Municipal Solid Waste Management
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Lecture - 25
Factors Affecting Composting Process

So Hello students, today we will be continuing with the second lecture on biological treatment, biological transformation that we are discussing on composting.

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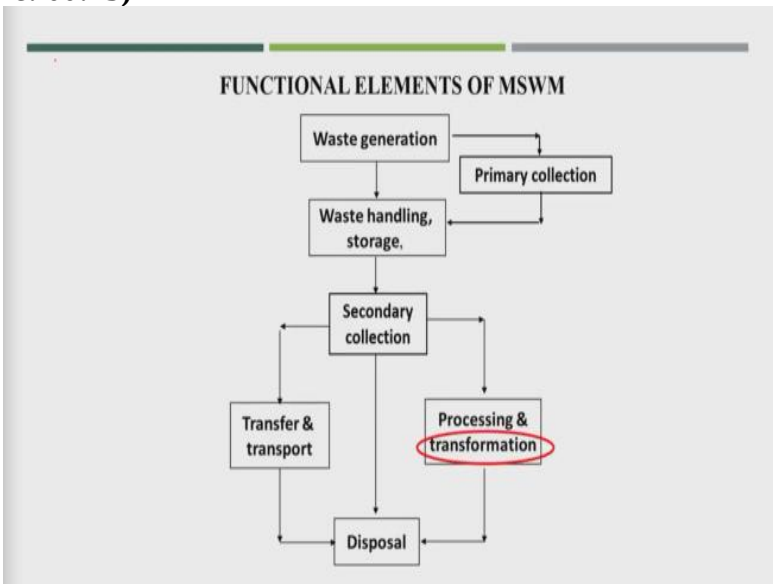

So under this lecture, we will focus on factors affecting the composting process in the previous class, I was talking about composting is a purely biological decomposition process and purely dependent on the microorganism and the major microorganisms are bacteria, actinomycetes and fungi. So obviously these are living organisms. So obviously there are a lot of factors that will be affecting their growth, their degradation process such as you take the example of human beings or animals.

We have a lot of issues like climatic conditions, we need water, we need food and climatic condition is a major issue like the coldest day we have different factors which are affecting us. So similarly in the composting process also these microbes will be required, the particular parameters need to be considered not only the physical one but also with the kind of food, how much moisture content will be required or how much water will be required for their growth and what kind of substrate are possible to degrade by composting process. So we will go one by one for the factors and we will discuss.

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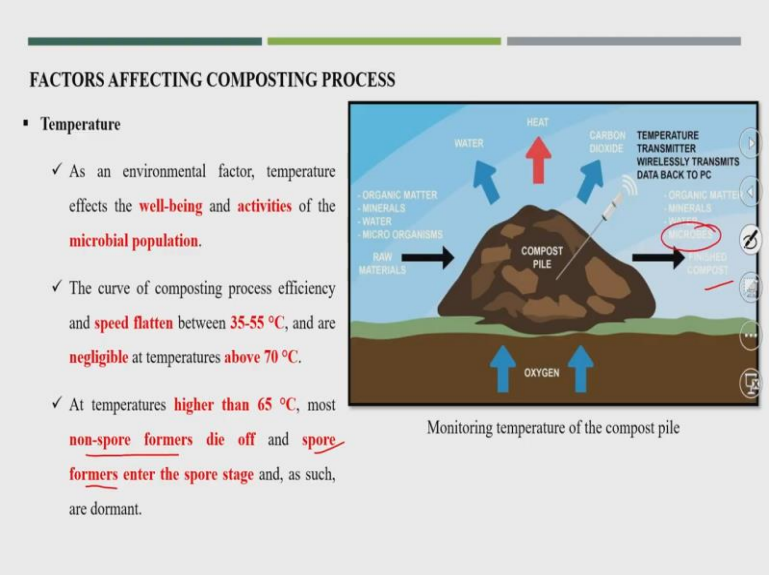

So the first factor is temperature and obviously this temperature is the ambient temperature and because of ambient temperature there are a lot of changes on to the growth of microorganism and obviously at lower temperature the growth of bacteria or growth of microorganism will be very slow at higher temperature like a 30°C, 40°C ambient temperature the growth of microorganism will be very high.

And you know that in the composting process also, the temperature is rising in the organic mass. So this is one of the important one well being and activity of microbial population is a one of the major factor and you see that the curve of composting process efficiency speed pattern between 35 to 55°C are negligible at temperature above 70°C.

So it is the temperature in the mass, composting mass and at temperature higher than 65°C most of the non-spore forming ones died off and spore forming ones enter the spore stage and the maximum amount will be, spore forming bacteria. See, I am talking about the temperature inside the composting mass or organic mass or organic fraction of MSW where temperature is rising.

And the previous class also I was talking about that when the temperature is rising more than 60°, 65°C where all these pathogens will start dying off and those pathogens will be mostly non spore forming bacteria and those are very important for the degradation process those will be the spore forming bacteria and they will be, available in the passive way and once the temperature will lower down they will be again starting degradation process and their growth also could be possible.

So again in the photograph it is showing that the monitoring of temperature. So in similar way the composting process again the raw material will process for the composting process. The water vapor will come out because of temperature, heat will come out, carbon dioxide because that carbon will get degraded and converted into carbon dioxide, carbon dioxide will come out. And finally we will get the finished compounds in the presence of the microbes.

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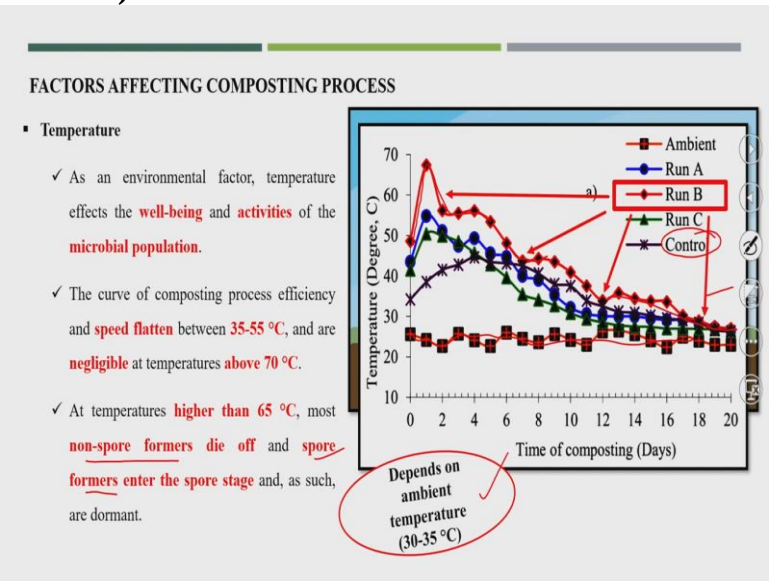

And one of the studies says that here the temperature graph. So here you are seeing this is the ambient temperature graph. And now here the composting mass C has been increased like this. So in one of the example temperature is very high, thermophilic temperature and again the temperature drops down and finally it comes to the ambient temperature, it is similar to the ambient temperature.

So is again depend upon the ambient temperature 30° to 35°C is one of the best temperature for the degradation process there not only the maximum degradation can be possible but also the growth of bacteria or other microorganism will be very high at this temperature. Now here this question will come up, sir if this temperature is best temperature so what will happen in case of cold temperature.

