Municipal Solid Waste Management
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Lecture – 26
Biological Treatment I - Composting

Hello students, so today we will start the next lecture on composting. And today we will talk about types of composting. So I thought of giving 2 lectures on the type of composting. The first one we will start with the conventional composting processes. And one more I think next lecture we will discuss the centralized or decentralized composting methods. So this is the type of composting the first lecture.

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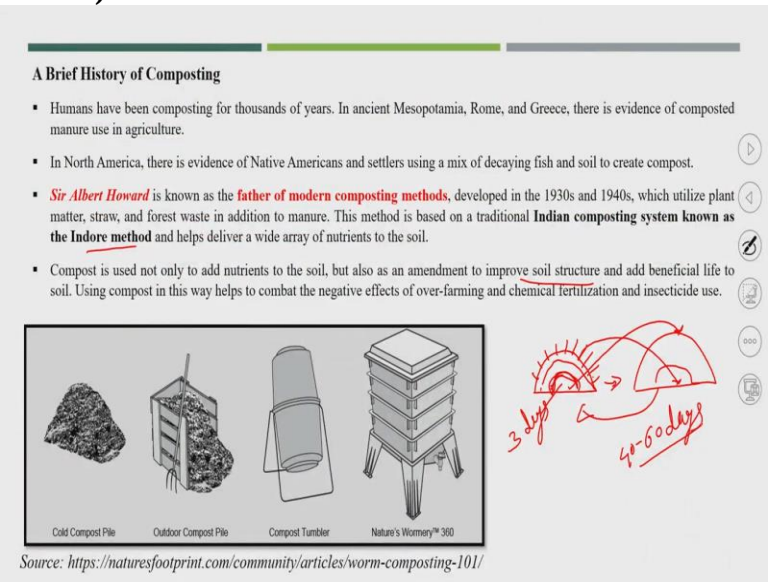

Source: https://naturesfootprint.com/community/articles/worm-composting-101/

So before going for the conventional pile composting thought of I will give some history about the composting process. So it is a very well known technology everyone knows from 1000s of years if you see the in the Rome, Greece, Mesopotamia even in India also the 1000s of year before also people used to they used to degrade the waste maybe the word that composting was not available on that period.

But the degradation of biological waste is especially the kitchen waste used to be degraded and whatever has the product used to get it that used to be you use for the agriculture process because that was very well known things is a whatever the final product will come up that will have a lot of nutrients especially the nitrogen and phosphorus. So even in North America, the Native

Americans used to degrade especially the fish or whatever the especially under the kitchen waste are to produce the compost.

In the modern era, you will find we normally called the father of the modern composting method Sir Howard and is good that he has come up with a very good method. The first time we explained technically that method called the Indore method. So Indore is you know that is a cleaner city of India in Madhya Pradesh. So I will talk about how Sir Howard has been explained for the degradation process or composting method.

And because compost is not only used for the nutrients to the soil but also an amendment to improve the soil structure. To see most of the local people or most of the farmers they will think that it is only for the nutrient purpose is not only for the neutral purpose but also it will change the improve the soil structure that also the 1 lecture I thought of I will talk about the soil quality and where I will explain that how the soil structure will improve by addition of the compost.

And also compost helps to combat the negative effects of over-farming or chemical fertilizer. That is also one of the major benefits normally found in the history of the composting process. And there are different kinds of the composting process has been used in the history as a cold compost pile, outdoor compost pile, even the compost tumbler also has been used for increasing the time period of the composting. And a few more technology has been come up.

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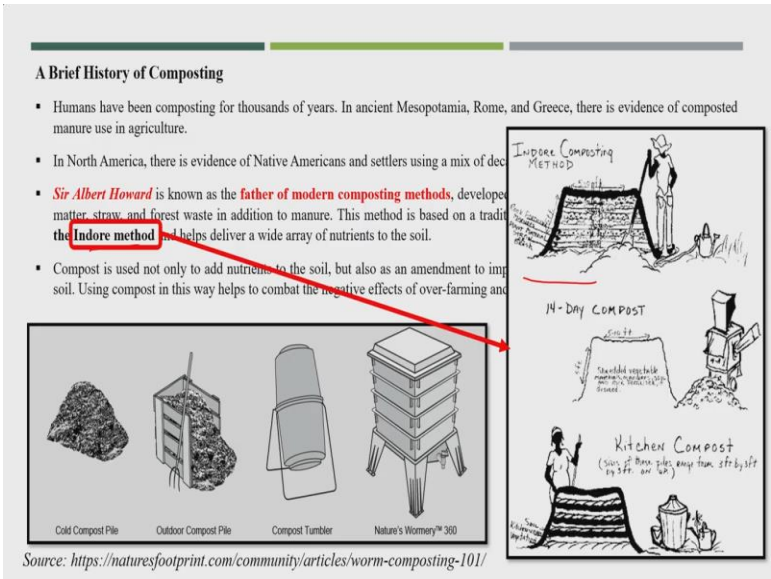

Source: https://naturesfootprint.com/community/articles/worm-composting-101/

And what I was talking about Indore method. So I think I will just explain what exactly was explained by Sir Howard in that that was around 1950, I think he was a very popular scientist especially in the agriculture area in Agriculture Research. And I think he was around 70 or 80 years old. He came up to Indore and also I think still he is 70, 80 years old he was doing so some research and they explained what exactly is the composting process.

So I will just explain how he has explained, what he told you to take the waste and put it in the pile form like this the entire waste you put it in the pile do the piling of the all biological wastes. So what will happen the top layer will be in aerobic condition this top layer because they open to the atmosphere? So obviously the upper part at least this particular part will be in the aerobic condition where air can be entered into that particular mass.

But the problem with this bottom waste. So what will happen the degradation will start because of biological waste so obviously the degradation will get started? So what will happen? Whatever is the poor area is available in the bottom one like this particular area. So initially in the poor the air will be there under maybe for 1 day that air will be available for the micros for the degradation process.

So because of degradation, the water will produce the moisture will produce. So what will happen? This moisture because is not getting you evaporated from the bottom area, the top area

is you evaporated? So whatever the pore area will be available all-new always air will be available in the top area but in the bottom area inside the pore water will be there. So initially microbes will use that dissolved oxygen for a few more hours.

But what he found after 3 days he found that some water has been come out means that the bottom ways are under the anaerobic condition. So what he adds he suggested after the third day you turn the material in such a way this put it in the same pile way and this top waste will go into the bottom and these bottom wastes will go on to the top. So that whatever is going to the anaerobic condition will be the aerobic condition.

And whatever is the very high aerobic condition. Now here the air will be available and this has to be again repeated for 6 day, 9 day, 12 day, and 15 day likewise he explained and after 40 to 60 days he found that entire waste has been degraded. So that is what I think the Indore method he explained that and see what was the important point for the entire degradation how best you can aerate the mass or aeration is the most important parameter he found for the degradation process.

