Urban Services Planning
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Lecture 28
Composting Part 1

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Welcome back, in the lecture 28 we will start Composting and this is the first part of the lecture. So, the different concepts that we will cover are on composting, the solid waste management rules 2016, and what it talks about composting, benefits and costs of composting, marketability of compost, the composting process, and the different components or factors that are considered in the composting process such as oxygen and such aeration, moisture and particle size, temperature variation during the composting process, microorganisms during used in the composting process, thermal kill of pathogens and pH level during composting.

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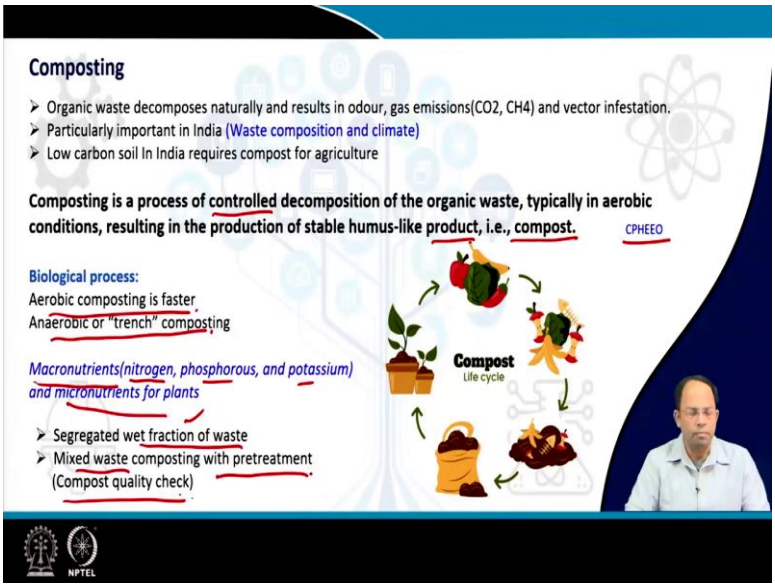

So, composting is the process. We will… it is a controlled process, of course, but as you know that organic waste decomposes naturally and this results in different kinds of gas emissions such as carbon dioxide, methane, and also it results in substance in bad odour. If the composting happens in anaerobic conditions, then it will result in bad odour as well. And also, because whenever certain materials decompose we can see some amount of vector infestation as well. So, that is the natural process every organic matter decomposes and composting actually utilizes this decomposition process.

So, composting is particularly important in the context of India, why this process the importance of this process, why? Because of the nature of our waste that we generate, because most of the waste that we generate from our homes are organic in nature, and it is that these are kitchen waste particularly and also because of the climate in most regions in India, which is more or less more to certain extent humites or an extent also hot. And so, that is what actually facilitates composting, or facilitates the decomposition process which is eventually utilized in the composting process.

And in the other way around, we can also say that the soil in India also is low is… has low carbon content, so it is low carbon soil and compost probably will be beneficial for also the soil in India. So, we can use compost for general conditioning of soil as well as also for agricultural purposes. So, now how do I define composting? If I take the definition given by CPHEEO then we can say that composting is a process of controlled decomposition of the organic waste, typically in aerobic conditions, even though it can happen in aerobic as conditions as well, resulting in the production of stable humus like product that is composed.

So, that means it is the same decomposition process that we are talking about, but it is a control process that means we will control certain parameters of the reactions that takes place and because we can control the parameters we can control the time, we can control, what sort of quality the final product will have. And so that is why we have to control it right.

Now, as because it is a decomposition process, primarily we use biological processes and as you know, we have learnt earlier about aerobic and anaerobic processes. Aerobic is when the decomposition happened in presence of oxygen. So, aerobic composting is faster than anaerobic composting. And anaerobic or trench composting is usually not preferred because of higher, usually a bad odour, as well as the process is slower as well.

Now, the composting result in accumulation of several macronutrients as well as micronutrients before the plants, which could be eventually taken up by the plants if this compost is applied to plants and macro nutrients such as nitrogen, phosphorus and potassium are the results of the composting process.

Now, composting happens on the weight fraction of the municipal solid waste that means we have learned earlier that the municipal solid waste, there is a dry fraction and the waste fraction and of course there is the hazardous waste attraction as well. So usually, the dry faction sometimes includes the hazardous waste fraction, which eventually has to be separated or sorted. Whereas the wet fraction is already segregated at the household level in most cases, in certain cities, there is still mixed waste. But in most cases, we are now segregating our waste. In that case the segregated waste fraction of the waste goes for composting.

Now, in case the waste is mixed that means, wet waste is mixed with dry waste or with certain other materials. In that case, we have to do some amount of pre-treatment, so, pre-treatment, pre-sorting, pre-processing whatever we can call it in by different names, but what it means is? That means we have to do some amount of sorting to take out the organic waste, or the organic content out of this particular waste, which eventually goes for the composting. And because it is mixed waste, there is still there is chances that contamination remaining. So, that is why we have to do compost quality checks as well.

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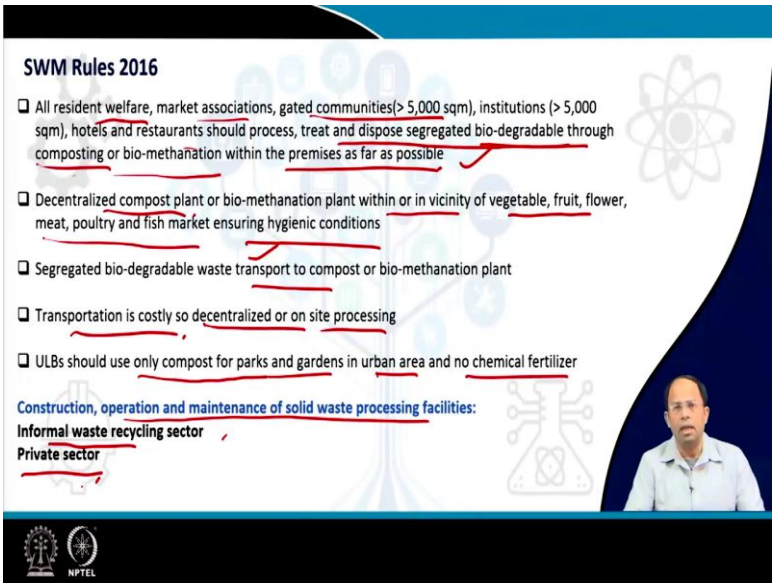

So, as per the software management rules 2016 composting has been made mandatory. For example, resident welfare associations, market associations, gated communities of greater than 5000 square meter or institutions of greater than 5000 square meter hotels, restaurants, all of this you know, particularly bulk generators should treat and dispose segregated biodegradable waste, through composting or bio-methanation. We learn about bio-methanation later, so, should because, we are talking about biodegradable waste segregated of course, so, in that case this segregated biodegradable waste should be treated via composting and it should be done within the premises as far as possible.