Where temperature reduced to 10° because in India the temperature difference is very high in the entire year where temperature maximum temperature sometimes goes to 45, 48° C and sometime temperature lower down to 5°C also or 10°C ambient temperature obviously there will be as some degradation will be different and normally the higher temperature

degradation will be more and lower temperature degradation will be slower down but is not that the composting is not possible at this temperature 10°C.

There are a number of composting plant and there are a number of success studies available in the European country where ambient temperature is 15 to 20°C and most of the time sometimes the temperature reduced to 0°C also still they are able to run the those composting plants.

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So here you see the hot climate region like in India this is a favorable ambient conditions so you can easily go for this is one kind of technology which again I am going to talk about in next class different type of composting technology. So where you will see in open area also we can do the composting process. So because it is a high climatic condition so no issues will be come up but only in the rainy season you cannot have the such kind of composting method.

So like if you see in the colder region what will be the problem you are seeing here in this photograph this excess water is coming out this is the excess water, this is leachate that is coming out and problem is that now this is coming out means the mass will have more amount of water then only the excess water will come out. So if there is a more amount of water into the mass so it is possible that this entire mass will go into the anaerobic condition.

And I have already shared that composting is an aerobic process and this is leachate, and excess water will come out only when the excess amount of moisture inside the mass and in

case of only anaerobic degradation process. So this is what the problem in the colder region. That is why I think most of the colder country they do not have more amount and more numbers of composting facilities.

Likewise, if you see in the hot climate region like South Asian countries where temperature always temperature you will find more than 20, 25° C that is one of the best temperature for the composting facility.

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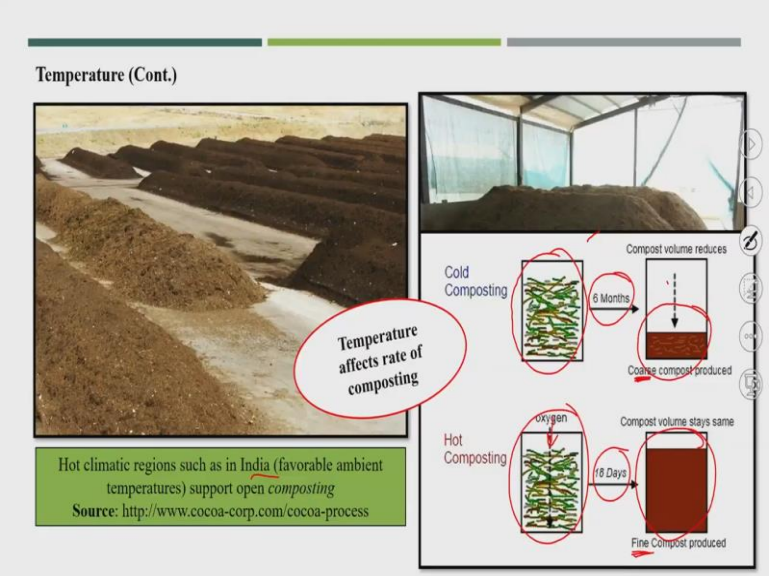

Now here you see here by this diagram you can understand that in the cold composting so this is the mass, is a composting mass and compost volume gets reduced and this volume is left after 6 months of composting period and here mostly will be the coarse compost, and it can be possible in the cold composting and in hot composting. Now the same amount of mass will be required to add oxygen into that and within 80 days' period we will get a very large amount of compost that can be possible and that will be fine compost.

So it is less than 4 mm size, compost will be able to achieve the hot composting process. So this is what the difference between the ambient temperature and the like in the India obviously the ambient temperature is in the hot condition. So I think we need to have more composting facility already in the most of the schemes I think composting plants are coming up but I think problem is that is not the only parameter is required, few more parameters are also affecting the composting process and that I am going to discuss in the next slide. So obviously temperature affect rate of composting.

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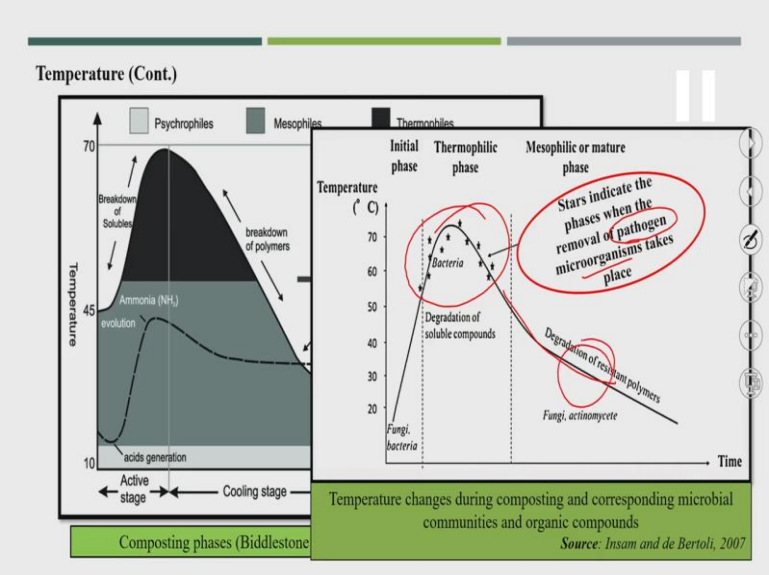

So this is the temperature graph. So, which in the previous class also we have seen so, here you see here this is the major one the thermophilic temperature and these star indicate the phase when the removal of pathogen microorganism takes place this is the one the thermophilic temperature where these all pathogens and pathogenic microorganism will get removed out of and the beneficial microorganism will be make spore and then finally this same bacteria will growth into those spore forming bacteria will be the in the active phase will be come up into the last phase of the composting process.

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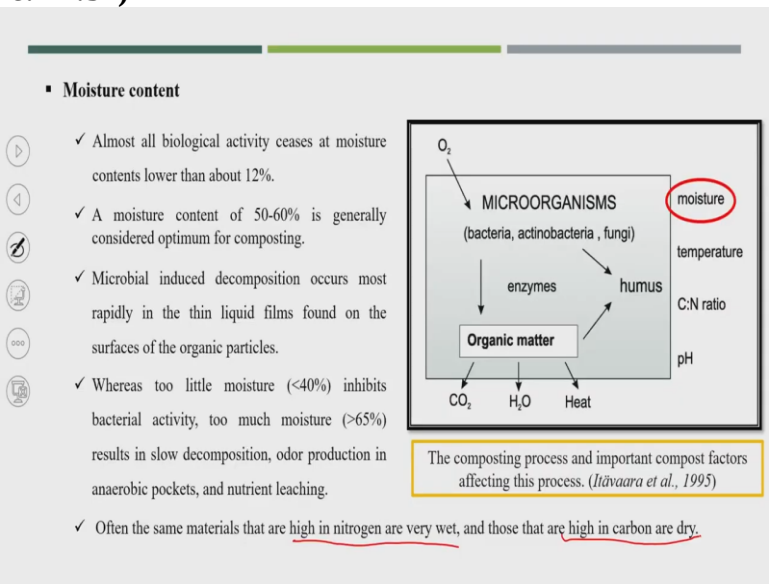

Now the next parameter is moisture content. So, almost all biological activity ceases at moisture content lower than about 12%. So this is also very important point please understand that any organic material if moisture is less than 12% it is very difficult to see that the live microorganism into that particular organic material take the example of agriculture

mass because the agriculture mass has more amount of lignin and cellulose percentage is there, moisture content is lower very low.

