Municipal Solid Waste Management
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Lecture - 29
Vermicomposting

So hello students, today we are in the last lecture of biological treatment-I, which is on composting. And in this lecture, we will talk about vermicomposting. So, this is also another method of composting. Normally, we believe that is vermicomposting is especially for the degradation process by the earthworms. But also there will be a role of micro-organisms like bacteria and other micro-organisms like in the conventional composting process that also is very required for the degradation process.

So, any time when you talk about the type of composting, normally people will say that agitated pile or agitated pile in-vessel composting, we will finish that and vermicomposting normally discuss in the separately but also you can consider vermicomposting also is one type of composting process, but as the name suggests, is a vermicomposting. So, it completely depends on the earthworms.

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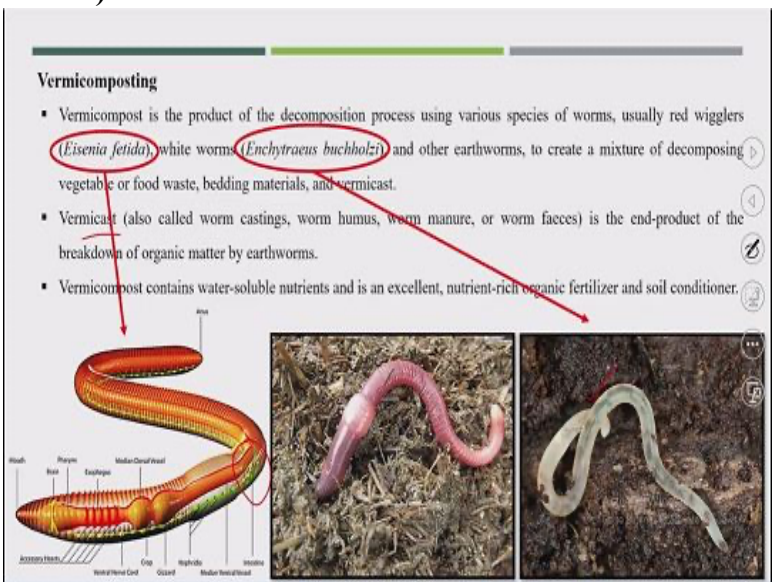

So, the vermicompost is a product of decomposition of the process using various species of the worm. Usually, I think the major one is E*isenia fetida* that is normally we call it is a red worm. And another white worm, that creates a mixture of decomposition of the vegetable food waste or

a different kind of organic waste is possible to degrade here need to be understood that all kinds of earthworms can be able to degrade the organic waste as you see in the rainy season.

You will see most of the earthworms or you will find in the soil, those soil earthworms can degrade the organic waste because the organic waste is producing water also, leachate the excess water that this kind of earthworm like soil earthworms can be possible to live into those conditions. Under normally this word also will come up normally when we talk about vermicast that this is the final product, we are getting it from the vermicomposting process.

This is normally is a vermicast means is a worm casting or worm humus are manure or feces that is called is a vermicast that is the end product is coming out from the vermicomposting process. So many times people will say is a vermicomposting process and the product rather than calling as a simple composed we will call it is either vermicompost are many times or many books or literature you will say vermicast both are similar one and these vermicompost content water-soluble nutrients and is an excellent nutrient-rich organic fertilizer and soil conditioner.

See this is somewhat different from the normal compost. So, here is water-soluble nutrients are available. So means I think most of the nutrients, also the amount will be high and also it will be very easily water-soluble. So, you see that the major earthworms researched the vermicomposting process i.e., *Eisenia fetida*. So, this is the *Eisenia fetida*. And here you can see the intestine is one of the best intestines u can find.

Where not only the organic waste is getting degraded very easily but also the mini the suppose the organic waste is having high metal content like sewage sludge water hyacinth different weeds these metal also will be in the intestine. So in the final cost of the vermicast, the metal would not come up so normally in the composting process the metal content is increasing, but in the vermicomposting process, the metal concentration will decrease because of the intestine of the earthworm.

This is the what is the exact photograph of earthworm is enough data this is a red one and another the white worm this is the white one but I think we do not find a lot of research for white

earthworm but we will find lots of literature for degradation of various kinds of organic waste which is including agriculture waste municipal waste industrial waste also a lot of studies are available.

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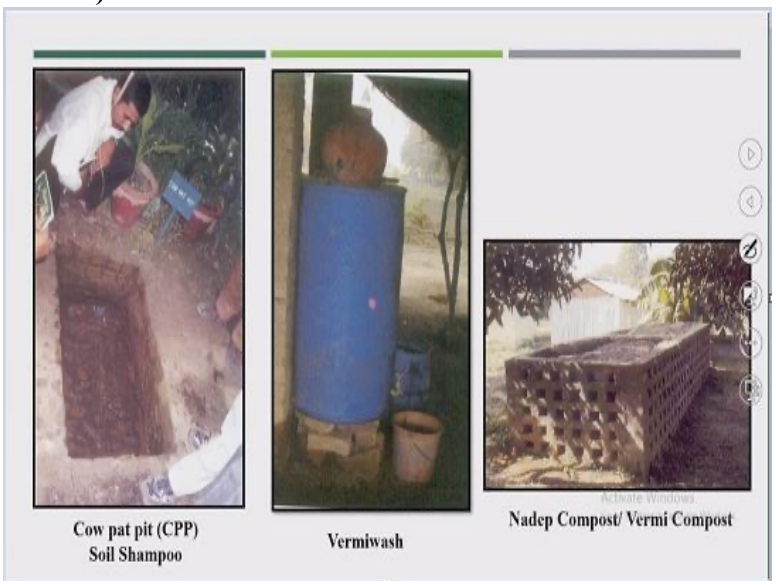

On this is a few different technologies or rather than technology different ways the vermicomposting is possible like the first is a cow pit, so, these the cow pit where the cow dung along with the earthworms put it into these with under this earthworm will degrade the cow dung similar this a vermiwash the similar way in the degradation process because a lot of water will get produced. So, whatever the water will come out that we called is a vermiwash under this is the very well-known process in the 90s.

In India, we find this Nadep composting method/composting system, so, is very simple for construction also here and in this one, the waste is getting disposed along with the earthworms. And within 45 days within 60 days, the entire degradation will be possible. So, the one major benefit of the vermicomposting process not only the degradation but also their population also will increase.

So, means, I think once here having supposed 500 or 1000 number of earthworms, you need not purchase afterworld because the same the 500 or 1000 earthworms will increase in the maybe 10,000 maybe it goes to 50,000 again I think we can continue the similar process also we can sell the compost and also we can sell the earthworms also. So, it is a highly beneficial method.

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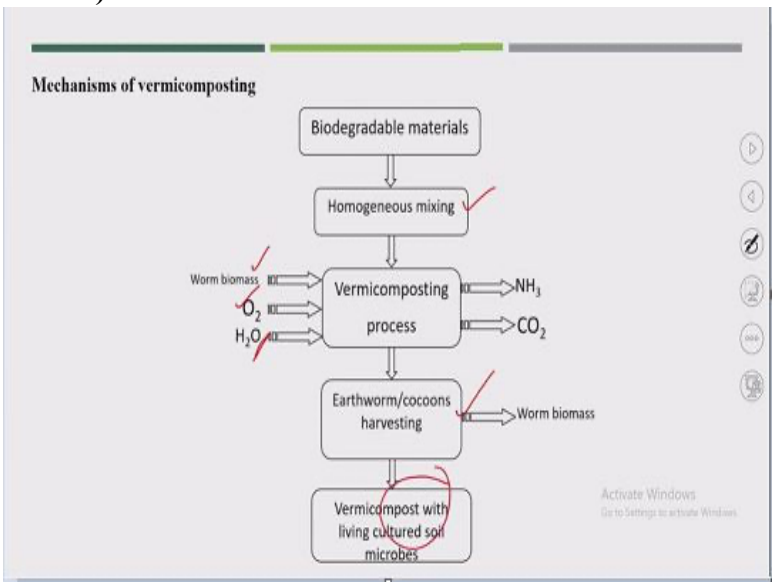

So, what is the mechanism of the vermicomposting process is a similar kind of composting process like biodegradable material here also we required a homogeneous mixing especially the brown waste and green waste should be properly homogenized mixed is required. So, during the vermicomposting process will put worm biomass and will be required obviously, will be required oxygen also the water will be also required, but if again the same discussion in the previous class if you have more water content like 95% 100%.

