Environmental Remediation of Contaminated Sites
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Lecture – 32
Introduction of Soil/Sediments Contamination with Some Examples

Hello everyone. So again welcome back to the latest lecture session. So until the previous class we have been our session pardon me we have been discussing the relevant aspects with respect to remediation of contaminated groundwater right. So we looked at different techniques let us say passive techniques like permeable (()) (00:45) so on and so forth. Obviously, there are other techniques too.

But you know we looked at or covered those aspects that are most widely used let us say right. So again depending on the site, you need to choose which condition which particular method to go for or not right and that is something we are done with let us say.

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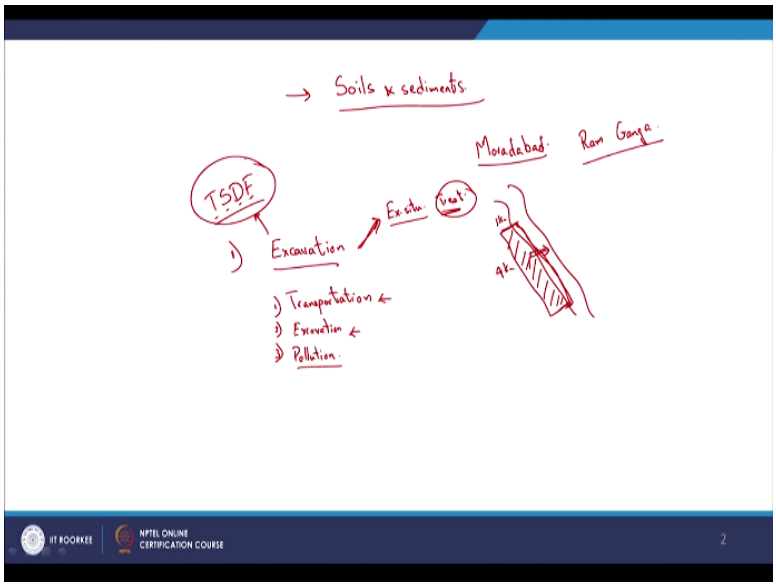

Now we are going to move on to obviously looking at contaminated soils and sediments let us say right. In subsurface, you are going to have obviously soil and sediments right and you are going to have contamination of these soils and sediments too depending upon the type of spill and also the type of contaminant right. Obviously, in this particular context, we are going to for the next half of the relevant class let us say, we are going to discuss various methods to deal with or remediate contaminated soils and sediments right.

So in this context let us look at one quick example. So the example that we are going to look for look at pardon me is let us say we have the case of Moradabad right and as some people might be aware of we have a thriving what do we say E-waste dismantling sector let us say typically unorganized right. We have huge volumes of E-waste that we are producing let us say, again smart phone I think nowadays people just throw that away after two years maybe or 1 year depending upon the model I guess right.

And so what happens to this particular what do we say cell phone that you dispose of let us say right. Typically, we are supposed to dispose of that in a scientific manner but typically we do not do that right. So those that are not disposed of in a scientific manner which what do we say consist of the majority of what do we say cases with respect to the disposal let us say right.

And where do they end up? They end up with let us say you know these or end up at these unorganized E-waste dismantling centers. So if not the cell phones let us say your computer what do we say your CPU units and so on where you have the PCBs let us say and such. So again you have rare earth metals and these particular what do we say E-waste right and so obviously in country like India, we have I mean where we have considerable unemployment, people obviously look for what do we say means of survival and income right.

So there is a thriving what do we say E-waste what do we say dismantling economy out there. Again, obviously it is supposed to be illegal but again people do look for sources of employment right, they do not look for typically whether it is legal or illegal especially when it hits the stomach directly anyway right. Again, one such particular capital of E-waste what we say dismantling let us say is in Moradabad.

So I heard you know when I visited the site that I came to know from the relevant people working there that you know waste from as far away as Tamil Nadu or Andhra Pradesh and that Moradabad right again so this is on the around bed of the river Ram Ganga okay. So I am going to present some pictures later on maybe in the next session anyway. So for now we are going to just look at or have an overview here.

So what do they do, they more or less you have different what do we say elements out there but obviously they want the relevant rare earth or the relevant heavy metals let us say right so

they either you know segregate that the chips let us say and so on of the circuits or circuit boards right and then they you know pulverize that and then burn that into relevant what do we say mold let us say or balls if I can say that.