So that is why you would not see, very easy degradation of that particular kind of mass because moisture content is very low into that and moisture content of 50% to 60% generally considered optimum for the composting process. Now this is another very important point that moisture content is 50 to 60% is best for, or optimum for the composting process, and now you see here in the in the composting process already temperature is rising and because of that rise in temperature, water will get vaporized.

So we know that thermophilic temperature rises up to 65°, 70° C temperature and there also a lot of moisture will get vaporized. So there also the moisture content will be removed out from mass but also while degradation also moisture will get produced. So see this is very important to understand that how much moisture has to be maintained in the initial composting mass that 50 to 60% even you can go up to 70% of moisture content.

But also you need to see that how best you will be able to get the thermophilic temperature so that the excess amount of water will get vaporize through the rise in the temperature because while in the degradation also more amount of moisture will get produced. That is why you see in the colder region the excess amount of moisture is leached out from the composting mass.

And along with that excess moisture content which is coming out from the composting mass a lot of nutrients will also remove out from the composting mass which is required to find into the final compost product. So microbial induced decomposition occurs most rapidly in the thin liquid film found on the surface of the organic particle so the organic particle is a very thin liquid film will be there and where the microbes will be trying to decompose the particular organic matter.

So here these are the few different parameters where the first is moisture content whereas too little moisture less than 40% inhibit bacterial activity and too much moisture, more than 65% result in slow decomposition, odor production in anaerobic pockets and nutrient leaching this is the what I was discussing suppose if you have the low amount of moisture content like

30%, 40%. So, obviously the degradation is possible but the growth of microorganism will be very slow.

So that will also inhibit the bacterial activity. So your required composting time will be very, very high in that case you will be requiring 3 months, 6 months for complete degradation of these organic materials and if we have more moisture content like 70%, 80%. So, which what I was sharing that while in the degradation also moisture will get produced. So it is possible that if more moisture will be inside the mass because of degradation also.

and if you are not able to get the thermophilic temperature no vaporization could be possible then it is possible that entire mass will be under anaerobic condition because whatever the small pockets are there into the that particular mass now initially there will be air into the pockets but after degradation process if more moisture will be there inside that pocket moisture will be there.

So obviously if there is a moisture the water will be there means there would not be a air. So obviously that entire mass will be under the anaerobic condition if there is anaerobic condition means there will be odor production I already talked about in the last lecture that in anaerobic condition methane will produce, ammonia will produce these are highly odorous gases and also it will produce now the excess amount of water that will leached out.

And because of that lot of nutrients also will get leached out from the composting mass. So it is very important to maintain the proper moisture content that is easy to maintain properly in the composting mass. So often the same material that are high in nitrogen. So this is also one very important point the same material that are high in nitrogen are very wet. So high in nitrogen are very wet and those that are high in carbon are dry.

So this is very important point you can easily see that where the more nitrogen is there in the organic material that will be a very wet material it means more moisture will be there and where more carbon is there that will be dry in nature.

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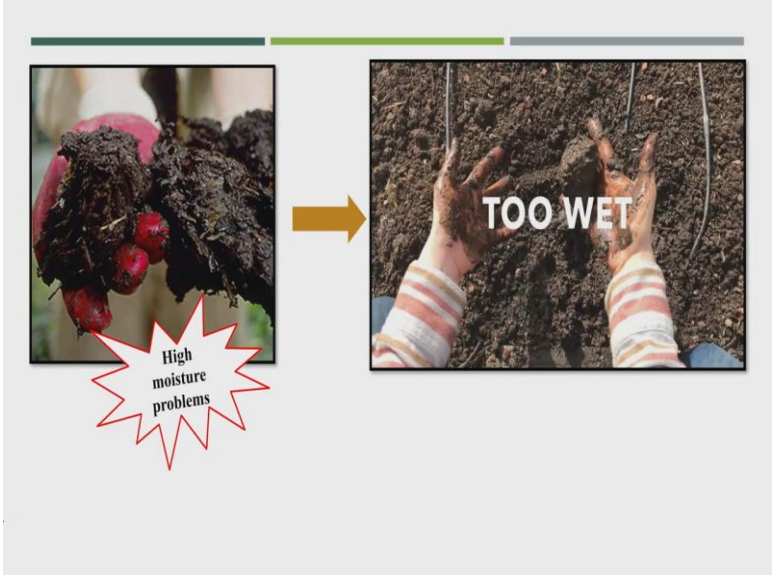

So that also you can see that now here if there is more moisture so how we can see the composting mass. So very high moisture problem in this, too wet you can see here, just by hand you can see, it is a very wet material.

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Now here in this case, it is a complete dry in both the cases the proper degradation will be possible.

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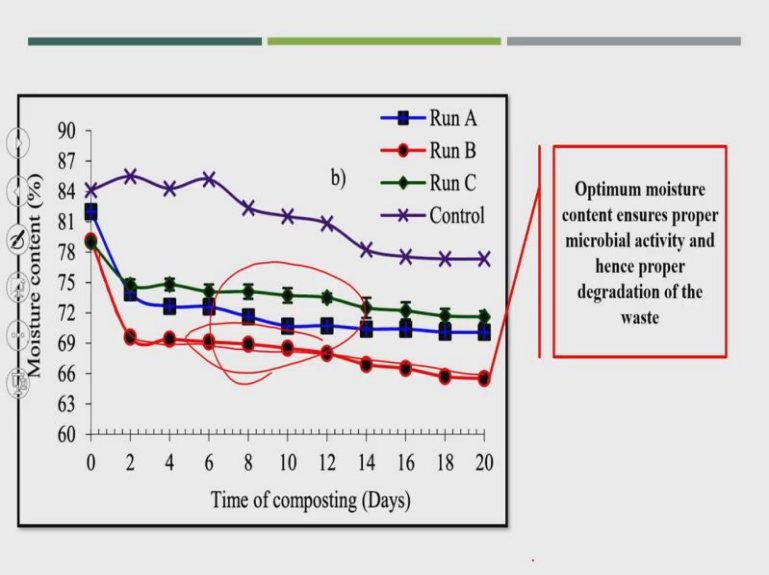

So here you see that the optimum moisture content ensures proper microbial activity and hence the proper degradation of the waste. So here I showed that how moisture content is changing. So in the different completion of the waste material you can see that how the moisture content is reducing and this you will see here there would not be much changes in this one because while degradation also moisture will be produced. So that also has to be seen that the moisture content should be 50% to 60% or 65%.