So, Welfare Association or a colony will probably should try to do the composting within its boundary itself but if not, then it can also look into some options of decentralized composting or composting at the ward level for that matters. Now, decentralized compost plant or bio methanation plant should be within or in vicinity of vegetable, fruit, flower, meat, poultry and fish markets, ensuring hygienic condition.

So, either this compost can be treated, this kind of organic waste should be treated within the colonies or within the associations and all or it could be sent to a decentralized plant as well. And in any case, decentralized compost plant has to be provided for creating market and other kinds of waste. Now, segregated biodegradable waste should be transported to compost or other bio-methanation or other sorts of processing plant. So, that means transportation is also now made mandatory and transportation is as you have earlier learned that transportation is very costly.

So, definitely if I go for decentralized or on-site processing of biodegradable waste to make it compost, obviously, we will save on the transportation cost, why? Because after composting automatically the volume of the compost is the volume of the organic waste reduces a significant amount it reaches around 15 to 20 percent of the actual volume of the waste.

And of course, you will recall smaller because to transport it, and it is transported directly for marketing to the distributors and so on. So, in case that should be taken out of the ULBs jurisdiction. So, overall otherwise, I would have not done for a composting at a decentralized level that is at the ward level. In that case, I would have to transport this entire amount of waste to the landfill site or to other sites where it would be eventually processed and disposed.

So, that is why transportation cost is actually reduced, by composting process or decentralized composting process, you will be should also… Only compost should use only compost for parks and gardens in urban areas and no chemical fertilizers should be utilized. So, that means ULBs within its jurisdiction whatever parks and other gardens and other sort of green areas that they maintain for maintaining soil quality or improving soil quality or we also call it soil conditioning you will be should utilize their own compost, the compost that is produced in the urban area and no chemical fertilizers should be utilized. So that is to facilitate the use of compost.

So, construction operation and maintenance of solid waste processing facilities is now made mandatory for all urban areas. And usually, it is suggested that decentralized facilities should be we can engage in formal waste workers or the waste recycling sector should be you know integrated with this particular you know this kind of solid waste this organic waste processing facilities or composting facilities and we should try to involve the private sector which will improve the efficiency of that entire process. So, that is how the software management rules covers composting and this is the different points that they have made mandatory and this has to be really taken up in a big scale in Indian urban areas.

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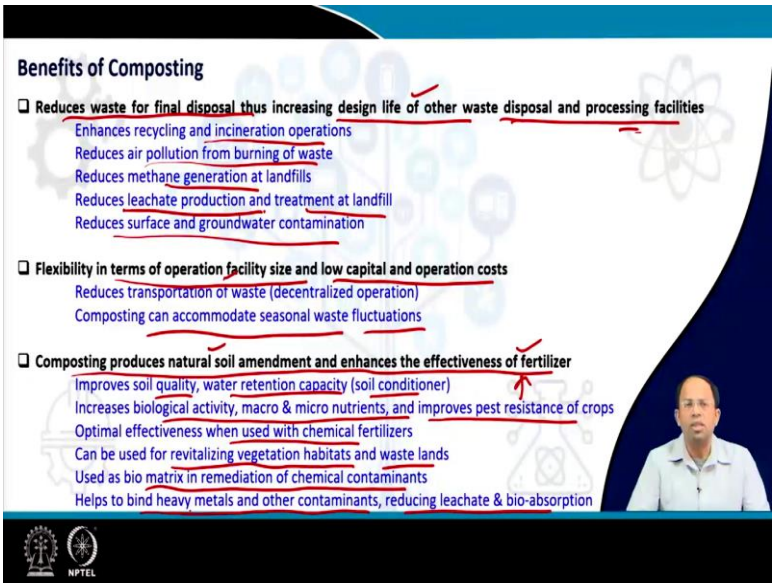

Now, what are the benefits of composting? One benefit we already talked about it is reduction of the transportation cost. But in general, composting reduces waste for final disposal, thus increasing the design life of other waste disposal and processing facilities. Now, it is not only increases the design life, it also improves the efficiency of the processes that are taken up in those kinds of processing facilities.

Now, processing facilities or disposal facilities could be a landfill site, could be a incineration plant, like where waste is incinerated or we convert waste to energy or it could be a group processing plant or wherever it is. That means if I do composting, then automatically what happens? The contamination of the waste from the drivers toward the recyclable waste reduces and automatically we can use those recycling facilities in a better efficient way. And also, in case of landfill or even in some other facilities, that design life or the period for which those facilities are designed could be extended.

Now, what are the other benefits which comes along with this? It enhances recycling and incineration operations which we discussed, reduces the air pollution from burning of waste because we are sending less waste for burning or incineration the organic content is less so automatically the air pollution would be less it reduces methane gas generation at landfill. Organic waste is the reason why so much amount of methane gas is produced in our landfill sites.

So, if I can take out the organic waste automatically, the methane gas generation will be lessened. And also, as you know, methane is quite potential compared to carbon dioxide, the effect on greenhouse gas emissions is also lessened. So, because organic waste contains a lot

of moisture, so if I remove organic waste, it also reduces leachate production and treatment at landfill sites. Reduces surface and groundwater contamination same leachate goes and mixed with groundwater. So, if I reduce leachate, obviously contamination will be less.

Then composting has two issues. One is the scale of composting, that means we can do it at the house, at a residential scale. We can do it at a decentralized scale, or we can do it at a centralized scale. And also composting, the quantity of waste that comes for composting varies a different seasons, because we are using so many decentralized facilities and also your (())(12:39) house compost a composting facilities. In that case, we have flexibility in terms of both the facility size as well as it requires low capital and low operation cost.

