Geoenvironmental Engineering (Environmental Geotechnology):
Landfills, Slurry Ponds & Contaminated Sites
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Lecture – 28
Closure, Rehabilitation and Expansion of MSW Landfills

Good day all of you. And welcome to this lecture on closure rehabilitation and expansion of landfills. So, you know we been talking about a large number of garbage dumps been there in all cities. One is you want to design new landfills so, will make a liner we will make a cover and we will we will do all the design that we have done. But what do we do with all the large old waste dumps where a lot of waste has accumulated, near the cities inside the cities just outside the boundaries of the city so that is what we are going to look at today that how do you close old waste dumps. And you remember in the beginning I had shown you a large number of photographs of these small mountains of waste in various cities that we find.

So, what would you like to do with this waste terms, we will ideally we would like them to disappear we would like to be able to utilize the waste for something and that land area beneath the mountain should become available to us for making a for utilizing it in a proper manner, making a playground putting a shopping mall putting a hospital putting a school. I want to release that land from the waste. So, ideally I am wanting to completely make that waste vanish. But then where will the waste go? We have done we have done integrated solid waste management principles we can reduce waste. But we cannot eliminate it completely. So, let us see how we tackle this problem, what are the what are the what do we mean by the term closure what do we mean by the term rehabilitation and we will take it from there.

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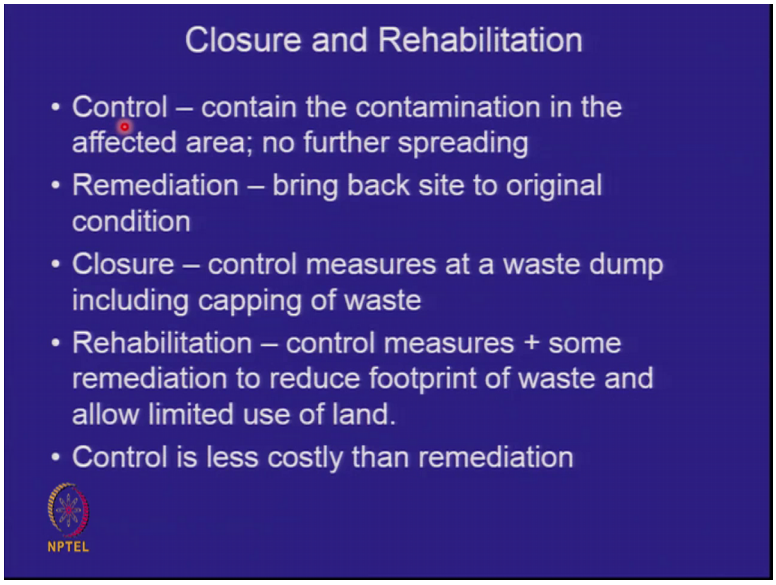

So, closure rehabilitation and expansion of municipal solid waste landfills. Now you will find the few words control or control measures at old waste dumps. It means I have to do the containment, such that the contamination remains in the area and does not spread further. So, control means I know that a waste dump is causing contamination via the air root via the surface water root, via the ground water root I want to adapt measures that it does not extend beyond what it is today; that means, I have controlled it that is called control measures at waste terms.

Remediation is the other extreme, remediation is I want to bring back the site to it is original condition. I have to make the waste vanish if there is already even if I remove the waste there may be contamination below I have to remediate that, suppose the ground water has got contaminated by some chlorides I have to remove those chlorides. So, I have to bring back the site to the original condition. Extremely expensive not often doable, but that is what you mean by the term remediation. People tend to use you know words interchangeably, but that is not the case, what is closure? Closure is same thing adds control, but the waste dump remains where it is and it is capped or you know encapsulated in a suitable manner.

So, in control measures you may remove the waste. Suppose you have a small amount of waste lying over a area of a 50 meters by 50 meters. So, a control measures may include removal of the waste. Whereas, closure means you will tend you have a large waste dump it is too expensive to move the waste, you will cap the waste dump you may put

other measures for controlling the contamination from spreading, and that is the term closure. And is rehabilitation the same as remediation no.

Rehabilitation means control measures. But do something such that the foot print of the waste is reduced. You have a waste dump which is occupying one kilometer above one kilometer area. Can you do control measures to stop this spreading? Yes, but can you also do additional measures of remediation first that half that land becomes available to you. That is rehabilitation, closure means you cap it or put the vertical cut off walls or whatever measures for containment that you want to take rehabilitation means not complete remediation, but your first set of steps trying to release the land which is buried under the waste.

So, rehabilitation means control measures plus some remediation to reduce the foot print of the waste and allow limited use of the land these definition are not well described anywhere, these are the words that have come across many are used interchangeably, but we would like in our discussions to follow this these definitions for the purpose of this lecture. Always remember remediation is very expensive closure or control is less expensive.

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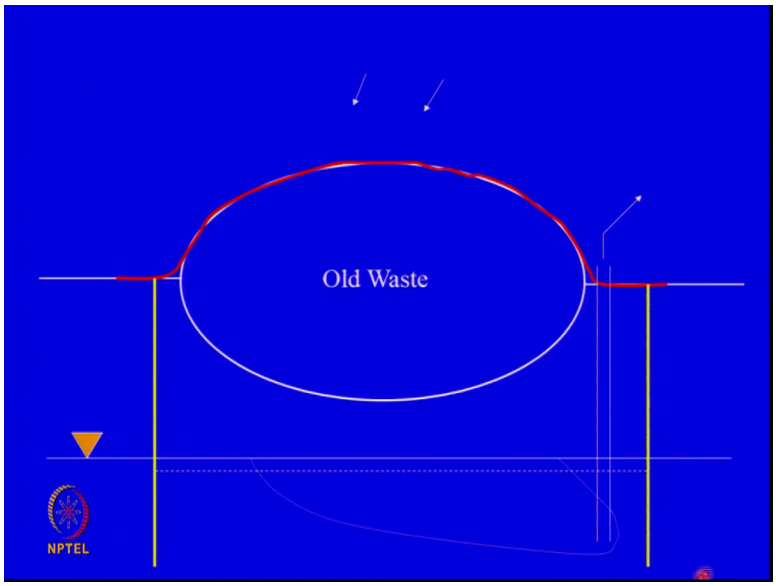

So, just to recall I have old waste we have done this earlier there is ground water at the bottom. When the rain comes leachate may be formed and you may have a contamination plume.

So, as a measure as a measure of to prevent further contamination I might put a cover if I put a cover then the rain water will not infiltrate in to the waste, to further prevent even if I put the cover this plume can travel downwards will the ground water flow, to prevent ground water flow from travelling downwards. I may a put vertical cut off walls you will look at what are these vertical cutoff walls in a subsequent lecture how do we make them, but these are vertical impermeable walls, not of concrete because concrete is rigid these are more like vertical flexible impermeable walls made of low permeability soil and we will look at them later.

So, now I have contained the contamination. The air root is blocked because there is a cover. The surface water root is blocked because the water does not come out from the sides and the ground water root is blocked. So, the 3 path ways are blocked ideally of course, I would also like to completely eliminate this because I do not want to learn that no this plume went down with time and you had a hanging wall and therefore, it bypassed. So, the tendency to make vertical walls very deep is always there, but you may not find a impervious strata at the bottom. It is possible to make an impervious stratum an impervious barrier at the bottom of a plume it is exorbitantly expensive it is not done. But technology is there if you want to make including going and tunneling underneath this and making a barrier.

So, what normally is done is instead of putting a barrier at the bottom we put a extraction well and keep the water table level inside lower than the water table outside so that the flow is always in words. So, therefore, you have assured that the contaminant plume will not fall down and you know bypass. You are able to allow since the water is flowing inward the plume is not going to drift towards the direction of the ground water flow.

So, let us look at the situation in India.