So, the earthworms would not get oxygen very properly. So, in the voids, you will be required moisture, but the complete moisture the entire voids will be filled by moisture. Again, the condition will be anaerobic, under these earthworms cannot be live in anaerobic conditions. And finally, we will get few gases. And as a product, we will get earthworm cocoons harvesting under this we have to segregate first and finally, we will get very good quality vermicompost.

So, which I was telling that will get the population of earthworms also will get increase and their cocoons also will increase. So, first, we have to harvest those earthworms are cocoons and then whatever is remaining that will be vermicompost.

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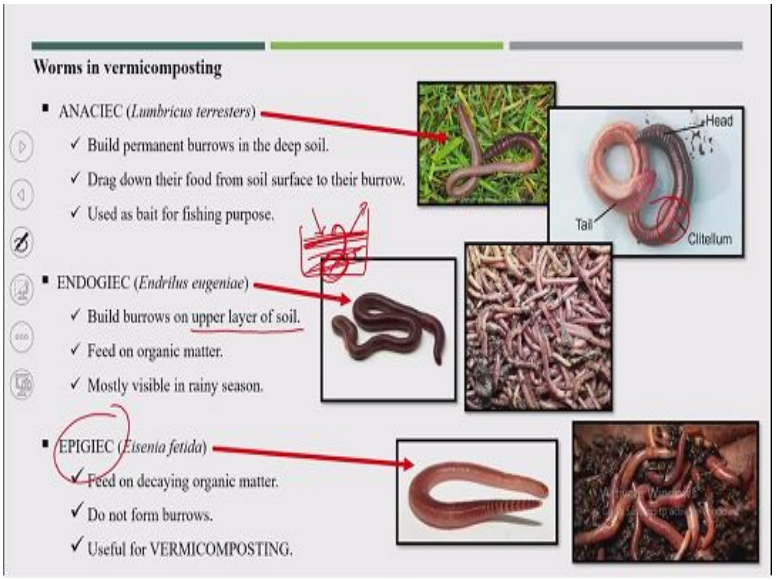

Now worms in vermicomposting, so normally there are 3 different types of earthworms normally getting used in the vermicomposting process first is the ANACIEC and this is not very well known one and still, not many studies are available for these kinds of earthworm, so here is the clitellum, from where the cocoons will get produce. So, these kinds of earthworms build a permanent burrow in the deep soil drag down their food from the soil surface to their burrow, and finally, it will come with a finished product.

So, now this is the important one, ENDOGIEC earthworm. This is also the lot of studies are available on these earthworms also. So, there this will build a burrow on the upper layer of the soil and feed on organic matter and most visible in the rainy season. So, here see idea is that it will be a burrow in the upper layer of the soil. So, suppose once you prepared any bed for degradation process, obviously, we will put the waste here and here suppose these are the earthworms.

So, they will burrow onto the top, they will degrade the upper location and again they will go to the bottom. So, we can collect we can harvest the compost and again we can put the fresh waste that is what the benefit of these kinds of earthworms. So, continuously we can work for the vermicomposting process and this is the well-known EPIGIEC that is the *Eisenia fetida* which we saw in the previous slide. This will feed on the decaying organic matter that does not form a burrow and useful for the vermicomposting process. So, I think most of the studies are available on the EPIGIEC earthworms and the major on *Eisenia fetida*.

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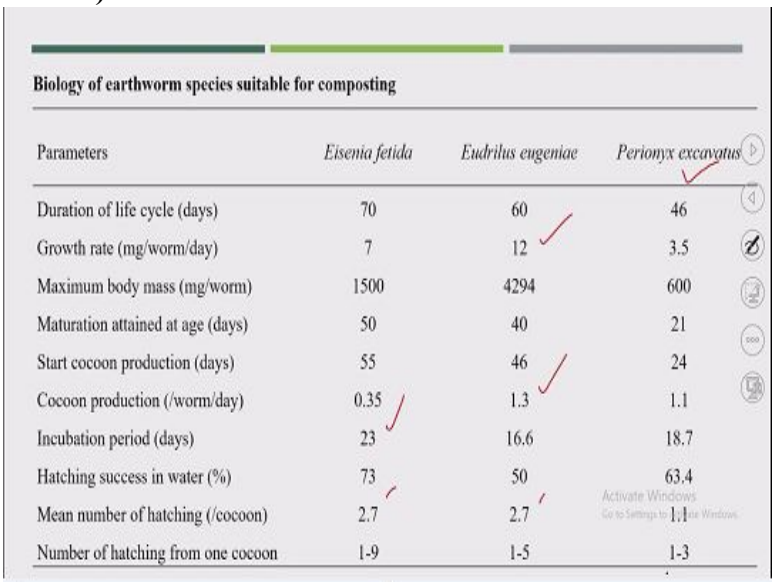

Biology of earthworm species suitable for composting

Parameters	*Eisenia fetida*	*Eudrilus eugeniae*	*Perionyx excavatus*
Duration of life cycle (days)	70	60	46
Growth rate (mg/worm/day)	7	12	3.5
Maximum body mass (mg/worm)	1500	4294	600
Maturation attained at age (days)	50	40	21
Start cocoon production (days)	55	46	24
Cocoon production (/worm/day)	0.35	1.3	1.1
Incubation period (days)	23	16.6	18.7
Hatching success in water (%)	73	50	63.4
Mean number of hatching (/cocoon)	2.7	2.7	1.1
Number of hatching from one cocoon	1-9	1-5	1-3

This is now the 3 different kinds of EPIGIEC earthworms were based on the parameter we can compare like duration of life cycles. So, this is the local earthworm like we can say is an Indian one we can find very easily *Perionyx* the growth rate also you will see the maximum is available here maximum growth rate and incubation period also 23 days and cocoon production is also a very high here and a number of hatchlings per cocoon here I think is almost same in both the one. So, when you compare that the different earthworm species I think *Eisenia fetida* is well known and more popular.

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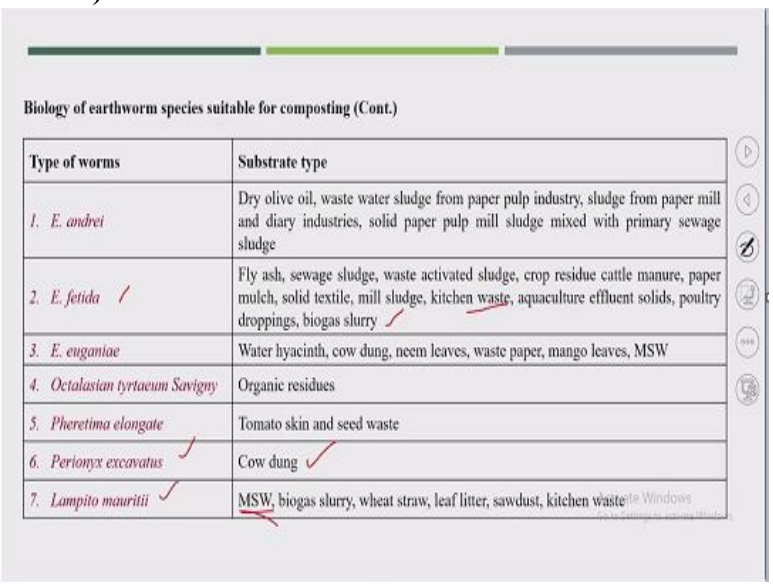

Biology of earthworm species suitable for composting (Cont.)

