Urban Service Planning
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Lecture - 19
Waste Composition

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Welcome back. In lecture 19 we will talk about Waste Composition. So, the concept that we will cover in this lecture are on waste composition its global outlook, determination of waste composition, how do I determine that? Then, we will study two case studies and one is from Cuttack the data is from 2008 and the other is from different ULBs in Karnataka the data collected is from 2012.

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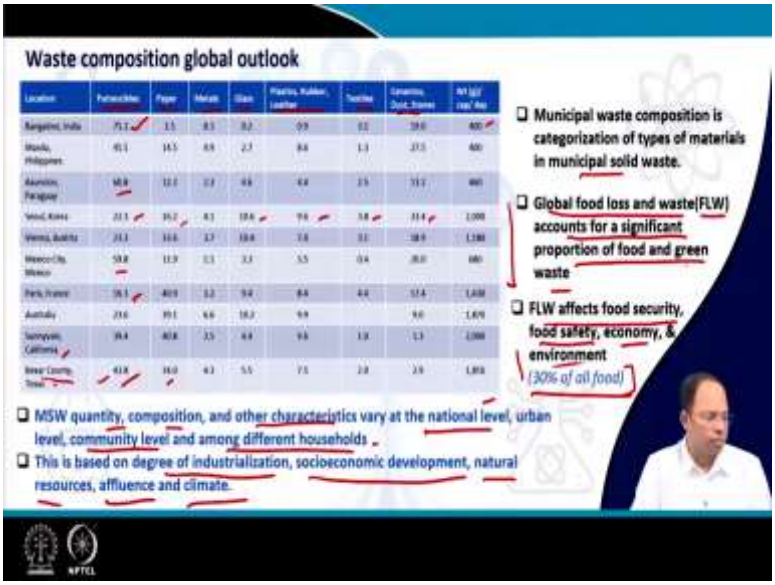

So, if I talk about waste composition in different countries this particular tables this data is from 1996. You can take a look at the different kinds of you know the material that is there in waste. So, putrescibles are the organic matter then paper, Metals, glass, Plastics, rubber, leather, textiles, ceramics.

So, if you see that the first line is for Bangalore, India. Where we see around 75 percent of the waste is organic in nature this data is again from 1996 so or during that time period so it is a bit old so maybe this compositions have changed now to a certain extent but this is what we got at that point of time.

Overall, waste generated is around 400 grams per capita per day and you can see that the values are different for different countries. For example, in Korea we see the value as 22.3 for organic matter paper 16 percent, Metals 4 percent, glass 10 percent, plastic rubber leather 9.6 percent, textile 3 percent and Ceramics dust around 33 percent. Now, if I go to Texas in US this value is around 43 percent so it is more than South Korea.

But, the other parameters like paper it is more in case of you know that means packaging and all these things are more in U.S. So, every country is different you see Paris 16 percent organic matter very, very less organic matter. So, usually we say that the more developed a country is more industrialized the country is it would have more less amount of organic content.

Why? Because, people are well off they will buy a lot of package material they do not cook themselves they will you know take food from outside so they have to buy a lot of packaging

materials and so on. So, that is why the organic matter content is very less and you would see more amount of packaging material and other materials in the waste stream.

But that does not mean that all developed countries will be same. Like for example, in Texas which this particular county there maybe it is a rural in nature so there the organic content is more. Similarly, if you take the difference between California not California this Paraguay the value comes to around 60 percent which is much poorer country.

Mexico is also 60 percent so it is also you know it is well often India but still it is a poor country right. So, that in that way that means waste composition will be different for different countries these are average value but what it means is if certain cities in certain countries also will have different kinds of estimation.

Like we have Texas and we have California both from U.S but the values are different right. So, there would be some differences as well because of the area the context and so on. So, municipal waste composition is a categorization of type of materials in municipal solid waste. Now, MSW quantity composition and other characteristics vary at the national level as we are seeing here at the urban level at different level cities the values are different right because, each city is different in character it varies as per the community level.

Suppose it is a residential area or it is a posh residential area or a very poor residential area it will have different values. And it also varies among households that means in the same residential area there are rich people poor people so individual household wise the composition will also vary right. So, this we have to that means that we have to be very careful about when we quantify the waste and we have to determine that who is generating what which generator is generating what category of waste what type of waste.

Because, if we do not do that then when we project it for the future, we may be making very, very wrong estimates. So, this variation is primarily because of the degree of industrialization maybe when I talk about countries or maybe even cities this play a role the socio-economic development of that particular area the natural resources which are available.

Some area is a rural area so obviously a lot of you know natural resources or the way what people consume is different from a very very urban area. Affluence of the society how rich people are and the climate of that area. So, all this influences the waste composition of our area.

