Environmental Remediation of Contaminated Sites
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Lecture – 33
Case Study: Soil/Sediments Contamination and Remediation by Excavation and Disposal

Hello everyone. So again welcome back to the latest lecture session. So in the last session, we have been discussing I believe the relevant aspects or aspects relevant to landfill and I think excavation and so on and so forth but the context was that we moved on from looking at remediation of groundwater to remediation of contaminated soil and sediments right. So at a minimum, we need to have some idea about the relevant aspects with respect to the leachate collection system right and leak detection system and so on and so forth.

So we looked at that briefly, so today we are going to look at a particular site that we discussed briefly in the last session. I believe the one that we discussed was Moradabad where we have a thriving unorganized disorganized if I may say so E-waste dismantling sector and also you know extraction of the relevant heavy metals from that particular what do we say dismantled E-waste right.

And thus the relevant pollution and so on and so forth, so we are going to look at that particular site in some detail and then look at let us say is excavation a feasible option for that particular site right and then we want to what do we say looking at what do we say some other more practical aspects with respect to landfill design and the relevant failures and so on right. So let us look at what I have here.

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So as you see here you know this particular picture let us say is you know from a particular site visit that was mandated by the National Green Tribunal or NGT right that typically looks after or deals with what do we say the relevant aspects or legal aspects let us say or disputes let us say relevant to environmental concerns and such and tries to improve the state of what do we say the environment if I may say so among other aspects right NGT.

So typically as a part of NGT inspection teams let us say people from IIT let us say are requested to act as independent observers and so on and so forth. So this particular visit that I am looking at is again as I mentioned to Moradabad E-waste dismantling facility. So people from that locality or downstream of that particular locality let us say you know file I believe a particular case in NGT.

And thus you know the relevant push for let us say looking at what is out there and what are the remedial measures and so on and so forth. So typically we see such facilities but keep in mind that we are talking about what do we say stretch of almost 4 kilometer length and half a kilometer width to 1 kilometer in some places right. So in all these particular what do we say this particular area anyway you know you have a thriving neighborhood typically a slum though right where they extract the relevant what do we say heavy metals let us say right.

So one particular unit on banks you know this is what you see here, so this is the powdered what do we say E-waste from which they are going to extract the particular heavy metals right.

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So here we have one such units at least the one along the bank anyway right, here you see the Ram Ganga, this was during I believe summer right that is why you see little to no flow out there but in the rainy season you are going to have considerable flow out here in this direction anyway right. So what do we have here, as you can see you have this particular unit that we are going to look at let us say.

And here they collect right collect the waste and then segregate it right and then pulverize it or you know put up in a furnace or you know they form certain balls as such right and then pulverize it right and form the relevant powder that we were talking about or looking at (()) (04:07) this fine powder let us say and once they get that fine powder or you know you see different stages of washing right.

They washed that particular powder right so that you know during this washing let us say the relevant heavy metals will be separated from the other materials let us say right from this fine particular waste. So typically they looks like at least the people there told me that they go through around 3 levels of such washing before they get they mentioned that they get around 90% recovery but I am not obviously sure of that.

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So let us just look at some of the details here. So if not E-waste even other kinds of materials but I was not able to get a very good picture where they looked at or where segregating E-waste right. Obviously, I was not allowed to.

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Obviously, different types of scrap material so the furnace used if required let us say to what do we say melt the relevant stuff and then you form this relevant kinds of balls. Typically, they are either from the furnaces right slag and such or you know after melting it in the relevant furnace that we have looked it earlier right. So they get stuff from furnaces, industrial furnaces and such or also by obviously melting that as in the segregated E-waste in the relevant furnace right. So then they form these particular kinds of solids if I may say so right.

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Again, these are from furnace right say right from furnace right.

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These are the kinds of what do we say solids that they end up forming after putting in the relevant furnace here.

