Integrated Waste Management for a Smart city
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Lecture 42
Landfill Disposal(Continued)

Ok, Welcome back so will continue from where we left so far if you have remember for the previous video, just before this one we were are looking at how to predict the leachate quantity and how to collect this leachate. So now once we have collected the leachate what are the basic design elements for leachate collection system we looked into that, now once you have collected the leachate I said that you have to treated and so we have to transport it as well so we talked about those aspect as well as we then carry on further.

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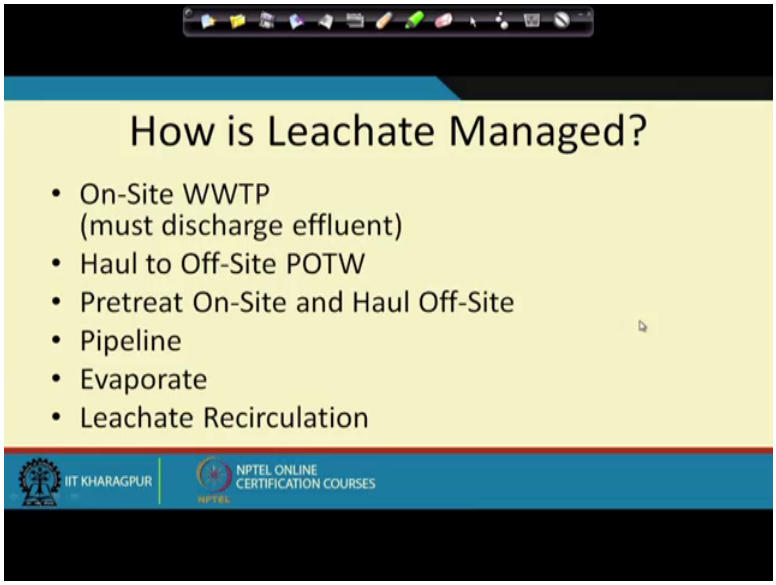

So in terms of leachate we have to treat this leachate, now how to do it? Many times there is a you have a onsite waste water treatment plant. You can have a let us say huge landfill it is a big landfill you produce enough quantity of leachate, so you may see that some of its landfill has on site waste water treatment plant.

So this treatment plant is used to treat the leachate and then the effluent is discharged to surface water and The efeffluent has to meet the effluent quality standard. so thats there the other thing is that if you can Haul it, you can Haul it to the publically owned treatment works so its POTW stands for publically owned treatment works basically it's a city level waste

water treatment plant or a regional waste water treatment plant and which is treating the sewage coming up from the city and from the municipal areas so it is like a typical sewage treatment plant. But you are mixing your leachate to it as well and then you make it for waste water like a leachate treatment plus sewage treatment plant.

And for this you can some cases for this or you may have to do some pre treatment on site because if you think about leachate it is a nasty thing its a sewage that you flush down the toilet is your mostly organic matter these days maybe some pharmaceuticals and other this going into there and we are not treating pharmaceuticals anywhere the sewage treatment plant but mostly organics and other stuffs is there and not much heavy metals and other things swap in a sewage.

Maybe in traces might be over there but if we think about the leachate with all the different types of waste being disposed into the landfill if the leachate quality will be much different than typical sewage so you may have to when you mix them together you may disturb their microbial population and sewage treatment plant you may have to do some sort of pretreatment often.

And then you mix it to waste water treatment plant so you may do some pretreatment on-site that is and then haul off-site at a publically owned treatment works. You can use pipeline to do that, You can also do some evaporation stuff in there and if there is a provision of doing a leachate circulation as well .Leachately circulation is essentially what it does it helps into waste degradation much faster

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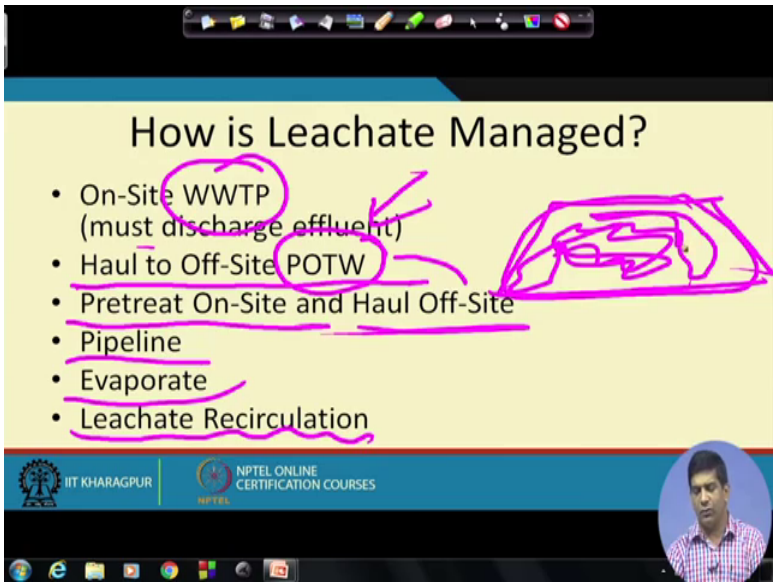

As we have talk earlier that when you have this waste in a dry troom condition because what is this landfill? Landfill is essentially a you can think about the offset at many times. This Landfill you can think about as a huge polyethene bag so this like a this is now a huge polythene bag here and you put this garbage you put lots of garbage in this polythene bag and does not and so part of it will be moisture will be moist part of it will be dry.

So that is dry pockets may not degrade that much because the microns does not like the dry area. So to make this dry pockets wet what you will come out with these leachate recirculation system while you start putting some of these leachate back into the systems. And that helps in the leachate treatment as well because leachate goes through the garbage, garbage acts as a filter and then over time it becomes more like a some of the heavy metals and other things will get filtered out Inside the landfill.

Ammonia gets build up in the leachate recirculation system in a (())(04:18) landfill, your leachate in terms of the leachate quality ammonia is one thing which really builds up but other than ammonia most of these things actually gets treated because of its leachate re circulation. And it also helps in terms of waste degradation and reduces the cost of leachate treatment at least for the first several years when you are doing the leachate recirculation.

You cannot do Leachate recirculation forever, at some point of time when the waste is degraded enough there is no more the quantity of gas production and is very low, that means

the waste doesn't have any more potential of biodegradation. You need to stop leachate recirculation and then leachate and then you have to collect those leachate volume and treat them. But those leachate is slightly matured leachate you be better to treat. You can use mostly bio like a different treatment and we will talk about that in a minute.

So in a leachate treatment method you can have aerobic, anaerobic treatment again if you have taken a waste water course same thing you talk about the waste water courses as well. You have activated sludge for process, these are the aerobic treatment.