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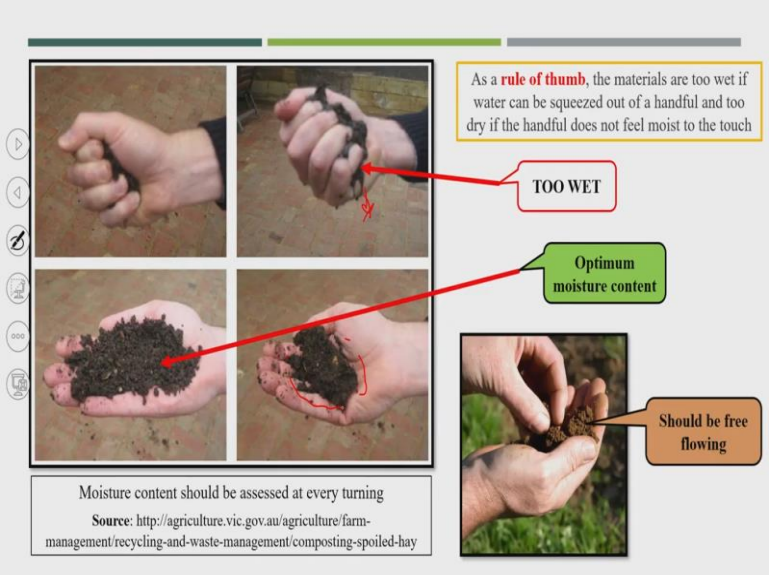

So, this is moisture content you can easily assess on the field. These normally we can easily measure moisture content in the laboratory. I can explain like this, you take 500 grams of composting mass or 1 kg of composting mass, measure the weight and note it down and put it in hot air oven for 24 hours and see that how much moisture will get vaporized in 24 hours and again you note the weight of that mass.

The weight that has vaporized is your moisture content. You can but in the field I think sampling collection you need to go to laboratory to check the moisture content. So if such kind of facility is not possible you can easily do it in the field, like take the compost mass in your hand and you see that excess water is coming out. So it means, this is not proper composting mass this should be dry like these.

So is as a rule of thumb the material are too wet if water can be squeezed out of handful and too dry if the handful does not feel moist onto the touch. So like in the 2 cases you can see here when it has squeezed the moisture is coming out. But in this case even there will not be you will see any water onto the hand. So here this is proper composting mass or degraded mass. So is there too wet and here proper moisture content. So what we are saying that it should be free flowing material and then only we can say is it properly degraded material.

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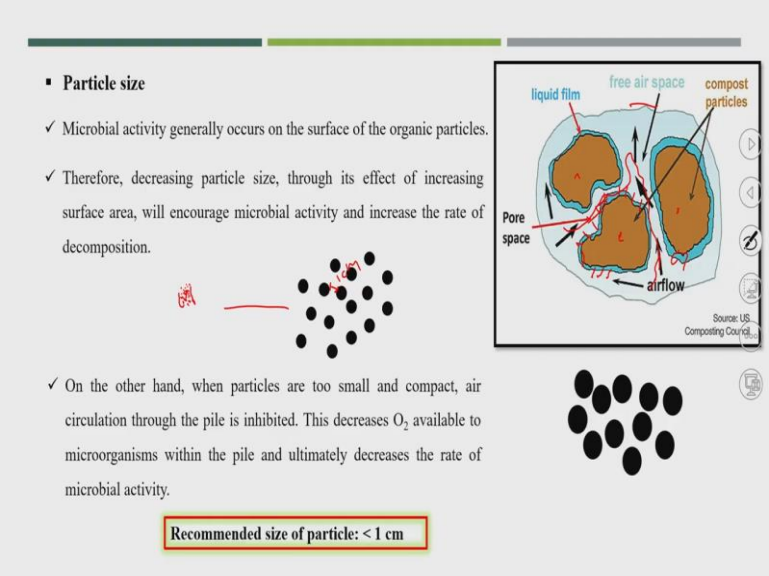

Now the next parameter is particle size. Now this is also a very important parameter because you take an example of a large material obviously the microbe has to enter into that particular mass for the degradation process if the size is big obviously it will take more time to access inside that particular material. So that is why the size is also very important for the degradation process.

So, microbial activity generally occurs on the surface of the organic material. Therefore, decreasing particle size through its effect of increasing surface area will encourage microbial activity and increase the rate of decomposition. So now here you see that this is a small size.

So small size how this we can show here this is the composting mass, this is the organic mass and whatever the pore space available here this is free air space.

Now because here the air will be available and here the microbes will get degraded from the surface here. On the other hand, when the particles are too small and compact air circulation through the pile is inhibited these decreases O_2 availability to the microorganism within the pile and ultimately decreases the rate of microbial activity suppose the size is too big then the whatever be the pore spaces available that will be smaller than the bigger size.

So, that the availability of oxygen also will be less in that case so, the because of that rate of microbial activity will be slowing down and degradation also will be slow in that case. So that is why the recommended particle sizes are around 1 centimeter or lesser than 1 centimeter but again another issue here you can say that why only for 1 centimeter why not we go for 1 mm size. So that is easy for the microbial degradation.

Now the problem is now the same suppose here the difference is 1 centimeter. Now the same material if, you put it like this like 1 mm size material. Now you see here the in the once the degradation will be there the particle what could possible in this particular pore space that size will be very small and whatever the size is available rather than air the water will be there because of degradation water will also produce.

So that water will be in that particular pore. So if there is water in the pore means that will go in anaerobic condition. That is why the smaller size is also not that beneficial having like 1 mm size or 2 mm size if you make that particular material and also for that you require very special kind of grinder or shredder to reduce the size. But I think that is why the recommended value is 1 centimeter. And if you increase the size obviously your degradation will slow down.

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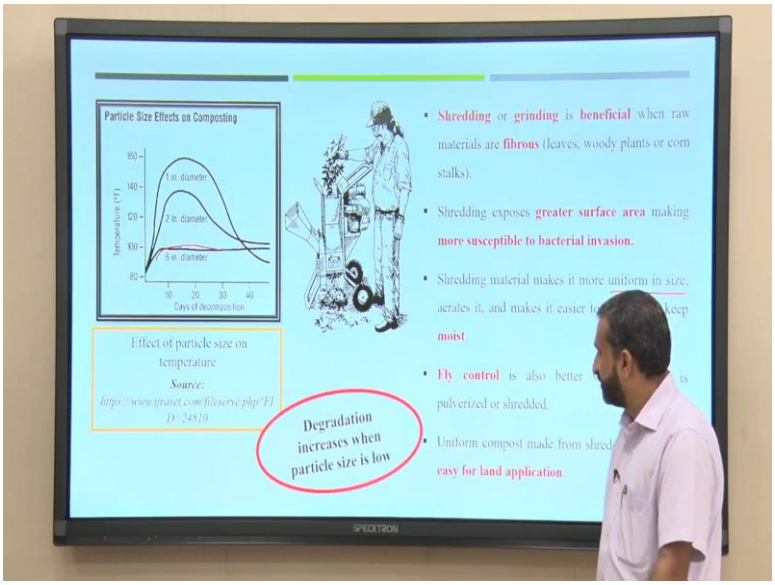

You see here based on the diameter of that particular material the degradation. So in case of decomposition you see that, in case of 1-inch size will reach maximum temperature, in case of 2-inch size, the temperature will fall down slightly, and in case of 6-inch, we are unable to achieve the thermophilic temperature.

because your degradation will be very poor if the sizes will be more that is why the size is also very important also wherever and whenever I personally visited composting site, I never saw waste being shredded and proper size being maintained in that one but I personally believe that wherever the composting plant is available, we need to have one proper shredder and also the wastes needs to come up to the shredder for the size to be maintained properly.

Now we can see that form household's kitchen, it is not possible to get same kind of size of material especially the peeling waste on that size sometimes goes to 2 centimeters, 3 centimeters, 5 centimeters has to be reduced down to one particular size and if there is a proper shredded material same sized material will be there, as obviously your degradation also will be improved in that case.

