Industrial Biotechnology.
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Lecture-54.
Biofertiliser.

Welcome back to my course Industrial biotechnology. Now last lecture I tried to cover 2 important topics, that the bioenergy, the one biodiesel, another is Bio butanol which is, which is considered as a promising bioenergy source for the future. And let me deviate from that little bit, let me talk about some typical type of products that has biotechnology as, biotechnology plays very important role. And you might be aware that environmental pollution is a great concern nowadays, because if you consider any kind of chemical or biochemical industry, they are the, before that let me tell you little bit story behind that.

Because we have Central pollution control board, that is their main office is located in New Delhi and we have, they have state branches in different states. And they take care of the environmental pollution problems, that you know not only water source but other sources also. Now we find that water sources industry, particularly chemical and biochemical industry, they are playing massive role to pollute our water streams, which is the major concern nowadays. Now and so, whenever any industry comes, chemical and biochemical industry, new industry comes, they have to show that whatever waste is generated, wastewater is generated by the industry, it should be 100 percent taken into account.

And biotechnology process plays very important role for removing the pollutant present in the wastewater. Because I can I can, as I talk little bit more, when I will talk about the activated sludge process and also I shall talk about some biomed methanation process, because these are the 2 processes largely in operation for the removal of the pollutant present in the wastewater. Today I want to discuss another very interesting topic, little bit related with this comment is called bio fertiliser. Now question comes, what do you mean by bio fertiliser. Bio fertiliser means that we get the organics that we produce in the day-to-day, our day-to-day life, how those organics can be utilised for the betterment for the plant growth.

Because particularly I want to know, I want to say that agriculture sector for increasing our plant so that we are in a vastly populated country and we require lot of food production, so

that we can feed our all the people. So this is a very important aspect to not only India but all the countries throughout the world.

Now when we do that, one thing is very important because initially that we find due to the advancement of this technology, we developed lot of fertiliser, the inorganic fertiliser, particularly like urea, ammonium sulphate, different type of phosphate or combination of different organic, different inorganic fertiliser with different NPK ratio because that fertilisation, that capability because we need to talk about the growth of the plants, they require different ratio of NPK, NPK means nitrogen, phosphorus and potassium.

That, you know ratio we they require the ratio for the growth. So when they use the inorganic source, now they found that you know that soil is becoming fragile or some kind of contamination problem that we have in the soil. So and another important property of the soil is the water retention property. The water retention property gets greatly affected when you use the inorganic fertiliser. So one way, if you use the inorganic fertiliser, I have agriculture productivity increases to a great extent, either way, if we use the inorganic fertiliser for a long rid of time, your soil will lose the fertility.

Fertility means because if your water retention property of the soil decreases, then you have to use more water for the cultivation purpose. And you know, we all know that plants usually take their nutrients to the process of diffusion because it takes the nutrients to the roots and the process is diffusion. So today we have chosen another very interesting topic that is largely in operation in India, what is called bio fertiliser. And bio fertiliser can be produced by 2 means, both by Aerobic process and the anaerobic process.

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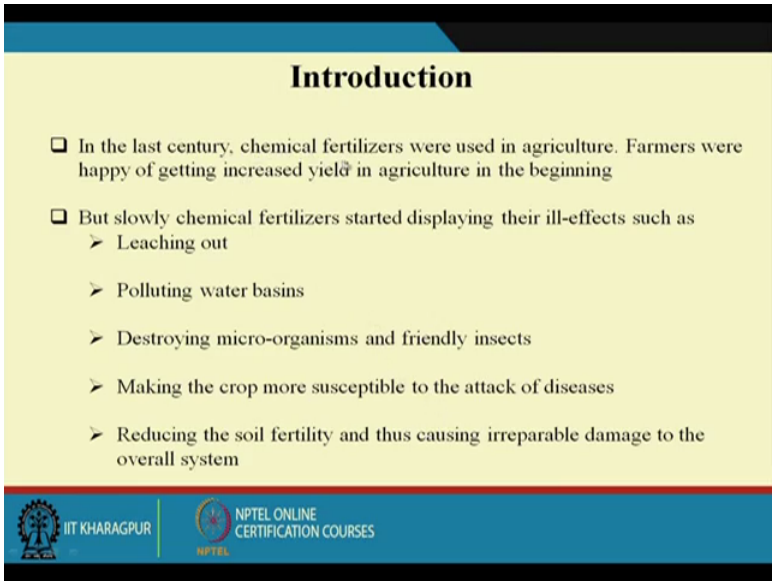

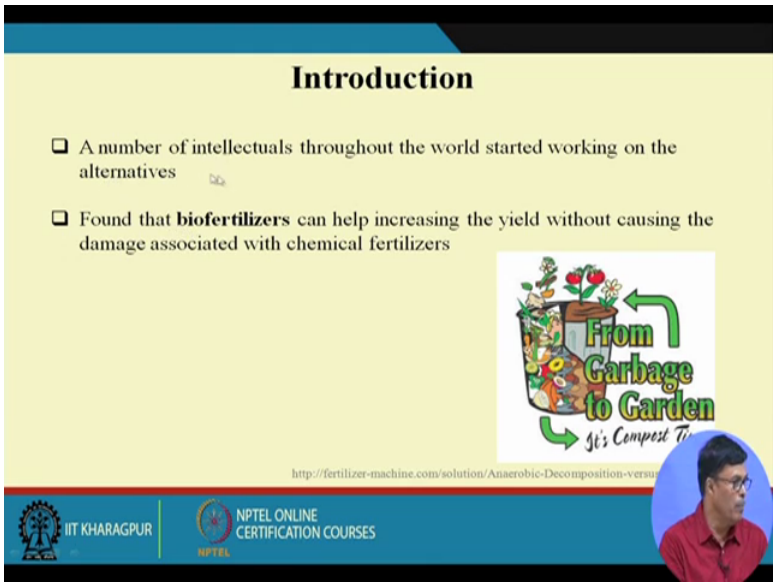

Now in the last century, the chemical fertiliser were used in the agriculture, farmers were happy in getting of getting the increased yield in the agriculture in the beginning. But slowly chemical fertilisers started displaying their ill effects such as the leaching out because it causes some kind of pollution of the water basins, destroying the microorganisms and friendly insects because some microorganisms are also very useful and some insects are also useful, that also they killed making the crop more susceptible to the diseases and reducing the soil fertility, what I pointed out one important characteristics is the water retention property, thus causing the irreparable damage to the overall system.