Type of worms	Substrate type
1. *E. andrei*	Dry olive oil, waste water sludge from paper pulp industry, sludge from paper mill and diary industries, solid paper pulp mill sludge mixed with primary sewage sludge
2. *E. fetida*	Fly ash, sewage sludge, waste activated sludge, crop residue cattle manure, paper mulch, solid textile, mill sludge, kitchen waste, aquaculture effluent solids, poultry droppings, biogas slurry
3. *E. eugeniae*	Water hyacinth, cow dung, neem leaves, waste paper, mango leaves, MSW
4. *Octalasian tyrtaeum Savigny*	Organic residues
5. *Pheretima elongate*	Tomato skin and seed waste
6. *Perionyx excavatus*	Cow dung
7. *Lampito mauritii*	MSW, biogas slurry, wheat straw, leaf litter, sawdust, kitchen waste

This is also another one more table where the suitability of earthworms for various kinds of waste like for *Eisenia fetida* you will see here for *Eisenia fetida* the fly ash sewage sludge waste

activated sludge various kind of cattle dunks and the even the kitchen waste the MSW the biogas slurry, this all could be possible even I think this is one the Indian one I was talking *Perionyx* which is specially for the cow dung.

And there are other earthworms also which are possible to use for the MSW like this is these earthworms this is also for MSW and because see, when you say the organic waste is not only the MSW, organic waste or municipal solid waste, organic waste, there are organic waste is coming from the agriculture area sewage treatment facility the organic waste will come from the industrial area. So, the different earthworms will be useful for the different kinds of organic waste.

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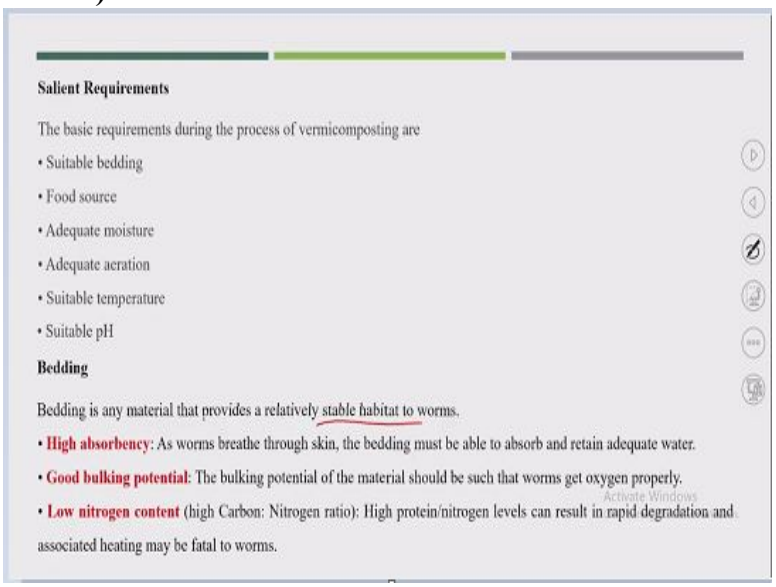

Now, there are some salient requirement of the vermicomposting process like there are basic requirements or you can say that there are a number of factors are affecting, the vermicomposting process like suitable bedding, which I am going to talk again I think it required the special kind of bedding if they do not like to eat the material eat the organic matter. So you will be required suitable bedding food source, the proper kind of subject is required. Adequate moisture is required for the degradation process.

Adequate aeration is required. Suitable temperature this is also very important one because see the earthworms also are live conditions obviously, in the colder condition like when the ambient temperature is 5 degree 10 degree difficult to have the growth into the into their population there

is no growth, the even the decomposition or degradation also would not be that fast and suitable pH. This is also a very important one. So, all for the vermicompost process neutral pH is now is a very basic requirement for the degradation process.

Now, we will go one by one. So, the bedding, bedding is a material that provides a relatively stable habitat to the worms. So, normally in a reactor or any anywhere, if you are going for a vermicomposting process, you need to put the first bedding. So, the idea of the bedding to provide relatively stable habitats to the worms means, because you see earthworm also required the acclimatization for that particular kind of organic material and acclimatization at least that 7 days or 15 days will be required for the acclimatization.

In that particular organic material or maybe from time to time you can change the organic matter also are suppose if you are starting with the one particular kind of organic matter, acclimatization will be always required. So, during the acclimatization period, how they can be in the live condition because they have to particularly acclimatize that condition. So, they will be required the special kind of bed, so that in that bed, they will be in the live condition and once they will be acclimatized they can go and they can degrade the organic matter.

Whatever the organic matter was supplying for their degradation process. So, what kind of bedding you will be required first is the high absorbency as earthworms breathe through the skin the bedding must be able to absorb and retain adequate water see as worm breathes through their skin. So, the bedding must be able to absorb and retain adequate water. So obviously water will be required. Good bulking potential the bulking potential of the material should be such that worms get oxygen properly.

So, now is also a very important point that so you cannot have the much depth of the reactor because your oxygen is required either if you are increasing the depth means, you have to have some kind of opening in the bottom so that the air can be entered into the bedding material. Low nitrogen content and high carbon. High carbon to nitrogen ratio, high protein nitrogen level can result in rapid degradation and associate heating may be fatal to the worms.

See, whatever the bedding material you are using this bedding material should have low nitrogen content, why? Because if suppose there is a large or very high nitrogen content will be there then obviously the nitrogen will degrade or will create some gases because the degradation will be there obviously. So either heat will be get produced or some odorous gases like ammonia will get produced. And they do not like odorous gases like ammonia or H 2 O as if there is an odor then their growth will be completely fertile for the worms.

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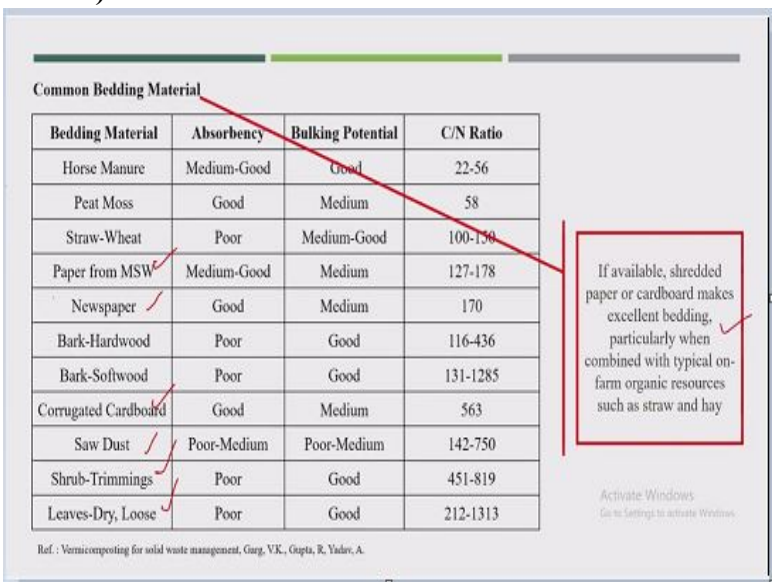

So these are some bedding materials/common bedding materials used. And most cases I think you will see the dry leaves, we are using shrub trimmings, even sawdust corrugated cardboard, even newspaper paper from MSW even some kind of different manures also or different kettle dunks also we can use for the bedding material. So here it has been compared these different bedding materials for their absorbency its absorption of water, bulking potential and carbon to nitrogen ratio.

So you can see here I think the bedding material like dry leaves sawdust is somewhat good. Even the box of food is also good bulking potential carbon to nitrogen ratio is also high. But most of these materials are very poor in the absorbency because of that, if you are using any kind of bedding material you need to add more amount of water and not only the more amount of water but also continuously you have to add the water.

So, because the absorbency is very poor, so, time to time we had to add the water for the degradation process. If available, the shredded paper or cardboard makes excellent bedding particularly when combined with the typical on form organic resources such as straw and hay, I think this is one more important point you can use as shredded paper cardboard or if you are doing the vermicomposting bed form itself. So, why not the other organic resources like straw hay we can use and also we can add these kinds of material with prepared compost so that the water absorbency also can be increased.

