Urban Services Planning
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Lecture 29
Composting Part II

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Welcome back in lecture 29 we will continue with composting, this is composting part 2. The different concepts that we will cover is municipal solid waste composting, composition of the feedstock or the incoming organic matter that comes for composting, scale of composting, bin composting, box composting, centralized large-scale composting, we will do a case study of Mysuru city cooperation which uses both centralized as well as decentralized composting. And finally, we will talk about compost quality.

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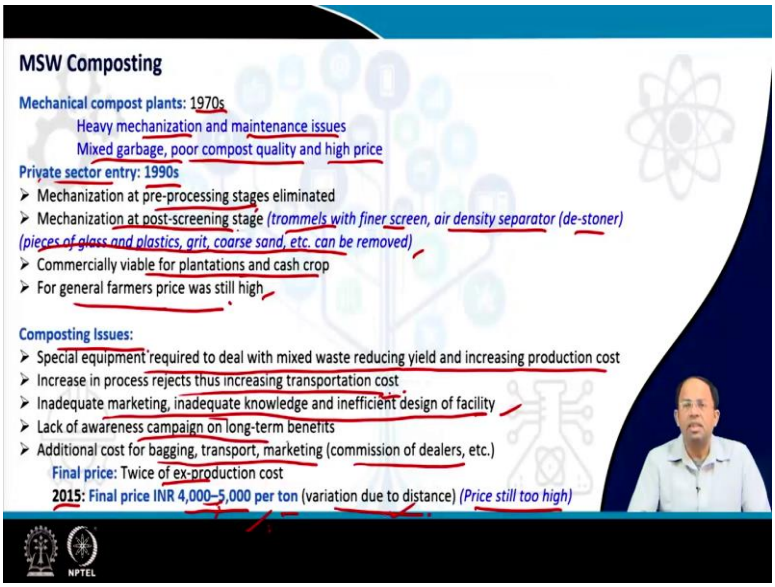

So, it is the Municipal Solid Waste composting started in India during the 1970s and initially a lot of mechanical compost plants came up. So, we have earlier talked about mechanization, where mechanical and manual operations. So, in mechanical compost plants, in the initial days this was setup, this had got a lot of processes mechanical process.

And because there are a lot of machines and all there were a lot of maintenance issues, most of the equipment was also imported, and also this has got a lot of maintenance issues. And because the garbage was mixed garbage, there was no segregation at the beginning. So, that is why these kinds of plans were introduced, but our garbage was so mixed or the quality of the garbage was such and the final resulting compost quality was pretty poor and because of high mechanization, the prices were also very high for this kind of plants and that actually resulted in failure of this kind of plants.

So, in this next you know, generation of compost plants came started coming during the 1990s and usually the private sector started working on this particular sector, that means there were lot of operations set up by private entities. And here the mechanization was removed at the pre-processing stages, that means initial sorting was done manually to certain extent.

But mechanize, already the waste was segregated, but still some amount of manual sorting was required, because not everybody segregates perfectly or sometimes some areas of the city do not segregate and they give mixed sort of waste. So, this so that when some amount of sorting is required, but the mechanization of that particular process was eliminated, and mechanization was only adopted in the post screening stage, that means one compost is produced, it is cured or maybe in the in between mechanization was introduced, so that we

can clean the final compost and using trommels with final screens, in the pre-processing promise of larger screens are used, but in the post processing promise of minor screens or air density separators which removes the stones, pieces of glass, plastic, grit, coarse, sand etc can be removed from the final composting.

So, that means this is not removed at the beginning it is removed at the end once compost is formed. This improves the commercial viability of the compost improves the quality of the compost and so on. And this kind of compost was found to be very viable for plantations and crash crops like banana sugar cane, you know, like your grapes which were used for wine production, because these were exported.

So, but for general farmers, when a lot of more new plants came up this compost was taken to the general farmers, but for them, the price was still found to be very, very high. So, that is the challenges of composting, that is the price subsidization all these things are very, very challenging that needs to be looked up. But anyway, some other issues, composting issues, special equipment is required to deal with mixed waste reducing yield and increasing production cost.

So, in case the waste is mixed, we as I told you earlier that we may go for manual sorting, but sometimes it is not adequate, we have to use some mechanical means and that is where the cost increases, that overall yields reduces and so on. So, that is one of the biggest issue that is if the waste is mixed, then composting is difficult.

Increase in process rejects thus increasing transportation costs. So of course, if you deal with composting with mixed garbage, in that case, a lot of rejects will result in and that will increase transportation costs. This reject has to be transported to the landfill. So, it is doubled transportation costs you have to transport compost to the compost plant then again transport it to the landfill site, inadequate marketing, inadequate knowledge and inefficient design of facility, that means each facility of composting estimate designed as per the character of the waste, as per the final product characteristics and so on.

So, if you lack inadequate knowledge in the plan design, it will result in a wrong design. Similarly, inadequate marketing means I have to know where I can sell my product or what quality of product so, these are the things which are important, lack of an awareness campaign or long-term benefits.

Now, you have repeated utilization of chemical fertilizers reduces the overall fertility or the condition of the soil. So, what are the benefits of composting? Composting includes the condition of the soil and repeated application also does not create a problem. So, this kind of awareness needs to be built up for that campaigns needs to be done.