So this is what I was telling about that we need to have proper shredding or grinding is beneficial when raw material is fibrous like leaves, woody plants or cornstalks and shredding expose the greater surface area making them more susceptible to the microbial invasion shredding material makes it more uniform in size. So this is also that if it is more uniform in the size aerate it and that makes it easier to handle and keep moist.

Fly control is also better when the material is pulverized or shredded that is also one very important point fly controls will be always there and uniform compost made from the shredded material is easy for land application. So, final product also will be a fine material that is very easy for the land application in the agriculture area. So degradation increases when particle size is low. So that is the final conclusion of this one.

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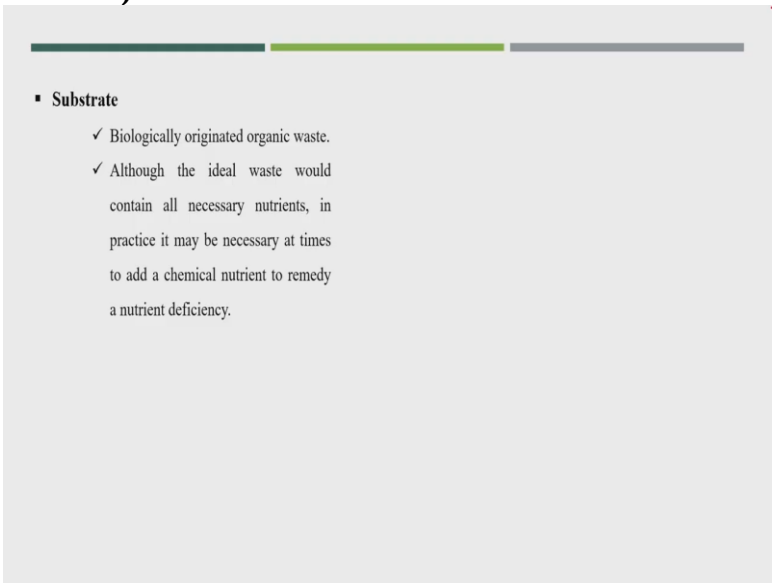

Now the next parameter is substrate, substrate means whatever feed we are giving to the composting process that called substrate. So obviously that should be organic in nature. But I think many time these discussions also are there that it is all organics could be possible to process by composting method? I believe that yes possible but I think which is very difficult to get biodegradable for them is not acceptable for the composting mass.

So rather than organic I think more biodegradable waste material is beneficial for the composting process. Although the ideal waste would contain all necessary nutrients in the practice it may be necessary at times to add a chemical nutrient to remedy a nutrient deficiency. This is also 1 point where I think it is added to the nutrient available in the substrate because if there are not much nutrients available.

And still we are looking for the composting process like specially the agriculture mass or sewage sludge if you are proposing that so there is also some nutrient addition could be possible that nutrient addition could be possible by addition of cow dung or any dung we can add to get the nutrients and also some microbes could be possible to add the into the that particular degradation process.

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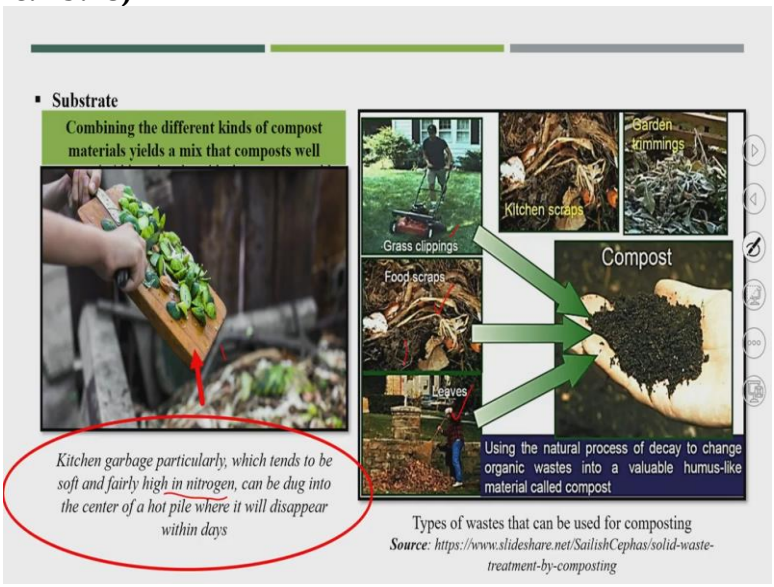

So here you are seeing here the grass clipping food scrap leaves that could possible to get utilized for the composting process. And especially the kitchen garbage that is a maximum percentage in the MSW that very easy to use for the composting process. So the kitchen waste which is very highly acceptable for the composting process which is having very high nitrogen in that particular mass I think there only we need proper segregation we need proper shading of that particular material and easy to go for composting method.

So the combination of different kind of compost material yields a mix that composts well. So now here it is possible now see these kinds of material like grass clipping, food waste, leaves contain low amount of nitrogen and more amount of carbon whereas in the kitchen waste more the amount of nitrogen less amount of carbon. So it is possible by mixing both material together is possible to get proper mix for the composting mass. So your substrate will be more beneficial for the degradation of bacteria or microorganism.

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So here the can see here the different material could be possible to process through the composting process. So specially for the kitchen waste or specially for the high nitrogenous waste if you use the wood chips this also is possible if you use sawdust, that can be added to increase the carbon percentage in the mass. So that is also more beneficial also sawdust is beneficial to reduce the moisture content in the composting mass.

So if you add these kinds of material so obviously we can easily maintain the moisture content and also in the composting process or even sewage sludge also can be possible to control the moisture content or addition of more nitrogen more carbon in the composting process.

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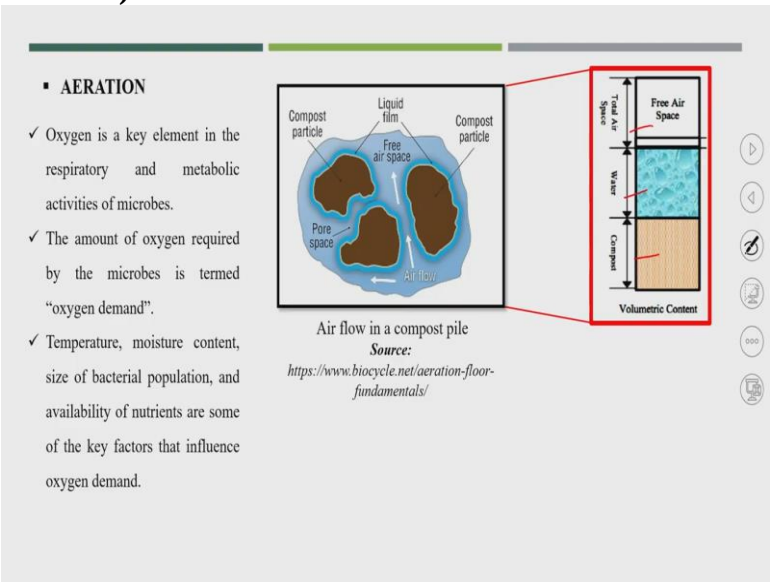

So next parameter is aeration I think this is the one of the most important parameter in the composting mass if you are able to aerate it very well. So obviously the microbial growth

also is possible to a very high extent and if microbial growth is high obviously degradation also will be very fast. So oxygen is the key element in the respiratory and metabolic activity of microbes. So amount of oxygen required by the microbes is termed oxygen demand.

and temperature moisture content, size of bacterial population, availability of nutrition is some of the key factors that influence oxygen demand. So here we were talking about that in the compost pile or compost mass whatever the pore space will be available, there the air will get supplied for growth of microorganism. So the entire composting mass you can separate into the 3 different phases, one is the compost that is the major amount of water and free air space, that will be available in the composting mass.