And based on the aeration application into the mass or the pile we can go for a different type of composting method. There are different kinds of aeration methods which we are going to talk about and based on that this type of composting also has been explained or discuss later on. So now the same way the first conventional method like windrow method that also has the similar way of the turning of material which I am going to discuss later.

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Now, this is another way method like the conventional pile composting method but again in the same piling the aeration is the most important one but it is in the pile form. Now this is another pit composting this is also very well known but here I think mostly in these technologies there was not much aeration and under depth also is not that very large. Likewise not like 1 meter or 2 meters.

So the depth is very maybe around 1 foot, 2 feet so that the aeration could be possible into that particular depth could be possible. So here in this method, there was no aeration system. But I think it is a very well-known technology if you see in the 70s, 80s in India also the pit composting was very popular especially in the ruler areas. This was another method like the trench method. Many textbooks have also has been explained that.

If you can put the entire waste into the soil by making some kind of trench under put it in the soil and cover it by the soil. And after 60 days, 70 days we will get the compost but I believe that I think the degradation was there was not in the complete aerobic condition was in the anaerobic of a condition after a few days. So I would not say that that is a proper compost we will get it. And I already explained that the same material will get degraded in the anaerobic condition your quantity also will be very low and there could be a possibility of odorous gases on leachate production also could be possible.

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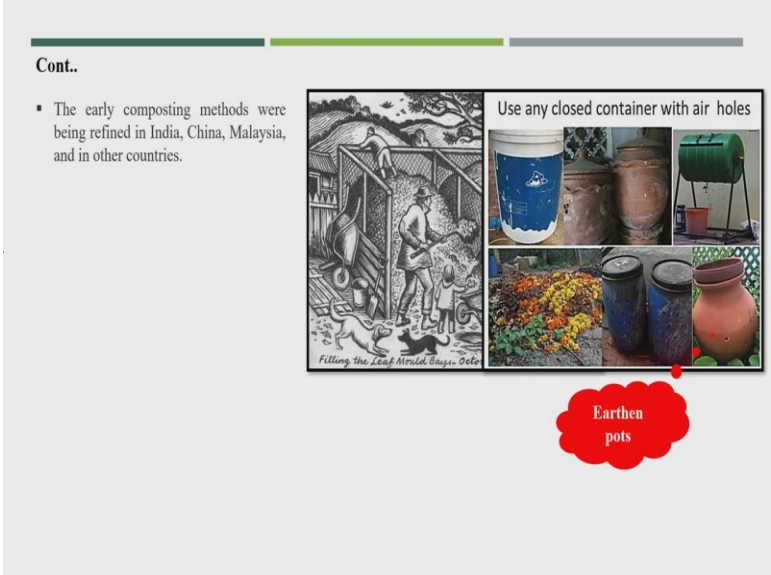

Now the early composting methods were also refined by India, China, Malaysia and other countries. So this you see that these most of the country or Asian countries especially South Asian countries because the temperature was very good further degradation process. So this was another one this is also similar kind of that pile composting. Now I think also because this was the centralized way or the large quantity used to be get degraded.

But here in the small quantity like in the household level also has been found that different kinds of units have been used for the composting method for the composting process even you see here this is called is a Matka compost and is a simple earthen pot is see if you use the kitchen waste because kitchen waste is highly degradable material if you just put it in the somewhere in the open area it will get degraded.

Now there is no issue about that degradation process but I think the again the major point that will come up was how the best quality of the product you are getting it nowhere see if you are running any particular composting plant and if you are not able to produce good quality of compost what I mean by good quality of composes at least they should have good nutrients under for that nutrients and should not have the pathogens into that.

And see in the last lecture our first lecture also explained that how important is the thermophilic temperature now you see here is it possible in these particular methods the thermophilic

temperature could be possible and see thermophilic temperature the most another very important factor which I explained in the previous lecture the aeration is very important because if there is no proper air addition how the microbes will grow and increase the temperature into that particular mass.

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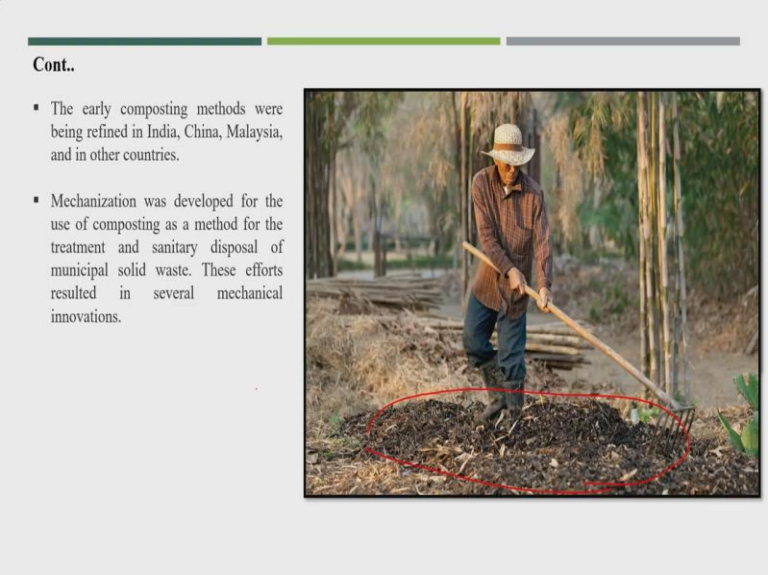

So this is one by the way this is also a simple pile this particular so far aeration is a manually mixing was there. And see the similar way of Indore method they use to prepare this is a particular pile or windrow. So this is the side view under the front view is similar with the Indore method now the same that it has to be the top material will go bottom and bottom material will come to the top.

So for that, you need agitation and so likewise for a small quantity that agitation could be possible manually you can change. And this is also one more thing that people would not find more aesthetic when somebody is working with the waste. Now here you will see you are seeing that this is already a degraded material but when you talk about the turning of fresh material so obviously I think handling also is one of the important issues.

If you go for manual turning of a particular material. So the mechanization has been started. So mechanization was developed for the use of composting as a method for treatment sanitary disposal of Municipal Solid Waste. So there were a lot of mechanical innovations that what was

the meaning of mechanical innovations is a how basically you can turn that particular mass that was the innovation has been come up.

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So this is also this 1 particular machine has been used there is also simply for the turning process only, this is from India. And some of the main objectives of this process were to improve the aesthetics of the composting process by enclosing the material in some type of structure and to reduce the amount of time required to stabilize the composting material see that always it has been targeted that to reduce the time required for the composting method.

And also to get the stabilizing material as in the final product and especially these aesthetics also has been properly discussed. So likewise new technologies also had been come up where touching of that particular material, people would not find that that good and people do not like it to touch that particular matter whether with gloves also nobody like such kind of task for turning off that particular mass. So this kind of technology has been come up.