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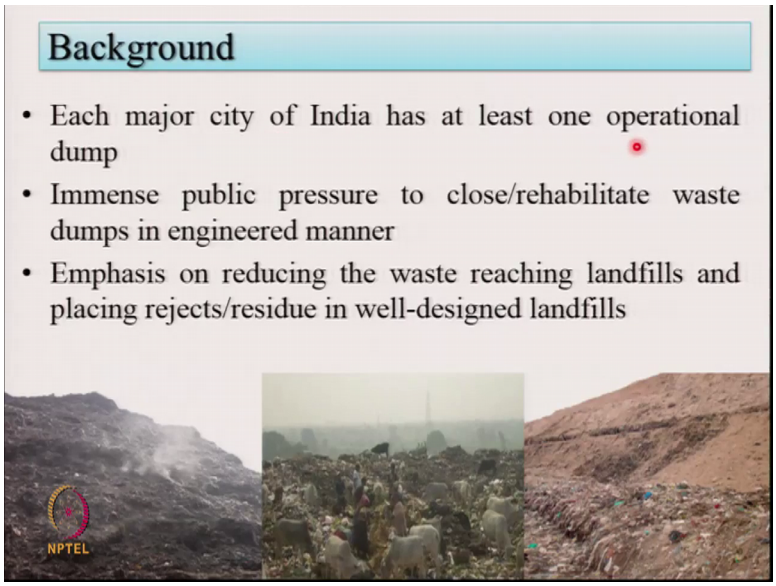

Each major city of India has at least one operational dump. How many operational dumps in Delhi? We have 3 operational dumps, one at Okhla, one at Ghazipur and one at Bhalswa. So, we have 3 operational dumps Bombay has 2 or 3, but every big city will have at least one dump, which is operational and there is a immense public pressure to close or rehabilitate these dumps. You see the beginning the dumps were outside the city limits, but city they have expanded and what happened these dumps came within the city limit is and therefore, there is an emphasis now of course, on reducing the waste reaching landfills and placing the rejects in well designed landfills.

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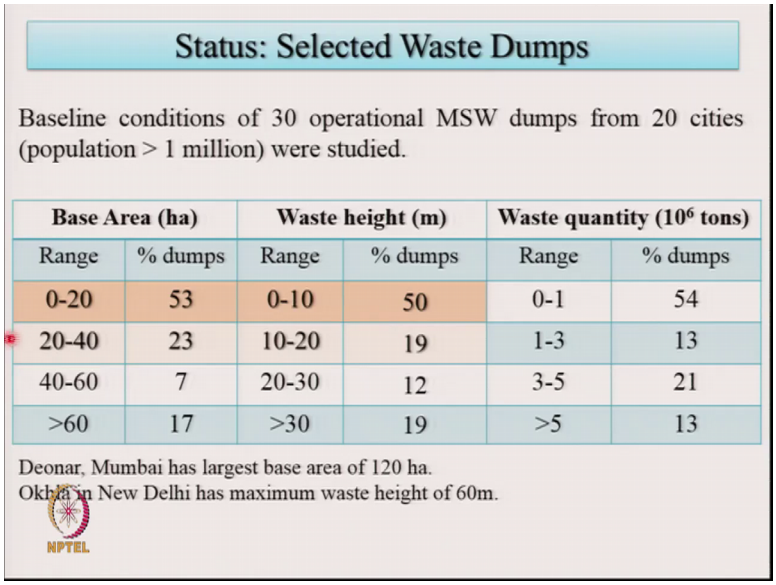

If I take top 20 cities of the country, and look at the 30 odd operational waste dumps what data emerges from India? What is the kind of areas that we have? 53 percent of the waste dumps are in the area of 0 to 20 hectares, or one hectare is how much?

Student: (Refer Time: 09:22)

10000 square meters, if it is square how much is 10000 square meters? Hundred liters or hundred meters. That is like a football field or a cricket field. So, 0 to 20 cricket fields. Most of them are in that range, but there are some which are bigger 20 to 40 hectares there are 40 to 60 hectares and even greater than 60 hectares. So, bulk of the dumps are less than 20 hectares, what kind of heights, most of the dumps are 0 to 10 meters. Many are up to 20 meters, some are up to 30 meters and we have even above 30 meters.

So, in terms of area the largest waste dump is deonar at Bombay which is 120 hectares, not bad. A hundred football fields put together. And the okhla in new Delhi is the highest ever you want to take a leisurely walk or a drive go to okhla have a look at the okhla waste dump. It is now touching 60 meters and just to remember qutub minar is 74 as I said. So, who will win at the end I do not know. And they have several million tons of waste in them at the presents period of time. So, how bad are they in terms of environmental impact?

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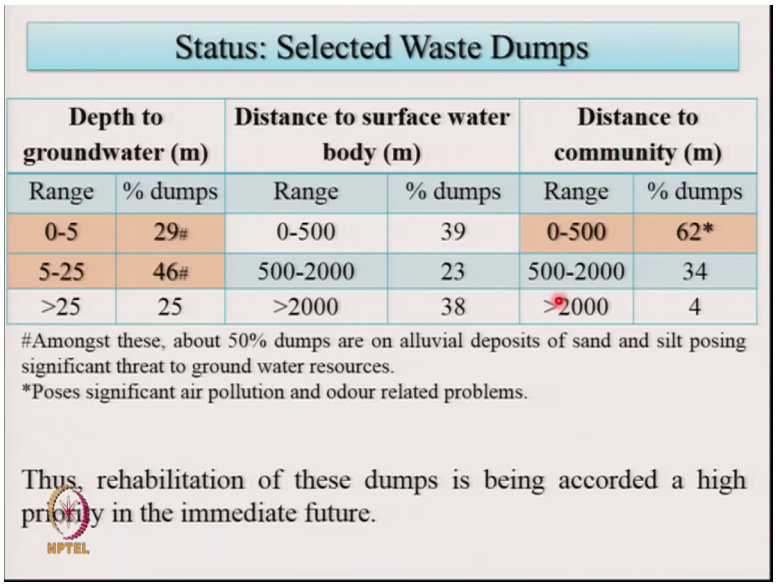

The question is how close are they to the ground water. In 29 percent of the dumps the ground water is between 0 to 5 meters below the ground surface. That is pretty bad, but in many dumps the range is 5 to 25 meters and in others more than 25 meters.

Distance to surface water body typically within 500meters if you recall that is the buffer zone some 39 percent dumps have water body in the buffer zone. If you have a lake you are in the buffer zone and yours ground is sloping towards the lake because lake is in a low lying area. And surface run off leachate is going to go in to your lake and spoil it. But luckily for us most of the water bodies; that means, 61 percent are more than 500 to 2 kilometers away. So, they are a little further than the buffer zones. But how close are our dumps to the cities.

62 percent of our dumps are either in the fringe of a city or in the side of a city or in the middle of a city. That is the worst part. So, being in a city if your water level is deep below and your got clay it does not make effect to the ground water, if your river is 5 kilometers away, but being in the city there is smell, there is fire, there is smoke there is dust, there is litter. So, air is the biggest problem. Ground water can also be a problem if you are sitting on pervious soil and the water table is shallow, but in the city means a lot of problems.

So, out of these 29 and 46 which means 75 percent waste dumps, please note that the 50 percent of these dumps are on alluvial deposits. Alluvial deposits mean silty sand is silt. So, there water is between 25 meters and the sub soil is pervious. Now that is trouble if it was 20 meters, but you had clay you could be safe because the rate of travel of leachate as we have done is pretty slow.

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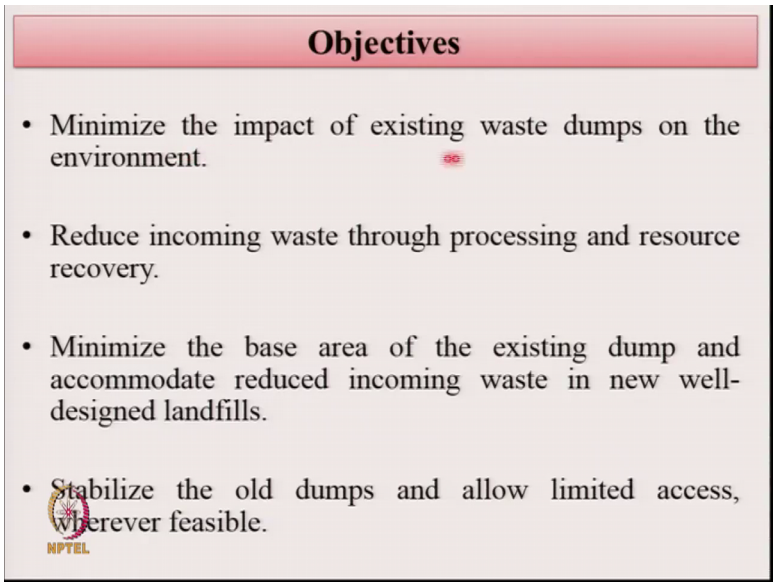

So, objective is to minimize the Impact of the exiting waste dumps and human (Refer Time: 13:19) is always about small and odor and dust and fires. Reduce the incoming waste So that you can put more waste in it in the sense that your life becomes longer I mean what capacity which is finishing in 15 years can you extend it to 30 years.