Then additional cost for bagging transport and marketing of compost. So, because we have to give commission to the dealers and so on. So, usually the final price is twice up that production cost and usually in 2015, the rate was around 4000 to 5000 rupees per ton, even though some ULBs do subsidize, they sell it at much, much lower cost.

But in general, if I really want to sell compost through a pan India distribution network, then for a large commercial composting plant, then this would probably the price that you have to sell it at. So, that is why the price is still not up high. And this also variation due to distance like these 1000 rupees variations is just what different distance of the final end consumer.

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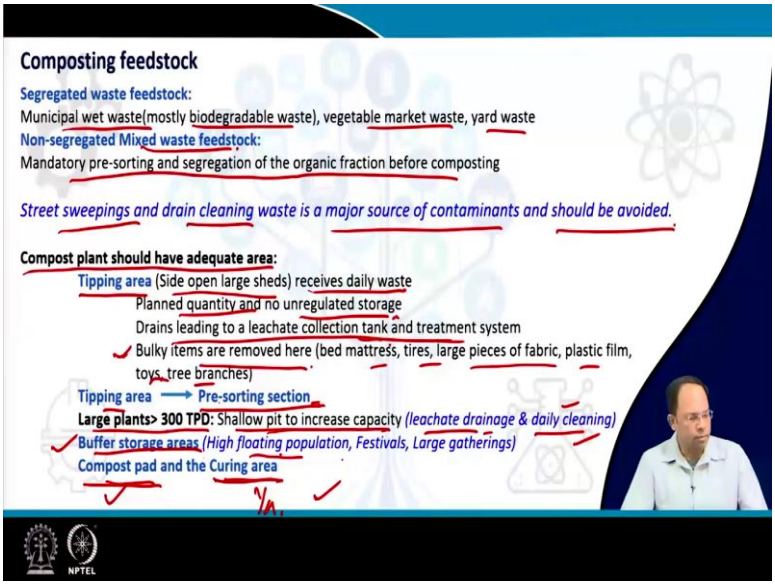

So, coming to the composting feedstock, if it is segregated waste feedstock that is mostly the municipal wet waste, which is biodegradable waste, vegetable market waste, yard waste then there is no problem. But if it is mixed waste feedstock that is the waste is mixed then mandatory pre-sorting and segregation of the organic faction has to be done for composting.

Street sweeping waste, drain cleaning waste, these are major sources of contaminants and this is absolutely this has to be avoided. So, this is something which we have to be careful about if this gets mix them the entire compost will batch will also get contaminated and we cannot use that as fertilizer.

Now, coming to composting plant, overall design, the first area that you have got it is divided into multiple zones. The first area is that tipping area. So, usually it is a side open large shade, it is a large shade with sides open this is the area which receives the daily waste and we have to plan it because composting takes a certain amount of time. So, we have to store waste for a certain amount of time. So, that means all the everyday waste comes from the urban area. So, we have to have storage capacity for holding waste for that much amount of time.

So, the quantity has to be really thought up accordingly the area has to be planned and unregulated storage is not there, that means we cannot store like some day it is more, some day less, someday we will not store that kind cannot, that kind of operation cannot happen. So, everything should be planned earlier.

Now, there the storage area has to have drains because it is organic waste lot of moisture is there, so leachate to definitely be generated. So, this leachate has to be drained by these drains and take into a leachate collection tank. And finally, it has to be (())(8:42) bulky items are removed. Like when it is organic garbage, lot of many things like bed mattresses, tire, large pieces of fabric, plastic film, particularly if it is a mixed waste, all these things are toys, tree branches, all these things remained mixed if it is a mixed waste, in case it is segregated waste maybe not too much a bulky items are there but still some remain. So, this can be removed in that tipping area itself.

So, from tipping area, the waste goes to the pre-sorting section. So, that is where we prepare the waste before it goes into the wind rows or goes into the actual garbage piles where it is composted. So, this pre-sorting section is where we remove certain amount of mixed you know larger size usually it is manual sorting is done, we remove some plastic part, some plastic bag or we remove some amount of papers may be removed something like those kinds of smaller things.

So, in case this tipping area is also the pre-sorting, then it moves to the pre-sorting area this particular waste and sometimes, we have in case of large plants, for example, more than 300 tons per day. Then we can increase the size of this holding area by creating a shallow pit, that means that because we create some extra volume below ground, but because we do that there has to be there will be a lot of leachate that will come out so, leachate drainage and daily cleaning of that particular area before we remove that waste to the next area.

So, all this thing needs to be calculated and this needs to be also daily those areas needs to be cleaned. And buffered usually we have some buffer storage areas as well areas we were there

a lot of these events, festivals, a lot of floating population, large gatherings and all so we need to have some I want a buffer storage areas as well in that plant.

Finally, from the pre-sorting section, the compost goes into the compost pad, where actually we create these piles of garbage which actually is composted. And then this after the basic composting process is over we leave the compost for curing that also requires some area usually this area is one forth of the area required for the compost pile. So, we have got compost pad and there is a curing area as well. So, these are the area which is required for setting up a composting operation or a composting plant.