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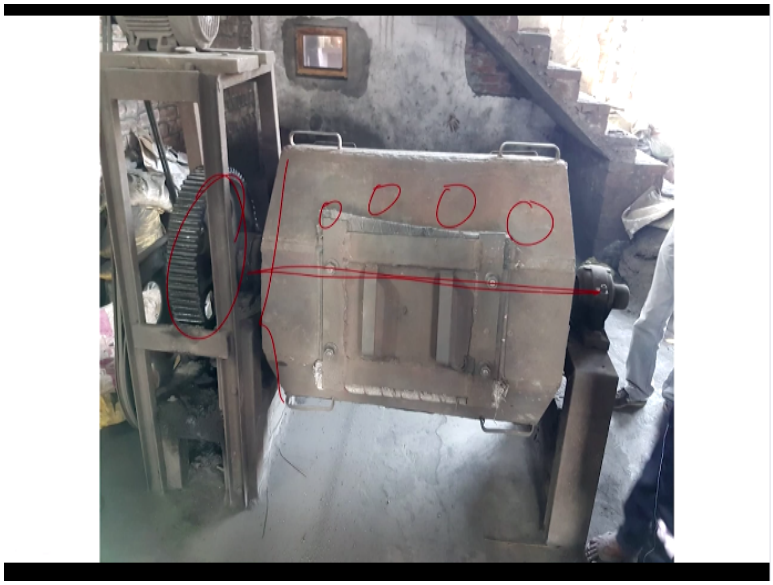

And then let us say they put it in this kind of unit right and as you can see you have a rotor here that let this particular turn along this particular access right and they have metal balls in here right and then they put the chunks of solid as we looked at earlier right the chunks of solid right, so these solids they are placed in this particular churner if I may say so and then they churn that until that fine powder as we looked at the earlier case right you know that comes out let us say right.

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So once that comes out what do they do? Again, as you can see here this is the fine consistency of the powder here right. They have lots of bags of you know 1000s of bags of such powder. So one aspect is even during segregation let us say right they are obviously burning this E-waste and then considerable levels of pollutants typically dioxins let us say were released.

And they are remarkably toxic or you know cause adverse what do we say or lead to adverse effects on human health let us say right. So that is something that we can even sense once we are in that particular locality even let us say half or 2 kilometer away let us say. We can sense that you know we can sense the air pollutants let us say right.

Again, also during this time let us say observed that many of the people working there had not many at least higher fraction than what we would expect typically let us say had deformities of some kind even the children or such. I am not sure if it is due to them working in the close proximity of such toxic or hazardous materials or if there are any other aspects but that is something that I guess we need to keep in mind right.

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Again, this kind of a powder and then obviously you see children well that is what you would expect too right and they wash that particular powder in this particular kinds of pits let us say different stages. So the one that is washed material that comes out here as you can see right.

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And here is where they are collecting the metals here and the pans let us say right segregating that here. So as we can see here once they what do we say clean the relevant or try to separate the relevant metals where does the waste to end up.

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As you can see, all these heavy metal contaminated waters let us say they obviously flow out here and then they leach into the relevant soil or at the banks of the river and also all these mounts of material that is separated from your these particular heavy metals again. You know this ends up contaminating all these banks of the relevant river. So you know the entire stretch of this particular river is remarkably contaminated with high concentrations of the relevant heavy metals now right. So now we are going to look at one video.

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So just a video where obviously they are washing the relevant particular powder here right typically lot of child labor out there but again that is expected.

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And here you see the mounts of this particular separated material that is dumped out there, so again different stages of cleaning out here right and then you can see you know have good view of the relevant wastes that are disposed let us say right.

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So as we can see here right or at least as we saw you know Moradabad I guess there are other centers too but Moradabad is one thriving center for such what do we say dismantling of E-waste and thus obviously you are going to have considerable levels of air pollution and this particular soil pollution let us say right. So let us say whenever you have rainfall let us say or you know let us say the water in that particular area comes in contact with these heavy metals.

Obviously, you are going to have transport of these heavy metals downstream and depending upon the levels of concentrations to which the relevant populations are exposed let us say and the duration and frequency and so on and so forth. Obviously, you are going to have relevant

health issues right. So in this context let us see or let us try to look at let us say excavation and disposal in a landfill.

