Course on Integrated Waste Management for a Smart City
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Module 5
Lecture No 25
Waste Collection and Transport (Contd.)

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Okay so welcome back so we are looking at now this is the last module for week 5, so will continue our discussion as we did in the last module our focus on looking at how information we have learned so far will be applied in a practical scenario, so we have looked at how if you remember from the last problem from the previous module from previous video was on how with a better recycling system actually you end up reducing the calorific value. I am not saying that recycling is bad but what I am saying is we should be aware that if we do good recycling of course it will have some impact on the calorific value, so those things are important especially when you doing to some calculation for waste to energy and other stuffs.

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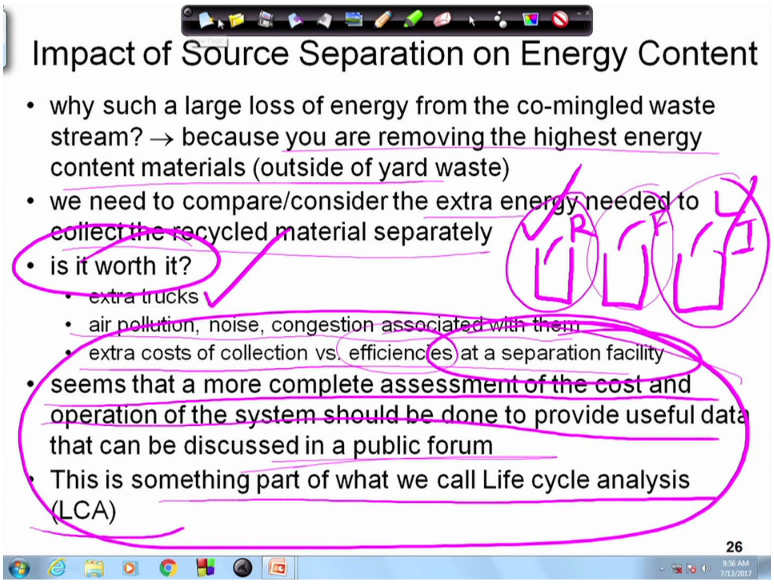

So let us continue some of those other scenarios where practical scenarios out there, so if you have a we were continuing the impact of source separation on energy content, we already the math part of that, so what is its implication. So when we have when we have a large loss of energy why? We discuss that so this is whatever I was talking earlier has been kind of put a bullet from here because you are removing the highest energy content material, so in a highest energy content material in terms of like a paper, plastic were removing them that is why we are seeing a reduce in energy content.

Now but the question is a good? Is it really doing good for we are going to do recycling, so that means we are removing some of these recyclables out and in general when we talk about recycling we have a positive feeling about it recycling is always seems to be better but how much better? Are they really better? Some there could be certain scenarios there are certain scenarios where actually if you take the recyclables have to carry the recyclables around for around 100 kilometers or several kilometers before you can put it in a recycling plant and it gets processed.

So the amount of energy, the extra truck that you required because if you are doing a source separation, so separation means what? You have this recyclables in a separate container, so we will have like a three-way bin here we have recyclables, so here we have the recyclables, here we have the food waste or any waste and then here we have whatever can go to a landfill or potentially to an incineration plant, landfill or an incineration plant. So now we need 3 trucks to collect these 3 separately or we should have a truck which has 3 compartments so that they can be collected separately, so but in that case as well if you have the 3 compartments sometimes what will happen is because the recyclables are the bulky material, they are lighter but they take more volume.

So since they take more volume the truck your this compartment may get full while the other 2 compartments are still empty, so in that case so you will have to take the truck back and then empty everything and then come back and do your collection, so ultimately there may be need for more trucks, so if you have need for more trucks, if you have extra energy needed to collect the recycle materials separately, is it worth it? The question is, is it really worth it? Now how will you find that out?

There is maybe actually requirement of extra trucks we can find out how much extra truck will be required. Extra truck means more gasoline, more a pollution, more noise, more congestion associated with them, so there are some environmental impacts associated with those there are extra cost for collection those things are there as well. So the thing is that many ULBs what they are do around I am talking about in a global sense, many ULBs what they do they said okay let us collect everything together then we will bring it to the separation facility and then we will do the separation over there.

That is a good thought but the problem there is what, what happens? Since you are mixing them altogether there will be cross contaminations. I think I mentioned you earlier that say if you have many times what happens so your drinking a Coca Cola or Pepsi from that plastic bottle that 500 or 600 ml one then at the end you kind of you have to rush for something you just kind of said okay this is enough and not going to consume it any further, so you put this plastic bottle with little bit of Coke left or little bit of anything like that left in a recycling stream.

So now what is this happening? Like if in the recycling process the first thing they do is the poke a hole in those bottles, so when they poke a hole this coke will go and contaminate other plastics is well. Now is that Coke or Pepsi or whatever juice was there needs to be cleaned up, so the has to be a process to do that, that requires machineries, that requires a certain setup, certain unit processes, so there is a cost environmental cost and economic cost both are associated with that.