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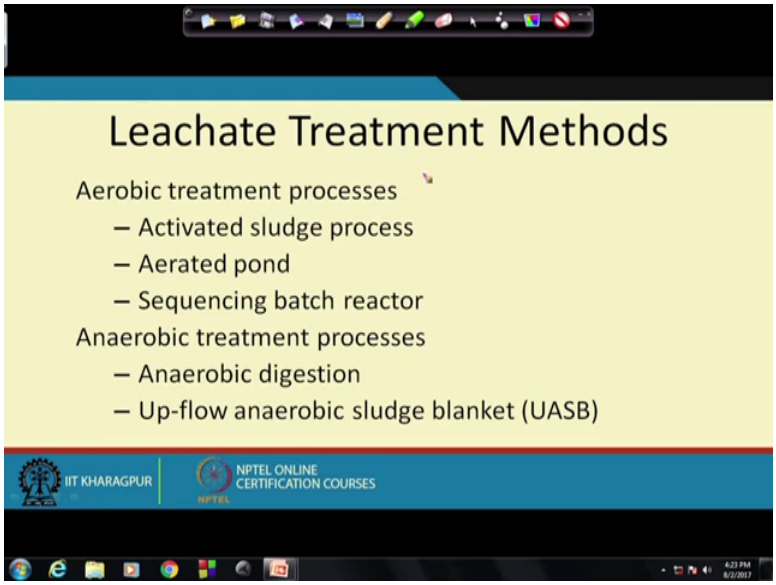

You have this activated sludge process as you can see over here. You have this activated sludge process, you have this activated sludge, Aereation pond, sequencing batch reactor.

So this is what you do for leachate like a waste water treatment as well. If you have anaerobic you can do anaerobic digestion or you can go for anaerobic digestion, you can go for up flow anaerobic sludge blanket which is the (UASB), up flow anaerobic sludge blanket is also used, so that is the UASB which can be used as well.

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And this is how the leachate looks like you can see this nasty colour leachate which is coming out from this from this landfill. So you see those here based on the level of the leachate in this tank. The pumps kick in and the pump will pump out this leachate to the leachate treatment system. So it will be piped to the next treatment unit.

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Lined leachate Lagoons are also used where you have this lined Leachate Lagoon and then you put the leachate in here and let it evaporate. And this evaporates and you have more

concentrated leachate to worry about now so moisture has all the moisture is so you have a concentrated leachate to deal with.

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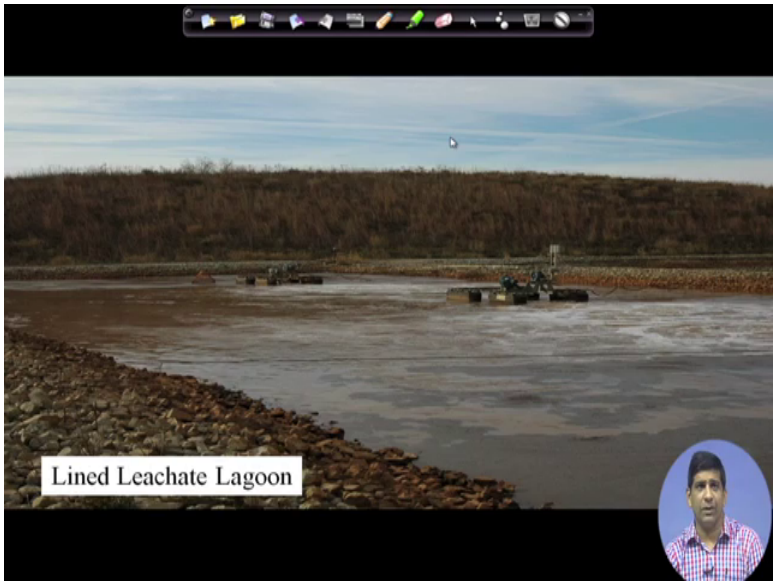

So another picture of lined leachate (()(06:57) there is a places where aeration is also done. So you aerate it this aeration breaks down the organic matter as well because the aerobic reaction will take place. So those things do as well.

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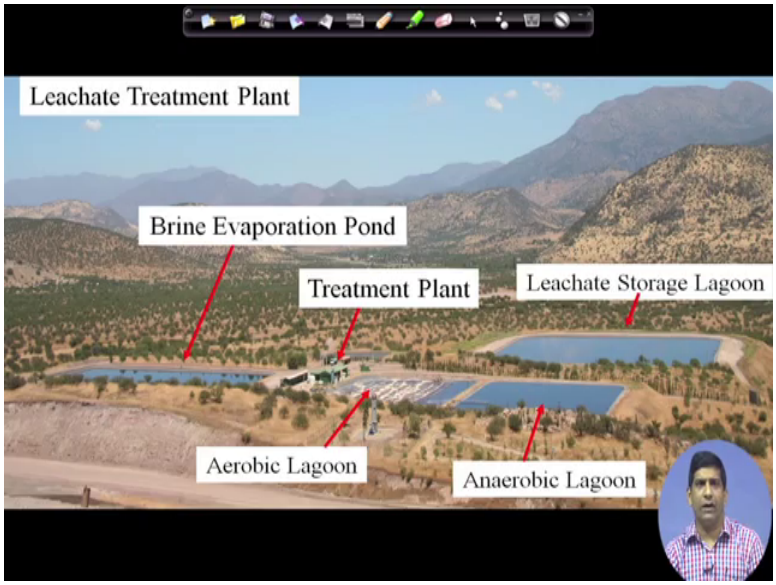

So here, another picture of a like a leachate treatment plant. This is in Chilli where I think showed you a particular like a transfer station where those cylose were there. If you have

remember from a very big for the very big name one of the videos in the collection system. Where we had those cylose taken off and put it on the railway and taking out to the landfill side. This particular leachate treatment plant is for the particular landfills in Chilli.

So you have this leachate brine evaporation pond. You have some treatment system going on both there is a leachate storage lagoon, Anaerobic treatment, Aerobic Lagoon, anaerobic means you just put it like that you are not doing any aeration in the aerobic you can see aeration going on, you can see lots of fog and lots of foams and another things that white white stuff that you see on this particular area, that is because of the air been circulated into the system.

So combination of a anaerobic and aerobic as we do for waste water treatment plant as well. Because some of these organic material they are easy to degraded anaerobic bacteria and some are easy to be degraded with aerobic group of bacteria.

So we use like anaerobic and aerobic combination to break down these organic matters. And this is and then you can also have some sort of like nano filtration, reverse osmosis. If you want to make it a very clean water you can also go upto reverse osmosis too. But its costly affair but people do that as well.