This is the concern of throughout the world that how this inorganic fertiliser use can be minimised. Because in the Western country also we have seen that, that greatly they reduced

the consumption of inorganic fertiliser and they always prescribe that we should go for using the bio fertiliser so that water characteristics, the soil characteristics will remain same, will be good for the growth of the plant. Now a number of intellectuals throughout the world started working on the alternatives, found that bio fertilisers can help increasing the yield without causing damage associated with the chemical fertilisers.

Now this is from garbage to garden, this is the kind of concept that we have. Now preliminary question that might arise that how this waste material can be used as a, used as a fertiliser. I can tell you very simple thing that we have, if you look at the organic material, it is comprises of carbohydrate, it comprises of protein, it comprises of fat, like this, so when you use any kind of microorganisms, then it will degrade and particularly protein I want to mention that would invent degraded it produces amino acids, protein is nothing but polymer of amino acids.

When this amino acid undergoes the deamination reaction, then free ammonia, it released in the liquid and organic acid present there. This ammonia can be, plant can take this ammonia as a source of high hydrogen, source of nitrogen. So this is and they can use this nitrogen for their growth and metabolism. So this is one very important aspect we have, another very important aspect that in the atmosphere we have, there are several different types of bacteria, different types of organisms, they can fix the molecular nitrogen that is present in the atmosphere and produce they organic nitrogen.

And then this nitrogen, they can convert the ammonia and this ammonia can be used as the for the growth of the plants. Now in large population of specific and in group of beneficial microorganisms for enhancing the productivity of soil, I told you this is how the productivity increases because I told you that through the degradation process, deamination reaction, the ammonia comes out and increase the nitrogen content of the soil and what the plant can use for their growth purpose, either by fixing atmospheric nitrogen or solubilising the soil phosphorus or by stimulating the plant growth synthesis of growth promoting substances.

Bio fertiliser based on renewable energy source are cost-effective, eco-friendly, can help to economise on the high investment needed for the chemical fertiliser. Now here I want to point out very simple thing that when you talk about bio fertiliser, we can have very small setup, we do not have to go for bigger setup. So in a small way you can produce bio fertiliser and lot of small small entrepreneurs, they produce, they have small small firms, they produce, they market their products and sell it in the market. But when you go for inorganic fertiliser, you

have to have very big setup, very big investment you require for the production of the inorganic fertiliser like urea and ammonium sulphate, etc.

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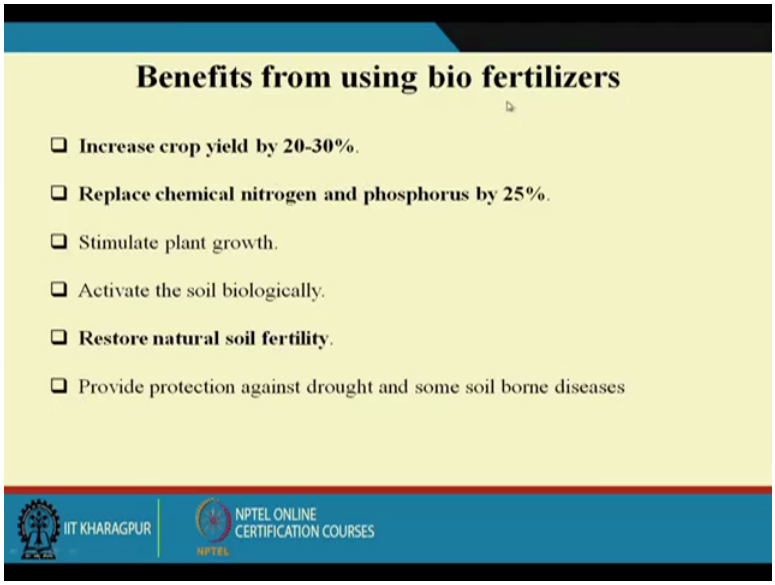

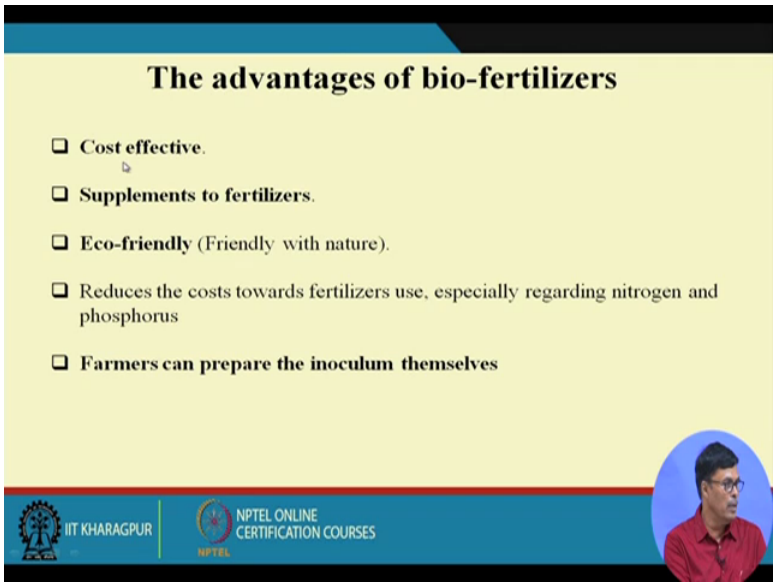

Now benefits of bio fertilisers is, it increases the crop yield by 20-30 percent, replace the chemical nitrogen and phosphorus by 25 percent, stimulate the plant growth, activate the soil biologically and restore the natural soil fertility. This is very important, what you call that if we keep on using the inorganic fertiliser natural soil fertility gets lost. But this is we use, that is, there is the compound called humus that, this kind of organic compound, this increases the water retention property of the soil which is very much required for the growth of the plant.

Provide the protection against the drought and some soil borne diseases. So this is another very important factor, another important thing is that it is cost-effective, supplements to

fertilisers, eco-friendly, reduces the costs towards the fertiliser use and farmers can prepare inoculum by themselves. That is exactly I am saying that farmer can produce this by themselves, we do not have to rely on the industry, it depends upon the industry, they can do by themselves.