Now, along with waste which we are getting like organic waste and all particularly in case of organic waste we have to be also careful about global food loss and waste. So, that is FLW this accounts for a significant proportion of food and green waste so organic waste is generated in urban areas of course but lot of this waste is also because of loss and waste of the food supply chain.

So, some of this loss is at the consumption level but most of these losses are the production and distribution level. So, production and distribution level mean the during production after production the food is stored and because of inability to sell the product or inability of storing the product the product may get wasted. So, that means lot of food waste gets wasted food gets wasted and that comes into the waste stream.

Even though it may not be part of the municipal waste stream but it may be part of the municipal waste stream as well if you have lot of cold storages in our municipality. Similarly, if during transportation also because of inefficient transportation distribution while food is traveling along the way it may get decompose. So, all these issues can happen so this food loss and waste affects food security, food safety, economy and environment and it is approximately 30 percent of all food.

So, waste that is generated from you know food and green waste that is created in urban areas may have a significant proportion of waste which is because of inefficiency in the waste production, collection, distribution sorry, food collection, processing and distribution process. So, there may be some amount of initiatives that could be taken to actually improve that that will reduce the quantity of waste that would be generated.

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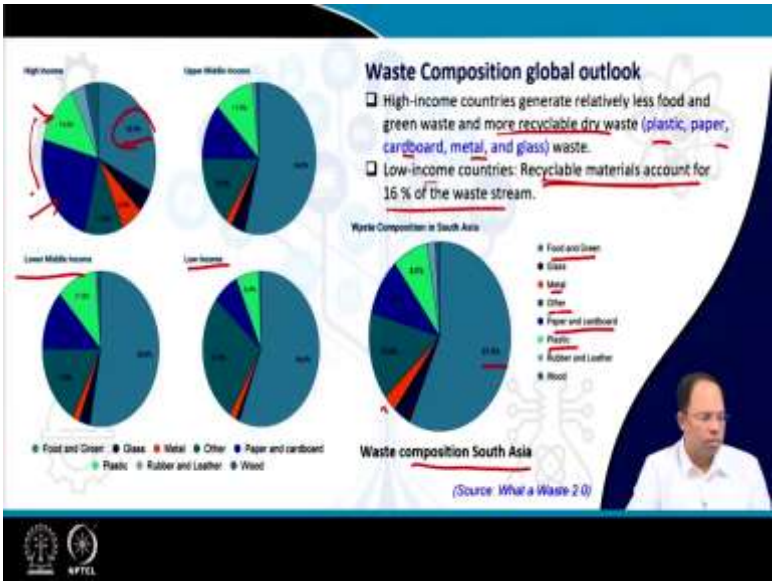

Then looking further if I look into the waste composition in South Asia you will see that South Asia is again India, Pakistan, Bangladesh and these countries. So, here we see that around 57 percent is food and green waste around 15 percent is other waste and metal and glass is something around 3 or 2 percent something like that and then 10 percent is paper and cardboard 8 percent is plastic waste. So, this is South Asia.

Now, if I look into the overall world who were very poor income countries lower middle-income countries where we are you see this more or less matches with this particular figure and but if I go into more richer countries you will see gradually the organic waste content is reducing. So, high income countries has got a very little organic content. Whereas, they have got lot of paper they have got lot of plastic in their waste stream.

So, this is the difference in the waste stream and in different countries. So, high income countries direct generate relatively less food and green waste and more recyclable dry waste. Now, this recyclable dry waste means even though they are generating lot of waste but they are also able to recycling those. So, at the end of the day there you know overall waste management process is more efficient.

So, plastic, paper, cardboard, metal, glass whatever waste they are generating they are able to recycle it much, much more and almost in many cases they are able to recycle it to the extent of 90 to 100 percent. Whereas, in low income countries recyclable materials account for only 16 percent of the waste stream and within that also we are only able to you know maybe the

material generated is maybe even a little bit higher but we can recycle 16 percent or even lower.

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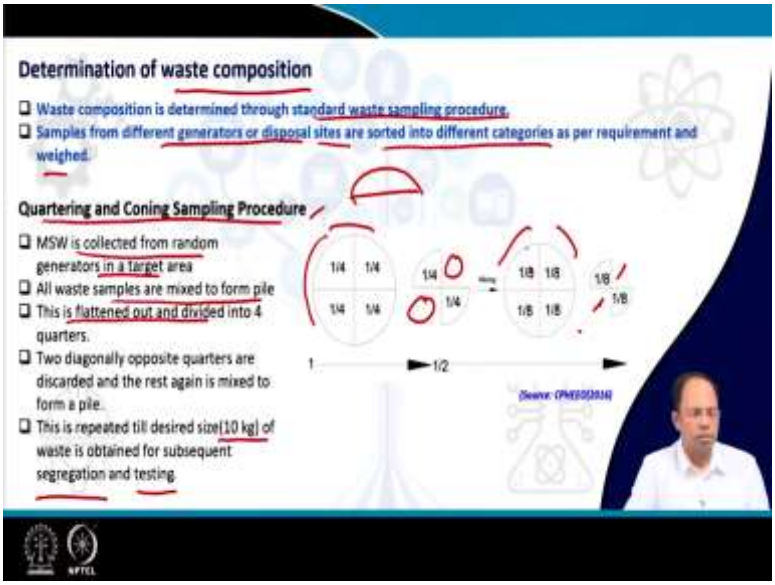