Minimize the base area of the existing dump we saw many of the dumps are between 0 to 10 meters high. Now that is not an efficient use of the area, we are saying from aesthetic point of view you can have a dump which is 15 meters high. And you really are short of space you can even take a dump higher. So, we have 10 meter high dump you are using double the area you make that 20 meter high, you can release half the area. So, minimize the base area of the existing dump to accommodate reduced in coming waste in new well designed landfills. And where ever there have old dumps please stabilize them so that the recent failure was in Brazil the one which you talked about a few days ago where 40 people died. So, stabilize the old dumps and allow limited access where feasible.

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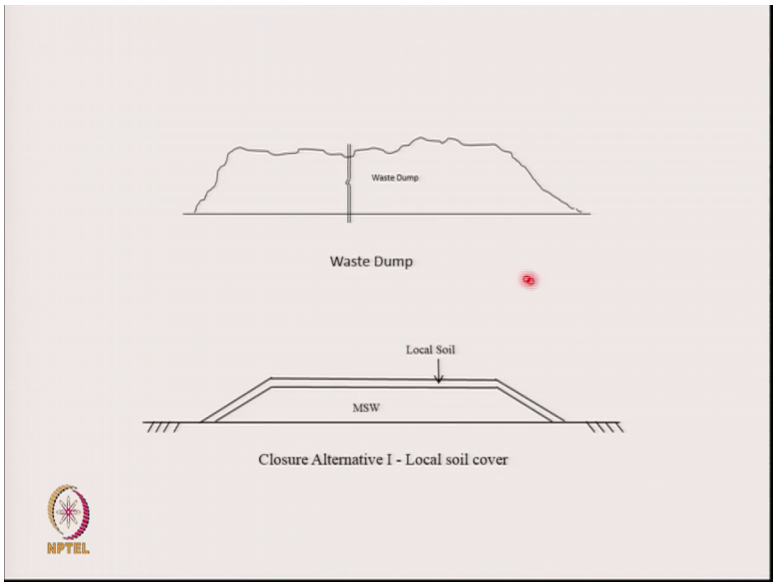

So, what are the alternatives for closing a dump? I have this dump the simplest and the cheapest alternative is to grate it and put local soil on top, out of sight out of mind. Beautiful grass please grow beautiful green grass and say I have rehabilitated the dump I made a park instead. Does not always work, but this is the cheapest and one of the alternatives which these are tendency of municipal corporations to adapt this. But then instead of a single soil layer may be you would like to put the municipal soil MSW cover, which we have done.

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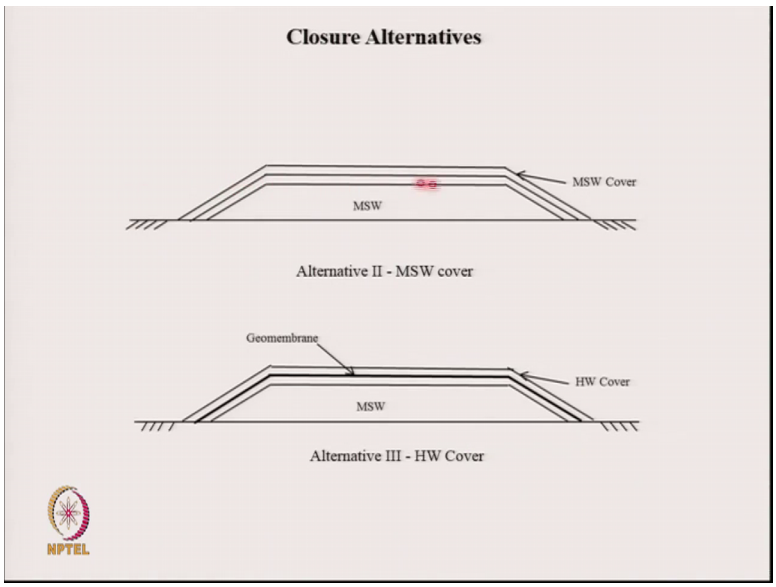

There the guidelines for it will have a top soil a drainage layer, a clay barrier, a gas collection layer and then the waste and passive vents. So, this is the second alternative. You want it to be more impervious you do not want any water to go in you might use a hazardous waste cover; that means, now you added on a geomembrane. Because there is no liner this is not a landfill if this was a land fill this cover is fine as long as there is a liner and leachate collection system, but this is an old dump. What else can we do?

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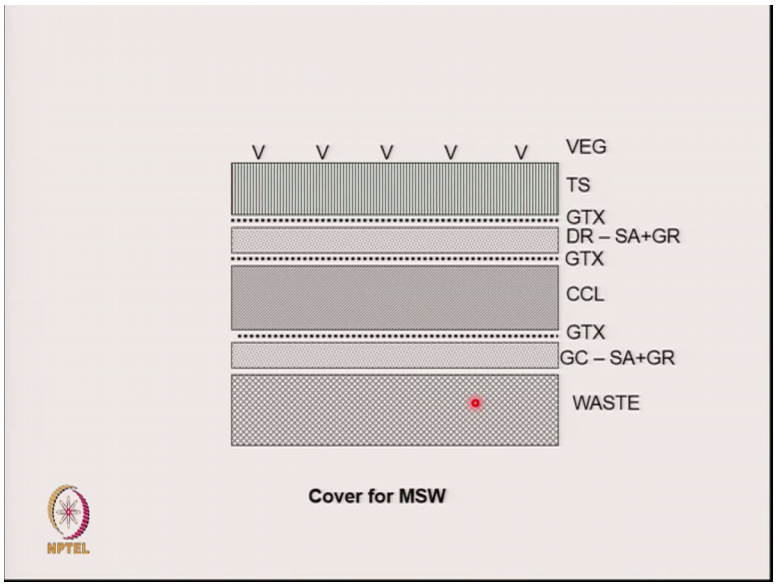

And just to this was just recalling that this the MSW cover and this is the HW cover which we can adapt.

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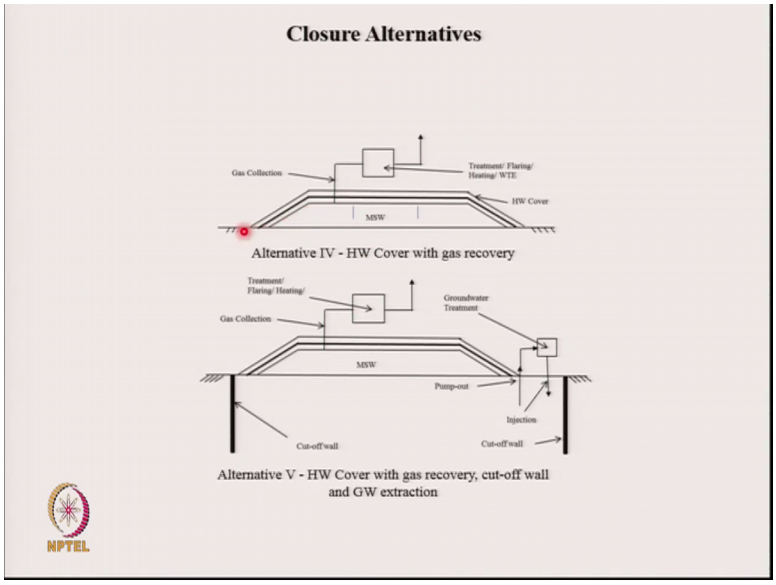

However you may want to actually completely eliminate the odor, add the greenhouse gases. Because if you are putting a hazardous waste cover with passive vents or a municipal solid waste cover with passive vents and greenhouse gas emissions are still taking place. So, then you might want to have a treatment or a flair or a heating or a waste energy unit you may collect gases using wells and other things. So, this is yet another alternative if your ground water table is closed and you are sitting on pervious soil just by doing all these nothing is going to happen because the plume is already moving. If the plume is moving then you need to put vertical cut offs.

So, this is yet another alternative, agreed?