We are going to look at that case and see if that is economically feasible right. So what are we looking at let us say excavating a stretch of 4 kilometers and maybe half a kilometer width let us say and then taking that soil let us say maybe 2 feet thick or 3 feet thick let us say or deep pardon me and dumping that in a landfill right. So let us look at that aspect please.

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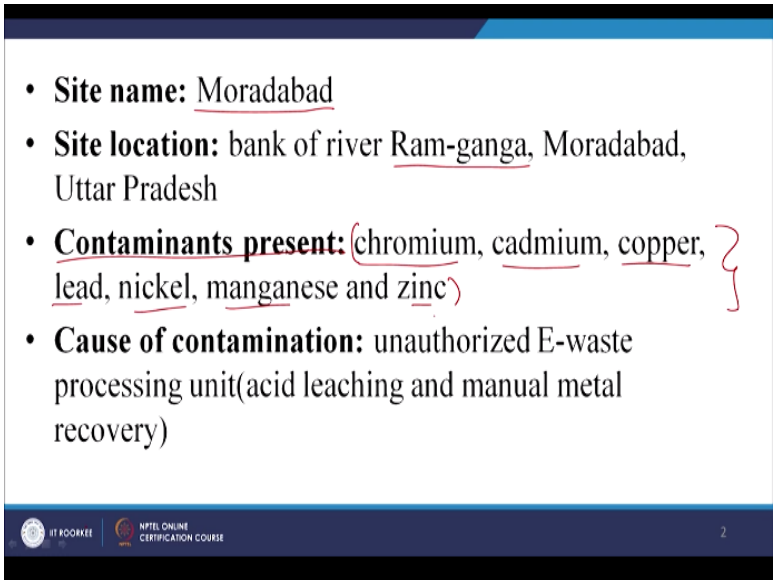

So let us look at this particular site and the relevant details. So obviously we are looking at Moradabad. Where is this? Ram-Ganga and so on we looked at but what are the typical contaminants that we were able to analyze and how did we analyze for these contaminants now. So we collected the relevant soil right and we conducted the TCLP test and what is this TCLP test now right.

Let us say toxicity characteristic leaching procedure test to tell us let us say which will give us an idea about let us say the hazardous nature of a relevant sample let us say right. For example, in this particular case, the soil is contaminated right. So how do I analyze for that for the different heavy metals and such? So I have relevant acetic acid in contact with this particular soil for relevant 24 hours.

You know end over end mixing so after that particular case I extract that particular leaching or leachate let us say right. So after 24 hours of you know this soil sample and the relevant acid at the relevant proportions let us say what will happen you will have what do you say

equilibrium between what do we say soil and the acid with respect to the heavy metal right. The heavy metal will now be in both soil and the acid in most of it would typically leach out into the relevant particular acid let us say right.

And now what are we going to have or we are going to do, we are going to analyze that particular leachate let us say right. So that will give us an idea about obviously the concentration that we expect in this particular soil. So from what we have seen we looked at chromium, cadmium, copper, lead, nickel, manganese and zinc right. Typically, what you would expect in different what we say E-waste.

Obviously, they were some other rare earth metals which were relatively low but these were at relatively higher concentrations right. Again, this is something that we looked at.

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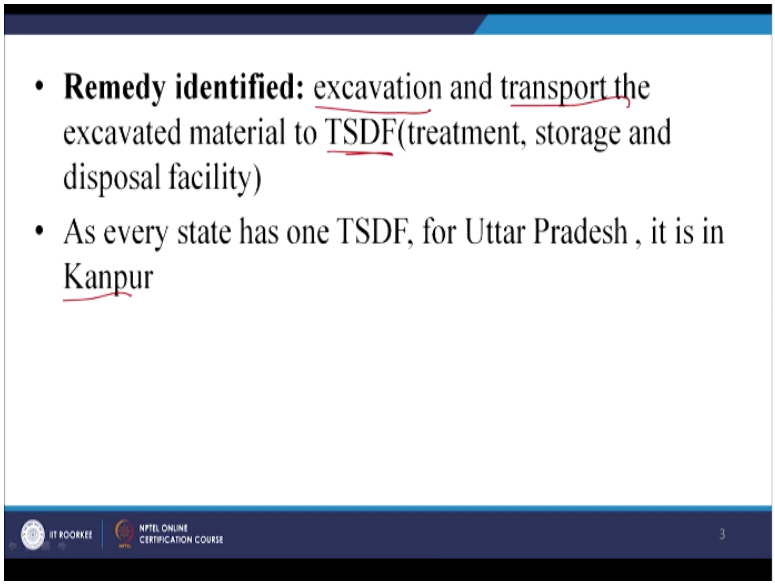

