Course on Integrated Waste Management for a Smart City
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Mod 09, Lecture 43
Landfill Disposal (Contd.)

Okay, welcome beck, so we will continue our discussion from the previous lecture. If you remember in the previous module we were talking about landfills, we were talking about the especially towards if you to most of the module content for the previous video is on landfill gas. So we have kind of wrapped that part in the previous video. So we will continue our discussion and today, we will if you remember from all the discussion we had with respect to landfill specially when we are talking about landfill trying to make the landfill more (()) (0:57) as a treatment unit to rather than a containment unit. So there is a difference.

the typical landfill even in the engineer landfill of course, the landfill that as we know of in India if you go to say Kolkata or madras or any of most of there is dump sites like in Delhi, there are 3 big dump sites. So those dump site are not landfill, (we have) I think that must be very very clear in your head by this time, that is not landfill that we call landfill from a technical point of view. That is a dump site, where we are just putting waste, we have some may be little bit of control here and there, but essentially there is no leachate collection system. There is no gas collection system and there have been.

Then some of the sites people have try to collect the gas, but that is again, it is not really designed as a engineer landfill. So there is some, there is stop gap measurement, some retrofit measurements are retrofit arrangements have been done. So but as per MSW management rules 2016, the way we define engineer landfill they are not. There are some engineer landfills out there in the country (())(2:01) one, Surat had one (())(2:03) for the long time and they had some issues of disposal of garbage where the landfill was built, but did not get garbage for a long period of time, we that is that issue was there, but in the in general, but even those landfills, it essentially what you have, you have the liner (())(2:18) at the bottom you have liner at the side slop and when you put all the garbage then you put a top cover on top.

So what you have is a huge polythene bag, you can think up on again huge polythene bag and this polythene bag is carrying all these garbage and that is why when I said earlier, in one of the very initial video that even after 20-25 year, we could read (())(2:40) newspaper coming

out of those landfill. So that they had not degraded.So that is why this concept of, this bioreactor came in picture.

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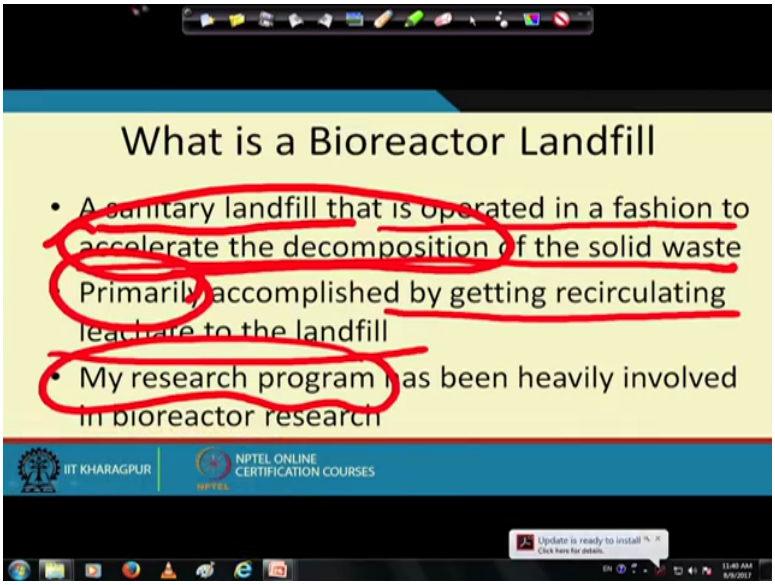

So we will today we will talk about this concept of bioreactor landfill and so what is a bio-reactor landfill? Bio-reactor landfill is essentially where you are trying to operate the landfill in a fashion to accelerate the decomposition of the solid waste. So rather than keeping it as dry (())(3:04), which is essentially you can say that is more as a containment system we are trying to use this landfill as a treatment systems. So you are trying to operate this, again we talking about the sanitary landfill, the same engineer landfill, but we are trying to operate in a fashion to accelerate the decomposition of the solid waste. So what happens in a landfill? It is mostly anaerobic. Initially there could be some aerobic, but mostly it is an anaerobic conditions.

So we have a anaerobic bacteria which is going to degrade the waste. We said that earlier the several videos as well the bacteria loves moisture and if it is a very good distribution of moisture in the waste that is very similar concept as what you will see in a waste water treatment plant. So waste water treatment plant, the basic concept is same as what we are talking about in this bio-reactor landfill, we are trying to make this conditions suitable for this bacteria a set of bacterias so that they can, if those organic matter which is essentially the waste and gone they if they those organic matter in the process, they degrade them and the they produce methane gas. So we can capture that methane gas for energy and other purposes and you saw those gas generation curves, so by we can, so with the operating, it is a bio-reactor landfill we can reduce the half-life.

So with the waste will degrade the much faster and when it degrades much faster you will have the amount of gas produced in a shorter period of time. So you can have a portable (()) (4:34), you can do some electricity generation and all that. So it is a operated in a to accelerate the decomposition so that is the key word here to accelerate the decomposition. So because the decomposition will take place, but in a dry (())(4:49) land fill it takes place over a very long period of time.

