Water and Wastewater Engineering

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Sludge Treatment (Continued)
Lecture # 30

Last class we were discussing about solids and biosolids treatment. We have seen what all are the various sources of this solids or biosolids and what is the quantity of this biosolids coming from various treatment processors and what is the density specific gravity of the sludge and the solids and the characteristics of the solids because this characteristics are very important when we go for the design of the treatment system.

We were also discussing about the general flow chart of the biosolids treatment and we have seen that it involves various steps and we have seen in detail the process those are involved in the pre-treatment as well as the methods we can use for dewatering in the sludge because this dewatering is very important to reduce the volume of the sludge. If the volume is very high then naturally the treatment unit volume will be very high. The third step in the process diagram is stabilization. We have discussed about the pre-treatment which include grinding, blending and storage and then we talked about the dewatering processes.

Today we will be seeing in detail what are all the methods usually used for stabilization of the sludge. First we will see what is the need of this stabilization. The solids and bio solids are stabilized to reduce pathogens and to eliminate offensive odors and inhibit or reduce the potential for further putrefaction. We all know that the solids in most of the cases is nothing but it will be active biomass and the primary sludge will be containing lot of pathogens which comes from domestic as well as industrial wastewater depending upon the source. So, if you just put the sludge or allow the sludge to lay like that then these pathogens will be proliferating and it will be affecting the health of the people who are is coming in contact with the sludge. So it is very much required to reduce the pathogens concentration in the sludge.

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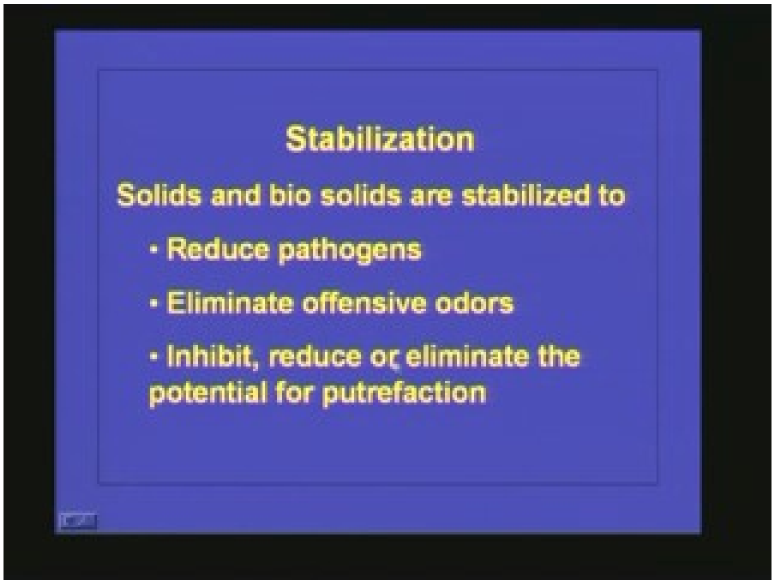

We know that if the sludge undergoes degradation it will be emitting some much of bad odor so the major objective of this stabilization is to inhibit the bacterial growth. Because of the bacterial growth we get small odors so if you can inhibit the microbial growth and stabilize the sludge then will not be having these associated problems.

Now we will see what are the various methods used for stabilization. There are different methods like alkaline stabilization, anaerobic digestion, aerobic digestion, autothermal thermophilic digestion and composting.

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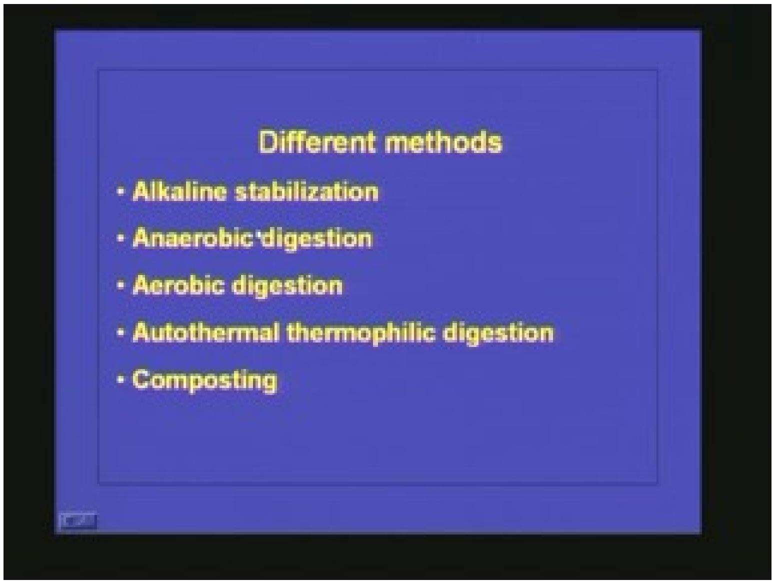

We will see each method in detail. But out of this one anaerobic digestion is the most commonly used method in wastewater treatment plants. So we will be seeing each one in detail. Coming to alkaline stabilization what we are doing is here we are adding alkaline chemicals that provide a condition non conducive for microbial growth.

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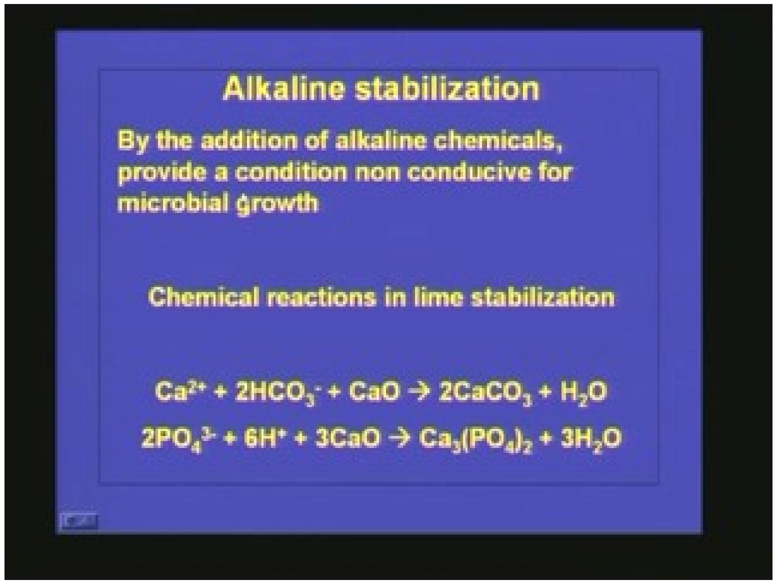

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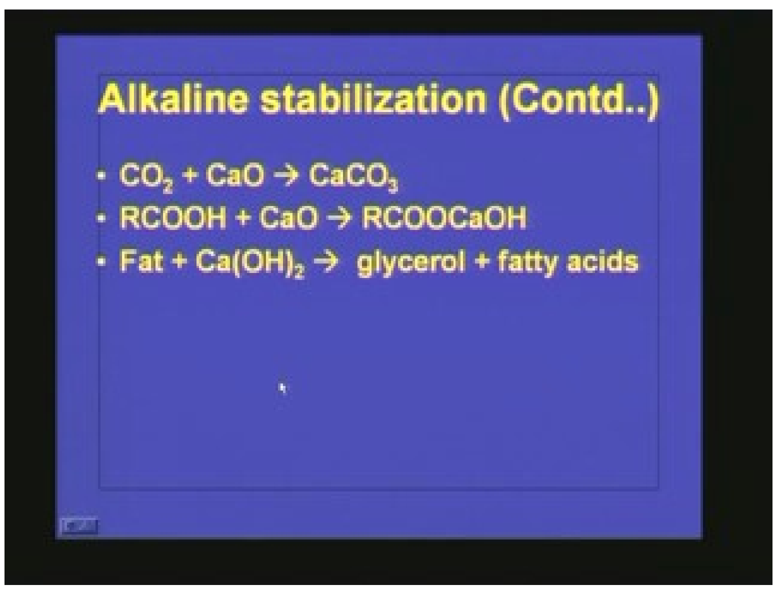

Because when we add these chemicals to the bio solids or the sludge what will happen the pH of the system will be increasing above seven above ten then the microorganism will not be able to survive under this condition. If microorganisms are not surviving so naturally there will not be any putrefaction of the sludge so definitely the problem associated with the sludge will not be there like small odors and other problems. So the chemical reactions involve in this alkaline stabilization are as follows. If calcium is present in the sludge it is combining with the bicarbonate because bicarbonate is coming from the chemical whatever we are adding or calcium and bicarbonate if it is present in the sludge.

When we add this lime calcium oxide you will be getting calcium carbonate and water and if phosphate is present in the system phosphate will be reacting with calcium oxide to give calcium phosphate and water and if carbon dioxide is there it will be getting converted to calcium carbonate because carbon dioxide can reduce the pH of the system. And if organic matter is there it will be combining with calcium oxide to form this calcium hydroxide and if fatty is present fat with react with calcium hydroxide to form glycerol and fatty acids.