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This is on more technology that was installed in Bengaluru silo type digester where mechanical mixing was possible. So this was the one particular house so small and where the air also is injected and the air also is coming out from that this is also one of the technology. This is normally called a solar composter. So the idea is that we can have, you can increase the temperature by solar so is solar energy. So that the entire model will be under the thermophilic condition.

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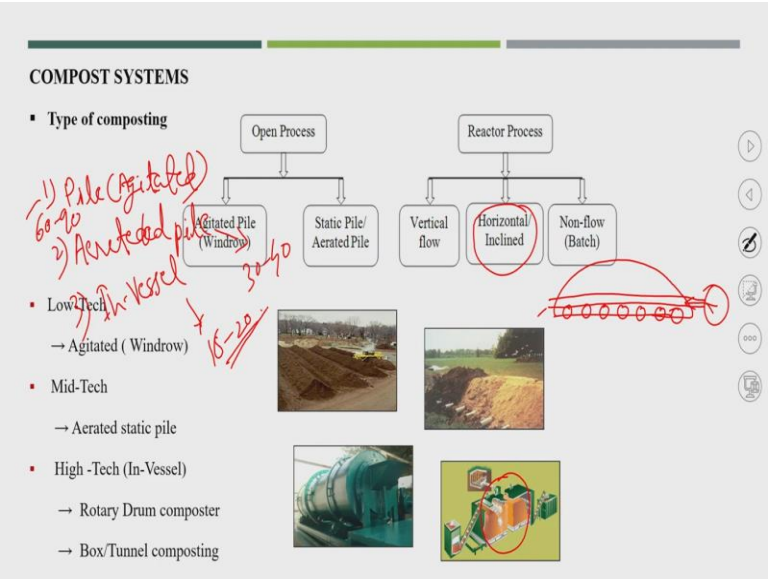

Now the type of composting is based on the aeration method. So we can say that there are 2 types of composting methods. The first is the open process and the second is the reactor process. And please remember that any textbooks or any report if you are studying that there are 2 types

of composting method one is aerobic one is anaerobic please do not go on to that I already explained and again I am telling today that the, if anyone is saying that there is an anaerobic composting, is not composting process is an anaerobic digestion process.

And that treatment is entirely different the product is different and what are the like gases are coming out that is also different in that case. So by default, composting is an aerobic process and these aerobic processes are 2 types one is an open process and the second is a reactor process. So open process also the first is windrow meter windrow or we can say pile method under another one the same way the aeration has been changed and that has come up with aerated pile.

This was the agitated pile where manually or mechanically pile has to be aerated, here aerated pile or static pile whereby some mechanism or some equipment has been provided for the aeration process and reactor process there are different kinds of reactor has been come up which in the last slide also you have seen that there could be a possible vertical flow horizontal flow or incline and nonflow that batch kind of reactor.

So whatever in the history we saw that like Matka compost and all that was the nonflow or batch kind of composting method. But there is a problem is that again that particular mass would not be in the aerobic condition but majorly is the horizontal or inclined method is very popular in the reactor process. Under these reactor processes also has been highly successfully accepted for the decentralized composting method.

Which I am going to discuss in the next lecture. So the low technology method is an agitated or windrow method or pile method we can say simply this pile formation and turning by some turner and mechanical turner will be our level or manual turning could be possible. Next the aerated static pile now because here you will be required one spatial kind of turner if you do not want to go for manual turning of the material.

So another technology has been come up that is aerated static pile. So what is the aerated static pile because the same pile. Now initially we have to in the first technology we had to turn mechanically or manually. Suppose the size is too big maybe the sizes the width is 5 meter and

height is 3 meter. So obviously manually is not possibly turning and mechanically also we need special kind of turner for that and those turners are very costly lot of fuel also will be required to use that particular kind of turner.

So what could be possible that like he in this photo you can see there are some pipes has been provided maybe pipes could be like this these are perforated pipes or could be possible like put this perforated pipe in the bottom because see what was the problem in this particular technology that bottom waste is going to anaerobic. So why not in the bottom we can insert 1 perforated pipe both will be open from both side or could be possible that somewhere you provide some motor and add the air that is also possible.

So these aerated static piles also we can say that is an active pile or active variation and another is a passive variation where there is no motor along with the pipe. Now the high-tech technology or we can say the reactor process that is in-vessel process and it is very popular is a rotary drum composter that is the spatially horizontal or inclined method I like this kind of technology. So our next lecture I thought of I especially talk to the in-vessel composting method.

Because I think these kinds of technology highly beneficial for the decentralized composting method and another this a box or tunnel composting. So there will be a particular box where the entire degradation could be possible. So this is the type of composting method. So majorly if you can say that if this question will come up how many types of composting methods are available. So you can simply say that there are 3 types of composting methods.

First is the windrow method or pile method that you can say is an agitated pile second is aerated pile and third is In-vessel composting. This way also you can simply say that these are the 3 types of composting methods. So the all 3 types by based on aeration. So now in the first technology pile agitated pile aeration will be manually or mechanically could be possible but the turning is important whether done manually or mechanically in the aerated pile.

We can put some perforated pipe inside the mass or the pile and we can aerate that particular mass and In-vessel there will be a reactor and a reactor is designed in such a way that the

aeration could be possible whether you go rotary drum composting or whether you go any box or tunnel kind of composting process there the important is that In-vessel composting the time requirement is low.

Like if you compare all the technology the agitated pile is normally required 60 to 90 days, agitated pile also can be reduced 30 to 40 days, and in-vessel could be possible 15 to 20 days could be possible for the degradation process. But again the size is also important and if you know that MSW the quantity production is very large. Suppose if you are getting 100 tons of biological waste.

And we want one centralized composting facility we would not go for In-vessel composting we need to go for either pile composting only that could be possible agitated pile if we can aerate that particular pile or we can go for an aerated pile by installing some perforated pipe inside the motel and the space requirement will be large and say open to the atmosphere.

So obviously it will affect the local conditions. Especially I think I would not much worry about the cold condition but in the rainy season, that entire area has to be covered. So obviously if you are saying the covering of that particular area of one particular acre of a particular area. So obviously the cost will be very high into that.

