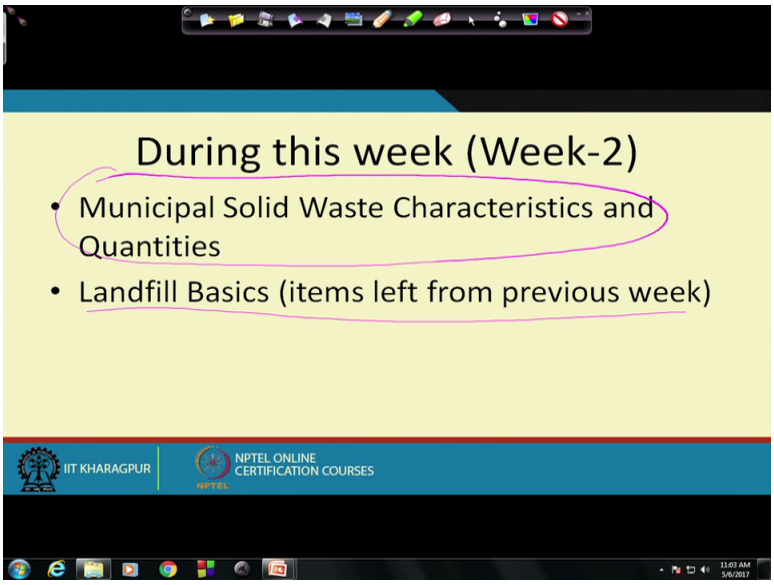
Course on Integrated Waste Management for a Smart City
Professor Brajesh Kumar Dubey
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Module-02 Lecture-06
Introduction

Okay. So welcome back. So this, now we will start the week 2 of this course. And in the first week, we had gone over kind of the big overview of waste management system, what are the different components, we talked about recycling, composting, waste-to-energy. And we did start talking about landfill. Part of that landfill discussion has been left. So in this week, we will try to do two things.

(Refer Slide Time: 00:48)



First, we will go over these landfill basics which is as mentioned over here, the second bullet we will go over the landfill basics first which is left from the previous week. We did started that but we did not get a chance to finish it. And then we will do the big, municipal solid waste characteristics and quantities. That is, say whenever you start designing anything, first of all, you need to know what you are designing it for and what are its properties are there.

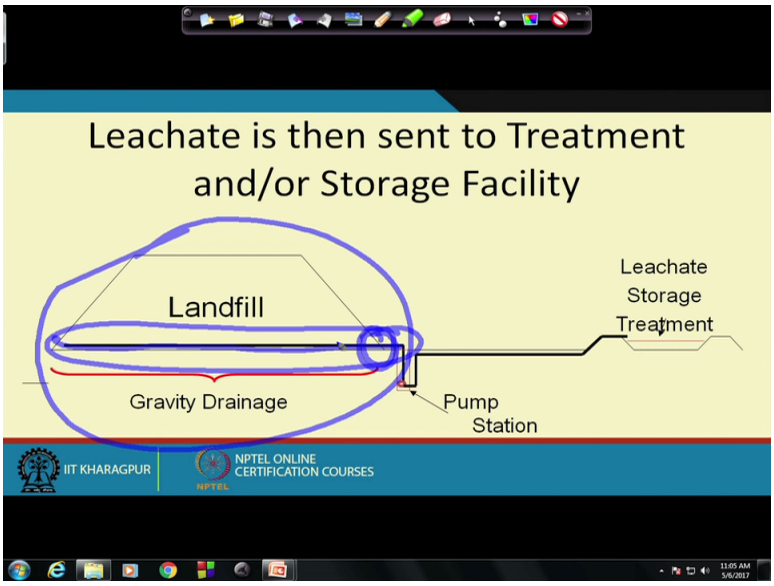
So we will look at the quantity of waste, how much waste is out there, how we find out how much waste is out there. Say for example, if you take city of Kolkata and in Kolkata we want to know how much waste is being produced. So how to, how we get those numbers? You may have

seen as a solid waste management reports or in a book chapter somewhere that you see several pie charts.

Those pie charts telling you in terms of in the waste this much paper, this much plastic, this much organic, this much inorganic and all those kind of stuff. So but how those pie charts are developed? So we will talk about that. And we will also talk about what is, how the waste is defined as in terms of regulation, what is a hazardous waste, what is a non-hazardous waste. So we will have those kind of discussion.

So to get started, let us look at the landfill basics part first which we have been trying to do like a in the previous week. So last module, so let us get started on the landfill basics.

(Refer Slide Time: 02:31)



And as you can see here, so we were looking at, if you remember from the previous module, we were looking at that different liner system, the leachate will be produced. So once the leachate is produced, they have to be collected and we talked about the leachate collection system.

So kind of that is where we left in the previous module. So once the leachate is collected, it has to be treated. So in this sketch, starting from this sketch, this is, what we are looking at is actually a cross-section of a landfill. And in terms of the cross-section of the landfill, this portion is giving you the landfill cross-section. So you are just kind of looking at landfill from the front. And this, that pipe over here is our the header pipe.

So all those different pipes we are talking about which I showed you earlier, the those pipes connect to this header pipe and then it comes out. And if, we will talk about this more in when we go to the landfill chapter. So do not worry too much about, so you can trust me on some of the stuff, we will explain it more over there. So what you are looking at is a landfill cross-section and you are looking at a header pipe right here. So that is the header pipe and it is coming out of the landfill. So there is only one hole in the landfill right over there.

So that is because remember we have a liner system. We do not want too much holes in the liner system, otherwise the water will tend to go into the landfill from that particular hole, so we want to avoid that. So we have just one hole here through the liner to take the pipe out. Then we take it to a pump station and that is your pump station right there. You take it to the pump station and from the pump station, you can pump it to the leachate storage and treatment. That is how the leachate is managed.

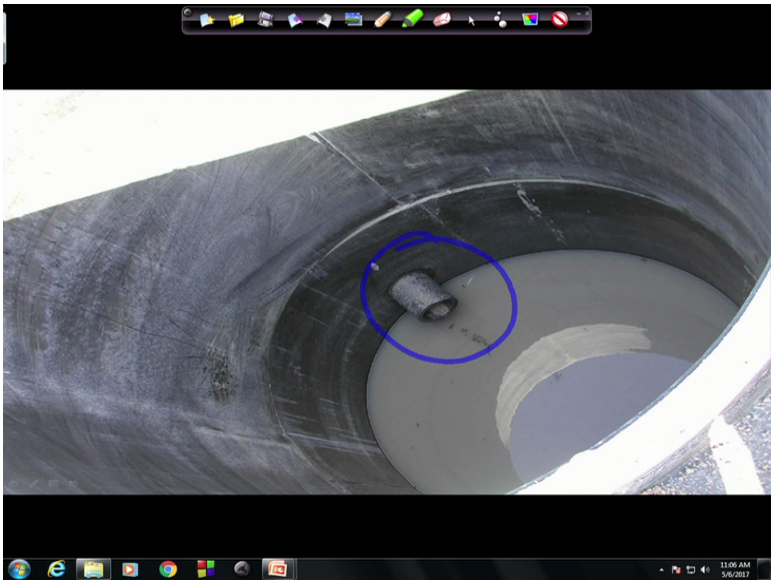
(Refer Slide Time: 04:19)

(Refer Slide Time: 04:22)

In terms of the leachate, what is a leachate? Leachate is essentially a industrial waste water and we will talk about that. So leachate, these are some pictures. Let us look at some of the pictures. These are the where the pumps, so this pump station that you are looking at over here is what you see in this particular picture right over here.

