in, I can decide how much area I require for setting up this kind of plan.

So this kind of decisions are taken. So which requires us to quantify the waste at different levels but at C, D even in F which is the landfill site where finally all the waste is going then we can see that here the waste causing using lorries and all and we can measure the weight of those lorries or waste carrying vehicles are weighed at municipal or private way we just add there, we can get the amount of waste that is going into this kind of facilities.

But when we are talking about waste generated in that case waste has to be sampled and we have to determine the waste locally by using some scale surveying some way to measure that it is not because waste is yet to get into a vehicle and then transport it. So total waste collected if we are using a weighbridge and for this kind of facilities, we can determine that total waste collected is based on the number of trip a vehicle multiplied by the weight of waste in that way.

Now weight of waste that is collected is basically volume of the waste multiplied by density. So we know that density of waste collected in India is something around 400 to 500 kilograms per cubic meter. So if I know the size of the vehicle, the volume of the vehicle I will be able to determine and I know the density of the waste I will be able to determine the weight of that particular waste.

So this is how we calculate but sometimes what happens, trucks carrying waste sometimes not full and maybe filled with material of lower density. So in that case, the measures that we will devise that may be wrong. So we have to be careful about it. But again I will stress upon that once it reaches a facility then vehicles and all these things could be weighed, but it be before it reaches a facility or even if I am collecting with door to door collection is difficult to measure its weight. So there has to be some other procedure for that. So we will talk about that.

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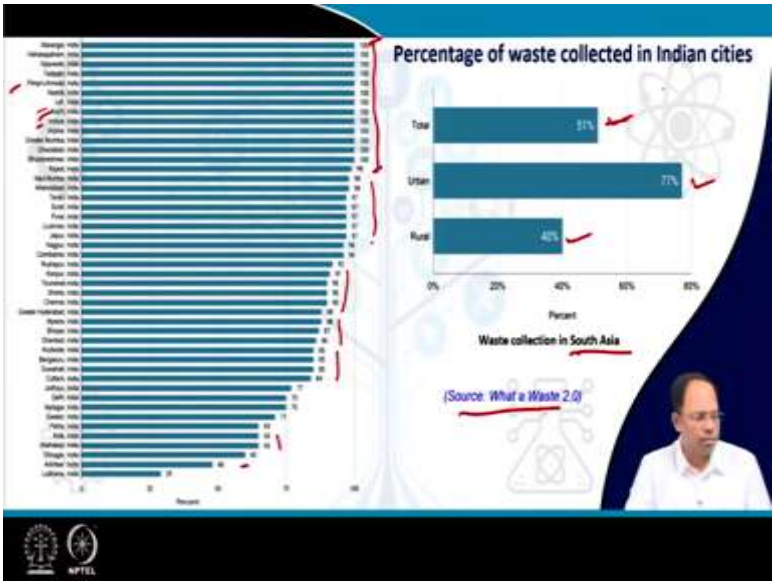

So this figure shows you that how much amount of waste is collected in different Indian cities. So you can see that this group of cities are showing 100 percent collection this include Warangal, Vishakhapatnam, Vijayawada, Pimpri-Chinchwad, Nasik, Kochi, Indore, Imphal. So these are some of the municipalities where 100 percent waste has been collected. There are some municipalities where more or less 97, 98 percent includes Navi Mumbai, Rajkot, Surat, Pune, Jaipur, Nagpur and so on.

Whereas, another level that is 90 percent 80 percent 87 percent you can see cities like Chennai, Shimla, Rudrapur, Nagpur, Mysore, Bhopal and so on. And finally very very poor situation which is in Patna, Kota, then Allahabad, Srinagar, Amritsar, where very little amount of waste is being collected. So this is data from the World Bank, this is the source maybe it has been this is recent data to the 2015, 2016 data.

So some of this may have changed now, but anyway so this is the data given by the source maybe some discrepancies could be there, but more or less this gives us an idea that, not all cities are safe the collection system is not efficient. So in most of the many cities we have to actually improve our collection system.