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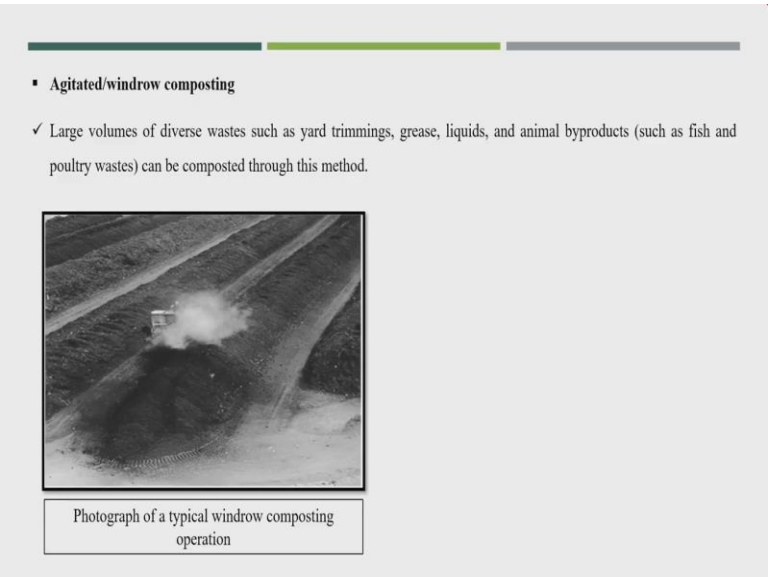

Now the first technology is agitated or windrow technology. So is a large volume of diverse waste such as yard trimming any animal by-product could be composted by this method. So this is one of the photographs of typical windrow. So you see these are the different windrow so you see how much area will be required now this is the turner. So you see that by turning the material you see the color. Color of this, this particular area becomes more black and these the brown material is a black material and see how much is the temperature that is coming out while turning of that particular mass.

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So this is another turned and static windrow. So this is the windrow. So here also you see the by turning and these are huge area is required for the compositing method, but in the all the photographs see that there is no cover onto the top. So it means rainy season is difficult to work for such kind of methods.

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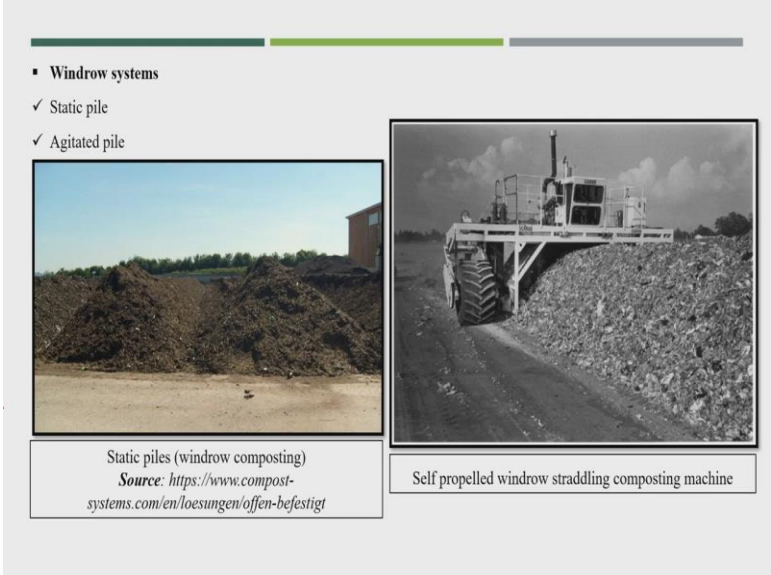

Windrows system so there will be static pile or agitated pile. So is a simple static pile means piles are not getting agitated. So this self-propelled windrow composting machine. So I think this machine will make that entire material in this particular shape. Shape also will come up by this machine. So I asked for my information in India we do not have such kind of machines. That is why I think winter also we made it by simple way, by using some kind of machines but not specially composting machines.

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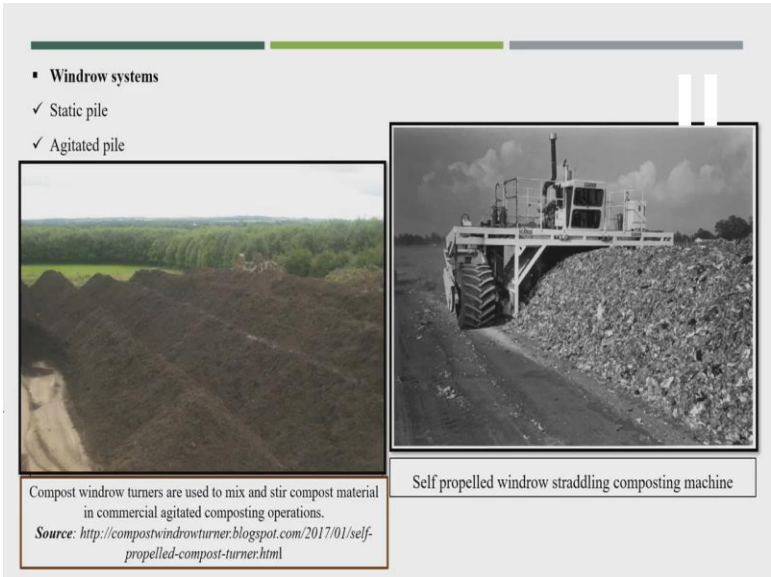

So this is another compose windrow and turners are used to mix and stir the compost material in the commercial agitated composting operations.

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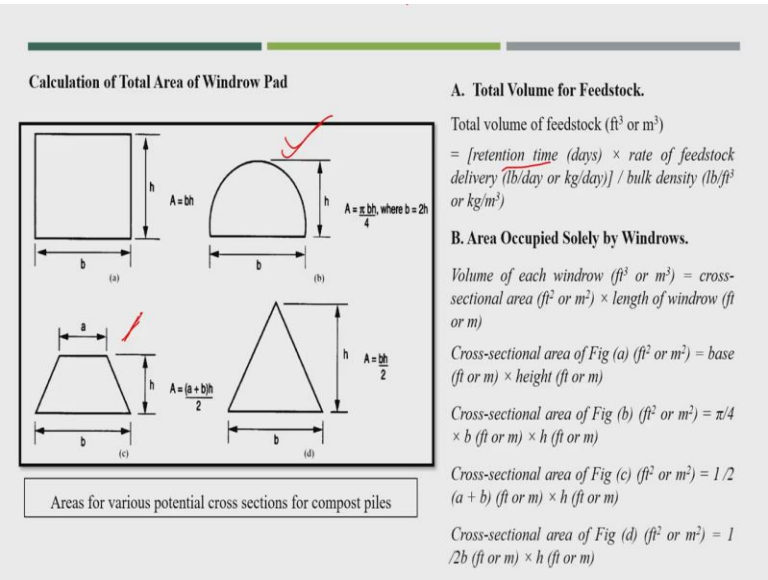

So you see here this is also with the Turner. Now, this is the important one when you talk about the windrow method or pile method the how much area will be required for that windrow area that important to know. So this is what I am showing the different cross-sections of the compost piles normally the cross-sections you find this is the way we discussed in the Indore method. But it is possible to how these kinds of methods also are again dependent upon the how best you will be able to make that particular shape are could be possible.

But this is difficult and this is also is a simple one where the entire material is flat onto the top. So you see here the area has been calculated. So first is to know the total volume of feedstock we

can calculate in meter cube that is a retention time. So here retention time is nothing but a composting period. Normally I explained that 60 days, 90 days are required for the degradation process.

And that will be your retention time multiply by the rate of feedstock delivery how much kg per day is getting faded and divided by the bulk density of that particular material. So by that, we can calculate the total volume of feedstock or total volume of the substrate can be utilized into the windrow area. Similarly we can calculate the area occupied only by windrows. That is calculated by cross-sectional area of that particular pile multiplied by length of windrow that you see here there are different ways.