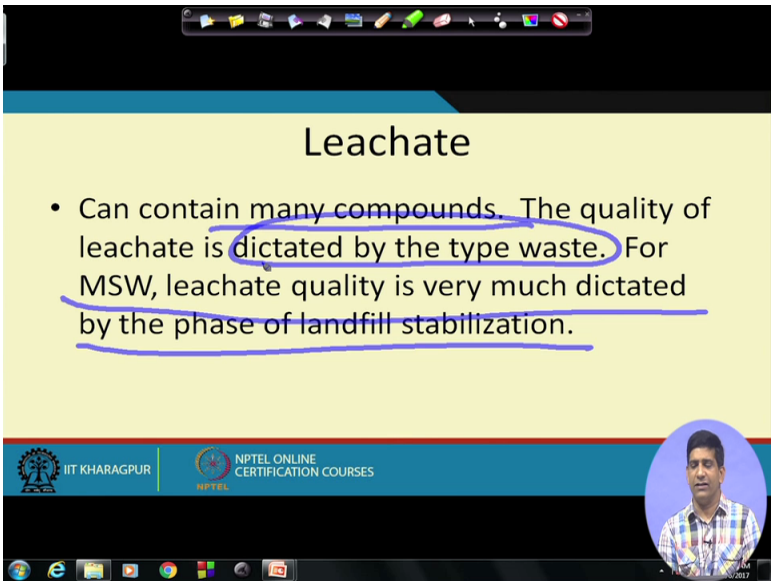
So these are our pumps over, these are the, those are the wells, those are the wells that you were looking at on that particular, in the particular sketch. So these, so our leachate is getting transferred outside the landfill coming into these wells. We also call them leachate wells.

(Refer Slide Time: 04:56)



And as you can see and this is how it looks like. This is the leachate pipe coming in. This is the pipe which is coming in from the landfill and it is getting into this leachate slump. And we will put a pump in here and then that will pump the leachate out and then the leachate will be taken out for treatment and disposal.

(Refer Slide Time: 05:23)



So what is leachate? Leachate is, it is essentially, it is industrial waste water. So it is very similar to any waste water that is produced from an industry. Now as where the leachate is coming from? How the leachate is produced? So those are the questions which should naturally come to your

mind. So when the waste degrades, one of the byproduct of the waste degradation is the moisture. The garbage has some inherent moisture as well.

So just think about food waste. Food waste that you throw away, there is lot of moisture there, there is lot of water there. So this water is what makes the leachate. And what are the other components? When it rains, so you have your landfill, working phase of the landfill, I showed you some pictures of the landfill. So where the garbage is being decomposed, the garbage is being disposed, that area is exposed to rain. Because whenever it will rain, the rain water will percolate through that and then it will come in our leachate collection system too.

So the rain water going through the garbage, garbage some moisture which is there in the garbage to start with and when the waste degrades when especially, when we say degrades, it is mostly the organics. And organics, any chemical formula of organics you look at, it has the carbon, hydrogen, oxygen and all those different atoms present there. The hydrogen and oxygen atom when they get together in the form of H2O, it is water.

So one of the byproduct of the organics degradation is also moisture. So all these things together is what is produce the leachate. But when the leachate, when this water, leachate is essentially a water and depending on the age of the landfill if it is a very new landfill, the leachate is, the color of the leachate is very similar to a black coffee color. It is a next time when you take, next time when you drink a black coffee, you will think about me because like because it is a black coffee color is what is the typical leachate color, very fresh landfill leachate.

But when the landfill have aged, when we say aged, it means when the waste has been degraded where waste is disposed and after few years, after say five years, ten years, gradually the color of this leachate moves from coffee color, black coffee color to apple juice color. Just to kind of give you some example and apple juice as you know, it is like a very light in color comparatively. So that is how the leachate color changes. And what, how this color comes?

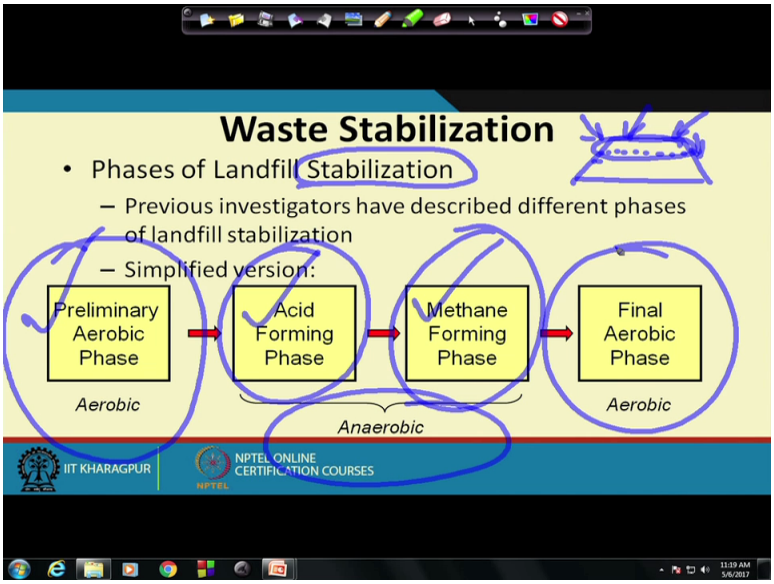
It depends on what kind of compounds are present in there. So initially since it is a waste will degrade, there will be lot of organics which will get, whatever can dissolve into this water will be there in the leachate because what will not dissolve, will not be there in the leachate. That is very simple, is not it? Water is percolating through, the water that we call, we are calling the leachate, it is percolating through the garbage layers. Whatever has a tendency to dissolve in water will

dissolve into this and it will come into the leachate collection system and it will be taken out of the landfill.

So it can contain many compounds as listed over here. It can have many compounds. And these compounds it depends on what type of garbage has been disposed there. Because depending on what is, say if you are disposing lot of industrial waste in the landfill which has lot of heavy metals and other things present there, so that is that means lot of heavy metals may show up in the leachate.

But if there is no heavy metal, it is just organics, just mostly stuff from municipalities, from your houses, your and my houses. It is, there will be some metals because metals are everywhere these days but the quantity of metal in the leachate will be very, very low. So depending on what goes into the landfill, the leachate quality will vary. So that is what we say that for MSW leachate, the leachate quality is very much dictated by what is the type of waste that is disposed there. And the other thing is that what is the phase of landfill stabilization and we will talk about phase of landfill stabilization. It is, that basically tells us that what is the age of the landfill and in few slides from now and we will go over that in detail.