Here, we are trying to make in in a much faster way. So it how it do it? We do it by getting recirculating leachate to the landfill. So what I said? I said that we have to improve the moisture content inside the landform. So since we have the improve the moisture content inside the landfill, no regulation if you look at the any regulatory body, I do not think any regulatory body around the world will allow us to put clean water inside the landfill, because once the water goes inside the landfill, it becomes leachate. So they will you will rarely you will find that where the clean water, ground water or surface water will be allowed to be put in the landfill, because essentially what you want, we want to increase the moisture content.

So to increase the moisture content we need to put some water we need to put some liquid in there. So what is the, since leachate is produced at the landfill site itself. So we have the leachate production system, sorry leachate collection system. So all those pipes that I showed you, so we have this leachate being collected. So the thought is why do not we just take these leachates, which is already there and then we recirculate it back into the landfill. So that is what the what we do here is, it says primarily accomplished by getting recirculating leachate to the landfill. It says primarily, because that is one of that is the main way of doing it, but there would be other way too, you can inject sludge (you can) sludge is usually have say if you have to dispose waste water sludge. Waste water sludge is very high moisture content, so that could be dispose, so that will help in increasing the moisture content and the make waste degrade faster. So those things are done.

We have been working in our research program we have done, so lot of work on bio-reactor research in the past and also write now, in a mostly from the large labs (())(6:39) scale in the Indian contest (())(6:41), we amorphously working in the lab scale, we would like to do in a pilot scale or a field scale, but we have not (())(6:45) got the chance to do it, but that is there is lot of work needs to be done, because when you are trying operate this landfill as a bio-reactor landfill, you have to be careful in terms of the hydrostatic pressure being built up inside the landfill.

So there is those things are there, the lot of work from the hydraulic site care had need to be done. There are lot of work from landfill gas collection system. How to occument (())(7:08) the collection system. Now you have more gas being produce so that you can capture those gas not the let the gas is scape out is a fusutive (())(7:15) emissions then there is a lot of works needs to be done in terms of leachate recirculation system.

How to design this leachate recirculation system so the moisture evenly distributed and then how to measure the moisture content inside the landfill so that we know that the yes the moisture is really travelling. So how make sure the design of leachate recirculation system is actually working on field. So those lot of research or applied research essentially need to be done and as engineer, it is our role, as engineer our role is to like apply the science, of course science is very important, but application is more important in my view.

If we have to unless you apply that, for human good for their then there is no point of all those science, see papers been published from the lab and with no application gives a good CV (())(8:02), gives a good thesis, but nothing gets nothing changes on ground.

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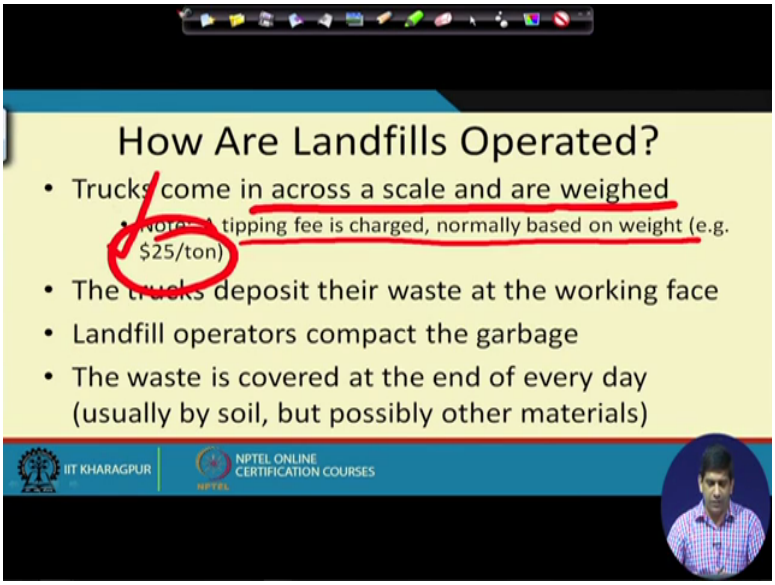

So coming to this so this is a concept of the bio-reactor landfill and then so how we operate, so there was just to you give you an kind of quick overview of the bio-reactor landfill what is a concept. We will not cover too much detail about the bio-reactor landfill that could be itself 4 week course on NPTEL program may be sometimes later in few years when this technology gets popular in India, if it does get popular in India, but we will talk about that, but right now we will just focus mostly on in this video, right now we are focusing in general landfills.

So we will talk about now, how the landfills are operated, so for if you remember we talked about landfill like how to liner system, we talked about the leachate collection system, we talked about the gas collection system introduce you to the bio-reactor landfill concept. Now we will talk about once the landfill is being built, how it is going to be operated, the economic side of it, the management side of it, so the operational issues, management issues that we are going to cover in next few slides.