Now, how do I determine waste composition in the last lecture we have decided discussed how do I determine the quantity of waste. So, same way that means once I collect samples from different generators from different parts of the city then the job is to determine what is the composition of waste. So, we can first standards waste sampling procedure could be done to collect the waste and samples are from different generators or different disposal sites are sorted into different categories as per requirement and then they are weighted.

So that means we can take the waste we can separate that into different components as per our requirement like if I want to separate into, into wet waste and dry waste that is all if I want to further separate into plastic paper and so on so we have to do those separation and then we have to take their weight so that is what we do.

Now, sample sizes how many samples when to collect that we have discussed earlier. Now, once the waste is collected for our urban area now what we use something called a quartering and coning sampling procedure to actually determine what is the best composition. Now, why is this method important because this method ensures that waste that are collected from different areas of the city and for different generators these are thoroughly mixed and then based on that mixed waste, we can determine what is the percentage composition of different you know constituents of the waste for that urban area or for that particular category of generators that we are actually addressing.

But if I want to just address look into the waste composition for commercial areas then we will only use commercial areas and then mix the waste from all the different individual generators from commercial areas and then we will follow this quartering and coning sampling procedure. What is this procedure MSW is collected from random generators in the Target area that is our first step that random generators are selected and we collect waste from them all waste samples are mixed to form a pile.

So, we will first spread it out and make a pile then this pile is flattened out and divided into four quarters so this is the flattened-out pile and we divide into four quarters then two diagonally opposite quarters are taken out like this side and this side is taken out then whatever waste is remained, remained they are mixed together and then then we create another pipe.

We keep on doing this and then we remove that again the diagonally opposite parts could be taken out we keep on doing this till we are left with around 10 kilograms of waste which is the appropriate size which is used for subsequent segregation into different components and then finally weighing them or finally testing them. So, this is the quartering and coning sampling procedure which is adopted for determining the composition of waste.

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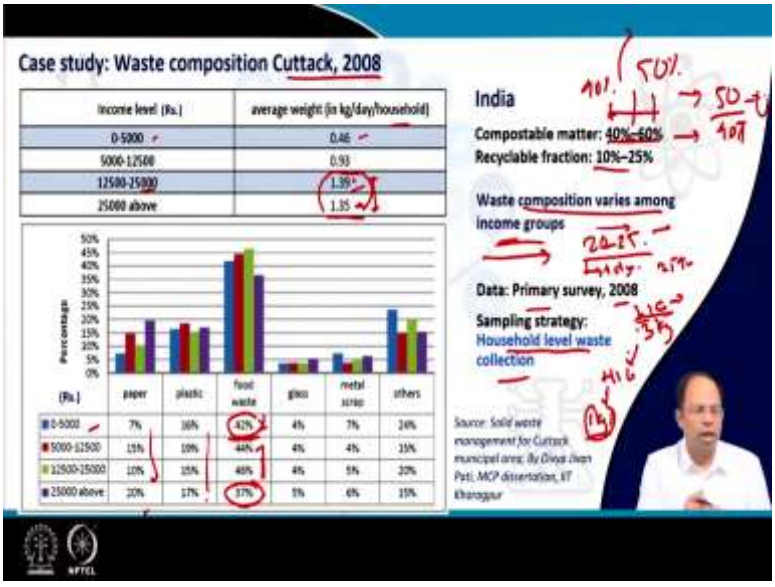

Now, coming to two case studies both of these case studies has been conducted by students from our lab and we have students working in during different like for this this in different parts of the country. for example, this study was done in Cuttack in the year 2008 so it is a little bit older study some of the data may not match but what we want to convey is that the

waste generated in different cities are different the composition of waste, the waste generated by different categories of people are different.

So, for estimating future quantity of waste or for proposing certain measures we cannot go with very you know standards which are for the overall the country that means we can adopt country level standards but we may end up with very, very wrong estimates so that is what I want to convey. So, in India compostable matter is, is you know ranges from 40 to 60 percent so that is a very big range. So, in some cities it may be 40 percent in some cities it may be 60 percent.