So and your efficiency also goes out that is why so is separation is actually better you can do so separation and we also encourage people to not to that thing like I think I told you at in Auckland, New Zealand they even tell people that why do not you wash your bottle, you just rinse the bottle one-time with water before you put in the curbside of course you are increasing the water footprint there so you need to be careful you are increasing the water footprint by watching those bottles because you creating more waste water now.

Again you have to look at the whole thing in a totality that is what I was trying to explain in the previous course that we had I had in the NPTEL platform on the Swayam as well so the Swayam platform which is around parallely on life cycle analysis so that is what this whole concept is all about, looking at the big picture, systems approach looking at things from a holistic perspective, so you need to do a more complete assessment of the cost and operation of the system provide useful data and then talk.

May things which may sound good which will look good from a surface may not be as good as it looks, so for that we will do something what we call life cycle analysis we already kind of talked about that and I think there was an NPTEL course offered on it in the last semester and I guess it would be offered in the future semesters as well. So based on this, this is again these kind of discussions this is what I want out of this like after you are done with this course that is what I said that if you look at the intended audience for the course I want the people from the ULB take this course as well.

I hope they are and because this is these are things that they need to discuss when they choose a certain integrated waste management system or their ULB because otherwise we will be making mistake we will be we will not be looking is in a holistic perspective and we will have we will make certain calculation which is not true and then we will have problem of what we are witnessing over last 10 - 15 years where we are designing certain system and then many of the systems of failing.

There has been a recent book done in this area not in my backyard which is from CSE Center for Science and Environment and they had tried to documented waste management system situation in country. That book I think around may be a year or year and half old now, so but it is a pretty good summary of what is what are the different we had try to do composting many of the compost plant did not work, we try to do waste-to-energy many of this waste-to-energy plants were struggling and the reason for that is you do not take this whole we have to kind of the systems approach and this whole thing has to be taken into perspective.

We need to start looking things I would say in a systems way rather than just focusing on one, okay so will do this and just do it but not realising the implication of doing that on all the associated factors all the associated units and other stakeholder associated with that. So I hope like these things are getting clear as we are trying to make some discussion in this particular course again discussion board, discussion board, discussion board. I want you to keep that active so that we want this course to be lively course we do not want the one-way traffic so please do that.

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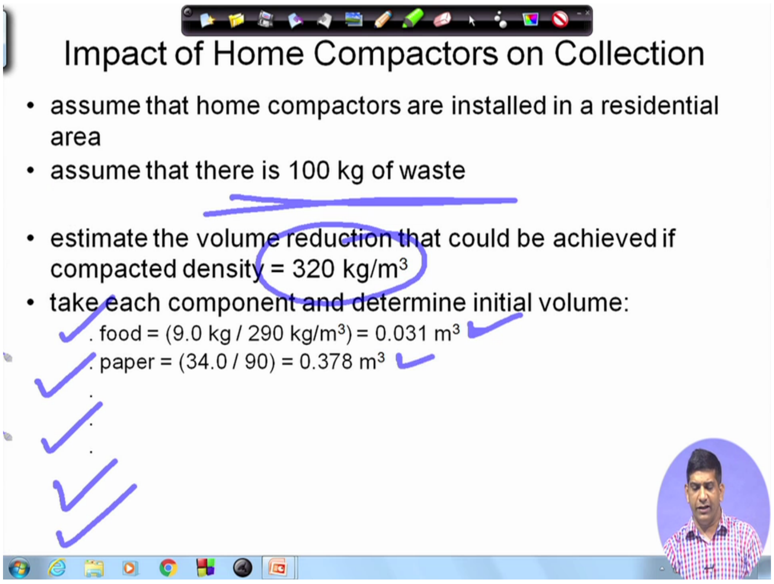

So then another thing is that another like will look at some maths in terms of impact of home compactor on collections, so if you are say many places they are suggesting that why do not we do a home compactor, so every houses they have a small compactor, you use it in the house where you compact the garbage, so if we assume that is around 100 kilogram of garbage present, 100 KG of waste the volume reduction that could be as, so if we use of compact of career and 20 KG per metre cube.

So for each of the component remember from the previous slide… Paper and how much the other components out there was a long list so if you do for each of those components, you can find out what based on their compactor density you can find out how much what is their initial volume what is the initial volume each for the each components from their density again that table 3.4 which has been presented in previous slide you can see it in the previous video and you will also have a PDF of this whole slide set which you can look at. So based on that initial mass versus initial volume we can calculate what is the sorry initial mass divided by the initial density we can calculate the initial volume each of these components.