So, it is not only takes care of the fluctuations, because we have so much decentralized options, it also gives us options to go in an urban area to go for different sites of different facilities. Then finally, composting produces natural soil amendments and enhances the effectiveness of fertilizer. So, sometimes compost are the quality of compost in from the waste that is generated in urban areas is not adequate for growth of plants.

So, sometimes we make some other nutrients to the compost, so that we make it more effective or we use it along with fertilizer that means with some amount of fertilizer we also make some amount of compost. So eventually it increases the effectiveness of fertilizers or we can use it as natural soil amendments in areas like parks gardens and also that it facilitates growth of grasses and all the other you know, it improves the soil conditions.

So, overall composting improves soil quality water retention capacity, that is the job of soil conditioner, increases biological activity macro and micronutrients and improve pest resistance for crops if it is applied with fertilizers. Optimal effectiveness when used with chemical fertilizers alone, instead of alone, it should be used along with chemical fertilizers, can be used for revitalizing vegetation, vegetation habitats and wastelands, so some of the areas waste areas in in around urban areas we can actually improve or we can mix compost in those areas in those soils that will facilitate growth of vegetation, plants and all will make those areas more aesthetically pleasing and use as a biometrics in remediation of chemical contaminants in case there are chemical contaminants in soil we can use compost to reduce it help and bind heavy metals and other contaminants reducing leachate and by absorption. So, these are that different positive benefits are the benefits of doing the composting process.

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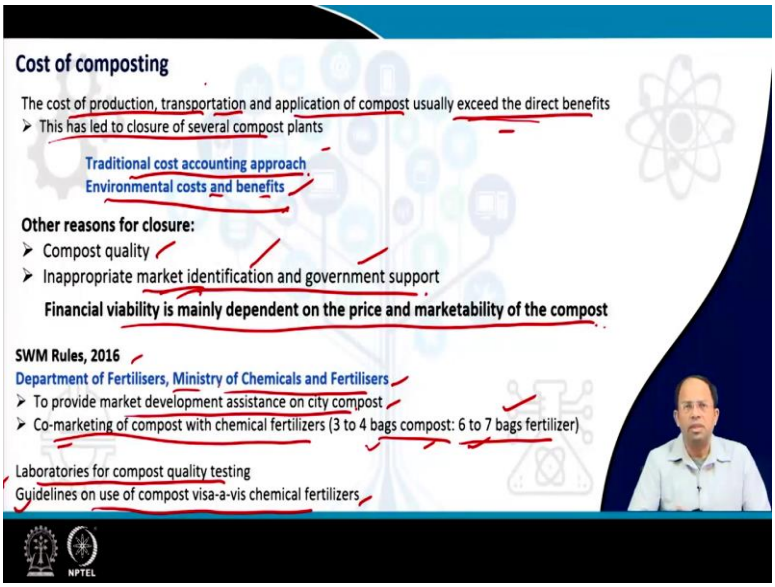

So, as you can understand these benefits or environmental benefits, but at the same point of time, there is actual we have to do the cost calculation of composting because it is an additional process that we are introducing for solid waste management in urban areas. So, usually what we have found out is that the cost of production, transportation and application of compost.

So, it is not only the process of collection segregation and also production of the compost, but also its transportation and application of this compost usually exceed the direct benefits. So, that is one of the problems because the other option is that we will buy chemical fertilizers which are subsidized by the government and it is usually cheaper in cost as well. So, is a cost wise, does it really is beneficial for the end user probably not.

So, this has led to low demand of compost for in the surrounding agricultural fields of urban areas, and there is no takers for the compost that is produced in urban areas. So, usually it is not only because of the market, but also the compost quality in urban areas. For example, the compost that is produced from mixed bases, urban areas, remains contaminated with many other hazardous materials as well if we do not do proper screening, or we do not do and take adequate precautions.

So, in that case, sometimes people will not want to use compost which is produced in urban areas. But the other thing is inappropriate market identification government support, that means no subsidy from the government, government is not facilitating the distribution of compost. So, or maybe the market analysis is not properly done, there is no demand for compost in the surrounding area and to transport it far away. So, that will increase

transportation cost. So, all this analysis needs to be understood, so that we can determine how best we can sell compost.

So, the traditional cost accounting approach, if I consider that then usually we see that the cost actually exceeds the benefit. And this has led to closure of several plants. So initially, government invests money, the plants are started, but eventually because of low demand for compost, the plants get stopped. So, this has been have… This has happened in many parts of the country.

So, that is why we have to consider the environmental costs and benefits to justify new compost plants or the composting process. Because composting brings in lots and lots of benefits like we just discussed earlier, but usually those are ignored when we do this direct cost estimation. So, that is the problem. So, in general, we can say composting should be done, but at the same point of time, we should make sure that there is adequate market for the compost to be sold and there has to be adequate corporate support as well.

So, financial viability is mainly dependent on the price and marketability of the compost. So, this is what we have to consider. Now, software management rule 2016 it also talks about produce to provide market development assistance on city compost and Department of Fertilizers, Ministry of Chemicals and Fertilizers, they are the ones which should you know, facilitate all this. So, this is the main department of the government which is looking into marketability, quality and all these things for compost.

And so, market development assistance has to be provided for compost, city compost particularly, and also co-marketing of compost with chemical fertilizer. That means what every 3 to 4 bags of compost, we can have 6 to 7 bags of fertilizer. So, when you sell 7 bags of fertilizer, you should also sell 4 bags of compost along with it. So, that should be that is called co marketing of compost.

So, maybe with 6 to 7 bags of fertilizer this amount of compost is given free. So, that means people will use it not by choice maybe, but by making giving it using some amount of subsidy or including the price of compost with fertilizers in that case people would be able to use this and eventually that would be a lot of benefits environmental benefits to overall society or for the urban area.

So, at the same point of time, there has to be a lot of proper testing of compost there has to be laboratory setup for testing of compost and guidelines on use of compost vis-a-vis chemical

fertilizer. So, application of chemical fertilizers people have been using them, so people are aware of that but how to apply compost? What is the best way or what should be the guidelines these are the jobs that has to be determined by the government and that will actually facilitate the use of compost.