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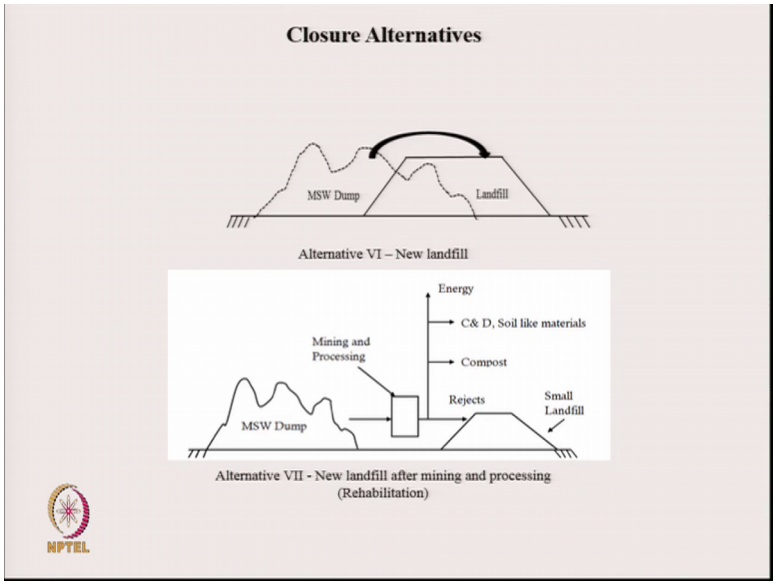

And if you have a little bit of land on the side may be you would like to put these dump into a new landfill, right on that area adjacent to it or may be a little far away. Expensive, but can be done it is an alternative it is for the community to decide whether they want to do this or not. But the ultimate rehabilitation which is being talked about today is if you have dump, you please mine it remove this take it out if you can get an edgy burn that portion you know take out the waste fractionate it using different sieves. If you get a lot of cloth and plastics and paper burn it. If you can get compost out of it; that means, old soil with organic carbon in it then you can use it as a compost if you can get building materials construction and demolition waste which you can use as a aggregate use it. And finally, this huge dump should become this small rejects, this is called landfill mining and this rehabilitation. It is not a remediation still because you still are not going to occupy the land to the smaller land filth.

So, these are the alternatives which exists as far as closure is concerned. Any questions? Any doubts? Any other alternative which comes to your mind? You can become progressively stringent, that is what I am saying. So, I put those 7 alternatives local Soil cover municipal solid waste cover, hazardous waste cover, hazardous waste plus gas treatment, hazardous waste plus gas treatment plus ground water.

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Closure Alternatives (I to VII)

Alternative # (Short Name)	Remedial/ Closure Measures
I (LS)	Re-grade top of dump, nominally re-grade side slopes and provide local soil (LS) cover of 45 cm.
II (MSW)	Re-grade top of dump, re-grade slopes, provide cover as per MSW rules, compost window, passive gas vents, surface water drain and leachate drain/pit
III (HW)	Same as II but with cover as per hazardous waste (HW) rules (geomembrane as additional barrier)
IV (HW+ Gas)	Same as III + gas collection wells and flaring/ utilization/ treatment
V (HW+Gas+GW)	Same as IV + vertical cut off wall and ground water extraction wells with treatment
VI (New MSW)	Excavate and place in new lined landfill (in same /adjacent/local area) as per MSW rules, provide compost window and passive gas vents
VII (Mine+New MSW)	Excavate and process the waste to recover resources and place as in G.

Pump and treat with slurry walls put in a new municipal solid waste mine and put in new municipal you have the 7 alternatives, which are increasingly expensive as you go down.

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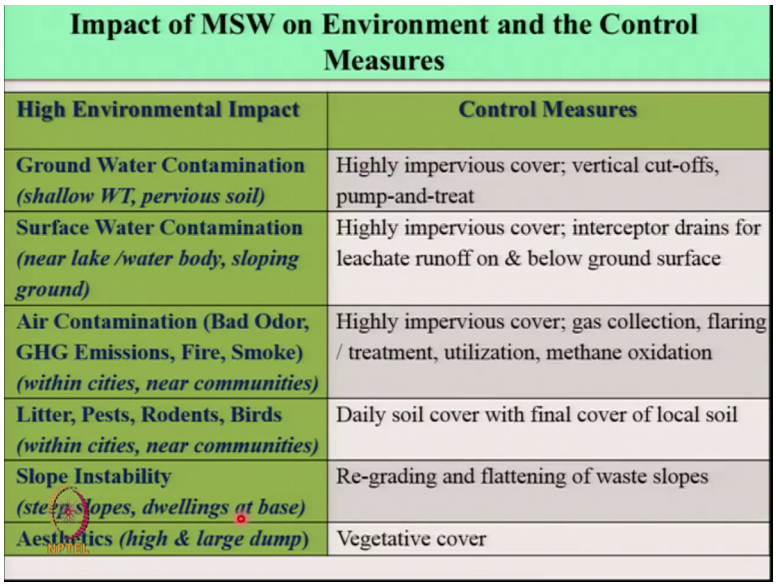

Impact of MSW on Environment and the Control Measures	
High Environmental Impact	**Control Measures**
Ground Water Contamination *(shallow WT, pervious soil)*	Highly impervious cover; vertical cut-offs, pump-and-treat
Surface Water Contamination *(near lake /water body, sloping ground)*	Highly impervious cover; interceptor drains for leachate runoff on & below ground surface
Air Contamination (Bad Odor, GHG Emissions, Fire, Smoke) *(within cities, near communities)*	Highly impervious cover; gas collection, flaring / treatment, utilization, methane oxidation
Litter, Pests, Rodents, Birds *(within cities, near communities)*	Daily soil cover with final cover of local soil
Slope Instability *(steep slopes, dwellings at base)*	Re-grading and flattening of waste slopes
Aesthetics *(high & large dump)*	Vegetative cover

Now, if you have a landfill which is having one high impact. Can you tell me when will the ground water impact be high? You have a waste dump when will you say that in this side ground water impact is high or you know, same ways dump here the ground water impact is low. So, what are the variables which you will consider for ground water impact?

Student: (Refer Time: 18:41) family whole it is.

Well the first is where is the ground water table. Is it near or is it deep below. So, if there is no ground water in the first hundred meters below then ground water is not an issue, but if the ground water is between is 5 meters below ground water contamination is an issue. And as rightly said the second issue is are you on permeable strata. And the third is are you in a higher rainfall area.

So, if you have (Refer Time: 19:11) or pervious soil, shallow ground water table higher rain fall ground water can be impacted. Just flip it around when will it not be a major problem. You have clay water table is not at shallow depth, but deep below, and we are in a relatively aired climate, when ground water contamination is not a problem. That does not mean other things are not a problem. If ground water contamination is not a problem, you can have odor as a problem. So, first what we see is, ground water contamination is a high impact factor if you have shallow water table pervious soil and you can add high rain fall, when a surface water contamination going to have a high potential. When we

are sitting adjacent to a water body and worse if you are sitting adjacent to a water body where the water is not a running water.

So, if you have a lake or a pond then water is not being if you have a river water is flowing by some contamination will go it will flow down, but of you have a lake or a pond you are accumulating water and if some black dark brown colored leachate goes into it will contaminate it. So, surface water contamination immediately is a problem if you are at near a lake or a water body you have sloping ground. When is air contamination problem? When people are around, I have a dump which is in a very remote area, it will create smell it will create dust litter smoke fire greenhouse gas, but there are no people around it. So, if the receptors are not there it is not that major a problem. You have a much smaller dump in the middle of a city, huge impact because the receptors are getting all kinds of problems you are getting air pollution the quality of the air is falling.

So, air contamination in terms of bad odor greenhouse gas, emissions fire smoke, when the dump is within the city or is very near to communities is a big problem and this not an issue about the dump being small or big. You have a source of smell it is going to be typically that smell is significant up to one and half kilometers. And depending on wind direction it can be up to 3 kilometers. So, you know these are the type of situations in which you can have different impact; the same waste will give you different impact. What happened in Brazil? Slope instability, why? Steep slopes dwelling unit is where on the slope. We have a high impact of slope instability.

Aesthetics you have a high and large dump the dump is this big and the dwellings are this small. So, you drive up to it. And for each of them there is the solution. We have talked about the control measures and there is the solution. And just for aesthetics a vegetative cover is fine. But if you have groundwater contamination you need a highly impervious cover hazardous waste cover vertical cut off walls and pump and treat. Surface water contamination highly impervious cover interceptor drains so that the leachate does not go along the ground to the lake on and below the ground surface.