So, each and every component present in the sludge will be reacting with calcium oxide or lime whatever we are adding and the corresponding products will be forming and the entire PH of the system will be above ten so no more microbial growth will be taking place so naturally we will be getting a stabilized sludge which doesn't have much problems. In alkaline method we can go for pre-alkaline treatment or post-alkaline treatment. Pre-alkaline treatment means it is applied before dewatering and post-alkaline treatment is after dewatering and other treatments we are adding the alkaline. So it is divided into two categories.

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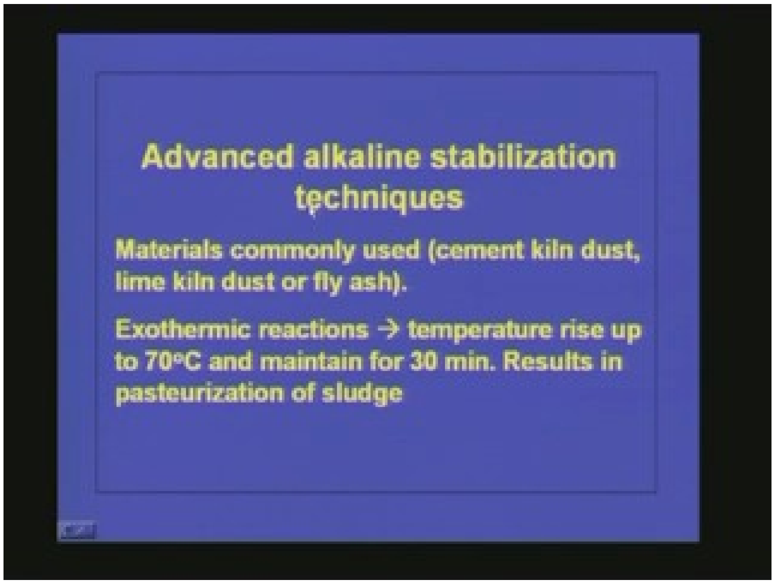

Now we will see what this advanced alkaline stabilization technique is. In advanced alkaline stabilization technique we add quick lime along with other materials like cement kiln dust, lime kiln dust or fly ash. So what will happen is when the quick lime react with this sludge it is an exothermic reaction because of that one the temperature of the entire sludge will be rising up. So at high temperature what will happen is pasteurization of the sludge will be taking place so whatever pathogens present in the sludge everything will be getting destroyed. And the materials like cement kiln dust, lime kiln dust or fly ash will be reacting with the sludge and we will be getting a stabilized sludge. That is what I have written here.

The quick lime reaction is exothermic so temperature rises up to 70 degree centigrade and this temperature and as the reaction takes some time this high temperature will be maintaining for thirty minutes so a high temperature for a long time will definitely result in pasteurization of the sludge. This is the schematic of advanced alkaline stabilizations system.

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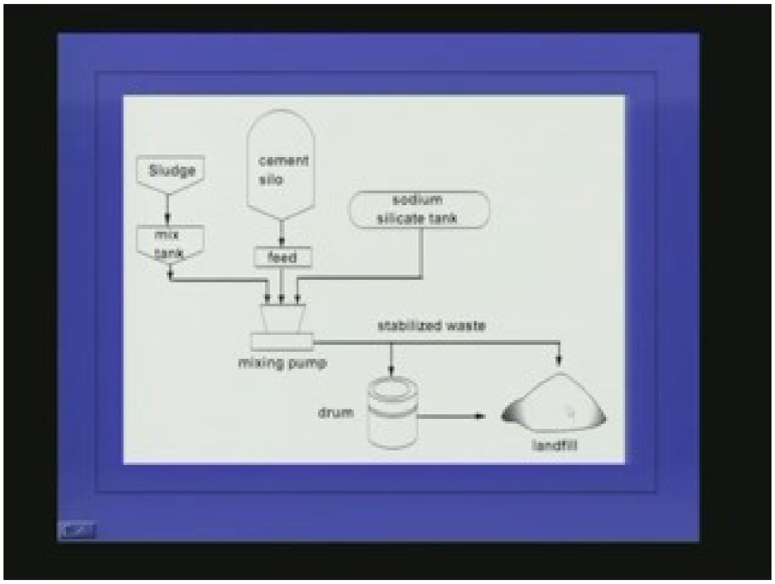

Here we have the sludge, this is the mixing tank and here dust from the cement silo is coming and this is the feeder and we are having a sodium silicate tank and everything is getting mixed up here. We have a mixing pump here (Refer Slide Time: 8:15) and from this one we are getting the stabilized waste it is going to a drum and from here it can come to landfill or directly we can put the stabilized waste into the landfill. So we can see how the sludge is getting stabilized by this alkaline stabilization method. Now we will see the next stabilization method that is anaerobic digestion it is the oldest and most commonly used method.

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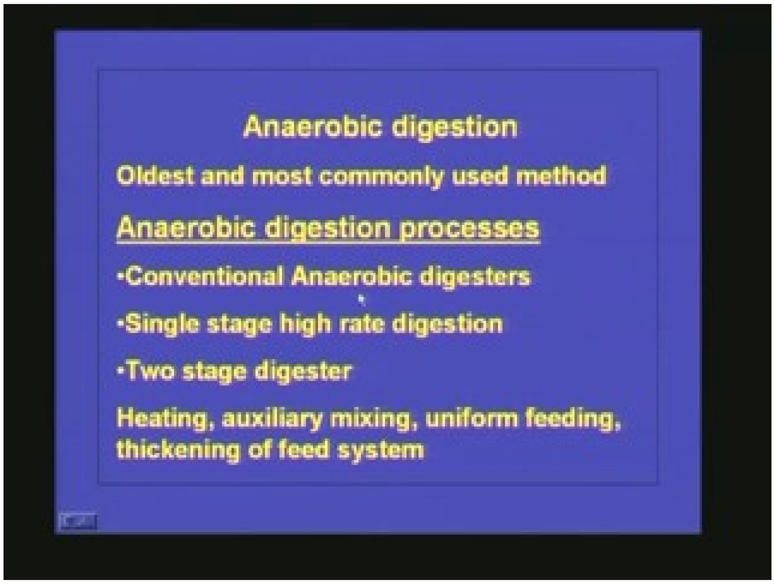

We all have seen the anaerobic digesters in wastewater treatment plants which are used for treating the sludge whatever is coming out of the secondary sedimentation tank as well as the primary sedimentation tank. For this anaerobic digestion process three different configurations or three different steps are available. One is conventional anaerobic digesters, second one is single stage high rate digesters and third one is the two stage digester.

In conventional anaerobic digester there is no recirculation or no external mixing so whatever sludge is coming it is put in the digester and the anaerobic microorganisms present on the digester will be degrading the sludge whatever is present in the digester. So the mixing is taking place in the system because of the gas form in the system. We know that when the organic matter undergoes anaerobic digestion it will be producing biogas which consists of methane and carbon dioxide and because of this gas formation there will be turbulence in the system and the mixing of the constituents in the reactor will be taking place because of this gas.

There is no provision to maintain the microorganism or the anaerobic biomass whatever is generated in the system because there is no attached growth system or there is not any specific arrangement to retain the sludge in the system so what will happen is the sludge will be getting digested and the suppurated will be going out of the reactor so along with the supernatant a portion of the anaerobic microorganism also will be getting escaped so naturally as the biomass concentration in the system is less the detention time required for sludge digestion in convention anaerobic digesters are very, very high.

Usually a detention time of 30 to 40 days are provided in conventional anaerobic digesters. We will see in detail the design of conventional anaerobic digesters.

Now coming to single stage high rate digester here we are providing external heating and auxiliary mixing and uniform feeding and there is provision for thickening of feed system so what happens is we are heating of the system externally and we are mixing the system externally and we know that in anaerobic process to get optimum performance or maximum performance the temperature of the system should be in the range of thirty seven plus or minus two degree centigrade. So if you can increase the temperature definitely the activity of the microorganism will be increasing compare to low temperatures.

And we are providing external mixing so what will happen definitely there will be much better contact between the organic matter and the microorganism present in the system so that will definitely increase the ability or increase the efficiency of the treatment system. This is what is done in a single stage high rate digester. Here again provisions are there to maintain high microbial concentration and that’s why we are calling it as a high rate digester. We have discussed in detail about this high rate reactors when we were talking about anaerobic treatment of wastewaters.