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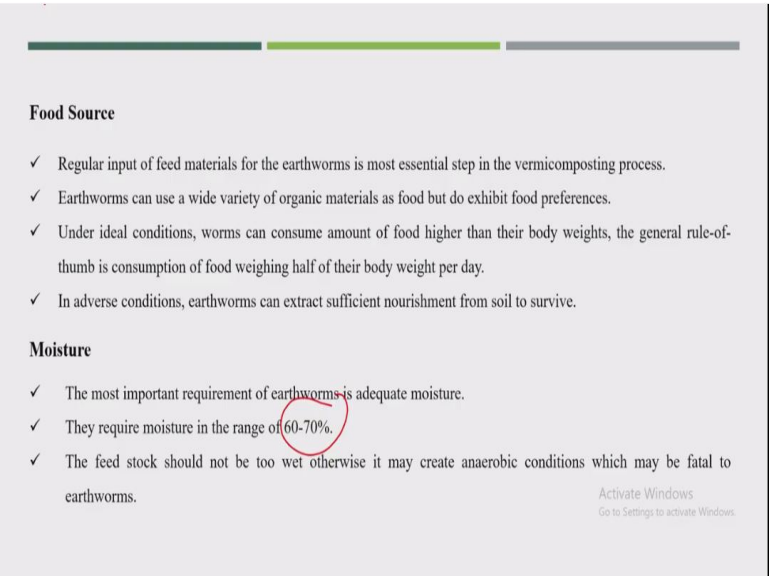

Now the next point is the food source. So, regular input of feed material for the earthworm is the most essential step in the vermicomposting process, earthworm can use a wide variety of organic material like food, but to exhibit food preferences under ideal conditions worms can consume the amount of food higher than their body weight, but a general rule of thumb is the consumption of food weighing half of their body weight per day.

So, you see here the under ideal condition is what could be the ideal condition that pH is neutral moisture is very good, the proper optimum moisture is there and whatever the substrate has been added that substrate is not producing any kind of gas and not possible to increase the temperature in the degradation process. So, this is also one important point which I am going to again discuss about that. So, once these wet waist will get degrade, obviously, the temperature will increase.

So, that is not good for the vermicompost process. So, if in the reactor the ideal condition could be possible then the earthworms will eat more than their body weight. But normally are there is a rule of thumb, how much amount of earthworms need to be added into that particular reactor or a particular system. So that is based on this information that so, every earthworm will eat half of their body weight per day. So, in that way, we can also fix the time of the vermicomposting process.

And also we can put that number of earthworms for the degradation process for a particular amount of organic material. In adverse conditions, earthworms can extract sufficient nourishment from soil to survive, see any live material or any live sale will try to be in the live condition they do not anybody wants to die very easily. So, even earthworms also in very adverse conditions, they will be trying to in the live condition and trying to degrade the organic material.

Like take the example of this *Eisenia fetida*, this is normally is not the Indian one, this is the European earthworm, it has come from the European. So, you see the ambient temperature in the European country, their local conditions are different ambient temperature never reached to 25 to 30 degree. So, that same earthworm now, we can easily find in the African country in the American country, even the same earthworm we can find in many locations in India.

Even they in India the climatic conditions in the central part of India or central India like Nagpur and Madhya Pradesh kind of area where the temperature is very high, there also you will find the *Eisenia fetida* and if you come to the northeast India where the temperature is very low and mostly in the rainy season, almost 6 months 7 months rain still will find these *Eisenia fetida*. So, that means you see their survival in very diverse conditions and very adverse conditions also are possible.

Now, the next point is moisture the most important requirement of earthworms is adequate moisture, so, they required almost 60 to 70% of nitrogen. And the feedstock should not be too wet otherwise it may create an anaerobic condition that may be fatal to the earthworm.

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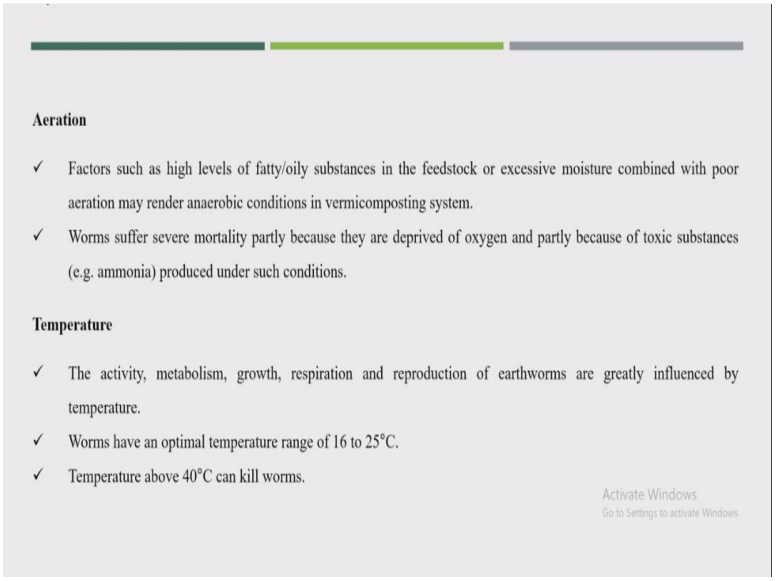

Next is the aeration. So, the factors such as a high level of fatty or oily substance in the feedstock or excessive moisture combined with poor aeration may render anaerobic condition in vermicomposting process and worm suffer severe mortality partly because they are deprived of oxygen and partly because of toxic substances produced under the under such condition. So, aeration is also very important.

So, now, I think we talked about aeration in the conventional composting process even in the in-vessel composting process that aeration does not like in the vermicomposting process, if you turn the entire reactor for aeration, I think I do not see that the earthworm will be beneficial because of that, now, because of that, just for the aeration process, we should not go up to the large depth. So, normally I think some research share this the depth should not be more than 500 centimeters.

I think that is very small one we can get because until that the aeration could be possible and also any reactor should be some things from the other part of the system or other part of the reactor so, that air can be sufficient can be injected into the particular system or in the reactor. Next is the temperature the activity metabolism growth respiration and production of earthworm generally influenced by the temperature worms have an optimum temperature range of 16 to 25 degrees centigrade, but temperature above 40 degrees centigrade can kill earthworm.

So, these are this is the problem or maybe is a good climatic condition they can find in the European country, even in India also I think except the summer will have these kinds of

temperature. So, for India or South Asian countries, we need to see that how these earthworms could be possibly worked into winter conditions where temperatures lower than 10 degrees. So, there could be also possible that could be some kind of mortality.

We can find under where the temperature is more than 40 degrees that is possible in most part of India like in central India, South India, or in North India also the temperature goes to 40 to 43 or even 48-degree temperature. So, there the mortality is possible. But again, I am saying that this *Eisenia fetida* in Africa is a very high survival earthworm and there are some studies are showing that this earthworm is possible to grow in 0 degrees to 2 degrees centigrade.

I think there is one study in Shillong, in northeast India where the temperature reached to 0 degree or 2 degrees centigrade in the night, still the earthworms fall in the live condition obviously, there will be some kind of mortality, but, the parallel growth will be also there, I think the cocoon productions is not that large, but the cocoon productions will be also possible in that condition. Even in some studies conducted in such part of India where the temperature rose to 45 degrees centigrade, there also we find some mortality.

But growth is also possible. So, in that case, I think we need to see that how best we can optimize the other conditions like moisture, substrate aeration if we can how the optimum condition for their growth. So, we can easily reduce the mortality of earthworms.