(Refer Slide Time: 09:32)



So here it is. So in terms of waste stabilization, it is the phases of landfill stabilization. Now we have to be, there are certain terms here. Stabilization, what does the stabilization really means? Stabilization actually means that when the waste is degrading. So you start with 1 kilogram of

garbage, you we have put it in a landfill. The (land) waste land, the microorganisms have started working on it, it is a food for microorganisms, so they will start degrading it. So once they degrade it, the quantity, there would be mass of the solid or semi-solid is getting converted to liquid and gas. And gradually your and since it is getting converted to liquid and gas, liquid is going in the leachate collection system, gas is going out in the gas collection system.

So the mass of the waste decreases over time. So there will come a point where whatever the mass of the solid getting converted to liquid or gas has stabilized. That means after this point, there is no further degradation of the garbage. So that is called the stabilized form. So now the waste has stabilized, no more degradation.

And other way of why it is the term stabilized is used is because when the waste degrades, now you have a, if you think about, if you, this is the, if you look at the landfill like a sketch that we had just earlier, when the waste starts degrading, that is you will have your top liner coming down. Why? Because that will, whatever the gas escaping, water is escaping, mass is coming down, so the volume of garbage inside the landfill is coming down. So your waste will start, the level of waste will start going down.

At some point of time, you will have no more decrease in the level of garbage. And that is called a stabilized. So there is no more further settlement and that is the other term we use from a geotechnical perspective. If you are a civil engineer, you understand what I am talking about that in a civil engineering, in the soil mechanics for that we use a term settlement or for the foundation and other design, we use the term settlement.

So here also many times you will see the term being used ‘landfill settlement’. So that settlement is when the waste is, has degraded enough like a, and now that is kind of final settlement. So landfill, as we do monitor settlement of the top of the landfill and then when there is, we see there is no further settlement, that means the garbage has stabilized. So in terms of that is the stabilization.

When we talk about these phases of landfill stabilization, it goes through certain phase and that is where it, these boxes tries to explain that. So how we come to these boxes? There were lot of research has been done. There is one, he is no more now but he is (con), the person was considered the father of bioreactor landfill. Or even you can think about one of the pioneers in

terms of engineered landfill as we know of them today. And that was Professor Frederic Poland, he was in Georgia Tech.

And Frederic Poland and I was lucky to have met him, so he is kind of, you can think about that he is like a father of engineered landfill. And he has done lot of work in this area. So this, what you are looking at in terms of these boxes essentially coming from the research done by Professor Poland over (many) few decades, so here is the simplified version.

So in terms of the landfill stabilization, the first phase is the preliminary aerobic phase. Now when we say preliminary aerobic phase, what does that mean? Initially as you saw some of the sketches of the landfill, some of the pictures of the landfill as well, we have the liner at the bottom and we are putting the garbage in, it is exposed to air. Since it is exposed to air, you will have the aerobic going on. There is air, it can go into the garbage, so things are aerobic.

So aerobic bacteria will be active, there will be, waste degradation will start happening. But once you have a kind of reached the level, when we say reached the level, reached the height of the landfill and which is the permissible height based on regulation and there is a limit to what height you can go, then you put the top cover on top. We put the top cover. Once you put the top cover, no more oxygen getting into the landfill.

So no more oxygen getting into the landfill, that means what? Your, because oxygen is needed for the aerobic degradation, degradation of the garbage but once that oxygen is used up, no more oxygen going in, so things will start developing as a anaerobic system because there is a lack of oxygen, that is what anaerobic means. So that is what we are talking about here is the anaerobic system. Now after we put the cover, we go to the anaerobic system.

So this anaerobic system is being, it is kind of divided into two form. First, you see is the acid forming phase, that is your acid forming phase. Then we have a methane forming phase and we will explain that what it is. Acid forming phase, if you think about our food waste, one of deadly degradable garbage is, most of the easily degradable garbage is food waste or something which is similar to food waste.

These waste are high molecular weight organic compounds. So once they go into the degradation phase, these high molecular organic compounds starts getting converted to low molecular weight

organic compounds. The bacteria will act on it and they will convert into low molecular weight organic compounds. And then further from the low molecular weight organic compounds, it will go to finally to what very simple form of acid and that acid is acetic acid, it is same as vinegar which probably you use in your kitchen as well.

It might be, you may have a bottle in your fridge, that vinegar is acetic acid. And as you know as you, as soon as you open the cap of vinegar, you get a lot of smell. So that is why in the landfill leachate have that smell, there is lot of other smells there too but you can feel vinegar smell there as well. So that acid is acetic acid which is the some simplest form of acid. And other than acetic acid, we have butyric acid, propionic acid and other forms of, and all these together we call them VFA.

You will hear a term VFA, Volatile Fatty Acid. What is the name, volatile means what? Volatile means something which can go to the air quickly. So if it is go to the air quickly, that is how we can smell. If it does not come into the air phase, we cannot smell it, is not it? So that is the acid forming phase and finally it will go to the acetic acid. So this is done by group of bacteria which is called acidogenic bacteria. Acido, a-c-i-d-o, there is a acidogenic bacteria, they produce this VFA, volatile fatty acids and ultimately to acetic acid which is the simplest form of acid.

Now once these acids are formed, then we have a another set of bacteria which starts acting on it which is known as methanogenic bacteria, methanogenic bacteria. As the name suggest, methanogenic means what? They will generate methane. So this methanogenic bacteria will produce methane. To produce methane, they need a substrate, they need something which they will work on and that substrate is acetic acid which has already being formed by this acidogenic bacteria.

So once this acidogenic bacteria has formed this acetic acid, methanogenic bacteria will start producing methane and that is what is known as the methane forming phase. So that is your methane forming phase, methane gas will be produced. And then you can use that methane gas for either a you can to electricity or heat or whatever and we can talk about, we will talk about that as well. So that is the typical landfill phases.

And once the waste has degraded as I was talking to you earlier in this particular sketch that I drew on this corner, that once the waste degraded, now we will have some sort of void space on

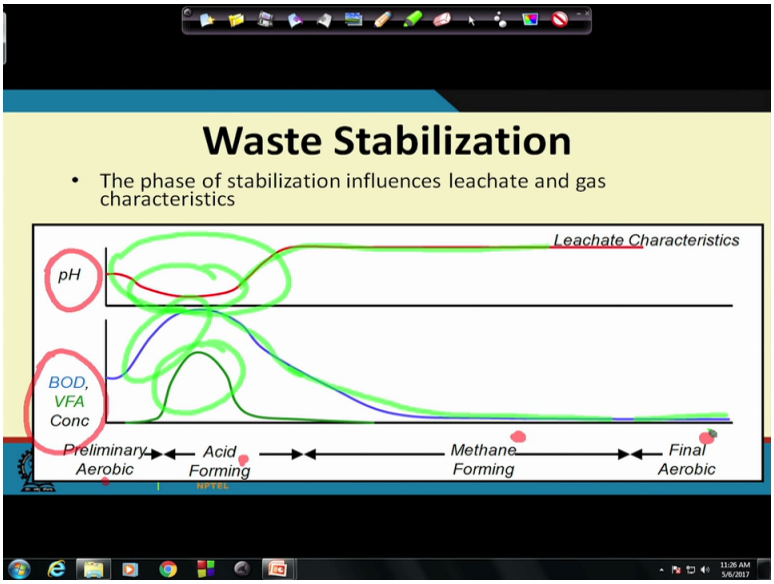
top here because the landfill has settled down. So this, in these void spaces, there is a tendency of air to try to intrude and once the air intrudes into the system, you will have another aerobic phase coming in. So that is your final aerobic phase.