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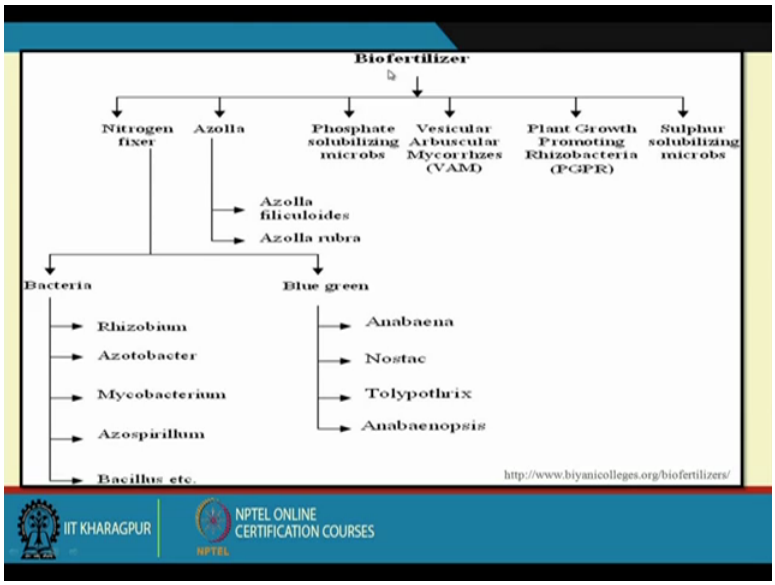

As well I will show you how it can be done, that this is the bio fertiliser, how it is produced, this is the nitrogen fixing bacteria, you have, we have phosphate solubilising microbes, the vesicular, there is some kind of microbes product, then plant growth promoting rhizobacterium, rhizobacterium is used for fixing the nitrogen, molecular nitrogen, sulphur solubilising microbes. So this is nitrogen fixing bacteria, we have several, we have Rhizobium, Azetobacter, Mycobacterium, and Azospiridum and Bacillus.

Then we have some blue green algae, I told you this is largely used, the use the way, also used for fixing the molecular nitrogen also is used for removing the pollutant present in the industrial wastewater. So this is and they convert this to nitrogen sources.

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Types of fertilizer

- The following types of biofertilizers are available to the farmers in India.
  - Nitrogen fixing biofertilizers
    e.g. *Rhizobium*, *Bradyrhizobium*, *Azospirillum* and *Azotobacter*.
  - Phosphorous solubilising biofertilizers (PSB)
    e.g. *Bacillus*, *Pseudomonas* and *Aspergillus*
  - Phosphate mobilizing biofertilizer
    e.g. *Mycorrhiza*
  - Plant growth promoting biofertilizers
    e.g. *Pseudomonas* sp

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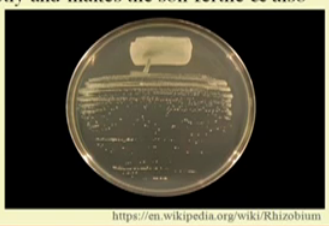
Rhizobium

- *Rhizobium* fertilizer contains *Rhizobium* microorganisms. These microorganisms live in association with the roots of leguminous plants in the form of root nodules.
- These micro-organisms fix the atmospheric Nitrogen in the roots & make it available to plants, which plants cant fix directly and makes the soil fertile & also increases the plant health



https://en.wikipedia.org/wiki/Rhizobium

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How biofertilizers work?

- **Biofertilizers** fix atmospheric nitrogen in the soil and root nodules of legume crops and make it available to the plant.
- They solubilise the insoluble forms of phosphates like tricalcium, iron and aluminium phosphates into available forms.
- They scavenge phosphate from soil layers.
- They produce hormones and anti metabolites which promote root growth.
- They decompose organic matter and help in mineralization in soil.
- When applied to seed or soil, **biofertilizers** increase the availability of nutrients and improve the yield by 10 to 25% without adversely affecting the soil and environment

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Now, type of fertiliser that is available with us, this is the following types of bio fertilisers are available to the farmers in India, one nitrogen fixing bio fertiliser, Rhizobium, one of the, Azospiridum, then Azotobacter that is used, phosphorus solubilising bacteria, we have fertiliser, we have bacillus, pseudomonas and Aspergillus, phosphate mobilising fertiliser is mycorrhiza, then plant growth promoting bio fertiliser is pseudomonas species. Now Rhizobium fertiliser contains Rhizobium microorganisms, these microorganisms live in association with the roots of leguminous plant in the form of fruit produce.

So these microorganisms fixed the atmospheric nitrogen in the roots and make it available to the plants, which plants can fix directly and make the soil fertile and also increase the plant health. So how the bow fertiliser works, bio fertilisers the atmospheric nitrogen as I mentioned, then it solubilises the phosphates, scavenges the phosphate from the soil layers and they produce also some hormones and anti-metabolites which promote the root growth, they decompose the organic matter, helping the mineralisation in soil and when applied to seed of oil, bio fertilisers increase the availability of nutrients and improve the yield by 10 to 25 percent without adversely affecting the soil and environment.

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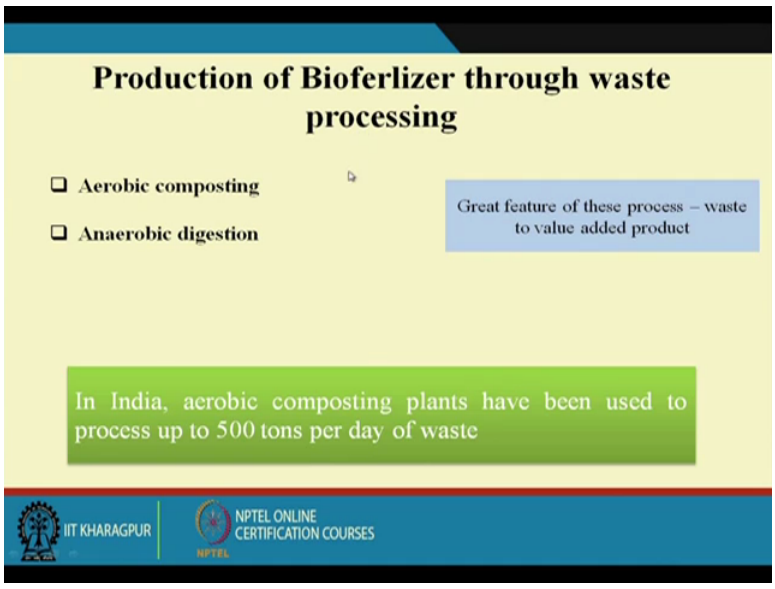

Now as per bio fertiliser is produced through the process of composting and 2 types of composting process we have, we have aerobic composting that means under aerobic condition we produce this fertiliser and another is the anaerobic composting, in absence of oxygen we produce this fertiliser. In India aerobic composting plants have been used to process up to 500 tonnes per day of waste material. This is greatly used, I mean that, if you look in the village, you will find that farmers, they can easily produce the entire big bio

fertiliser because they can dug, they can dig the land and put all the organic waste there for some time and close it, then after sometime they take the material out, maybe after 2 or 3 months and use them as a bio fertiliser.