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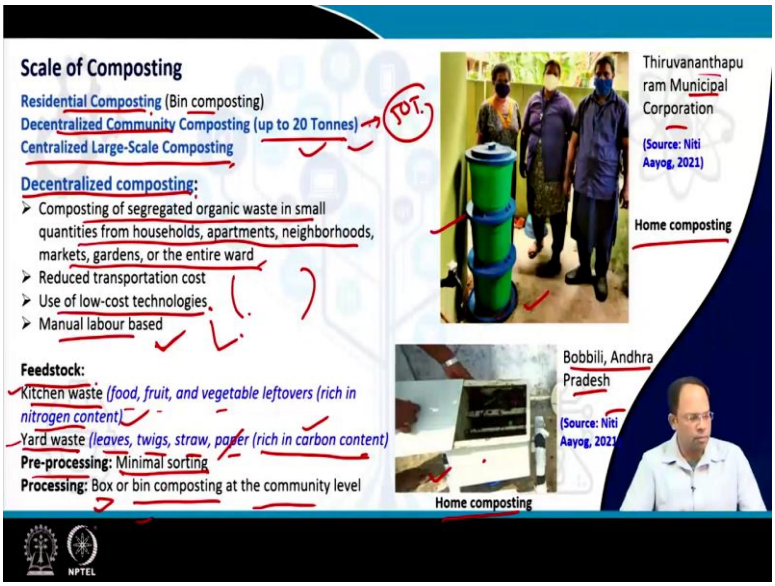

Now, composting can be done at multiple scales, it could be a residential composting scale that means it is done at individual residences, it could be done at a decentralized scale or it could be done for the community, here we can go up to 20 tonnes in some countries they may even go for 50 tons as well but in Indian conditions we can say around 20 tons is adequate, then, there could be centralized large scale composting in case the value exceeds this we can go for centralized large scale composting.

So, coming to been composting as you can see in these images, this is in Bobbili Andhra Pradesh. So, this is home composting is done this kind of a container or you can see like this kind of containers were provided by the ULB in case of Thiruvanthapuram Municipal Corporation and this is where home… This is how home composting or residential composting is done.

Now, when I talk about decentralized composting, of course it is a larger scale than this kind of operation. And here we also use different kinds of technologies as well, so I am going into that. So, decentralized composting means refers to composting of segregated organic waste in small quantities from households, apartments, neighbourhoods, markets, gardens, or even the entire ward and why we do decentralize composting because it will reduce my transportation costs.

And we can use the manual labour from informal waste collectors, ragpickers those people could be engaged with at the community level we can create some jobs and also, we can use low cost technologies we do not even have to invest too much into the composting process. So, whatever compost is produced locally also could be reused in the local parks and gardens and all and then you know, then we do not have to think about selling this compost as well.

So, this kind of operations are usually taken up at the community level or at the ward level maybe and this is usually taken up by self-help groups or informal waste workers who come together and they create a operation which is sometimes subsidized, sometimes not subsidized, sometimes it is a profitable operation, because recycling also is you know is done along in this particular centres. So, some amount of money is also generated by the central groups.

So, the feedstock that comes for this kind of decentralized composting is primarily kitchen waste, which is reach in nitrogen content because we have got fruits, food, vegetables, leftovers and so on. And also, yard waste also comes. So, either it is kitchen waste or yard waste which is generated in the gardens and all this. Now, yard waste has got leaves, twigs, straw, paper and so on.

Particularly you know this dry items, brown items, which is rich in carbon content. So, this is rich in nitrogen content and this is rich in carbon content. So, we have to mix them in a proper way so that we have got proper CN ratios good for composting. So, some amount of sorting is required minimum sorting is required in the pre-processing stage because still as we say that even though we sought at the household level, some contaminates remain that needs to be removed, and then processing is done by a box or been composting at the community level. So, we will learn about how what is box a composting and been composting. So, these are two techniques of composting, which could be adapted at the community level.

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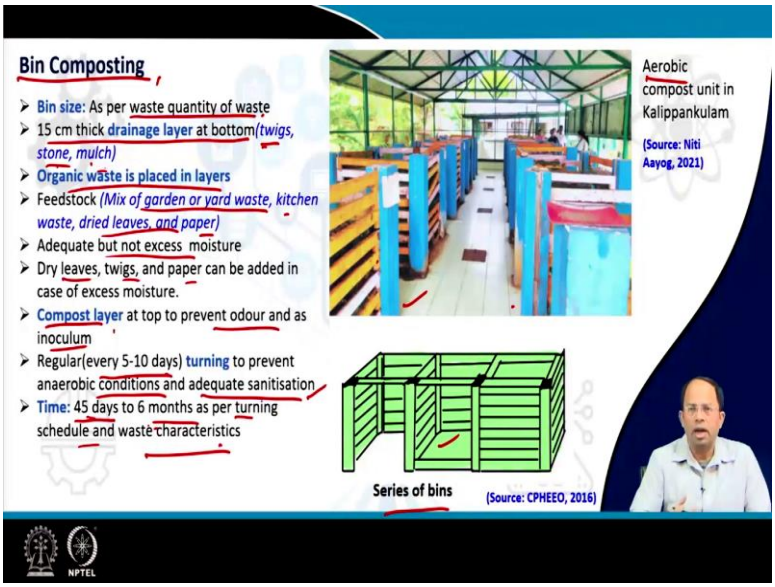

Now, in this image, you can see those box composting it is pretty as the term in referes to these are boxes either it could be a series of boxes, like over here or it could be individual boxes as you can see in this image and here the you know, so sorry these are bin compost, these are bins. So, the first we talked about bin composting. So, the bin size is determined as per the quantity of waste is generated at that particular community or that particular ward, and the bins as you can see is designed like this, the walls are perforated so that it allows air to you know mix, so it is an aerobic process.