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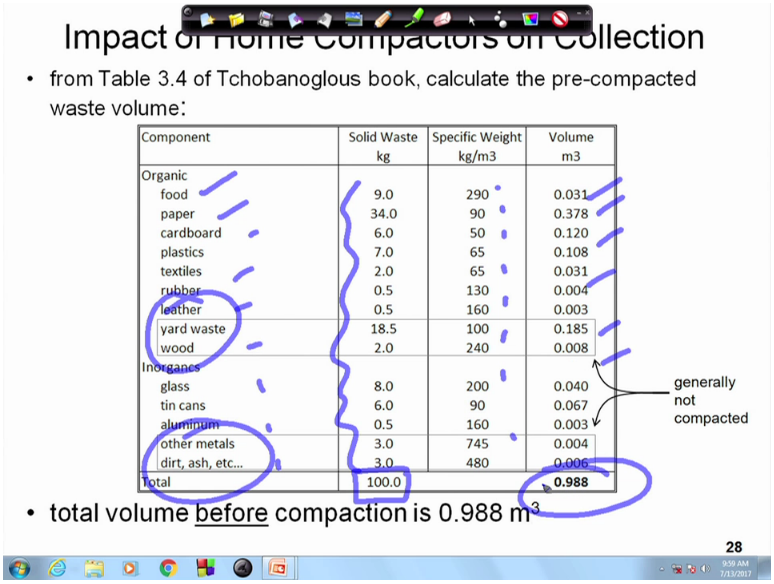

So once we know that so here it is again reproduced for you, so you have to look at the previous video, so here you have this different components, so these are the solid waste out of 100 kg based on their percentages. These are the specific weight so we can calculate what is the individual volume, so we can say 100 kg is around 0.988 metre cube, this is based on their specific weight this is un-compacted we have not done any compaction yet and there are certain items here we are waste, wood those thing usually does not get compacted, so this one and this one, other metals dirt and ash they do not get compacted so will not consider them so compaction so we will take the volume off of this total of 0.988.

So here what we have done out of 100 KG based on the composition of the waste we have found out what is the weight of each and every of this component and for different components we know each one of those specific weight, we have calculated what is their initial volume and these are there are un-compacted volume and we added them up so the total un-compacted volume and what we are saying is that yard waste, wood, other metals, dirt and ash these are typically not compacted, they do not get compacted, so we will exclude these volumes wrong is when we do this compaction calculation.

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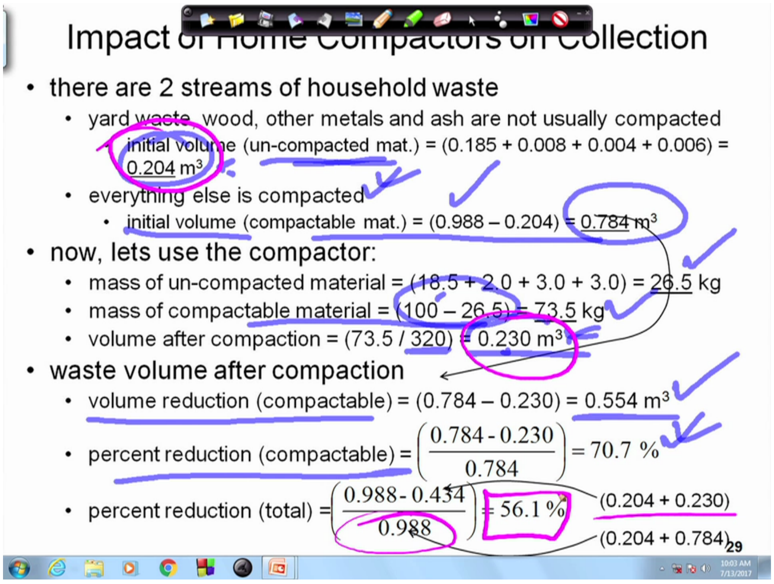

So let us go ahead and do that so here the 2 streams of household waste, yard waste, wood, other metals and ash there what usually compacted so we add them up and we get the value of 0.294. So that is the volume for the non-compact it is not going to get compacted everything else can be compacted, so what is the initial volume of the compacted materials. Total was 0.988 from the previous table minus this value over here, so we get 0.784. So that is the volume of initial volume which when we apply this compact of 325 KG per metre cube we can compact it further.

So now let us use the compactor, so in terms of the mass of the un-compacted material we got mass of un-compacted material if you add the mass of these one yard waste, wood, other metals and ash, so that is around 26.5 KG. Mass of the compactible material which is 100 minus that because total was hundred, is it not? If you remember from the previous table again all this math I am going little bit little bit faster because these are all simple math and you guys are like a undergraduate graduate student or some practising professional, you all know this is pretty straightforward but you go through this, use your calculator and go through this calculation once by yourself as well if you need to use calculator you can do it without calculator as well but does go through this number.