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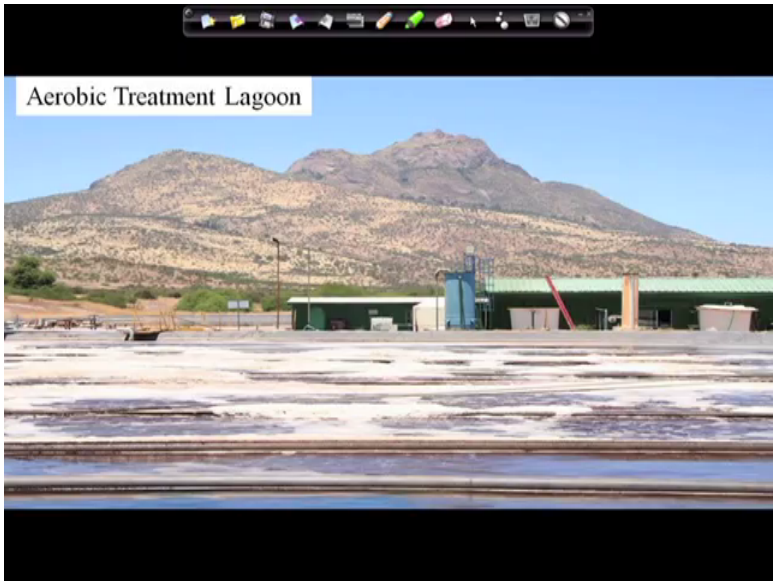

So here you see the aerobic treatment lagoon and one more close picture of that. And as you can see that close picture of aerobic treatment lagoon you see lots of because of the aerations you see all those white white white white forms because of the aeriation going on.

And so that is a used in many like very similar you will see in a waste water treatment plant as well.

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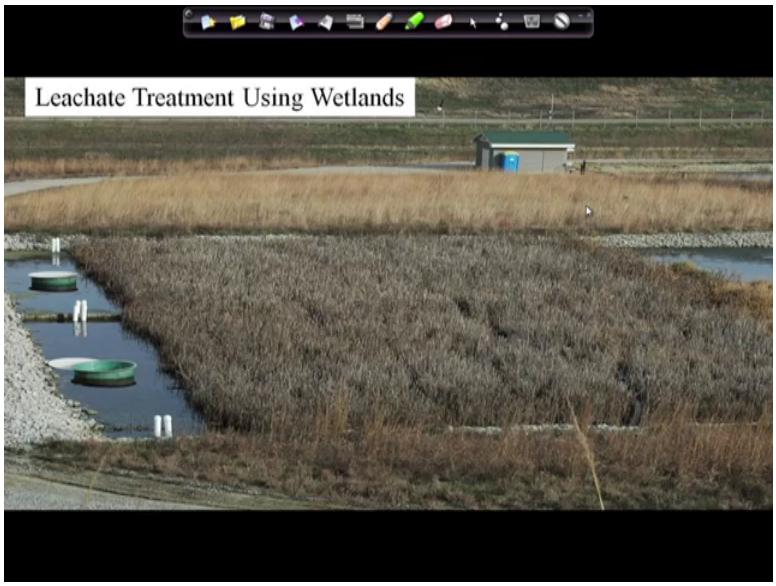

Then leachate is also treated using wet land. So you have the leachate passed through the wet land. So it acts as the wet land does treat leachate overtime. So say many times you can have a natural wet land or you can have a constructed wet land.

So use of constructed wet land for leachate treatment is very very popular. Its also use of constructed wet land for waste water treatment plant is also very popular but the problem with I would not say problem, that the requirement for these kind of system is that you require huge area in a place like India it may not be possible if because I do not know we may have some areas where we can use it for but like a wet land it does require lot of area, this constructed wet lands requires area but its a good treatment system as well where this treatment is done over time.

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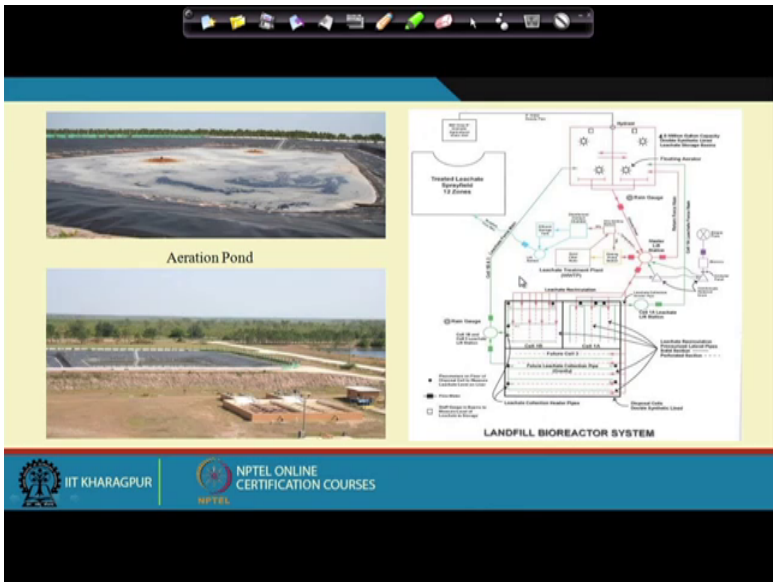

So then we have this we can have some aeration ponds or we can have some aeration ponds we can have other kind of systems here this the landfill of bioreactor system which is there is a leachate recirculation system. And from the leachate recirculation once the leachate is taken out. You don't have to worry to much about this sketch over here all though we provide you in the as part of the reading material. You can look at it I am sure you cannot see it very clearly from this particular video right now because of this small small boxes.

But essentially what they have is this a existing bio reactor lateral landfill. This is the sketch for landfill in Florida. This was a project that I worked on almost 10 years ago now. So where we had this leachate recirculation system as you can see over here they had this leachate recirculation going on. And from the leachate recirculation system after the always, as I said you cannot do the leachate recirculation for a long period of time.

So at some point of time, you will start or you can circulate he part of leachate but part of the leachate has to be treated. So they had a leachate treatment plant where it was essentially a mixture of a aeration pond and they had some anaerobic pond as well and then there was a aeration pond, so both anaerobic and aerobic.

And after that this was a sand filters system that you can see over here. That system was sand filter system, which is it passes through a sand filter essentially multimedia filter and then it use to treat the leachate. And then once we have this treated leachate is spread fill in different

zones. So you have this treated leachate which you spray fill around the landfill area. So this is thats one way of managing leachate as well but this is a small landfills, this is not a like big regional landfill.

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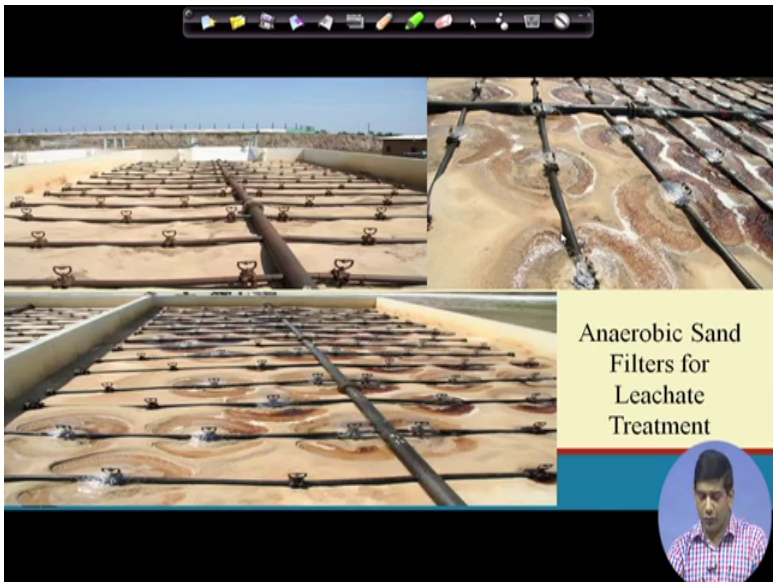

So you see a close picture of anaerobics sand filters for leachate treatment. So these are the anaerobics sand filters you see that its being aerated and at the same time it is passing through the sand filter and its moving some of this contaminates organic contaminants which is are present there.

