**Wastewater Treatment and Recycling**
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**Lecture – 42**
**Wastewater Sludge Processing and Treatment: Dewatering, Hygienisation Disposal/Reuse**

Hello everyone. And welcome to this last lecture of the week 8 where we will try to conclude the discussion on Wastewater Sludge Processing and Treatment what we generate. So, we have discussed various preliminary step in the form of first sludge thickening, then digestion of this sludge, dewatering of this sludge in the earlier couple of lectures. And this final lecture we will be talking about dewatering the hygienisation which is kind of disinfection, then the disposal and reuse options of the sludge ok.

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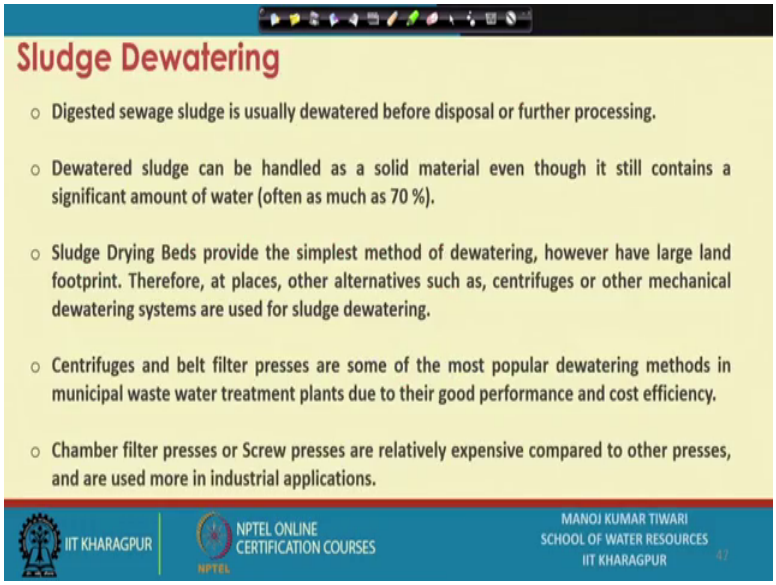


So, the sludge which is stabilized and thereafter conditioned is bought to the dewatering systems. Now this digested sludge is usually dewatered before disposal, or further processing. The dewatered sludge can be handled as a solid material, so that is the advantage of dewatering that because until this stage whatsoever this sludge we are getting is actually in the form of fluid has lot of though viscosity.

But it flows it is a liquid form through dewatering process this sludge can be converted to solid material. Although there will still be significant amount of water content which

could be as high as 70 percent ok. Generally like the dewater sludge has a solid content typically in the range of 30 percent. At times if our dewatering technique is quite good we can get up to 40 percent solid content in that way.

So, but still there is more than half of the liquid content water content, but this sludge is so thickened, or so dry that it can actually be handled as a solid material. So, that that is the kind of advantage of sludge dewatering, and which eventually converts it from the liquid stage or a slurry stage we can rather say to the more or less solid stages ok.

Now, the drying beds or what we typically call as sludge drying beds are the simplest methods for dewatering ok. And what we do in there like we have this sludge and we let it kind of spread on a drying bed ok. Of course, the drying bed has typical design then there is a sand layer in order to kind of see the in order to see where the liquid is going.

So, liquid can actually be move in two ways from these drying beds through a evaporation or through kind of draining to the lower strata that way, but that is what is the most popular, and most common and most simple approach for this sludge dewatering; when sludge is put to the drying beds. But, the problem is that it has a very large land footprint.

Because if you want to use land for sludge drying. So, you need to allocate large amount of land where you can spread this sludge right and that becomes a challenge particularly in the urban setups where there is a land is a very precious resource. And, you do not want to waste the land for just purpose of holding and dewatering sludge ok.

So, that is why at several places the alternatives such as the centrifuges or various other mechanical dewatering systems are used for sludge dewatering. We are not going to discuss all these dewatering equipments in the detail. Because there more or less similar to the one which we discussed for thickening purpose. So, we can have like centrifuge, belt filter presage, those kind of thing and then various screw presses for the dewatering purpose as well.

So, a centrifuges and belt filter presses are some of the most popular dewatering methods for the municipal wastewater treatment plants due to their good performance, and relatively low cost when we compared with the other processes like chamber filter press,

or screw presses which are relatively expensive ok. And then various other processes and that is why they are more used in the kind of industrial applications.