So how the landfills are operated, first of all the tucks has to come in. If you go on again if you, I encourage you to go on YouTube and other places or you can go to certain landfill websites and you can see several videos, I do have several, but I did it is difficult form a to incorporate everything in a like a 30 minute video slots (())(9:33) that we have, but you can find it on YouTube.

So there are lots of videos which will say how the typical landfill is operated, you will see several videos from around the world. So essentially you will have a trucks comes in and they will come on a scale, the truck will come in on the scale and on the scale and a weight. So you will have the truck being weight and truck is also weight on the way out (())(9:57), so you have the truck being weight go into way in and also from the way out and the difference of the weight actually gives you gives the weight of the garbage is not it.

So you have initially the truck coming in, so it is weight of truck plus weight of garbage in there. Then it goes to the landfill site where the waste is being decompose, it drops off the layer of the garbage. So what is left now, it is and then when it comes out again you weight. So it is so now it is empty truck. So empty truck the first weight which was the weight of empty truck plus the garbage minus weight of empty truck that gives you the weight of garbage. So that is how you know how much garbage got the disposed into the landfill on that particular day and that is based on that only you play tipping fees and the other fee that we charged. So then the tipping fees charged.

Tipping fee is the fee per unit of weight that say municipality have to pay. So I own a landfill, if I am owning (())(10:52) a landfill or within a municipality even if the municipality owns a landfill. It is the different division. So landfill division is there, which owns the landfill. then you have the waste collection division which does the collection part. So this waste collection division as part of its disposal at least one it books (())(11:09) they may not be transfer of money, but at least on the books, it will so that per turn if there is a charge of say, 25 dollars, 30 dollars in Delhi, it was 1500 rupees per ton, so that is a tipping fee for waste energy plant

that, it general waste energy plant that they told as 15 to 1600 rupees per ton that is what they get.

So here like a tipping fee is a fee for disposing of the garbage in the landfill facility or even to the waste energy facility, compost facility, anaerobic digestive (())(11:38) facility. So you need to charge money, unless we charge the money how will you run them. So to run your facility, you need to get money. So this is a revenue source we charge money and this money gets charged to residence ultimately. So if I and you as per the municipal solid waste management rules 2016, it says that user has to pay a fee , designated for waste, this (()) (12:00) as a waste disposal fee and right now at some places it is most of the places, it is part of the property tax, but if it is separate fee that fee will to (())(12:09) municipality, these used to pay the tipping fee that it has to pay in terms of a waste disposal.

So it is a tipping fee is usually a normally based on the weight, so that is how it is a charged a dollar 25 per ton. It is a typical like, it is on the lower side, especially for the North American standard if you go to Canada is much higher, in U.S also it depends it to depending on the states to keep on changing. So they were the truck deposit truck will take the waste and deposit waste at the working phase.

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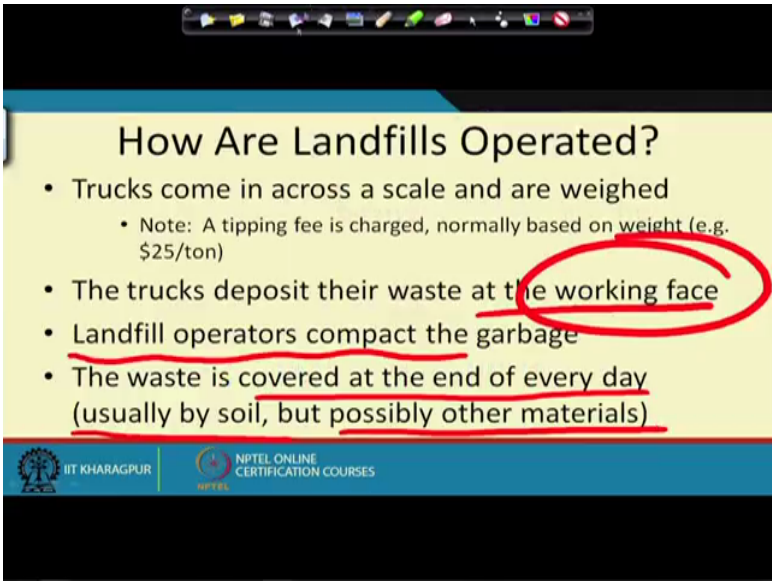

So now we are here using a term working phase. Now what is this working phase? So you have the landfill as I said earlier, the typically the landfill site is selected for the period of 30, 40, 50 sometimes even up to100 years. So you will not you will have several Acers of land. So you do not want to use those several acres of land and develop the whole area at one time what you do is you divided into different cells (())(13:04).

So there are different cells which is there and then each cell is has few Acers and so where the waste is being decomp where the waste is been disposed at that particular time that is known as the working phase. So if it a cell one in that cell one area where the waste is (())(13:24) be taken, so there will be approach road, you go there and you dump the garbage. So that area is called the working phase of the landform. So that is what we are talking we are talking about, (())(13:32) where the work is going on right now and there be if the landfill operated, which will compact the garbage, garbage compaction why it is done we already talked about it.