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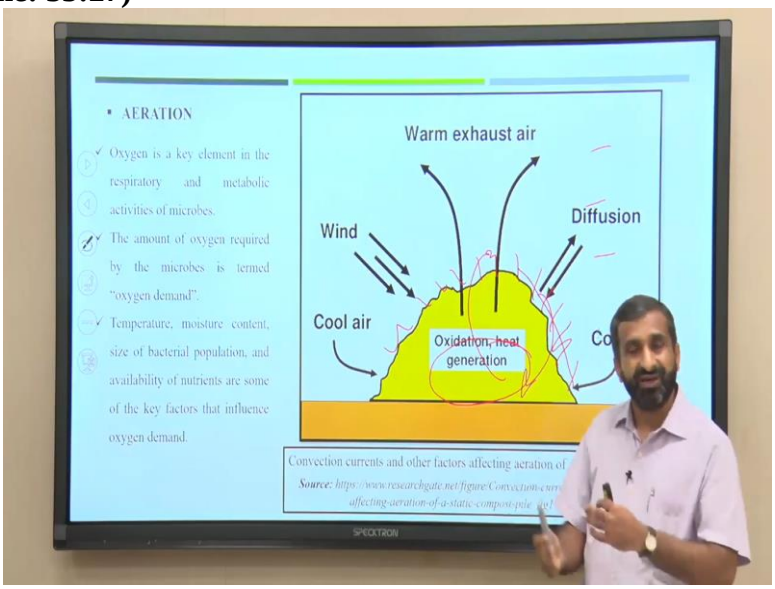

So obviously while in that aeration process the gases also will be coming out. So for the aeration process we need to turn the material, so that entire mass will be in aerobic condition. Now in this case it is possible that the top layer will always be in the aerobic condition but after particular time period maybe after 24 hour or within 2 days this kind of material the bottom material will be under the anaerobic condition.

Because whatever air is available in those spores that will be filled by water that is produced during degradation process. So now obviously this comes in anaerobic condition so odorous water will also start generating in the composting mass. So immediately you have to replace the material in such a way that these bottom waste will go on to the top for the aeration process. Now it is a highly aerated material we will go into the bottom. By that way if you

turn the material every 2 days or every 3rd day so the entire mass could be possible to aerate properly.

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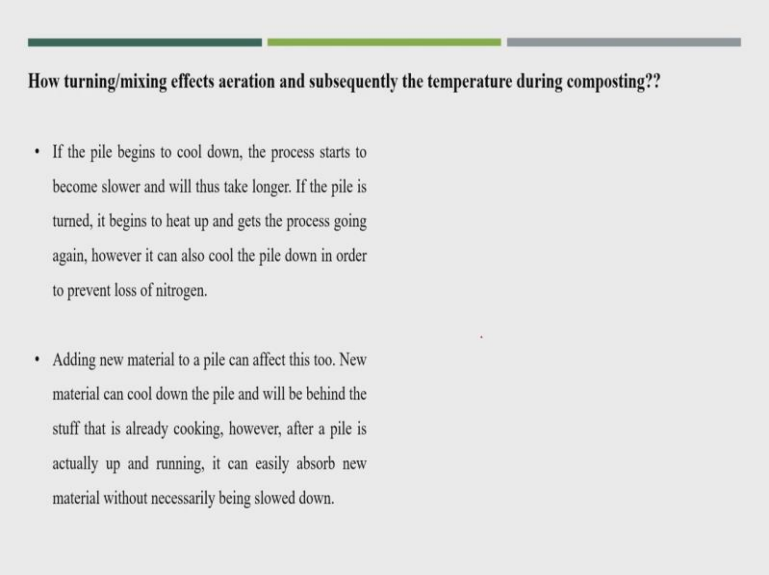

So this is how turning and mixing affect the aeration and subsequently the temperature during the composting process. If the pile begins to cool down the process starts to become slower and will thus take longer if the pile is turned, it begins to heat up and gets the process going again however it can also cool the pile down in odor to prevent loss of nitrogen. So adding new material to a pile can affect these 2.

New material can cool down the pile and will be behind the stuff that is already cooking how where the after a pile is actually up and running it can easily absorb new material without necessarily being slowed down. So how the turning is affecting the entire temperature? So if you turn the material again the microbe will get a lot of air. So their growth will start up so your temperature will also increase and after that it will also lower down again, you turn, again it will increase the temperature.

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So here now the addition of here is discussion on to the addition of new material. So what could possible that because already this is the degraded material is already degradation is there into the mass now we are adding the new fresh material into the composting mass obviously it will reduce the temperature of the composting mass but I think because this all is organic in nature so obviously after a particular time period the temperature also will increase. So the compost mass pile is capable of reaching up to 70°C in just few days.

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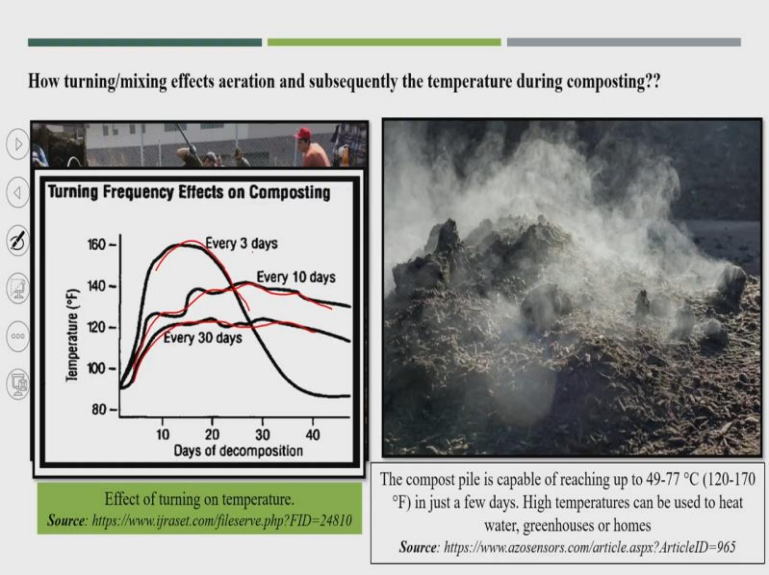

So here this is important graph where it is showing that, days of decomposition versus temperature. So if the temperature is very high, you need to turn every 3rd day if you are able to get very high temperature and if you turn every 10th day your temperature will be like this every 3rd day temperature will lower down. So you see here how important is the turning frequency.

So if you turn that composting mass in every 3rd day you will be able to achieve thermophilic temperature but if you are turning at 10 days or 13 days you are not able to achieve the thermophilic temperature into the composting mass. So this turning also is very important factor for turning or aeration and also very important factor for the degradation in the composting process.