This is largely practised in the rural areas. Now let me tell you some information about the aerobic composting process how it is taking place, rapid but partially decomposition of moist and solid organic matter, primarily garbage which contains the plant nutrients like nitrogen, phosphorus and put ashram by the use of aerobic organisms under the controlled conditions. Now here I told you previously also, aerobic organism, they work much faster as compared to anaerobic organisms, so what you have to do, you have to spare the organisers on the surface of the organics and then you to redo the surface again and again so that and spray some kind of moisture in it because your organism requires some kind of liquid for their growth and metabolism.

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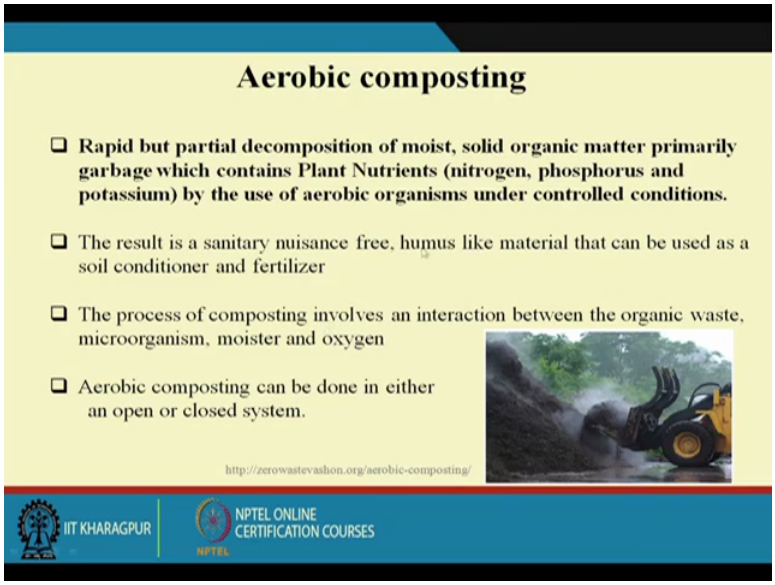

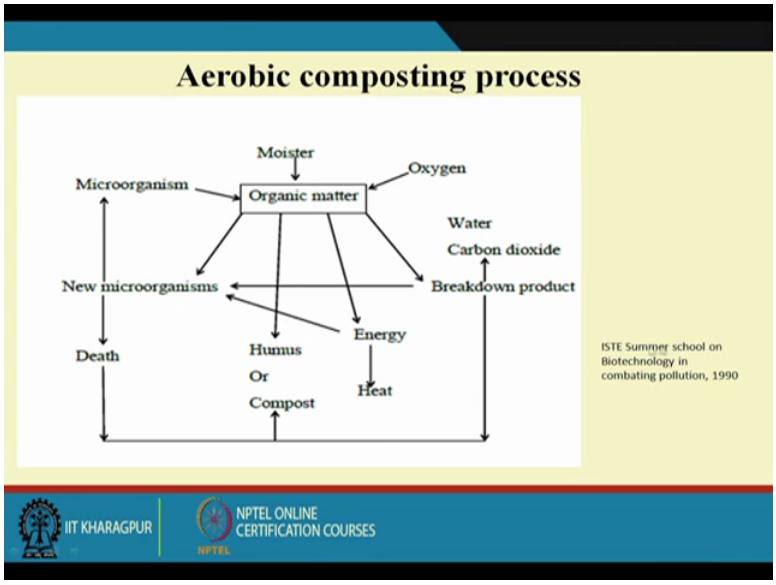

So that is the prerequisite for carrying out this kind of aerobic composting process. Now results, it is sanitary nuisance free and humus like material that can be used, there is a humus like material actually improve the soil retention property of the soil. So this is, which is considered as a soil conditioner and fertiliser. The process of composting involves an interaction between the organic waste, microorganism and moisture and oxygen.

This I have, this is like the raw materials is coming here and it passes through this composting process whereas the oxygen and microorganisms and water, they all take part in this reaction and finally it produces the organic matter including carbon, chemical energy, nitrogen, protein, humus type of material, minerals and microorganisms which can, which is beneficial for the plant growth.

Now schematically this process can be explained like this. You have organic matter, here is organic matter, they put moisture, then we put the microorganism, then oxygen because this is the aerobic process, and to aerobic process it is quite faster, then we get the humus or compost and it is, it can be used as a fertiliser. Then here also we can have the breakdown product which can be used as a compost and then this here, here we have from that the new organisms recycled back to the system. So then you can see you can take the, this you can use as a inoculum for this process also.

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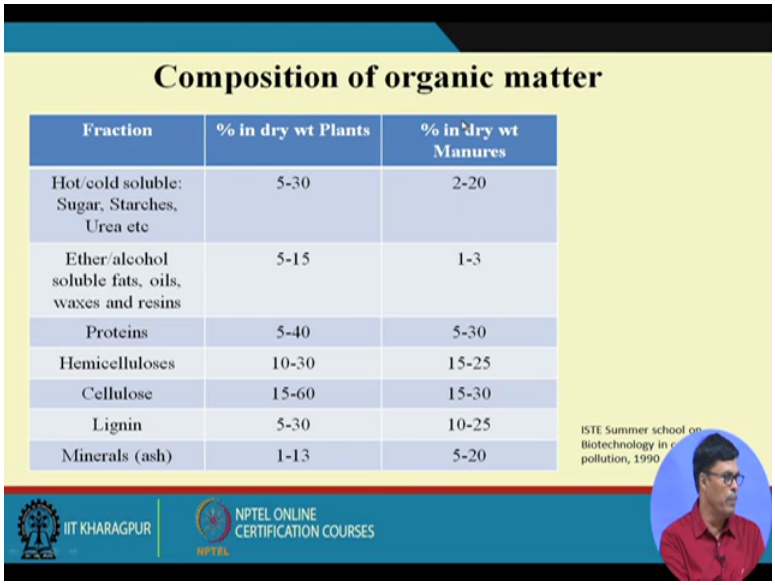