We calculated the area cross-sectional area like in the finger A, simple length width into height could be possible. A similar way the finger B finger C, and finger D. So we can calculate how much area occupied by windrow.

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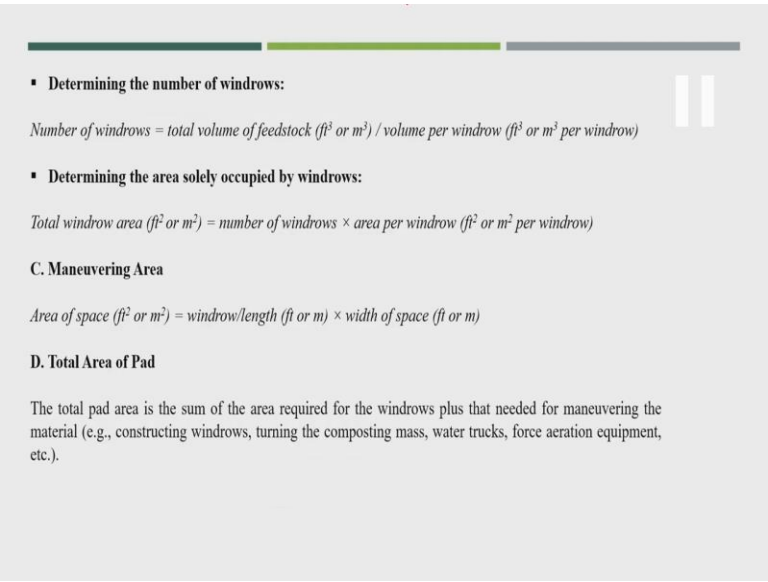

Now the number of windrows this number of windrows can be calculated by total volume of food stock divided by volume per windrow this is a simple way we can calculate the number of windrows now that determine the area only occupied by windrow that is total windrow area is equal to number of windrow into area per windrow. So if you know the how much area for the 1 windrow we can calculate the number of windrow.

Now there is another area that we call maneuvering area that is the distance between the windrow for turning purpose are to movement of that particular machine for the turning facility and also the final product also has to be collected. So one particular vehicle has to be entered into that maneuvering area that we can calculate by area of space that maneuvering area equal to Windrow length into width of the space.

So we can calculate by total sum of area the area required for the windrow and plus maneuvering area we can calculate that like the constructing windrow, turning the composting mass, water truck, force aeration equipments you will be required a lot of area for that. So by that way we can calculate how much total area will be required for the windrow method.

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So this is a mechanical windrow composting with the tractor in Turner. So here this is the turner.

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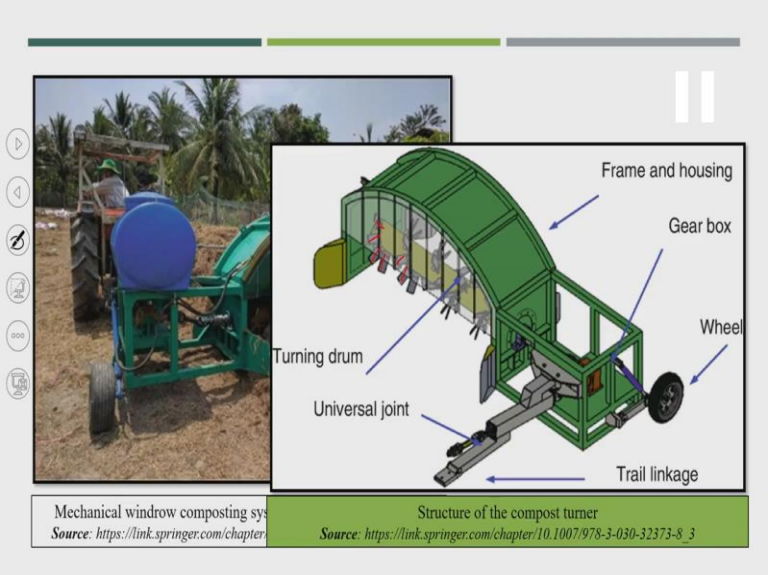

Backyard composting. So this is 1 photo you can see that the turner, how is working so this is the blade these are the blades by that way the entire material will get mixed. So mixed also and this bottom metal will come on to the top and this top material will go on to the bottom the mechanism is same.

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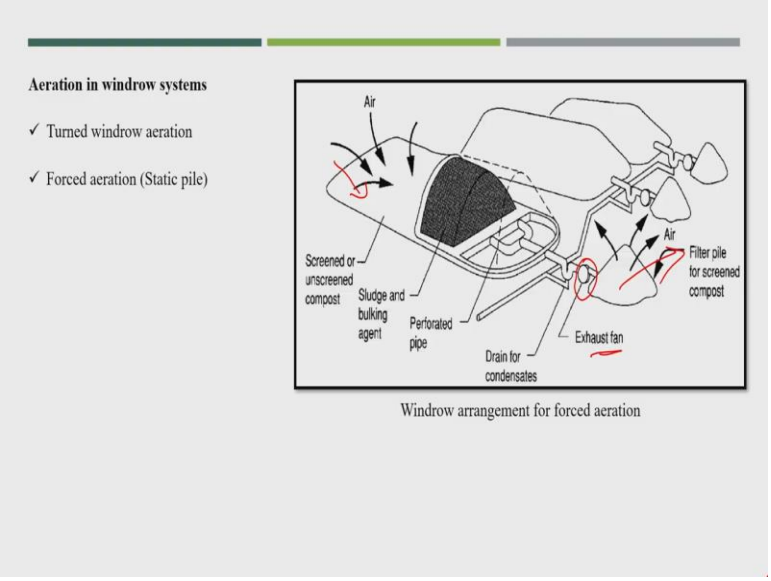

Now the aeration windrow system so is a turn windrow aeration like the force aeration. So you see here the pipe has been injected perforated pipe and now 1 exhaust fan is given here. So the exhaust fan means from the other part air will inject and from here the area air will come out. So by putting 1 exhaust fan so that is force aeration and these force aeration also we did not require

for the entire composting period like 60 days,70 days only the major degradation in the initial 15,,20 days.

So initially we can use the force aeration after that no need for force aeration otherwise what will happen if you put more air could possible that the entire material will get dry, harm the moisture the proper moisture could not be possible because we need moisture for the growth of microorganism. So minimum that 40, 50% moisture is always required for the proper growth of microorganism.