And one aspect that somebody proposed was as I mentioned excavation and transport to the TSDF treatment, storage and disposal facility right and as we mentioned or I think we briefly discussed this we typically have at least in India one TSDF per state and where is this located at? Kanpur right.

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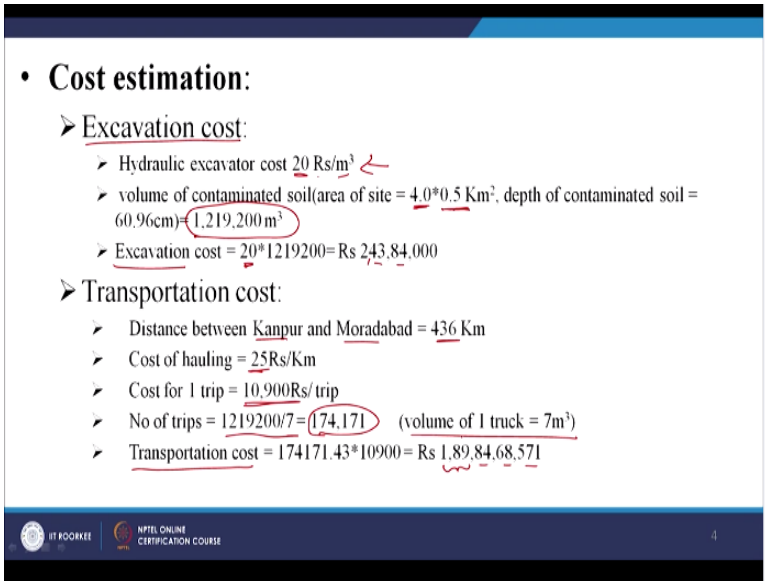

So let us go ahead and look at the cost estimation. So for excavation cost let us say right first we need to excavate it, then transport it and then pay the TSDF owner or operator for the you know dumping the relevant wastes right. So here let us say hydraulic excavator cost seems to be around 20 rupees per meter cube right and volume of contaminated soil based on the area of the site and what do we say the length and the width and depth at particular 2 or 3 feet let us say, 2 feet I believe.

We end up with this meter cube of soil and then excavation cost at this particular rate as we see is I believe 2, 43, 84000 just excavating the soil now right but obviously you know I am maybe estimating the soil to be relatively higher let us say right. As in maybe not the entire 0.5 kilometer width or you know the entire 2 feet might be contaminated but that was a conservative estimate but as you can see even if you decrease this particular what do we say cost by twice or you know thrice the cost still considerable right.

Anyway that is one thing and distance between Kanpur and Moradabad from Google earth let us say or Google maps 436 kilometers and estimating that particular lorry or you know such units let us say the transport soil will cost around 25 rupees per kilometer and end up with cost of 10,000 rupees per trip. So number of trips right and so on and so forth based on volume of this particular truck end up with these many number of trips.

And again thus the total transportation cost comes out to be 1, 89, 84, 68, 571 rupees. Again, maybe slightly conservative estimate but even if I take this to be lower by let us say a factor

of 10 or even 100 you still see that the costs are still in the range of crores here right and then coming up to disposal cost.