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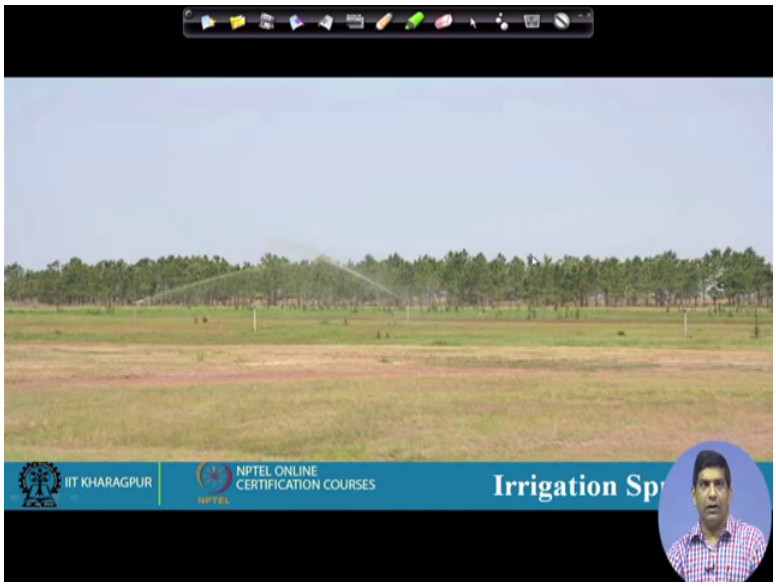

Ok, and then it is a spray as you guys can see it is sprayed around the landfill property. So that is the irrigation is done and along the landfill property for this leachate.

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Leachate storage tank this is how typical storage tank looks like many times it has a double layer so this is you see outer layer and then we have a inner layer just to prevent any leakage so even if the inner layer gets broken for some reason this outer layer will prevent the leachate from going out so those are used as well. Leachate recirculation is also done using this spray irrigation. So this is on top of the landfill as you can see the garbage is there and the leachate is spread directly on ground.

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As you can see over here the leachate is being spread around this system where this it is being used the spray irrigation for the for this to recirculate the leachate.

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So as you know the recirculation of the leachate the goal of this recirculation is to have a to have this we do this leachate recirculation because to increase the moisture content, the goal is to increase the moisture content as we have been we have talked earlier.

Why we want to increase moisture content because increasing the moisture content makes the life of microbes comfortable and then the microbes love that more moisture. And it helps in degredation of the garbage. So here you saw that the spray irrigation in the previous slide, this is how the leachate recirculation can be done on top of the landfill.

This is the another way where you have trenches been lead, so you have these trenches in the garbage, so this is a trenches in the garbage where we have laid this pipes, this pipes have actually perforations in there and then will pump the water leachate back into this system and then the water will actually go out from site and then it will try to distribute moisture in this area.

So we will have one pipe here the another pipe could be somewhere here another pipe could be somewhere here , another pipe could be somewhere here and then we had to actually calculate this spacing of these pipes and what should be the diameter of this pipe and those things will become part of the leachate recirculation system design. So those things for the leachate recirculation is also done using this what is known as this wizard known as horizontal trenches. And you can do it for vertical trenches as well.

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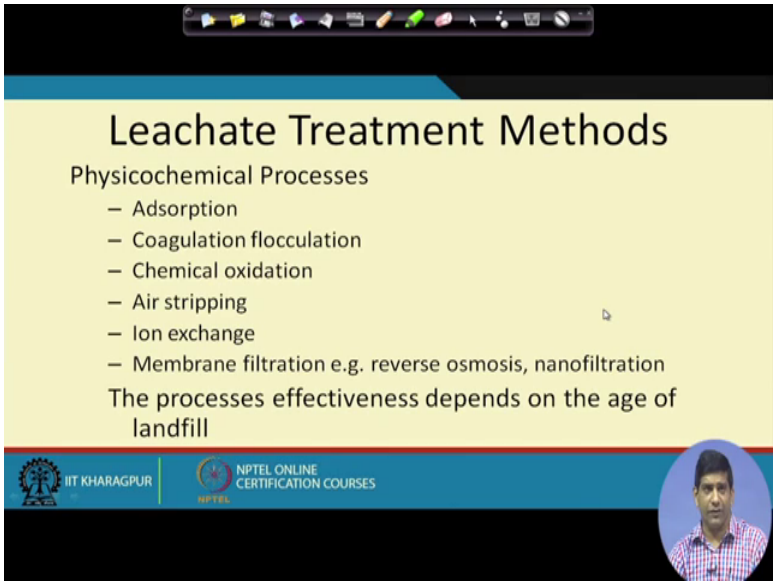

So in terms of the leachate treatment methods will not go too much into those leachate recirculation system because that is when we talk about bilateral landfill in detail that's where we cover those aspects. But if you look at coming back to our basic we had started talking in

this video that once we collect the leachate we have to treat it. So in terms of the treatment there we are different process which can be used, we can use physical chemical process.

So here are the some examples of physicochemical process you can use as absorption, coagulation flocculation and as you read these processes they seems to be very similar that you have seen in waste water treatment plant. So these processes are also most of these processes are also used for water treatment plant. As you know water treatment plant is mostly physical chemical usually there is no biological system in water treatment.

Waste water treatment has both physical chemical and biological process. In terms of the physical chemical you can have absorption you can have cogulation flocculation chemical oxidation, air stripping and exchange, memberane filteration like reverse osmosis, nano filtration ultra filtration, so those things are used. So the process which process will work it depends on the age of the landfill, why? Because of based on the age of the landfill the leachate quality changes as you saw earlier based on in the previous video based on the stages of decomposition, based on which stage are the landfill is the leachate quality changes.

Similarly based on the age of the landfill you have there will be different processes that you would like to use. So in terms of this different physical chemical process we have we will try to compare which one will work good for what?