So, where the industrial effluent or this sludge so like the screw presses is very good for when you are sludge is having lot of fibers. So, far say you have pulp, and paper industry, or textile industry which produces this sludge with lot of fibers. So, if you kind of like dewater that sludge. So, it one can go for screw presses which would be very effective there probably the most suited one right.

The chamber filter presses are again since it is very expensive. So, has generally or typical municipal water treatment, or wastewater treatment plants does not go for these systems and these are more kind of used in a large industries which can afford such system. So, for say mining industry, or those kind of places this is far more popular as opposed to the typical traditional municipal wastewater treatment facilities.

So, these are the kind of some of the mechanical dewatering units and since their principal their approach is similar to the sludge thickening. When we discuss the mechanical sludge thickening steps so we are not going to discuss those in the detail.

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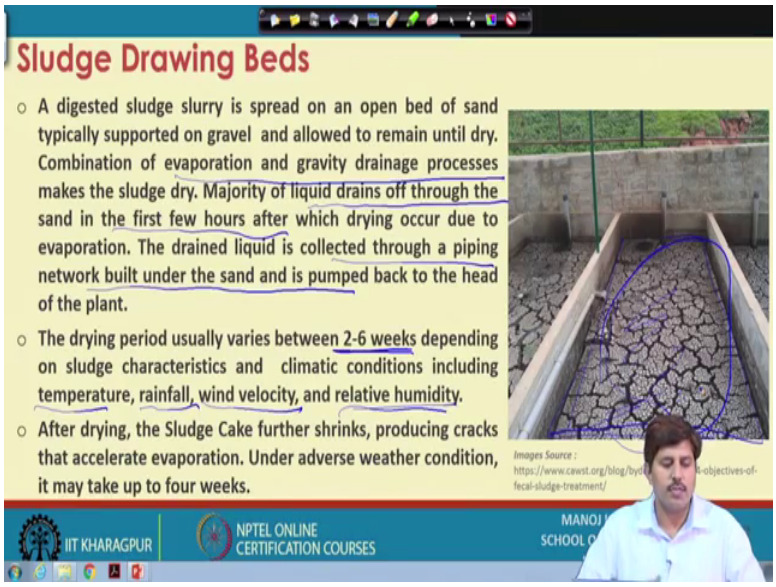


Then the sludge drying beds which are there, so it a typical sludge drying bed will traditionally look like this ok. So, this is kind of a sludge drying bed. Now what happens that the digested sludge slurry, slurry which comes after the sludge digestion and

conditioning which is an optional step, but if you provide conditioning; so, the condition sludge is spread on a open bed of sand and typically a kind of supported on gravel and allowed to remain until it becomes dry ok.

So, it will be spread that way and so, if you see the design of these drying beds it is there will be a kind of under drainage system which will be provided. So, what happens that the combination of evaporation and gravity drainage processes makes that sludge dry. So, there is going to be the evaporation process, so water will get evaporated and then water gets drained out through it sand bed. So, because it is laid on sand and of the gravel is only for support.

So, that sand will allow the solids to basically pass through, but that water can squeeze it through those sands and can actually go down where are this liquid drains off through the kind of sand in the first few hours only ok. So, this draining out process is quite fast, and then the slowly the evaporative drying which will take place in quite some period. And this drained liquid is collected through the piping network built under this sand and then again is pumped back to the starting point or to the head of the sewage treatment plant.

So, the water because that is a contaminated water coming out of the sludge, so that water is channelized back to the sewage treatment plant recycled back at the entry point of the sewage treatment plant. Typically to the primary sedimentation stage and then the solid part will be left over there for quite some time, and then since the major liquid drainage has already taken place. So, the rest of the drying is primarily due to the evaporation.

So, this drying period again varies typically between 2 to 6 weeks depending on the characteristic of the sludge in climatic conditions. So, how is the climate, how what is the characteristic of the sludge whether it has been kind of like conditioned or not. So conditioned sludge again can has the better dewatering this thing. So, they will dry out relatively faster the non conditioned sludge may take a little longer time. Because drainage will not be more much and major water has to be go through the evaporation process. Further the climatic condition plays a lot of important role in this.

So, depending on the temperature this is obvious that if you are doing it say in a colder climate where there is temperatures are not high. So, it is going to take much larger time period then when you do it in a warmer climate where particularly warm arid regions

where it can drive within let us say couple of weeks only ok, but if you do it in a like colder climate or humid region. So, what is the relative humidity? What is the wind velocity? Because wind also plays a large role in drying this, the rainfall you have spread these are generally open system. So, you have spread in and then rainfall occurs. So, again your water your bed is going to basically require a lot of water again.