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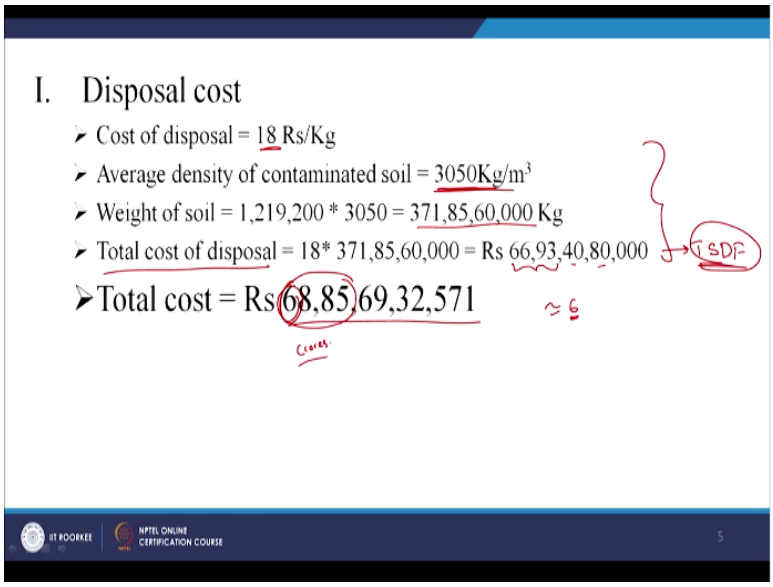

Cost of disposal is typically 16 to 18 rupees per kg of the contaminated waste to dispose in the landfill typically and density we took it to be relatively higher this actually out there on the soil the one that I measured was lower but to be on the conservative side I took the density to be relatively higher but if you want you can take the density of what do we say relatively lower density and then weight of soil we calculated that.

And obviously the total cost for disposal now is let us say this is 40 lakhs so these many crores 66, 93, 40, 89, 000 and this is disposal cost for the landfill in the TSDF. How much I need to pay the TSDF guy, so obviously adding the transportation costs, the excavation costs and the disposal costs I end up with you know these many crores right crore is how many again people can look at that I guess if you are looking at millions or billions.

But these many crores of rupees now, so even if let us say you cut this down by factor of what do we say 1000 let us say assuming that maybe I took conservative values here and there even if I cut this down by factor of 1000 I would still end up with something around 6 crores here right around 6 crores right even if I cut it down by a factor of 1000 let us say.

As we see you know the costs are considerable and even then disposing it in the landfill as I mentioned there are some regulations as in with respect to the quantity not quantity the concentrations of heavy metals that can be present in the relevant what do we say material

when you dump it out there. There are some aspects that we need to look at typically solidification and stabilization might be required, we will look at that later.

Again, the take home message here is excavation let us say is limited to let us say some particular what do we say scenarios when other aspects maybe are not feasible though but as you can see here when we are talking about relatively larger quantities and such you know that is probably not a very good way to go about it. At best, you can take this particular soil to a particular nearby location and treat the soil there right.

Rather than transporting it all the way to the TSDF and disposing it in the TSDF as we see or saw the major fraction of the costs are from disposal to the relevant TSDF right. That is something that is obviously not feasible right. So one aspect is that you can excavate the soil, take it to maybe a few kilometers of location exceed to and then try to treat the soil there by various means or you know keep it segregated or such and so on and so forth right.

Again, one aspect that we looked at typically excavation costs, transportation and disposal costs are remarkably or you know considerable I guess right. So with that I will end or you know will move on to the relevant aspects with respect to landfill and with respect to landfill we did look at a few pictures where we looked at one particular landfill and we had the infiltration galleries or the pipes pardon me not the galleries.

