Municipal Solid Waste Management
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Lecture - 27
Types of Composting – II

So, hello students, so, we are on module 9 biological transformation where we are talking about composting. So, in the previous class, I shared about types of composting that was the conventional composting process. Also, I had to explain 3 methods, the popular methods I had explained. The first one was the windrow method or pile method that normally caught is an agitated pile composting process or vegetated windrow composting process.

Second was aerated pile where aeration is very important. Third was in-vessel composting process. So, in this lecture, we are going to talk about in-vessel composting and also I will cover whether the centralized composting process is more beneficial or decentralized composting is more beneficial and which is also when you talk about decentralized composting, this in-vessel composting process is very good for the decentralized composting system.

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So, this is what the in-vessel the name itself vessel understandable. So, in-vessel means the composting process inside the vessel, the vessel could be vertical vessel could be horizontal, but these are inside the vessel and the idea behind this method was, because if you talk about the

disadvantages of the conventional system like windrow or pile method the disadvantage is that the space requirement is very large.

It is again dependent upon the local climatic conditions because it is open to air, so, obviously it will affect more with the season and also in the rainy season it is very difficult to go for windrow or pile composting method in the centralized location where large amounts of waste is coming to only one location, so, that was the idea if the entire process will be in the in-vessel.

So, it will not have much climatic issue will further degradation process and also in the rainy season it will not be much affected, why because inside the vessel. But now, the major is that if it is inside well vessel again you need to remember that the aeration is very important because again I am saying that composting is an aerobic degradation process. So, obviously, if it is not the vessel also how best you can aerate the mass inside the vessel.

Based on that, there are different designs available, like if you see here, the bin or tumbler composting. So, here you can see that is the open area, this is for the aeration process like here also this is the opening under even the other products also you will see that the openings are available for the aeration process.

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Like this is another one, this is the drum rotary drum process. And this is another box kind of composting process you see here the by that air is getting inside the box and also this is for the

leachate collection or excess water collection. So likewise, there are different vessels are available.

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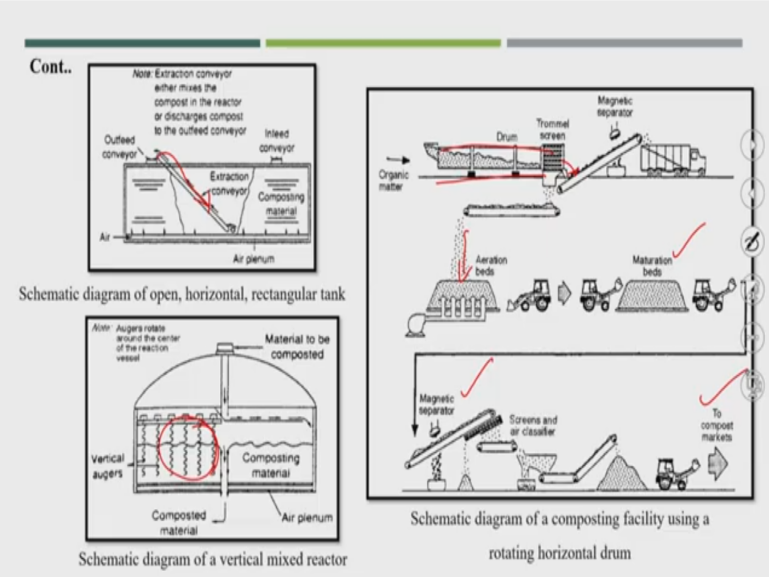

Now, what configuration is important for the in-vessel systems? So first is the horizontal drum or vertical silo that is also in the drum type or box kind of vessel. Open tank so, here this is a plug flow horizontal reactor. So, here material is entering from this particular area and this is composted. This is where the entire degradation is possible and this is the air distribution and the air is coming out also such as the gases like carbon dioxide will come up that also the collection system is available into such kind of system.

This is the vertical silo of vertical reactor. So, here the material is getting entered into the vessel this is the composting area under air is provided for the aerobic degradation process and here you will get the final product i.e., compost. So, likewise this is another one the open horizontal rectangular tank. So, this is also similar above only here one conveyor is provided for feeding the material inside the reactor.

So, likewise this is another vertical mixed reactor. So, here are the augers are provided these are the augers so that the mixing also is possible. So that the entire waste will get degrade together. So, here is the entire schematic diagram of horizontal rotary drum composting process. So, here now, you start from here. So, this is the drum so, initially the organic matter will go for composting.

But after that whatever the compost is produced, from that with the magnetic separation, the metal part will be removed out. Again it will go for the aeration process and again for maturation process and finally, again magnetic separator and finally, the product will go to the market. So, likewise, this is the schematic diagram of in-vessel composting process.

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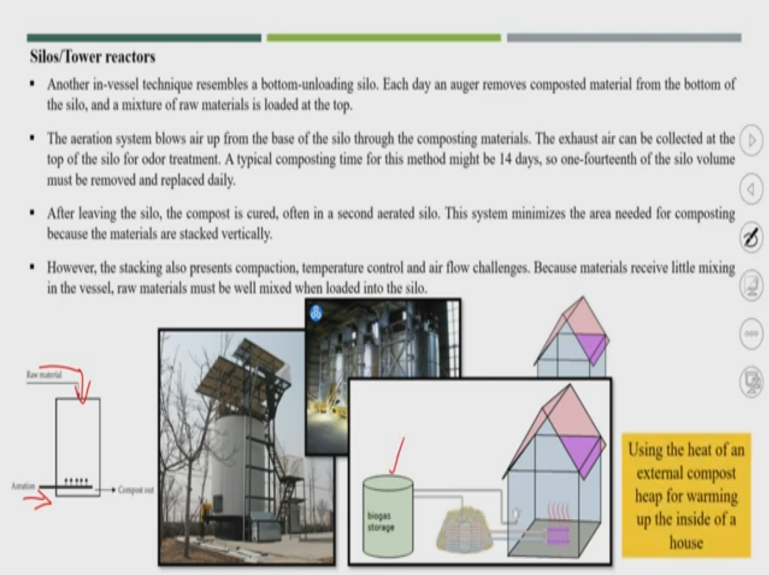

Now, this is another one like Silos or tower reactor. So, now, here you can see by photograph like this will be a vertical tower under from bottom the aeration will be available under the raw material is loaded from the top. So, the technique of bottom unloading Silo each day an auger removes composting material from the bottom of the silo and a mixture of raw material is loaded at the top.