Air contamination highly impervious cover, but collection systems collect the gas collect everything, burn it, flare it, treat it, deodorize it, highly impervious cover active gas collection flaring treatment utilization methane oxidation. So, we have different solutions

for different problems out of these 30 waste dumps that we talked about. We did the relative ranking for 12 of them. These are the big waste dumps of the country.

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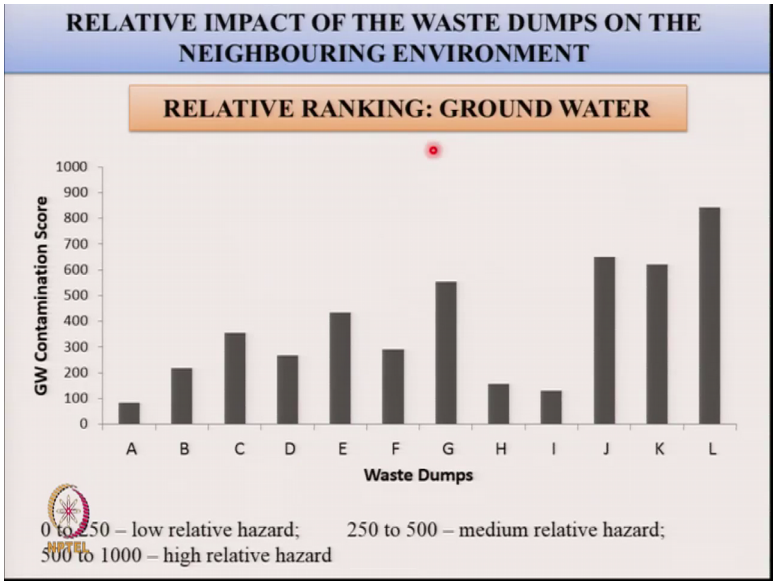

Now I do not want to go into the relative ranking systems, but if I am doing ground water rank hazard the important factors are depth to ground water table, rain fall and perviousness of the soil.

So, you please find in a 0 to 1000 scale, waste dump jkl have high impact. Probably the ground water is shallow and the soil is pervious they are probably in the (Refer Time: 23:25) I am, I am not showing you where these are. But other dumps may not be that bad. If I look at surface order contamination same dumps which are very jkl at a high ground water contamination potential, but here h has got high, why? Because h is sitting next to a lake. It is on clay. It is on clay, it is not going to have a high ground water impact. But the water will go off clay will not allow the rain water to come in it is an open dump and it is sloping towards the lake it will go in to the lake, or it is a fresh water wet land I am not I would not be surprised if this is the Dhapa landfill of Calcutta. The Dhapa landfill it is sitting next to a fresh water wet land, which is called a Ramsay sight which is now almost protected land.

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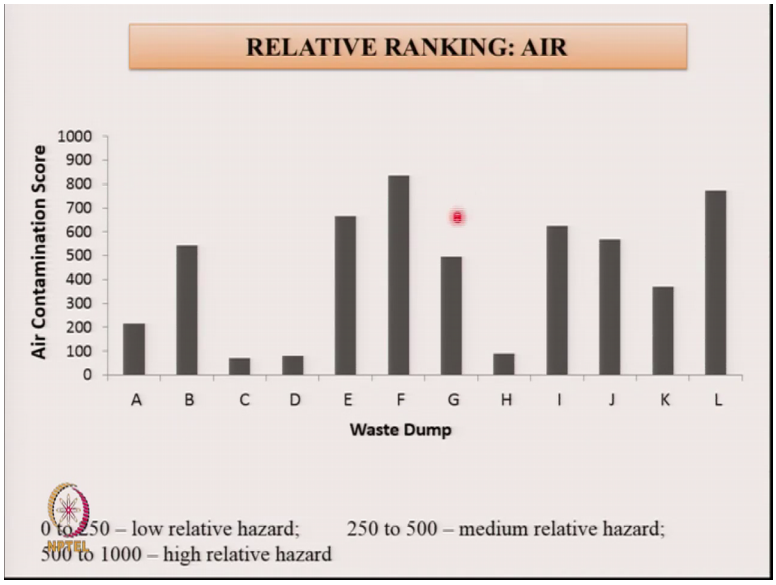

So, and if I look at here then Dhapa is remote wet land far away or whatever, this landfill was it has been come very low nobody around it, but these are the one which are within the cities. If you are within the city you are in air impact is very high.

So, different landfills in different geographical and environments it sub soil environments will give you different ratings. So, what do we do? I come back to my 7 systems I can do local cover municipal solid waste, hazardous waste, with gas recovery with extraction wells, put in a new landfill and mining.

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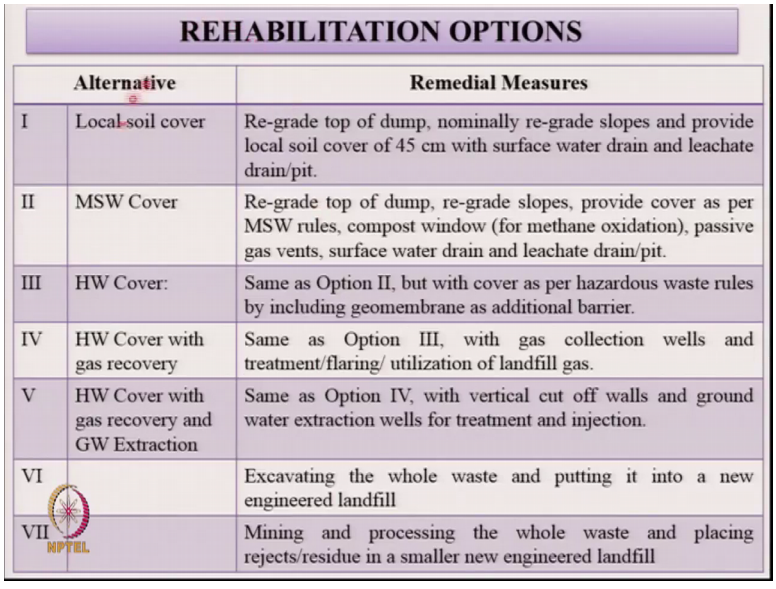

REHABILITATION OPTIONS

	Alternative	Remedial Measures
I	Local soil cover	Re-grade top of dump, nominally re-grade slopes and provide local soil cover of 45 cm with surface water drain and leachate drain/pit.
II	MSW Cover	Re-grade top of dump, re-grade slopes, provide cover as per MSW rules, compost window (for methane oxidation), passive gas vents, surface water drain and leachate drain/pit.
III	HW Cover:	Same as Option II, but with cover as per hazardous waste rules by including geomembrane as additional barrier.
IV	HW Cover with gas recovery	Same as Option III, with gas collection wells and treatment/flaring/ utilization of landfill gas.
V	HW Cover with gas recovery and GW Extraction	Same as Option IV, with vertical cut off walls and ground water extraction wells for treatment and injection.
VI		Excavating the whole waste and putting it into a new engineered landfill
VII		Mining and processing the whole waste and placing rejects/residue in a smaller new engineered landfill

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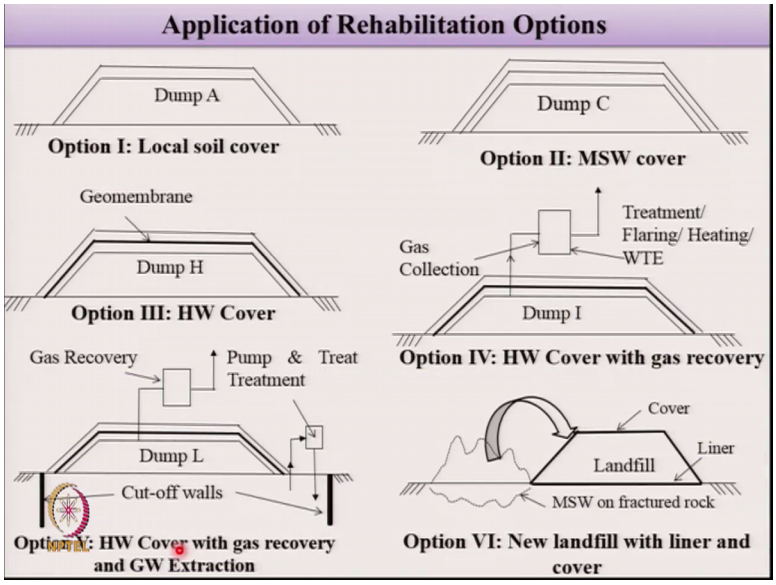

And these are your options, local soil cover municipal solid waste cover, hazardous waste with gas recovery (Refer Time: 25:11) extraction well like this. So, tell me where will you adapt this. When will you adopt a local soil cover, only a local soil cover.