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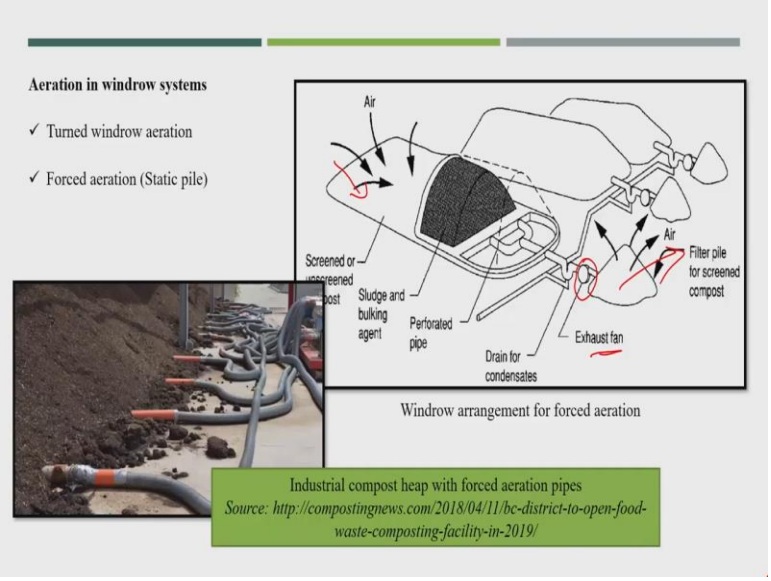

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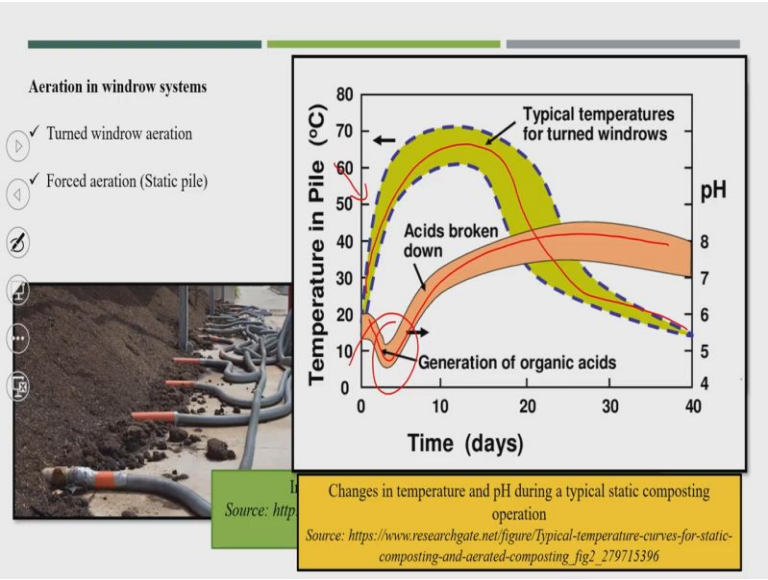

So you see here the industrial compost heap with force aeration pipes. There is also a lot of energy is required for this. Now see here there is a graph for degradation process. So in the windrow process or force aeration, the temperature is a thermophilic temperature in the typical turn windrow and there is the pH. So it is possible that initially, pH will drop because of organic acid production and the buffer system available. So obviously initially the pH could be dropped.

But after that the pH could be neutral pH could be possible by their buffering system in the composting process. But I think if you talk about in-vessel composting I think such kind of drop is not possible in that case because the degradation is so fast. So these organic acids will produce only when the entire material is under anaerobic conditions. Otherwise aerobic condition these organic acids would not come up these organic is the acid nothing but is a volatile fatty acid is very easy to get degrade again easy to produce carbon dioxide and methane from that.

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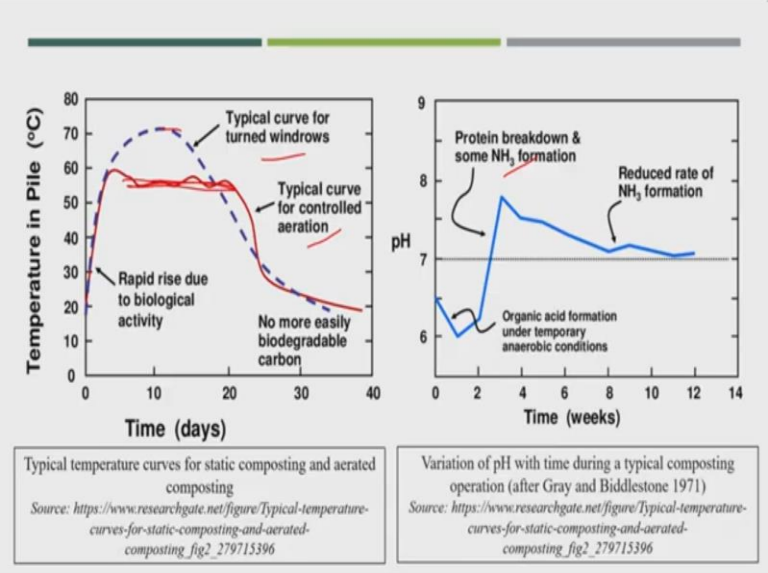

Typical temperature curves for static composting and aerated composting
Source: https://www.researchgate.net/figure/Typical-temperature-curves-for-static-composting-and-aerated-composting_fig2_279715396

Variation of pH with time during a typical composting operation (after Gray and Biddlestone 1971)
Source: https://www.researchgate.net/figure/Typical-temperature-curves-for-static-composting-and-aerated-composting_fig2_279715396

So here you see the typical temperature curve for static composting and aerated composting. So here you see the temperature graph for the turn windrow and control aeration are the aerated pile in the aerated pile where control aeration could be possible. So here the temperature you see is the more compared to the control aeration but here you see that is for a longer period the maximum temperature could be possible in controlled aeration.

It is not like the temperature of the turned windrow or agitated pile but still, I think that temperature is good around 60°C temperatures is possible to achieve into the aerated pile. Now,

this is another graph same pH could be possible and finally because the nitrogen will get degrade so because of ammonium formation that NH_4 formation pH will increase. But as I said this could possible only in windrow methods or pile composting but in-vessel composting I think is not possible to have organic acids formation.

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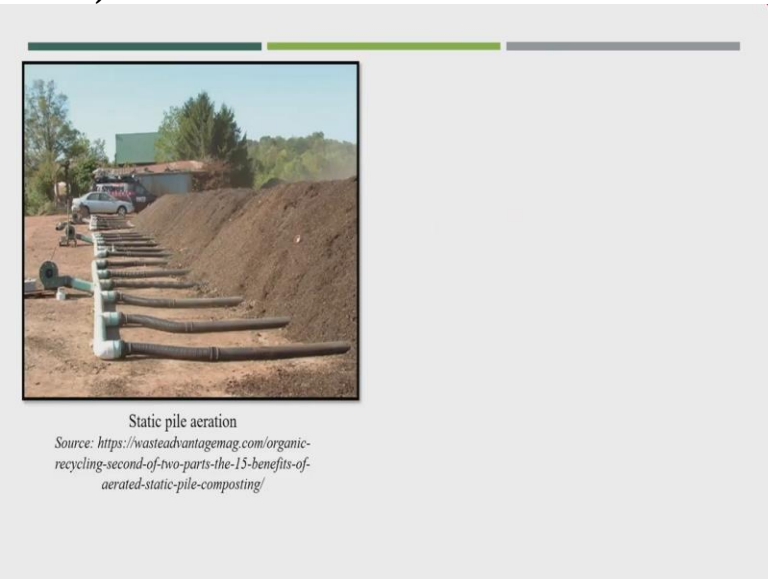

So this is another one the static pile aeration so this is a different way the pipe has been injected.