And that is where things may change. As you know if you are a, I am pretty sure you have done some chemistry if you are taking this course, so as from your chemistry, you know that once things move from aerobic to anaerobic and vice versa, the chemistry of many of the compounds or metals do change. For example, if you think about lead, lead sulfide, lead hydroxide, they are not soluble. They are, they try to be in a solid form. Their solubility limit is very low.

The Ksp as you know the solubility product is very low. So they exceed their solubility product. What happens if something exceed the solubility product? It will precipitate down. So it will precipitate down, it will stay inside the landfill. But when it goes to this final aerobic phase, if the air gets intruded, is getting into the system, things will, the sulfide will become sulfate, the hydroxide will become oxide. So once you have the lead hydroxide getting converted to lead oxide or lead sulfide getting converted lead sulfate, this lead sulfate and lead oxide they are soluble.

So then you will start seeing them in the leachate. So those things does happen. So we need to, so these phases does have very very importance in terms of the leachate management or as well as the gas management which we will be talking about in next couple of slides where we will try to go. So I hope you understood this waste stabilization. If you have not, kind of replay the video and see it again and again and then again if you are confused, send us a question on discussion forum because this is a very important concept in terms of landfill both as well leachate management as well as the gas management.

(Refer Slide Time: 19:27)



So once based on this waste stabilization phase, let us look at how the leachate quality will change. And here we are looking at only few parameters. We are not looking at a lot of parameters, we are just seeing few of the parameters here. And we are looking at pH, we are looking at the pH, we are looking at BOD, VFA and BOD and VFA. BOD as you probably must know, BOD is the biochemical oxygen demand. VFA as I mentioned to you just earlier, volatile fatty acids and pH, we all know that pH is basically details you how much acidic is the system is. Remember from the previous diagram that we looked at, we had this preliminary aerobic phase which has been mentioned at the bottom here, acid forming phase, methane forming phase and final aerobic phase.

So these are the four phases we looked at. So preliminary aerobic phase, since we start producing as from, let us look at, let us follow leachate first, sorry, pH first. And these are all for leachate, these are the leachate characteristics. Initially, since the acids are being formed, remember we talked about that the organics will start degrading high molecular organic acid to the small molecular organic acids, high molecular organic compound to the small molecular organic compound and finally to lot of like acids being formed.

As the acids being formed, that means what? Acid means there will be H plus+ ion there, is not it? So H plus+ ion means low pH, acidic pH is less than 7. So more H plus+ ion, lower the pH. So that is why you start seeing a dip in pH over here. As you can see there is a dip in pH because

of the acids being formed. So there is a dip in pH and then once the pH has like the acids are being converted to methane, you start seeing pH going up and then it stabilizes, has a stabilized form and it is typical pH of a landfill leachate, is around 6.5 to 8.5, so it is around that range.

That is the reason why it looks like that. So we should have a, again I think I have, may have told you earlier as well, for each of this discussion that we are having, you try to understand, do not try to memorize. If you try to memorize, you will forget. But you try to understand why the pH curve is like this, why this BOD curve is like this and then it is, it becomes easier on you to kind of understand and use this language, use this information later on. I think I have explained it enough. So once the pH like because of the acid being formed, we have a low pH and then once methane is being formed, you have high pH being shown, higher pH shows up over there and then it is kind of stabilizes around that pH which is around 6.5 to 8.5.

Now coming to the lower part of this sketch, BOD which is the blue curve and then we have VFA which is like a dark green one. So BOD as you can see again initially it starts and kind of goes up. Why it goes up? What is BOD? Biochemical oxygen demand. And demand is coming from where? The demand is coming up because of the organics presence. Initially since it is big molecular weight organic compounds, although the bacteria may be present and the organic compound is also present but they cannot really interact with each other.

Because of the big molecular organic compounds, this bacteria cannot there, they cannot eat that. It is too big for them. So once they started some of, they start, I am talking about the bacteria which kind of creates this BOD demand, so once this big molecular organic weight is being kind of broken down into smaller molecular organic one compound, now this, there is a demand for oxygen there because of they want to convert this to ultimately like a they want to oxidize this organic matter.

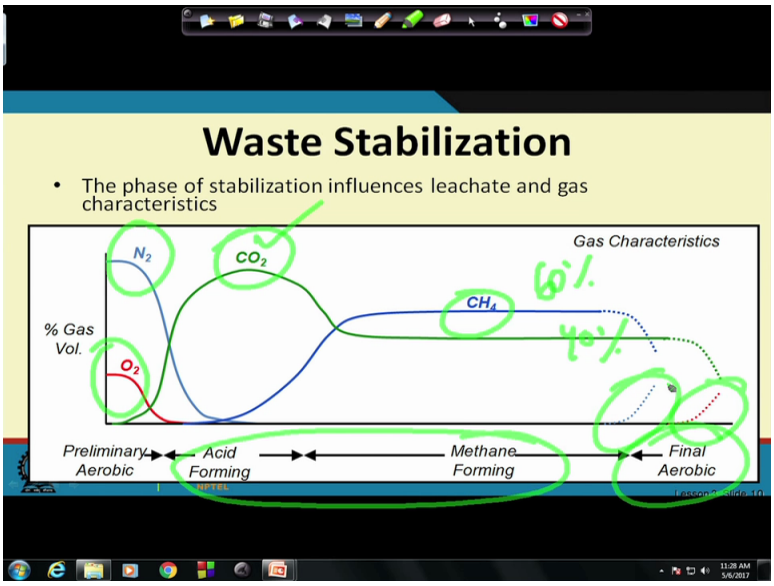
When they want to oxidize this organic matter, when I say they, I am talking about the microorganisms, so this is, there is oxygen requirement, so oxygen requirement means BOD requirement. So that is why you see when I revise, as this is smaller molecular weight compounds are being formed, you start seeing there is a increase in the BOD number. And once it kind of reaches a level and then as the smaller organic compound already started degrading, your BOD number kind of goes down and ultimately you will see the BOD going to almost

closer to zero. It will never be 100 like a 00 but it will be very closer to having an illegible demand.

That explains why BOD curve is like that. And then and the VFA, volatile fatty acid as I told you earlier, this, it kind of fertile fatty acid will kind of follow the pH, acids are being formed which creates like a drop in pH. So similarly here, since acids are being formed, drop in pH or VFA will go up once because the acids are there, is not it?