The aeration system blows air up from the base of the silo through the composting material and the typical composting time for this method might be 14 days see that this is another benefit of the industrial composting process where the degradation period is just 14 days or a maximum of 20 days you will get the proper degradation process. Now, this is the silo you can see or vertical tower so, there are a number of silos. So, whatever is the energy also is producing that also is possible to use for the biogas reactor. So, using the heat of external compost heap for warming the inside of the house, that is also possible

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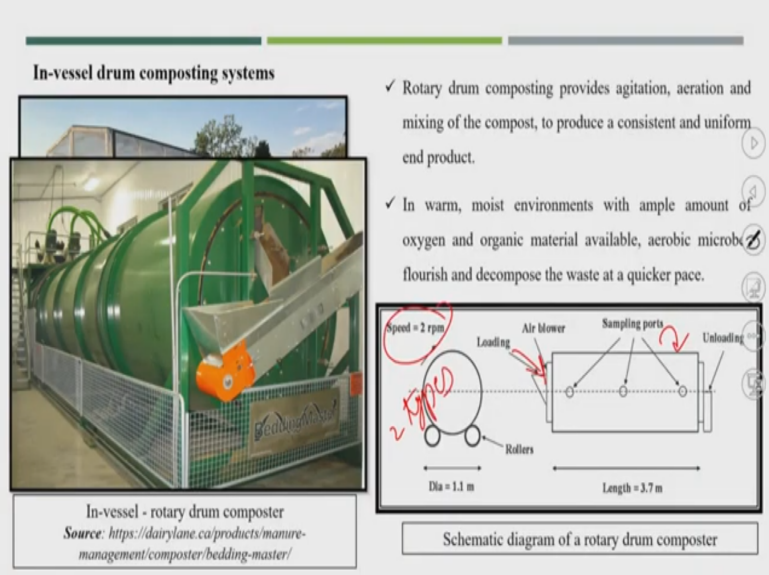

This is another kind of in-vessel drum composting system. So, this is another so, there are a number of private companies especially in the European countries they started the design in a different way of in-vessel composting. Why I said that for the European countries because the climatic condition there is not that good for the degradation process. The temperature will be maximum 20-25°C.

So, their degradation is not very fast. So, by putting the entire feed or entire material inside the vessel, they will be able to get more thermophilic temperature by providing more amount of air for the degradation process. Because of that, not only that composting is possible in such kind of area, but also the degradation time also will be very low, maybe 15 days or 20 days we will be able to produce good quality compost.

So, in the rotary in-vessel rotary drum composting process provided agitation aeration and mixing of the compost to produce a consistent uniform end product. So, this is one of the very important or major processes in the in-vessel composting process that is rotary drum. So, in warm moist environment with ample amount of oxygen and organic material available, aerobic microbes flourish and decompose the waste at a quicker pace.

So, this is another schematic diagram. So, this is the loading or feeding under this is getting turned. So, speed is 2 rpm. So, maybe you need not turn every time only maybe 2 times in a day you will be required for turning off the rotary drum.

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This is another unit of the rotary drum. So, a drum about 3.35 meter in diameter and 36.58 meter long as a daily capacity of approximately 50 tons with a residence period of see here residence period is 3 days this is what the major benefit. So, you see here the capacity is also 50 tons, now for 50 tons per day for windrow composting facility will be required huge amount of area for the degradation process and even degradation time also it goes to minimum 30 days and maximum goes to 90 days.

But even 30 days also is very difficult to get proper degraded or proper compostable material, but here you see just for a residence time of 3 days, though 50 tons of organic matter is getting degraded. But I believe that in 3 days it is very difficult to get the complete degradation. So what could be possible that in 3 days, the thermophilic condition will get over and after that, once it is in the maturation period, you need not put it into the Rotary drum.

For maturation you can again come up with the windrow kind of facility and there rather other than waiting for 30 days 40 days, within 15 days of maturation period, the product will be available as per the requirement of the market. So, in that drum, the composting process starts quickly and the highly degradable oxygen demanding material are decomposed for the

decomposition he accomplished through a second stage of composting usually in the windrow or aerated static file, this is the second stage.

So, the first stage is the rotary drum and the second stage is windrow aerated static pile degradation will be required air is supplied through a discharging and is incorporated into a material as it tumbled once it will turn. So, air moves in the opposite direction to the material. So, from the backside air is discharged into the reactor. So, this is the small reactor. So, this is a batch process. The batch process means only once in 15 days you can feed this reactor.

So, you have to again wait for 15 days and then once that 150 or 200 kg of waste will get degraded in 15 days. After that, you can again feed after 15 days and that is why it is called is a batch reactor. But earlier reactor what I had shown that is a Fed-batch reactor. Fed-batch means every day you can feed the material and every day the product will come out from the reactor. The drum can be open or partitioned.

An open drum moves all the material continuously in the same sequence as it enters the speed of the rotation of the drum and installation of the excess of the rotation determines the residence time and in some commercial system the composting material spent less than 1 day in the drum, see only less than 1 day that degradation could be possible, but it is very difficult. But if you are thinking about kitchen waste highly degradable material and not in one day, but 3 days, 4 days the entire thermophilic degradation is could be possible.