Student: (Refer Time: 25:22) rainfall

Even if it is low rainfall. So, what it can still contaminate if it is on pervious ground and water table is at 2 meters depth, it will contaminate the ground water. So, one it is remote right, 2 it may be low rainfall area. Still you do not want to contaminate the groundwater. So, my answer to this is if you have cleared the bottom. If you have cleared the bottom it becomes a natural barrier. If water table is deep below, rainfall is low and your remote, if you are not remote if you are with in a city please understand what I am saying. You can put a local soil, but the smell is keep on coming out, because it is coming out slowly it wot come out that badly if there is no cover.

So, if you have a remote dump, second one clay, low rainfall area, away from a surface water body, you just put a soil cover and it will work. The same if you bring it in to the city if this will not work, when put up municipal solid waste cover. If the as I said you put a municipal solid waste cover over liner exist at the bottom. So, if you have natural clay at the bottom, if you have natural clay at the bottom then you will design it like a new land fill. So, a municipal solid waste cover can be used. But do remember gases will still come out because this is not designed for greenhouse gas emission control. When will we use a hazardous waste cover? This is on clay, this is on clay, this is on clay, but if

this is close to a water body, please understand if this is close to a water body in a municipal solid waste cover leachate will be formed because it will not be completely eliminated. So, it can grow to the surface water body if the ground is sloping.

So, close to a water body we are (Refer Time: 27:47) on clay just encapsulate it with a composite cover. That will prevent any water from going in and spoiling everything. When will you use this active gas collection and flaring? Sitting on clay, but you are in a city. The residents will not tolerate bad odor. Because it depresses the real estate in a city if you have a bad odor dump please take a 2 kilometer radius around the dump and all the real estate properties will be depressed. If the rate of selling the property is 10000 rupees per square meter at a location x, the one which is close to the dump will be selling at 2 thousand rupees square meter. Who will stay there who will [FL], right?

So, if you close it and you treat it and there is no odor and this is on clay this is inside a city. And when will you do this? And not this? If by chance you are in impervious soil then inside a city then you have to add on the vertical cutoffs. Then you have to add on the vertical cut offs. Of course, finally, you may want to say no I do not like all this I do not know whether my vertical wall is made properly or not, I still have a risk I want 0 risk. Then I will make a new landfill for you. With a leakage detection system and I will put all the waste in it very expensive, but is got to be done.

So, these are the levels of options for the rehabilitation. The problem here is once you close this. You cannot put additional waste and cities do not have additional land. So, you have to build in expansion with your closure and rehabilitation option. So, where ever the height is not very high, you can know look at what are the expansion alternatives. So, let us say I have this much land by god’s grace.

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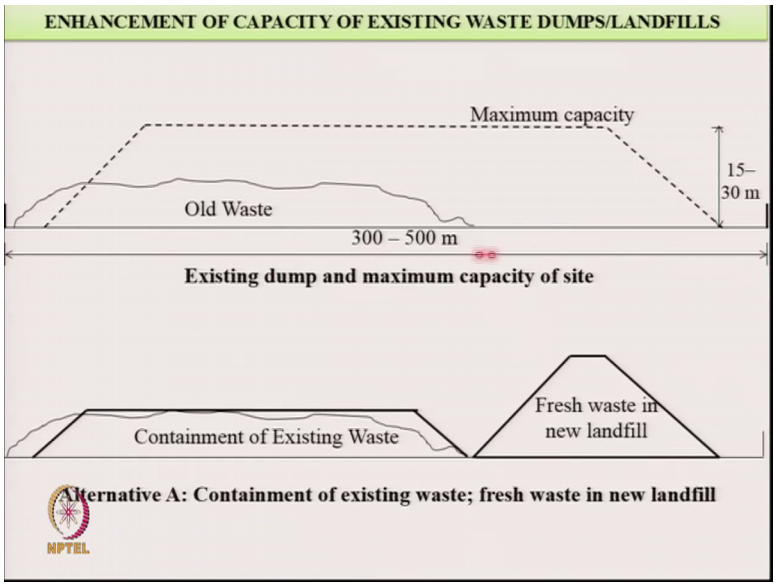

I have only filled this, well let us say this is 300 to 500 meters on my old waste dump is only here. Now clearly the moment I see this land leaving the place for road and green belt and leachate pipe I can see that this is what my landfill should be look like. And typically it should be 15 meters only 30 meters, if you do not have any other location.

So, one thing is very clear I must use this space if I can. Now how do I use it. One option is contain this whether by this or like this whatever, but you do the containment as per the 7 alternatives which should give an earlier. Now for their fresh waste you make a new landfill. It is a very not such a good technique why you still have lost all this space which you could have utilized. And all this space which you could have utilized. So, this is alterative a this is one technique which can be used, but only to be used if this wait has waste height has become very long very high.

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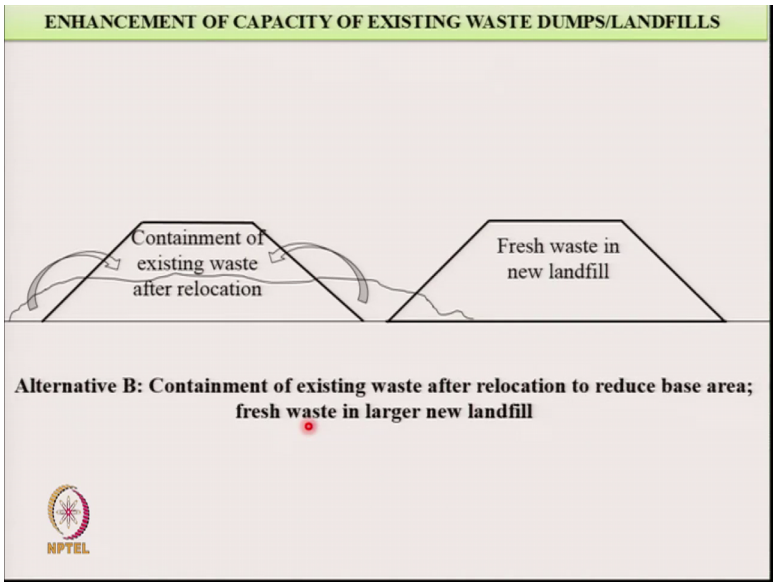

The other alternative is, I pick up this waste from the low height area and I will put on top ok.

So, what will happen more space will get released for the new land fill? I pick this waste put it on top, put it on top and close it as per the 7 alternatives that I have. That is a capped land fill. Now I have a larger landfill which emerges. So, this is good this is better than alternative way, right? But still I am not using the full space I want to use the full space.

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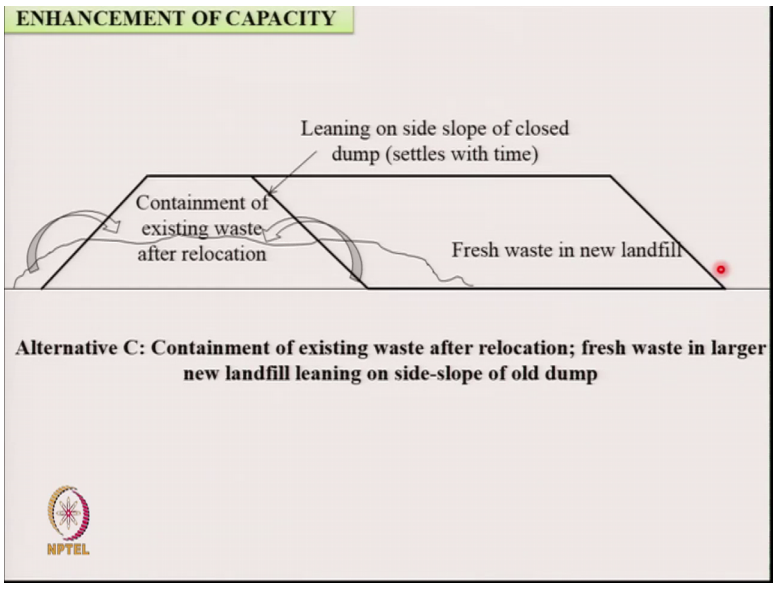

Just look at 3, alternative 3 is I pick up the waste and put it on top and I close this landfill. And I make my new landfill like this, do you like it? This as a liner this is the cover, this is the cover, I do not know what is this is supposed to be liner.