And this figure actually of this slide shows that in rural areas approximately 40 percent of the waste is being collected, in urban areas approximately 77 percent of the waste is being collected, and these figures for south areas this is data from both India, Pakistan and other you know Bangladesh and other cities in South Asia, this part of the world and average waste collected is something like 50 percent.

So you can understand that out of 100 kilograms of waste generated 50 kilograms goes to either a processing center or to the disposal site, the rest 50 remains in the city that is the cause of hundreds of problems, both sides health problems, aesthetic you know cities look bad, filled up with litter aesthetical it is displeasing and also it creates other issues as well, it clumps the drain it creates flooding. So this kind of problems are a result of improper collection or inefficient collection in cities which has to be addressed.

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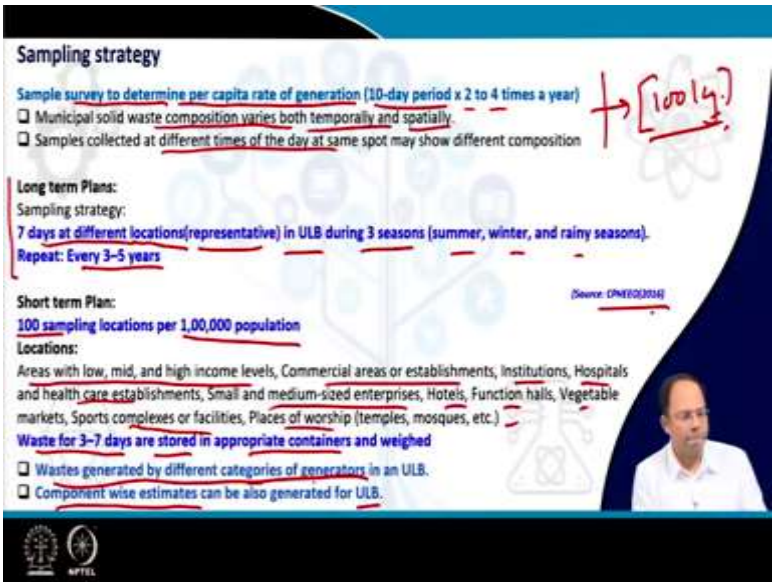

So now coming to the sampling strategy that is suppose, I need to determine how much amount of waste is being generated. So waste is either collected in wheelbarrows by door to door collection, and what we can do is we can collect waste from wheelbarrows from certain households, and we can take a certain quantity of waste because if I measure one household on a particular day, it may not have consumed a certain amount of normally, they consume certain amount of waste, but they generate a certain amount of waste, but this day they have not.

So it is better to take a larger size of size, so that we can generalize or we can find the average waste that is generated in that particular area. So municipal solid waste composition varies both temporally and specially. That means at different times of the day, different times of the year, at different seasons, the quantity of waste that is generated and the characteristics of the space, these are different, spatially at different locations of the cities to is different.

Similarly, as that is what I was seeing samples collected at different types of a day maybe also different like the restaurant in an area where there are a lot of restaurants that kind of is

the gap in the morning and in the evening that will be different then what we need to do is when we talk about sample survey, we determine the per capita rate of generation.

But the what it means is we have to do data collection over a larger period that is a 10-day period, approximately some variations are also there. And it has to be done 2 to 4 times a year at different seasons during winter months different kinds of waste generated during summer months different kinds of waste is generated during rainy seasons, a lot of moisture is there in the waste.

So character keeps on changing. So we have to do it multiple times in a year and has to be done for a 10-day period so that we get consistent benefits. Not only that, it is better to once I collect the waste at all at least take that 100-kilogram sample and then determine what is the waste content, what is the characteristics of that waste and so on. So this is also important.