So once just to make yourself and if there is any mistake do let us know I hope there is not but if there is then it will make us happy if you let us know if there is any problem. So mass of compactible material because total was 100, un-compacted is 26.5 so subtract that and then you get 73.5 KG that is un-compactible material. Now the volume after compaction since total mass is 73.5 remember the compactor what was 320 KG per metre cube, so the volume after compaction we can get up to 0.230 metre cube, so initial volume is 0.784 the final volume after compaction is 0.230, so there is a lot of reduction in volume.

Now so what is the volume reduction 0.784 initial minus 0.230 the final and this is the volume reduction you are seeing in terms of that, so now if you want to convert that as a this is the actual volume reduction but if you put it in the terms of percentage reduction, so percentage reduction of the compactible material, so initial volume was 0.784 final volume is 0.230, so which is this divided by the initial volume 0.784 so it is 71 percent is what of the compactible materials, so 71 percent volume reduction is there.

Now if you look at the total in terms of the total volume, so if the total was percentage reduction total this is the 0.988 minus 0.434 because these are cannot be compacted and this is the initial volume of un-compacted material which will say as it is and after compaction the volume, so if we add this with this that is the total volume, is it not? Because this material is not getting compacted, this is the material which was compacted and as the final volume for that so if we add this two that this number let us change the color here.

If you have this number if this number that will go was the total, so that is what we have done it over here we added those 2 to get the percentage like a reduction of the volume and this is our total to start with which was there in the previous table and so if you take this 56.1 percent. So in terms of the total although it is 56.1 percent if you look at just the compactible material it was around 71 percent, so these things needs to be these kind of calculation needs to be done if we are trying to come up with… If we try to say okay we will use compactor or we will try to avoid advice people to use some sort of compaction at home, so we need to do this kind of calculation to really see the numbers and without good numbers cannot really do good design.

So for that is the I am trying to hit this point again in this course is good data, good data and good data that if somebody asked me what is the 3 most important things in terms of solid waste collection solid waste improvement our country in India I would say collection of good data, collection of good data, collection of good data. We have to collect the data from each and every for each and every ULB.

It will require sometimes it will require some money but it is worth doing it is worth doing it because then we will have a system which will be really design for that particular scenario otherwise what is happening is we are just design system and taking some theological calculation some examples here and there and then we are seeing lots of failures and we need to avoid those failures.

Most of the technologies which have been tried in India is working somewhere else so it is now the technologies fault, it is the fault many times people say this technology is not going to work in India I do not agree with that, there could be some but for most part most of the technologies which is being used elsewhere in the world can be used in Indian context but we need to do proper preparation for that, we need to do proper homework for that, we need to do proper calculation for that, so that is what I am trying to illustrate in this particular course.

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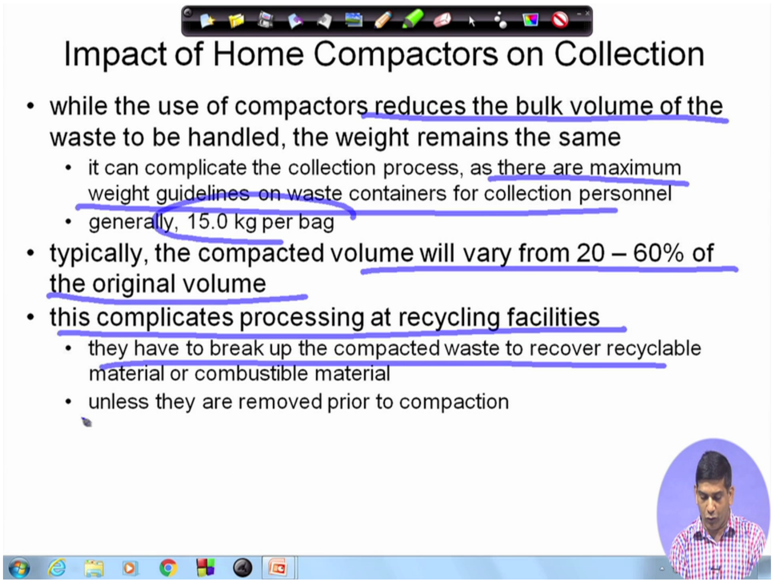

So once another thing is that what is the problem if you start using this compactor, what are some of the issues? Not problem like some other issues which comes to the compactor? Now if you use the compactor it will reduces the bulk volume of the waste but the weight remains the same although the volume goes down the waste remains the same, so what does that mean that actuality it can complicate the collection system, why?

Because our maximum weight guidelines, there are maximum weight guidelines on waste containers for collection personnel because those collection personnel, they have to live those garbage bags and put it the truck, if it is a manual collection or if you have a hydraulic arm which is again very costly truck, so say if we 10 years 15 years 20 years down the line we get those kind of trucks as well then those hydraulic arms is lifting more weight so that means more energy is being used to collect the garbage too, so you need to be again more energy you are using there.