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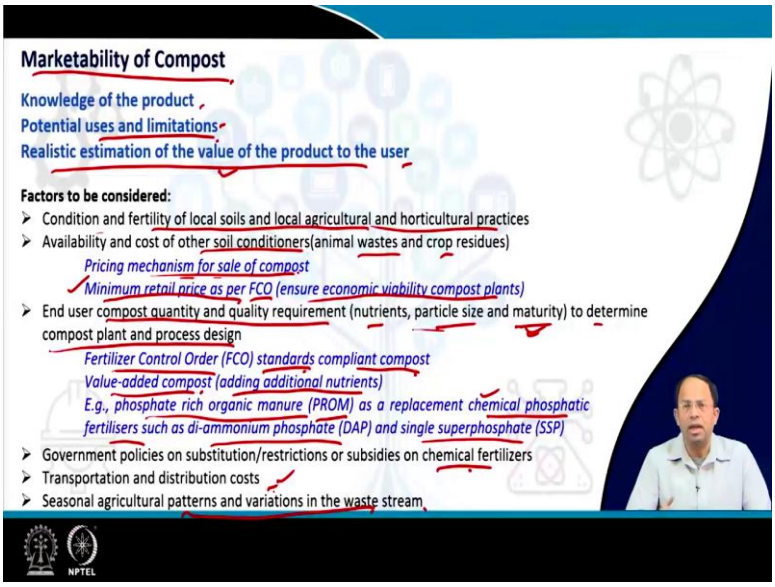

So, to market compost or marketability of compost we have to have… We have to consider many factors. First of all, we have to have knowledge of the product, that means the compost that we are producing we have to first understand about its characteristics, about his composition, about benefits and so on, and what could be the potential uses and limitations of this particular product.

That means, certain kinds of compost are good for banana plantations, other kinds of compost a good for grapes and other kinds of cash crops. So, because these are ex crops which are exported abroad. So, in that case what happens? There are strict regulations on the kind of chemical fertilizers that could be utilized for these particular crops. And usually we have found that compost works best for these kind of crops.

So, potential uses and limitations has to be known that means, I can produce compost but if I do not know how it will be used, where it would be used then probably I will end up either producing the wrong quantity of compost or wrong quality of compost. So, realistic estimation of the value of the product for the user. So, that is another thing that means, we should really know how much value this gives people give to this compost, because there are so many other alternatives available as well.

So, in that case, for like for example, people can use animal manure or people can use the crop residues in there locally in their own agricultural field. So, compost is a competitor of this kind of organic manures. So, in that case, we really have to estimate how much we would are willing to pay for this product. So, we can as for the production costs we can set a price for this compost but there may not be any takers for the compost. So, this has to be very carefully thought about.

So, we have to understand that condition and the fertility of local soils, local agricultural and horticultural practices, then we know that what kind of compost or what quality of compost is required, and availability and cost of other soil conditions such as animal waste crop residues, pricing mechanism for the sale of compost.

So, based on that we have to determine what sort of price we can set for compost and FCO or this Fertilizer Control Order from the Department of Fertilizers and all they have set a minimum retail price of compost which ensures the economic viability of the compost plant because at the end of the day, the compost plant will produce compost and if it has to sell it at a certain price, so that it can keep its operation going, if it cannot sell it at a certain price, it cannot keep on operating at a loss.

So, that means this minimum price guarantee is there, but at the same point of time, if it is too high for the people to buy them, nobody will buy it. So, in that case some pricing mechanism for the sale of compost, some subsidy, some co-branding, co-marketing all these issues comes into play. So, end user compost quality and quality requirements in terms of nutrients, inside compost, particle size, maturity level of the compost, we will talk about maturity later on.

That means we have to after composting process we have to allow it for a certain amount of time for it to mature, during this process also some amount of decomposition goes on but very minimum amount and also break the complex materials are broken down further. So, this maturity level also is important and once the compost is matured, you will not find any smell coming out of it, it will have a proper texture. So, this maturity also matters.

And so, this determines that what people want? Based on that we should design our compost plant and the processes within that that we adopt within that plant. So, the design of the plant is based on the need for the compost quality. So, there are standards which is set up by the fertilizer control order even solid waste management rules gives us certain standards.

Now, fertilizer control order is you the compost that should be compliant with those standards are usually for agricultural purposes whereas for solid waste management rules they give us standards for compost as a soil conditioner. So, we can also add some additional nutrients in the compost and we can say it is a value added compost for example, ROM which is phosphate or rich organic manure. It is a replacement for chemical phosphatic fertilizers such as diammonium phosphate and single super phosphate.

So, this is what we have been looking at that means we can add certain nutrients and then that will make the compost even better and that can be at act as a replacement for chemical fertilizers. Then government policies on substitution restriction or subsidies on chemical fertilizers. So, not only we have to market compost, we have to subsidize maybe we have to remove some subsidy from chemical fertilizers, transportation and distribution cost of compost how far away it is transported, how it is distributed, because almost the cost of the compost from production to final you know the price after distribution transportation is doubles.

So, a lot of money is goes into that. So, this that part has to be really worked upon, and seasonal agriculture patterns and variations in the waste stream, that means, a difference is in different kinds of food is consumed different kinds of crops grow that will result in different kinds of compost. So, the compost quality will change during the entire year from the same plan.

So, what to do to keep that compost quality consistent? So, this is another thing. So, how do I look into the parameters of compost and to determine what sort of standard should be there at the end, after the compost is formed from the organic waste. So, this pattern is this you know, the seasonal distribution variations also plays a role, we have to understand for during what season what kind of compost is generated and accordingly we have to take measures.