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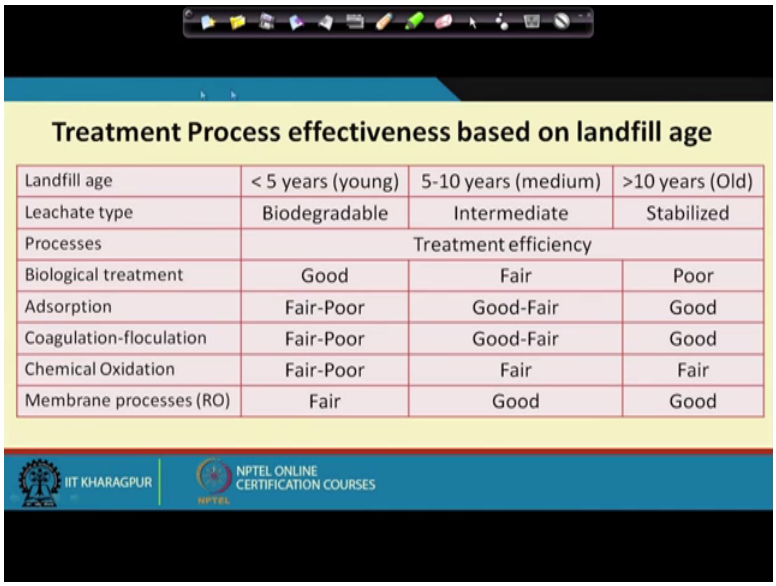

Landfill age	< 5 years (young)	5-10 years (medium)	>10 years (Old)
Leachate type	Biodegradable	Intermediate	Stabilized
Processes	Treatment efficiency		
Biological treatment	Good	Fair	Poor
Adsorption	Fair-Poor	Good-Fair	Good
Coagulation-floculation	Fair-Poor	Good-Fair	Good
Chemical Oxidation	Fair-Poor	Fair	Fair
Membrane processes (RO)	Fair	Good	Good

So in terms of the landfill age, so if you look at the treatment process effectiveness based on landfill age. Based on leachate type if it is less than 5 years we are mostly looking at it is a young leachate, we call it a young landfill less than 5 years is your young landfill. So it is for the most of these leachate when we talk about most of these leachate when we talk about this leachate many bio degradable component there, if it is 5 to 10 years it is called intermediate.

So again we have intermediate in terms of the biodegradable leachate type and more than 10 years it is a stabilize leachate. So less or biodegradable organics, so in terms of the treatment efficiency for different types in terms of the biological treatment since we have the biodegradable it is good.

And it is fair and then it is poor because we do not have much biological degredation left, so biological treatment is not going to work edge options since you have things building up initially you have the fair to poor then you have good to fair and this one is good because you have it is a matured stabilize landfill you can use the edge option to whatever some of these contaminants there it can absorb in those surfaces that is provided to us.

Coagulation flocculation again it is initially you do not have any of those like a colloidal particle in there but it starts building up and then it does build up chemical oxidation because it is mostly biological treatment if it is good for biological we do not have to use chemical oxidation but as you move as age the landfill ages it can gets better a membrane process initially you do not need membrane processes but as for the matured landfill you start using this membrane process as well.

So based on the age of the landfill based on the type of the leachate the treatment process effectiveness will change. But since we are talking about one landfill we cannot really change say if you start setting up this reverse osmosis in the beginning so you cannot what I am saying is you cannot you have to think about the leachate treatment system from the very beginning.

Yes you can add things as the landfill progresses as the landfill ages, we can add things to the leachate treatment system. So what it says that initially we may not have to go for this membrane process. Initially we can go for a biological treatment first and then as the landfill ages we can think about adding some more stuff because landfill will work for 30 35 years.

So these because of the different cells in the landfill there could be a cell which is already at this phase and there were at the same landfill site will have some cell which is at this phase. So we will have combination of all these different phases existing within this same landfill property. So we can have it as designed the system in such a way so that we can make use of all these different treatment technologies based on like cell one is being treated by biological treatment is being treated mostly by chemical oxidation and reverse osmosis and all those kind of stuff.

While the cell two which is the brand new cell which is a still young leachate we can use the biological treatment more for that. So we can use different combinations so that can be done in terms of the landfill like a treatment process.

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RO is used quite extensively these days especially if you want to make water to be really clean and that can be reused as portable water. So you can have a RO system is used for that.

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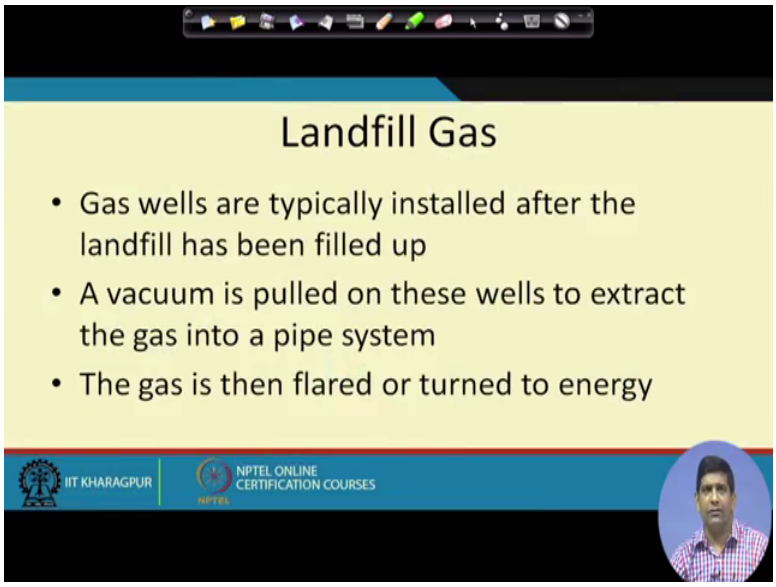

Then other thing is that we talked about the landfill leachate. Now the next big thing is landfill gas, so landfill gas is also a it is important parameter.

So as I said earlier in terms of the landfill design there are lot of things that we need to worry about we need to worry about the liner we need to worry about the leachate collection system we need to worry about the leachate treatment system, storm water management system, ground water management system and but one of the important component is also landfill gas management system.

Because landfill will produce gas ultimately what is the goal of this environmental protection is to make sure the environmental like we should have less impact on environment. So this landfill gas the methane gas which is released during the anaerobic decomposition of waste it is a green house gas. So we have to collect this landfill gas which is predominantly methane and CO 2 and then treat this gas and make or if in if we cannot do anything with that we can flare the gas to convert everything to CO 2 to make it less harmful.