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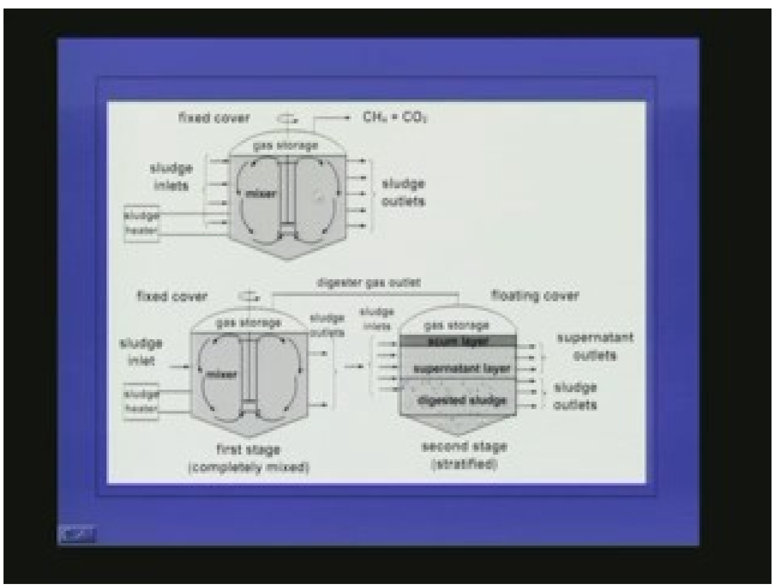

For example this picture shows a single stage high rate anaerobic digester. As you see this is the sludge heater so it will be heating the sludge inside the system so definitely it will be having a high temperature. Here as you can see these are the sludge inlets 1 2 3 4 parts are there so the sludge is equally distributed along the depth of the reactor and we are having an external stirrer. And here this is the mixer (Refer Slide Time: 12:53) it is rotating and because of that one high turbulence is generated in the system. And because of the high turbulence the sludge and microorganisms are having very high contact. Here theses are the sludge outlets. We get digested sludge from here and this is the fixed cover (Refer Slide Time: 13:15) so whatever biogas is generated in the system will be getting stored here and it is collected through these outlets. We can see that we are getting methane and carbon dioxide.

Therefore, because of this sludge heating as well as the mixing and proper distribution of the sludge in the system the reactor performance will be much better compared to the conventional anaerobic sludge digesters. Now we will talk about two stage digester. The two stage digester is having two different tanks, the first stage tank is for digestion and is heated and mixed externally and the second tank is usually unheated and used as a storage facility. This two stage digesters are not commonly used but a modification of this one that is known as high rate anaerobic digesters is being used nowadays commonly.

We will see how this two stage digester is performing. As I have already told it is having two different tanks this is the first stage and this is the second stage. So here what is happening is the sludge heater is there and sludge inlet is there and there is a mixture so it is mixing the sludge and here we have a fixed cover and gas storage and the sludge outlet, these are the sludge outlets, this is exactly the same as this one so what is happening in the second digester is this (Refer Slide Time: 14:52) will be acting as a storage device so we can see that since this is acting as a storage and there is no turbulence proper settling of the digested sludge will be taking place.

Hence, here we can see the digested sludge and here we get the supernatant layer and this is the scum layer and this is the gas storage and it is having a floating cover and as and when the gas volume increases then we can collect the gas and use for other purposes. So in this digester the advantage is since the solids are getting concentrated and the water is getting separated in the sludge the digested sludge volume in this reactor will be much less compared to a single stage system. So we can see that we can take the sludge separately and we can take the supernatant separately. So this is the advantage of a two stage system.

As I was mentioning, there are high rate single stage anaerobic digesters. So what is being done is the first digester that will be exactly this way and whatever sludge is coming out will be allow to settle in a secondary sedimentation tank and from that one the settled sludge will be compared to the first digester so what will happen is the biomass inside the first digester will be keep on increasing. So if the biomass concentration in the digester is more then definitely the performance of the digester will be much better.

And if you want to see the bottom plan of the system we can see that this is the bottom plant here the sludge will be getting distributed and these are the withdrawal ports, if you want to withdraw the sludge the ports will be located around the periphery of the digester and this is the cross sectional view of anaerobic digester. We can see that this is the sludge withdrawal pipe and this is the top lid from where the gas can be collected and sometimes instead of providing a mechanical mixture the biogas whatever is produced and collected from here the same gas will be re-circulated in the system so here we can see the gas recirculation.

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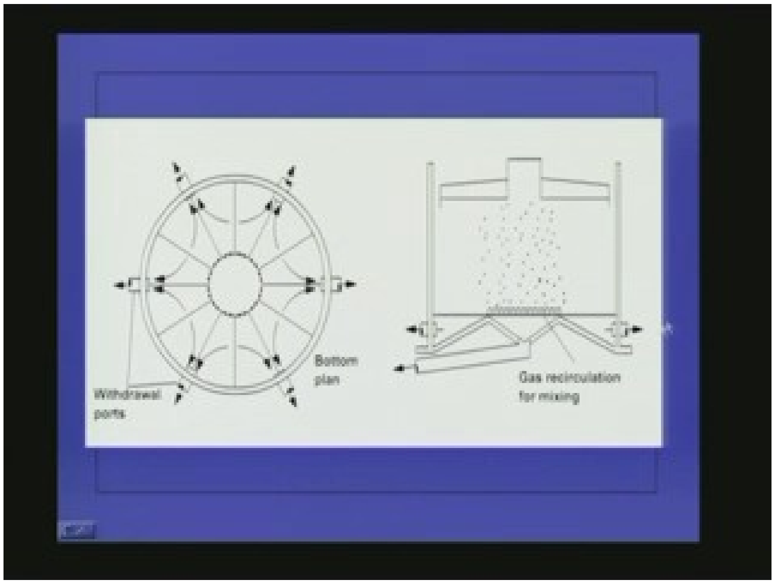

The gas recirculation itself will be giving a proper mixing of the system. Thus by this way the efficiency of the system can be improved or increased.

Now we will see how to design an anaerobic digester. I am going to explain the design of a low rate digester. This is the one which is commonly used in wastewater treatment plants. First we have to find out what is the amount of sludge we have to treat, we will get it by knowing the volume of sludge from various treatment units because if you take a wastewater treatment plant basically the sludges whatever is coming from the primary sedimentation tank and secondary sedimentation tank are sent to the anaerobic digester so we know what is volume of sludge and we have seen what is the sludge specific gravity. so from that one we can find out the mass of the sludge or if the mass of the sludge is known then we can find out the volume of the sludge. Once we know the volume then we have to decide the percentage destruction of volatile material we need in the digester.

Usually we design the system for 50 to 60 percentage destruction of volatile material. That means the sludge will be having fixed solids as well as volatile solids. The fixed solids will be remaining as such, there will not be any change occurring are the fixed solids, only the solids which can be destructed is the volatile solids because volatile solids are organic matter or organic solids. So we decide this one or choose this design value then we have to find out what is the hydraulic retention time required to achieve the desired efficiency.

While we were discussing about the anaerobic ponds or the pond system we have seen depending upon the efficiency we can find out what is the K theta value and from that one we can find out what is the retention time required. So if you want to achieve 50 percentage efficiency we need a hydraulic retention time of forty days. This is available from the chart. This chart we have seen earlier.

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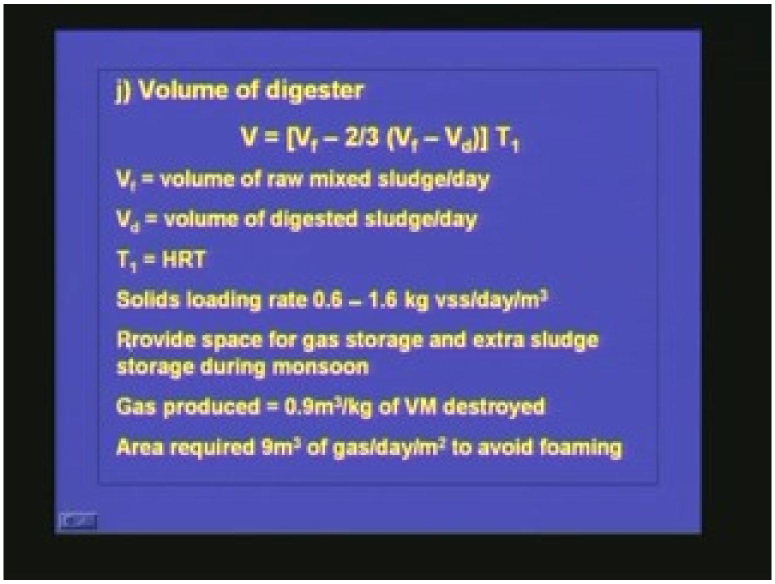

We have decided what is the destruction required and we have seen what is the hydraulic retention time required. Now we have to see what is the quantity of volatile material in the total sludge. We can also find out this one because we have the mixed sludge sample so from that one we can find out what is the volatile material in the total sludge.

Take the sample, take the pivate and put it in the muffle furnace and increase the temperature up to 600 degree centigrade so whatever is lost at the temperature that is the volatile solids and whatever is left over in the system or in the muffle furnace heating is the fixed solids so that one also will be available then the next step is find out the quantity of inorganic matter in the digested sludge. we know what is the total volatile solids in the sludge then we know that 50 percentage of the volatile solids are getting destructed in the digestion process so we can find out what is the inorganic matter in the digested sludge because volatile solids concentration will be getting reduced by 50 percentage but fixed solids concentration will be remaining as such so we can find out what is the inorganic material present in the digested sludge.