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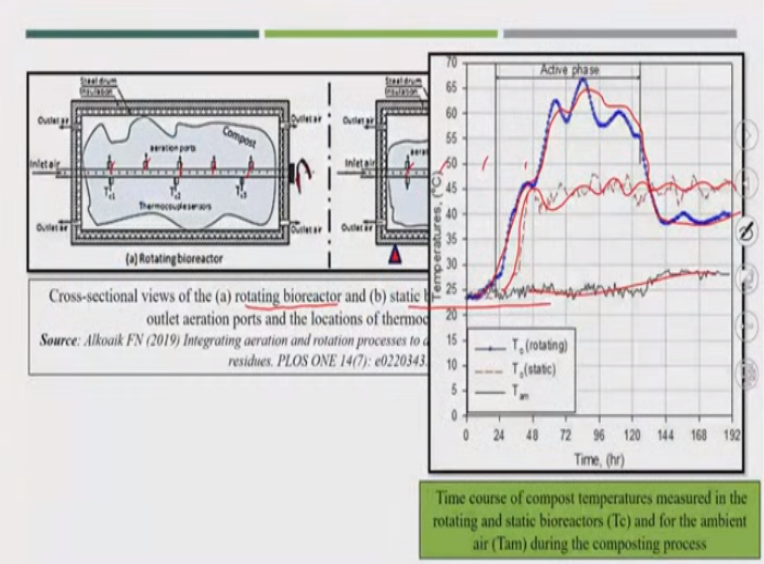

Cross-sectional views of the (a) rotating bioreactor and (b) static b
outlet aeration ports and the locations of thermoc

***Source**: Alkoaik FN (2019) Integrating aeration and rotation processes to a*
residues. PLOS ONE 14(7): e0220343.

Time course of compost temperatures measured in the rotating and static bioreactors (Tc) and for the ambient air (Tam) during the composting process

So, here are the other, it is the cross-sectional view of the rotating bioreactor. So, here the explanation about rotating bioreactor means is a rotating reactor and this is a static reactor. So, here are the aeration ports here available this is the aeration ports. So, if you see the temperature in both reactors, nowhere you see that this is the temperature of the rotating reactor and this is the static reactor.

You see the compare both the temperature if you rotate that temperature goes up to 65 to 70°C temperature but if you are not rotating then you will get a maximum of 45°C. So, difficult to achieve the thermophilic degradation process this is the ambient temperature. Now, again you can see them here.

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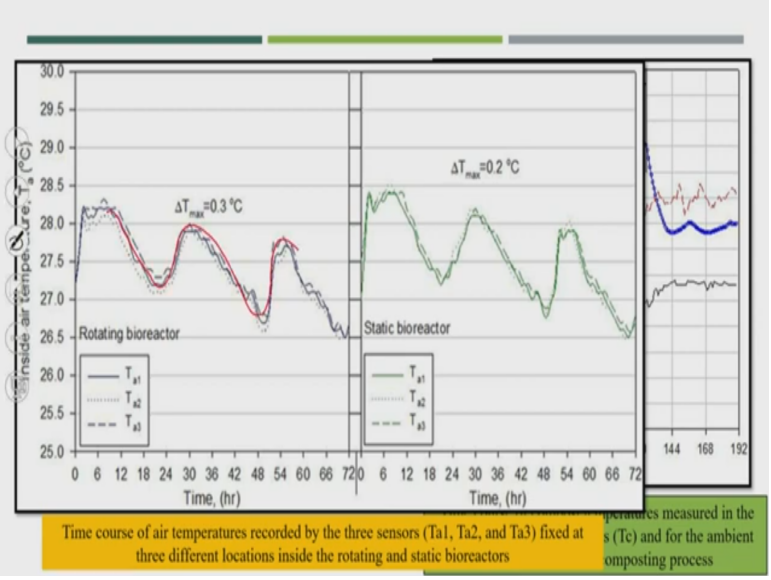

So, the rotating by reactor this is the while after turning the temperature will reduce down for every turning. And here also the static reactor temperature will be lower down but still the rotating reactor you will be able to achieve very easily thermophilic conditions.

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This is another system that is Ridan composter is a simple economic solution for the industrial composter range of this company coming from the UK, this is the Ridan composter.

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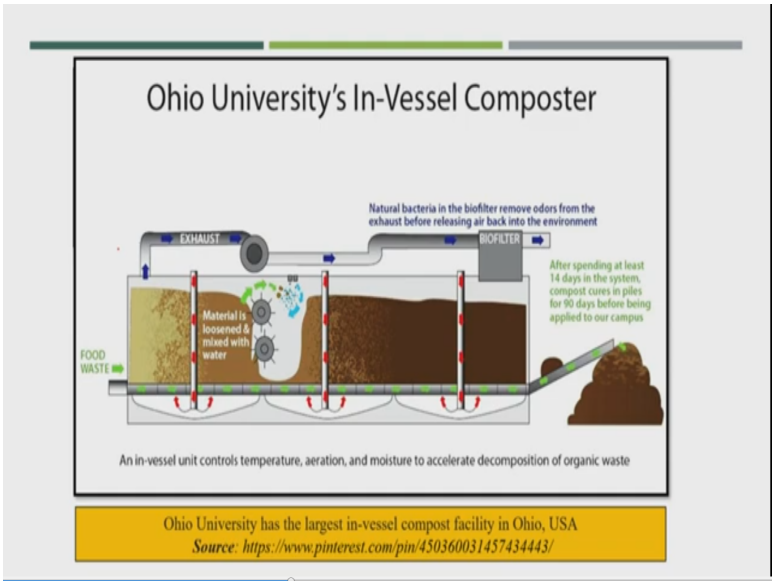

This is another technology that Ohio University in-vessel composter. So, the idea the mechanism is same, what exactly is the mechanism the entire material will be inside the vessel and how based you will be able to feed the year so that the thermophilic condition could be possible to achieve and in the limited period how based we will be able to degrade the material. I am not saying that within 3 days, you are required to get the product but at least for 7 days, 8 days, or within 10 days.

If you are getting the matured material that will be highly beneficial in such a reactor. So, there are a number of private companies that started their own technology by designing different kinds of reactors or majorly the rotary drum composter. So, the diameter has not been increased as much that diameter started from 1m to 3m or 3.5m because that particular reactor is required to turn. So, the diameter has not been increased, but the length has been increased up to 35-40 m. So, that the daily feed could be possible, and the entire reactor can be run for 60 to 70 days continuously because of the length that has been increased.

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Novi-Comp design - perfecting the best sizing, insulation and speed of rotation, eliminating corrosion internally
Source: https://novid.ca/2019/06/13/the-in-vessel-compost-solution/

One operator can handle the entire composting process because of the automated features
Source: https://xactsystemscomposting.com/composter-rotating-drum-technology/

This is another reactor Novi-Comp design that is the best sizing, insulation and speed of the rotation eliminating corrosion internally. This is the blade is available in this reactor. So that the entire material will get mixed completely. So, feeding these reactors is the same reactor that you can see.