And 15-centimetre-thick drainage layer at the bottom, this is prepared using twigs, stones and mulch, mulch is like made of organic matter like trees, leaves and all these things which is not composted, but it is a gradually decomposes to a certain extent but we call them mulch because it takes a long time to decompose as well. We sometimes sprayed this in the gardens and all instead of making compost we just sprayed those leaves all around and automatically eventually they will mix with the soil.

So, this kind of material is usually laid at the bottom, so it acts as the drainage layer which allows the leachate to pass through and the leachate is of course collected, organic waste is placed above this in layers and usually the feedstock is mix of garden or yard waste, Kitchen waste, dried leaves and paper, moisture is also provided but it should be adequate not excess because excess moisture will lead to excess leachate production.

If we find the moisture is too much in the waste then we can add dry leaves twigs and paper which will reduce the moisture content. Finally, at the top we provide a compost layer which not only provides insulation at the top but also prevents odour and acts as a inoculum each

starts up you know this composting process and every 5 to 10 days we turn it regularly to prevent anaerobic conditions and also adequate sanitization of the entire mass, so that was intake heat is produced so that the overall compost is sanitized.

So, the total time taken could be from 45 days to 6 months as per the turning schedule and waste characteristics. So, that means as per the waste characteristics or how much often we turn it, it may take from 48 days to even 6 months for the organic matter to convert into compost using bin composting.

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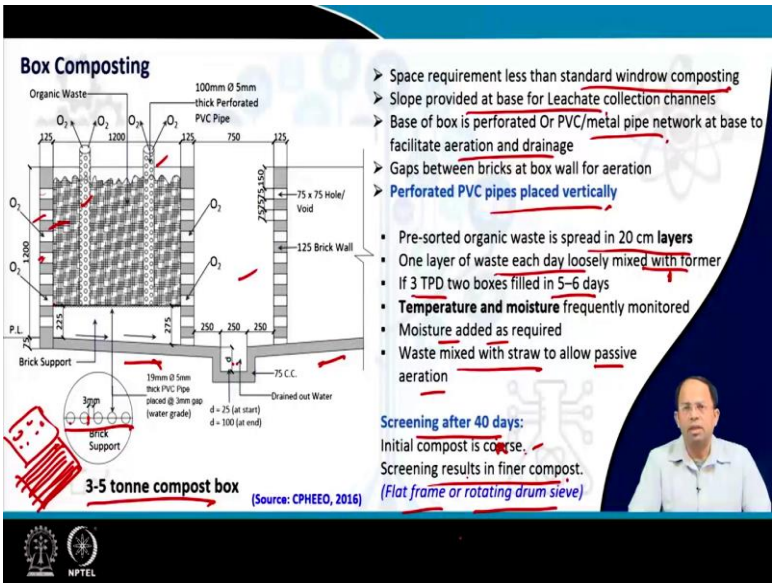

Then we come to box composting, it is similar to a bin composting but with some changes as you can see in this particular image, this is the structure the floor is sloped so that the leachate is collected in the drains and the bottom of this is looks like this. So here either I can have a base which is perforated for the moisture to come out or I can create the base with a you know some pipes so that automatically there are gaps between the pipes like over here and the moisture can come out.

And inside also the walls are also perforated like in the previous image we saw the walls have been gaps have been left in the wall. Here it is a brick wall because it is a larger in size, it is a 3 to 5 ton compost box, here also some gaps in the bricks are kept, so that moisture here can actually you know go through. And in between the compost also we keep some perforated pipes which actually takes the oxygen inside and also helps him release of the gases as well.

So, space requirement is less than standard windrow composting, we will learn about windrow composting in the next lecture, but windrow composting is basically where we pile

the garbage in large shapes in a you know garbage pad or you know compost pad. So, it is less than that slope is provided at the base, the base is perforated or PVC metal pipe network, which facilitates aeration and drainage. And then perforated PVC pipes are also placed vertically as I in lecture discussed.

So, pre-sorted organic waste is sprayed in 20 centimetre layers one after another. And when one layer is added this layer comes as the as every after certain days, new waste after each day new waste comes in and it is laid out in layers one above another. And whenever one layer of waste is added we loosely mix it with the former layer by we disturb the upper layer of that waste and we mix it so that the bacteria that is there in the bottom layer will also move up to the upper layer as well.

So, usually if you say that if 3 tonnes of waste is generated per day, then it takes about 5 to 6 days to fill this kind of a box, temperature and moisture is frequently monitored in this particular boxes. And if these find the compost is dry then you have to add moisture and sometimes if you see the moisture is too much or we see the compost is compacted to allow passive aeration we mixed straws and other kinds of dry matters so that there is gaps inside the compost and air can pass through.

So, after 40 days it takes roughly around 40 days for the compost to be ready which is a little bit lower than the last one in case of being composting. And after then we scream the compost and initial compost… The compost that is produced initially scores as we have discussed sorry is course. So, we need to put it through a screen. So, the larger particles are taken to maybe some may be taken to RDF plant.