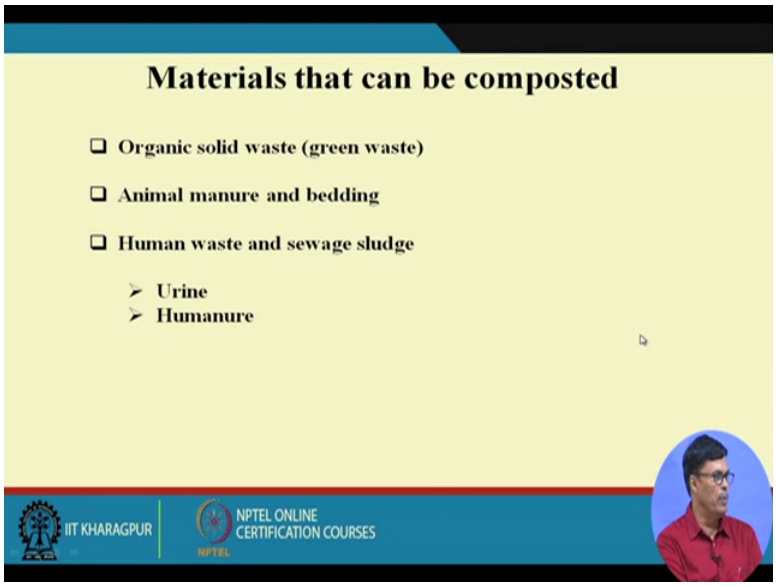

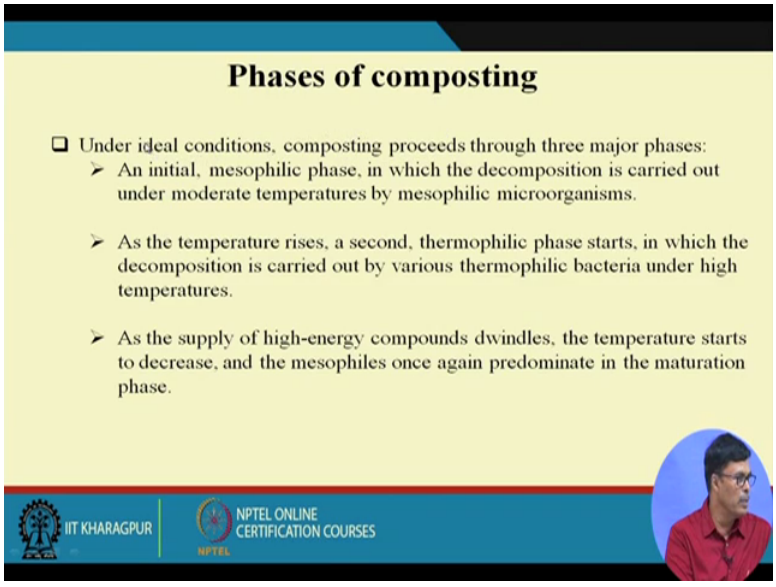

Now composition of organic matter is like this, the heat and cold soluble sugars, starches, and use your common races 0.5 to 30 percent of dry weight and percentage private of manure is 2 to 20 percent. So different composition of the fertilisers is given here, that, now material that can be composted organic solid waste, animal manure or beddings and human waste and sewage sludge, including the what you call urine and humanure, that is used for this.

Phases of composting, that under ideal conditions composting proceeds through 3 major phases, and initial mesophilic phase in which the decomposition is carried out under moderate temperature by the mesophilic organisms. I told you mesophilic organism is usually work at 35 to 37 degrees centigrade, it is close to our ambient temperature, as the temperature rises, it is again thermophilic phase starts in which the decomposition is carried out by thermophilic bacteria under high temperature about 45 to 60 degree centigrade. As the supply of high-energy compounds is dwindles that the temperature starts to decrease and mesophiles once again predominant in the maturation phase.

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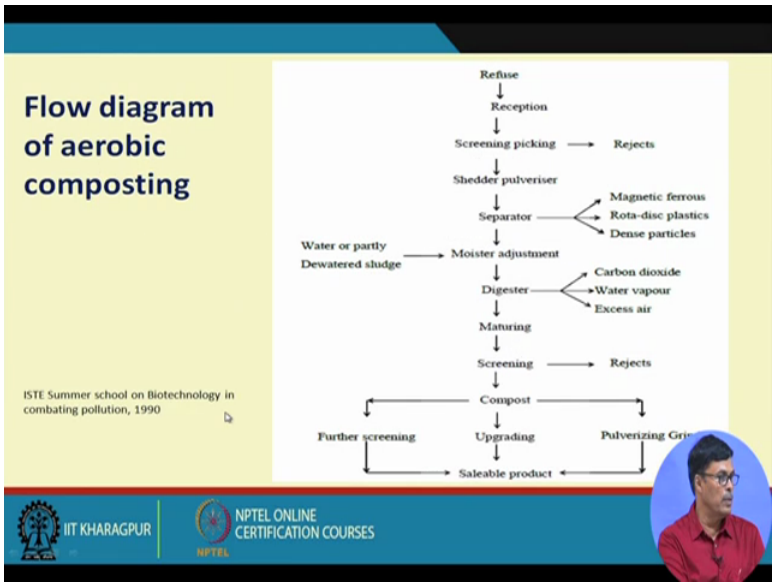

So this is how we can show the aerobic composting process, refuse, it comes to the reception, then we do the screening because it contains lots of plastic and other types of material that we have to reject it, you have to take mostly the organic material, then you have shredder or pulveriser, pulveriser means you to take the, make it powdered form, then it is separate, you can pile the magnetic form by using magnet you can separate the iron type of material and the rota disc or plastics and dense plastic that you can, with respect to density we can, they separate the particle.

Then we have moisture adjustment, then it undergoes digestion, then we produce carbon dioxide, water vapour and excess air, then maturation, then screening, we, whatever big particles there, we take it out at this composting, we do, we can do the upgrading because I told you that quality of the fertiliser depends on the NPK ratio, the NPK ratio they have in particular plant has that NPK ratio, this NPK ratio is to be maintained and suppose in case of bio fertiliser, the desired NPK ratio is very difficult to establish, so we might have to add some kind of inorganic fertiliser to maintain a particular NPK ratio which is in the sellable product.