So, as per that if I assume if I do not do any kind of survey any kind of estimate for that local area and I take this figure as 50 percent as average so I will design my composting plants all these processing facilities as per that but that will end up with lot of wrong estimates for example if the actual value is 40 percent so that means we are over estimating by 10 percent.

So, if I say that every you know for that particular city every day, we have to handle around 50 tons of waste that means roughly around roughly around 40 tons of waste is the actual value for organic waste whereas 10 times is overestimated or 5 times is overestimated. So, that builds up for over time and that is a lot of waste. So, we need to be very, very careful about what values we adopt and it has to be as per that particular urban area.

Similarly, recyclable fraction is 10 to 25 percent but that varies is for different urban areas it depends on the segregation mechanism adopted and so on. So, what we thought of is well waste composition varies among income groups that we discussed earlier. Now, why this is important now if you remember from our earlier lectures, we said that obviously income is a big indicator of how much amount of waste is generated.

Now, with time income changes that means people will not remain in the same income bracket because our country at least we are growing so our GDP is growing so obviously income levels are increasing. So, with more income people will consume more and when they consume more, they will generate more waste so if I am making a 20-year plan or a 25-year long-term plan so in that case the waste that is generated in the first year and the waste that is generated in the 25th year that this would be significantly different.

Why? Because, the income pattern will change during this time period even if I assume that the people will remain there the way the consumption patterns will remain same that is a person who belongs to the high-income bracket in today will consume similar items in future

also. That means if a person, rich percent of today and a rich person of a future time period, they will have similar consumption.

But it may change because, you know lot of new technologies are coming lifestyle patterns are changing this will also change but if I assume that the consumption habits will remain same so a rich person will consume similar things if he is rich in future also. But, the problem is the number of people who will become rich in future that is not known that we have to project right.

So, a person who is LIG he may be generating 0.3 kg of waste per day today but 20 years down the line this LIG person will become a HIG person. Because, his income will increase then this generation would be maybe 1 kilogram per kg per day. So, that transformation has to be asserted. So, today whoever is rich is consuming 1 kilogram but in future some LIG people of that particular city will become HIG and they will also consume 1 kilogram.

So, this transformation in the income is very very important and that is why when we did our research, we looked into how waste composition varies along the different income groups. So, this data was collected in 2008 we did primary survey we went to each household we measured the waste that they are generated and then we have determined what is the percentage composition of waste in this particular areas.

So, this is sampling strategy was household level waste collection and then weighing them. So, because our sample size was less so some of the results are a little bit you know not as per the expected trend but still it will give you an idea about how these changes. for example, we found for income level of 0 to 5000 rupees the average weight generated is 0.46 kg per day per household per household not per capita.

So, every household may be 4 or 5 people or even 6 people there in per household. Then people with 12500 to 25000 their ways the amount of waste they generated was 1.39 kilograms per day per household and then above 25000 it came to around 1.35 which is lower than this this should not be happening because more richer the person they should be earning more but it all depends on the sampling strategy the sampling procedure how many samples I collected and so on.

If we would have collected more samples than probably this value would be higher but right now, we can say that well this income brackets are showing similar consumption patterns or waste generation patterns you can also say. So, that means 1.35 to 1.4 this is the amount of

waste that is generated by these poor richer households. Now, coming to the composition of waste you see that in the lower income brackets food waste is around 42 percent and as we go higher up it increases a bit and then again comes down.

Now, why this is so we have did discussed earlier that the, the more richer a person becomes he will consume more like he will consume more package material you know he will cook less he will eat outside. So, that means the organic waste generated would be less so somewhat we are seeing a value but in Indian cities our people are still not at that level like foreign countries where they are going to consume lot of package material and all.

Now, not in 1996 now not in 2008 at least right now still you will find lot of families you know gradually moving into that bracket where they consume lot of this package materials and all but still if you see the data that this value is less organic matter compared to these the other two groups. But, this 0 to 5000 group is also showing similar values actually they are showing a little bit lower value they should be higher as per the same logic why because these are very poor people and very poor people do not waste you know food material food.

So, usually the amount of vegetable peels generated by a middle a poor household and if you take a richer household you will find that the rich person will throw out more amount of part of the vegetable which he is not going to consume whereas the poor houses will actually consume more. So, probably that is why the food waste is even less in poor household. So, this kind of insights needs to come out when you do analysis of waste generated in urban areas and that is why we need to do very very detailed analysis to determine what kind of waste should be generated.

So, same goes for you know paper waste you can see that as the income level increases the quantity of paper waste also increases same goes for plastic more or less we found to remain similar and glass also similar scrap metal similar because they were so less quantity if there was some amount of measurement error as well you can say but if we would have done a proper sampling where we have collected from multiple areas of the city 100 kg samples then probably we would have got much much better than this this was done by one of our students so it was not that in detail right.