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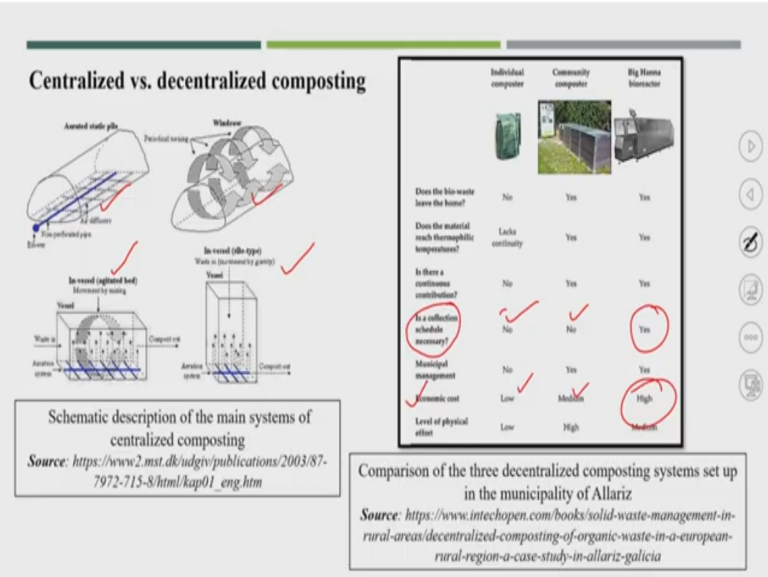

Schematic description of the main systems of centralized composting
Source: https://www2.mst.dk/udgiv/publications/2003/87-7972-715-8/html/kap01_eng.htm

Comparison of the three decentralized composting systems set up in the municipality of Allariz
Source: https://www.intechopen.com/books/solid-waste-management-in-rural-areas/decentralized-composting-of-organic-waste-in-a-european-rural-region-a-case-study-in-allariz-galicia

Now, few people have understood, why this rotary drum is highly beneficial. Again, I will show some model slides onto the rotary drum. I will take one case study onto that. But before that, we will just compare centralized composting with decentralized composting. And I believe that one of the very important issues especially in the South Asian countries or India, because we started the centralized composting long back in 1970-75.

But still, we do not have a proper composting facility in India, because, the point is that segregation was not possible. But under the Swatch Bharat mission, segregation is possible now. But again, the problem is one particular location, if you are receiving 200-300 tons in a day, so, how big area will be required and you cannot just believe on to the windrow system, you know, because there are a lot of issues regarding the windrow system.

And you also require to produce a good quality compost for sustainability because that mark that particular product has to be sellable into the market, otherwise, the entire compost plant cannot be sustainable. So, need to be discussed that whether decentralized composting could be possible because the benefit of decentralized composting is not only that, the scale is small. So, obviously, the operation maintenance will be not that high.

And also your collection of that entire material will not be required, so, the entire collection cost of 200-300 tons will not be required, but the problem in the decentralized composting is that the local people should accept such kind of facility to their nearby locations. So, now, here I am showing these photographs like this is the centralized facility either we can go for aerated static pile or windrow facility.

And if you go for decentralized one, we can go for in-vessel either for a vegetated air or is a horizontal reactor or vertical reactor could be possible because size is small here. So, now, here I am comparing that the individual community composter and one particular bio-reactor. So, if you see that the bio-waste leaves the home, especially if the collection schedule is necessary, no here does not require it. But for the large scale or centralized facility will be required schedule of collection and even though you see the economic cost is very low compared to the centralized facility.

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So here the first case I am explaining that is a centralized composting facility. So I take an example of a centralized composting plant at the Boragaon dumpsite of the Guwahati is a northeast state of Assam. The Guwahati has this compost plant has been come up in 2007-2008 under the JNNURM scheme, because they are the PPP projects has been come up in JNNURM scheme. So one of the private Hyderabad-based companies, the RAMKY, along with the Guwahati Municipal Corporation, came up with this 50 tons per day capacity plant.

So that capacity is 50 tons per day capacity plant, which I am going to explain that under similar kind of facility you can find it in anywhere in the elsewhere in India, there are a number of cities has come up with these kinds of mechanical composting facility.

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So this is the waste collection, they are collecting by stationary compactor vehicles. So, in these kinds of ways, there is no segregation. So, once they will collect the waste, they will store the material in the form of windrow or pile so you can see few more photographs.

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So this is the pile I am sharing. So, this is the pile under you see here shared Because there is a lot of rain in the northeast for almost 6 to 7 months, you can see the rainfall. So, shade is always required. So this is another windrow so you can see, this is how they are making the windrow or pile.

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So, once this waste will dry for 30 days, it will feed into the trommel. Trommel is nothing but a filter. So, they are feeding that vehicle is feeding into the first trammel.

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You can see the this is the first trommel in the size of the trommel is starting 35 mm our first phase and the second phase is 16 mm. So, what is the meaning of these 35 mm and 16 mm? So, because there is no segregation, the entire waste coming from the city area is available for the windrow composting. So, they will prepare the windrow and they will wait for 30 days 40 days for complete dry of the material.

Drier material means whatever is the organic or degradable material, obviously, in 30 days, 40 days that that will be degraded. So now how best we can receive or we can collect that degraded material is very difficult now, so we will be required filters for that. So here filter means trommels. So, it is not that directly we can go for a 4 mm size filter, because it is very difficult to get filtered for directly from the 4 mm sieve, so, initially, the entire material will be sieved from a 35 mm sieve.

So, a size of more than 35 mm will come out. And then it will go to the second unit that is 16 mm. So, the material larger than 16 mm will come out. Now, we will get so, this is the unit. So, this is the final product, this is material less than 16 mm. Now, the problem is that because after 30 days 40 days also the degradation would not that, good. So, these kinds of material will have very high moisture and if it is more moisture, again it will be very difficult to filter out from the 4 mm sieve, so, they will go for the drying method again.

So, for drying, they will put it the entire area, the compost will be put for 15 to 20 days for allowing the removal of moisture content and then they will feed into another trammel. So, now, these are dried materials, again they are feeding into another trommel that is 4 mm trommel. So, the material is larger than 4 mm will come out and this final material will come out here also these one more unit is provided where they are passing the air with the final product.

So, air passing means the lighter material will come out and the larger material or thick material will be removed out there. So, this is especially this unit for the removal of sand particles or soil particles will get removed out and finally, this will get compost.