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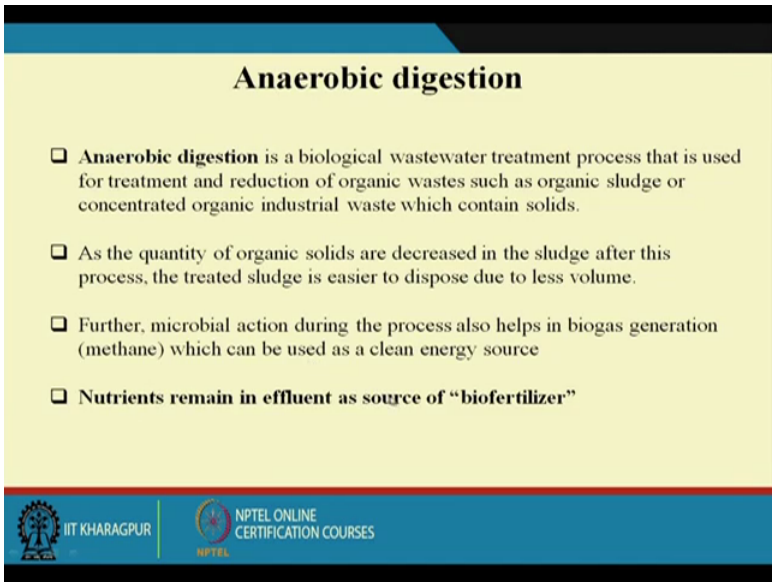

So this is how the aerobic composting process is in practice. Let me talk about some anaerobic digestion process, what we call anaerobic composting, the anaerobic digestion is the biological wastewater treatment process, then the treatment reduces the organic matter, such as the sludge and concentrated organic industrial waste which contains solid. Now let me tell you very simple the anaerobic digestion process is such a process with the invention of this process, it is possible to take a lot of revenue from the waste material one is obviously the bio fertiliser, how it is done because it is very simple, it will this is an ancient in practice that you know, the villages, the farmers that , they take the waste material and they digs the land and put all the organic waste material there and they close the pit and after sometime, maybe after 2 or 3 months, they take out this material, and use it as organic fertiliser.

It is a very simple process. Now question comes how the anaerobic process works. Because the anaerobic digestion process comprises of 2 type of bacteria, one is called, 2 groups of bacteria rather, one called acetogens and another is methanogens. So acetogens actually, they

regret the organic material, they degrade the different polymeric material because solid waste comprises of cellulose, protein, lipid and this types of material they will degrade that and solubilise that. And then methanogenic bacteria, they can convert it to methane.

So it has been observed that landfill graduation process is kind of waste disposal process that, there is largely in operation in western country and they are successfully use what is the generation is for the methane and carbon dioxide. And not only that, the fermented material that after the digested material can be used as a good fertiliser. And because, all the landfill, they are making golf course or they are doing good nursery or good playground, it is very, because you do not have to use the additional fertiliser there because the land is already fertile.

So this is, as the quantity of organic solids decreases, decrease in the sludge after this process the treated sludge is easier to dispose due to less volume. And I can tell you tell you here a very interesting story that we have, that you know, when I was invited by small scale industry division of West Bengal and in some meeting, where they discussed about the suitability of this anaerobic digestion process and in process we visited one site in the in place what is name is Barasat, it is very close to Kolkata.

And there we observed that one particular household, he has a very big poultry farm and as you know, he told us when he established that form, the population was very less, as we know, as the population increases, most of the Cosmopolitan cities, they have expanded, so like that Kolkata has expanded and the Barasat became overpopulated. And as soon as it is populated, then all the people residing there, they gave the strong objection to this person and asked him to shift his poultry farm from that place to other place.

Now that gentlemen come in contact with the small-scale industry division of West Bengal and this (())(26:52) for the anaerobic digestion plant and by anaerobic digestion plant, since it is a closed system, after the digestion, there is no smell in the any kind of waste material and that can be used as a good fertiliser, bio fertiliser. It is a very good use that we have and he told us that he is running a good nursery, he showed us there is a good nursery and also whatever methane is used, they are using as a source of fuel. So nutrients remain in the affluent as a bio fertiliser.

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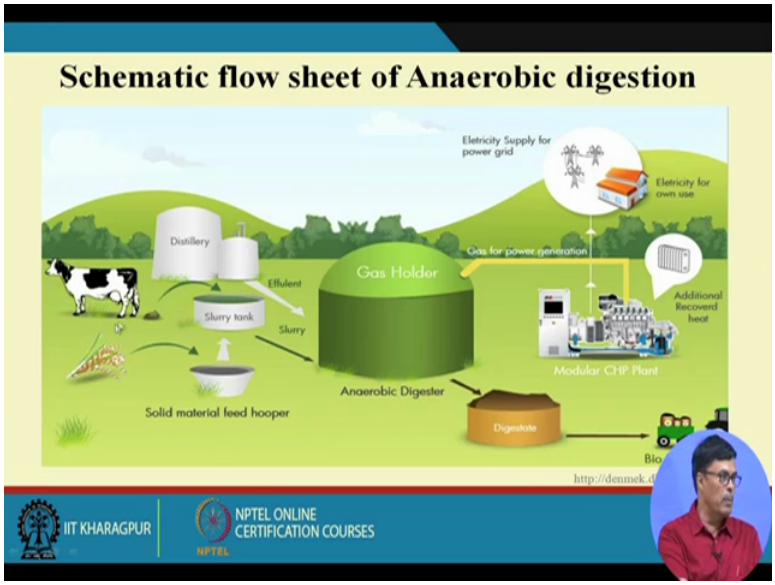