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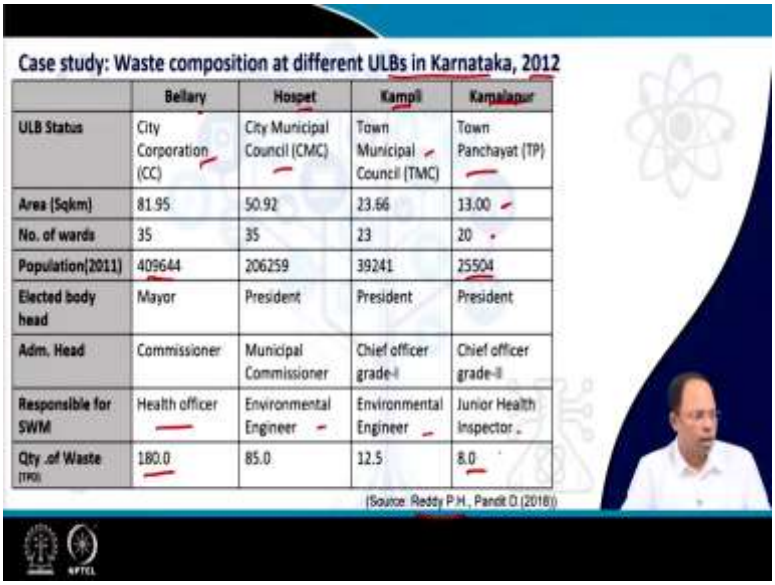

	Bellary	Hospet	Kampli	Kamalapur
ULB Status	City Corporation (CC)	City Municipal Council (CMC)	Town Municipal Council (TMC)	Town Panchayat (TP)
Area (Sqkm)	81.95	50.92	23.66	13.00
No. of wards	35	35	23	20
Population(2011)	409644	206259	39241	25504
Elected body head	Mayor	President	President	President
Adm. Head	Commissioner	Municipal Commissioner	Chief officer grade-I	Chief officer grade-II
Responsible for SWM	Health officer	Environmental Engineer	Environmental Engineer	Junior Health Inspector
Qty .of Waste (TPD)	180.0	85.0	12.5	8.0

Next, we come to a case study where we discussed a waste composition at different ULBs in Karnataka and this was done in the year 2012 again it was done by one of my students Mr. Reddy so he was engaged already in waste management in this particular state. So, he was able to collect much more samples and he has got a lot of help also from the ULBs as well. So, in here 4 ULBs studied Kamlapur, Kampli, Hospet and Bellary. See this each of these cities are different so one is with a population of 25000 whereas Bellary is the biggest one with the population of 4 lakhs.

The number of wards also are different area is also different area is much smaller and the ULB status or the governance system is also different. So, we have a town panchayat in Kamalapur, we have a Town Municipal Council in Kampli, Hospet there is a City municipal Council and in Bellary there is a corporation. So, we have already discussed about the municipal organization structure, the governance and all this the finance and all this part so all these plays are all in the waste generation and the collection process in the urban area.

So, again the health officer is responsible in Bellary whereas engineer environmental Engineers or a junior health inspector is responsible for Waste Management in this particular city. The total quantum of waste generated in the city is around 180 tons per day in case of Bellary. Whereas, it is only 8 tons per day in case of Kamalapur.

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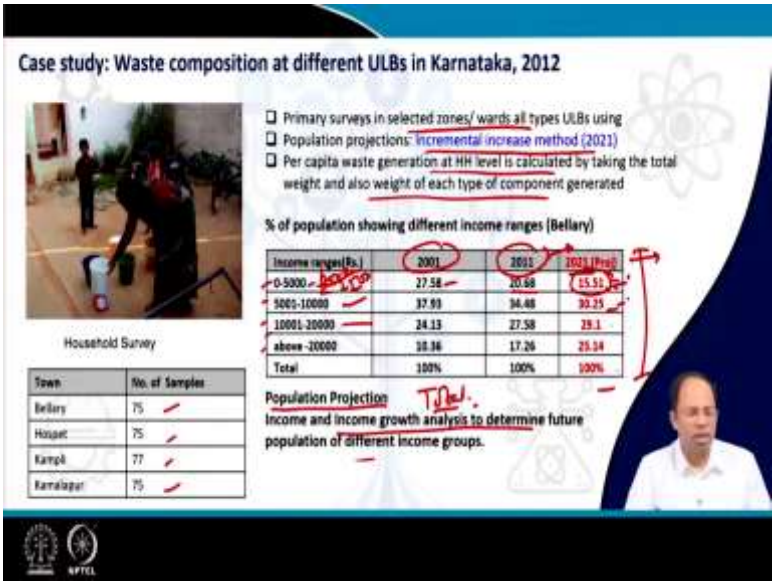

Now, we are more interested in the composition of waste. So, again we did a similar study that we did earlier where we divided the population into different income brackets and studied how what kind of waste, what kind of composition they generate. And this income bracket division was done so that when we do projections for the future, we do it more efficiently. I will come to that. So, this is how we had done the household service we asked people to get you know bring the garbage outside and then it was measured and the total quantity and all this thing was recorded and this will repeated in multiple households.