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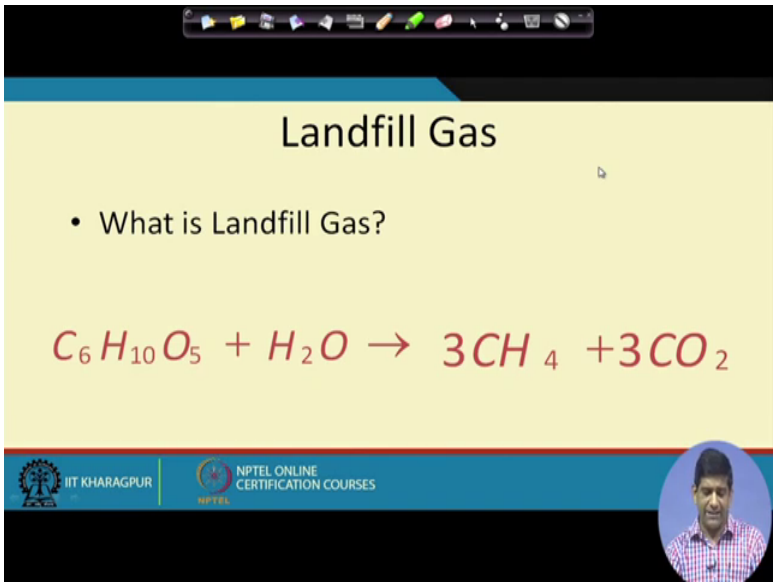

So in terms of the landfill gas we use gas wells are typically used you install gas wells to once the landfill has been filled up and the vacuum is pulled on these wells you apply vacuum to extract gas into the pipe system. The gas can be flared if you do not have the waste energy or it can be turned into an energy. So it will be very nice to have a gas to energy system where if you produce an f gas.

So again when I am saying if your landfill produces enough gas that means that gas quantity has to be significant there will always a economy of a scale we talked about it earlier in the thermal treatment too, there has to be a economy of the scale there should be sufficient gas.

So that is why the concept of this regional Landfill are coming up because we are trying to go for a bigger bigger Landfill. And we use that for a that. So in terms of the landfill gas you have waste degrades. So we have essentially methane and CO 2 that is being produced so those are the landfill gas that is produced from from the degradation of waste.

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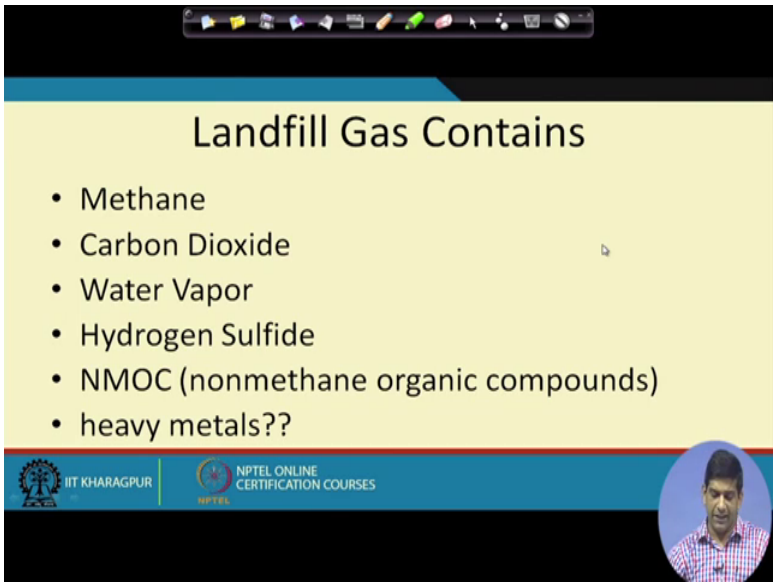

And there are other things in the air too we have methane and CO 2 those are the two major ones and but there are some water vapour there is some hydrogen sulphide which creates a smell because methane does not have any smell.

NMOC is non methane organic compounds of their, there could be potential of some heavy metals so especially if you think of arsenic and mercury you can see them where you can arsenic is in a very reducing environment arsenic goes to Ash 3 which is an arsain gas and which is garlic kind of a smell gas and that you can see over there.

Mercury is a sulphate reducing bacteria condition, mercury have a tendency to convert to methyl mercury and then methyl mercury can goes into it is a volatile, so it can go into the gaseous form. But there are some other gases in here especially sulphur based gases, the sulphur based gases is the one which causes lot of smell. One gas which is called Mercaptan which is the most nasty one which smells a lot.

So those are like a those are the ones which are of concern in terms of the landfill gas. So why bother with the landfill gas the smell we talked about is a toxic hydrogen sulphide as you know it is a toxic gas it is a green house gas it is explosive gas all those things are because we have to bother. So those are the reason why we need to bother with these landfill gas. And then it is a potential energy so landfill gas is a potential energy source it can be used for energy generation so that is important as well.

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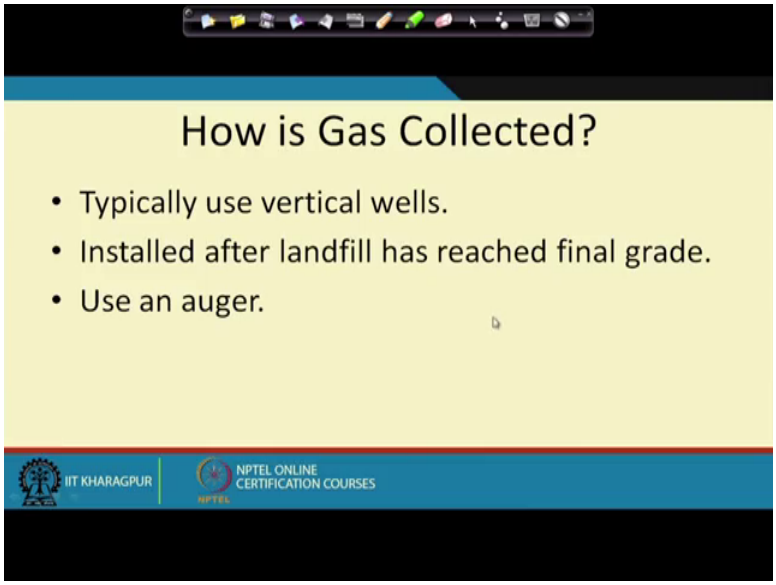

So how is the gas collected? We typically use vertical well to collect the gas, so you will have the vertical wells and we apply vacuum so we install the soft the landfill has reached a certain weight of to have reached the height and then you will use a Augr to drill the hole which also you know.

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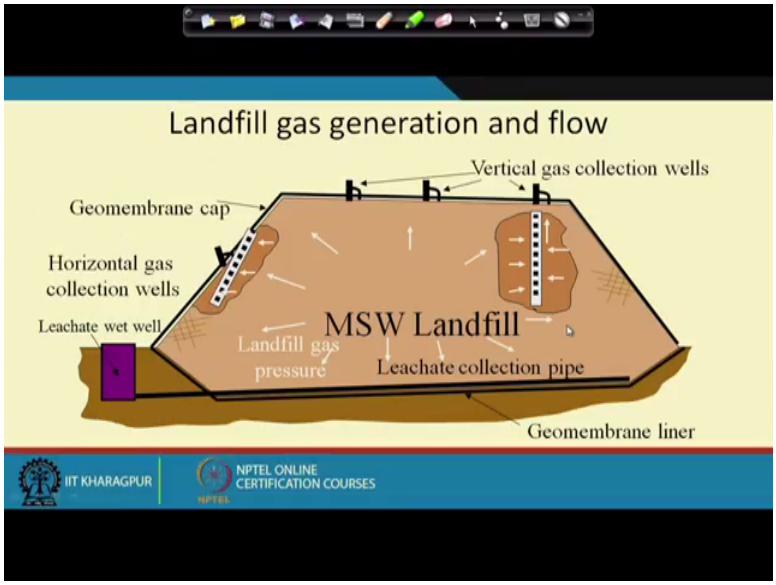

So this is a typical landfill cross section so you have these vertical gas wells. So this is your vertical gas wells similarly you have the other wells and we are looking at the cross sections so we will have several wells on top of the landfill. So that is your that is a typical like gas fill

how it looks like we have used an Augr to drill a hole and this has a some drainage material it could be crushed glass crushed chips or like a trus tyres or anything which can go there and then you have this landfill gas pipe which is the perforated pipe.