And then crush them again let us say into smaller pieces or relatively smaller pieces and then they wash them by hand so that you know by gravity they relatively what do we say heavier compounds, they settle down typically they are your metal states right. So obviously in this process let us say they burn these relevant boards. Again you have dioxins you know considerable levels of air pollution and air pollutants are you know emitted in that particular vicinity.

And again you have let us say when you wash this particular powdered material let us say you have considerable what do we say contaminants again leeching out right. You know all that washed water that they use they just you know let that flow out onto the into the river but obviously you know the river is not perennial so it typically turns up to be you know contaminating the soil or the banks of that particular river let us say right.

And also you have let us say you know no processes obviously 100% efficient they tell me that they as in the people working in Moradabad let us say they mention that their efficiency ranges from 70% to 90% but you know we could never be sure but again you know even after their recovery let us say you are going to have considerable concentrations of heavy metals leeching out onto the banks of this relevant river now.

So what do we have here let us say I think this is the river out here and I think on this section let us say for 3 or 4 miles by 2 or 4 kilometers let us say by 1 kilometer bank you have a thriving industry here let us say supported by all kinds of people from what you say the administration maybe again here this is conjecture obviously right but again this is how things work to political bosses and so on and so forth.

But obviously the people on the ground let us say you know they thrive for you know they are out there for their survival anyway right. Again, so we have a thriving industry out here and people have tried to take steps but obviously unless you provide a worthwhile alternative to these people who are depend upon this particular activity for their survival you know even

if you try to shut this down by some manner or the other by bringing everyone together let us say the enforcement agencies, the political bosses and so on and so forth.

You know they will just mushroom somewhere else in nearby right unless address the causes you will never be able to address issues such as these let us say right. Again, so moving on so we have a thriving industry here and so all along this the bank let us say is heavily polluted with heavy metals of all kinds now right the soils and sediments. So whenever there is rainfall let us say you are going to have you know the relevant leeching.

Or you know your contact of the relevant water with this soil and then transport of these heavy metals downstream and looks like there are considerable cases with respect to health or even cancer I believe downstream and people obviously file some cases and NGT west or east still looking into you know this particular aspect as in how to remediate this and so on and so forth right.

So again you also have considerable levels of what do we say high levels of air pollutants emitted in this area typically dioxins again that is remarkably toxic again right. Again, there are many aspects, again I will present some pictures in the next session but I want to talk about a few aspects now. So in this kind of scenario let us say where you typically have let us say maybe a few feet of what do we say soil let us say.

That is contaminated with different heavy metals and maybe some other compounds too. How would you know? how would you go about it? let us say; keep in mind that the area is considerable so if not the entire 1 kilometer at least 0.25 kilometer stretch of the particular bank is remarkably polluted now right. So 4 kilometer by a point 0.25 kilometer that is considerable area and then a few feet you know that is considerable volumes of what do we say soil now.

So what are the options that people look at, so one particular person let us say you know even proposed let us say excavating the entire soil and then transporting it to a TSDF. What is TSDF? So we come across this term called TSDF that is unique to the case of India right that is a transportation, storage and disposal facility. This obviously caters to the needs of the hazardous waste generated in a particular state now right, so TSDF.

So when I refer to a TSDF I am talking about a hazardous waste landfill let us say right. Obviously, it should be scientifically constructed and maintained. So typically in Indian context we as of to my knowledge anyway as of now we only have one per state right so we have one TSDF per state. So let us say few are to excavate this entire you know stretch of a few feet thick of soil transport that to let us say the TSDF in Uttar Pradesh is only in Kanpur.

So I think that is a few 100s of kilometers away maybe 300, 400 but I will get the data again or we will look at the data. We will crunch the numbers in greater detail in the next session. So you know if you want to do that right, what are the relevant issue that you need to consider let us say right. So let us just look at those aspects. So we are talking about excavation now right.

So this is obviously one particular way that people look at, you know when considering remediating soils and sediments. So you know excavation let us say right so that is part 1. So what are the aspects that I need to consider. Obviously, transportation costs right. So there are many ideal case scenarios or you know ways to get things done but obviously everything boils down to the resources available right.

And how feasible is it and let us say again we are going to crunch the numbers so typically for this case of Moradabad we are going to look at the numbers later on but you know transportation costs are you know something that you certainly need to look at and obviously the excavation costs too, cost for excavating the soil right that is major factor that we need to look into right.