So, those kind of thing actually are important in deciding how much time this sludge is to kept in this drying bed which typically varies from 2 to 6 weeks. So, within a span of 6 week it almost eventually dries and we can get solid content as high as 40 percent ok. Now, after drying when this gets dry, the sludge cake further strings, and what this shrinking does, then it will provide lot of cracks as can be seen in this figure. So, when there is lot of cracks developed, so the like earlier when you just put the sludge on this surface of this drying bed.

So, this surface area is the one which is exposed and the evaporation takes place from this surface area, but when this cracks start developing. So, we get lot of lot more of surface area is exposed that way and that through these cracks, or the through in the newer surface area exposed due to these cracks. The process of evaporation accelerates and then the subsequent drying can actually be even faster. So, under adverse weather conditions it may take up to kind of 4 weeks or up to 6 weeks though, so that is how the drying actually takes place.

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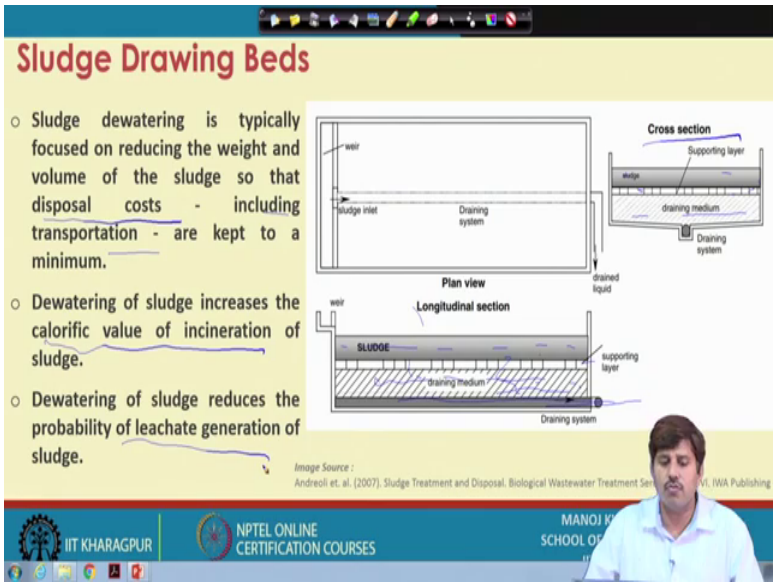

Now, if we see the kind of how these drying beds are laid out. So, we will have a drainage system. We will have a draining medium which is sand kind of this and then on the top of this sludge is put in we can have a supportive layer as well ok. So, sludge is loaded this thing is collected and through drains it comes here. If you see the cross sections, so it will look like this. So, this drainage system will look like this and then this is draining medium supporting medium and sludge is put on the top and this is the plan view how it is designed that way.

So, sludge dewatering is typically kind of focused on reducing the weight and volume of the sludge. The idea is to reduce the disposal cost or the final trans including transportation that can be reduced and can be kept minimum this dewatering of sludge increases the calorific value of the incineration of this sludge, because you get rid of the lot of water out of there.

So, if you basically get rid of the water. So, your the for the net weight per unit weight your calorific value increases and this reduces the possibility of leachate generation of this sludge. Again if you go it for land filling, or dumping because since the water content has reduced, so there is not much of the leachate will be generated from the sludge.

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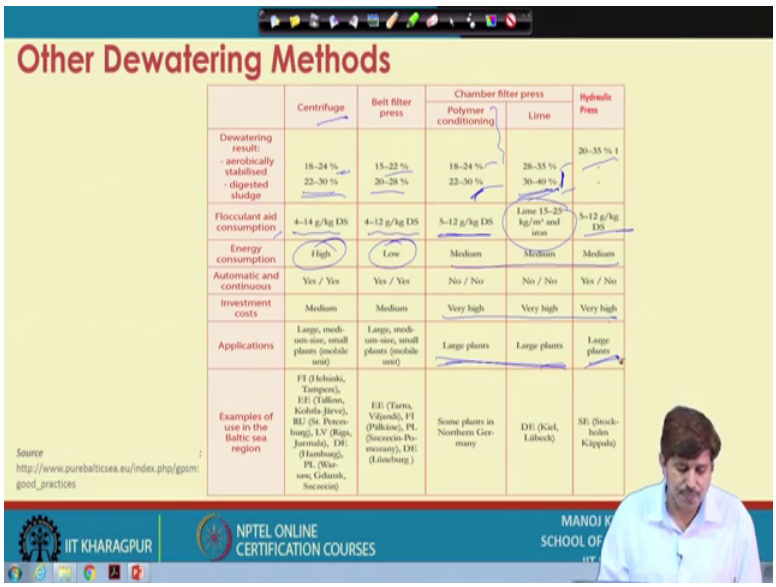