So volatile fatty acids, they are creating, they are increasing the concentration of acids there. So that is why VFA is going up. And then after the acids are being converted to methane, you are, you see the numbers going down as well. That is kind of explains why like this, they behave this way. And it is very important for you to understand this stuff, it will help you for understanding of this, how the leachate quality will change.

(Refer Slide Time: 26:38)



Now if you look at the gas, we already looked at leachate, now let us look at the gas, what will happen to the gas because these are the two important components of in terms of the environmental control. We have one is the leachate collection system, other is the gas collection system. So if you look at the gas part, as the gas, as you can see initially it is aerobic phase. So you have some oxygen present, some nitrogen present because of the organics like aerobic phase.

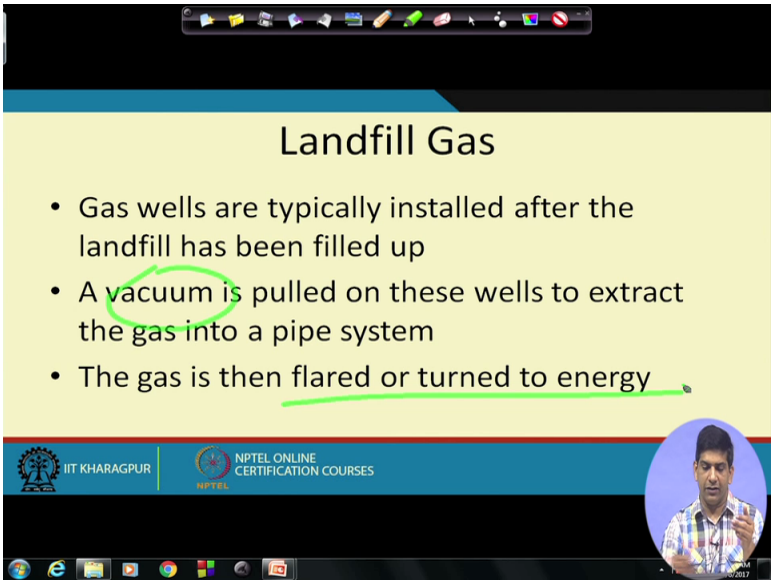
Once it starts going into the anaerobic phase, these two were anaerobic, remember acid forming and methane forming were anaerobic phase. So now anaerobic phase, what happens when the waste degrades in anaerobic phase, both methane as well as CO2 is formed. If you look at the anaerobic degradation of garbage, in the aerobic system only CO2 is formed. In anaerobic, both methane as well as CO2 is formed.

So you see, because initially you see more CO2 because it is an aerobic phase. Then as the anaerobic system takes over, you see the methane starts picking up and CO2 goes down. And then we have around (60), this is, methane is around 60 percent. That, around 60 percent methane and 40 percent CO2, that is what we see typically for in a landfill gas and then it will stabilize. Finally if it gets into the final aerobic phase, since the oxygen is being added to it, so methane will get started getting into, convert into CO2.

But percentage-wise, nitrogen will start picking up, oxygen will start picking up, that is what you see over here. And these are all shown as dotted because we do not have any data right now to prove that. We have to kind of look at some of this landfill gas data to prove whether that really happens or not. That is why it is in a dotted or in the dot dot dot, not a firm line. So this is how typically the gas composition will change over time.

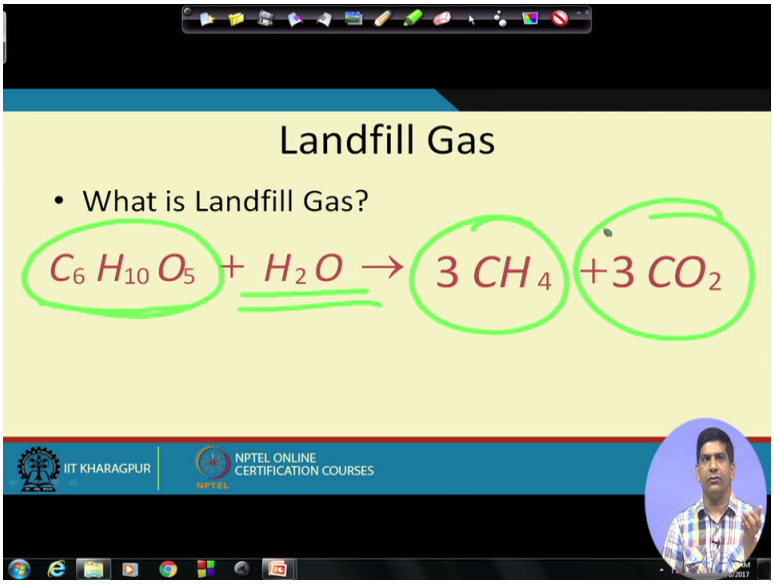
And when we talk about this preliminary aerobic, this is around maybe once initially as long as the landfill is not closed. Once the landfill is closed, it will go into this acid forming and methane forming phase. Even when the landfill is not closed, the lower layer of the garbage may still start going into acid forming or methane forming phase. So because of there is an good amount of insulation on top and that lower area will start behaving like a anaerobic system. That is kind of explains to you the how that landfill gas and the leachate will change.

(Refer Slide Time: 27:30)



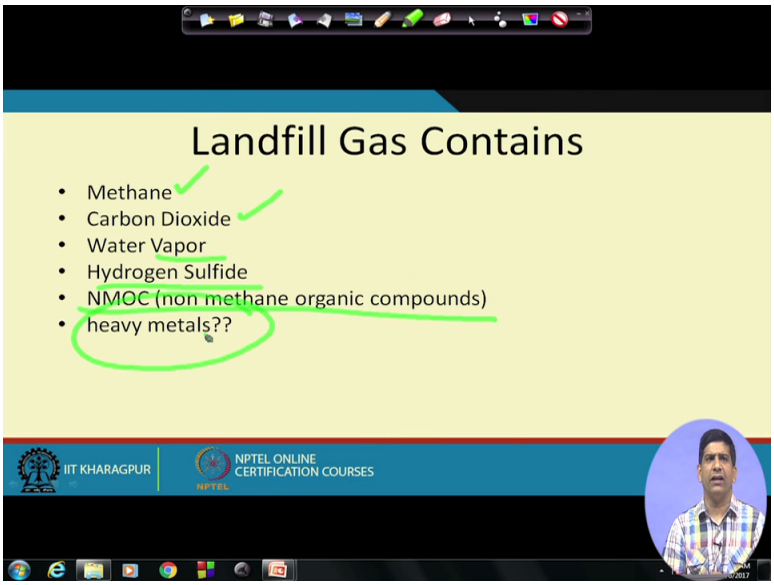
So in terms of the landfill gas, what is the gas? Gas wells, how we collect this landfill gas? We looked at how we collect leachate. So in terms of how we collect landfill gas, gas wells are typically installed after the landfill has been filled up. We have been doing gas wells and we use a vacuum. A vacuum is used to pull up the gas, so a vacuum is used to get the gas out and the gas is then either flared or turned into energy. So either of those two is done in terms of the gas collection system.