And then what say you know pollution during transportation as in not is the pollutants from the relevant vehicle but let us say you know depending upon how well you cover this particular waste let us say or you know contain that within your particular vehicle let us say you can have what do we say release of this particular soil let us say all along the relevant location, though there is a minor aspect depending upon the type of what do we say contaminant that can be an issue now right.

So these are some of the aspects obviously that we need to certainly consider now. So excavation we can take that the two ways to then deal with relevant waste, we can take that two what do we say an offsite let us say so ex situ location and then treated there. So right

now we are not looking at treatments you know, keep in mind that excavation typically we take it to a different site and treat it.

But let us say if you do not have the options to treat it let us say what can you do now? You can let us say dump it in a landfill right. You can excavate it, transport it to a TSDF but what is the issue here let us say at least in the Indian context that we are looking at, keep in mind that we are talking about many what do we say maybe 1000 meter cube or such will look at the relevant data again right.

You know huge volume of soil so if you take out all this particular what do we say contaminated soil and take it to that particular landfill let us say right and again there are some regulations because it is not a you cannot directly damp everything into a landfill, there are some thresholds or such because you do not want you know landfill to be a ticking time bomb right.

So there are some issues that need to be addressed there too before you dump it there but we will reach or consider those aspects later but for now if you want to dump this huge volume of waste in this landfill what is the issue here right. So issue is that you know landfill obviously limited space available so you if you dump this huge waste you know huge volumes of waste.

In that particular landfill, we are obviously going to consume precious space right and you are going to have limited space available for the hazardous waste that are generated throughout the year and for many years down the line from many of the industries in Uttar Pradesh right. So these are the aspects that obviously we need to consider let us say when we are looking at excavation.

There are some other aspects but will come back to that right. Again, we will crunch the numbers but I want to do that in another context. So here let us say we came across something called TSDF right or came across TSDF.

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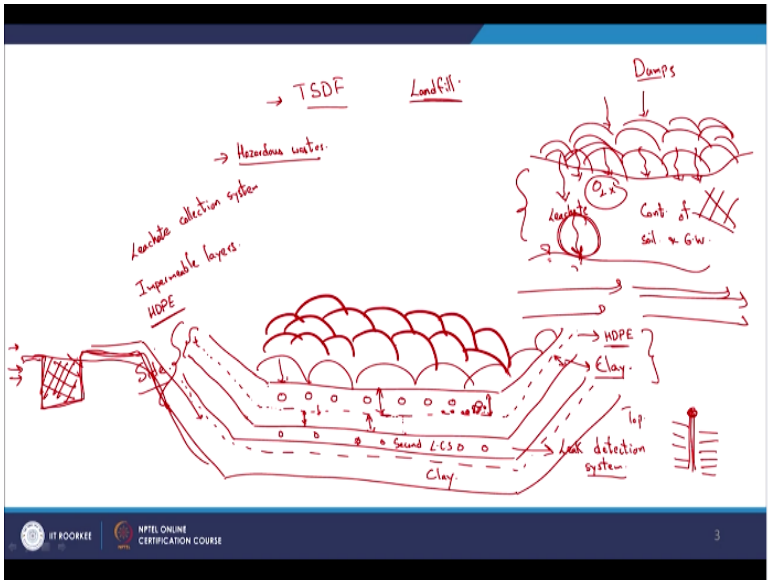

TSDF or this hazardous waste landfill right, so typically though where do the waste that you know are generated in most of the Indian cities end up let us say most let us say not all. You know depending upon the kind of soil waste management programmes that people have in place right. You can have different types of modes of disposal but typically let us say where do most of our municipal wastes anyway end up in.

Most people might not be aware of hazardous waste, they are relatively better maintained let us say but where do the municipal waste you know end up, they end up in some dumps outside the city right typically let us say you know dumps as in you know just an open space that is far from city or you know that would have cause less immediate what do we say adverse effects on the relevant population.

And thus people just dump it there or still used to or even now people dump it there let us say and over time you have what do we say as this is the site let us say and people are dumping wastes let us say, this is just a dump keep in mind, so you know and now it is a mount and it is no more economical or not feasible to dump more waste into this side right. So they let this waste be, so what is going to happen in the meantime right?

What is going to happen here? So here now these particular organic compounds let us say do not have access to oxygen right, they do not have access to oxygen here let us say right. They do not have access to oxygen, so all this particular what do we say organic matter or even let us say plastics they do not degrade though right but you know let us say other organic matter that we have let us say in this municipal solid waste dump let us say what is going to happen?