So whatever the compactor you use by saving some space but since you are using more energy like those in the collection system, you would really doing environmental good? We have to life-cycle again we are kind of going back to that, so it is not that simple things does require little bit of thoughts, there is little bit of thought process is required coming back here there are maximum weight guidelines of us if it is too much of a weight, it will start hitting the back of the person who is like me and you lifting 15 KG one-time in a week or twice in a week is okay but thing about that person who has to work in the waste collection system every day lifting that weight at several places, think about what will happen to his or her back.

So it is from and agronomic stand point, from an occupational health and safety stand point there is a limit of you cannot have more than 15 KG per bag. So that is if you start compacting, you may exceed this 15 KG, so you need to be again look at that aspect and typically the compacted volume will vary around 20 to 60 percent that also depends on the type of waste that is there and now since you have compacted it and your bringing it to a recycling facility and papers, plastics, textile everything is compacted together nicely compacted.

Now what you need to do at the recycling plant, you have to start un-compacting it because they cannot be you have 2 separate all these different materials paper has to be separated, plastics has to be separated, textile has to be separated because each one is recycle separately, so if you are sending it to a dumb or if you are sending it to a waste-to-energy plant that is a different matter but if you are sending it to a recycling facility, some sort of processing facility you have to it will complicate the process, now you need to start having this un-compaction device, first you compact it because it way you will save some transportation cost for sure but then there will be additional cost for un-compacting the same material at the recycling facility.

I am not again I am not we have to look at all these from an unbiased perspective, data has to make the decision it is not you and me that is the problem, many times we make a decision based on our biasness, based on our intuition. What I am trying to say let us have good data and let us used that data to make the decision. So I am trying to illustrate those examples here and what all things that potentially happens.

So it will complicate things at the recycling facility because you have to break breakup for the compactor wish to recover recyclables, unless they are removed prior to compaction, if we do it prior to compaction means again source separation is happening, so that is different thing away so there are several scenarios can be lined up scenario A, B, C, D and we have to do the maths find out which scenario works best for that particular city based on what is the market and all those things around here as well. We talked about the recyclable markets and other things earlier in the class.

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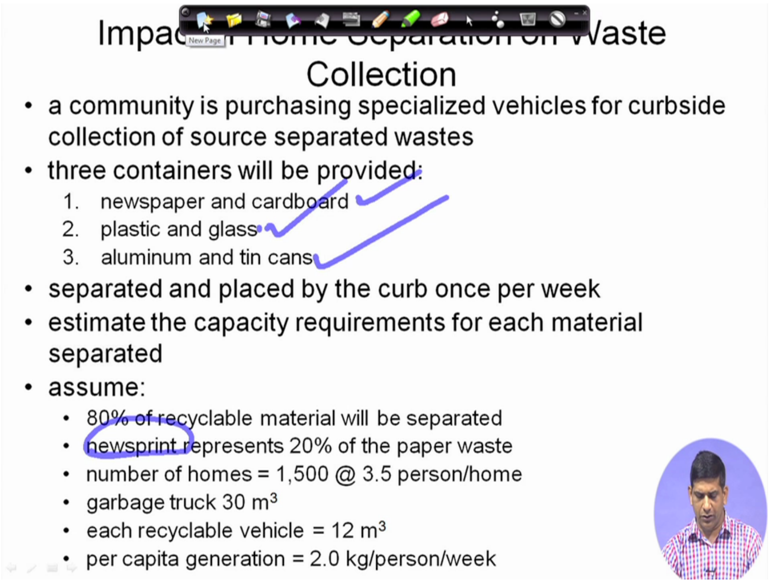

So now in terms of impact of home like if you have source separation what impact it has if you do the source homes separation of waste on waste collection., if the community is purchasing specialised vehicle for curbside collection for the source separation, so 3 containers are provided. Now if you want to do some sort of source separation along this line where you have 3 containers you provide to every house one is for newspaper cardboard, one is plastics and glass one is for aluminium and tin can, so you have these 3 separate recyclables in mixed good recyclables will be separate.

You can process them separately you will be able to sell the materials higher price but that means more money required for the collection system. So here separated and placed by the curbside once per week estimate the capacity requirement for each of these stuff that there is certain data given to us data in terms of what like 80 percent of the recyclable materials will be separated.

We are assuming that 80 percent will get separated newsprint represent 20 percent of the paper waste, paper waste is newspaper, office paper other things. Newsprint is essentially the newspaper when we say newsprint it is essentially we are talking about this newspaper that is in the number of homes around 1500 homes at same we have taken at what we had earlier 1500 homes, 3.5 person per home, garbage truck is 30 meter cube, each recyclable vehicle is 12 meter cube per capita generation is 2 KG per person per week and this data can varies, this is just an illustration these data can very so there is no problem like there is no issue associated with that.