The waste is cover at the end of every day. So usually by soil, but possibly the other materials other waste materials as well, anything which is inert, we does not have smell that is used for any industrial waste or wood (())(13:54), those kind of material is used there. If the soil is available that is used as well and so that is call (())(14:02) cover, but why it is done is, because you do not want to attract birds and all those are control some smell for the neighborhood, so that is the reason why if these things are done.

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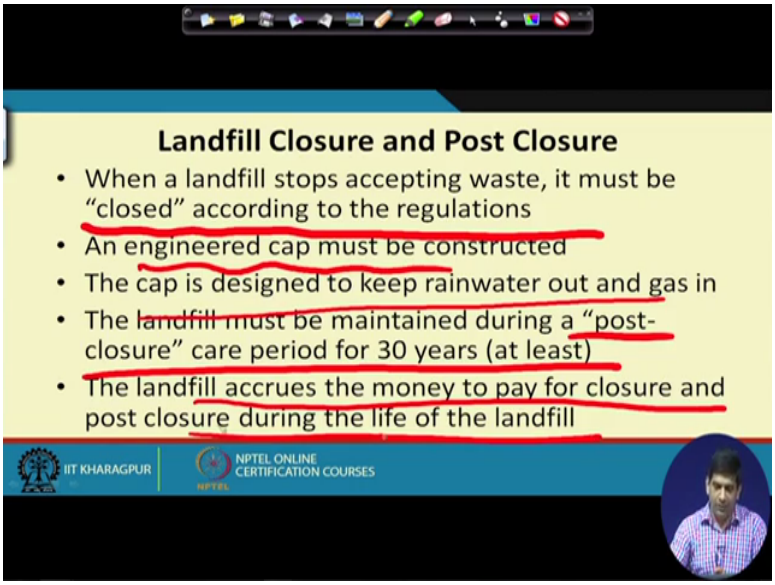

So you have then landfill has to be once you have you start say you are working on cell one and which is a 2 Acers or 3acres then you put garbage in that based on what is the waste generation rate for your particular town, say after 5 years or 10 years or about your cell is full now. When we say cell is full that means it has reached the height, which is the permitted height. So based on you have to take the permit (())(14:45). So it is the based on the permit document you were told that you can go say, up to 25th 35th 45th or higher or lower depending on the soil profile the soil baring capacity and on the other factors around the site. So which we discussed in the past as well. So it is so you have a certain height, so you reach the certain height then you put then the landfill you put there or put the liner cover on top. So then is call the landfill is closed.

So once the landfill is closed, so we usually the say cell one is closed, so and then we close it according to the regulation. So when we say regulation you put the top cover then you put some soil on top, you put some vegetation on top. So there is a cap is designed. So landfill cap is called landfill cap, because you are putting a cap on the landfill. So this engineered cap must be constructed. So it is there is a way to do it and then again your rules will tell you how to do it, the cap who (())(15:45) the purpose of the cap is to design to keep the rain water out and gas is in.

So cap we do not want rain water to percolate to the garbage, because if the rain water touches garbage, it becomes leachate and your leachate volume goes up. So you try, you put the cap in such a way, so the rain water intrugen is a less as minimum as possible and then, no gas getting (())(16:08) from the landfill sites. So gas emissions (())(16:11) is also controlled.

So then landfill has to be maintained and so because the landfill as the waste is degrading it will produce leachate, it will produce gas.

So to have and it produces for the long period of time is specially in a dry (())(16:28) landfill as we to explained earlier. So we have a post closer period of 30 years at least. So that is what the regulation wants (())(16:36) at least 30 years. Some of there is landfill which is as essence this line landfill concept globally came in early 80s. So now we have some landfills, which were built from early to mid-80s are already exceeded (())(16:51) the 30 year, but a still those landfills since they are producing some gas, producing some leachates, we are still monitoring them. So it is a we have an stopped monitoring them.

So when I say (we) I am talking about the big waste management futurity (())(17:04) around the globe. So it is not like, it is not me and my students one monitoring it, it is the where the different companies on a different landfill sites. So it is a still being monitored, because still it produces some that is why the concept was as a bio-reactor landfill. What happen say early to early 2000s late 90s early 2000 after having operating this landfill the engineer landfill for 10-15 years, people will started realizing that waste is not really degrading very fast. So this waste will remain for a longer period of time even after post closure care period which is of 30 years. So why not we try to operate, it in a way so that it becomes the reaction is faster. So that is the whole concept behind bio-reactor landfill.

So it is we have to do this post closure care for 30 years such costly is not you have to observe that site over a period of 30 years. So there is would be few people who are employed, they will be going and collecting leachate sample, collecting gas samples, collecting ground water monitoring sample, surface water sample if needed. So (it is) there is lot of things that has gone through and of course, it is job for the consulting form, (they can) you can give a contract to the consulting from they will do everything for you, but still when I say as a landfill manager we can do that, but it is the problem is it the money, you have too much money to spend on that.