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So, this is the final compost maybe you can see that there are a lot of in-organics a lot of plastics small metal parts, glass parts because less than 4 mm could be anything that could be possible. And you know the in India 30 to 40% is an inert material street sieving material and there is a very high-density material why because it contains soil and that soil also will be mixed here that is an inorganic material. So, this is the final compost.

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So, it is very poor quality organic residue, I think is very difficult to say that particular material is not compost but still is marketable. So I think these kinds of units are available in many cities and similar kind of trommel composting facilities. So, there are these composting plants normally called is a mechanical composting plant, here why they are called is a mechanical

composting plant because the mechanical units are available that is a filter unit that called is a trammel.

And the cost of each trommel as per my information this cost goes to 40 lakhs 50 lakhs rupees is very costly units. So, these particular factors facility that is only 50 tons per day capacity plants also required around eight to 10 crore rupees. So, I hear I did not include the cost of the space or land is not included into that what facility and we will be required lot of energy to running those trommels because you are continuous though trommels are running maybe 24 hours in a day, or at least 18 hours in a day that trommel has to be rotated. So, that the filter could be possible.

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So, this is another compost plan is the Okhla compost plan, this is one of the oldest compost plants in India, these available in Delhi. So, in a similar trommel facility in Okhla, there will be 4 units are available. So, parallelly these 4 units are working together and these also packaging for marketing purposes. This is the Agra compost plant; this is a different kind of trammel. So, this is the Ambala compost plan, these are the trommels you can see this is the trommels.

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This is the Trichi compost plant, this is the Chandigarh compost plan. So, this is the trommel.

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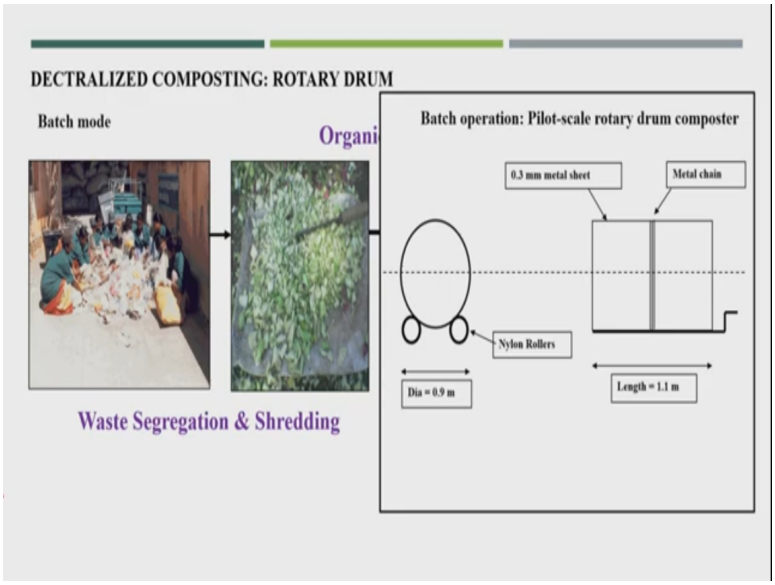

So, now, you see here, these kinds of trommel facility because there is a capital cost is very high and second, the operation cost is also high because it required a lot of energy and also the manpower is required for that and also we are not able to get good quality material out of that. Now, these questions will come up see there are 2 views of having such kind of compost plan one thing we want to reduce the amount of waste to reach the disposal site.

So, these kinds of composting facilities are good. So, here the thought is that for the degradation of material or reduction of biological material into the disposal site, so, these kinds of compost plants could be very useful, but now, problem is that see, if you are able to run such kind of treatment plant and whatever the product come out, if it is not that good, then what is the benefit of that plant? Then there also you can say that sir why to talk on to the good quality compost production.

See now, because it required a lot of operation cost and maintenance cost is very high. So, from where these kinds of operation and maintenance cost will come up and how these kinds of compost plant will be sustainable, if you are not able to sell that final product and if you are talking about selling that final product, you required very proper composting facility and that quality has to be looked upon them.

So, if you talk about the decentralized composting facility, obviously we talked about the rotary drum, so, is a batch mode also and fed-batch mode is also possible. So, once we segregate the material, we required the shading of the material size is very important and once we feed it into the reactor, the marketable compost could be easily possible to achieve. So, these are batch operation is one of the studies has been explained that if you have the diameter of 0.9 m and length 1.1 m, it is a manual rotation.

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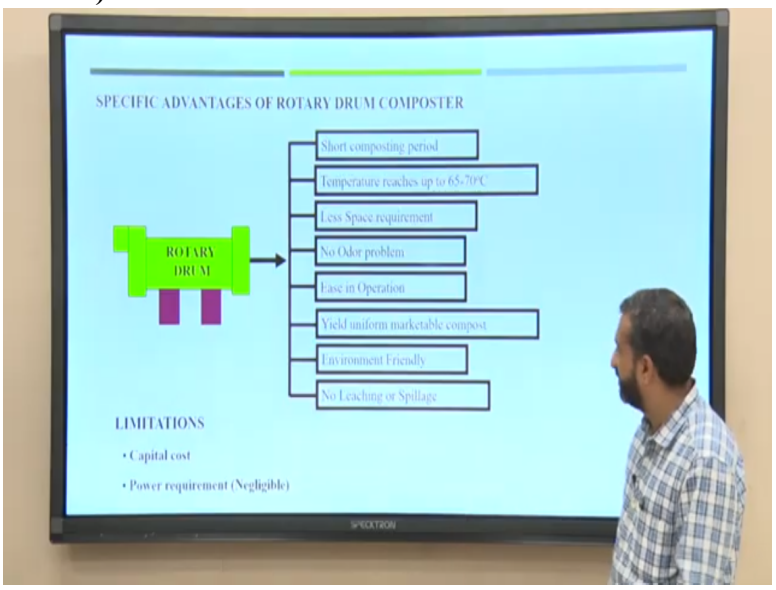

So, what are the specific advantages that could be possible? A short composting period is one of the benefits. Within 15 days or 20 days, degradation is possible. The temperature reaches up to 65 to 70°C means the product is very good. A less space requirement no odor problem easy in operation environmental friendly no leaching all these benefits or advantages are very good for the decentralized composting facilities.