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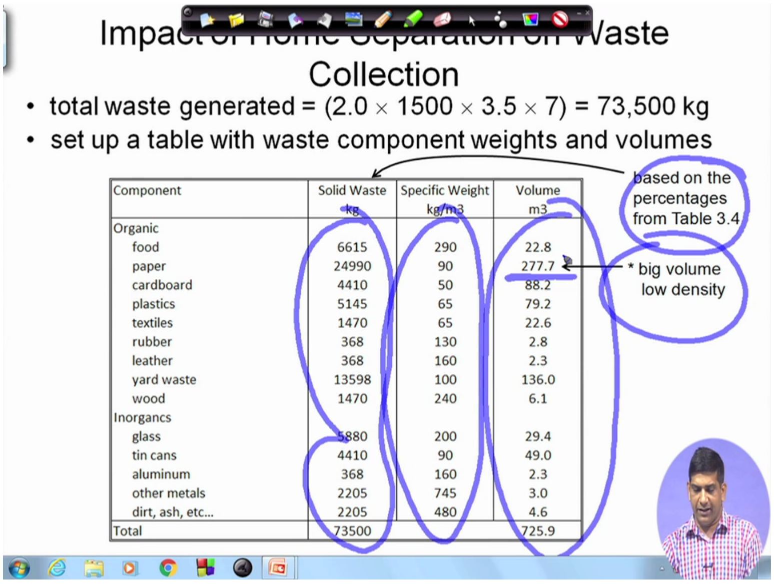

So let us look at the math part of it, so again will go back to the table where the total waste generation 2 KG per person per day, 1500 person 1500 homes, 3.5 people in one home 7 days a week, so waste generation is 73,500 KG so there is the waste we are generating in a week. Now let's set up the table with different stuffs again we will use the same percentage, composition as used earlier from the table 3.4 which I kind of thing I say it over here, it is over here.

So based on the percentages from the table 3.4 which already has been provided to you earlier, so and then you have so these of the solid waste different components for both organic and inorganic, the specific weight came from there we can calculate the volume that is required so this is as you can see the for some items big volumes because of the low-density, it is high volume shows up over there, so now this is the basic information that we have for different waste components.

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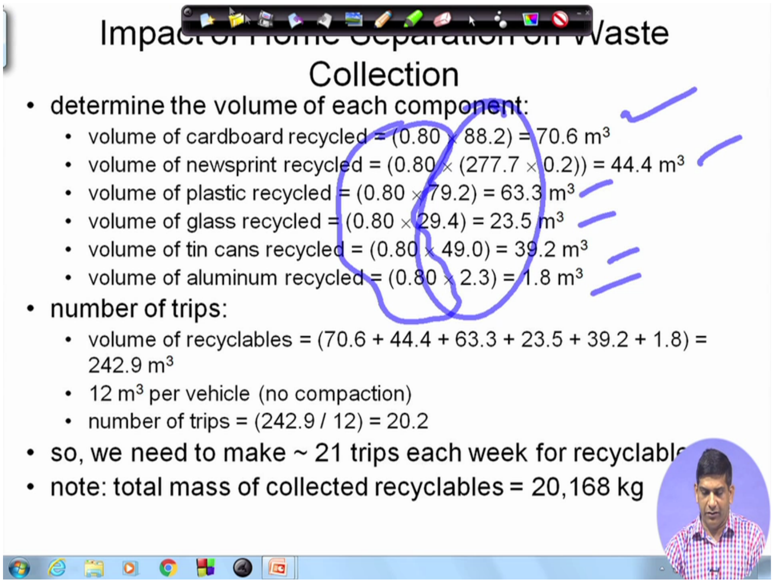

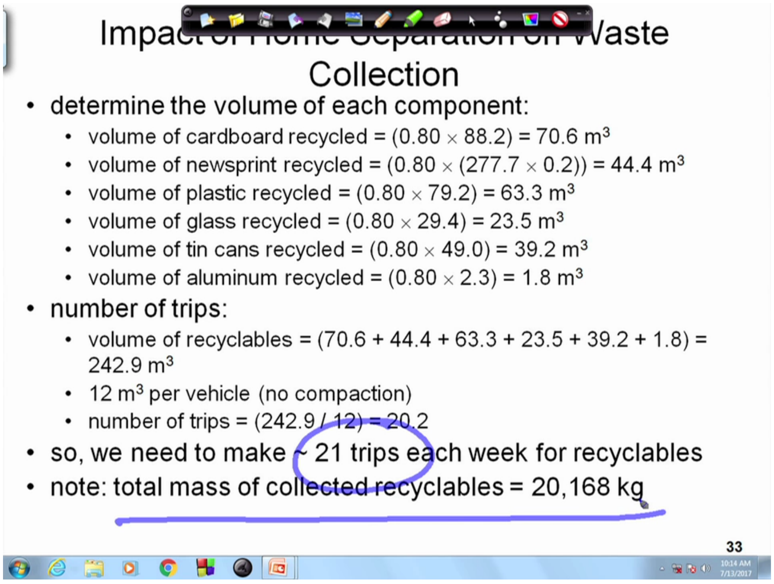

And when we go if you look at volume of cardboard, volume of newsprint, volume of plastics because base on the data that was given to us that 80 percent gets recycled, we know the individual volume just from previous slide we can calculate the volume of each one these. Again I will encourage you to do all these math by yourself once to kind of check it is all pretty straight forward because 80 percent was the we have the 80 percent was recycling given to us.