So or the smaller particles can be again used a screen for the you know we can you know put it as covered as insulation for the other compost and this screening process results in the finer compost and this could be achieved by a flat frame or a rotating drum sieve and the screening process actually prepares the compost for the next stage which is curing or maybe some amount of screening could be done even after curing and after that the compost is ready to go to the market.

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So, over here you can see box composting happening in Keonjhar Municipality over here you can see the boxes, there are some pipes, these are the pipes which are for aeration and this kind of stuff and also some conveyor belt segregation of biodegradable waste. So, some amount of segregation, mechanical segregation is being done using conveyor belts over here and garbage is taken along the belt and some amount of segregation could be done.

And finally, this is a micro composting centre and the organic manure that is produced over here is branded as 'Mo Khata' and sold at rupees 20 per kilo grams at outlets throughout this particular state. So, that is how composting, this micro composting centre is operated at your municipality.

Then in Vijaywada Municipal Corporation around 190 tonnes of organic waste is processed for composting in food, decentralized waste to compost plants. So, this is one of the plants you can see in the image. So, all biodegradable waste comes here it is put inside a shredder. So, it is shredded into smaller particles over here, then these particles are put inside the boxes where it is composted. So, this is box composting also happening in Vijayawada Municipal Corporation.

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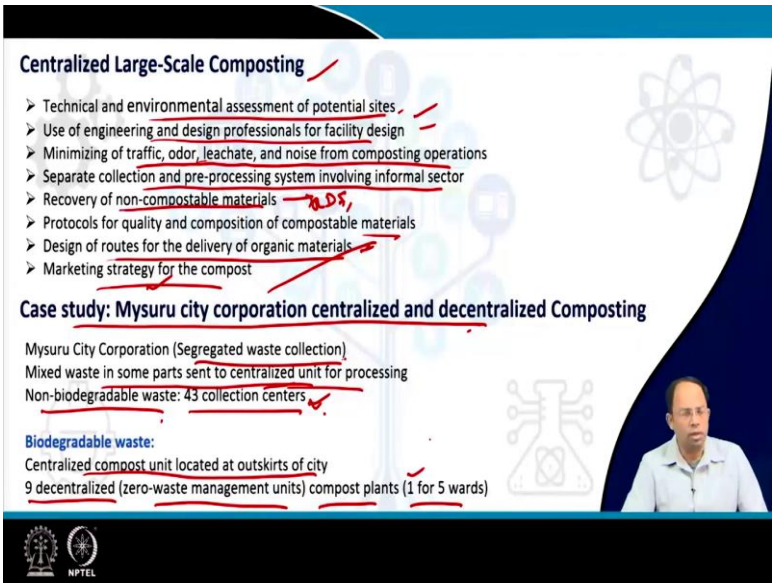

Then coming to centralize large scale composting, this is where plant sizes can reach around even 500 tons per day that means 500 tonnes per waste tonnes per day. So, definitely we have to do you know a proper analysis of the location of the plant or the design of the plant has to be thought up properly. So, technical and environmental assessment of potential sites has to be done like we have learned about this analysis for site for a landfill, similar… We will learn about that or similarly we can also do the analysis for potential site for, a composting site as well.

Use of engineering and design professionals for the facility design proper it has to be designed particular procedures, we have to minimize traffic odour, leachate and noise from composting operations because it is a large plant, it is like, it has to be set up in an industrial area. So, it cannot be set up like in the normal residential areas. And we have to minimize all these.

Separate collection and pre-processing system involving informal sector. So, we can do pre-sorting involving informal sector. And we have to recover non-compostable materials some can go to RDF and some can go to as process rejects to the landfill site as well. Protocols for quality and composition of compostable materials, design of roots of the delivery of the core organic material and marketing strategy or compost.

So, all this needs to be worked out for us centralized large scale plant. Why? Because this requires a lot of investment. So, if we are doing proper investment, we because a lot of money is involved, we have to do proper analysis for which locations are suitable. So, that later on there are no protests, which can what should be their proper design, so that the

resulting compost is a proper quality, we have to also do marketing strategy for the compost that is being produced and also designed routes and all for distribution of this compost. So, that overall the system is successful and there is no loss of demand after a certain amount of time.

So, we do a case study of Mysuru Municipal Corporation, which goes which does both decentralized and centralized composting. So, segregated waste is collected in Mysore and this is being composted, mixed waste is also there in some parts, which is not sent to the decentralized plants but goes to the centralized unit. And also, non-biodegradable waste is collected Mysore which goes to 43 collection centres.

So, this is where the waste gets segregated and recycling takes place. So, in, but for, wet waste, we have this both a centralized plant as well as decentralized plants. So, the centralized compost unit is located at the outside the city whereas, 9 decentralized zero waste management units that is what they call them or compost plants is located inside the city and one for every 5 wards. So, that means one plant has been created for every 5 wards.