Because we are talking came about decentralized composting facility into the apartment area nearby the residence facility. So, these benefits are advantages and highly beneficial for such kind of treatment facilities, only the limitation is a capital cost because the metal material, so, the one capital cost will be high under but power requirement also is required for the rotation, but in the batch mode, you do not require power but in the Fed-batch mode where required power but that is also negligible.

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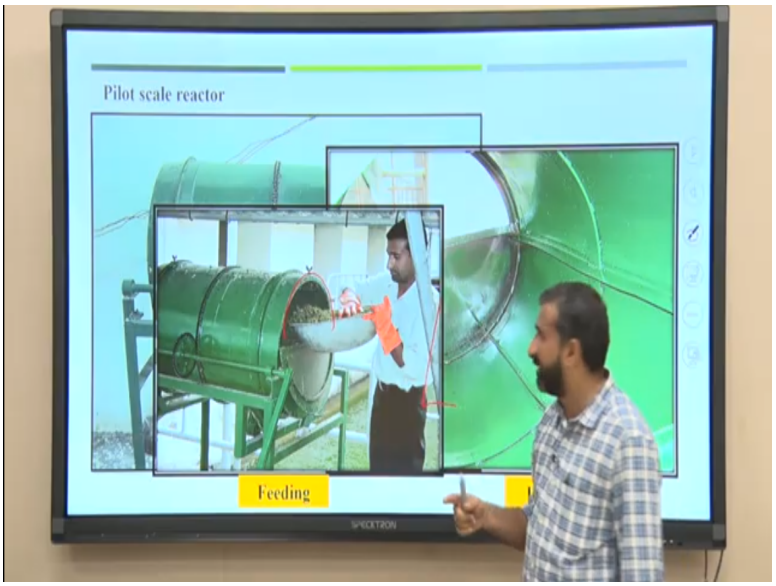

So, in a pilot-scale reactor, you can see this is the particular way we can turn the particular actor is the inside view, this is the feeding. So, while feeding, we can feed through the opening, and while turning you close the opening turn. So, we will be required only 1 turn in a day for the degradation and after turning you can open the doors so, that the aeration could be possible.

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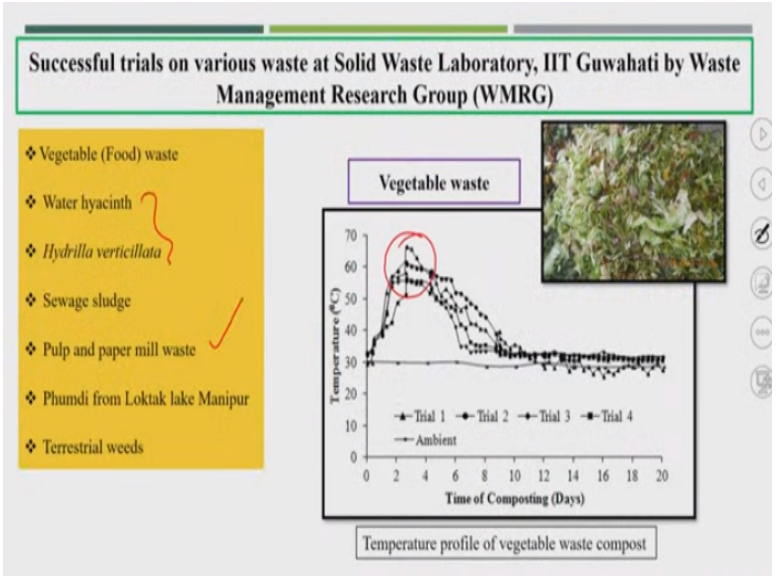

So, there are many successful trials done in the Solid Waste laboratory of IIT Guwahati by Waste Management Research Group or WMRG group. So, in IIT Guwahati, a successful trial has been done on vegetable waste, water hyacinth, hydrilla verticillata which are water weeds and very difficult to degrade, because of high lignin and hemicellulose content, sewage sludge, pulp and paper mill waste.

This also has very high lignin content and a few more terrestrial weeds also have been successfully studied. So, you can see here the temperature of 60 to 65°C temperature for vegetable waste could be achieved.

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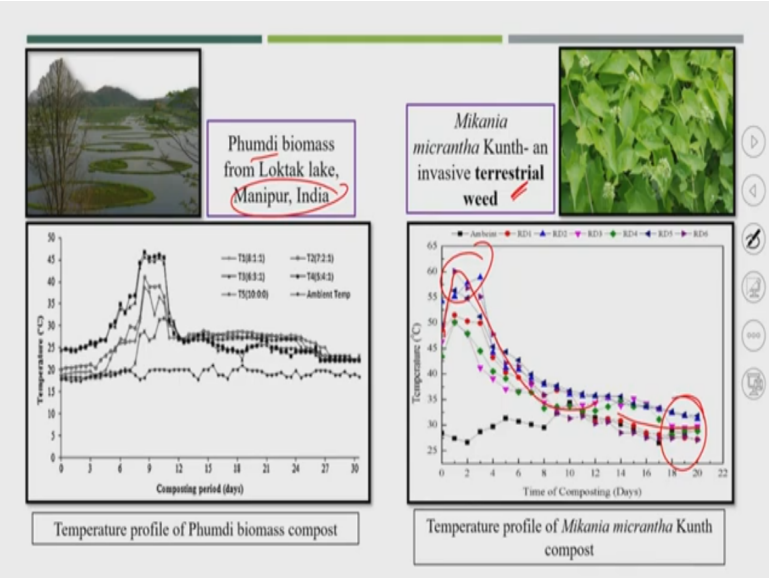

These are the water hyacinth, temperature is achieved up to 60°C. Under temperature you see here the degradation period is only 20 days in each trial, the degradation period is only our maximum 20 days. Here Hydrilla verticillata, these are another kind of weeds. So, in the pond that you can see onto the top of water this water hyacinth and underwater, you can find these kinds of weeds there also you see the temperature reaches up to 70°C. The sewage sludge temperature can reach upto 55°C.

Pulp and Paper Mill I think here the temperature has not reached, but still, we will be able to produce a quality product from these rotary drum facilities. This is the Phumdi, this is another kind of weed normally we will find in Manipur, the northeastern part of India, that is in Loktak Lake. There also the maximum temperature reaches 46-47°C for the degradation process.