We knew this volume this data came from the previous table and we use that to get the volume of different materials of each of this components. Now if you want to collect is volume is a friendly and so there will be volume of recyclables if we add all these up we get 242.9 meter cube around 243 meter cube. 12 meter cube is the vehicle which no compaction which recyclable truck, so 242.9 divided by 12 so that is 20.2 so that means we need around 21 trips. So if we use that truck, we need around 21 trips to do the collection. So if it takes around 21 trips each week for recycling and the total mass is 20,168 which was we did it in earlier slides, so that is for that.

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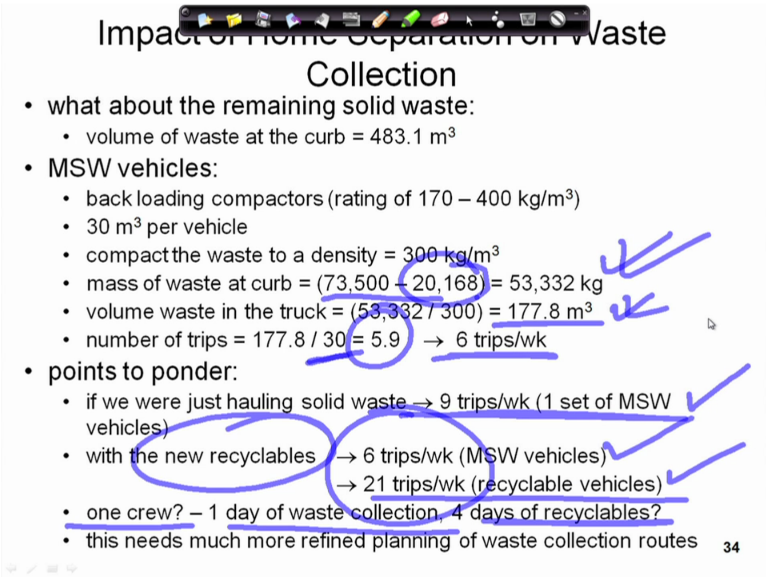

Now this is what 21 trips required each one of those if you do the all the recyclables are collected separately sorry together and now if you do the remaining solid waste, volume of waste is 483.1 what is minus separate the recyclable part that is the volume you get for separate MSW. Now if you use the compactor which is 30 meter cube per vehicle and let say the compact the waste to a density of 300 KG per meter cube so mass of waste 70,500 was total if you remember and 20,168 was the recyclables.

So if you subtract that this is the MSW that should be collected as well, this is non-recyclables. Volume, we know the volume based on the KG 300 KG per metre cube is a compaction so this is the volume that will be needed, now 30 meter cube per truck, so we need 5.9 so that means there is 6 trips are required. So if you just hauling solid waste we need 9 trips per week one set of MSW vehicle, so if you do not do like a recyclable collection separately you need 6 trips plus 3 trips today 9 trips you need for one for vehicle but if you collect this recyclables separately you have 6 trips per week for MSW and 21 trips per week when there is a smaller vehicle for recyclables.

Now so in terms of this collection system that means more trucks required that will require you have to look at typically one crew is one day of waste collection, 4 days for recyclable they can do probably and then we have to look at the we have to do this collection routes as well, how this waste will be collected so that needs to get done as well for in terms of the collection system, so that is gives us how to go about this.

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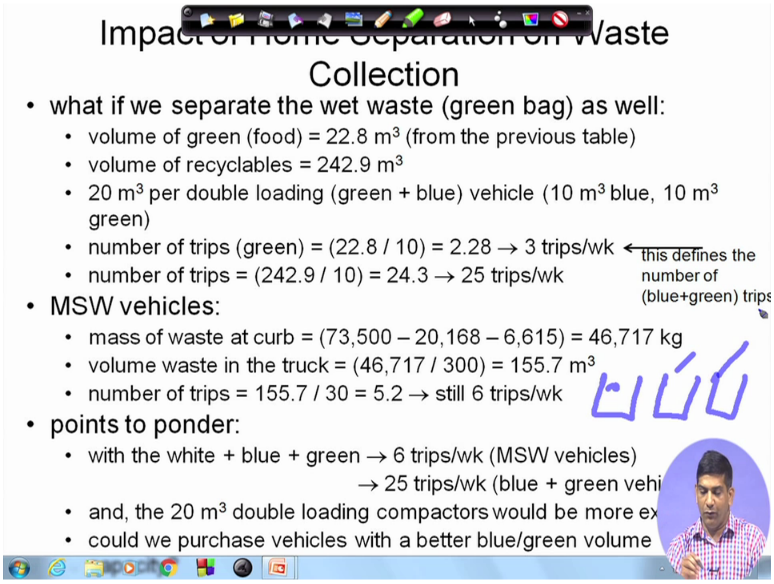