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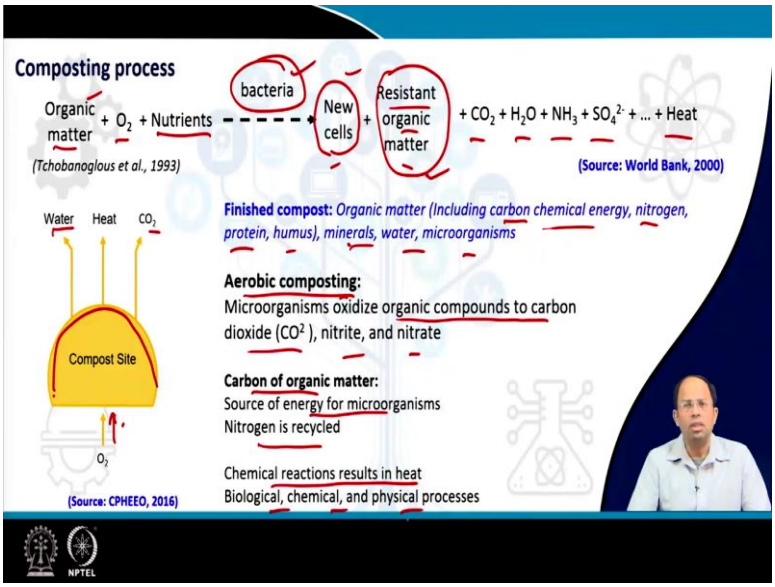

So, here you can see the composting process we have organic matter oxygen is required, it is a aerobic process and nutrients some amount of nutrients could be also added and then we have got the microorganisms or bacteria which actually acts upon this organic matter. This results in new cells or new bacteria because bacteria you know, they reproduce they eat the food which is carbon from the organic matter, then they reproduce new bacterial cells upon and we break down the compost into much smaller particles but these are resistant organic matter.

Along with that, when this is like you know the compost pile we create a pile of compost and then oxygen is there. But after the reaction we it results in CO2, water, moisture as well as other kinds of nitrates, sulphates and nitrites, nitrates and also it produces a lot of heat because it is a chemical reaction, it is a reaction.

So, the finished compost that is this resistant organic matter it includes carbon or you can say carbon chemical energy, nitrogen, protein, humus and also minerals water and microorganisms. So, this is what it remains and because there are still some microorganisms maybe we allow it for curing and all and eventually there is not many marks microorganisms left but usually there is simpler organic matter is left which could be applied with minerals and nutrients which could be applied for as fertilizer.

So, usually we as we talked about earlier we go for aerobic composting, anaerobic is also possible but we usually the preferred method is aerobic and microorganisms oxidize organic compounds to carbon dioxide nitrite and nitrates, and carbon acts as the source of energy and

nitrogen is acts helps in the recycling process and nitrogen is also recycled inside that entire after the reaction.

Chemical reactions result in heat. So, this is a big factor in the composting process, because there are two kinds of effect of that, that means when the microbes act upon the compost then automatically the heat is increased. And because the heat is increased some pathogens or some amount of weeds or seeds of weeds, which are there in a compost organic matter those are those gets killed and we get more cleaner material that means these are materials which will not contaminate further, so that heat is important in that sense, but too much heat is also bad, too less heat is bad. So, we say that we sanitize the compost because of this heating process. So biological, chemical and physical processes all simultaneously happen during this composting process.

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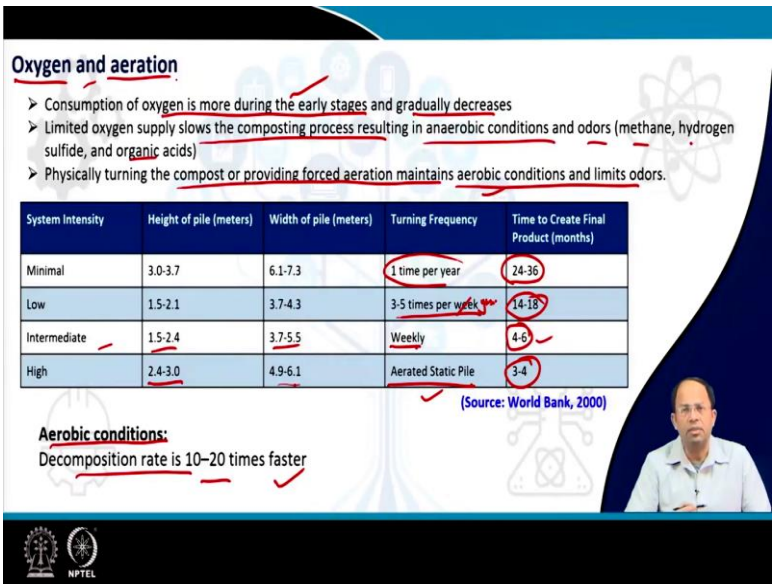

So, the first parameter we will talk about is of course, oxygen and aeration you can say that once we introduce oxygen into the compost, we can do it do it in two ways we either can introduce compost air by pushing air or you know sucking air out of a compost pile. So, that means we introduce air from outside or we can say that we can make sure that we turn the compost at certain intervals that is we the pile we break up the pile at certain intervals.

So, that the interior you know that this is broken into smaller components and the overall the interior part of the (comp) this organic matter gets exposed to the air and in that way it can get oxygen body composition. So, consumption of oxygen is more during the early stages and gradually decreases so, more microorganism activity happens at the beginning so of course the consumption is more in the beginning and then gradually reduces. So later on, when we

will check the compost quality or if the curing has happened we will see that how much oxygen is being consumed.

So, if oxygen consumption is low, that means curing is done, limited oxygen supply slows the composting process resulting in aerobic condition and orders where methane, hydrogen sulphide and organic acids are generated, physically turning the compost or providing post radiation means aerobic conditions and limiting odour.

That means, the more we turn the more we introduce air mechanically, then we can reduce the air in aerobic conditions and we can also limit the smells. So, this table gives you an idea about what sort of turning schedule we follow in case we are not using post air via perforated pipes inside the compost if we do the turning of the compost pile, in that case, you can see that there are different kinds of intensity of the system. Now, as you can see, the last one is the aerated static pile.

That means here, it is a pile where we are introducing here we will discuss about this process later. So, here the time taken is very less 3 to 4 months. And over here the width of the pile you can see the height of the pile is around 2.4 to 3 meters, it is not too high and the width is something around 5 meters. Whereas in case we go for lower intensity of turning or introducing year in that case, you can see that intermediate you know this weekly turning that is we turn it once a week. So, it takes around 4 to 6 weeks.

And in this case, you see that the height of the pile is less and also weight of the pile is less and in case it is a low turning frequency that is 3 to 5 times per week. And it is 3 to 4 times sorry, this is not 3 to 4 times per week, it is 3 to 5 times per year. So, in that case, the time taken would be much higher and also if in the turning frequencies only once we just leave the compost like that, in that case it will take a lot of time.