So, I can always make this like a liner right, but the problem with this is it is leaning on this and you know this is going to undergo bar degradation settlements will be large over the next 20 years. So, this liner may have to settle a lot and it may undergo rupture or some kind of defects. So, the liner may not function. So, there is a risk involved in this, but now I have use my full space.

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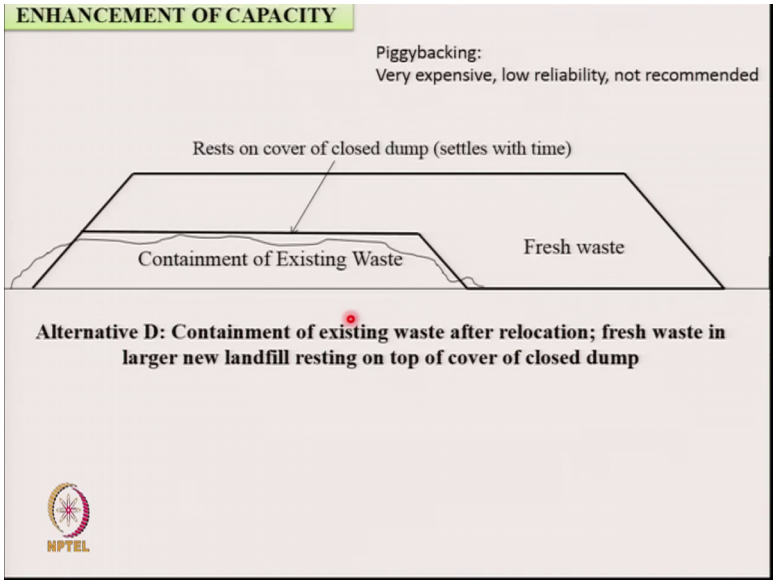

Yet another alternative is why should I waste the money to pick up this and put it on top, pick up this and put it on top, and then do this let me do the following. This is called piggy backing. This is my old landfill, I will close it and I will raise my new landfill on top of the old landfill. This is called picky backing in America. Here it says piggybacking very expensive, low reliability not recommended. Because this is going to settle. Suppose this is 10 meter high waste if I am having settlements of 15 to 20 percent over the next 20 years. This will settle by one point 5 to 2 meters. If this we settles this liner will go like that. And I cannot tell you whether the liner will malfunction or not, agreed?

So, this is piggybacking it can be designed you have to put 7 layers here, you can design for a very deep settlement also, but then it becomes prohibitively expensive. So that expenditure has to be compared with relocating like this expenditure.

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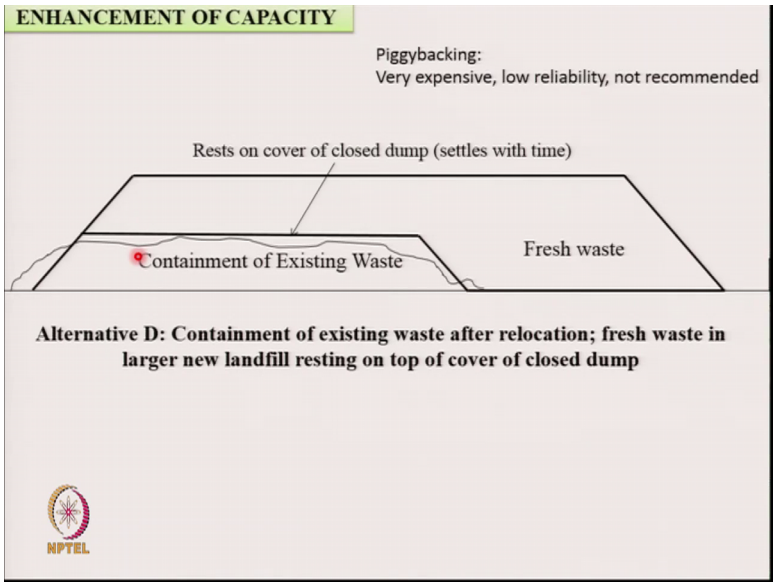

So, this was alternative d, other more alternatives yes. Let me start a new landfill in this end, let me put a liner. Let me pick up this waste and put it in this landfill. And then as I have finished this entire waste here then I move forward with a new waste.

So, in this there is a liner completely below. Now any relocation of waste will create some odor. So, the residents will complaint while your a relocating the waste, remember that? But it is a it is something that you can do in 6 months. And then you have a completely fully contained landfill, more expensive because you have to move all this waste from here to here. Finally, of course, the rehabilitation, the mantra of today take this waste, put up a mining unit. What is the mining unit? Dig the waste dry it (Refer Time: 35:12) use sieves normally the course fraction will either have bolder or cobble size construction and demolition material or it will have plastics and cloth and wood and cardboard and burnable materials. So, send some of the material for burning.

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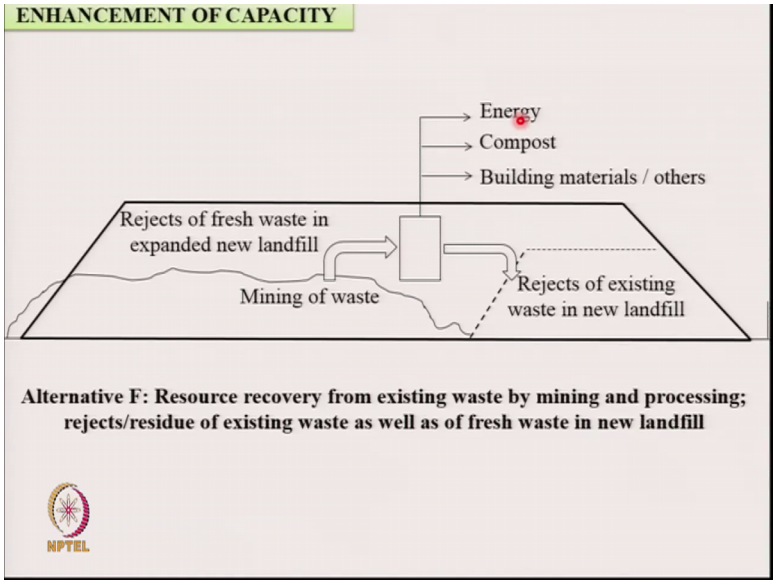

Some of the material for building Materials what will remain at the bottom in the fine fraction will be like compost or soil this question is on. So, you can use all that material the rejects will come, but now they will come in a much smaller area right. And your new ways will also come through this plant and you will have it will be accommodated in a smaller area.

So, these are the alternatives for closure with expansion. And all cities need this and not closure. So, I will give the example of gorai landfill which was closed. And there was a big problem because after that where will the waste go then it went to the deonar, but this was quick recap this was the landfill.

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I have probably shown these figures to you that is the leachate that is the creek.

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And the idea was That this waste was about 15 meters high 15 to 18 meters high.

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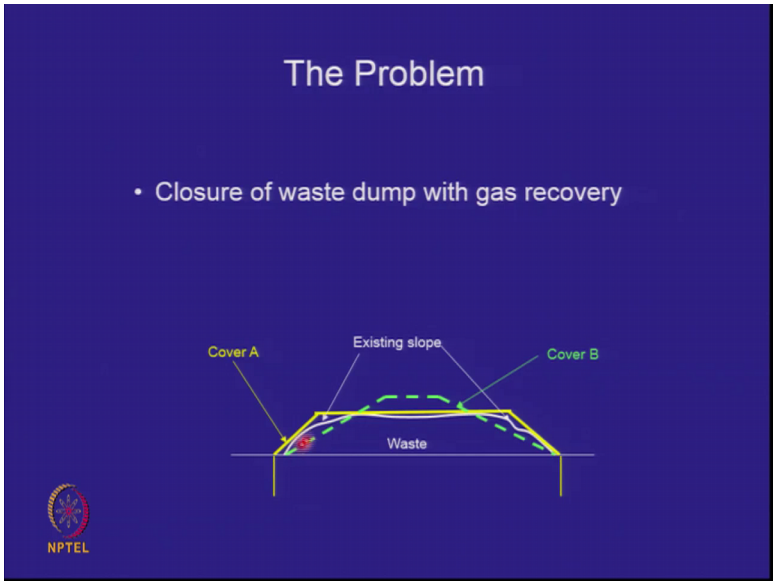

The slopes are very steep and we thought we could put a cover like this. It was sitting on clay, but still some vertical cut off walls were attempted. But the final solution was that this was too steep for the slopes to be because there was a geomembrane in the cover.