Then if you separate the wet waste say if you decide to do the wet waste like the green bag as well remember some when you are talking about the collection system from different places around the world I showed you in for example in San Francisco you have a wet waste separate like food waste separate and the dryer recyclable separate and then the thing going to the landfill. So there are 3 way collection so this is for food waste, this is another for recyclable, this goes to the landfill.

So if you want to do that kind of system here if you want to implement something similar over here, so volume of food was 22.8 meter cube again from the previous table, recyclable was this much, 20 meter cube double loading green plus blue vehicle you can use that as well some cities use that and we take you for blue 10 meter cube for green, blue is for the recyclable and green is for the compostable or the food waste.

So again you can calculate the number of trips how much trips you be required for recyclables as well as for the green and know how much you require for MSW vehicle and then you if you look at that, you need 6 trips per week if you have done everything together than but if you do blue and green separate you need 25 trucks per week. So we need to have will probably have to have that but what we have seen is green for the green, you can do it in

3 trips but for recyclable you need 25 trip that means we actually need more volume on the recyclable part.

So this truck with 2 compartments the compartment which will carry the recyclables probably needs bigger volume because these are bulky materials and the compartment which will carry the food waste can work with a smaller volume, so we may have to work with the truck manufacturer and redesign the truck that our collection system gets more efficient, so those things again practical application again those things once you do these kind of maths.

And then you can talk to those manufacturer rather than since if you are buying several number of trucks you can always convince them that I would want your truck but what you have to do is increase the volume of recyclables side and reduce the volume of food waste side. So that I can reduce my number of trips going back and forth otherwise what will happen recyclables will get filled up then I have to come back although my food waste still empty, food waste side is still empty I have to come back unloaded again go back and collected so those things are have to do for that.

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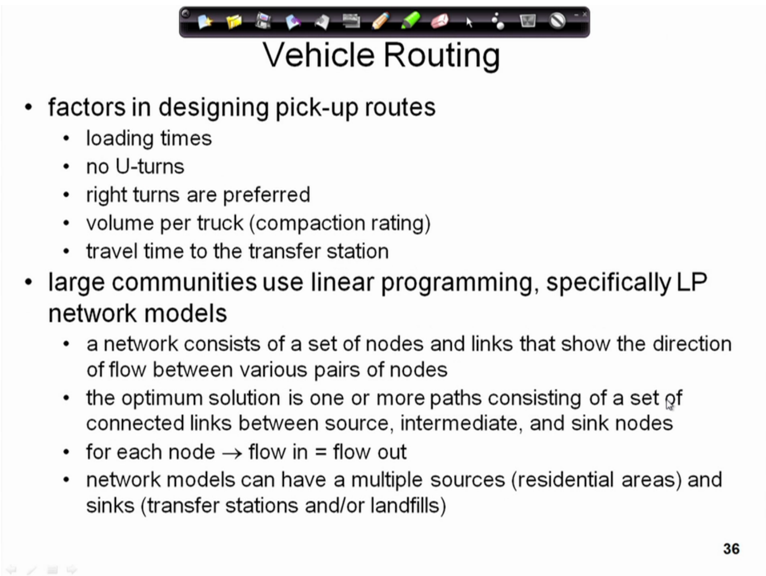

So these are some like a real problem which needs to be done and so let us how will kind of stop this video at this particular point. So again what I have done this last say 2 in half video is that I have tried to illustrate all these different types of practical issues that may come up when you go for designing of integrated solid waste management system specially for the collection and the transportation part. We have not gone into treatment part yet which will do we will do simple maths the treatment part as well for the collection and transportation part when you go for the design of any ULB for any of this upcoming smart cities in the country.

We need to do these kind of mathematical calculations these are not difficult it requires some time but again can be done and the design that will come up being more realistic and we will have less failure happening in terms of waste management infrastructure. So with that lets start this video, I encourage you again make the discussion board lively, ask questions, go over this math, go over this problem by yourself if you have any issues feel free to send us through the discussion board a platform that we will use in terms of the more of communication. So we are using and we will be using, so with that lets close and then in the next week which will be the week 6, we will talk little bit about some of this collection routing issues and then we will start looking at treatment and the disposal system. So I hope you are enjoying this course, thank you and look forward to seeing you in the next week.