So the tipping fee that you charge is (should be) should take into account that money that you need for 30 years for the post closure care and sometimes even beyond 30 years. So those things, so tipping fee calculation has those things built in as well. So the landfill has to accrue money to pay for closure and post closure during the life of the landfill. So that is also that is a kind of very important part of a landfill management and operation.

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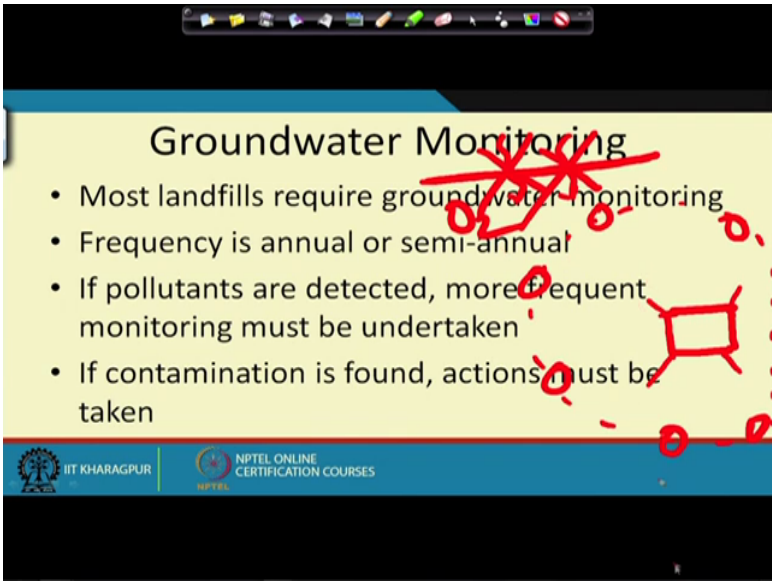

Then the ground water monitoring, I mention that using that is sketch that if you had along the periphery of the landfill. So if you are looking at the landfill boundary. So this is from the if you look at the plan view of a landfill. So this is your landfill which is a plan view of course things will go something like this and then you will have the bottom part, but if it (()) (19:24) this is the plan view of the landfill just the top part and then what we do is the whole landfill boundary this will go kind of out of this screen here, but all along this we put several wells and then we will monitor the ground water from these wells.

So the reason for doing that is to find out if there is any contamination happening from the liner system. If the leachate is passing through the liner system and going and contaminating the ground water, sometimes even with in changing the hydro geology of the landfill site, because once you put the liner system in here, you are cutting of the oxygen supply and since the oxygen supply is cut off, the bioreactors geochemistry inside the sub-surface changes and that also leads some problem in terms of ground water contamen ground water, it may not be contamination coming from the landfill, but the landfill created condition such as so that some of the contaminant which was non-leachable earlier is becoming leachable now, a big example that I have seen in the research poses(())(20:31) that I have been involve with is we have seen the iron, especially since many many parts of the world has very iron content.

Iron content is very high in the soil and as you know iron typically exist in the environment as a iron three. So it is oxidation is state of three, which is non-soluble form. It does not get solubilized in water at the iron three form, but once if you cut off the oxygen supply and you

say if you put a big liner, now the liner acts as an impervious layer. So this is your, this liner system is there, so that an impervious layer.

So if just assume that this is a liner, this part of the liner earlier we had some oxygen getting into the system. Now there when we put this liner, this oxygen supply got cut off, because of impervious layer. Now the oxygen supply is cut off, so what will happen? It will for the organic degradation if you remember from your bio geochemistry or any chemistry that you have done, we have for organic oxidation we need electronic acceptors.

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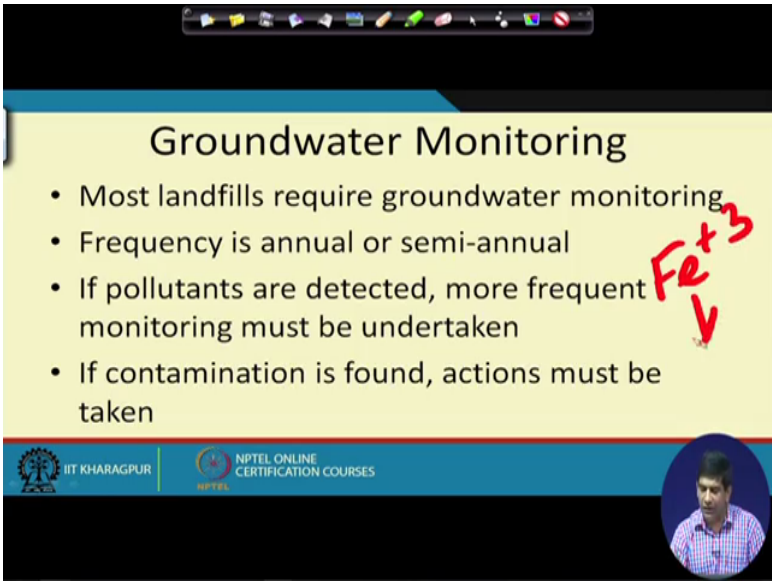