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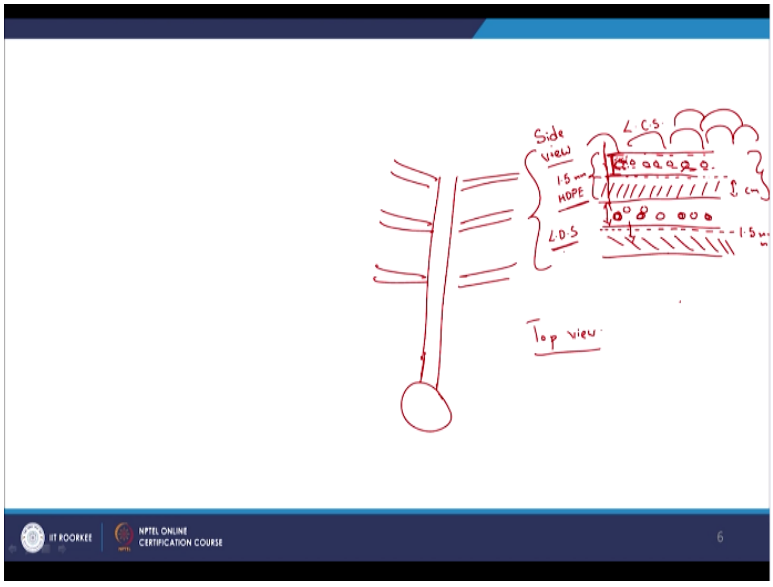

The leachate collection system right we looked at that as in we looked at pictures where we had let us say the leachate collection system right. We had something like this and then a

central collection pipe here and then this going to particular sump, this is obviously the top view right. We looked at some of these particular pictures from the actual landfill right and now today we are going to analyze that in bit more greater detail right.

Again, what are the major aspects that we need to look at so we typically have a leachate collection system right. We have these particular pipes and this is the side view now side view right. So we have these leachate collection system here so typically some sand here at the bottom let us say and then gravel out here so few centimeters 30 centimeters or so thick let us say leachate collection system.

And typically you have geotextile either over these pipes or typically you want them to be over your particular layer. What is the role of this geotextile now right? If I do not have this geotextile what is going to happen is all the fine particles or the fine materials in the particular waste let us say they are going to be transported and now they will end up blocking the relevant pores here right in this leachate collection system.

If you do not have the geotextile layer above this leachate collection system, you know the fines let us say will seep through let us say if I can say use that term and then what do we say clog your leachate collection system. So what is going to happen, the leachate is going to accumulate pardon me but is not going to be collected by your relevant system here.

That is something that was observed in many what do we say landfills where due to cost cutting measures let us say or the relevant operator trying to cut the costs you know people observed that and that leads to considerable failure of the landfill obviously right. So below that obviously you want to have the HDPE layer and as I mentioned I think we talked about it in the previous session typically a few mm thick from what I looked at for a recent case it was around 1.5 mm thick the HDPE membrane let us say.

So this will you know cut down try to cut down all the what do we say permeation of leachate into the sub soil but typically you are going to have punctures, leaks and so on and so forth in this. Keep in mind we are talking about a 1.5 mm thick HDPE membrane right. So you know they are going to have some failures or so. So beneath that you are going to have another semi impermeable layer typically a clay layer, maybe bentonite clay and soil layer.

A few centimeters thick, this will be typically a few centimeters thick right and this is my first what do we say hurdle to or this is the first hurdle that I am placing so that to the leachate so it does not reach the groundwater but assuming that you know even this particular hurdle is not good enough. I am again going to have a leak detection system or a secondary leachate collection system.

Again, so whatever I have out here is going to be repeated out here. So again the leachate collection system where the gravel and so on and so forth. These are the pipes obviously and so a few centimeters thick leak detection system right. So any leachate that can let us say and here you have your wastes obviously right your wastes so the leachate that can bypass or you know bypass let us say that you know gets through this particular system well have to be captured at this particular leak detection system right.

So that is something that we need to keep in mind right because if this goes through right you are now going to have contamination of your particular groundwater or soil. So beneath that again you are going to have a HDPE membrane again typically 1.5 mm thick in this case depending upon the operator maybe slightly greater thickens and then again semi impermeable clay layer of a few centimeters thick right.

And then depending on relevant operator or site conditions, you can have another layer typically though this is mandated by law two particular layers now right. So that is what we have here so again we are going to look at you know some practical aspects in greater detail right. So let us go ahead and look at that.