This is another weed Mikania micrantha, a terrestrial weed. They are also the temperature you see temperature graph immediately the thermophilic condition achieved within 2 to 3 days. And finally, within 20 days, we will get the temperature like ambient temperature.

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So, this is another unit that was a batch unit and this is the Fed-batch unit is also available in the solid waste laboratory of IIT Guwahati. So, this is an inside view. So, these are the blades are provided for the proper mixing of material. So, this is the front view, the rearview is the feeding of material. So, waste within the drum, you see the water vapors while turning of the material. So, it will be required only 2 turns in a day, one before feeding one after feeding. So, these are proper mixing of material once you feed. So, feeding these the inside is the outlet after 7 days and you will be required curing for 15 days and after sieving will get good quality compost.

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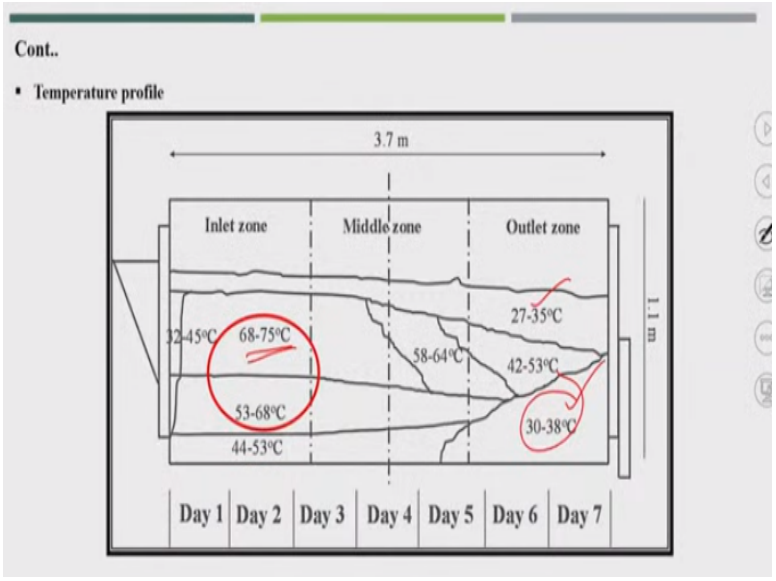

So, you see here the temperature profile. So, this is the rotary drum. So, if you can separate these particular reactors into 3 zones the inlet, middle, and outlet zone you see here temperature goes

to 68 to 75 degrees centigrade and the outlet temperature was achieving 27 to 30°C. So, it comes to the ambient temperature.

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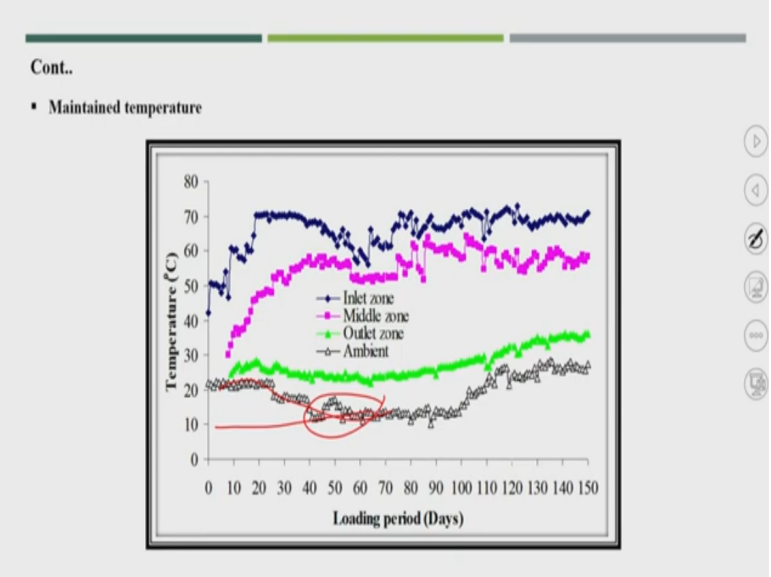

So, you see here the temperature. So, now the ambient temperature is lower down. So, it is around 10°C temperature still the reactor temperature is more than 60°C temperature. So, it is not affected by the local temperature or when the ambient temperature is in the winter season temperature is 10°C below. Also in the reactor temperature is able to achieve 60 °C temperature means in the winter season also it will be work.

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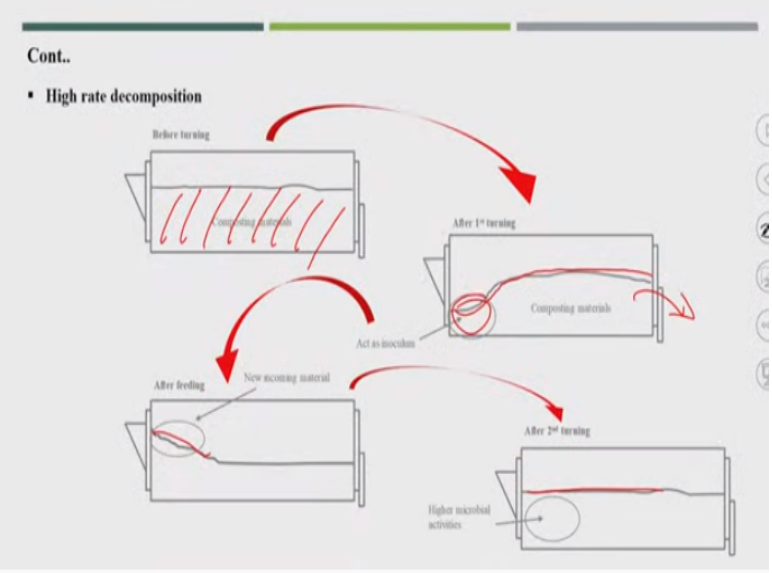

So, why the High rate of decomposition now, this is the composting material in the reactor. So, once you turn after the first term, this will be the view of the material. So, because some amount will come out from the reactor. So, this remaining material will act as an inoculum. Inoculum is nothing but is consists of a large number of microbes. So, once you feed after that you feed so, this is the feeder material, new feeder material. Now, you will be required one more turn so, that the entire material will be stabilized.