(Refer Slide Time: 28:18)



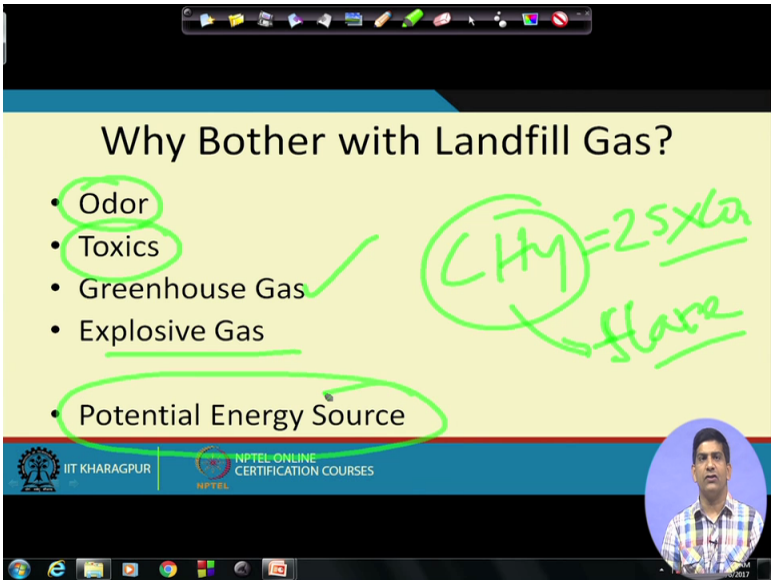
What is the landfill gas? We already talked about that. You have this, this is your organic matter, this is the typical very simple organic matter. And in the landfill water is present, so it will react with water and then it gives you methane and CO2. Kind of those are the two which is produced in a landfill gas and this is an anaerobic system. In aerobic system, we will have oxygen being supplied and we will see only CO2 coming out of that.

(Refer Slide Time: 28:30)



So what are the things there in the landfill gas? We have methane, we have methane being present, we have CO2 which we talked about that. There could be some water vapor, there are some hydrogen sulfide which will create some smell. And then there are some NMOCs, non-methane organic compounds and there could be some heavy metals. So with a question mark there, that could be there, may not be there. Some heavy metals which can potentially volatilize at a low temperature may show up but most of the time you will not see any heavy metals showing up in the landfill gas.

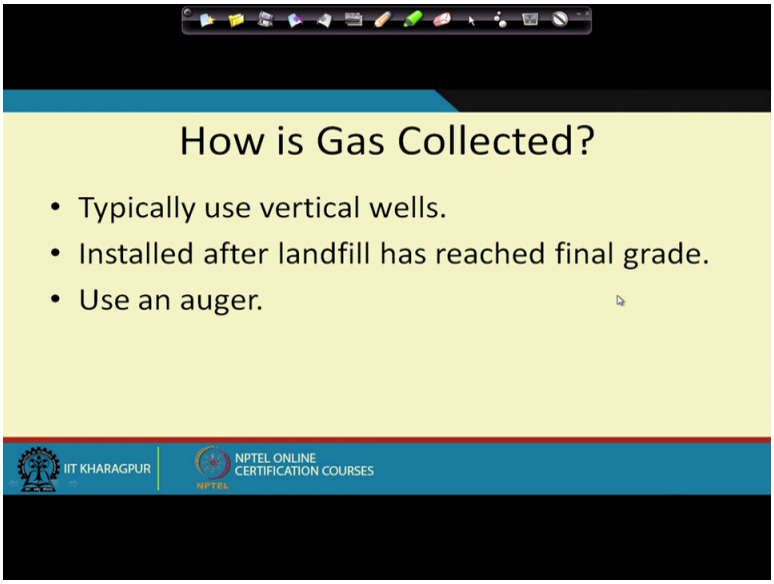
(Refer Slide Time: 28:59)



But why bother about landfill gas? The reason we have to bother about landfill gas because it is a, there is a smell issue, things are toxic. We talked about H2S gas, it is a toxic gas, it is a greenhouse gas. Greenhouse gas, obviously we talk lot about climate change, global warming and all that, it is a greenhouse. Methane is actually 25 times more potent than CO2.

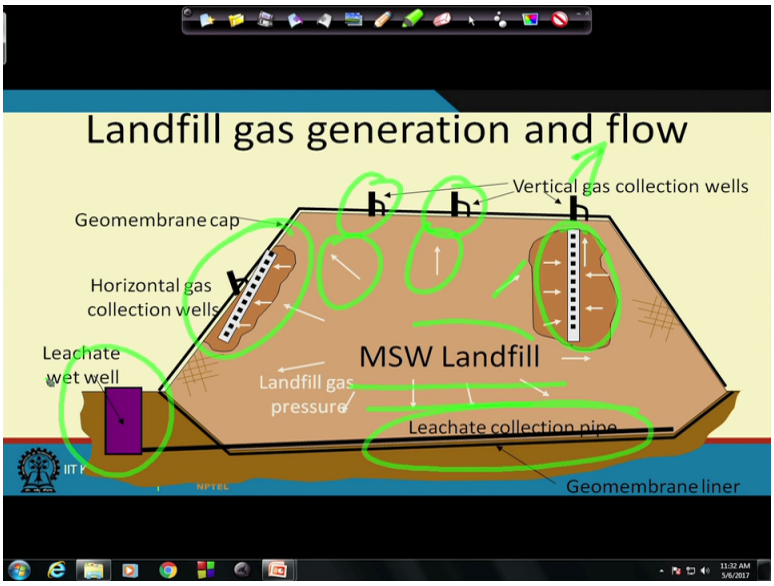
So that is why we have to either use methane as a energy source or we can, we flare this methane. When we do flaring, what we are trying to do is we are, when we do the flare, what we do is we are converting this methane to CO2. And that way, we reduces the impact in terms of greenhouse gas. It is, some of them could be explosive gas and it can be used as a potential energy source. So why not just use it as an energy source rather than letting it go waste. So that is the reason why we have to kind of think about landfill gas.

(Refer Slide Time: 29:58)



How is gas collected? We use vertical wells and we install after landfill has reached the final grade. We can use an auger to do that.