The various other dewatering methods as we said that there could be various mechanical methods apart from the thickening. So, as we will not be going into the detail as

processes are same what we discussed during the time of sludge thickening. So, there are centrifuge which kind of like aerobically stabilized sludge it can bring it down to 18 to 24 percent dry solid content.

And digested sludge it can bring 22 to 30 percent, belt filter presses are there which can again bring from 15 to 24 means up to 30 percent they can bring, then chamber filter presses similar performance. The lime is relatively if we add lime in the chamber filter presses. So, the polymer conditioning in the chamber filter process will let you like digest, let you dewater up to 30 percent solid content.

Whereas, lime can actually have more effective results can actually produce up to 40 percent solid content in the water. The hydraulic presses are also another option which can be used the flocculent aid consumptions is of the order of 4 to 14 kg per kg of dry solids in the centrifuge, in the belt filter it is 4 to 12 kg, 12 gram per kg of dry solids and the polymer doses here is 5 to 12 gram per kg, but the lime doses are far more higher.

So, lime doses if you are trying to put which is for achieving good performance. So, we have to add some 15 to 25 kg per meter cube of and based like iron concentration is also to be seen there ok. In hydraulic press also of the similar range energy consumption wise the belt filter press has low energy consumption. Centrifuge has the roughly highest and all other will have medium energy consumption when we compare them across each other. The investment cost wise the chamber filter press lime with either polymer, or lime, or hydraulic presses are very high whereas, the belt filter press and centrifuge will have the medium cost ok.

Application wise again we can see that like where they can apply. So, the chamber filter presses are for large areas this is also for large plants. So, that way we can have the different one the comparison of these things.

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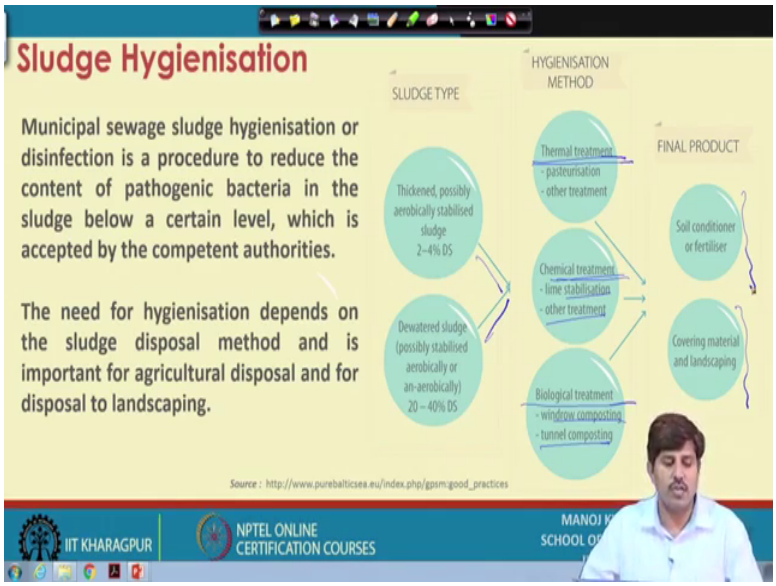


So, after we are done with the sludge dewatering the dewater sludge is then basically processed for the disinfection, or what we typically called hygienisation. So, we in order to mention maintain the hygiene of the sludge ok. So, the municipal sludge are kind of disinfected to reduce the content of pathogenic bacteria in this sludge below a certain level which is accepted by the competent authority before going for the final disposal or those kind of thing.

So, this again this need depends on the sludge disposal method it is not necessarily that will always go for this step if you just want to like dispose of sludge. So, the dry cakes that we produce out of the sludge drying beds can directly be sent to the landfills we may not actually need a hygienisation method over there. But again particularly for if we are planning for agricultural disposal, or for landscaping or for other purpose. So, we may need to go for a hygienisation method.