So, if that is how this entire composting process that time will vary. And as you can understand if I can keep on introducing here or we turn it regularly in that case, we will be there… It will have the composting process will happen very very faster. So, aerobic (condi)… So, in case we can maintain aerobic conditions it is the decomposition rate is 10 to 20 times faster. So, compared to anaerobic conditions. So, this has to be considered. So, that is why you can see that oxygen presence of oxygen and aeration is very very important.

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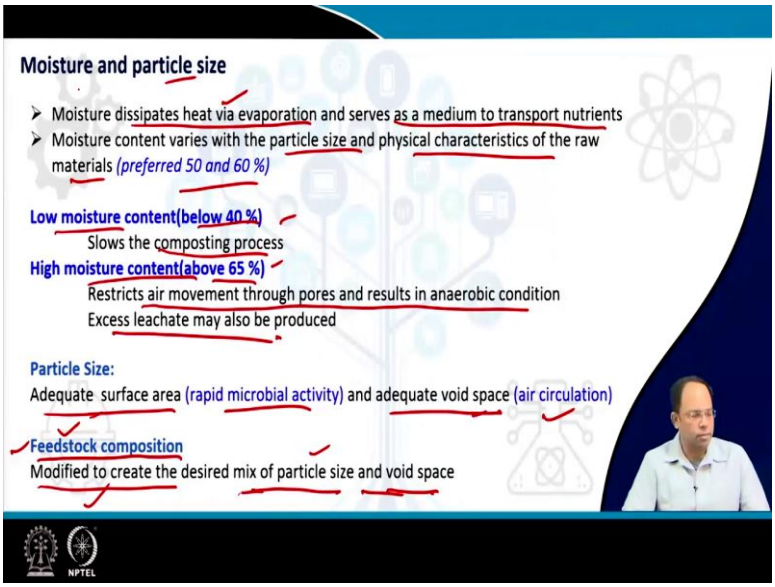

Then coming to moisture and particle size. As you see that the composting process generates water or moisture. And there are two purpose of moisture the roles the moisture plays one is moisture dissipates heat by evaporation and serves is a medium to transport nutrients, that means it acts it transport nutrients between the different parts of the compose that actually helps the microorganisms to grow, at the same point of time it uniformly spreads the heat all around, otherwise some zone will have very high heat, other zones will have lesser heat.

And moisture content varies with particle size and physical characteristics of the raw material. And preferred is around 50 to 60 percent moisture in this particular compost heat. So, when it goes below 40 percent we say it is a low moisture content and this slows the composting process. And if it is very high moisture content above 65 percent that also slows creates problems because it restricts air movement through the pores and results in aerobic conditions which again slows down the overall composting process.

And also, it will result in excess leachate which also needs to be managed. So, that means whatever leachate is produced, we cannot allow it to mix with the normal drainage system. So, this has to be first treated and then let it out in the drainage network. So, that is why more moisture is also a problem less moisture is also a problem.

Then particle size, we have to the particle size plays a big role the more bigger is the particle size more is the surface area of course, more amount of microbial activity will happen in the overall surface that will improve the decomposition or increase the decomposition rate at the same point of time, the void space also needs to be calculated if it is very slow small they need to be closely pack there will be no air circulation that will also be a problem.

So, we would always increase the gaps or the pores between the particles and also the pores the particles should be adequate in size so that they the more amount of surface area is generated. So, if I keep the particle is very large in size, there also it is low surface area. If the particles are very, very small, then also it is a problem because of adequate wide space. So, the particle size has to be somewhere in the middle.

Then we talk about feedstock composition that is what sort of, you know, waste stream that comes as input to the composting process. So, that is called a feedstock. So, if the feedstock is not correct, like as I was discussing earlier that during differences the feedstock composition varies, that means we will get different kinds of fruits being consumed at different seasons, different kinds of vegetables. So, the feedstock varies.

So, this mod we usually have to modify this feedstock, so that eventually we get desired size, the particle size has to be of desired sizes that we want and also this in terms of this void space, but at the same point of time, it is also important in terms of the nutrients, the final compost quality for everything requires us to change the feedstock composition, but here for the particle size as well as the moisture content also we have to maintain certain particle size and moisture content, we have to also introduce different components in the feedstock so that it becomes of a certain consistency so that it is easy to decompose.

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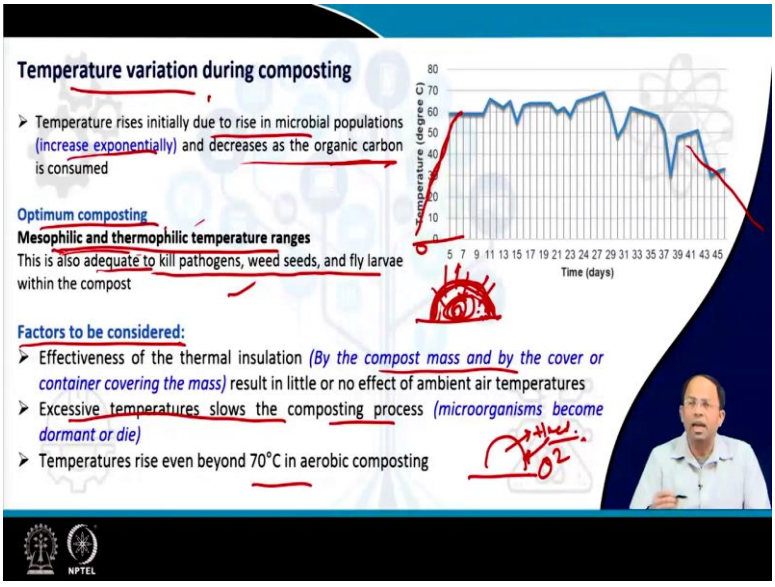

Then temperature definitely varies during composting that we already discussed, you need it because of microbial activity the temperature rises initially and then it increases very fast and decrease and then decreases as the organic carbon is consumed. So, usually it starts around 30 and then within 0 that is 0 day (())(36:27) around 30.

Then it climbs up it reaches this particular high level and then gradually it comes down, so, that is how the composting process takes place. So, once the organic carbon is consumed by the microorganisms, automatically microbial activity will come down and then the composting process gradually ends and also the heat also will come down.