Now we can find out what is the total quantity of solids. The total quantity of solids is nothing but volatile solids plus fixed solids. Then we have to find out the percentage of volatile solids in the sludge and find out percentage of fixed solids in the sludge. Now we have to find out what is the volume required so we have to assume the consistency of the digested sludge. This consistency of the digestive sludge is depending upon the withdrawal frequency.

Usually the consistency of the digested sludge in a conventional anaerobic digester various from 4 to 6 percentage so we assume 5 percentage say in between this 4 and 6 so we can find out what is the volume of sludge because we know what is the total quantity of solids and we know what is the consistency then we can find out what is volume of sludge. We also know what is the volatiles solids, what is the fixed solids and what is the digested volume then based upon that one we can find out what is the volume of digester, volume of digester V is equal to V_f minus 2 by 3 V_f minus V_d into T_1. So V_f is volume of raw mixed sludge per day and V_d is the volume of digested sludge per day and T_1 is the hydraulic retention time.

Usually we give a solid loading rate of 0.06 to 1.6 kilogram vss per day per meter cube so you find out the volume of the digester and check whether the loading is coming within this permissible limit. Then we have to provide space for gas storage and extra sludge storage during monsoon because during monsoon period we cannot take out that digested sludge and send it to the sludge drying beds frequently or in summer because during monsoon period what will happen is sludge drying will take lot of time so we have to provide provision of the extra storage.

Now we only got the volume so how can we decide the height as well as surface area of the digester?
To find out the surface area of the digester the criteria is this gas production. What we assume is the gas production per kilogram of volatile matter destroyed is 0.9 m cube so the area required is 9 m cube of gas per day per meter square. If we have 9 m cube gas production then at least we should provide one meter squared area because if the gas production is more than this one and the area is less so lot of foaming will be taking place in the reactor so to avoid the foaming we have to give more surface area. This is the way we have to design the anaerobic digester.

We can find out the volume of the digester for the digestion purpose then we have to find out what is the extra volume we have to provide to store the sludge during monsoon period when we cannot withdraw the sludge frequently, then we have to provide the space for gas storage and we have to also provide some depth or some space for the grease and scum storage. We have also seen what is the area required based upon the gas production. So we know the volume and the extra volumes whatever we have to provide also we know so based upon that one we can find out what is the depth of the digester we have to provide. This is the design details of conventional or standard rate anaerobic digester.

Now we will discuss about aerobic digestion. We have seen already alkaline digestion as well as anaerobic digestion .and I have already mention that anaerobic digestion is the method which is most commonly used in wastewater treatment plants for the stabilization of sludge. Now we will see how the aerobic digestion is being carried out. This process is used to treat the sludge from waste activated sludge process, mixtures of waste activated sludge and trickling filter sludge and waste sludge from extended aeration system.

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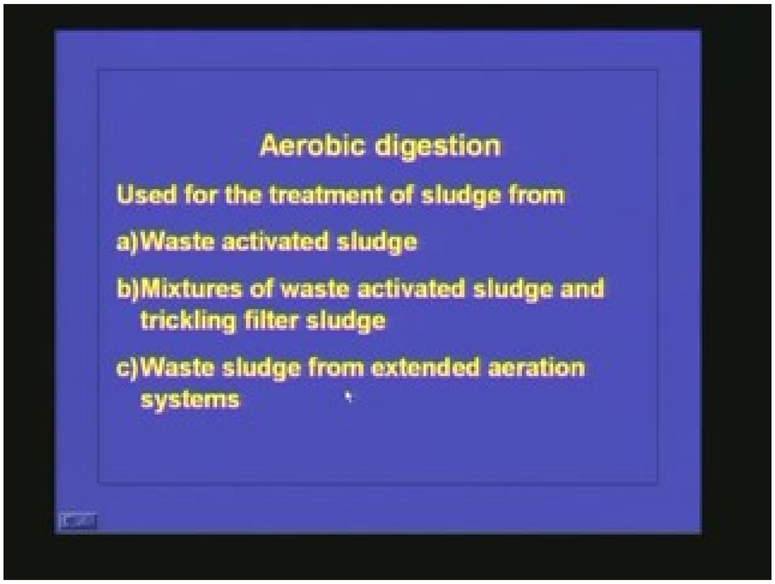

The working principle of this aerobic digestion is the same as that we have seen in activated sludge process. This sludge is nothing but the organic matter. So if you provide microorganism and sufficient oxygen what will happen is the microorganisms will be utilizing the organic matter and oxidizing it to carbon dioxide and water and in that process they will be getting energy and more and more new cells will be generated.

We have also seen that in certain modification of the conventional activated sludge process like extended aeration system. We are aerating it for a long time or the food supply to the system is limited so in the initial stages more and more organic matter will be getting converted to biomass but once the food is limiting the biomass thus generated will be getting auto oxidized and it will be getting converted to carbon dioxide and water for the maintenance of the remaining cells and towards the end what will happen almost all the biomass present in the system will be getting exhausted or getting destructed.

Therefore, the same principle can be used in aerobic digestion and definitely this performance or the volatile matter destruction efficiency is much high in aerobic digestion compared to anaerobic digestion. the reason is aerobic process is more efficient because more energy is liberated in aerobic process so the material whatever is required for catabolism is less compared to anaerobic process so definitely more microorganisms will be there in the system.

Now we will see the entire advantages of this aerobic digestion over anaerobic digestion. These are the advantages.

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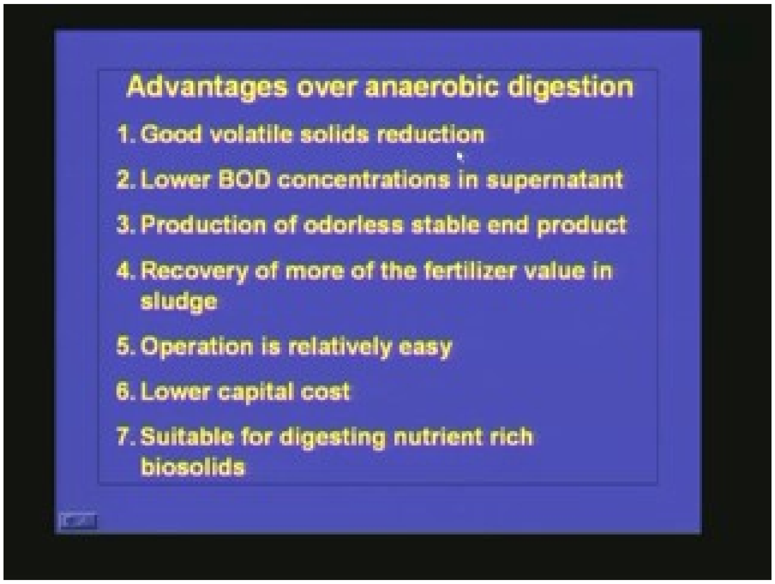

As I have already mentioned it is having good volatile solids, reduction potential and lower BOD concentration in the supernatant. If you see the supernatant from anaerobic digester the COD will be or the BOD will be very, very high. But in aerobic digesters the supernatant or the liquid whatever is coming out of the digester will be having a lower BOD and it produces odorless, stable end product whereas in anaerobic digesters odorless gasses like hydrogen sulfide etc will be generated.

Recovery of more of the fertilizer value in the sludge: The sludge from aerobic digester will be having more fertilizer value compared to anaerobic sludge and here the operation is relatively easy and it has lower capital cost and suitable for digesting nutrient rich bio solids. But it is having definitely certain disadvantages because here the power requirement is very, very high. We are giving such a concentrated organic matter to the system. If you want to completely oxidize that organic matter an equivalent amount of oxygen should be supplied to the system.

So, if you want to supply high concentration of oxygen definitely the power cost will be very, very high and the second problem is whatever digested sludge is coming out of the aerobic digester is having poor mechanical dewatering characteristics. That means the sludge will be containing lot of water and dewatering the sludge will be very, very difficult compared to anaerobic sludge so we may have to go for some chemical conditioning and so on if you want to try it properly.