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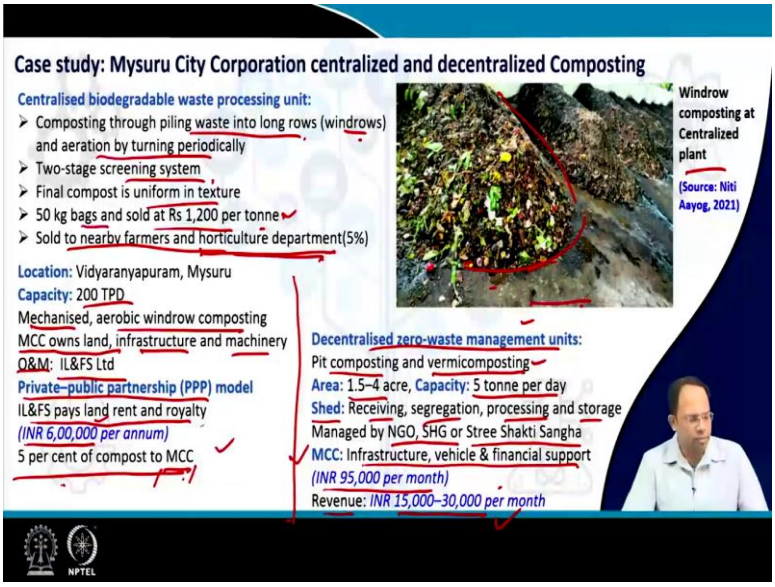

So, over here you can see a windrow that is in the centralized compost plant in Mysore, this is how the windrow has been created, that is how the garbage has been stacked and this is left for a certain amount of period then it is turned as well, how do we turn it and all this we will learn that in the next lecture, but this kind of windrows are being utilized and compost is done through piling waste in long rows which is known as windrows and aeration by tanning periodically.

So, we turn the garbage after certain intervals. Then once the garbage becomes compost to stage screening is done, final compost because of the screening becomes uniform in texture and 50 kg bags are being prepared and sold at rupees 1200 rupees per ton, so amount of the cost is not that high. It is sold to nearby farmers and this operation is done by a private of company of course, and some amount of this compost is used by the Horticulture Department of the city for application in the urban areas.

So, the plant is located at with the Vidyaranyapuram Mysore and capacity is 200 tonnes per day Vidyaranyapuram sorry, mechanized aerobic windrow composting, so it is aerobic windrow composting and it is the turning is done by a mechanized process we will learn in details later. The corporation owns the land, the infrastructure and the machinery that is being utilized whereas the operation and maintenance is done by IL&FS which is a private infrastructure company.

The overall model is a PPP model, where both the government and the private company works together IL&FS pays land rent and royalty to MCC. So, that means they pay some amount of money for utilizing this particular area as well as royalty for production of compost. So, the profit they make by selling compost is that is what the company keeps, but they will pay around 6 lacks rupees per annum to the corporation, so that they can as a royalty or as a token amount. So, that this operation can happen. 5 percent of the compost that is being produced is also given back to MCC, which MCC is utilizes the Horticulture Department of MCC utilizes for their use in the local in the urban parks and gardens and so on.

Now, this is the centralized plant, whereas in the decentralized Zero Waste Management Unit, the composting happens via Pit composting. So, that means the compost is done in sort of a chamber it is a pit and vermicomposting also take is utilized, we will learn about again vermicomposting process later on where we use earth warms for the composting, area of each of this is around 1.5 to 4 acres. So, this sort of areas needs to be also, put in development plans, so, that we reserved these kinds of areas in development plans for this kind of composting operations, capacity of these plants around 5 tonnes per day.

So, that each of these decentralized unit have got a shade which receives segregates, processes and stores the waste that is received, this is managed by NGOs, Self-Help Groups or Stree Shakti Sangha, where women are being empowered to you know, run this kind of operations. MCC infrastructure vehicle and financial support is given by MCC and they pay

around 95,000 rupees per month, revenue coming out of this which is kept for the self-help groups or the people who are working there which comes to around 15,000 to 30,000 rupees per month. So, that is by selling the compost.

So, this is what it looks like. So, decentralised operation is actually not profitable. But we because it is decentralized a lot of we save on transportation cost. We save on you know this particular compost could be utilized locally. And so, on so there are a lot of environmental benefits as well. But in centralized plant there is of course profit by selling of compost.

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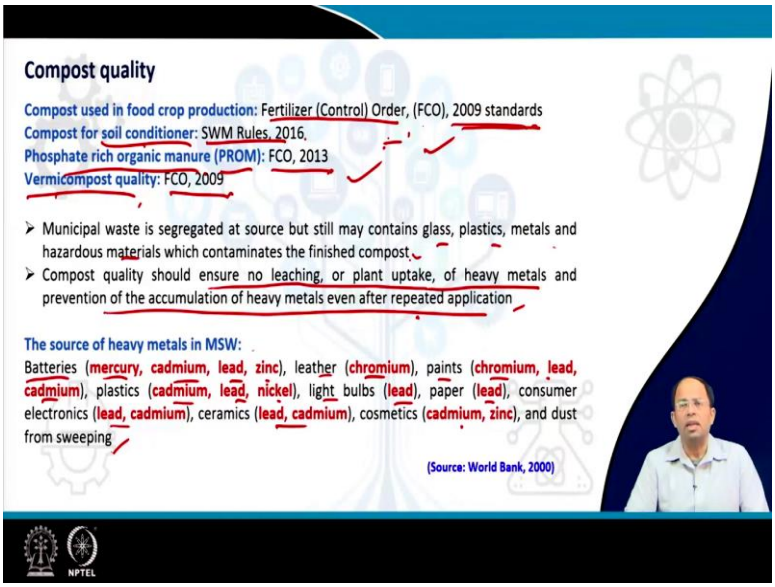

Then coming to the final product quality or the compost quality and compost is used in food crop production it could be used in soil conditioner. Some special compost could be produced like phosphate rich organic manure prom, which we discussed earlier. Then vermicompost is also there, vermicompost is compost by earth warms.