So the electronic oxygen acts as electronic acceptors. So once the oxygen is used up the other is nitrate and after nitrate, it is iron and manganese then the sulphate. So iron if the iron is there in the soil in the sub-surface what happens is iron with oxidation is state of three, we need acceptors (())(21:52) an electron goes to oxidation state of two and this Fe plus 2 is soluble. So it start showing up in the ground water. So although, it has nothing to do with leachate or, but it is the condition made, because of the liner system becoming impervious and no exchange of oxygen, no dissolve oxygen percolating through the rain water, because of the liner and so that is it is a conditions created, because of that is leading to iron three go into iron two and the iron two sowing up in the ground water.

So when you pump the ground water or you see lot of red water, because as soon as the iron two, iron two is soluble, but as soon as the iron two comes in contact with iron three when you pump it out this sorry, comes in contact with oxygen when you pump it out iron two gets converted to iron three, because that is the most that is the more favorable condition. So when

it goes to iron three immediately, it will precipitate out. So you will see lots of red things on your on in the water. So that is your iron being coming out.

So you may have seen that if you have bigger high iron content in your area and you use ground water wells for your regular water consumption, you take some water out and then you put it in the in a bucket later on you may see some iron traces in their as well, because this iron is a precipitating out iron two is getting converted to iron three. So that is that is the basic chemistry happen behind it.

So so that may cause it certain, since it is caused by the landfill, many time the landfills are told that you need to clean it up, although it has nothing to do with the leachate, it is nothing to do with the municipal solid waste, it is just to do with the changes in the hydro geology condition of the site, which happen, because of the liner system and so that then it becomes reliable for that landfill to clean it up to come up with a system to have group like ground water iron contamination has to be remove, iron, I am just giving you one example, but there could be other examples out there, where things add the reducing condition becomes more mo (())(23:54) and more than the travel and contaminate the ground water.

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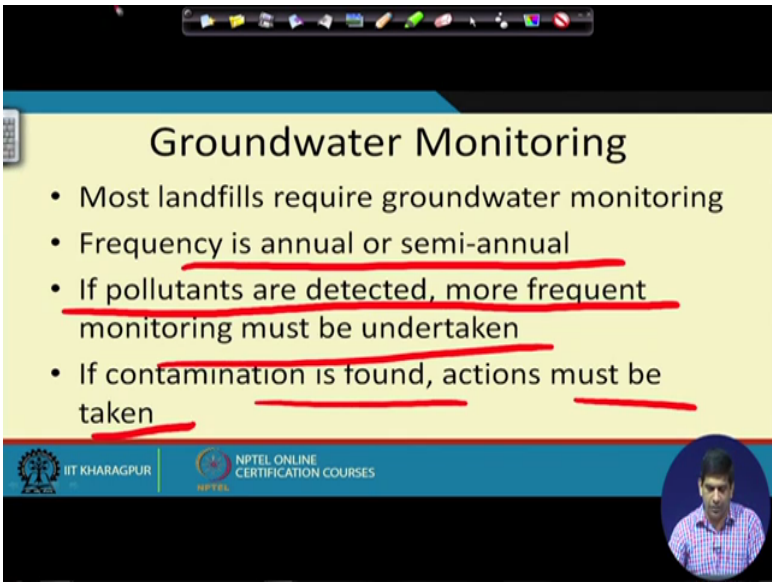

So and then we have to monitor it annual or semi-annual that is the ground water monitoring has to done every every 6 months or every year, initially it is done in more quick interval, but then the if want (())(24:12) any pollutants we do not have to do it in quick interval as regulator as a CPCB, SPCB (())(24:16) you make that decision and but if the pollutants are detected more frequent monitoring must be undertaken. So if there is a and then if the

contamination is found we have to take action. So action has to be taken in terms of cleaning a (())(24:31), we have to clean up the contaminated uh water which is which has happen.

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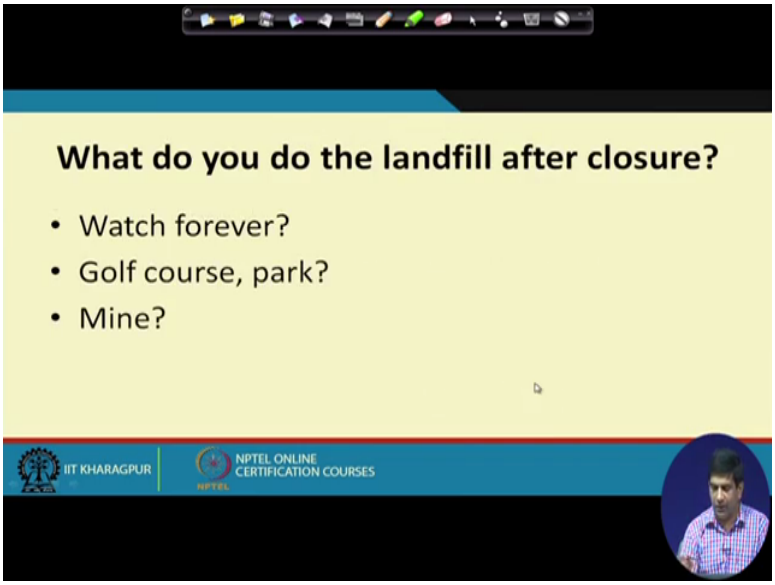