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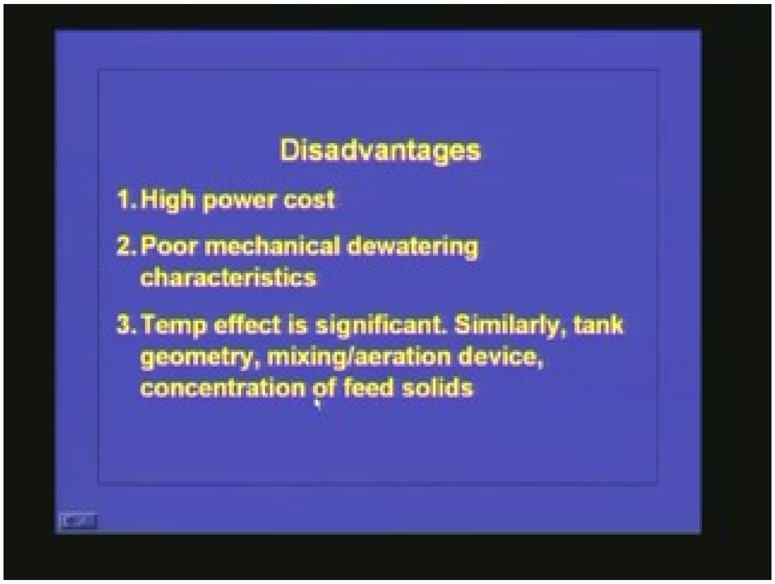

This aerobic digestion will be easily effected by the temperature, tank geometry, mixing and aeration devices and concentration of feed solids. If the feeding is not proper or if there is fluctuations in the feeding that will be affecting the system. The geometry of the tank is very, very important when we talk about the efficiency. As we have already discussed in aeration systems here also the tank geometry is very important and another thing is temperature effect. In any biological system when the temperature varies if the temperature comes down the efficiency of the system will be going down.

We have discussed many times that for every 10 degree change in temperature or rise in temperature the activity will be increasing 100% and for every 10 degree decrease in temperature definitely the activity will be decreasing by 100% or the efficiency will be coming down by 50 percentage. That is what is happening in aerobic digesters.

Now we will see what are the reactions taking place in aerobic digestion.

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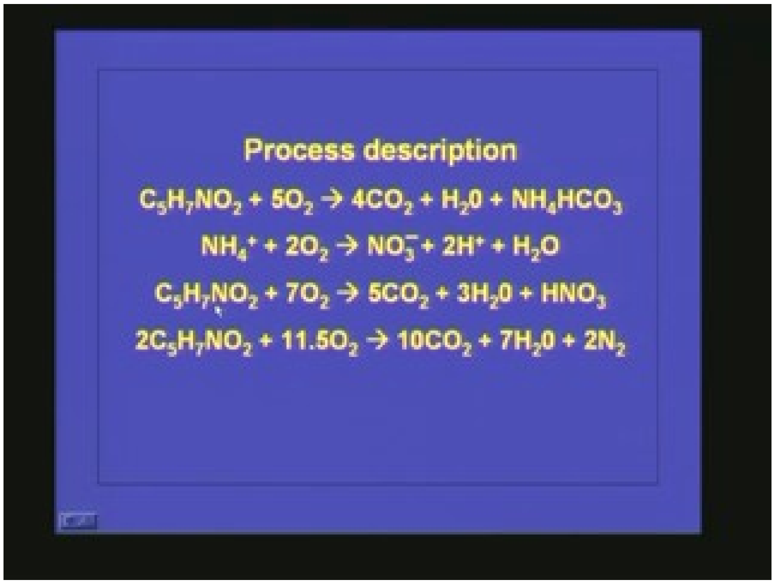

This is the organic matter, it is having carbon atoms, hydrogen atoms, nitrogen atoms and oxygen so in aerobic process what is happening is we are completely oxidizing the organic matter so we are adding oxygen externally so the carbon will be getting converted to carbon dioxide, hydrogen to water and this nitrogen whatever is present is getting converted to ammonium bicarbonate.

Again the ammonium whatever is present in the system if you supply excess oxygen that will be getting converted to nitrate plus water and here again this is the same organic matter (Refer Slide Time: 31:34) if you supply the same oxygen together, here the oxygen supply was limited that is why we are getting ammonia as one of the byproduct. But if you supply excess oxygen then in the first step itself everything will be getting converted into carbon dioxide, water and nitrate or nitric acid. This is another equation. Here instead of complete oxidation of this ammonia or the nitrogen to nitrate it is getting converted to nitrogen gas. Here we are optimizing the oxygen concentration.

We can see that if you supply exactly this amount of oxygen and control the biological process we will be the getting the byproduct as carbon dioxide, water and nitrogen. That means nitrification and de-nitrification is taking place in the same system. Now we will see the other method which is commonly use for stabilization of the solids or bio solids whatever is generated in various treatment processes used in wastewater. That is nothing but composting. All of us are familiar with this word composting because in most of the households we go for this composting. So we will see what composting is. Composting is a process in which organic matter undergoes biological degradation to a stable end product.

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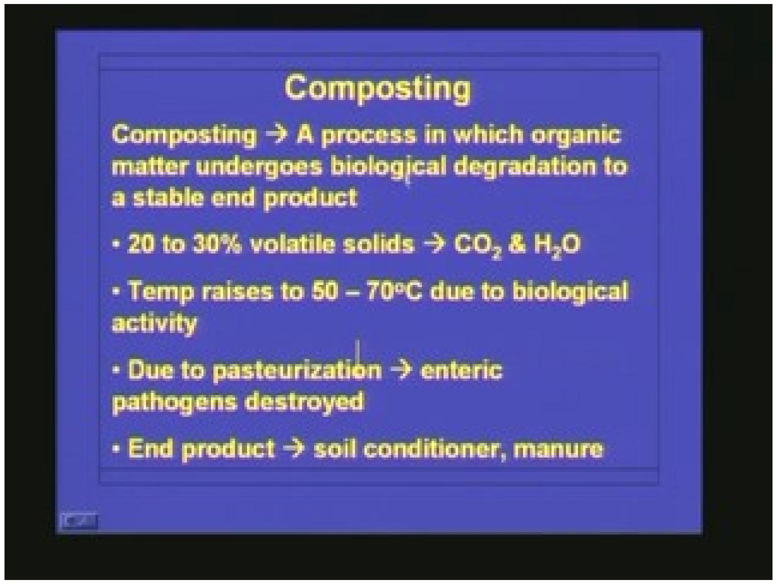

Here the organic matter undergoes biological degradation and we are getting a stable end product. It is not that everything is getting converted to carbon dioxide and water. We are getting a stable end product and in composting around 20 to 30 percentage of the volatile solids are getting converted to carbon dioxide and water and remaining will be present in the system.

During this composting what is happening?
Initially the biosoilds are there that will be undergoing degradation so the microbial activity in the system will be very very high. We know that the microbial degradation process it is an exothermic reaction. So as a result of this one what will happen is the system temperature will be increasing up to 60 to 70 degree centigrade and that high temperature will be maintain for a long period of time.

So at this high temperature the pathogens whatever is present in the sludge will be getting destructed. That is what I have written here. The temperature rises to 50 to 70 degree centigrade due to biological activity and the sludge is exposed this high temperature for a long period so because of that one pasteurization takes place and because of the pasteurization whatever enteric pathogen that is present in the sludge will be getting destroyed and we will be getting the end product which can be used us soil conditioner or manure.

It will be having vary high fertilizer value because only 20 to 30 percentage of the volatile solids is getting destructed and remaining volatiles solids will be there and nitrogen phosphorus etc. The nutrients whatever is present in the solids that also will be remaining in the end product so it will be having high fertilizer value so most of the time the end product of composting is being used as a soil conditioner or a fertilizer.

Composting we can do either in aerobic condition or anaerobic condition. Most of the time people prefer aerobic composting. The reason is it will not be giving any small odors or it will not be generating any odorous gases. But in anaerobic composing what will happen is definitely the solids whatever is coming from the wastewater treatment plant it will be containing lot of sulfides and sulfur components. So in anaerobic process this sulfur will be getting converted to hydrogen sulfide and along with hydrogen sulfide other gases like ammonia etc will be coming out so that will be creating problem.

Now we will discuss about the process microbiology. Here complete destruction of organic matter coupled with the production of humic acid to produce stabilized end product is taking place. So the destruction of organic matter is taking place and humic acid is produce and this will be stabilizing in the organic matter whatever is present in the system. And the microbes involved in this composting process are bacteria, actinomycetes and fungi. So a mix consortium of microorganisms are present in the system so it consists of bacteria, fungi and actinomycetes and we will be getting a stabilized end product.

So what is the function of these bacteria?
The decomposition of proteins, lipids and fats are basically carried out by the bacteria and as a result it is generating lot of heat energy. So the temperature raise in the composting plan or composting system or composting reactor is because of the bacterial activity because bacteria will be acting on the organic matter which consists of carbohydrate, lipids and protein and fats so the degradation takes place or decomposition takes place as a result the temperature will be increasing.

Actinomycetes and fungi are responsible for the destruction of complex organics and the cellulose because the sludge will be containing lot of cellulose and other complex organic material which the bacteria may not be able to take care or bio decompose in such cases the actinomycetes and fungi are very very helpful.

Now we will see what all are the different phases of composting. It can be divided into three groups. First one is mesophilic phase, second one is thermophilic phase and third one is the cooling phase.