Now, as far as CPHEE to guidelines, it says that there are we can go for both short term and long term plans for solid waste management. If I am going for long term plans, the sampling strategy should be 7 days at different locations at these are representative locations in the ULB what it means that means if I want to find out how much waste is generated in residential areas, I will select a few residential areas which are representative areas and then analyze the garbage that is generated over there.

Similarly, if I want to determine what kind of garbage generated by the commercial establishment, I will find some representative areas and then do the estimation over there. And then this has to be done over 3 seasons that is summer, winter and rainy season and this has to be repeated every 3 to 5 years.

So for long term survey that means we have to repeat the survey after 3 to 5 years because it is estimated that the characteristics and the quantity of investment will change after that PD. So what happens during short term plans like we have to immediately do it. So the other ways to go ahead with if for every 1 lakh people, we should collect samples from 100 sampling locations.

Now, what are these sampling locations, these could be areas with low middle and high income levels, even though all residential areas but some are posh areas, some are slum areas. So that quantity are the characteristics of waste that will be generated from these areas are definitely different, because rich people will consume a certain kinds of goods poor people will consume other kinds of goods maybe packaging would be much less over there.

So that requires us to collect samples from both the areas commercial areas or establishments which have a totally different nature of waste that has been generated. Institutions hospitals, healthcare establishments generate different kinds of waste, small and medium sized enterprises, hotels, function halls, vegetable markets, sports complexes, places of worship, temples, mosques, they generate different kinds of waste.

So we have to take samples from different areas of the city and for different category of waste generators to determine who generates what kind of waste what quantity and what characteristics of waste based on this we have to in future, I will teach you that based on this we have to design the collection system design the way the collection vehicles will be designed all this thing is depended on this.

So in this particular case short term plans and 100 sampling locations, waste for 3 to 7 days are stored in appropriate containers for and then it is wait. So we will ask those people to store the waste do not throw it away store it for a few days 3 to 7 days, and then we will measure it and we will find the average. So that means waste generated by different categories of generators and then you will be can be estimated has to be estimated separately.

Similarly, we can also combine all this waste and we can also determine component wise waste estimate that is in this urban area, what percentage of waste is organic, what percentage is plastic that also could be determined and we can also do this component wise if I have an adequate sample size, then we can do component wise estimate for also different categories are generators as well.

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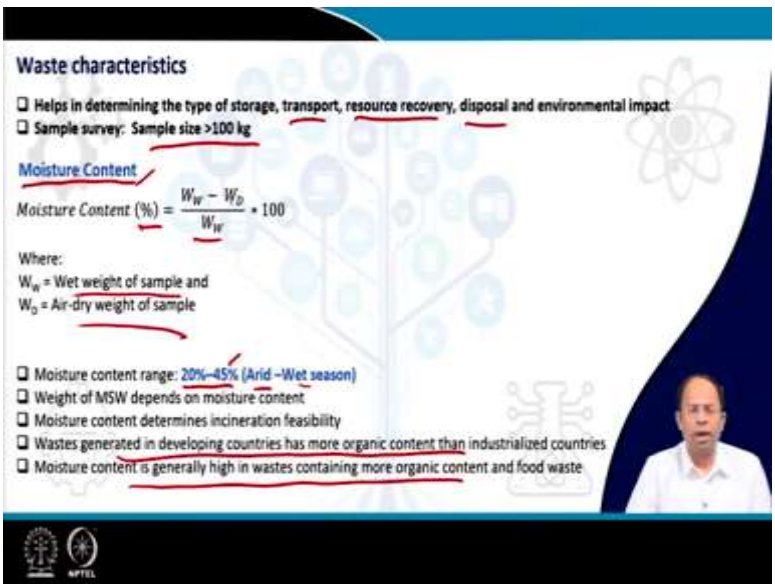

Now, coming to the way different characteristics of waste, first we have to understand what is the quantity of waste, then we have to understand what are the different characteristics of waste and finally, after this we will also learn about what are the what is the composition of waste. But characteristics of the waste is important why because of you know the characteristics, it will help me to design a better storage system. It will help me to decide a better transport system, it would help me to decide what kind of resource recovery is possible and what should be disposed and what would be the environmental impact of this particular waste.