So, you in each of these cities in Bellary, Hospet, Kampli, Kamalapur we took 75 samples each we could have gone for a little bit higher samples but time or you know the manpower did not permit it. So, primary service were conducted in selected zones or wards in that particular ULB and per capita base generation at household level was calculated by taking the total weight and also the weight of each kind of component that was there in that particular waste.

Now, finally we also did project the population to project the population from year 2001 data we had got 2011 data we had got but we projected the total population for the year 2021 and this was done using the incremental increase method which was found to be appropriate for this particular ULB's. So, first we you know projected that total population so total population was projected but we also wanted to understand that what would be the pattern in change of the populations belonging to different income brackets.

For example, we again use range 0 to 5000, 5 to 10000, 10 to 20000, above 20000 and initially in the year 2001 and 2011 we had the data along with us we had 27 percent people in 0 to 5000 income bracket in the year 2001 then it got reduced in 2011 that means people are moving up the income ladder and we have to now project how many of them will move into the next income you know in the year 2001 into the next income bracket.

So, we what we did was we knew the GDP growth rate of this particular area or this income growth rate and from that we predicted that each of these population groups with mean income of in this particular bracket the mean income is 2500. Now, we projected that using that rate of income growth or GDP growth for the urban area and found out that how much of this people belonging to this group will move on to the next income bracket which is this group.

So, because this value this mean value be you know when we increase by 3 percent every year it some of it reached beyond this 5000 value. And for whichever value when starting like from 2000 suppose there are you know from there the income actual income is 2000 after 3 percent projects in every year it became 5000 so all people above 2000 earning now is shifted to the next income bracket in 2021.

So in this way we determine what amount of people from each income bracket will move on to the next income bracket and you see that this is what has been projected over here. Now, why this is done this is done so that that we can say that in future the number of people in this income bracket is 15 percent in 5000 to 10000 this is 30 percent and so on. And the waste generated that we would estimate for each of these income groups so we can multiply the waste generated and we will assume that the similar lifestyle similar kind of ways should be generated would be in future as well.

So, but the quantity of people in each of these groups has 10 so automatically the total waste would also change. So, that is how we did the estimation for future about a waste that will be generated.

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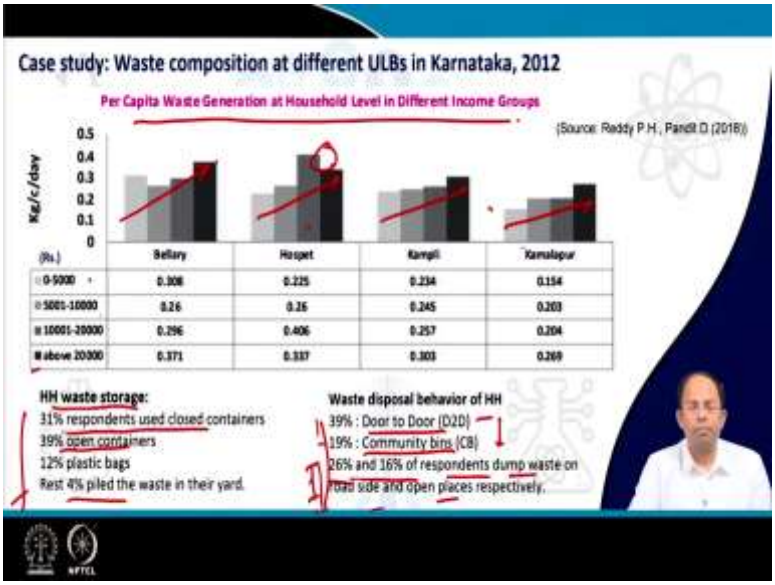

So, some more data on the survey part what we found out was 31 percent responded used closed containers 39 percent used open containers 12 percent stored waste in plastic bags and the rest 4 percent piled the waste within their premises but in outside that building. So, that is how waste was stored. Now, disposal behaviour or collection system in that particular area 39 percent were found to use door-to-door collection this was much earlier nothing door to door collection was not made mandatory, 19 percent threw their garbage in the Community Bins.