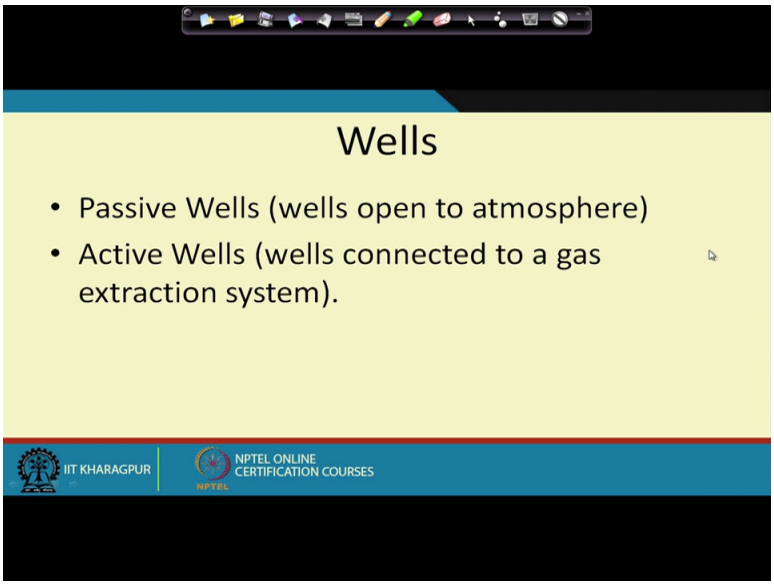
(Refer Slide Time: 30:04)



So this is a typical landfill gas generation where you have, we have to blend MSW landfill and that is the like our MSW landfill with the gas will start traveling in all these direction. You see these arrows where the gas will start traveling around. So we have provided a landfill gas collection system here where the gas can, this is basically we are providing a path of least resistance and vacuum is applied from here. So once the vacuum is applied, the gas will get

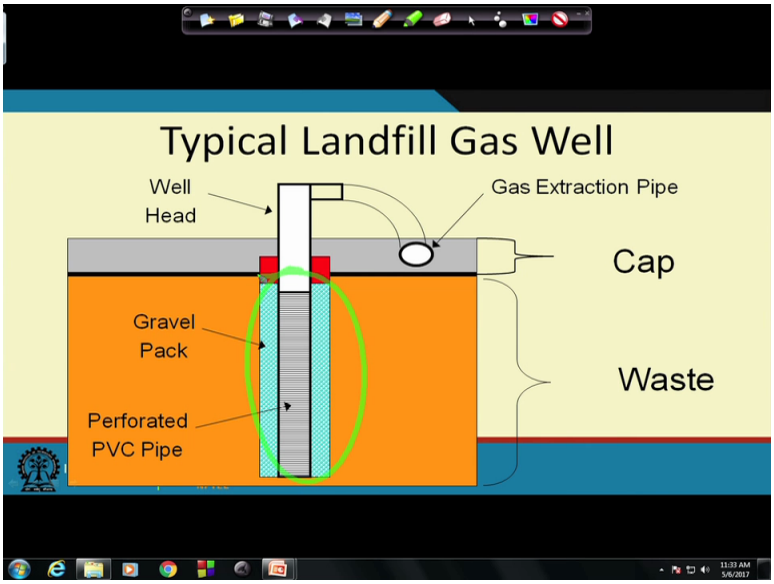
collected through these wells. These are the, there will be several wells like that on top of the landfill. There could be some wells even on the side of the landfill. Even some gas which go, makes way to the leachate collection system is also collected from this leachate wet well which you saw in the beginning of the module. So all these is how the landfill gas is collected from different systems. And that is used to like either for energy or for flaring system.

(Refer Slide Time: 30:57)



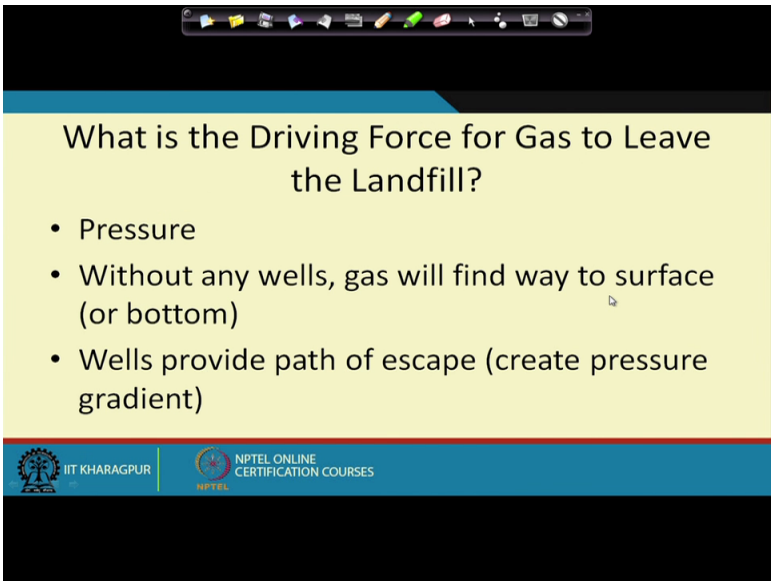
So wells, there could be passive well, there could be active well. Passive well is the well open to the atmosphere, you are not really doing a collection, you are not applying a vacuum. But that is not common any more, that used to happen for a small dump sites but now in engineered landfill system, you will have an active well which will be connected to the gas extraction system. Again, we will come back and spend more time on the landfill gas and landfill leachate both side.

(Refer Slide Time: 31:18)



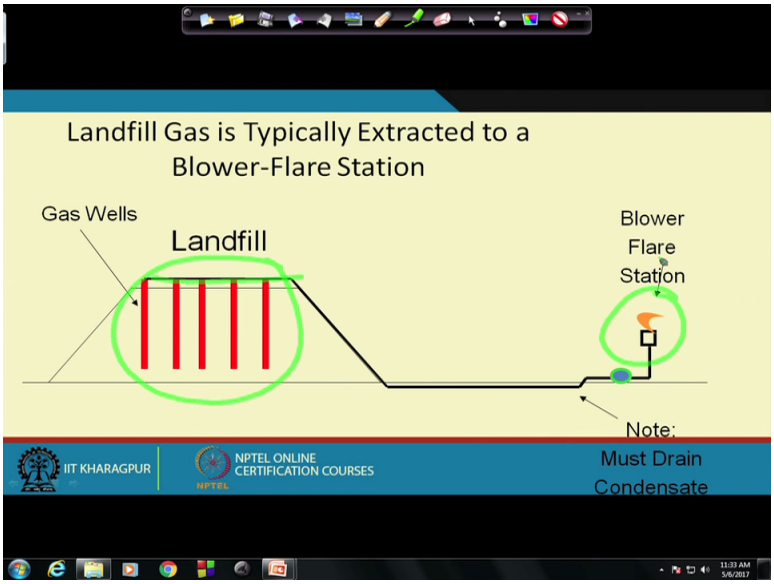
This is the typical landfill gas well, you already saw the picture earlier as well. This is a perforated pipe over here. This pipe is where the gas will move through. We have a gravel bed so that it does not get clogged and then you apply vacuum, it gets into the header pipe and taken for either for flare or for energy generation.