So, the sludge type that we get typically is the thickened and possibly like anaro possibly the stabilized sludge ok, and the dewatered sludge also like will come that way. So, the methods are the thermal treatment ok, where we can go for pasteurization or other treatment methods. There are chemical treatment methods of the hygienisation where we can go for lime stabilization, or other treatments. And then there are biological treatment methods which are kind of windrow composting or tunnel composting.

So, biological method that involves composting are by far the most popular method for these things ok. And then the final product that we get is the kind of convert like covering material, and landscaping and soil conditioner or fertilizers in the form of bio compost or those kind of thing ok.

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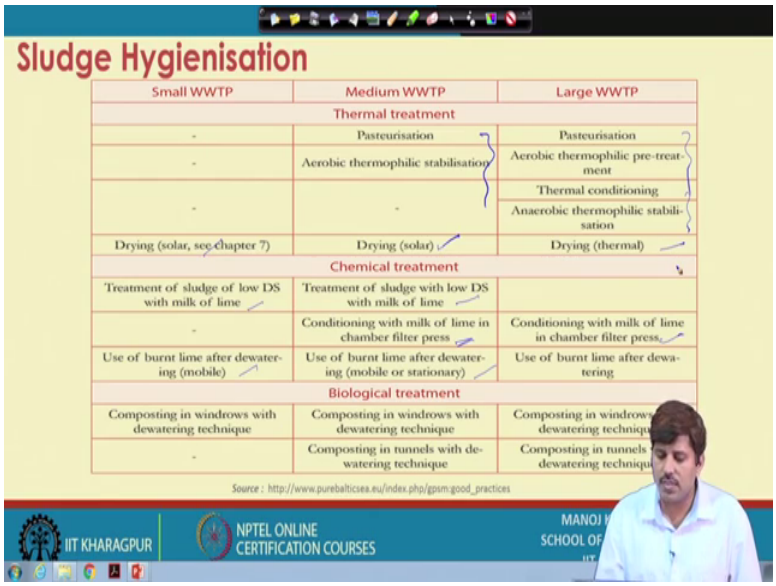


So, that is what the kind of purpose of the hygienisation. Now if we see the different method or different approaches of the hygienisation as we were discussing. So, for smaller wastewater treatment plants of course, going for thermal hygienisation in the form of like pasteurization, or aerobic thermophilic stabilization is not recommended we can just go for typical drying. In the medium wastewater treatment plant again we can go for drying which is up which is available for anywhere, but we can go for pasteurization, or aerobic thermophilic stabilization.

In the large wastewater treatment plant we can go for pasteurization, or aerobic thermophilic. Or thermal conditioning which we discussed earlier or anaerobic thermophilic stabilization also can be achieved. For the chemical treatment prospective in the smaller one we go for the treatment of sludge with low dry solids with kind of lime, addition of lime or we can use burned lime after the dewatering.

Here also we can use this burned lime or we can use the kind of sludge with low dry solids with lime solutions. We can also consider the lime in basically chamber filter press, and here also we can use for large wastewater treatment plants again we can use

lime in the chamber filter press, or use burned lime for the dewatering purpose. The biological treatment is composting generally windrows with dewatering techniques. Whereas, for medium to large we can go for either windrows composting, or the tunnel composting.

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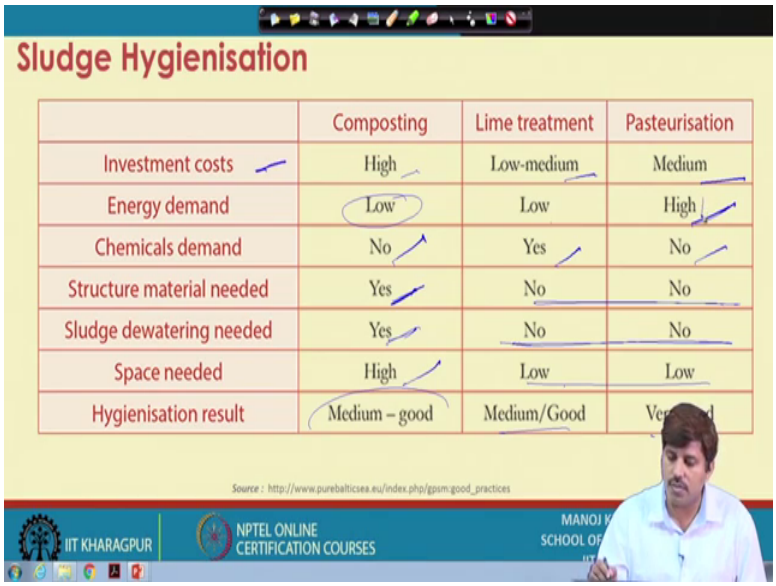