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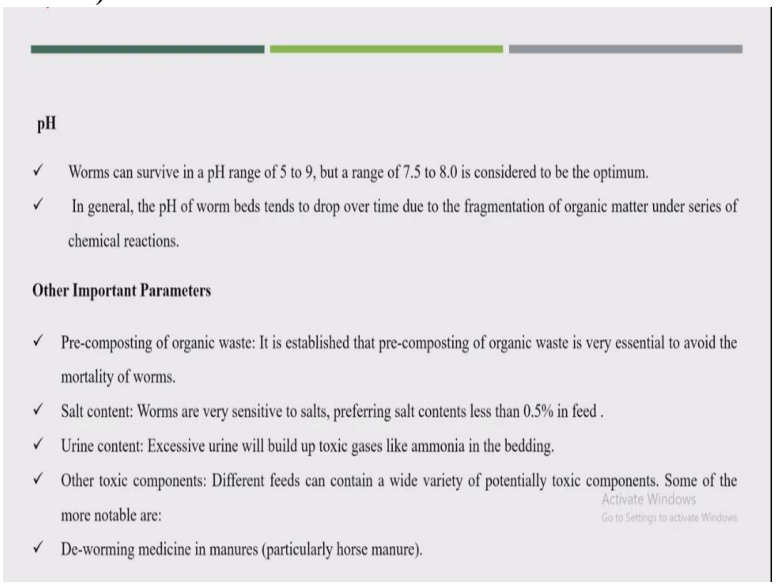

Now is another one is pH is one of the important factors, the worms can survive in pH range to 5 to 9 it is a large range. But if it is a range of 7.5 to 8 is considered to be optimum. In general, the pH of worm beds tends to drop over time due to the fragmentation of organic matter under a series of a chemical reaction. So, now the problem is our kitchen waste in MSW is highly acidic in nature. So, their pH goes to 4 even 5. So, that pH is not good for earthworms.

So, that is why either I think in the conventional composting also we did I discussed that if your mix different kind of material I like brown waste green waste or dry waste and wet waste together like kitchen waste if you mix with the agriculture waste, so, obviously, our carbon to nitrogen ratio also will be changed and obviously, it will affect the pH also or because of this pH issue or the high degradation of kitchen waste. This is also proposed by many studies that fresh kitchen waste does not apply the earthworms.

So, what this research says that, if you have only kitchen waste for the degradation process of vermicomposting process, so, you allow that particular material for 15 days for self-degradation process, up to 15 days, this green waste will convert into a somewhat brown color means, the normal degradation will be there under whatever heat is producing by the degradation process, that heat also will get removed out, I think the thermophilic condition would not come up.

But temperature more than 40-45 degrees also that will become out and then after 15 days now, you apply the earthworms into the degradation process that become one of the negative points of the vermicomposting process. So, there are many studies, I think there are 100 of research journal says that the earthworm should not be applied to the fresh material the only the problem is that, because that organic metal will go for thermophilic conditions or the temperature will increase.

And because of that high degradation process, the odorous gases will produce because of that, there could be mortality of the complete mortality of earthworms and some studies says that the entire the 100% mortality was found if you are applying the earthworms into the fresh material. So, but I think again if you mix the proper kind of material proper mix of the material if you

make that is possible to have the proper pH and even we can apply into the fresh material also other important parameters like the pre composting of organic waste.

It is established that pre-composition of organic waste is very essential to avoid the mortality of earthworms this is what I was talking about, it will be required the pre-composting of organic waste. So, I think some research says that why not these vermicomposting can do after the in-vessel composting process. So, the in-vessel process means a rotating composting process. So, in the rotary drum-like in the previous class I explained about the rotary drum composting for only 7 days and there also you are not able to find the mature compost.

So, that in the same compost, if you do that maturation by vermicomposting process that will be a highly beneficial process even the salt content worms are very sensitive to the salt. So, that also needs to see that urine content or other toxic components is also important for the growth of the earthworm and de-worming medicine in manures. And also I think these are some important parameter also need to be looked upon during the vermicomposting process.

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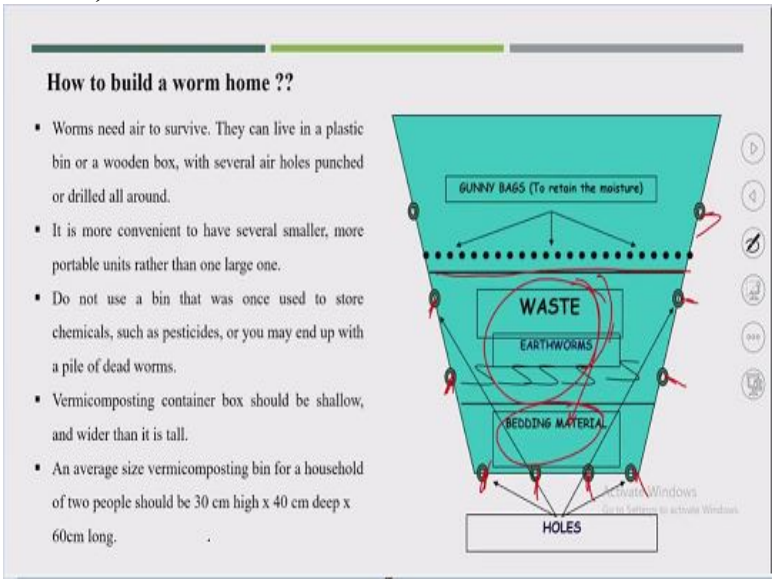

So, this is how to build a worm or how to build a worm home or vermicomposting process. So here you will see this one particular bucket where we can make these buckets themselves as a vermicomposting reactor or worm home. So you will see here in the bottom is a bedding material in the bottom followed by waste and earthworms mix. And in the top, we put it gunny bag,

gunny bag to retain the moisture, because moisture will get operated. So the upper surface will be dry.

So the degradation would not be possible in that case and also they do not like a light, especially the EPIGIEC earthworm do not like light. So the maximum degradation will be in the upper surface, on the maximum degradation we will be into the nighttime, where there would not be any light. So what they will do in the night they will come on to the top they will degrade the material in the morning they will go into the bottom.

So, that is why if you put some kind of cover onto the top material and here I put it the gunny bag because gunny bag also we can add the time to time water and we can make entire reactor proper moisture we can attain. So, worms need air to survive they can live in the plastic bin or wooden box with several year holes punched or drilled all around. So, these are the holes, this is for the aeration process, it is more convenient to have several smaller or more portable units rather than one large one do not use a bin that was once used to store chemicals such as pesticides.

And or you may end up with a pile of dead worms vermicompost the container box should be shallow and wider than it is tall. So, the container box is shallow and wider than it is tall. So, you can see here the average size of vermicomposting made for a household of 2 people should be a 30 centimeter high 40 centimeter deep, and 60 centimeters long if you are using it in the household area. So, this is what the unit could be possible that it should be a tall upper area will be more compared to the bottom area.

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So, this is the household vermicomposting reactor. So here 3 units first, second and third commercially these kind of units are available.

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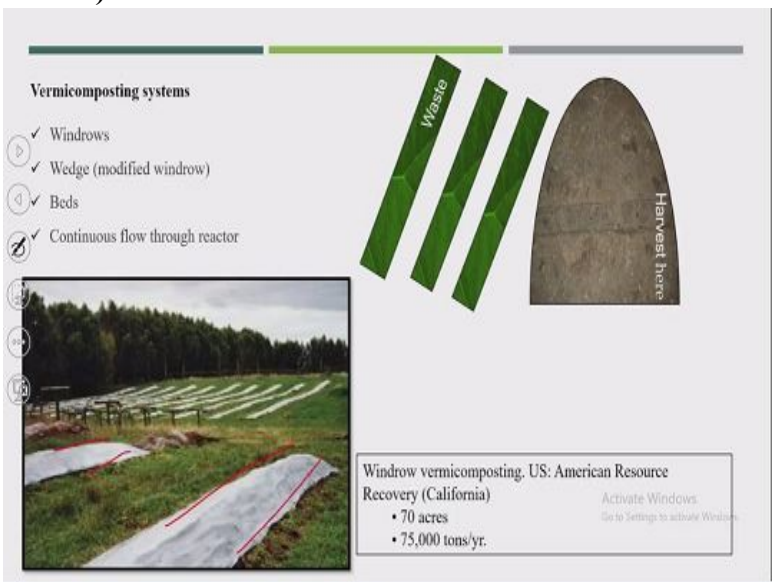

Now, the vermicompost system, when you talk about the types or different ways of vermicomposting could be possible like windrow wedge are is a similar kind of windrow system only modified one bed and continuous flow-through reactor. So, this is the windrow vermicomposting process. So, this is what the windrow is covered.