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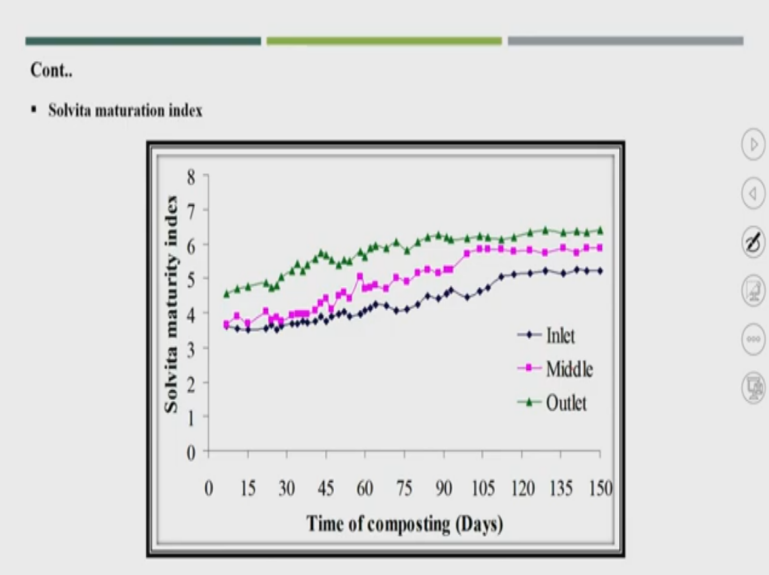

Now, that is the benefit of this turning you see a reduction in total nitrogen also you will see this is the final one is more than 2.4% nitrogen, carbon to nitrogen ratio is very good. So, the maturation index also is coming to 6 and 7 which is understood that is very good quality material.

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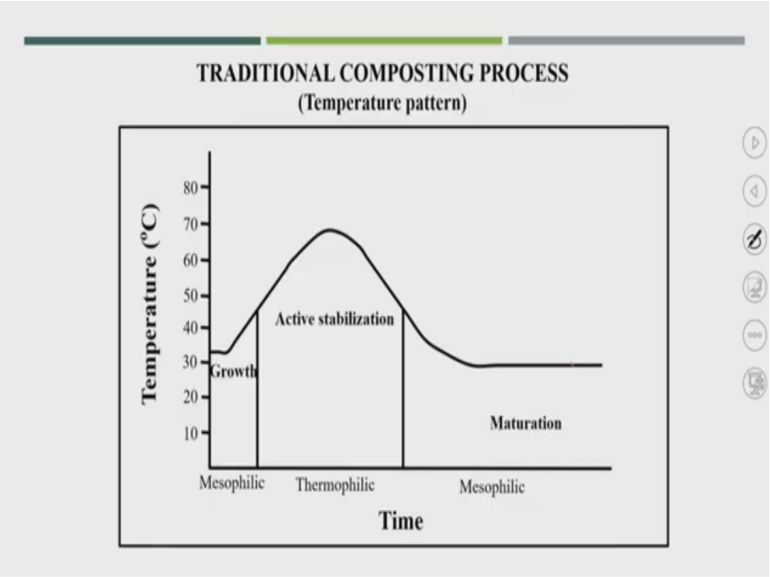

So, this is the temperature graph of a traditional composting process like the windrow and pile composting method. So, it will have the Mesophilic phase, thermophilic phase, and finally, maturation. So, now growth for the initial Mesophilic phase required 7 to 15 days active stabilization 10 to 25 days and maturation again 1 month to 3 months is required. So, finally, the total composting period acquired 45 to 190 days.

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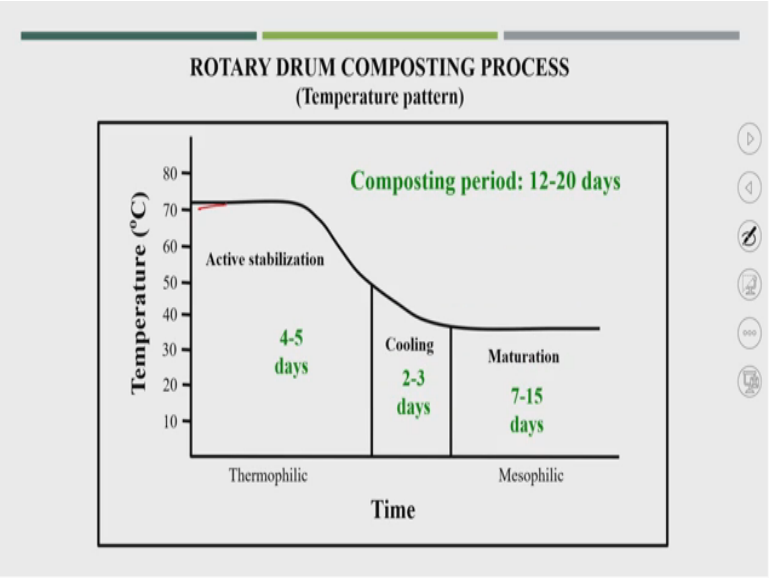

But in the Rotary drum composting facility, now, you see the complete change into the temperature graph it does not have the classical Mesophilic phase directly best under the thermophilic condition. So, which will have 4 to 5 days cooling 2 to 3 days, and maturation? So, the final composting period 12 to 20 days. So, in the inside reactor, the material will be for only

7 days. So, after 7 days material will become out but we required again maturation could be possible by windrow or aerated static pile method.

Which a number of private companies in European countries they studied because for maturation withdraw static file here it is possible that this maturation if you can run the vermicomposting facility so that the whatever the final quality will come up that that will be very good quality product could be possible to come up. So the conclusion of the time required for the 7 days in a rotary drum, and 15 days into the maturation phase facility could be windrow pile or even vermicomposting also is possible for such kind of material.

So here the conclusion that these kinds of technologies are very good for the decentralized composting facility it has a large amount of benefits advantages for the community level composting plants. So, again I am saying that we need to propose more kind of decentralized composting facilities so, that not only the degradation onto the source itself could be possible, but also the collection cost will be reduced.

And because of that number of composting plants could be run in the particular city. And these kinds of technologies like rotary drum Composting are highly beneficial for the decentralized composting facility I especially believe onto the for the apartment area. So these kinds of units if you install into the apartment very easily; too easy for the operation also and easy to produce a good quality product out of that. So thank you, for this lecture.