That is going to degrade but degrade anaerobically right so anaerobic conditions typically you will have acetic acid being formed among other acids and again all these particular leachate, let us say is going to travel or you know by gravity you know towards the subsurface and now you are going to have contamination of soil and depending upon the groundwater table right you can also have contamination of soil and groundwater right.

So this is a huge issue in the Indian context right and this is something that I think even the people at national mission for cleaning Ganga were grappling with and again most of the grade 2 tier 2 towns you know are facing such issues where to put their wastes and how to maintain that but obviously let us say if you just dump it let us say obviously you can look at recycling and you can look at composting let us say and so on and so forth.

Or energy recovery from the waste and so on, there are many other ways, some good, some not so good at least in my opinion but again one aspect is that you know in the absence of such measures you need to store your wastes let us say in some particular location and that is going to be a landfill but here typically we just have dumps here and as you see this needs to considerable issues down the line because now you are going to have all these contaminated soil here right.

And this groundwater taking the contaminant downstream so you have the leachate from this dump right contaminating all the soil here and then the groundwater. They come in contact and then the contaminants are now taken you know downstream from that particular location let us say and you know you have again further contamination over wider area now right. So these are issues that you face with.

So again let us try to understand let us see what a landfill should consist of or what are the major aspects that a landfill should consist of let us say. So obviously we are going to talk about hazardous waste landfill because that is what we have been discussing in this particular class anyway. So let us look at that. So let us say you have hazardous waste right or even municipal waste but they are slightly you know different waste to dispose that.

But will come back to that so let us say you have hazardous waste that are you know generated by the industries you know every day right. They can be let us say you know

somebody paints let us say and you have the particular residue from the paints, again that is toxic let us say or even the what do we say sludge from your primary settlement tank let us say from an industrial area let us say.

Let us say a CETPs catering to the needs of an industrial area and that particular primary sludge is going to be you know what do we say have high concentrations of heavy metals among other compounds let us say right. So all that is again classified as toxic or hazardous wastes, so where do you, you know how do you get that, how do you dispose that. So you need to send that to a TSDF let us say if you are lacking in other options.

So what are the relevant aspects that you need to look for? Obviously, one aspect is that we need to collect this leachate or restrict the movement of this leachate right. So in that context we come across impermeable layers right. So there are different kinds of impermeable layers now. So let us say you know bentonite clay let us say and that is relatively well with optimum compaction anyway let us say has hydraulic conductivity that is very low right. Again, that is one aspect.

But obviously you know even then depending upon let us say alternate cycles of drying let us say and you know being in contact with moisture let us say that can develop cracks and so on. Again depends upon the scenario of the site so that is not the only option that we look at so we also look at what do we say HDPE layers let us say high density polyethylene I believe right or geomembranes and so on and so forth.

So obviously let us just look at relevant scenario here. Let us say these are my different mounts let us say from different days when hazardous waste has been piled up scientifically will come back to this again right. So if that is my particular case let us say what do I need now? Obviously, I need impermeable layers and so let us say I have a few mm thick HDPE membrane here let us say right yes.

And below that I will have let us say a few feet or centimeter thick let us say this is mm thick, you know 6 mm so on and so forth and here a few feet, we will look at the relevant cross-section later on of an actual landfill. So this is the HDPE let us say and this let us say is your clay layer or bentonite clay layer let us say and what are the roles of these particular layers that we looked at?

They are going to restrict the movement of any leachate or leachate will be obviously generated what do we say you know to subsurface let us say right. So that is something that these are trying to do right. So obviously you know are we done here or is that particular unfit good enough, obviously not. Why is that? Because we are just restricting the movement of what do we say the leachate generated to the subsurface.

But obviously we also do not want to have what do we say pile up of a head of leachate here, you do not want to have considerable head of leachate developed here because let us say there will be some punctures form this HDPE either during operation or over time let us say right and you know that can lead to what do we say leachate going through and again hydraulic conductivity is less.

For clay it is not 0 so then over time leachate will go through this. So what should I do? Obviously, above this HDPE layer I need to have a leachate collection system right. We now have another term; we have a leachate collection layer or system let us say right. So let us say we have this is the side view obviously right and these are the pipes let us say perforated pipes and you are going to coat them with what do we say geomembranes or geo layer let us say. Why is that?