So, each of them has got certain standards and the standards are usually prepared by fertilizer order, you know, control order FCO, this is by the fertilizer control fertilizer departments of the government, and there are 2009 standards. And so, FCO has given this to in 2009, they have given the standards for organic fertilizer.

Similarly, solid waste management 2016 has also given us certain standards for compost which would be used as soil conditioners in the urban area, then PROM has got certain standards. And similarly, vermicomposting has also got some other standards. Now, what are the standards and all, I will come to that.

So, municipal solid waste is segregated at source but still contains glass, plastic, metals and hazardous materials, which contaminates the finished product this we have learnt earlier. And so, that means, we have to make sure that the final compost is of proper quality this kind of contaminants are not there, that is why we have created this kind of standards. So, that we can check against those standards if the compost is of adequate quality or not, then compost quality should ensure no leaching or plant uptake of heavy metals and prevention of the accumulation of heavy metals even after repeated applications.

So, what does that mean? That means compost should not have heavy metals or it should have heavy metals as per the standards, the heavy metals should be such, the standard value should be such that even after leaching or uptake of the nutrients by the compost. And even after repeated application of the compost yearly that means, over a period of years, the total concentration of heavy metals will gradually increase, but overall the plant we should not have this concentration of heavy metals which should be harmful for human health.

So, the initial standards has to be set considering all this. So, that is why we have to be very careful while setting standards for compost. And why? Because this is municipal waste we are talking about and municipal waste contains batteries which contains heavy metals such as mercury, cadmium lead, zinc, leather, which includes chromium, paints chromium, lead cadmium, plastics includes cadmium, leads, nickel, light bulbs has got lead, papers has got lead, consumer electronics has got lead and cadmium, ceramics has got lead and cadmium, cosmetics, dust from sweeping. So, all this includes a lot of heavy metals. So, these heavy metals should not come into the agricultural phase. So that that is our goal. And because we are dealing with urban city compost this we have to be very, very careful about, that is where all these standards come into place.

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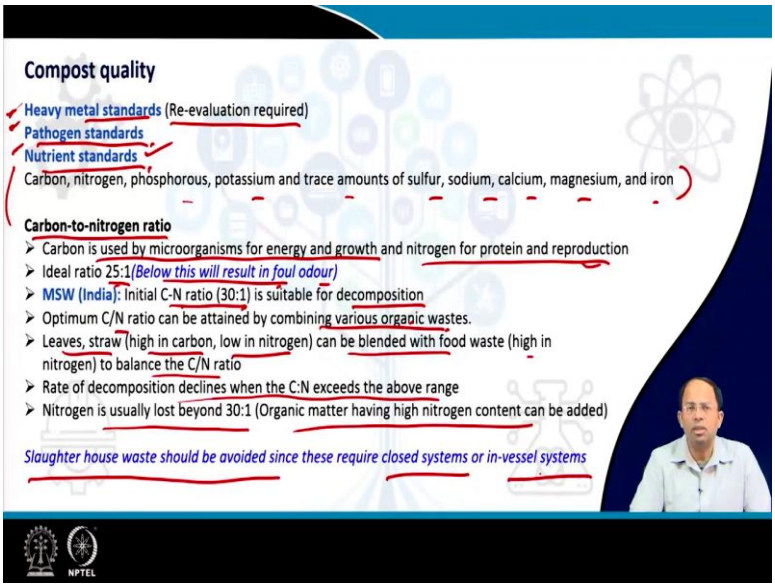

So, we have got heavy metal standards, these standards also needs to be re-evaluated after certain time periods that means up to maybe 5 or 10 years, the standards needs to be revised as part the health concerns or of that particular community or of that particular society. So, standards can be improved upon like earlier the standards were poor, but the more we progress, the standards are set higher and higher. So, that the final product is better and better.

Then we have got pathogen standards, that what sort of pathogens are allowed at the end, that means composting is a process where there are microorganisms and then there are pathogens. So, at the end there should not be any pathogens left in the compost, then nutrients standards, what should be the contents of the micro and macronutrients, so that it is beneficial for as a fertilizer. So, those standards also has to be maintained.

So, carbon, nitrogen, phosphorus, potassium, trace amounts of sulfur, sodium, calcium, magnesium and iron, these are the different nutrients that we are talking about. So, this sort of three standards has to be there. That means it maybe one set of standards for the compost, but actually we have to look into these three sorts of items that should or three groups of items that should be considered while we set a compost standard.

Now, compost should also have a desired carbon to nitrogen ratio. Usually this the value is 25 is to 1 for carbon to nitrogen, and carbon is used by microorganisms for energy and goods. So there has to be adequate carbon in the organic waste otherwise, the process will not happen properly and nitrogen is required as protein and reproduction for because you need to create more microorganisms. So, you require protein. So, nitrogen is required for reproduction of that microorganisms.

So, ideal ratio is 25 is to 1, but if it is lesser than that, then it will result in foul odour, that means carbon value is less and somehow it results in more odour and the process takes longer time and so on and also some anaerobic process starts happening. So, in India we usually find the CN ratio is around 30 to 1 which is suitable for decomposition.