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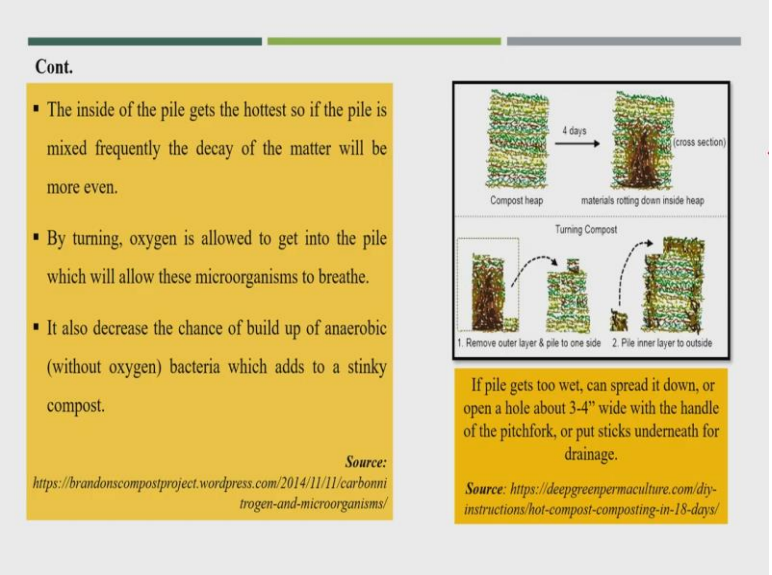

So you can see here after 4 days of composting it if you are turning this is the degraded material inside the mass. So if the pile gets too wet, it can spread down or open a hole about 3 to 4-inch-wide with the handle of the pitch fork and put stick underneath for the drainage if the excess moisture will be there that also is possible in the composting mass, the inside of the pile gets the hotter so if the pile is mixed frequently the decay of matter will be more even.

and by turning oxygen is allowed to get into the pile which will allow these microorganisms to breathe it also decrease the chance of buildup of anaerobic condition or anaerobic bacteria which leads to a stinky compost. So that is why in the field how to see that when to do the turning and how to know that whether that entire composting mass is converted into anaerobic condition if there is a stinking odor in that mass.

So obviously this stinking of because of methane because of ammonia gas there is a major is an ammonia gas and also some amount of H_2S also can be possible. The small percentage is a highly odorous gas highly stinky gas. So by that way you will come to know that now the pile your particular material has to be turned. So in the field how to know that if there is stinking

it turns the pile, again you wait for it and if stinking then you turn the pile in the large scale composting plants you can do that.

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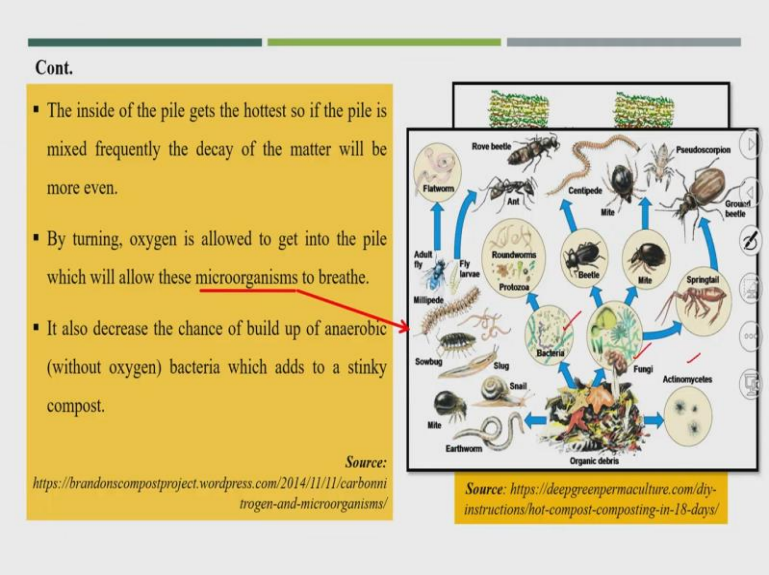

And these microorganisms are obviously that there will be bacteria, fungi and actinomycetes.

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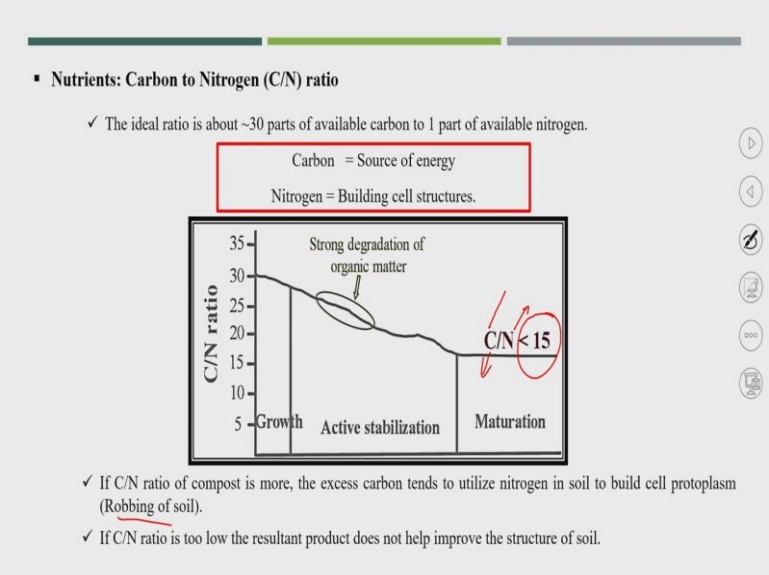

Now the next parameter is a nutrient or carbon to nitrogen ratio this is also one of very important parameter for the degradation process the ideal ratio is around 30 but many times it is saying that it is 25 to 30, is the best optimum carbon to nitrogen ratio for the composting process. So what is the benefit of that carbon is for source of energy and nitrogen is for building cell structure. So you see here this graph is showing this is the time versus carbon to nitrogen ratio.

Where the carbon to nitrogen ratio is reducing why because carbon is degrading and nitrogen is increasing but the decrease of carbon is more compared to small increase in the nitrogen concentration. So obviously carbon to nitrogen will reduce and if you are getting around 15 to 20 carbon to nitrogen ratio in the final product that found out to be most suitable carbon to nitrogen ratio in the composting mass.

If C/N ratio of compost in compost is more the excess carbon tends to utilize nitrogen in soil to build cell protoplasm or robbing of soil. So what could possible that if the if C/N ratio is compost is more so it is possible then whatever carbon is available so more microorganism will be there so they will be robbing the nitrogen from the soil. So that is why, it is very important parameter to measure in the final compost mass how much is the carbon to nitrogen ratio.

If the carbon to nitrogen ratio is 25 or 30 in the final mass and if you are putting that particular compost into the agriculture land obviously their nitrogen they will be utilized for the for the degradation of that particular material that normally we called as a robbing of nitrogen from the soil. And if C/N ratio is too low the resultant product does not help to improve the structure of the soil. So what will it be possible that in the initially carbon to nitrogen ratio suppose very low like 10 so what could possible the carbon is less nitrogen is more.

So the carbon means that is a source of energy means the food for the bacteria is very less if nitrogen is more means there could be a more amount of microorganism the microorganism growth is more because the that nitrogen is required for their growth. So now food is not remaining so it is possible that the same bacteria rather than utilizing carbon, is a source of energy they will be used nitrogen is in a source of energy itself.

So obviously in the final product your nitrogen concentration will be lowering down and that process will also will be, not that proper degradation can be possible into that particular composting mass.