Because let us say you have perforated pipes let us say and if you do not coat them with this geo textile or such let us say your silt and such let us say can block these particular perforated pipes let us say and the leachate will not be collected. So you will have what can I say your particular pipes perforated pipes to be coated with this particular geo textile let us say and here you will have relatively let us say gravel or such let us say and maybe sand layers.

You know a few centimeters thick above this HDPE membrane, obviously you know this particular leachate collection system what will it have? It will have perforated pipes let us say, it will have where through which the leachate is collected and pumped out, will look at a few pictures and will also have let us say what do we say geo membrane let us say not membrane geo textile layer wrapped around these pipes.

And you know above and beneath we are going to have relatively more pervious what do we say types of materials let us say gravel, sand or such depending upon the site obviously right

and obviously you want to have this placed in such a way that your HDPE beneath it is not damaged right. So you need to choose your particular layers accordingly so typically they will have some sand of a few centimeters thick 30 centimeters and so on.

And then gravel and so on and so forth, so let us say that is going to be the leachate collection system here right. So all above this you are going to then dump waste so a few centimeters thick leachate collection system and then the HDPE membrane and then again a few centimeters thick clay layer right. So any leachate that is formed let us say there will be a certain slope right, this particular leachate collection systems will be at a slope either towards the central what do we say collection pipe.

For example, if this is the side view that is what we have looked at but if you look at the top view let us say you know these are all the pipes that we have just looked at, these are all the pipes. So they can have a slope towards the central pipe right. That goes to a sump okay so there again the sumps can be at the center or at the sides. Typically, the one at the side is better but we will look at a particular example where it is a different case.

Or let us say you know all the pipes can be sloped towards a particular sump too right their different aspects. So but here what do we have, we have leachate collection system, we have impermeable layers and semi impermeable layers right so have I done with this, not yet. Why is that? Because you know even if you have a leachate collection system, impermeable layers, semi impermeable layer even then you know leachate will go through or can go through let us say right.

Typically, it will go through, so for this particular set of hazardous waste we are going to have an extra layer of protection and how are we going to do that. So we are going to have the same 3 layers here. As in what are we going to have? We are again going to have a leachate collection system, a second leachate collection system again with the pipes perforated pipes and so on right.

So any leachate that can break through this particular layer will again be collected in this leachate collection system and thus it is also called the leak detection system. So leak detection systems right, the secondary leachate collection system and again beneath that you

will have your HDPE the second HDPE and then again you will have your semi impermeable layer with the clay again right.

So you have two layers of protection right, again each one will consist of the leachate collection system, the HDPE layer and then your particular semi impermeable or the clay layer right. So again two particular what do you say layers for the hazardous waste landfill but if it is the municipal waste landfill you are not required by law to have two such layers, you are fine if you have just one layer.

But again in India for most municipal landfills or they are not landfills, they are just dumps so we do not have any of these particular leachate collection systems or the impermeable layers right. So again what is the issue here? The first one obviously typically let us say if you look at the relevant data which we are going to do in the next session let us say. We will see that most of the leachate is pumped out from the first leachate collection system.

And the second one as we mentioned service as a leak detection system or a fuel safe. Even if something goes through from the first particular leachate collection system and impermeable layers the second one should be able to capture that right. Again, why is that obviously we are, why is that that we are going two layers of protection here? Here obviously we have hazardous wastes right, remarkably toxic compounds and even carcinogens and so on.

So obviously we are going in for that extra layer of protection right and how is this slope going to be lifted at the sides, so typically let us say all these layers are supposed to be taken up here and there is a trench here and then here and this trench is filled with particular you know material. Why is that required? Let us say typically you know wind blows let us say you do not want to have this wind you know entrapping air underneath these pockets of impermeable layers right.

So again to prevent both slippage again you do not want this layer to slip right and also to prevent wind uplift or uplift by wind, you want to have a continuous trench throughout the perimeter or around the perimeter of your particular landfill right. Again, we will come across this in greater detail again. I am talking about landfill but I want you to look at a few pictures for now okay.

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So here you see that you know this is not, this was during the time of construction of a particular landfill. Actually, again this was in India let us say. Again, because there are different stages obviously you know it is not at you know pretty good or I would say it is not the ideal case for construction or an ideal example of construction. As you can see you know the number of folds out here obviously folds are a part of your particular landfill.