And so what we do is we apply vacuum we are applying vacuum, vacuum is pulling the gas all the gas is moving in in here so it is actually going into the system getting into this pipes and then it comes up. And this is your head you can have a header pipe in there which will collect to all these gas pipes and then the gas will go into the header pipe will be taken to the either flare station or landfill gas energy place.

So gas you will have several wells here there is a well here you will also have a well on the side slope and then we can also even in the leachate wet well sometimes we can have the gas there. So leachate it also does make way to the leachate collection pipe. So landfill gas actually try to move wherever it can find the least pressure. So as you know the gas travels the path of least resistance. So wherever it can find least resistance it will try to move into that particular area. So these are the called horizontal gas collection well this on the inclined side and these are the called the vertical gas collection wells.

So that is and we do not want to go too deep here because if we do not want to put a pinch in the liner. So we want to do not go too deep at crystal deep enough for a good collection of gas . So wells the wells could be a passive wells which is well open to atmosphere usually that used to be happen in a smaller landfill where you just put some well up there so that the gas can escape because we have to let the gas escape otherwise the methane may catch fire and then the whole landfill will be on fire.

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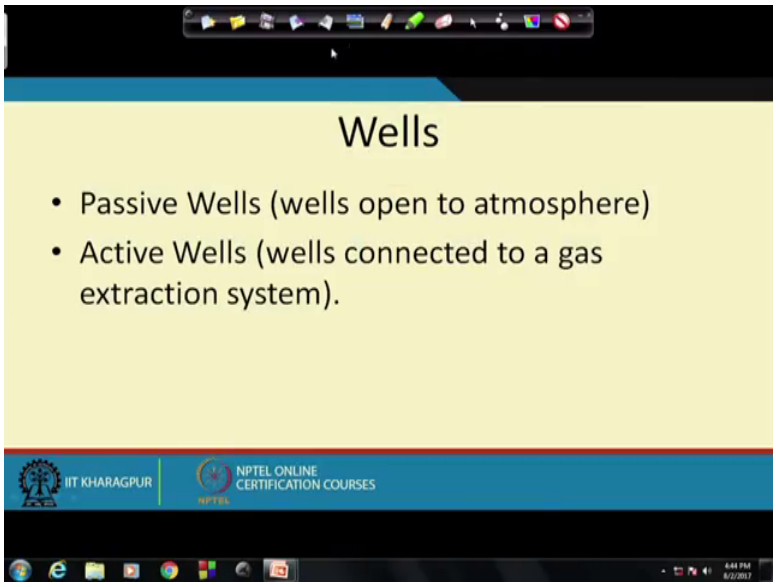

So but this is the first just an escape you are losing all the gas you are not really collecting the gas you are not treating the gas you are not using the gas for any purposes but that is kind of the thing of the past. You do not see passive wells in big landfills today so what you see is actually active wells which is connected to a gas attractions. So it is a gas attraction system we are using and so the active wells are used for that.

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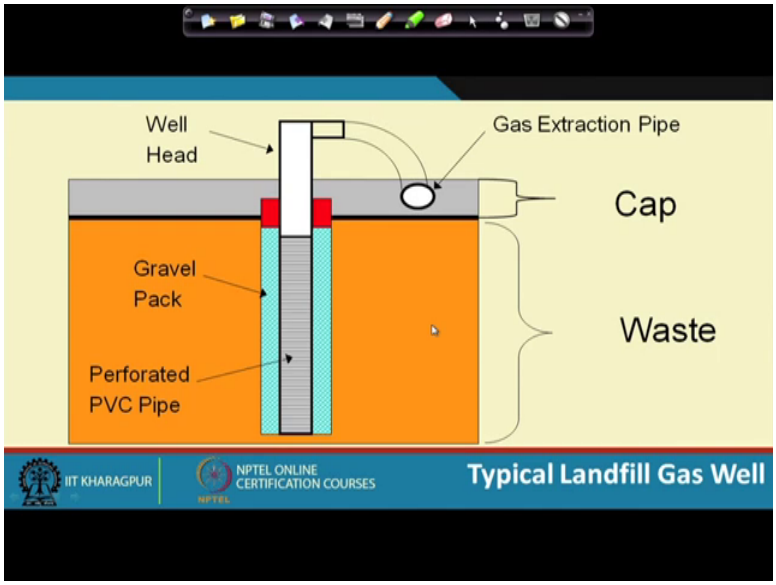

So this is another sketch for the so this is your like a gravel pack sorry we can use the gravel pack or you can use something other like a wood chips and those things as well but that is

your gravel pack in here. And then in the middle you have perforations and you have this pipe upto this point. And then here you put some seal, so these are the seals using mentonant clay or something like that.

So that when you apply vacuum you are not actually sucking from the outside as well. So you put a seal in here, so that the most of whatever is the gas will try to go from this side. And then you have a perforated PVC pipe that is on well head you have a gas extraction pipe its connected to the main header pipe and that takes it to for this one main header pipe and that will take it for like a to the flare station or for landfill gas to energy system.

So what is the graving force for the gas it is the pressure without any well what will happen the gas will try to find the surface or the bottom so if you do not provide any well the gas will just try to travel and go to wherever the path of least resistance and it ultimately may reach the top or if its towards the bottom layer of the waste it will try to go into the bottom into the leachate collection system.

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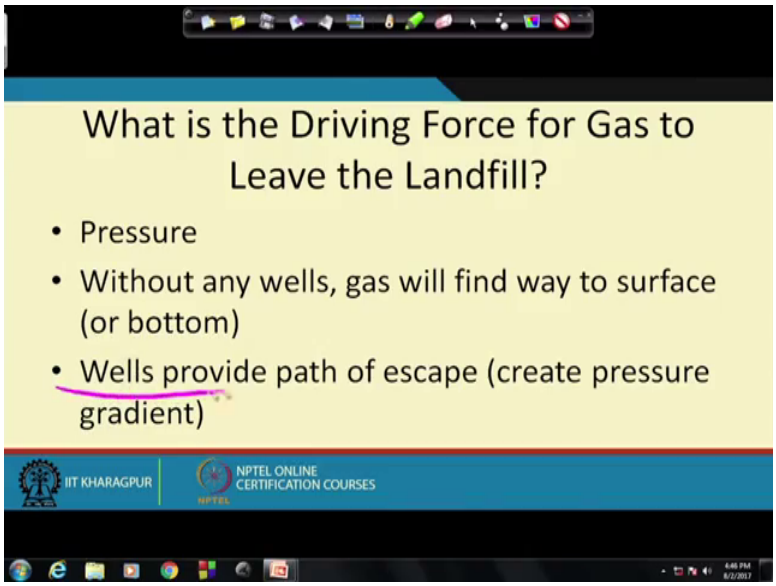

So what does the well does wells actually these gas wells provide the path of escape they create a pressure gradient so the gas travels in that particular path and gets collected. Gas collection system actually its a since most of the landfill are so huge so gas collection system efficiency is a bit low we do loose lot of gas those are called fugitive emissions. So when sometimes we have like around 65 to 70 percent gas collection is considered a very good gas

collection system because there is lot of fugitive emissions happening from this from the landfill slides.