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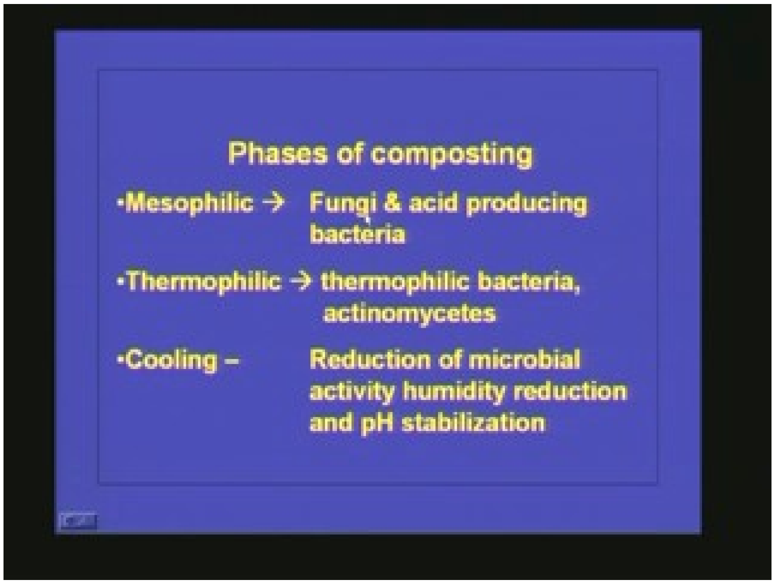

In the mesophilic phase the fungi and acid producing bacteria are active so they will be decomposing the sludge to a certain extent so as a result lot of acid will be generated in the system. And in mesophilic range or mesophilic phase what will happen is the microbial activity will be starting slowly so as the microbial activity comes up the temperature of the system will be coming up, that is what is happening in thermophilic system. Here thermophilic bacteria as well as actinomycetes are active and in cooling phase reduction of microbial activity will be taking place and in the same time humidity reduction and pH stabilization will be taking place because in mesophilic phase the pH of the system will be very very low because of the acid produce by the decomposition of the organic matter and in thermophilic phase the acid produced will be utilize utilized by the thermophilic bacteria as well as actinomycetes. In cooling phase everything will be stabilized.

This picture shows different phases in detail.

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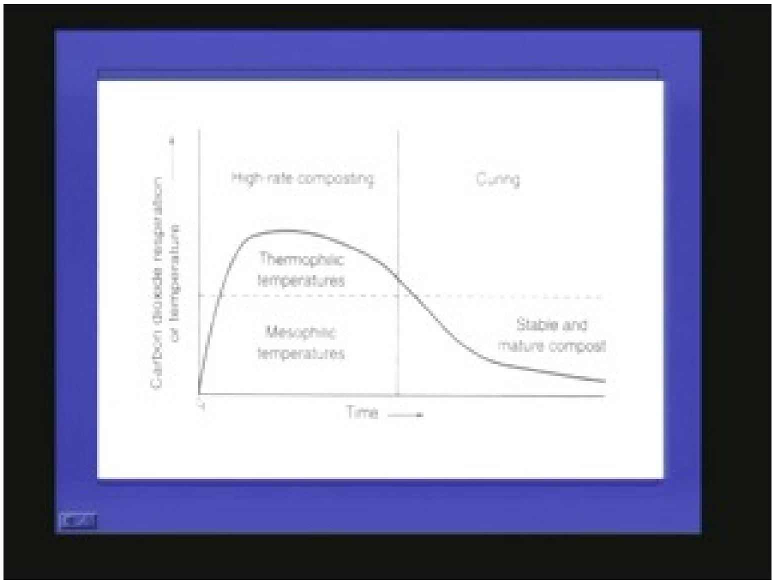

We can see that this x axis gives the time and y axis gives carbon dioxide respiration or the temperature. So how it is varying with respect to time?
Initially when we start the composting process the temperature will be very, very low and slowly the microbial activity will be starting. This is the mesophilic temperature range. Here fungi as well as the acid forming bacteria are active and as the microbial activity increases the temperature will be increasing drastically like this (Refer Slide Time: 39:55) and this range is in the thermophilic temperature range and from here to here we will be having high rate composting.

Here we can see that slowly with respect to time in the temperature will be coming down. Why the temperature is coming down?
The microbial activity in the system is decreasing that's why the temperature is coming down. This is the degradation stage and this is the curing stage. Here everything is getting degraded and the pH will be varying, the microbial activity will be varying and we will be getting many end products or byproducts. And in the second stage the pH will be getting stabilized and we will be getting a stabilized solid or compost and the microbial activity will be coming down so we can see that at the temperature is decreasing and is reaching almost same as the initial temperature so here we will be getting a stable and mature compost. So these are the three different phases that is occurring in any compost process.

Now we will see what are the steps involve or how to go around so this composting process. The steps involves can be divided into five categories. One is pre-processing. Here we are mixing the dewatered sludge with an amendment and or a bulking agent. Because if you provide the sludge or if you put the sludge alone in the compost it will be forming a compact mass and the aeration of the system will be very, very difficult. If the aeration is not there or the air circulation is not there microbial activity will be less and we will not be getting a matured compost in a short period of time. So, if you can make the air circulation proper we can increase the efficiency of the composting. That is the purpose of adding these amendments or bulking agents.

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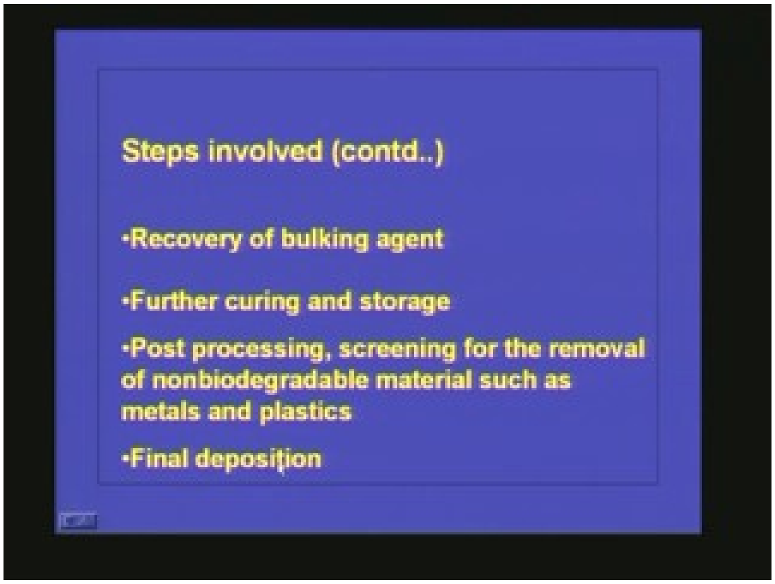

Most of the time we add wood chips as the additive or bulking agent. First this preprocessing is done then it undergoes the high rate decomposition. Here we are aerating the compost pile either by the addition of air or by mechanical turning or by both. So first we reprocess it and mix the dewater sludge with the additive or the bulking agent. So we have a sludge which is not very compact and air circulation is possible in the system. And in the second stage where the high rate decomposition is taking place and as we are talking about aerobic composting so definitely we have to give air or oxygen supply which is essential, the external oxygen supply is very much essential. This one can be done either by supplying external aeration or mixing the sludge pile. By mechanical means we can provide aeration so sometimes people practice mechanical mixing as well as external aeration so that the entire system will be under aerobic condition which will definitely increase the efficiency of the system. This is recovery of bulking agent because we have done the pre-treatment and high rate composting.

The next one is the curing step. In the curing step what we can do is this bulking agent will not be undergoing any decomposition in that period so we can recover this bulking agent and we can reuse this bulking agent. So the third step is recovery of the bulking agent, then allow the treated sludge for further curing.

The next step is post processing. Here what we do is usually the screening for the removal of non-biodegradable material such as metals and plastics. Most of the non biodegradable material like plastics and metals will be removed before composting but some materials will be left over in the sludge so we can remove this after the curing process then once this post processing is over we can deposit or use this one as manure or soil conditioner that is known as the final deposition.

We will discuss once again what are all the steps involved.

First one is the preprocessing and second one is the high rate decomposition. Here most of the microbial activities are taking place and to enhance the microbial activity we provide aeration by external means and some times mechanically mix the sludge pile also. The third step is recovery of the bulking agent because bulking agent will not be getting destructed during the composting process so we can reuse this bulking agent. The fourth step is further curing so that the pH of the system will be getting stabilized, the humidity of the system will be coming down and the microbial activity will be getting reduced then the next step is post-processing. In post-processing whatever the non-biodegradable material is left over in the bio solids we can remove them at this stage.