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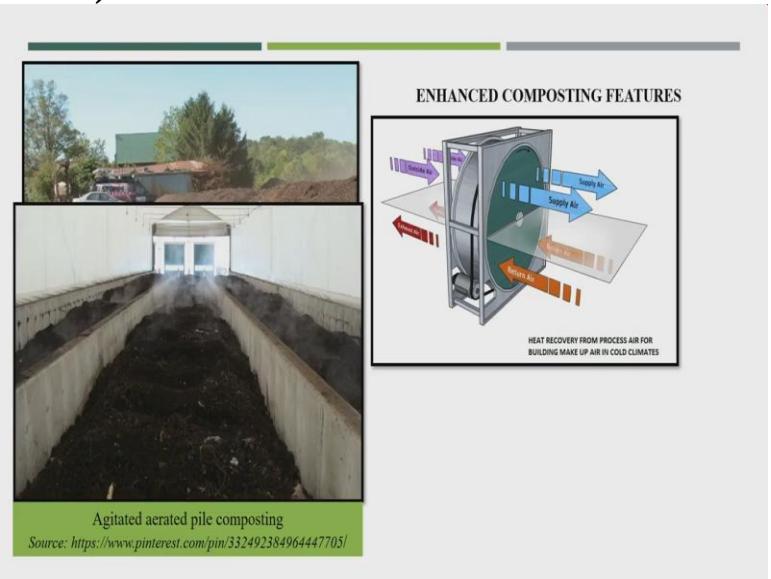

This agitated pile composting. So in the bottom there is a perforated pipes here has been provided. So this is cover method rainy season also we can use. So what is the benefit of aeration in that one it will enhance the composting process obviously see what microbes will be required the food, water, and air and food is already there because substrate is the entire substrate is edible

for them moisture is there, moisture will be always there because suppose there will be a lot of evaporation by thermophilic temperature or simply by ambient temperature.

But also the water also will get produced in the degradation process. So water will be also available only the major problem which that microbe cannot do it by their own that is air, aeration they cannot do by their own. So there will be a lot of benefits of air addition or aeration into that particular mass for the degradation process.

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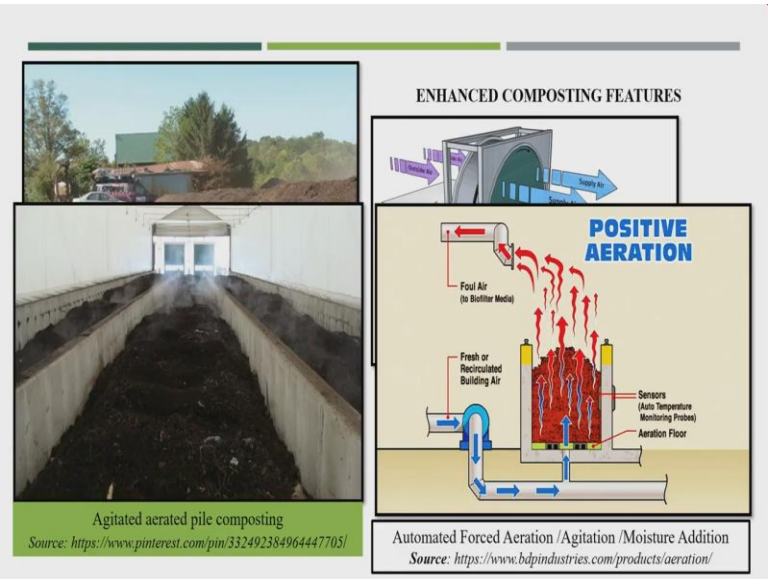

So obviously and could possible that if you aerate that so whatever foul gases also will come up odorous gases you can say that if it is a complete aerobic process by the odorous gases will come up but still there could be a possibility of leaking out of ammonium gas that NH_3 gas maybe H_2S also the small concentration will come up. I think there is also one question will come up whether in the composting facility whether the odor could be possible.

If you maintain the complete aerobic condition I can say that that would not be that kind of odorous in that particular plant. But I think this small odor will be always there into the mass in the degradation process because for every pocket of the mass is not possible to aerate. If you put number of pipes also into that lot of air you are providing.

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Now the community level composting they are also see the I think is a very popular in the European countries and American countries like we they normally call it a backyard composting a blog or neighborhood or even schoolyard or community level. In India is not very popular but I personally believe that we should also go for such kind of community kind of composting process especially in the apartment area is possible.

Whatever the 20, 30 or 50 numbers of households are residing into that particular apartment is possible to have such kind of method but I think everyone should be involved first is the segregation one that wet waste has to be segregated first and everyone that has to be worked to maintain the particular aerobic condition into the that particular mass. Here in this photo you can see that the local community people in the backyard you see the houses are there in the back side of the house they are turning the particular mass,

And see here this is the perforated pipe you can see the perforation also in the pipe these are the perforated pipe and also the mixing of both the materials like in the previous lecture also I talked about a wet material and dry material like agriculture kind of material. So here you see the green and brown both kind of material is mixed together, see proper brown to green proper carbon to nitrogen ratio has to be maintained then only the proper degradation is possible.

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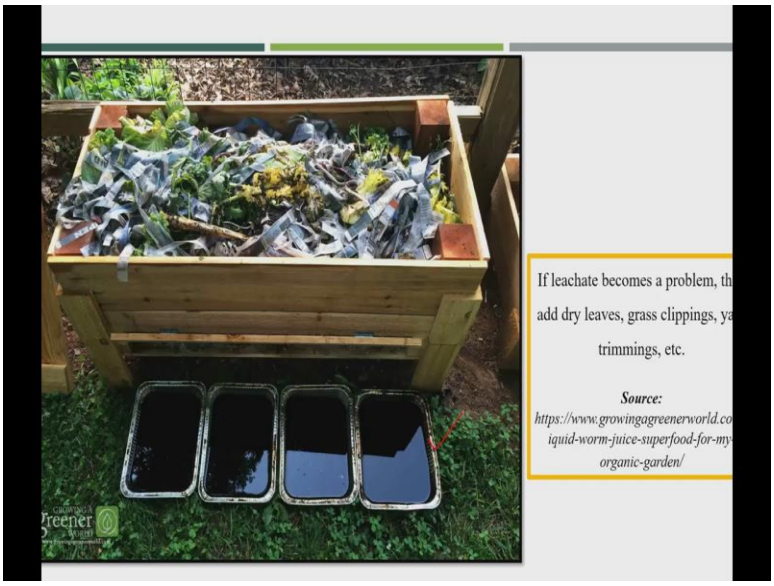

And there is always an issue about leachate production and again I am saying that these leachates will produce only and only can condition where the mass will be under the anaerobic condition. Now in this case you see that they put it into the 1 pot the entire mass you see here the paper even kitchen waste this is a mixed air but there is no aeration. They are not turning it. So obviously under the anaerobic condition, this leachate will come up.