Sometimes even though door to door collection is their people throw garbage in Community Bins because certain kind of garbage is estimated they do not want to keep it inside they will take it out and throw it 26 and 16 percent of respondents dump based on roadside and open places which they admitted themselves.

So, that means that even though door-to-door collection is there someday theirs the collection system may not be working or there may be a strike by the collectors or maybe the, the person missed the collection window so he has got garbage he throws it away here his house or in the community bin. So, this we found all this behaviour also there in the municipal area.

So, and also because we are dealing with different levels of ULBs like Kamalapur and all they did not have too much amount of door-to-door collection so most of the people either use community bins or through the garbage outside. So, that is why we see almost you know equal distribution of people adopting all these measures. Now, coming to the per capita waste generation at the housing level what we determined was in Bellary, Hospet, Kampli and Kamalapur you can see the values you can see two trends in this.

One is as per the different income brackets which you can see over here the more grey ones is the richer ones we can see a trend that the more higher the income bracket more is the waste generated that is the normal trend but sometimes there are odd values this is again because of sampling. We have taken 75 people if we have done more samples probably this value would be similar or even maybe higher.

But it is because of the number of samples in this particular group somehow on that particular day that time when we saw it this showed lesser value. But usually, you can see a general trend. The other trend that you can see is that is in this first trend is the more higher the income bracket they will generate more amount of waste.

The second trend is size of the city is the smaller city generates lesser waste compared to a larger size city. So overall Bellary is the amount of waste that is generated is higher than that of Hospet that and Hospet is higher than Kampli and Kampli is higher than Kamalapur. So, as per the ULB as per the income brackets of people in the ULB we have to determine what sort of waste (())(30:25).

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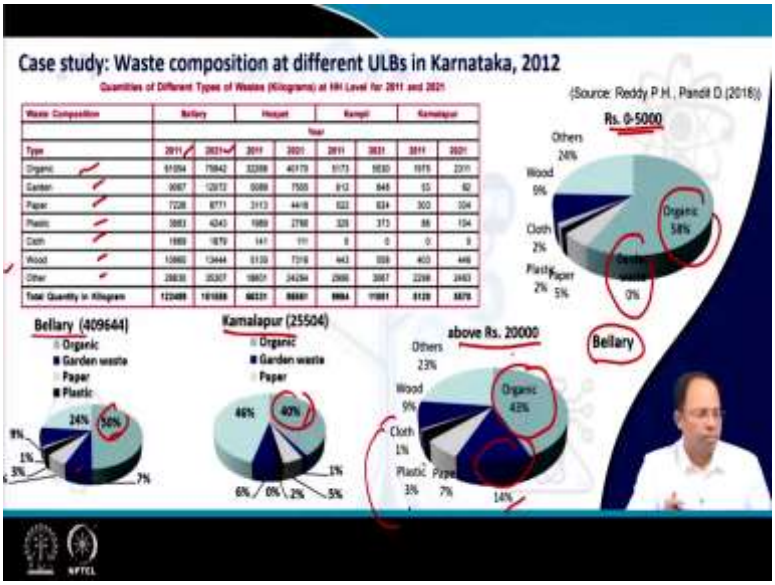

Finally coming to the composition of waste not only the quantity of waste we can see that this is stable actually will give you we have tested the composition for organic content garden waste because these two are taken separately, paper plastic cloth wood and other kinds of waste mixed waste you can say. So, you can see and we not only determined it for the year 2011 but we also projected for 2021 based on the calculation that we have done earlier.

That is we first projected the population we then determined how many people will move on to the next income bracket and for each income bracket we know per capita waste generation and that accordingly we multiplied and we determine the overall waste that would be generated in 2021. And then percentage companies' composition we assume that similar income groups will generate similar kind of waste accordingly we have determined that.

So, over here you can see if I take two cities Bellary and Kamalapur, Kamalapur is the smallest one Bellary is the largest one organic waste contained in Kamalapur is 40 percent whereas in Bellary it is 50 percent. The other waste like you know this Garden Waste is the blue one which is in Kamalapur it is very less whereas in Bellary we are seeing some values.

Paper we are seeing around some percentage roughly around 5 6 percentage, plastic we can see some values and all and more or less we can see that mixed waste is more in case of Kamalapur. But, interesting thing is you can see that the organic waste that is generated in a smaller city is actually less as we have discussed earlier.

And see and the same thing you can also receive discuss for different income brackets not only as per the city the composition varies as per the different income brackets. So, if I take the city of Bellary you see that the lowest income group is generating around 58 percent of organic content whereas the higher income group is generating 43 or lower amount of organic content.