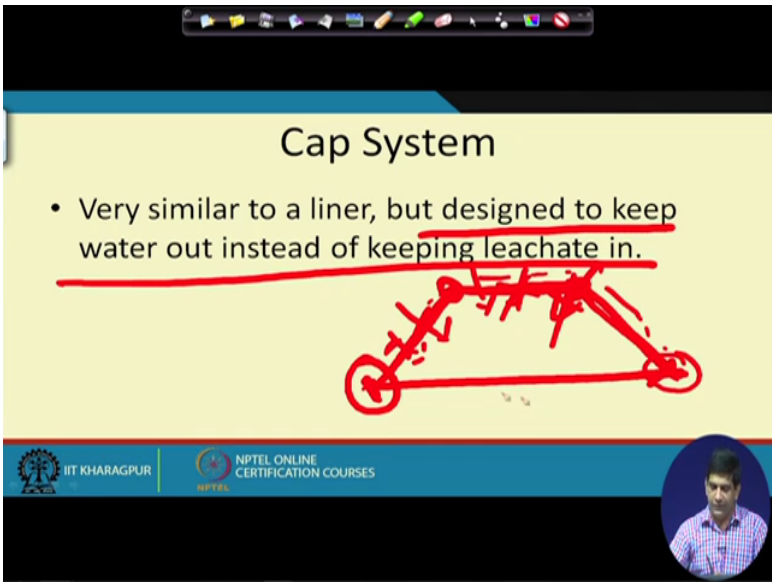

So we and then the cap system, we talked about the once we have talked about the liner system. Now we have the cap system. Cap system is **is** on the top, so if you look at the cross section of the landfill we had, sorry let see, so we have that cross section of the landfill, landfill is something like this, we have this top cover and then we have the slide slop. So this is at the bottom we had this leachate, sorry, liner system and the leachate collection system.

So once the landfill and then we have the side slop going on as the go up the landfill we have the side slop coming up and we use anchored trenches over here. So sometimes actually let us we if the civil construction job has to be done very very carefully, otherwise you may have a

seen arrow where this liner does not will meet very well and then in that case, you may have intrusion of water coming inside the landfill.

So but once you have this uh this you will go like that and then again on top this this cover separate. So you have to have a some sort of connection here and here. So at the end and on top of this and also on top of this side, top here and top here, we have to have a design the cap system design. So it is designed to keep the water out and instead of keeping leachate in. So we do not want any water percolating through, so we tend to design a system in such a way so that this water should not come in. So we should not have intrusion of water coming in there. So that is important point in terms of the cap system design.

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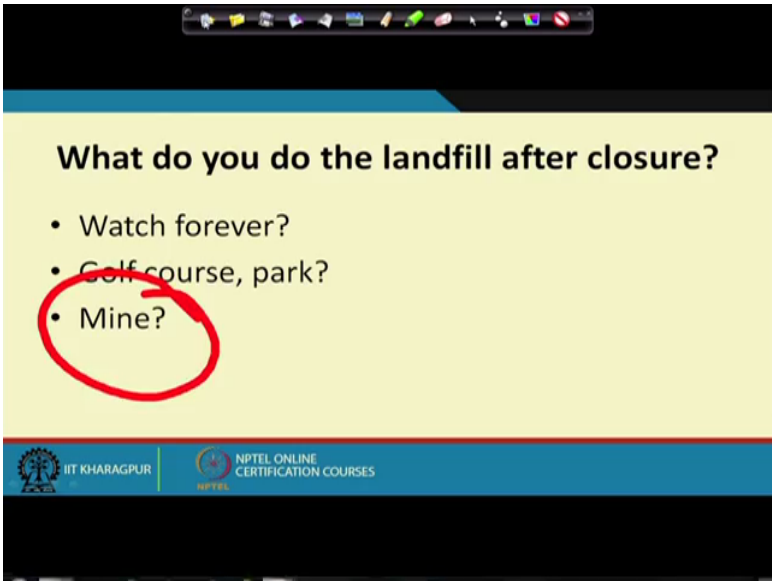

So in terms of, so what you do after the landfill has closed says, you have to have a for post-closure care for 30 years, but after 30 years and even during the 30 years if there is what you can do? You can if possible you can convert it to (())(26:32) course, you can convert it to a park (())(26:33) and even there is concept of landfill mining now, where you do go and do the mining of the landfill, especially for some of the raw materials , for which we now finding them is very difficult in the natural mines that we out there, we know that we have mine lot of those materials in the past and we have used it into different products and then we just dump it into this landfills in the past, because we did not have any technology to recycle those. So where so at that particular time to recover, those raw materials from that at that particular time. So we just dump it into those landfill.