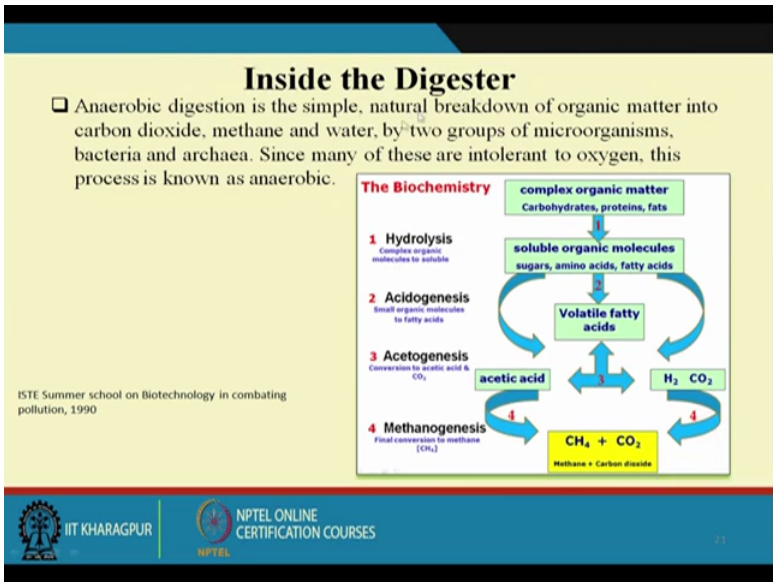

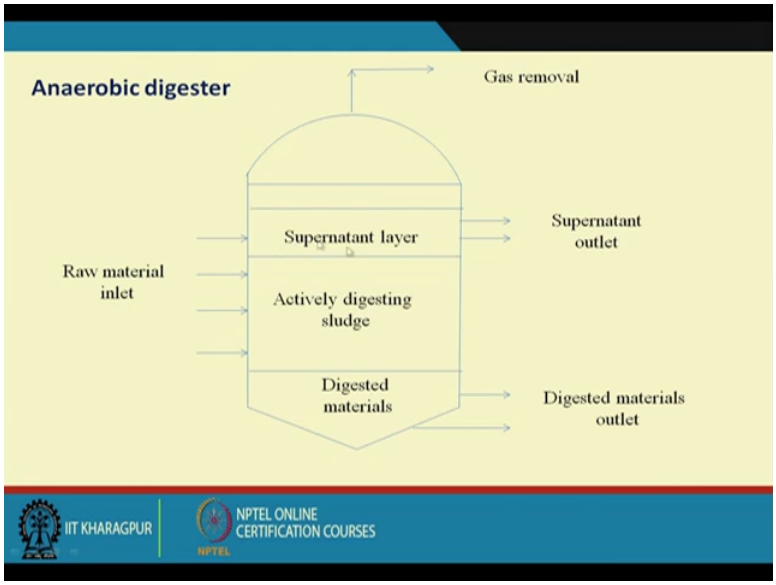

So it is, schematically it can be explained like this. The anaerobic digestion process, we have suppose the industry, the distillery, they produce a lot of organic waste, that we have slurry tank, we have solid material, feed hooper, agricultural waste we have, this all we can put it in the anaerobic digester. And from the anaerobic digestion, we can produce the gas and through which we can we can generate the power, we can generate the power, electricity we can generate. And then digested material, we can take it out and use it as a bio fertiliser. So this is largely in practices.

Now inside of the bioreactor or digester, this is the pattern of reaction, complex organic matter, carbohydrate, protein and fat, they are further hydrolysed to the soluble like sugar, amino acids and fatty acids and then it is converted to mixed volatile fatty acids. This mixed volatile fatty acid then converted to methane and carbon dioxide. So this is how the reaction takes place in anaerobic digester. Anaerobic digester inside looks like this, here at the bottom you will find the digested material and in the middle you will find mostly active digesting sludge and at the top you will find the super nutrient layer and then the gas will be removed.

And here I can tell you a very interesting story that when I was in Delhi, I visited a landfill area called Timarpur and where all these organic materials dumped in the landfill and when I visited that, I observed that there are at least 32 to 35 pockets where we have, I saw the continuous flame burning. So you know that when I asked them that you know, why it is burning, they told that when the trucks goes for unloading their waste, all the driver, they might be smoking, they throws their cigarette and other things and with that the gas which is coming out, that catch fire.

And this in the night, it looks like Dipawali because you know whole night that, at the different flames are there throughout this. Because in the western country, as I told you, they follow the international sanitary law and international sanitary law says that, after the disposal of the solid waste, it should be covered with 6 inch thick layers so that gas should not go out. And then they put some kind of perforated pipes under this landfill and they keep the negative pressure in the pipelines, so that all the gas, whatever produce, they can suck and which contains mostly the carbon dioxide and methane.

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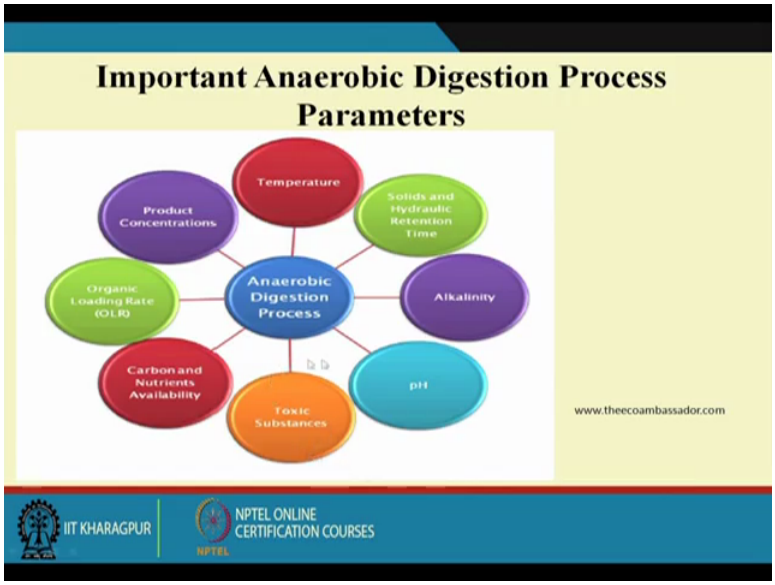