So, and similarly, the plastic and paper and all is little bit more in case of this higher income group compared to the lower income group. So, that is how the and again the other interesting thing is poor people do not have too much of garden waste because they do not have any garden, they do not have area probably for a garden whereas for rich people they have they may have a garden along with their buildings so they are generating around 14 percent is garden waste.

So every city is different income groups are different so we have to be very careful when we are determining that for overall for the city level or for different zones of the city level what kind of waste is generated what is that composition accordingly we have to design the collection system accordingly we have to design the decentralized treatment system and so on.

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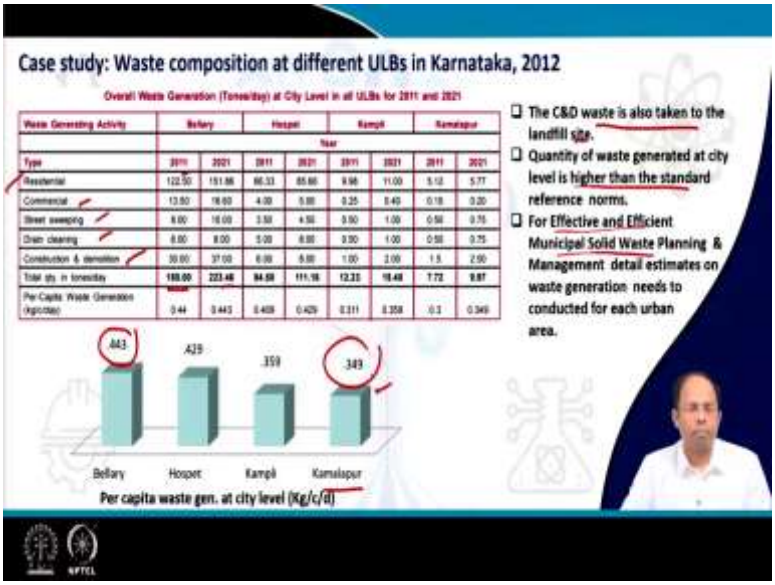

So, overall waste generation now coming to the final step, overall waste generation is not only the waste that is generated in residential areas or residential generators it is also from commercial generators, street sweeping, drain cleaning, construction and demolition and based on all this we have estimated the total quantity of waste generated in the year 2011 and 2021 for these cities Bellary, Hospet, Kampli and Kamalapur.

So, if I take now the average per capita waste generation including all this kind of waste not only the residential waste but the entire municipal solid waste that is being handled then it comes like Kamalapur is generating around 0.34 kilograms per capita Bellary is generating around 0.443 per capita and Hospet, Kampli is somewhere in the middle.

Now as you know that CND waste is taken to landfill sites in India in most cases so that is why we have included that in this calculation and quantity of waste generated at the city level is higher than standard reference norms. So, as per standards we are you know we can adopt certain things but as you can see in this study that the waste that we estimated is much higher than the standards.

For that means for effective and efficient Municipal Solid Waste planning and management we need to do detailed estimates of waste generation and for that we need to do we need to do a detailed study of that particular area then only we can determine what are the rates and based on that we can design the facilities of the infrastructure or the services that we require for efficient Waste Management in a normal area.

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So, these are some of the references you can see.

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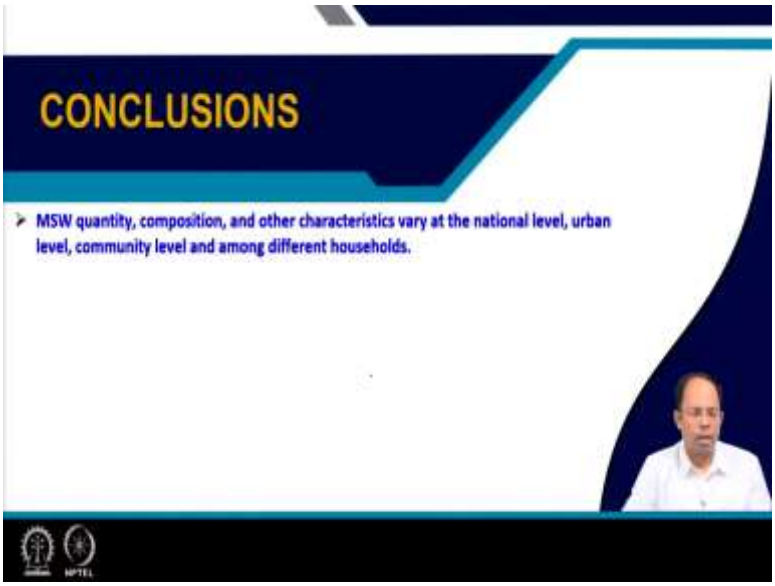

To conclude MSW quantity composition and other characteristics vary at the national level, urban level, community level and among different households, so this has to be considered when you plan for urban areas, Solid Waste Management in urban areas.