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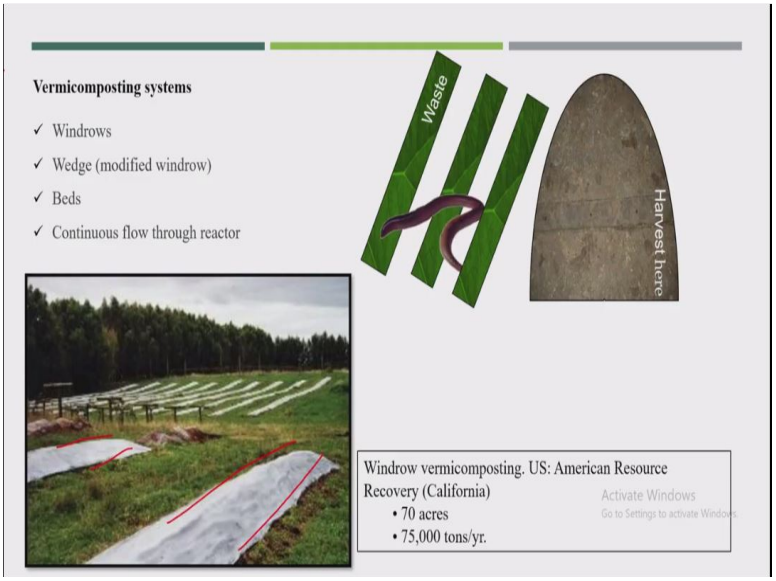

Under wedge composting also is a modified one, but does a similar kind of windrow composting process. So, here the harvesting also is one of the important issues.

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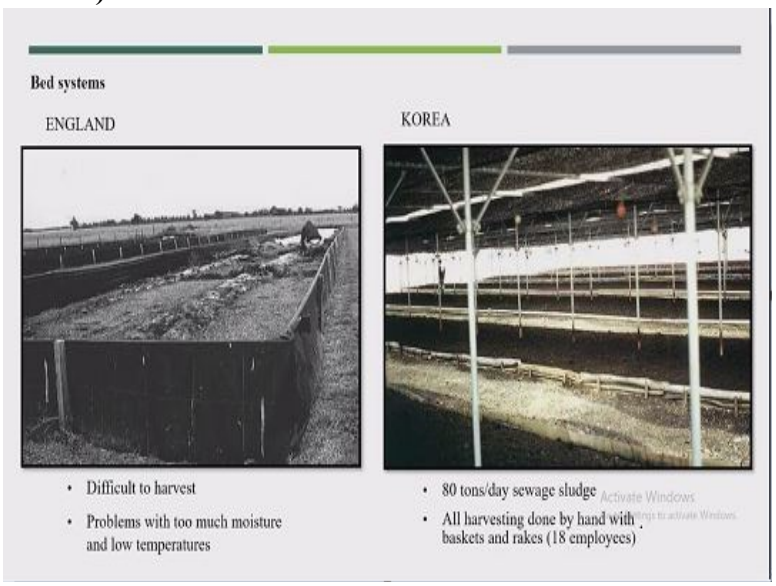

So, nowhere is a bed system. So, is a bed completely so, is difficult to harvest. So, now your earthworm has to be a harvest for collecting of vermicast or vermicompost problem with too much moisture and low temperature this is another photograph from Korea, where 10 tons per day sewage sludge all harvesting done by hand with basket and racks. So 18 employees are working regularly for harvesting of earthworm.

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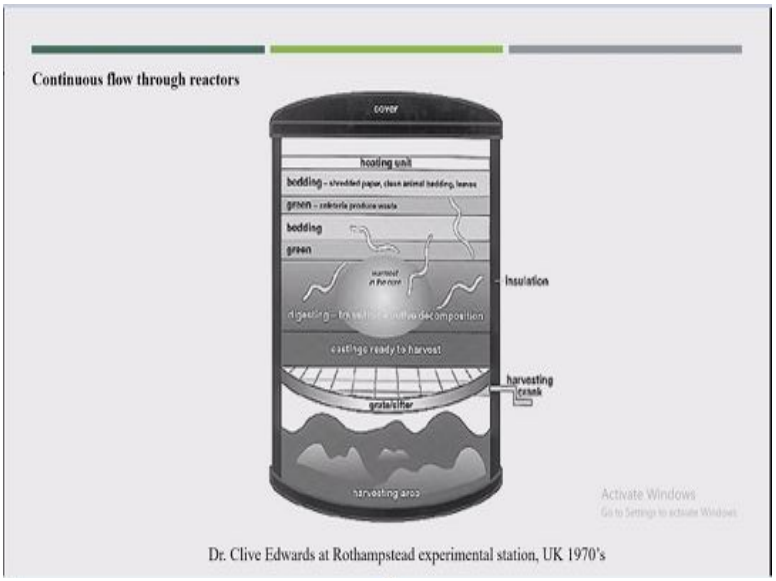

Now is a continuous flow-through reactor. So, these kinds of reactors also continuously we can add the material or organic material for the degradation process.

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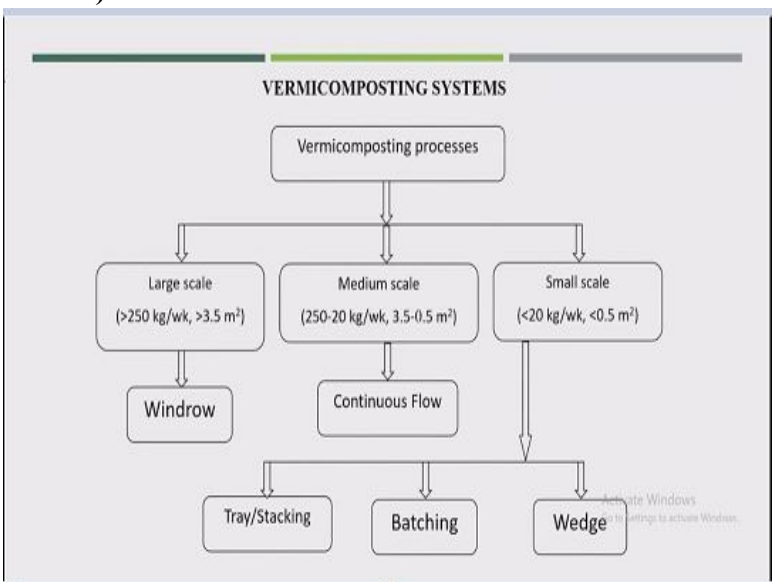

And when you again compare or when you talk about the different types of vermicomposting process, so is based on the scale large scale where the quantity is 250 kg per week, the medium is 250 to 20 kg per week small is less than 20 kg per week. So, for large scale is a windrow medium-scale continuous flow and for small scale, we can go for simply that tray stacking batching or wedge method and in the last lecture, I was talking about the decentralized composting process.

So, with this small scale also we can go for decentralized composting process especially these we can do it in the even apartment area also we can have the one vermicomposting unit, small vermicompost unit, not in the household level, but in the community level also is possible or some of the community there are some particular locations available in particular community area are some parks are available.

So, in that parks, we can create one vermicomposting bed or vermicomposting pit we can create and all organic waste we can add along with the kitchen waste also for MSW and even the horticulture area a lot of organic waste is generated that also we can utilize in the vermicomposting pit.