So as I discussed earlier, the sample size should be at least 100 kilograms. So wherever you are getting waste from certain generators and all, at least 100 kilograms have to be taken together to determine any of these characteristics or even composition that we will discuss in subsequent lecture. So the first characteristics is the moisture. Why is moisture content important? Moisture content determines the weight of the waste, moisture content determines if the waste could be incinerated, moisture content determines if the compost would be successful, if there is very little moisture, compost will not work. If it is too much moisture, then also it is probably for composting.

So this is one characteristics which actually influenced a lot of this particular stage. So moisture content is determined by as a percentage measure it is determined by w, w is weight of the sample minus the air dry weight of the sample divided by the weight of the sample multiplied by 100. So it we just determined what is the weight of the water that is the moisture content of that particular waste.

So this ranges from 20 to 45 percent in India sometimes it is even more than this. So usually in dry areas we will get moisture content or 20 percent in wet season, in another area other areas which is very wet we can get around 45 or even more and weight of MSW depends on moisture content that we discussed.

Moisture content determines incineration feasibility, that we see the weight with the waste is weight, then it we cannot burn it or actually we will require a lot of more energy to burn it which will make it unfeasible, waste generated in developing countries as more organic countries then industrialized countries and moisture content is generally high in waste containing more organic content. So more wet why that is why we call it wet waste because the organic waste has got a lot of water in it.

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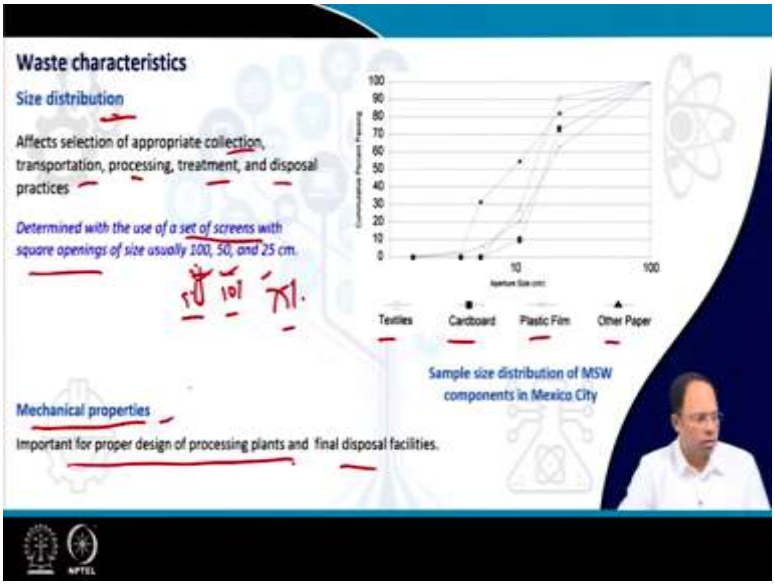

The second characteristics is size of the waste that is generated also is of different sizes as you can see that we can have waste which includes textile, cardboards, plastic claims, other paper. So there could be other types as well, but each of them are of different size. So to determine that size, we have to put the waste through some sort of screens or some sort of sieve through which the waste will pass.

So usually it is determined with the use of a set of screens with square openings of size equally usually of 100 centimeters, 50 centimeters, 25 centimeters. So we will say what percentage of waste is passed to 25 centimeters beyond that, what percentage will pass to 50 centimeter and what percentage will pass through 100 centimeters.

Now, if the amount of percentage which is passing through 25 centimeters is low, that means, the size of like suppose 75 percent of waste passes through 25 centimeters so 25 percent of it passes. So 25 percent out of that maybe 10 percent passes through 50 and the rest is even larger than 50 and maybe even 5 percent passes through 100 means 5 percent waste is even beyond 100 centimeter size.