So, optimum composting happens in the mesophilic and thermophilic, temperature ranges, there are even so, this is temperature ranges where starts around 30 degree and so on, but there even below that, that is compost some amount of composting happens. So, those are psychrophilic ranges and all but for us in our country, we are more concerned with the mesophilic and thermophilic temperature ranges.

So, this kind of temperature ranges actually refer to different bands of temperature and in this different bands of temperature different kinds of microorganisms, act upon the compost. So, one group of organisms act upon the initial time period and it can reach a certain very high temperature then in the second group of organisms act upon when the temperature is low. So, based upon different temperature ranges mesophilic and thermophilic bacteria, microorganisms actually act upon the compost.

Now, particularly in the Mesophilic states the temperature rises very high and this temperature is adequate to kill pathogens, weed seeds and fly larva into compost. So, that reduces contamination of that compost. Now, some factors that it should be considered in regards to temperature variation that means there are two points first of all, we have a pile of compost. So, of course, the heat at the centre is much high at the site the heat is much less.

So, sometimes because of the area because of the material that we put in the compost like we make it ‘kudas’, we make use some bulking agents and all, so the heat is lost because there is lot of porous. So, we have to give an insulation at that top of the compost. So, this insulation you know this effectiveness of thermal insulation is also important and so, by the compost mass and so, we usually cover either we can do some composting inside a vessel which is also known as in vehicle composting or we can provide a insulation at the top of the compost which results in retaining of the temperature so that overall the temperature remains high and that facilitates a composting process.

So, if the temperature is too high, in that case, we have done so much of insulation and the you know, the gaps are not too much spare, it may result in excessive temperature which also slows the composting process. So, we have to do the insulation, we have to design the entire

this compost mound in such a way so that the temperature ranges somewhere below 60 to 65 degrees or not more than that.

Sometimes it reaches more than 70 degree in anaerobic composting, but it should not be continuous. In that case, you have to turn the compost then break the compost so that also releases heat. So, that means that turning mechanism not only allows yet to come in but also breaks the compost, so that the heat also is dissipated. So, the turning mechanism helps in both ways.

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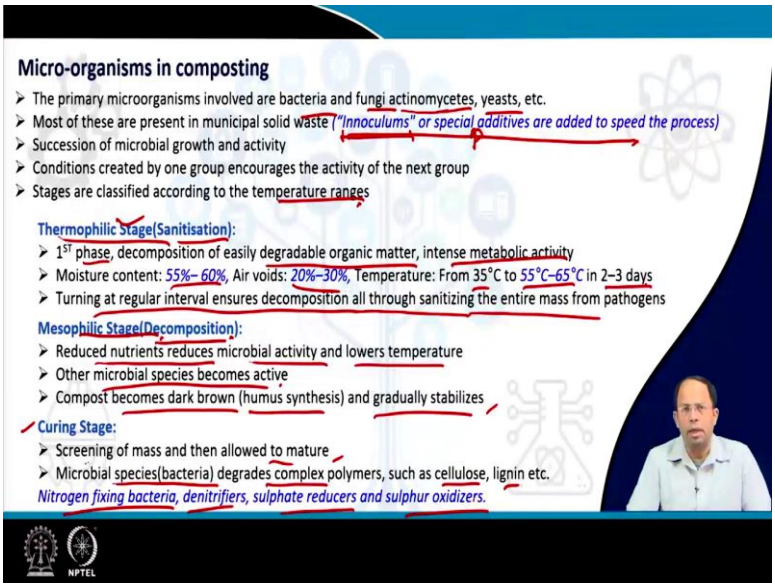

Then coming to microorganisms used in composting, so usually these are bacteria, fungi, and acid and fungi actinomycetes and yeast. So, these are the different microorganisms that actually act upon compost. Most of this is present inside the municipal waste already, so we do not have to add anything extra. But sometimes if you feel that we want to speed up the process we add a little bit of earlier compost or we add some special additives which are known as inoculants.

So, inoculants could be compost itself or some other material which has got a extra population of bacteria or fungi which could act upon this compost and start the composting process. So usually microbial activities happens in succession so one group of bacteria acts upon the compost then the next group acts upon each group is different.

So, if the first group may eat the carbon and then produce acid, the next group consumes the acid and they produces other nutrients and so on. So, each group's activities are different. And we usually stay classified as per the temperature ranges that we learnt earlier. So,

thermophilic stage, mesophilic stage, which thermophilic stage is also known as the sanitization stage because we sanitize the compost, because of that high temperature that we attained, and all pathogens are killed.

So, it is of, it is a first phase decomposition of easily degradable organic matter, intense metabolic activity happens, moisture content remains around 55 to 60 percent, air voids around 20 to 30 percent, temperature rises from 35 to 55 or 65 degree and this remains for 2 to 3 days. And we have to turn at regular intervals so that it ensures decomposition also and sanitizing the entire mass from the pathogens.

And the next phase is the mesophilic phase also known as the decomposition phase. So, here reduced nutrients the new, because the new some of it has been already consumed by the microbes and it lowers the microbial activity lowers the temperatures and all, and some other microbial species become active compared to the ones which are active in the thermophilic state and compass becomes dark brown in colour which is known as humus synthesis and because humus is being synthesized and gradually the world composting process stabilizes, stabilizes means the decomposition process gradually comes down.

Then the final stage is the curing stage of composting and here we first screen the compost that means that when the compost is formed, we can find chunks of organic matter. So, these chunks are not decomposed or there is difficulty decomposing them. So, those has to be removed sometimes we do multiple screenings using different seed sizes. So that we first remove the larger chunks then the smaller chunks are removed, some of it is returned back to those particular unit is composting pile and then they will use it as insulation cover or they could be further composted.

And this, finally this once the screen material is obtained, then we allow it to mature, maturing is nothing but again creating hips and allowing it to be there and microbe other microbial species particularly bacteria degrades, complex polymers during this process such as cellulose, lignin and so on. So, they are a nitrogen fixing bacteria which acts upon the compost at this point of time, denitrifies, then sulphate reducers, sulphate oxidizers. So, these are the different processes that happens during the curing stage and eventually we get compost up good quality.