So, therefore, we put we put a relocated this wastes. So, this slope was made flatter therefore, this went higher. So, this 15 to 18 meters became 25 to 30 meters high. And you were able to make a stable landfill, but this is not expansion. So, just to remember this is making the slope flatter.

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And that is putting the cover on top and these are bumps. So, it is it is a composite [FL].

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This is making the vertical cut off wall we will be doing this later, but you can it is like a vertical bar from wall.

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There is a vertical cut off wall at the base the work is going on. And putting gas wells you had because you are putting a geomembrane you are recovering gas from it.

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That is the gas flaring system, and that is how the land fill looks like in the end.

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Cannot put in any more waste much more flatter than what you saw in the beginning, but higher and greener and you know all around it you can see this houses there was the houses on this side also very close. So, well I was one of the consultants to the project. So, there were local I was said local estate agents [FL]. So, being a professor how to choose life.

So, being a professor I didn't make that investment. But the flat the cost of real estate went up 10 times in a year and half. When this got capped the odor went. There is still a little bit of odor. I but is no comparison to what it was earlier. And therefore, all the area now has got real estate around it. Can you see this new buildings?

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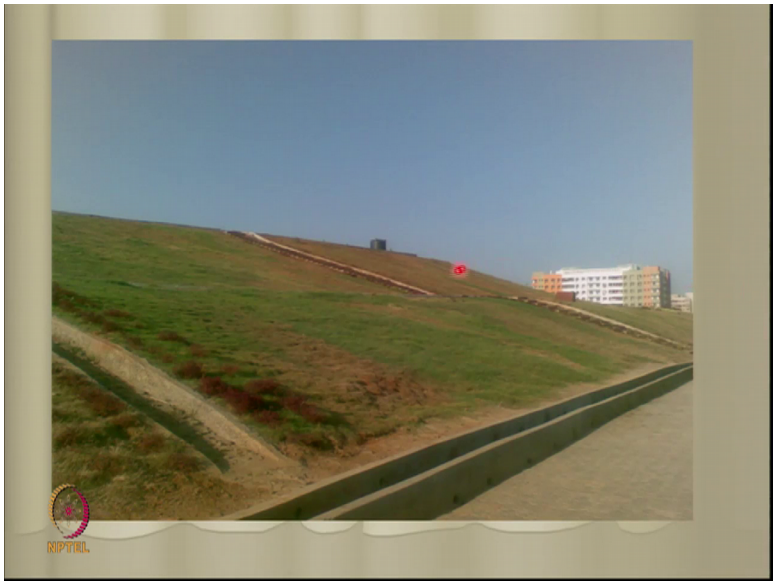

Only if I had made some investments, the second example is deonar where it is? Expansion also, the waste dump is like this.

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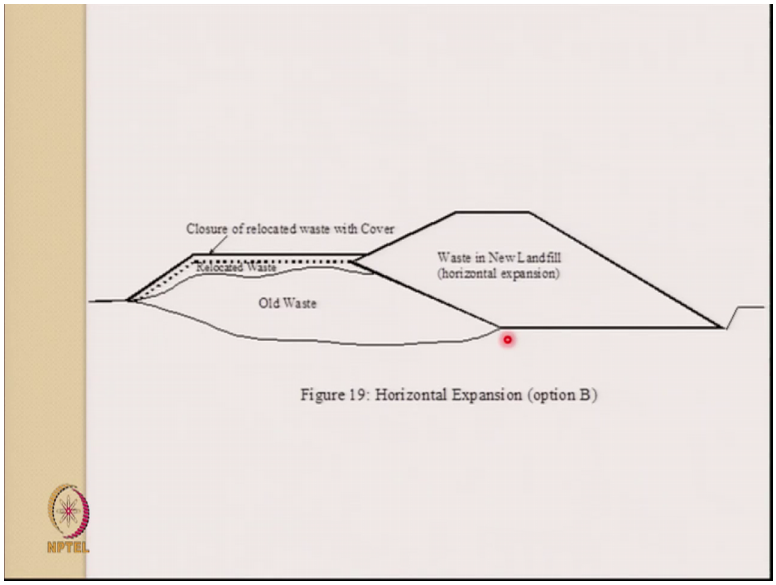

Little bit area is lying here. Various alternatives were considered you will close it, you will put the vertical cutoffs soil vertical cutoff wall. You will make an additional landfill for the new waste, you know? Because there was some area. Or we will do piggy backing or I will put the waste into this and then put the future waste like this. Or I will put it here, is it the difference is here you have to move more waste, here you have to move less waste and then by new waste will be like that all. These alternatives were tried, but finally, I will move the waste here and make my new landfill. This is the one which was adapted. This was not adapted because nobody could give a hundred percent assurance that this side slope liner will not fail because of lot of settlement.

So, this is the final thing which was adapted that was the topographic 3D view.

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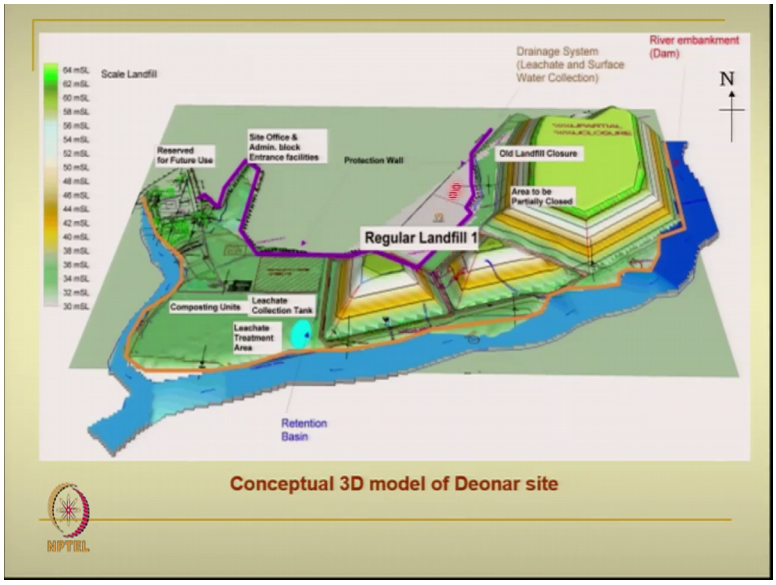

This is what it is. This is the old dump which will close, these are the 2 new landfills this is the compost plant and all that processing I come back again. This is c, can you see the c? Like a this is a c. This diagram is a [FL] c. So, please do not mind. If you look at it from that side it is a c. So, there old dump all this waste will be picked up and put on this old dump. And new landfills will be developed here, and this will be the waste processing unit.

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So, this is again the something waste dumping develop. That is the old waste dumping height is being raised this is the new landfill being constructed.

This went in to dispute and the operator moved off from the sight. And they were a lot of fires later, last year and last to last year were you heard about it. But when these people where in control of this site and we were also involved they were no fires and this was proceeding very wonderfully. And this is expansion with closure. So, thank you we have discussed a very major topic, because this is something which is you know occupying us all, that how do you handle these old huge old waste dumps. And really we want to gobble them up and utilize the waste.

But what comes out from a landfill is everything utilizable or it is not that is the scope for discussion on landfill mining. And as more and more experience and more and more data comes available you see whether towards the end of this lecture we end of this course we can address that issue. At the moment there is nothing that exciting, that if I have hundred percent area my landfill will by landfill mining will give me 80 percent back, no. If you do landfill mining hundred percent of the area may reduce to 70 percent, but you do not have very drastic reductions as of now.

We will stop here, any questions? Anybody has some new thoughts? Some new ideas as to what we should do with this beautiful old waste dumps which are like you know monuments of the city. Any city you go to first ask them, [FL]. Then only you say [FL] how good or bad a city is. Because if they manage the waste well, if they manage the sewage well, if they manage the garbage well, then it is a good it is a well planned city. We will stop here, have a good day.