So, composting essentially in the this thing can be done as a like standalone composting, or can also be done with the co composting where we like composed this sludge with the municipal solid waste. So, for composting purpose we will need probably to add some organic matter. Because the sludge is are the digested sludge has already been like lost quite a few of your forming matters in the form of sawdust, or something we can mix in the this sludge that we get and then we put it through the come then we put it for composting purpose ok

And the aerobic composting in the presence of air and then desired level of mixing will produced then compost in a span of say 30 to 60 days typically. At times it may take higher depending on the such characteristic though. So, if we compare these different methods of the composting lime treatment and pasteurization which are the common methods.

So, based on various criteria's so if we see the investment cost composting investment cost is relatively higher because we need the land area or we need other these things. Lime treatment is low to medium and this is medium cost, energy demand is absolutely

low no not much energy is required in the composting. You may need some for converting or those kind of thing, but otherwise not lime treatment will also low, but here the energy demand is quite high. There is no chemical requirement here you need a chemical here also you do not need chemical.

The structure material needed yes we need like structure for composting we do not need too much of structure materials here. The sludge, dewatering is needed yes we cannot compost with a very high water content. So, initial dewatering is needed this can be done without dewatering. Then the space needed is high for composting and that is what actually leads to the investment cost otherwise there is not much investment cost in the composting also.

And then here space needed is low and then results is here medium to good here also medium to good, but this leads to the very good result. But the again the energy demand is quite high and that way the operational cost is quite high and it is not preferred, and we may need skilled operators to operate the systems as well.

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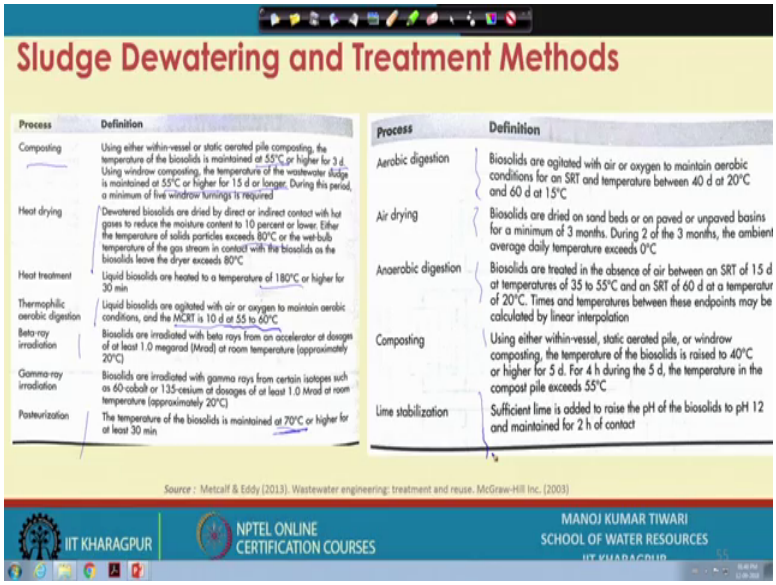


Now, if we see like this different dewatering and treatment methods. So, we have the composting which basically using either within vessel, or state aerated pile composting. So, temperature of the bio-solids is maintained at around 55 degree Celsius and for 3 days using windrow composting the temperature of the wastewater sludge is maintained

this for around 15 days or longer ok. So, during this period a minimum of 5 windrow turning is required for the composting.

Then heat drying we discussed that the dewater bio solids can be directly indirectly link through like can be supplied through hot gases to reduce the moisture content to 10 percent or lower. So, either the temperature of solid particles exceed 80 percent ok, so that way we can dry them.

The typical heat treatment where heated at a temperature of 180 degree Celsius for 30 minutes. So, almost all this thing will vaporized then we can go for thermophilic aerobic digestion where the liquid bio solids are agitated with air and oxygen to maintain the aerobic conditions. And the mean cell residence time is almost 10 days and it is done at 55 to 60 degree Celsius.

We have other methods in the form of beta ray, gamma ray, and pasteurization which is the temperature of the bio-solids is maintained at 70 or higher for at least 30 minutes. We have various digestion processes in the treatment. So, we majority of that we discussed we have aerobic digestion, air drying, anaerobic digestion, composting and lime stabilization methods. So, the different features of that are summarized ok.