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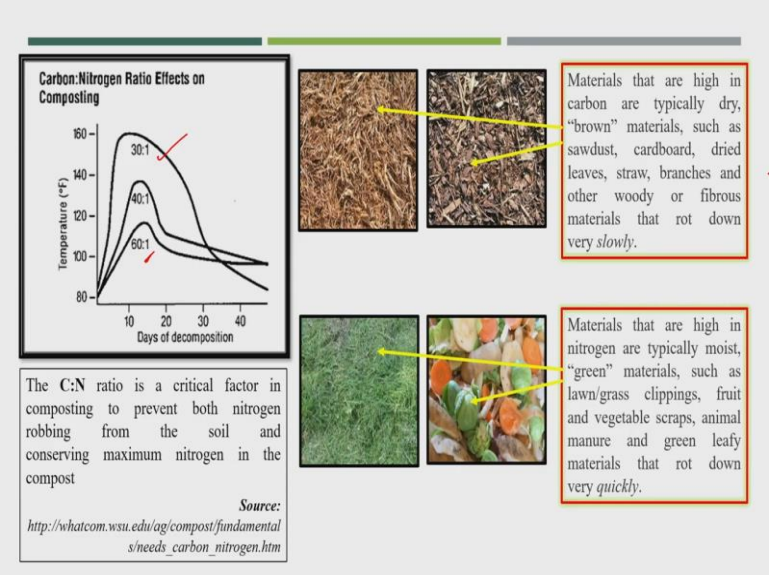

So here again this graph shows that days of decomposition versus temperature with C/N ratio. So you will see here C/N ratio if 30 is to 1 and 60 is to 1. So in 30 is to 1 you will be able to achieve the thermophilic condition but the carbon to nitrogen ratio 60 is to 1 we are not able to achieve the thermophilic condition into that particular compost mass. So now these materials you will see is a very dry material but organic in nature.

So materials that are high in carbon are typically dry brown material such as sawdust, cardboard, dried leaves, straw, branches and other fibrous material and the degradation also will be very slow. But whereas you see the green material that are high nitrogen typically moist green material such as lawn grass clipping, fruit vegetable scraps, animal waste and that is possible to degradation is very fast in that case.

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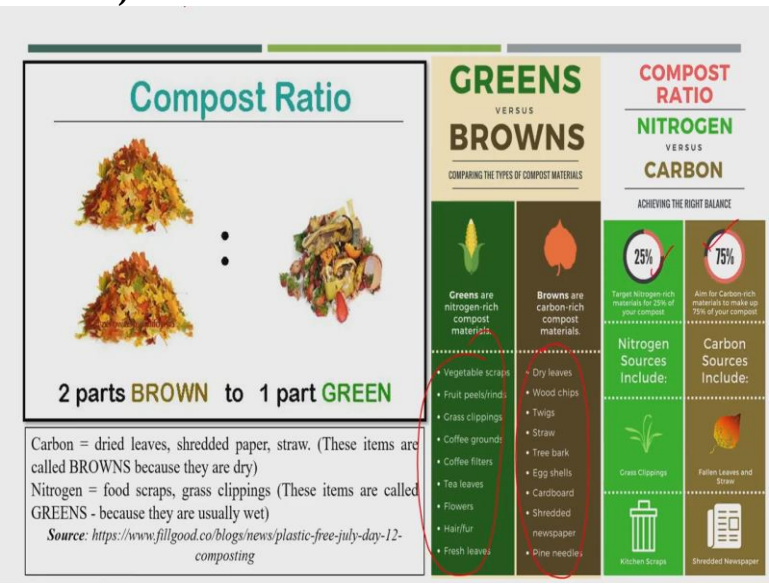

So this another one, so for the proper degradation process will be required 2 parts of the brown material or that dry material is with the 1 part of green or wet material and this is the another the same cases these are the different wet materials and this is different dry material or brown materials by mixing of both we can achieve proper carbon to nitrogen ratio. This is another way this is by that way different percentage is possible here to achieve.

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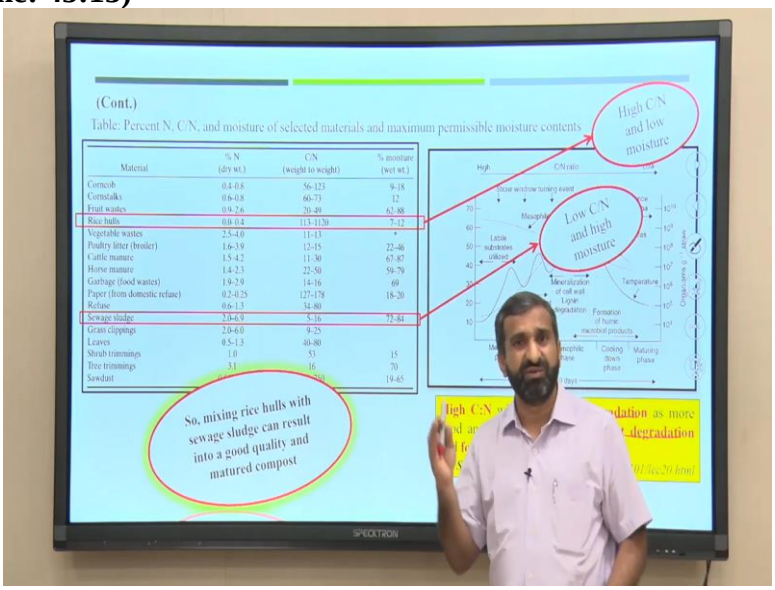

So high C/N ratio will lead to high degradation as more food and low C/N ratio will lead to fast degradation and formation if immature compost. So you see here high C/N ratio will lead to less degradation means that your degradation will be very slow and low C/N ratio is possible to have high fast degradation. But finally we will get an immature compost I think that does not have the more nitrogen into that particular mass.

So what can be possible that here I come up with the few different materials and carbon to nitrogen ratio our moisture percentage. So if you take example of rice or agriculture material which will have a very low percentage of nitrogen, carbon to nitrogen ratio is very high moisture also is very low. So high carbon to nitrogen low in moisture whereas you take the sewage sludge or even kitchen waste you take example.

Where nitrogen percentage is very high C/N ratio is low and moisture is high. So low CN and high moisture if you mix both the materials now we will be able to come up with a proper carbon to nitrogen ratio and your degradation also will be very fast in that case so mixing the agriculture residue or kitchen waste can result in a good quality and mature compost. Finally,

now these also sometimes questions will come how by this mixing it can be possible to achieve into the centralized composting facility in the different cities.

That is what actually I never proposed. I think this kind of factors are very difficult to maintain in the centralized facility. That is why if you go for a, decentralized facility were small composting plant where these kind of parameter you will be able easily could be possible to achieve and to maintain into the composting. So I think these are the very important factors needed to be on understood before going for the composting process.

Now I think you people have completely understood, how the temperature, moisture content, size, substrate, C/N ratio is very important, and these parameter is not that difficult to maintain the purpose of this lecture also and you need not to how to read a lot of research paper to understand these factors these we can easily achieve into the field by mixing 2 different material to maintain the moisture you take the wet material some part take the dry material mix it and because of that not only moisture, your carbon to nitrogen ratio also.

It can be easily achievable and because of that your thermophilic temperature also is achievable into the composting mass. So I hope that you people have to understood this parameter in the field, also this parameter can be easily achievable. Thank you!