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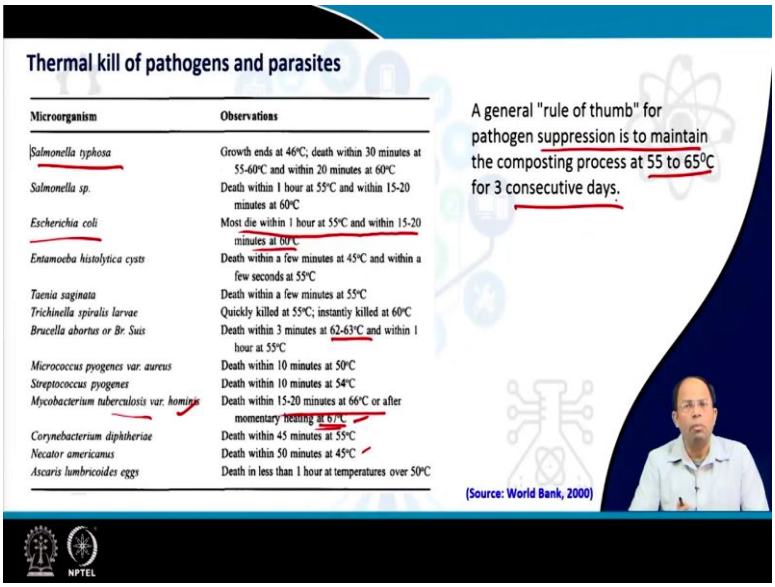

So, this table gives you an idea about what are the different kinds of bacteria microorganisms, pathogens inside compost and how they get killed. So, for example, salmonella typhosa, Salmonella typhi we call it, then E coli you can see that most die within 1 hour at 55 degrees centigrade and within 15 to 20 minutes at 60 degrees centigrade.

So, different temperature ranges are given for different pathogens to get killed. And once we can attain these kind of values, like over here like macrobacterium tuberculosis this gets these dies when 15 to 20 minutes or 66 degrees centigrade or after momentary heating at 67 degrees centigrade. So, if the (patho) if our compost pile reaches 70 degree automatically these bacteria will be killed. So, that is the purpose of allowing the heat to build up in the compost which sanitizes the compost. So, a general rule of thumb is pathogen suppression happens if the composting process results in 55 to 65 degrees centigrade for 3 consecutive days in that case, all pathogens are more or less killed.

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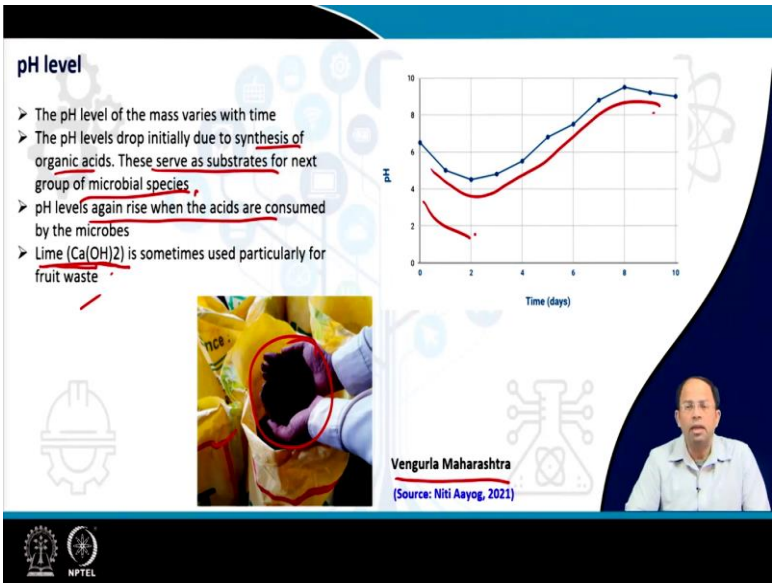

Finally, we come to the pH level of compost, the pH level changes during the composting process as well and usually initially it drops due to synthesis of organic acids because the first batch of bacteria creates organic acids and this these organic acids access food or substrate for the next group of microbial species and pH level again rises when the acids are consumed by the these microbes. So, as you can see the pH level initially comes down then again rises and stabilizes.

Now, sometimes if there is a lot of acid, organic acid in the organic waste itself for example, there are a lot of fruit waste. So, in that case we use lime or calcium hydroxide to bring down the acidity of the this organic matter so that the composting process can happen smoothly. So, if they are already we are having very high acidity.

So, that means it would be lowered and that would be a problem for the bacteria to work upon it work upon the organic matter to decompose it so we bring it up using line. So, this is some of the techniques that has to be adopted for the composting process. And as you can see at the end, this is from Vengurla Maharashtra this is how the compost looks like, this is how the final compost is produced and it is bagged and then distributed.

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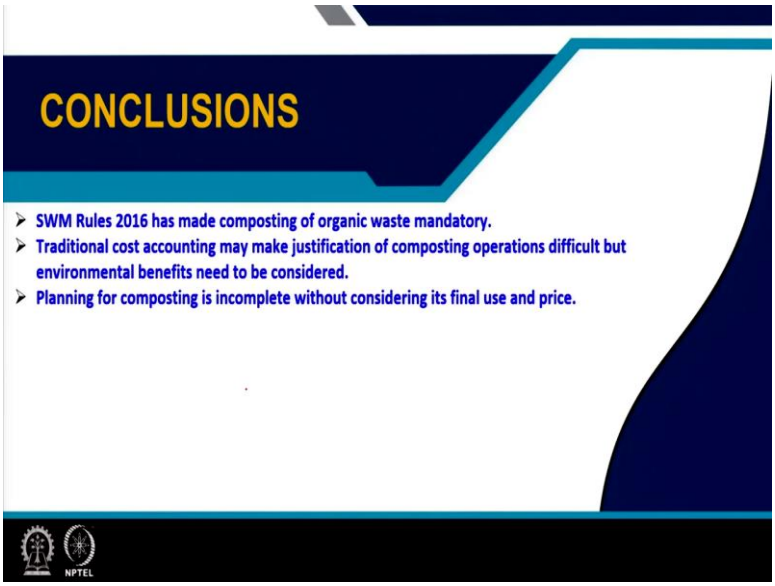

So, these are some of the references you can study. To conclude Solid Waste Management 2016 has made composting of organic waste mandatory and traditional cost accounting may make justification of composting operations difficult but environmental benefits needs to be considered. Planning for composting is incomplete without considering its final use and price. Thank you.