I think many people will say sir what is the problem of leachate production into this one? This leachate is not like what leachate was producing into the landfill area or disposal area that is a highly polluted one, but it contains a lot of nutrients and these nutrients could be nitrogen could be, phosphorus could be, sodium, potassium, calcium could be possible to come out into these leachates in this excess water we can say then other than leachate.

I think the excess water we can say that see and the 1 more point is that if leachate it becomes a problem then add dry lose grass clipping, yard trimming. So what it says that add more dry material and the what is the benefit of these kinds of material is also provide the carbon for the degradation process but also it will absorb this excess amount of water. So normally we call this a bulking agent.

And if you go into the small laboratories I think for especially for the research we use sawdust because sawdust we know that sawdust is containing more amount of lignin and their carbon is

very difficult to degrade by those composting bacteria within the 20 or 30 days period required longer period than is possible but in 20, 30 days is not possible to degrade that particular lignin carbon but that sawdust is very good for the absorption of excess water.

Excess moisture if you are not able to properly maintain the aerobic condition or even especially for the kitchen waste as highly degradable one. So within few hours, you will see the degradation one and the entire material will be underwater. So even you add more amount of sawdust or more amount of dry matter is very difficult to absorb that entire moisture. So I think we need to see that.

So for that, these are the other way we need to add proper carbon to nitrogen ratio is alone that kitchen waste should not go for the composting process. So the mixing of 2, 3, or more substrate in that particular mass. In that way we can have proper moisture production also in absorption also could be possible so that such kind of leachate should not be produced or should not be generated into the mass.

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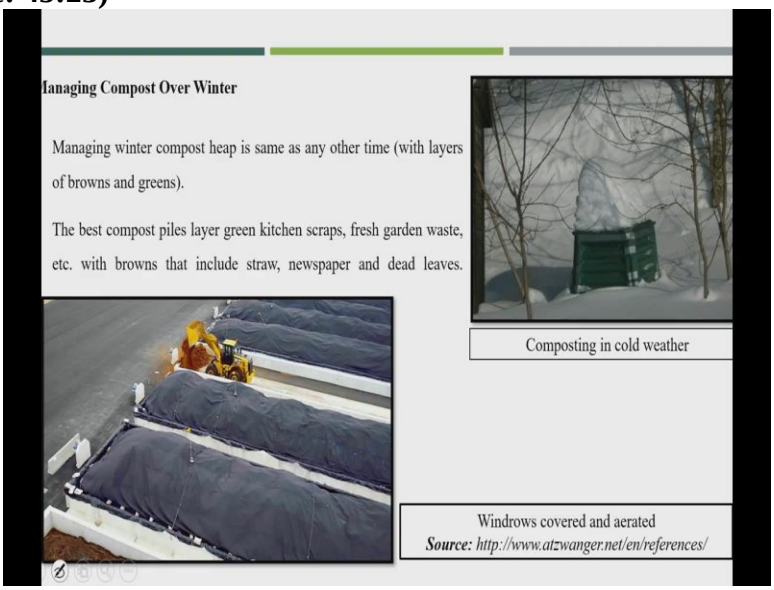

Now, this one more I think 2 move slides I had come up with that especially toward to talk about how we can do the composting in the winter season or the cold condition. So managing winter compost heap same as any other time with a layer of brown and green the base compost pile layer green kitchen scrap fresh garden waste with brown that includes straw newspaper and dead leaves or dry leaves by mixing of that and could possible that.

We can cover the entire material and go for that pipe perforated pipe aeration in the mass. So I think this is possible this kind of technology in the cold area but not like in India we can think about like in December, January the ambient temperature is 5 degrees. So we can go for this one I think we need not worry about that because microbes will get survive maybe we would not get that kind of thermophilic temperature in that particular season.

But at least if you can get a temperature around 55 degrees centigrade also I think is good for the composting method maybe the time requirement will be more into that particular season. So 2 months, 3 months it could be possible.

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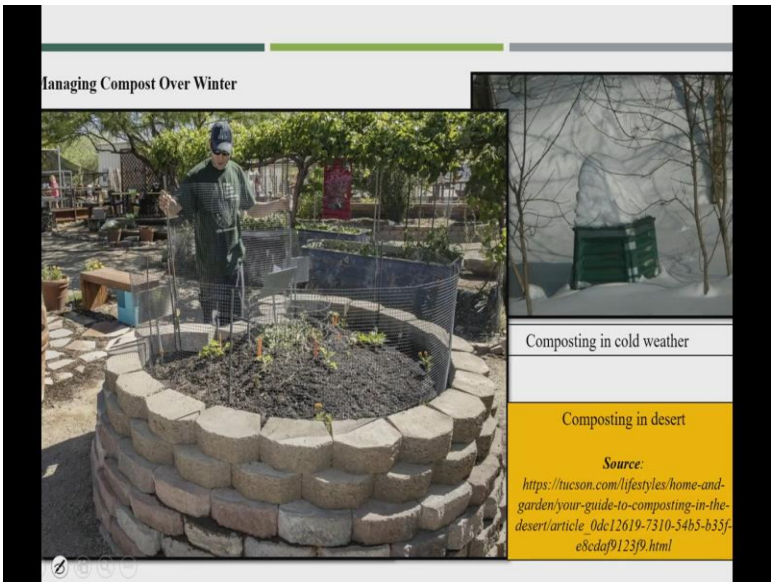

And specially in the desert area also we can have the composting by different methods the major point is here the aeration was the major point and the mixing of different materials also is one of the important point could be possible. But now like in India we have a number of centralized composting facility. And in that particular location around 200- 300 tons of waste is reaching in that particular composting facility see is a 200-300 tons in a day.

So it is very difficult to talk about in this way by mixing of dry brown to wet material or green material is very difficult to maintain there. And that is why I think you see that the operation also is very difficult in such cases because of biological waste. So if you are not able to make that

particular pile on the same day because the entire base will get degraded. And if you wait for 2 days, 3 days the entire mass will be will produce water and temperature will rise and such kind of material after 2 days, 3 days very difficult to handle them.

So I think that is why in India such kind of centralized facility we did not find much success to run those composting plants. That is why I believe that decentralized composting is possible at the community level or household level composting could be more successful than not only will utilize the material in that particular locality or particular area but also reduce your collection cost or transportation cost.

So what I am going to discuss in the next lecture where we will talk about another technology that is in-vessel composting. And in-vessel composting also the rotary drum composting is very popular. So much researches have been done on that. So that I am going to discuss in the next lecture. So thank you.