Because you are going to have what do we expansion when you know the temperature is higher and then contraction obviously depending upon the temperature. So folds are part and parcel but obviously though you know you would like to limit such particular folds let us say if there are issues and again secondly though one issue here in this particular landfill is that the relevant people did not cover this particular sides with the relevant what do we say layers like the HDPE layer and the clay layer too.

So what happens is let us say overtime when they keep dumping soil, not soil pardon me the hazardous waste that will be directly in contact with your this is the HDEP layer pardon me, so I should mention that. So this is the landfill and this is the HDPE layer, this black what do we say maybe 6 mm or 3 mm thick or 6 mm maybe I guess HDPE layer which is impermeable.

So this is beneath your leachate collection system and this is your leachate collection system as you see. These are the different pipes perforated pipes as you can see, all these perforated pipes are taken towards a central collection pipe here as you can see and this is your leachate

collection system and beneath this as in all this material here and obviously as you see it is not homogenous.

Obviously, the picture was taken during rainfall let us say but again it is not homogenous as you can see or again it was still under construction right. So here you have the leachate collection system and the gravel and sand but again the consistency and the homogeneity of the system is missing and then rather than you know maintaining the slope such that all these layers can be taken what do we say up along the sides, they only took up the relevant HDPE membranes.

So what are some of the issues you know in such a case obviously you know you have this HDPE layer now directly contact to the sunlight let us say and typically that can lead to considerable decrease in the life of your particular HDPE layer right. Typically, let us instead of having a 150 year what do we say lifetime it can end up with lifetime of around 60 years but landfills we want them to be you know what we say fuel safe for considerable number of years or decades let us say right.

So that is one issue and other than that let us say when I am dumping the relevant soil, not soil again hazardous waste let us say there can be punctures along the sides and that can lead to leakage but again that might be minimal in this case because there is no standing head right. Again, we will come back to this. I just wanted to introduce that.

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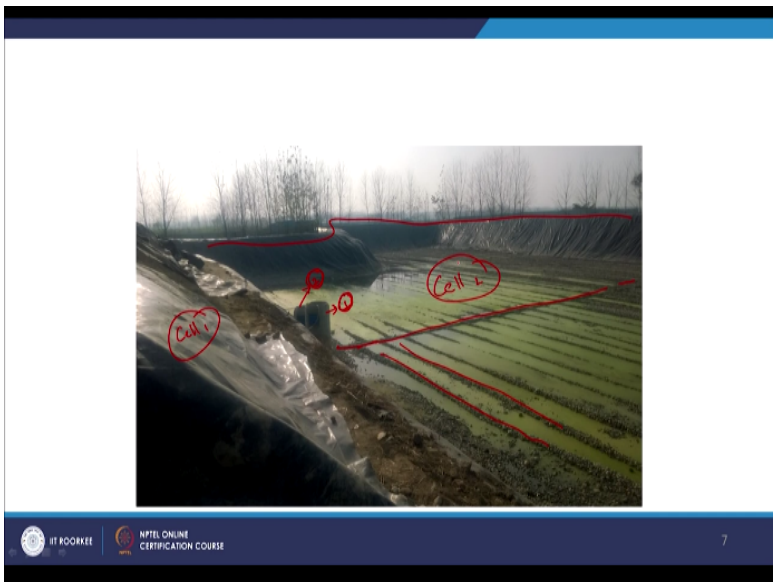

So another what do we say picture from another angle. So as you see, all these are the pipes leachate collection system pipes. They are now collected in this single pipe if I can say and then they are transported to these sumps here. Here I see two sumps, one sump and second one so the first one is the sump that is connected to the upper or the first leachate collection system, the second one is the one that is connected to the secondary leachate collection system or the leak detection collection system.

Obviously, that is underneath or beneath this particular set of layers and here you obviously see the relevant perimeter and here you see another almost full landfill here. I call this cell 1 and this is cell 2 right and this is just the picture of the relevant landfill let us say. Again, there are obvious issues and I am going to discuss this further but again landfill what are we concerned with?

We want to capture the relevant leachate right; any leachate that is not captured in the first particular layer we want to capture that in the second particular layer. Again, we pump that leachate out right and then we treat it let us say onsite or if there is no onsite what do we say management system for the leachate we are going to again have to take that too but typically most landfills have onsite leachate treatment systems right.

Again, these are aspects we are going to discuss in the next session and again we are going to have some relevant data too to be able to better understand the relevant aspects right but since the amount of time, I will end today's session and thank you.