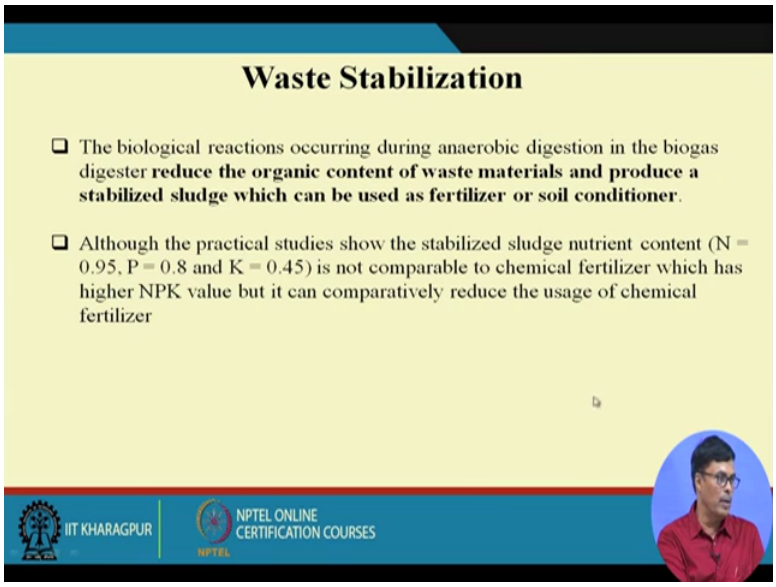

Carbon dioxide they can remove by passing through the cover and they get the pure methane gas which can be used as a pipeline quality gas for as a source of fuel. So this is, this is the thing that we have, anaerobic digestion process that that what are the parameters, temperature, product concentration, that organic loading rate, carbon and the nutrients availability, toxic substance, pH, alkalinity, solid and hydraulic retention time, this, all these things, that is important parameter that we have as far as the anaerobic digestion is concerned.

Obviously if you talk about the hydro retention time for anaerobic composting is more, it will be more as compared to aerobic composting because anaerobic organisms, they grow very fast. The waste stabilisation is very important because if you through any kind of waste in the

atmosphere, it will go through the natural degradation process, it produces a lot of gases which is not good for our health, methane, it comes, it has methane which is not good for our health, carbon dioxide also calls is some kind of greenhouse effect.

So this is and also they degraded this , this is to be treated properly, so digestion of this material is biologically it gets reduced organic content of the waste material and produce the stabilises sludge which can be used as fertiliser or soil conditioner. Although the practical studies show the stabilised slice nutrients, nitrogen is 0.95, phosphorus is 0.8 and potassium 0.45 is not comparable with the chemical fertiliser which has higher NPK value but it can be comparatively reduce the usage of chemical fertiliser, because we can add some kind of a chemical fertiliser with it so that total inorganic fertiliser consumption can be reduced.

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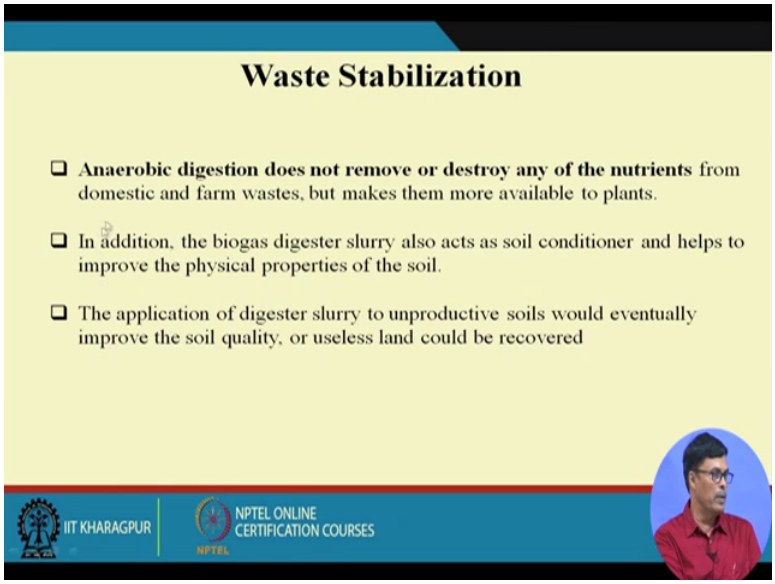

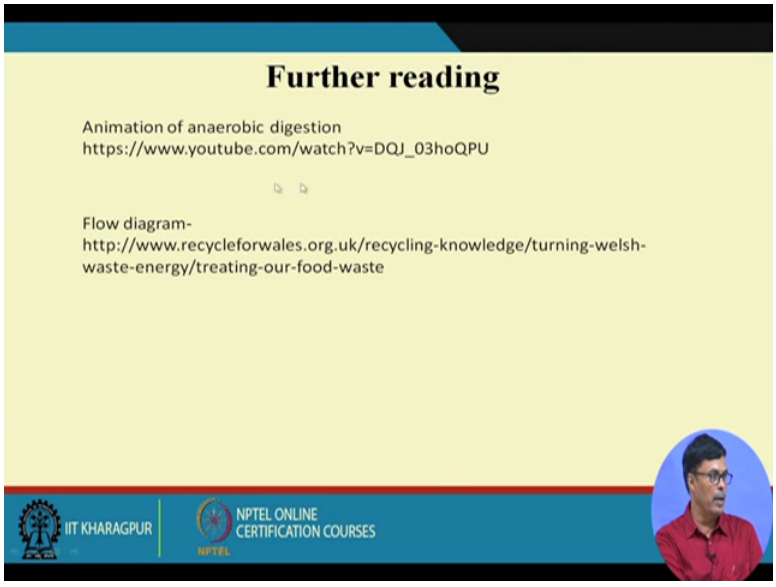

The anaerobic digestion does not remove or destroy any of the nutrients from the domestic or farm wastes but makes more available to the plants. Because I told you, the deamination process, the amino acids when decay, they degrade it and discharge the ammonia, this ammonia will be used for the growth of the plants. And also I told you it uses as a soil conditioner, this is one big application we have. So I request you, you can visit these different sources to get more information on this particular bio fertiliser process.

So today I tried to discuss one very important topic of bio fertiliser with largely operated, operation in India as well as abroad. I told you in the foreign countries, more than 50 percent, this fertiliser is replaced by the bio fertiliser, just to maintain the fertility of the soil. If we keep on increasing the use of inorganic fertilisers, the fertility of the soil is greatly lost. The 2 type of process through which we can get the bio fertiliser, one , aerobic composting and another is anaerobic composting.

Aerobic composting is comparatively very fast, they can, we can use artificial, we can use the microorganism to degrade the material and we put some kind of air to it or moisture to it so that rate of reaction will be faster. Anaerobic digestion and composting process is very simple, we can just put the waste material in a particular dumping place and then after sometime, after 2 or 3 months, we take the material, use as a compost. I hope this will give you some idea on bio fertiliser, thank you very much.