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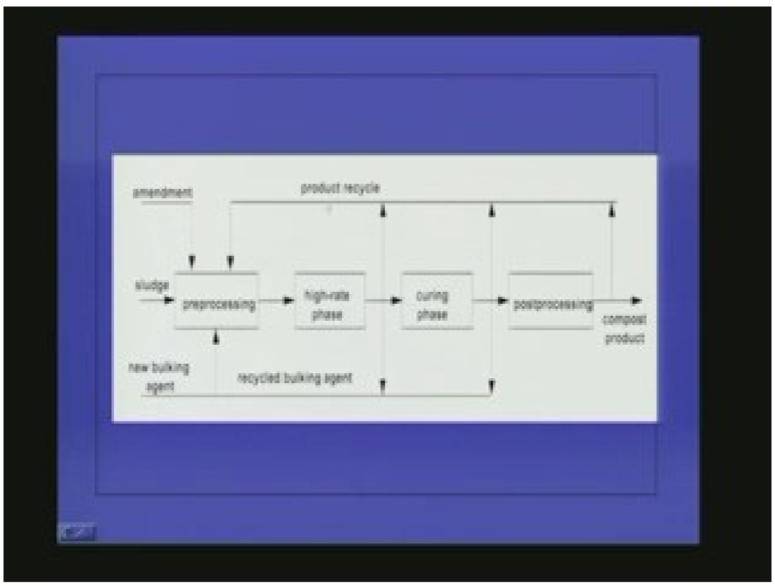

Finally we will be getting a matured compost which can be used for soil conditioning or most of them it is used as a fertilizer which is having lot of fertilizer value. So this is the flow diagram for a compost process the sludge is coming here and we are adding amendments or bulking agent and here the pre-processing is taking place after the pre-processing the high rate degradation phase is happening so after the high rate phase we are removing the bulking agent so whatever is removed is being recycle and it is coming back to the pre-processing unit then again we go for the curing. After curing, from whatever material we are getting we can recycle certain materials then do the post processing for the material whatever we are recovering.

Most of them will be having some resale value and a portion of the compose will be recycled to the pre-processing system so that we can increase the air circulation of the sludge whatever is coming into the pre-processing unit and whatever is the mature compost product we can use it as manure. This is the flow diagram of a composting process as shown above.

Now we will see how we can divide this composting process. Usually we can divide the composting process into two categories. I am talking about aerobic composing. One is agitated composing and another one is static pile composting.

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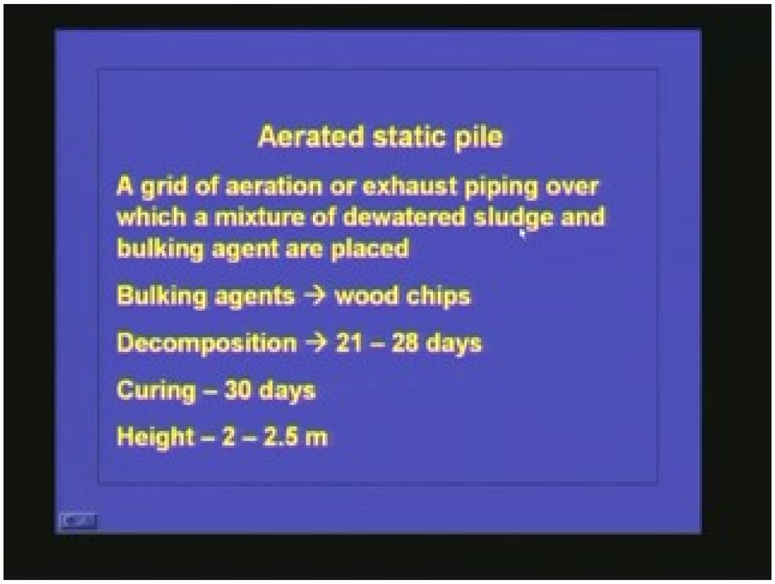

Aerated static pile composting: as the name indicates the pile will be in a static condition nobody is going to mix it up. Here we have a grid of aeration or exhaust piping over which a mixture of dewatered sludge and bulking agents are placed and most of the time the bulking agent is wood chips. We give a decomposition period of 21 to 28 days and curing for 30 days. Usually the height of this sludge pile is varying from 2 to 2.5 m. This is the example.

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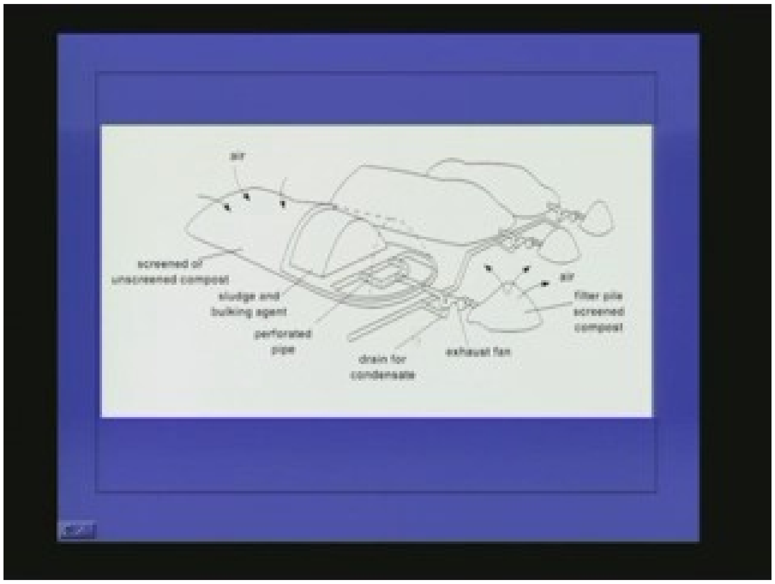

This is the aeration pipeline grid. It is connected to an exhaust fan and this is the air and this grid will be going underneath of this one over which we are putting the compost or the solids mixed with the bulking agent. So this is the sludge and the bulking agent. Here (Refer Slide Time: 48:27) this is undergoing high rate decomposition and we are supplying the air and finally after this one decomposition is taking place and this is the curing stage. Hence, after curing we will be getting much ward compost. This is screened or unscreened compost, this portion and this is sludge and the bulking agent. And with respect to time once it is decomposed this will be coming here and new sludge and bulking agent will be coming here. This is the perforated pipe (Refer Slide Time: 48:58) and the sludge whatever we are using for composting will be dewatered sludge mixed with bulking agent.

This is a full stack here and this is the air and this is the exhaust fan and this is the drainer content side so whatever water is escaping from the composting pile we can collect through this one. Another one is the agitated. It is known as windrow.

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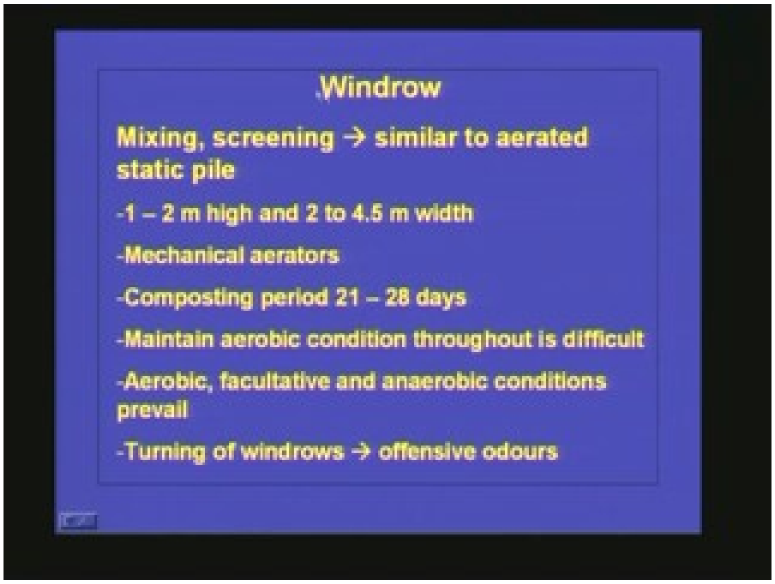

Windrow means we are mixing the sludge frequently. This is also commonly used for the composting of organic solids or sludge. Here mixing and screening are similar to aerated static pile and here we give a height of 1 to 2 m and a width of 2 to 4.5 m. Usually we use mechanical aerator and along with mechanical aerators the agitation of the sludge. So, composting period that means total degradation as well as curing period is 21 to 28 days. In the other case the degradation itself was for 21 to 28 days and for curing the same amount of time we were giving.

Here because the mechanical agitation is there and we are supplying air by mechanical means the aeration will be much better in this windrow process compared to the static pile process. But maintain aerobic condition throughout the sludge pile or in the sludge is very, very difficult because you know that the sludge is having very high consistency so it is very, very difficult to provide complete aerobic condition. Therefore, even in window process aerobic facultative and anaerobic conditions prevail. When we turn the sludge because of this facultative and anaerobic condition whenever the turning takes place offensive odors will be coming out. Because of the anaerobic digestion the odorous gases will be produced therefore, whenever we mix the sludge the odorous gases will be escaping from the solid and it will be creating the odor problem.