So, it is suitable of course is 25 is to 1 but even 30 is to 1 is fine. So, in case the CN ratio is not proper that means, we get a sort of waste where there is a lot of food waste, but there is no your nitrogen, no carbon in it. So, in that case I have to mix materials which will bring in more carbon. So, that means we have to combine various kinds of organic waste to reach that desired CN ratio before we start the composting process.

So, leaves, straw which are high in carbon but low in nitrogen can be blended with food waste, which is high nitrogen to balance the CN ratio, rate of decomposition declines when CN ratio is above ranges, and nitrogen is usually lost beyond 30 is to 1 and organic matter having high nitrogen content could be added in that particular case. Now, sometimes slaughterhouse waste is also added in the composting but in that case, we require special composting systems such as closed systems or in vehicle composting system to actually deal with slaughter house waste.

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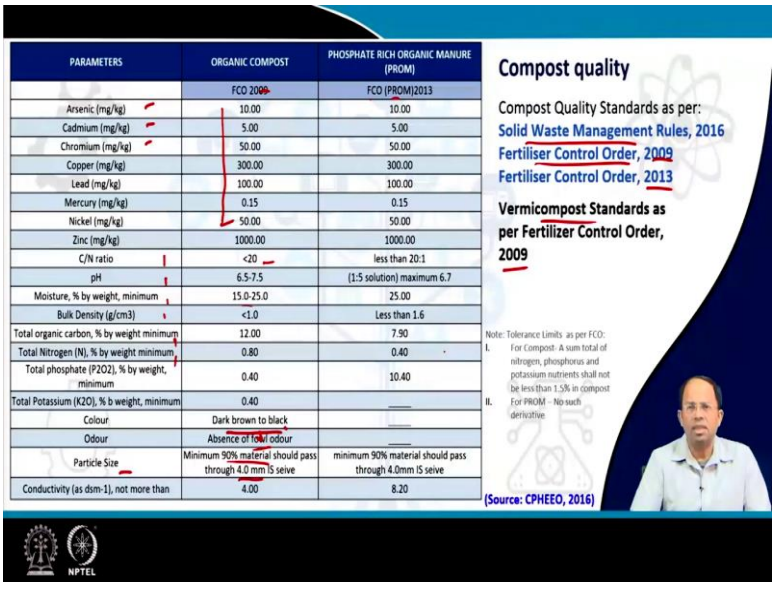

So, now coming to the compost quality, this compost quality standards are set as per the solid waste management rules, fertilizer control order 2009, 2013 And then there is the vermicompost standard again, which has been created in 2009. So, as you can see, the first group are the heavy metals arsenic, cadmium, chromium, so this standards are same for both PROM as well as FCO then there is the you know that the CN ratio, pH, moisture, bulk

density, these are the characteristics of the compost so, that values are given, same ratio is should be around 20 is to 1 less than 20 is to 1 final CN ratio, then pH is 6.5 to 7.5 moisture is around 15 to 25 percent the final more you know the content the compost that how it should have bulk density is less than 1 this is percentage of weight and so on.

Similarly, for particle sizes, all particles should pass through a sieve of 4 millimetres size and it all means 90 percent of the material should pass through. So, that means the compost should be of so small that it should pass through a 4-millimetre size, the odour should there should be no foul odour and the colour should be dark brown to black. So, these are the characteristics that has been said. So, we have to check the final compost against these characteristics and if we are compliant, then the compost is fine for use.

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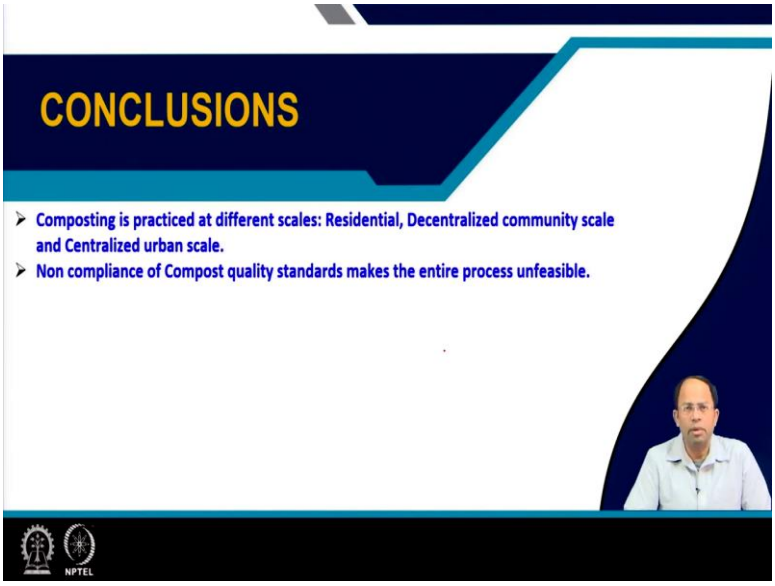

So, these are some of the references you can use. And to conclude, composting is practiced at different scales, residential scale, decentralized community scale or centralized urban scale. Non-compliance of compost quality standards makes the entire process unfeasible. So, that means we should be careful that when we design our processes in the centralized plant or decentralized plant, we have to make sure the final compost quality should be as per this quality standards set. Thank you.