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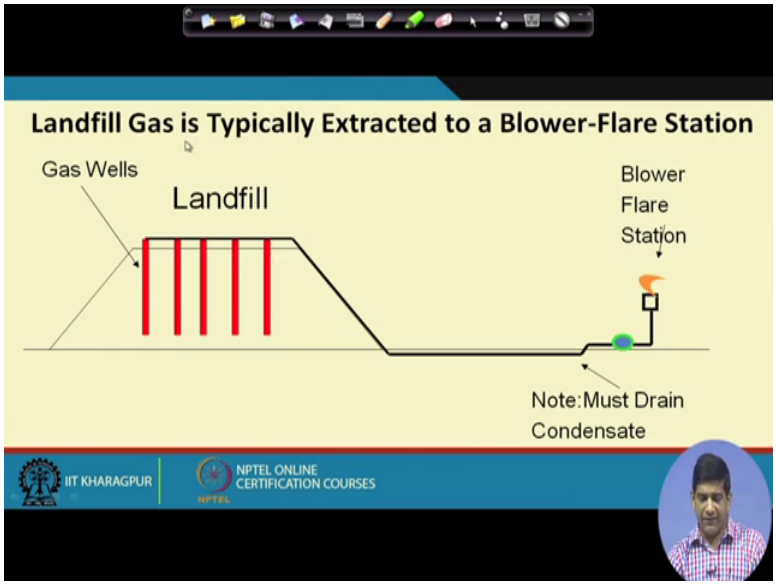

So what is the landfill gas its typically attracted to a blower or flare station these are your landfill so these are your gas wells as you saw earlier. So if these are the gas wells and then it all gets connected to the header pipe, the header pipe is taking it to the flare station before it gets flare station since this gas is little bit moist little bit warm when it comes out in the ambient temperature it tries to cool down. So you will have condensation happening.

So as part of the condensation you will have what is known as condensate. So this condensate since this water very low pH we need to remove this condensate before it goes to the blower flare station. So taht is one of the important aspect of Landfill gas collection system as well because we tend to forget that there has to be a condensate remover.

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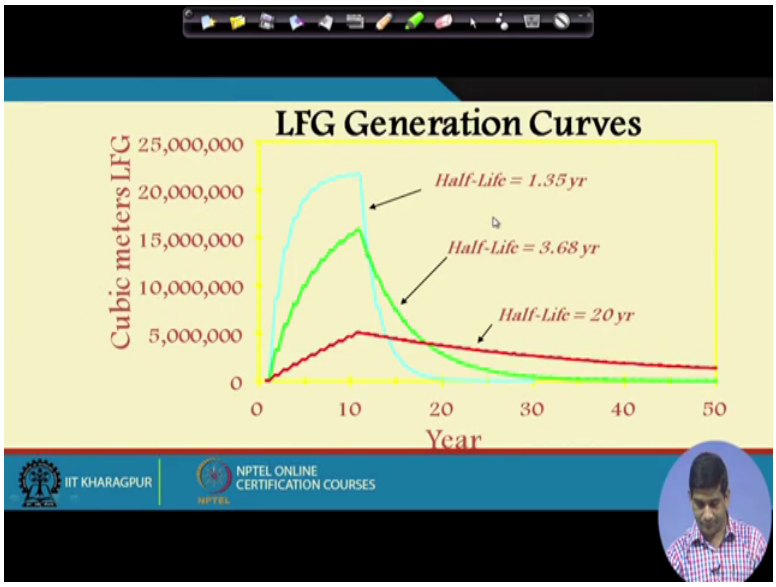

So in terms of landfill gas generation how the landfill gas will be generated over time if it is a dry tume landfill the waste is not have any recirculation going the moisture movement is not very good inside the landfill the gas production will be over a very long period of time.

So as you can see on this sketch over here we have presented three scenarios which has a half one is with a half life of 20 years and then 3.68 in 1.35 years. 20 years means it is a kind of dry tume kind of situation it will say half life as you probably assume that you know what is a half life. Say if you start with 100 kg of certain biodegradable waste after how much years it will be 50 kg.

So how much time it will require to degrade 50 percent so that is the half life. So half life of 20 years means if it is 100 kg of just biodegradable fraction organic waste it will take 20 years to degrade to upto 50 kg. And then another 20 years to come down to 25 kg and then 12.5 kg and then 12.5 kg. So it will take long time to degrade.

So if we can some how change the degredation if we can make the waste degrade faster using it as a bioreactor landfill with a reducing to half life to 3.68 years to 1.35 years we see that the gas production happens over a smaller period of time. Here for all these three sketches whether it is this one or this one or this one if you do the area under the curve is what gives you the total gas as it is being produced and it should be the same.

So if you have a certain mass of garbage if you have say 1 kg of garbage and it is the same garbage and then it is being degraded in a dry tume over 20 years or more over another system and a leachate recirculation kind of where you have half life of 3.68 or another half life of 1.35 years. So since what these numbers tell me the rate of reaction. The smaller the half life quicker is the rate of reaction. But the amount of garbage sorry the amount of gas that particular waste and produces the same.

So if you take the area under the curve for these three graphs if the area under the curve will be the same it is the total amount of gas that would be produced in that landfill. It is only the time period changes like how you make half life smaller and smaller like more and more faster and faster degredation happening there.

So when the condensate is the moisture that condense from the landfill gas when it cools down we already talked about that. So then it has to go to flare the station or to a landfill gas to energy. So with that let us kind of conclude this particular video where we can we talked about essentially about some of the leachate training techniques and we also looked into the landfill gas . from the basics of landfill gas collection system works we talked about that.

The we talked little bit more in detail about the bioreactor landfill we spent some time in the next video on bioreactor and we talked about some other aspect. So with that let us close this video I hope that you are enjoying the this course the videos and if you have any question feel free to put it on the discussion board we are trying to keep up with that we are trying to answering those discussion board very quickly.

Atleast within 24 hours that is our goal. So let us keep that active and that is the only place that is the where we communicate. We are that is we are communicating mostly through the discussion board we are not into any whatsapp group or other things in there.

So Ok so that is it and see you again in the next video.