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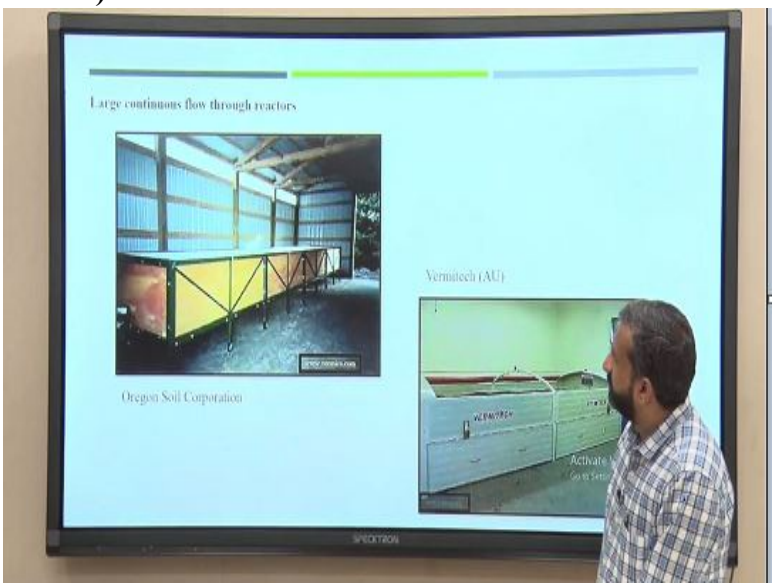

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So is a large continuous flow-through reactor this is also another unit. This is I think you can see it is a long pit for vermicomposting.

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Vermicomposting on a large scale. So, you can see here the large units this is all Indian way of the vermicomposting process.

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So, this is what the vermicomposting units in this Indian Veterinary Research Institute Bareilly they are also doing in the windrow based. So, here water pipings are available and are the time to time is getting covered also, this is in the Divya Nursery Haridwar also working on the vermicomposting process.

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This is the batch box batch type vermicomposting system. So, you can see here in the bottom opening scene has been created for the aeration process, this is the track or tray stacking vermicomposting system.

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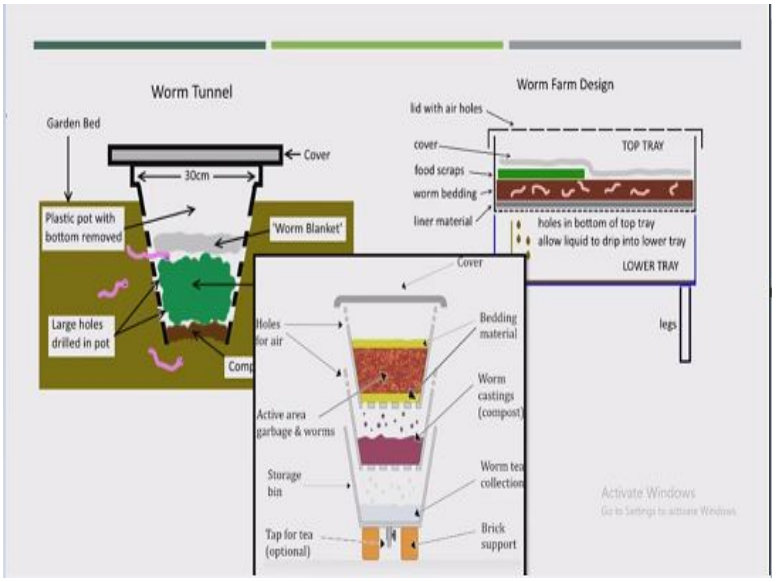

So, here also we can see that, how the vermicomposting can be walked into the particular reactors small, small reactors. So, here is stack-based reactors.

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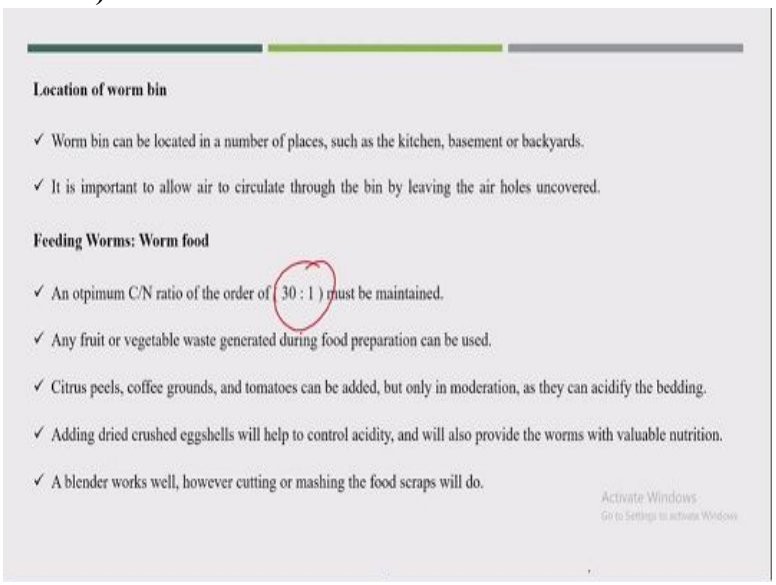

Now, location of worm bins like worm bins can be located in a number of places such as kitchen, basement, or backyard it is important to allow air to circulate through the bin by leaving the air holes uncovered feeding worms worm food and optimum carbon to nitrogen ratio of the order 30 is to 1 must be maintained. I think this is important for the degradation process. If we are able to achieve a carbon to nitrogen ratio of 13 is to 1 any fruit or vegetable waste generated during the food preparation can be used citrus peels coffee ground and tomato can be added.

But only in the moderation is they can acidify the bedding. So, this also needs to be looked upon that if you are using for any fruit material also if it is highly acidic and has to be mixed properly. So, adding dried crushed eggshells will help to control the acidity and will also provide the worms with valuable nutrients. A blender works well how we are cutting or mashing the food scrap will do. So, the size is also very important for the degradation process like same in the conventional composting process or in-vessel composting process.

So if you are using it household level or in the small apartment level, so I think and whatever the waste we are applying for the vermicomposting process has to be put into the blender, or particular mixture or one particular shader, where the size also can be homogeneous material can be created to supply for the vermicomposting process.

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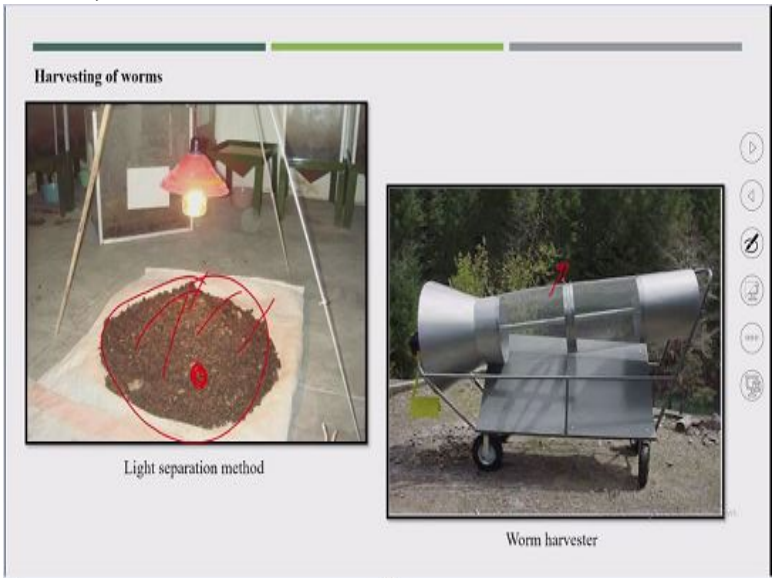

So, now, this is for the harvesting of worms. So, now these entire prepared material prepared compose will have the earthworms also and we have to harvest that earthworm. So, there are 2 methods, by that way we can harvest the earthworm by this is called a light separation method simply, you put one light, so, it is not only light but also some heat is also generating by that particular light means I think 1-degree change in the temperature.

So, because of that what will happen, all the earthworms will be at the bottom? And remaining part, you can collect properly. And finally, we will get a bundle of earthworms and that will take maybe half an hour or 1 hour, we can put under the light. So, normally in the laboratories, they

are using 60 Watt bulbs for harvesting earthworms. This is for the small scale we can use, but for commercially or commercially running vermicomposting plants, we can use a worm harvester.