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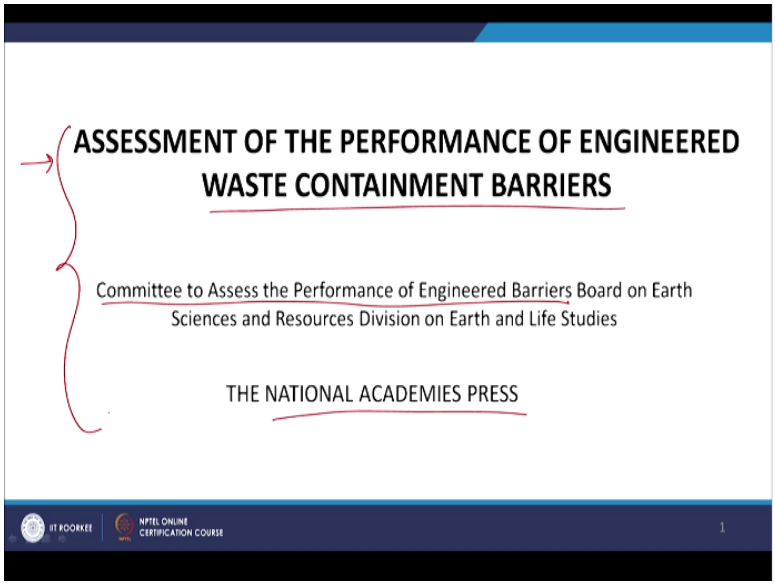

So the data that I am going to present is from a particular open source document that was prepared by the National Academies Press right and it was prepared by the committee to assess the performance of Engineered Barriers. These are obviously Engineered Barriers right and what is that particular document titled? It is assessment of the performance of engineered waste contaminant barriers.

Again as I am repeating myself right the relevant graphs or data that I am going to present in this particular session let us say is from this open source document an excellent source and again this data is not mine that is something obviously I need to make clear right now right. So I would suggest that people look this up and you know if people are interested in looking at the relevant cases for assessing the engineered waste contaminant barriers right.

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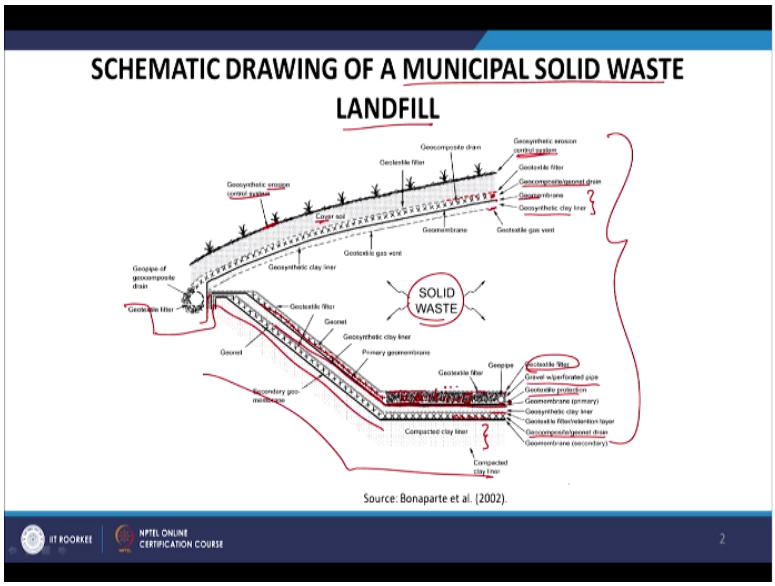

So let us move on, so typically let us say we are now looking at a municipal solid waste landfill right. So what do we have here? Let us look at the particular what do we say layers beneath the wastes. Obviously, here you have the solid waste, so here as we mentioned we have the geotextile layer right and then geo or gravel with perforated pipes and what does that typically mean.

Here you are going to have your leachate collection system right and again another geotextile protection here right geotextile protection layer beneath that because you do not want to puncture your HDPE membrane. So first the geotextile layer and then the gravel and the leachate collection system here right and then again geotextile what do we say protection layer and then the HDPE membrane and then the 1.5 mm thick HDPE membrane.

Or you know here they have the geosynthetic clay liner out here right, different what do we say setups out here right and then obviously we have what do we have here? This is again a geocomposite or geonet drain let us say that is at least Indian context I have not seen lot of people having that anyway and then obviously the compacted clay liner I guess. Yes, this is for municipal solid waste.