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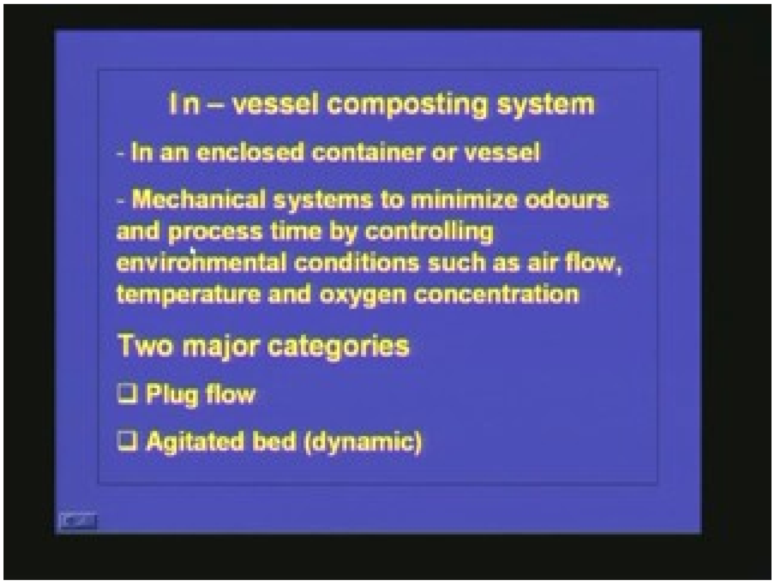

The third type of composting is nothing but inversion composing system. Everything will be put in a vessel which will be a closed one so the composting will be taking place inside that system and we will be having a conducive environment for the microorganism for the degradation of the organic sludge. Here it is an enclosed container or a vessel, mechanical systems to minimize odors and process time by controlling environmental conditions such as air flow, temperature and oxygen concentration. So when we go for in-vessel composting system we have a better control over the system so we can minimize the odor by providing aerobic conditions as much as possible and we can control the process time by increasing in the microbial activity. This is achieved by providing suitable environmental conditions such as proper and uniformly distributed air flow, high temperature and high oxygen concentration.

This in-vessel composting system can be classified into two major categories. One is plug flow and another one is agitated bed or we can call it as a completely tired tank system.

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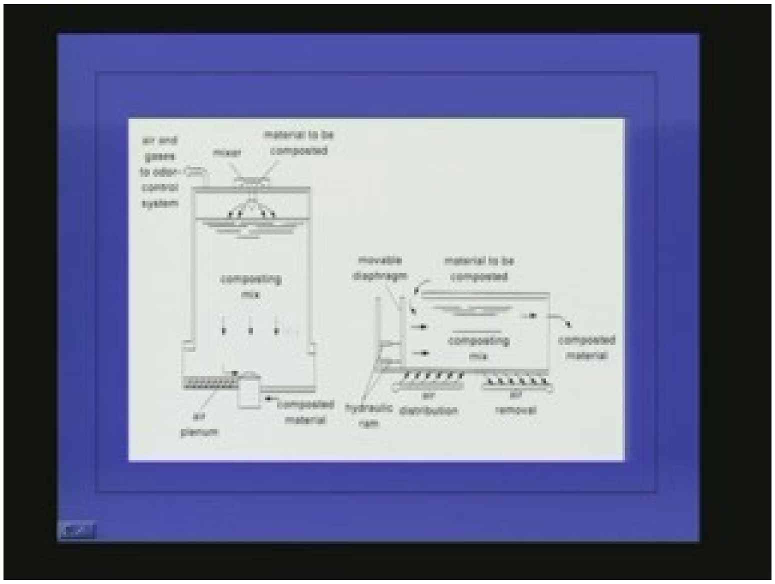

This is a vertical type of in-vessel composting unit and this is a horizontal flow system. Here what is happening is the material to be composted is fed here and here there is a mixture so that it will be ensuring uniform mixing or uniform feeding of the sludge and this is the composting mix (Refer Slide Time: 53:04) so the sludge will be coming through this reactor and lot of microbial activity will be taking place here. As a result the sludge whatever we are providing will be getting stabilize and we can get the composted material here and air is applied from here. The air and gases do the odor control system. Therefore, whatever gas is coming will be sent to an air pollution control system so that will be taking care of the odorous gases that are coming along with the air.

This is a horizontal system this is an overview diagram as shown above and this is the hydraulic ramp, here we are sending the material to be decomposed and finally here we will be getting the composted material. This is the air distribution and this is the air removal (Refer Slide Time: 54:03) and we can send this air for further treatment to remove the odorous material. This can be plug flow or if you mix it properly then it will be getting converted to an agitated type or a CSTR type in-vessel composting device.

When we talk about the composting what are all the designs consideration we have to talk about? We have to deal with the total volume. We should know what is the total volume of sludge we have to treat and what is the total weight of the sludge we have to treat. These things are very, very important. The total volume will give you an idea about the reactor volume and total wet weight will be giving you the data, so we have to design the structure accordingly and total solid content. Therefore, from this one we can find out what is the digestive sludge we are going to get and what is the gas that is going to be generated etc. we also want to know what is the volatile solids content because this is the one which can be degraded and the water content is very, very important, bulk density is very important and percent water content and percent volatile solids of the compost mix. These all are information essential for designing a proper composting system.

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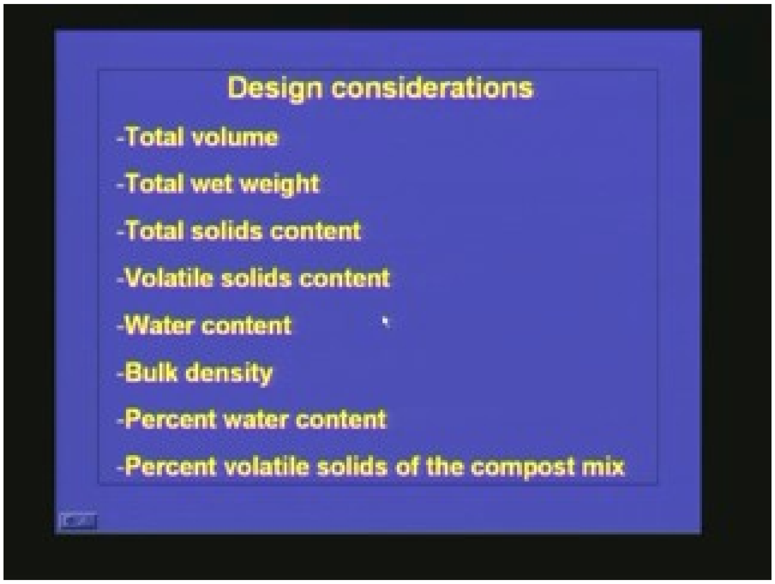

Sometimes what people do is instead of treating the solids whatever is coming from the wastewater treatment plants separately, there if you want to treat it we have to dewater it then add some bulking agents but to avoid that one the composting can be done along with the municipal solid waste known as co-composting. Both bio solids and municipal solid waste are composted together. This is having many advantages. The major advantage is sludge dewatering may not be required. the reason is municipal solid waste water content will be very, very less, so, that will be taking care of the water content of the sludge whatever we want to treat. So if you mix it together the sludge dewatering can be avoided.

The overall metal contents of the composted material will reduce. This is because the municipal solid waste will be having very less metal concentration whereas the sludge whatever is coming from the wastewater treatment plant will be having very high concentration of metals because the microorganisms can bio-accumulate the heavy metals whatever is present in the system. So, if you mix the bio solids along with the municipal solids the total sludge whatever we are getting will be having less concentration of toxic metals which get accumulated in the system. This can be reduced.

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Usually a 2:1 ratio of municipal solid waste to sludge is recommended. That means two portion of municipal solid waste and one portion of the sludge from the waste treatment plan can be used for this co-composting. When we go for this composting we have to be very, very careful about the public health and environmental issues because this will be containing pathogens and all other problematic substances. Once it is completely cured and when we get the matured compost that will not be having any problem because the pathogens are completely destructed. But otherwise what will happen is the pathogens will be there so it can enter into our body by inhalation or through skin or when we are handling the compost and afterwards if you are not washing your hand properly then through the hand the pathogens can enter into our body. So the workers who are dealing with this composting should be very, very careful about this aspect.

Another problem is the aerosols whatever is generated while mixing the compost. We have seen that in windrows process we have to mix the compost mechanically so that also can create some health hazard so we have to be very, very careful.

Today we were discussing about the stabilization process. We have seen four processes in detail. One is alkaline stabilization, then anaerobic digestion, aerobic digestion and composting. Among these four processes the most commonly used ones are anaerobic sludge digestion and composting. Anaerobic sludge digestion we can go for standard rate or high rate reactors and composting also we can go for aerobic process or anaerobic process. But we have to be careful about the health hazards whatever is associated with this process.

Next day we will continue with sludge stabilization.