This is the simple filter where size is 2 mm to 4 mm so that only the fine particles will come out and earthworms we can easily collect or easily harvest from such kind of harvester.

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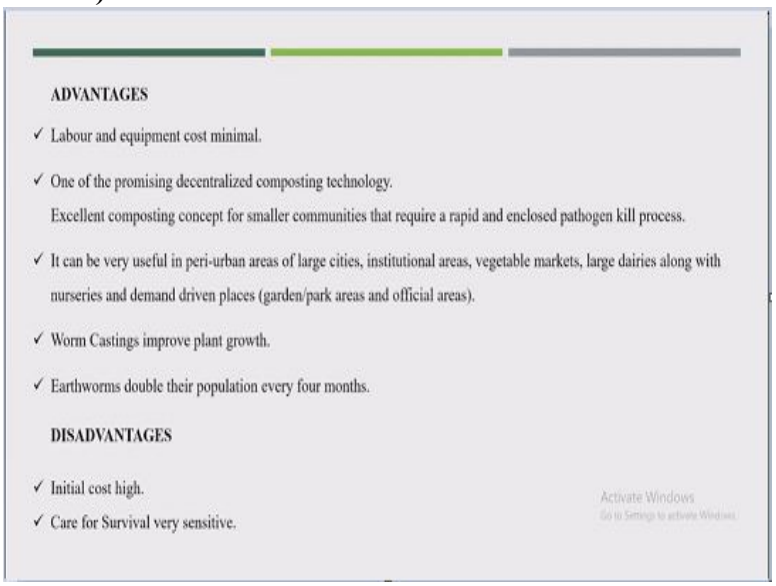

Now, what are the advantages of vermicomposting process, it is a labor and equipment cost is minimal. So, like we have seen the conventional composting process or in-vessel composting process is a manpower requirement is more a lot of maintenance issues are there. So, here labor equipment cost is minimal. Now, one of the promising decentralized composting technology excellent composting concept for a smaller community that required a rapid and enclosed pathogen kill process.

It can be very useful in peri-urban areas of large cities institutional area vegetable market large dairies, along with the nursery and demand-driven places like garden parks official area. So, likewise, a see in any city will have a lot of institutions. So is government institutions, civil offices, schools, colleges, now hospitals, park, garden and different small units that we can say is there a point source of waste generation.

So, in these particular locations, if you are using the vermicomposting process is highly beneficial to your collection also will reduce in that case, and these kinds of material would not

go to the disposal area. Worm casting improved the plant growth earthworms double their population every 4 months. So it is a highly beneficial one and when you compare it with conventional compost and vermicompost.

So, obviously, the vermicompost quality is far better than the conventional or in-vessel composting process produce not only the nutrients, but a lot of microbes also is highly beneficial microbes will be available in the vermicomposting process. So, like I was talking about the nitrogen content in the conventional compost can go up to 1.5 to 2% if you are using in-vessel composting process, but in vermicomposting.

There are always chances of getting 3.5 to up to 4.44% of nitrogen also could be possible to achieve in the vermicomposting process. And commercially if you see our as per the market, you will see we can easily sell this kind of vermicompost at a cost of 30 rupees 40 rupees per kg whereas, the conventional compost can go up to 5 rupees or 10 rupees per kg. And that is why is a lot of advantages of vermicomposting process.

Even the farmers along with the vegetation growth are along with the agriculture growth, they can also work parallelly with the production of vermicompost. So, that they will be highly economically beneficial for the farmers also under the disadvantage like initial cost is high initial cost means only the construction of the pit are the preparation of that particular system and the cost of earthworms.

These normally earthworms are available in our state agriculture board or Agriculture Department, they will have the earthworms and even any farmer they want to go for vermicompost production they can go to the Agriculture Department. And they will get 100 or 500 numbers of earthworms and the cost will be around 50 paise or in a 1 rupee, you will get 2 number or 3 number that they would not count it, but the one particular quantity or if you pay 100 rupees, they will give 50 or 60 numbers of earthworms.

So, it is not that very high cost. And the time required is more obvious as compared to the conventional composting process. So, like I was talking about the in-vessel composting process.

Where degradation in 7 days or a maximum of 20 days is required for the degradation process, but the vermicomposting process, because there is a slow degradation process. So, we will require 60 days - 90 days for the degradation process.

But the addition of more earthworms and having the optimum condition for the degradation process, it is possible to finish the vermicomposting process within 30 days 25 to 30 days, still, this is large compared to the conventional composting process.

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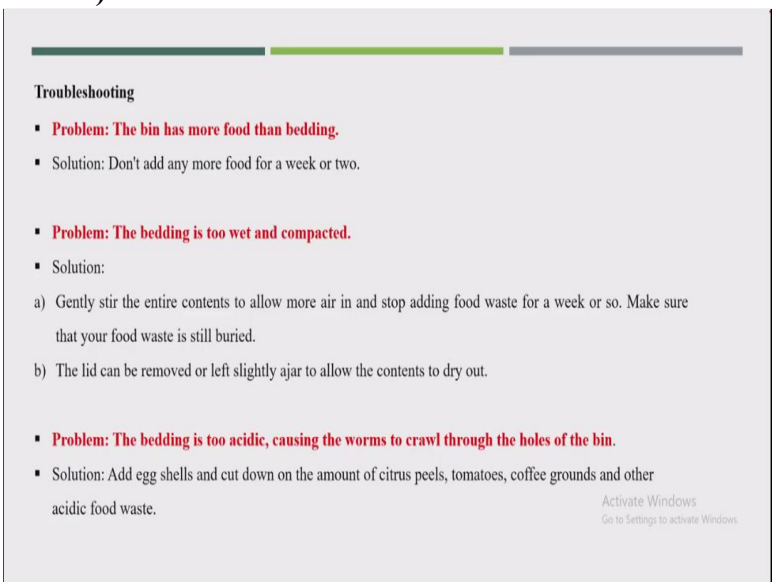

So, the troubleshooting could be possible like I come up with few questions along with their answers like the problem could be the bin has more food than bedding. So what could be the solution do not add any more food for a week or 2. Suppose if you find that more food or more substrate has been added into the reactor or in the bin, so in that case, do not add food for a week, 1 week, or 2 weeks. The problem could be the bedding is too wet and compacted.

So, what could be the solution, gently steer the entire content to allow more air in and stop adding food waste for a week or so, make sure that your food waste is still buried. So gently steer the entire material. So, that air can supply into the material the lead can be removed or left slightly to allow the content to dry out. Another problem could come up that the bedding is too acidic causing the earthworm to crawl through the hole of the bin.

So, whatever the opening has been given for the aeration process, it is possible that earthworms will come out from those openings. So that is possible when the bed is acidic. So, what could be the solution add eggshells and cut down on the amount of citrus peels. So means I the citrus peel do not add for a week or 2 weeks, tomato coffee ground or other acidic food waste do not allow to add into that particular bed. So that by that way we can reduce the acidity of the particular bedding.

So, we saw that there are lots of advantages of the vermicomposting process, but the scale is only the major issue. One very important issue here, the scaling how big we can go. So when we were comparing about conventional windrow composting process, which can accept the 200 tons 300 tons waste in a day. But we cannot allow this much amount of waste in the vermicomposting process in that case you will be required large area will be required a large number of earthworms will be also required.

So, that is what these vermicomposting facilities can be easily possible to do at the household level or community level. So as per the previous lecture, I was talking about and I was focusing on these centralized composting process could be highly beneficial for India or Asian countries or Developing countries. So, in that case, along with the in-vessel composting process, we can also go for the vermicomposting process, because the in-vessel is somewhat difficult at the household level, but the vermicomposting process can work for the household level also.

Or by the mingling of both the process together, we can work at the community level or apartment level or at the household level also can be worked. So, thank you