But typically in this class, we are talking about hazardous waste so in that context obviously we are going to have another particular layer out here and typically what do we have? The geotextile filter and then the leachate collection system and then the HDPE membrane and the protection layers and then the compacted clay liner. So as you can see these are the relevant aspects that we have now.

And one aspect as we discussed was if we do not have this geotextile filter out here right what is going to happen? The fine particles in the wastes are going to see through and clog your particular primary leachate collection system right and then you are going to obviously have issues with respect to the efficiency with which you remove your waste right and obviously let us say if I am done with filling up my landfill, I also need to have what do we say top cover let us say right.

What are some of the ways that we can have? So again geosynthetic erosion control system that is something that we have out here and then obviously the cover soil. I think this is the better way to look at it. So erosion control system right, you do not want to have obviously

lot of erosion from what do we say relevant run off and such right and again the geotextile filter here.

You do not want to have the relevant fine particles going through and again a drain out here, the drain and the geomembrane let us say and the geosynthetic clay liner but obviously sometimes people you know just go with one of these two and obviously a gas vent but again the role of gas vent let us say is important in municipal solid waste. Why is that? Because there you have typically higher what do we say concentrations or amounts of organic matter.

So this organic matter under anaerobic conditions as in when we have no oxygen let us say can lead to formation of relevant gases. Typically, those which have relatively high calorific value too. So typically you need to have a gas vent or gas collection system and the relevant disposal of that gas otherwise you will have relevant issues. As in I think, few years ago this case came up as in a slum came up over a particular municipal solid waste dump right.

A slum came up and people were heard of cooking from you know what do we say cooking you know their food obviously right above particular locations let us say where you know gas was being emitted and then I think there was an issue with respect to fire breaking out and then people had to look at the relevant measures. So what is the cause of this particular gas let us say or formation of this gas?

It is that you know the organic waste in that dump was degrading and then you are having these gases as byproducts right. So that is something that we are going to look at but typically though in landfill let us say or pardon me hazardous waste landfill we do not have what we say issues with what do we say relevant formation of these gases.

One reason is because typically microbial activities less and also your concentrations of organic content are that high but I am presumed that it is one of the major reasons is that microbial activity does not or is not great in this particular hazardous waste dump right. So that is something that we have here. Again, you know you can refer to these aspects obviously right and your textile filter and so on so forth.

Did we miss something? I think that is typically at and as I mentioned we will typically need to have a trench here right. So these liners as you can see and all the materials are taken up. It

is not just that the textile layer or the HDPE membrane that is taken up. You see that all these layers let us say the semi impermeable layers and so on and such need to be taken up along this slopes let us say right all along the perimeter.

But typically let us say in Indian context let us say depending upon the operator again or the relevant enforcement agency the people have not taken up this particular impermeable layers all the other layers up the slope. They have only taken up this HDPE membrane along the relevant slope and you know anchored that. Obviously, as you know we discussed this in the last session briefly you know.

Then, you are going to have maybe chances of greater chances of your waste directly obviously being in contact with your liner degrading the relevant liner or even puncturing the liner let us say right. So your liner is at the sides as we looked at some of the pictures and you are going to keep dumping waste. So depending upon you know how carefully the relevant operator is dumping the waste let us say right.

You are going to obviously have typically I would expect that you are going to have rupture of the relevant liner now right. So that is something to keep in mind and also the liner is going to be exposed to sunlight and that is going to degrade the quality and thus a life of the liner right. So these are aspects that we need to keep in mind and I guess I am running out of time.

So in the next session we are going to continue this particular discussion with respect to some of the general aspects that need to consider when we look at landfills and then we are going to look at another aspect where we try to look at soils contaminated with hazardous wastes as in we are going to look at containment, as in here we are only trying to see to it that the waste does not transport over wider area as in we are not trying to treat the waste.

We are just going to try to contain the waste wherever it is right. So that is something we are going to look at in the next session once we are done with these particular aspects of the landfill and that is it from me from today for today pardon me and thank you.