(Refer Slide Time: 31:40)



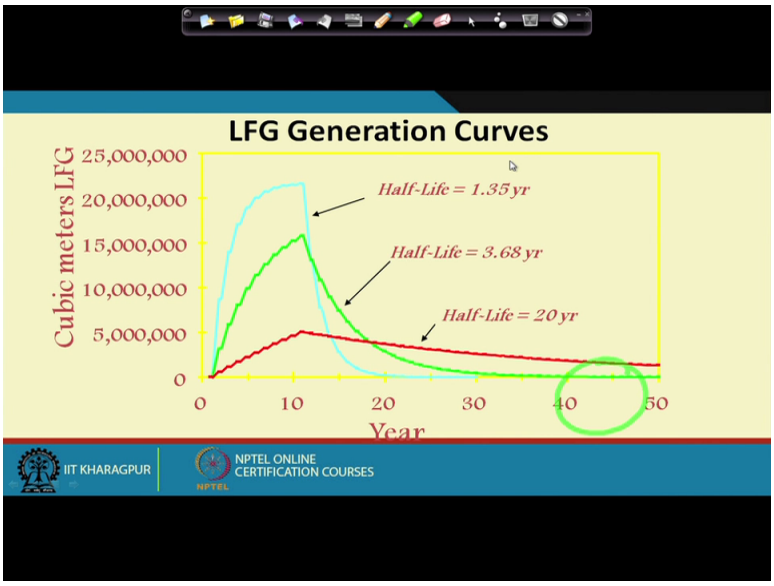
And what is the driving force? We talked about that pressure. Without any gas well, gas will go any side, either surface, bottom or top. Well, what it does, it provides the path of escape, creates the pressure gradient.

(Refer Slide Time: 31:48)



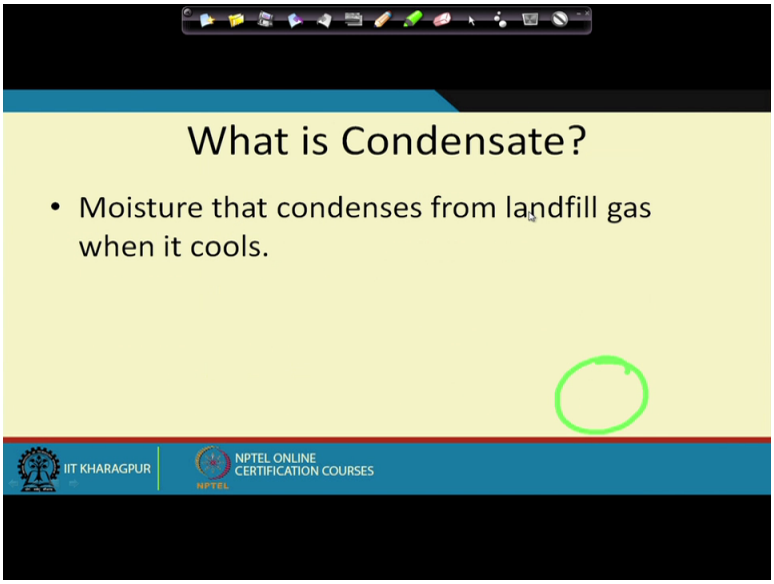
So once you have all these landfill gas wells installed, it will go on a header pipe, the header pipe will take it to a blower-flare station for energy generation. Once the landfill gas comes out, it will cool down and certain condensate will be formed and that condensate can be, needs to be removed before it is flared because that is the moisture. Moisture is, creates a problem for that.

(Refer Slide Time: 32:13)



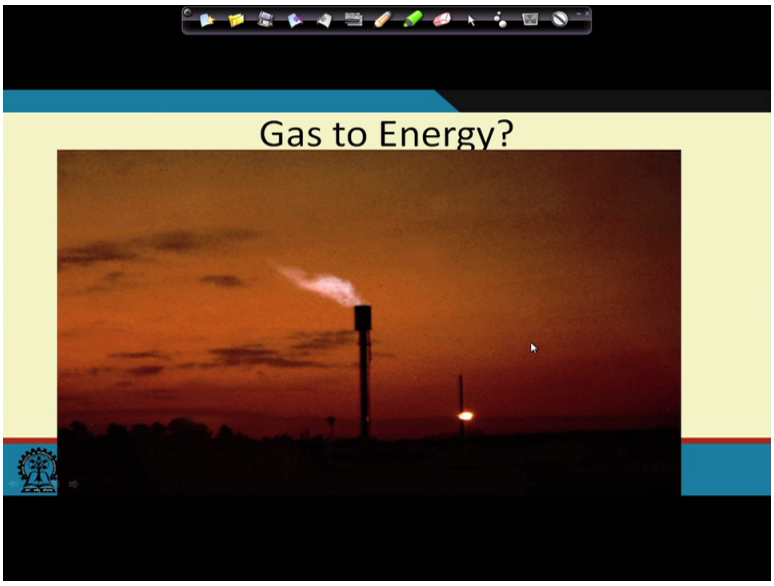
So let us, do not worry about this curve, later on we will come back and explain this later.

(Refer Slide Time: 32:18)



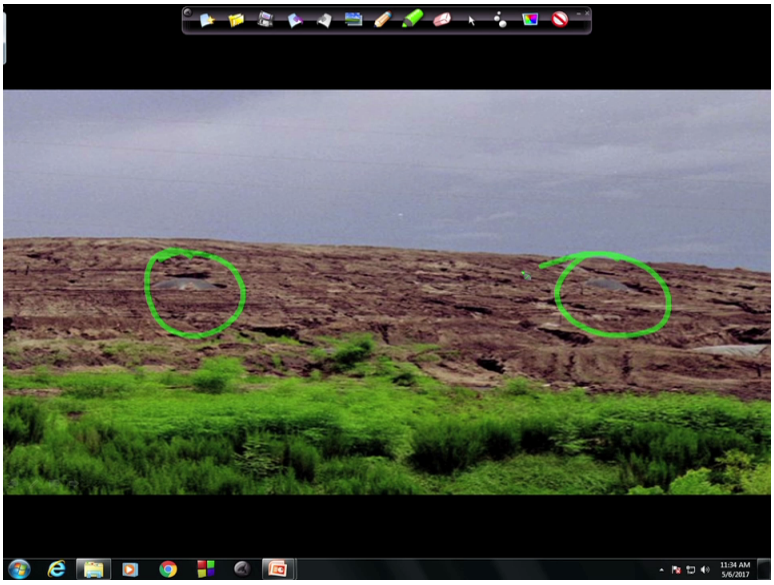
So condensate, we talked about that. It is a landfill gas when it cools down.

(Refer Slide Time: 32:30)



So once that after this landfill gas, you can use it either for gas to energy system.

(Refer Slide Time: 32:32)



Or, if you do not collect the gas properly, you will start seeing some, as you can see this is not a very great picture but you see some kind of a balloon, kind of things over here. And those are basically the liner, the top liner. Because of the gas not being collected properly, they are, gas is going up and you can see that balloon kind of things being formed on the top.

(Refer Slide Time: 32:56)

And then this is another picture of the same thing and close picture not a great picture. But as you can see here, that is where kind of balloon kind of things, that is the liner system on top. The top cover is showing up over there.

So with that, like a it kind of covers big picture in terms of different integrated waste management system. So this was what is left from the previous week, so that is what I wanted to cover.

(Refer Slide Time: 33:12)

So this is we looked at the source reduction, we looked at the recycling, reuse, compost. We looked at the waste-to-energy and we looked at the landfilling. So what I have done so far in this course in last week and the first module of this week is just to give you brief overview of the what are the things which we will be talking in more detail. So we will go and spend more time on each of those component. So thank you and I hope you are enjoying this course so far and so see you again in the next module.