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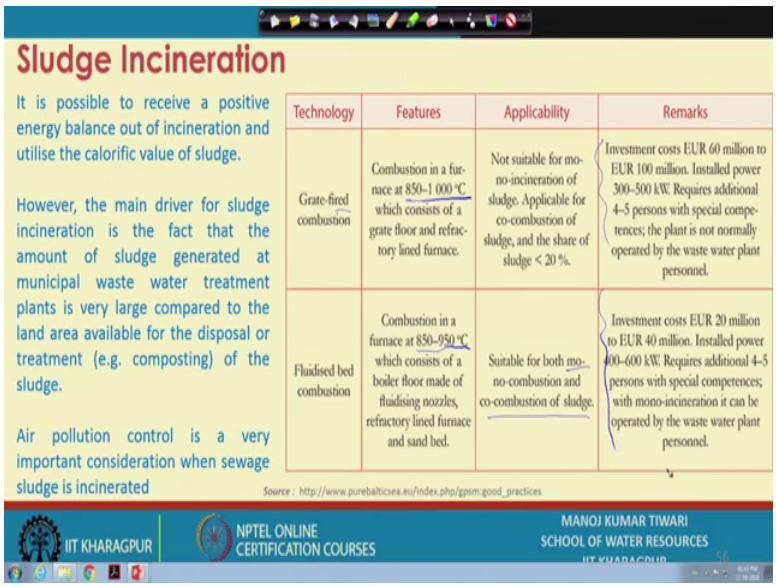


Now, then we go for we may go in fact it is not a necessity, but we may go for sludge incineration. So, sludge incineration is generally there are two motivations which tend to

take us towards the sludge incineration. The first thing is the like idea of generating energy from the sludge ok. So, it is possible to receive a positive energy balance out of the incineration and utilize the calorific value of the sludge, so again, but it depends on the scale.

So, if it is on appropriate scale we can utilize the calorific value of this sludge by incinerating it and then the kind of heat energy we produce, or we convert that to we can convert that to kind of electrical energy and operate the plant, or system within this space of the wastewater treatment facilities. So, that way it could be helpful that is one aspect.

However, the main driver for incineration is even though the sludge is dried, but still there is a lot of mass of the sludge. And if you go and like if you want to basically put it on to the landfill, or for composting purpose or land disposal. So, then there is a lot of like there is a requirement of a very large area, which is very difficult to find in the cities or urban space.

So, that is what that is why it can be incinerated. So, that the volume also reduces and just little ashes left and rest of things goes off. But then the air pollution control is a very important consideration when we go for this kind of incineration. And we must ensure that proper air traps or scrubbers are in place sort of to not let the generate lot of air pollution out of this incinerations.

There is a great fired combustion and fluidized bed combustion technologies for incineration ok. And this incineration is typically done at much higher temperature 850 to 1100 in case of this and fluidized bed it can be done around 850 to 900 ok. And then this is suitable for both mono combustion and co combustion of the sludge.

So, sludge can be like combusted as alone or can be combusted along with the along with the municipal solid waste, or those kind of thing ok. Whereas, the grate fired is not suitable for mono incineration it is applicable for co combustion, where the shear of the sludge could be around should be around less than 20 percent and then lot of the municipal solid waste could be needed ok.

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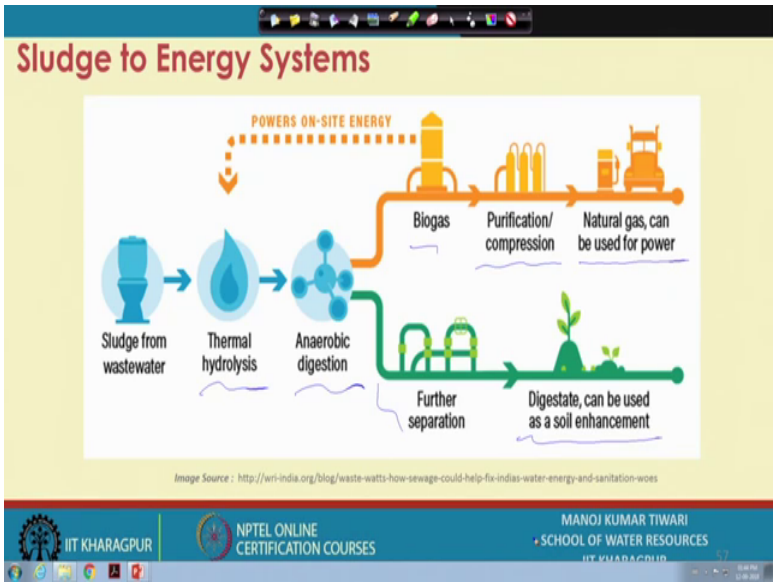


So, the investment in the European currencies are like this which is of course, high no need to way kind of discuss that that the cost of incineration is high, it is quite energy intensive process we are have to innovate the temperature of around say 900 or so. So then that is a approach for production of energy. So, if we see the sludge to energy system. So, the sludge that we get actually can be like through thermal hydrolysis, or anaerobic digestion. So, we can actually generate through anaerobic digestion we can generate biogas which kind of or after purification and compression can be taken care as a natural gas.