So now since we have the technology out there, there is a concept of landfill mining where you go and mine the landfill, try to find those material which could potentially be recycled, which could potentially be used as a construction material and then you can use it in those fashion. So there is a big area, actually of research and work going on in the world in globally (())(27:32) and on trend the area of landfill mining. So if you Google the term in landfill mining, you will find several projects happening around the globe on that particular topic.

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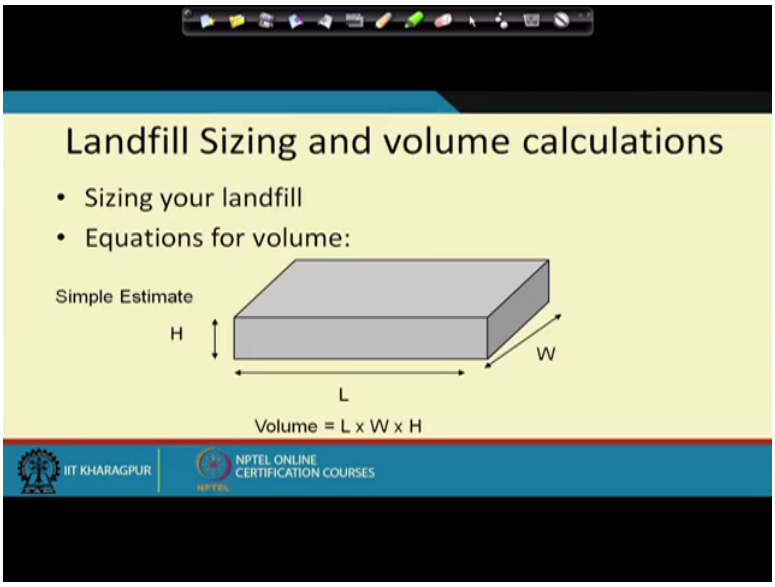

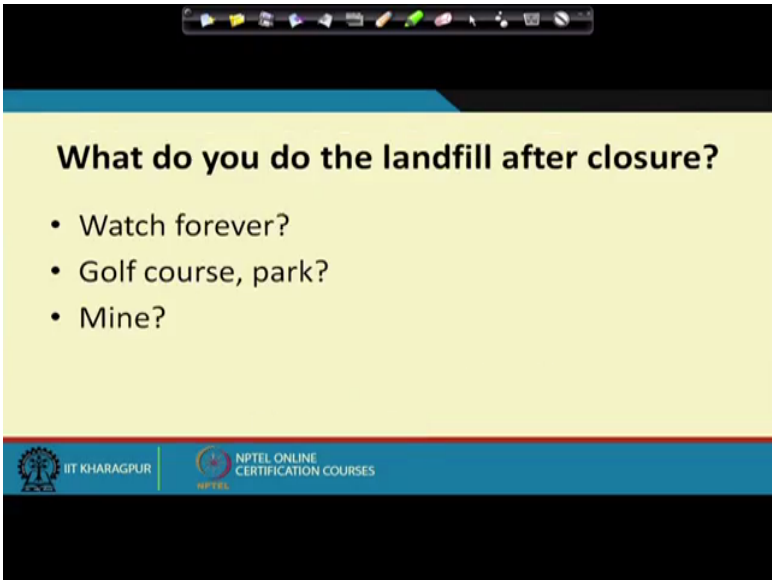

So with that let us kind of stop at that particular video, because we will the next video we will in the next video, I want to do some math problem. So it will take some I would rather started in the next video, because we are kind of close to our 30 minute duration here. So let us, so what we have covered in this video, we talked about we started with that bio-reactor landfill,

we talked about the concept of bio-reactor whether rather than operating landfill as a treatment unit. How to operate it as a containment unit then we also talked about the landfill operation in general, their concept of tipping fee, why tipping fee is important and you need money to operate the landfill during its operational time and also during the 30 years post-closure period.

So you need to have a pull of money for that and then we also talked about ground water monitoring system. We talked about in terms of how this landfill is offer like day to day operation of the landfill, compaction of garbage, daily cover, so all those concept were cover in this particular module and then in the next module, I will give you very simple calculation some math calculation and towards the end of the course you will have few math's video uploaded as well, which will help you specially those of you, who are preparing or exam who will take the example, we will do some solve examples, so **so** not so not worry.

there are lot of solved examples done as part of the course as part of the slides, but at the same time we will do some extra solve examples, which you will help you prepare for the exam. So let us the teachers will come in and they will do that recording for us. So that is pretimuch (())(29:24) for this particular video and I look forward to doing that math together in the next video, thank you.