So this helps us to determine that is there a need for shredding of the waste or should I make it in smaller sizes. So this affects both the collection process and it also determines what should be the vehicle size to collect this kind of large waste, transportation processing, treatment and disposal of waste.

Like for example, when you I will teach you how to design landfills, if waste is very large, then it will after a day's disposal of waste it will stick out we will not be able to cover it using

mud or using soil after everyday waste is put into a landfill we cover it with soil but if the waste is sticking out because it is a large size, we cannot do it. So there is a need to shred the waste that is why these characteristics is important.

Then mechanical properties this is also important for proper designer processing plants final disposal facilities and so on. So what is when we have got unsorted waste or we have got drivers which needs to be further sorted, we take them to a mechanical process sometimes and where the may be a vibrating bed or there may be a magnetic separator which separates out some metals and all and then there are vibrating beds which separates out waste of different density or weight and so on.

So in this way we can do a lot of processing and obviously, the properties of waste like what is the strength of that material this kind of things actually helps us in designing what sort of processes we should design in our processing plants or what sort of mechanical system we have to design. So that is why mechanical properties are also important.

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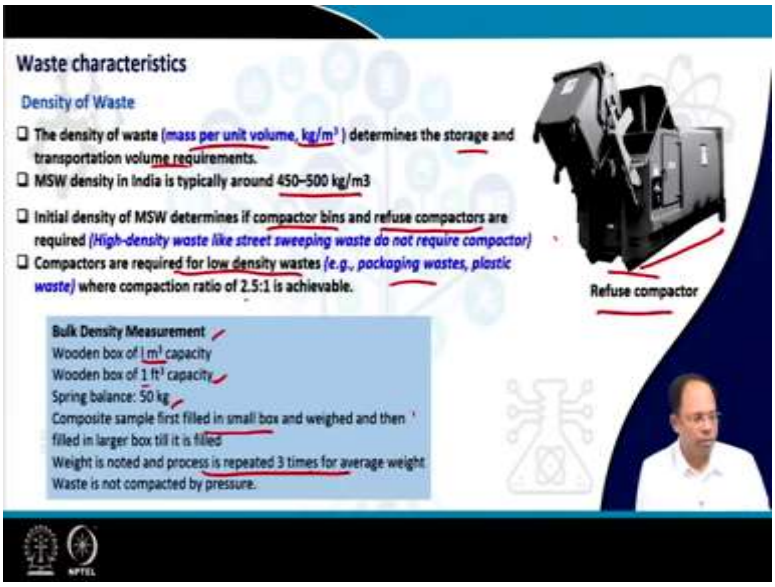

Then comes density of waste, density of waste is measured in kg per meter cube or mass per unit volume. And it determines the storage and transportation volume requirements. We have already discussed this and this is typically the value in India 400 to 500 kilograms, but of course, we can use refuse compactors or compactor beans before we transport the waste we can use this compactor bins or refuse compactors which will further compact it get water out or get compress if there are a lot of plastics that will also get compressed and this has to be

then transported at so we can utilize less number of trips otherwise we would record more number of trips to transport the same weight of waste.

So you can see this in this particular image we are showing you a refuse compactor. So this is just like a mechanical garbage bin which has a system to lift the garbage and throw it inside. And then there is a compactor inside or it is a hydraulic press which presses on the garbage and it makes it, it squeezes the water and squeezes air out of that particular garbage and makes it more compact.

So compactor are required for low density waste, usually for packaging waste, plastic waste and so on. And where we have to achieve at least a compaction ratio of 2 is to 5 is to 1 that means we have to make the waste both two and a half times compact. If it is not so then probably this would be not economically feasible. Because this kind of equipment also cost a lot of money.

So how do I measure the density of waste? It is pretty easy take 2 containers. You can take 2 wooden boxes for waste. One of 1-meter cube and one of 1 feet cube, so obviously, this one is a much smaller container, why it is small? So that it is easy to handle. So we should also have a spring balance, that spring balance is something where we hang up particular container, we will hang that 1 fit cube container. And using the spring balance, we can measure what is the weight of that.