And then we get the kind of further separation and the digested solid can be used for the soil enhancement in the form of compost or that way. So, that is the anaerobic approach of generating energy and of course, the incineration approach already there. So, the heat energy which we generate out of incinerating this can actually be further converted to electric, or any other system whereas, the anaerobic digestion leads to the biogas generation in the form of energy.

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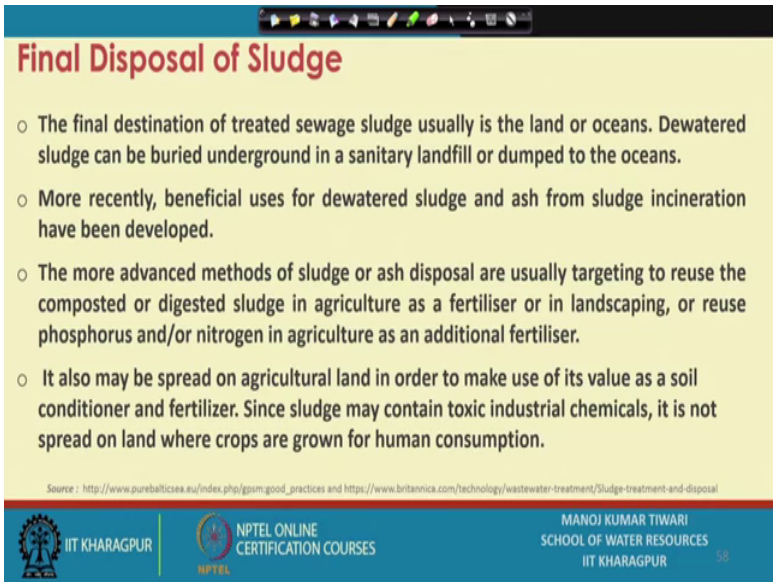


So, this brings us to the final disposal of sludge where the sludge is finally, disposed off. This final destination of the sewage sludge is usually the land, or the ocean the dewater sludge which we get can be buried underground in a sanitary landfills, or can be dumped to the ocean.

More recently, there has been lot of beneficial use of the dewatered sludge which has come actually and the ash from the sludge incineration can also be reused. So, as the reuse of fly ash or those kind of ashes are there, so same way the sludge incineration as can be used. It can be used as a kind of building material or those kind of thing possible uses are there.

The more advanced method of sludge and ash disposals are usually kind of targeting the reuse the like composted, or digested sludge in agricultural as a fertilizer. So, that is the most popular reuse option of the sludge particularly the digested and composted sludge. So, that can be used reused as a fertilizer in the agricultural applications or landscaping applications it can also be reused for like phosphorus, or nitrogen in agricultural as in kind of like additional fertilizers at times ok.

However, it for the using fertilizer we have to kind of spread it on agricultural land and make use of the value as a soil conditioner or fertilizers. But this spreading on the land comes with a risk also because the sludge may contain toxic industrial chemicals and then once we spread it on land and crop. So, that way so there might be like these toxic

chemicals find a route through which they can enter into the food grains, or the in the food chain of the human beings.

So, in order to avoid that it is kind of like this kind of sludge particularly coming out of the industrial chemicals industrial wastewater effluent treatment plants, where the possibility of toxic chemicals could be there. It is not used on the land where the crops are going growing being grown for human consumption.

So, for flowering, for horticulture for these kind of things it can still be used more. So, ever in the vicinity of the plant itself for gardening purpose or those kind of thing, but where the cropping is for producing food grains for human consumption it is generally avoided ok. So, that is the kind of final disposal of the sludge, so that way this sludge is managed

So, with this we conclude the discussions over here and thank you for being with us still this time. And in the next week we will then start discussing about the tertiary treatment, or advanced treatment options of the water which has come out of the secondary treatment, or typical biological treatment systems. So, then see you in the next week and.

Thank you for joining.