So this is this spring balance should have a capacity of 50 kilograms. And what we do is first the composite sample that we collect from different the 100 Kg sample that we collect, that will be first filled in a small box, the small one, and then we will wet that using that spring balance, we will record that weight and then put it in the larger box. We keep on doing this till the larger box is filled. And we do not compact it, we do not press it and so based on the weight that has been recorded, we add that up and we get the overall density of that particular waste.

So we can determine the weight of the waste, total waste and because we know that total volume is 1-meter cube and we can determine what is the density of the waste. Now, this entire process is repeated 3 times and we take the average to come to the final average density of waste in that particular area.

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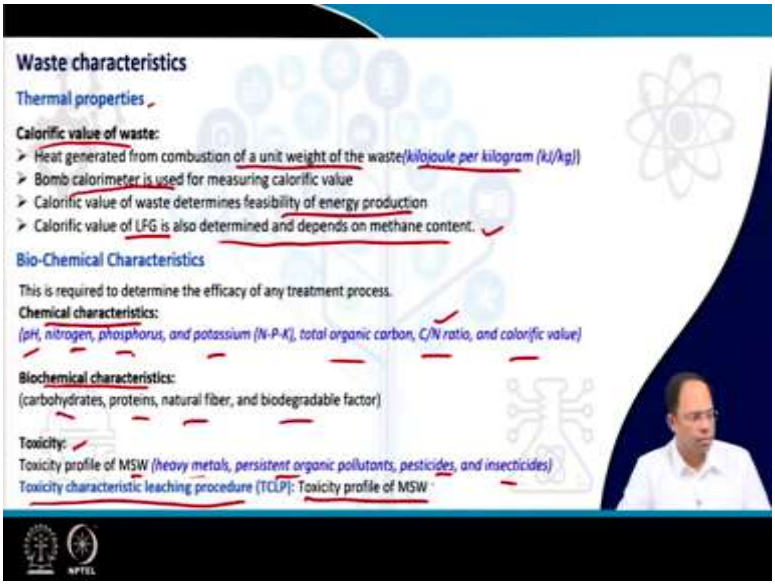

Then after that comes the thermal properties, which primarily we are talking about the calorific value of waste. So we have already discussed this the unit is kilojoules per kilogram, and it is the heat generated from combusting a unit weight of the waste. So 1 kilogram of waste if you burn it, what kind of it will be generated? Usually we use a bomb calorimeter for measuring calorific value and it determines the feasibility of energy production its calorific value and calorific value of landfill gases, landfill gases methane, lot of methane is generated in landfills.

So calorific value of landfill gases is also determined and depends on the methane content, of that particular landfill. So this is also determining then biochemical characteristics of waste this includes a lot of all the chemical properties because this also determines what should be the kind of treatment, what sort of biological treatment that could be also done, what sort of non-biological chemical treatment could be done and so on.

So what this chemical property include this is pH of waste, nitrogen, phosphorus, potassium content of waste, Total Organic Carbon, CN ratio, calorific value and so on. So you will see that subsequently when we discuss further you will see where we are using CN ratio to determine the ratio between carbon and nitrogen content in waste, we are totally determining this nitrogen phosphorus potassium to determine what kind of elements or what kind of minerals remain in the waste.

So then coming to biochemical properties, we can look into the you know for particular for organic waste, we can look into carbohydrate content, protein contain, natural fiber,

biodegradable factor, because these are sometimes play a role in determining what subsequent processes we will undertake, toxicity of waste toxicity profile of MSW how much heavy metals, persistent organic pollutants, pesticide, insecticide remains in waste, and also toxicity characteristics, leaching procedure, which is this is the procedure which is followed for determining the toxicity profile of municipal solid waste.

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So these are some of the references you can study.