Geoenvironmental Engineering (Environmental Geotechnology): Landfills, Slurry Ponds & Contaminated Sites

Prof. Manoj Datta
Department of Civil Engineering
Indian Institute of Technology, Delhi

Lecture - 08
Planning of Landfills - Part 1

Good day. And welcome back to at another lecture on Landfills. Today we are going to discuss planning of landfills and if you recall last time we discussed principles of landfills the whole philosophy of how landfills are designed and we introduced the principle of containment; that means, you isolate the waste from the environment. So, let see what we are going to do today. So, as I said we are looking at planning of landfills.

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And today we will cover these topics. In the next 2 lectures design life, waste acceptance criteria, site selection, site characterization. What was the landfill look in plant it is layout, what was the landfill look in section?

How do we estimate the capacity of a landfill, what is the concept of phased operation how do we manage the leachate and the gases which are coming out, what are the design aspects that we have to look into and what is the closure and post closure plan; that means, when we walk off a landfill how do we deal with it. Let us quickly recap very briefly what we did last time.

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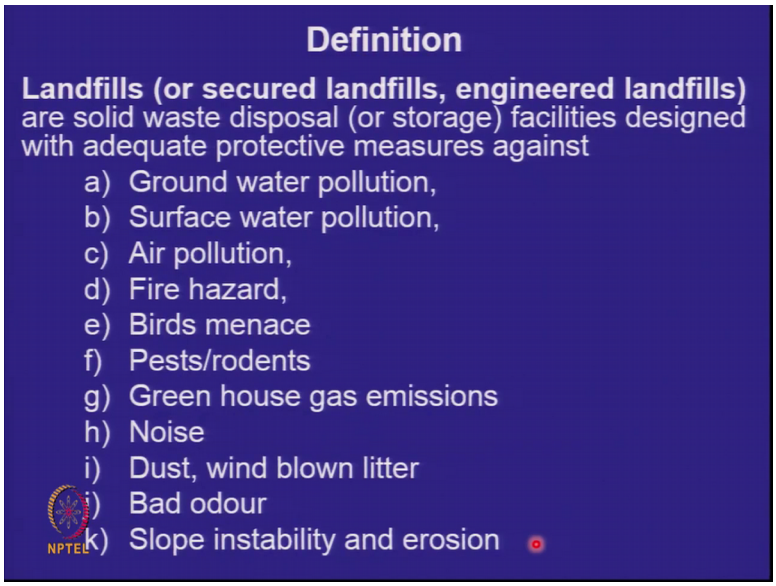

We talked about landfills being solid waste disposal facilities, designed with adequate protective measures against all this, ground water pollution, surface water pollution, air pollution, fire birds, menace, pests, rodents, greenhouse gases, noise, dust litter, bad odour slope instability and erosion.

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And we talked about basically 3 types of landfills adjacent to city hazardous waste landfills nonhazardous waste landfills. Hazardous waste landfills for industrial waste

nonhazardous waste landfills for municipal solid waste, inert waste landfills for construction and demolition waste.

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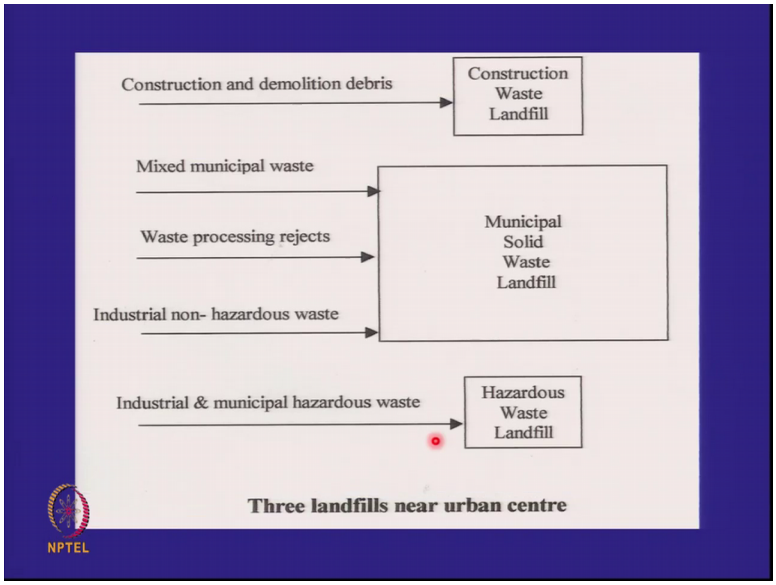

In addition, we said if we have thermal power plants or mine tailings nearby then we will have mono fills for these high volume wastes. And special landfills are designed for highly toxic and radioactive waste. We also said that a city could have 3 separate landfills, one for construction and demolition one for municipal solid waste and one for hazardous waste.

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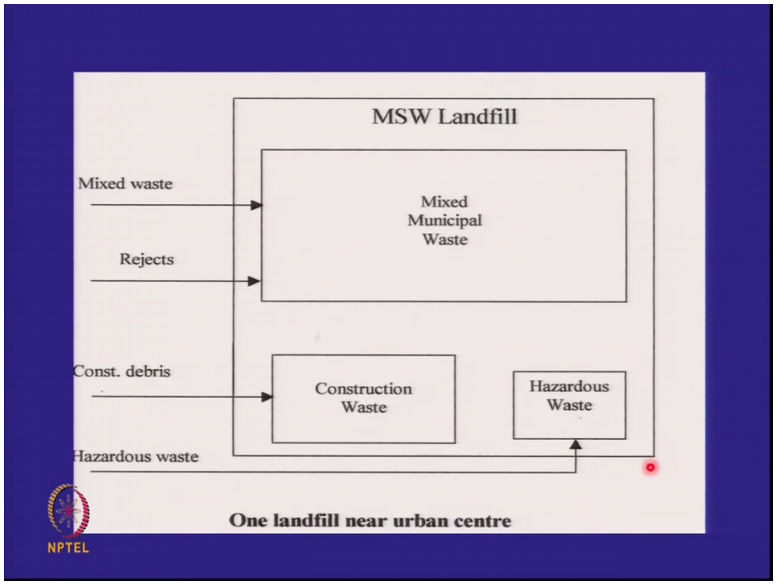

And we said all of them could be in one location together; that means, it could be largest part would be the mixed municipal waste, but construction waste and hazardous waste could also be in that area. Now the advantage of this is if you put them in one place then the infrastructure facility is required are only one. For example, you will have a entrance and a way bridge, if these are in separate 3 locations. So, for each location you will have to have a way bridge you for each location you will have to have an environmental monitoring facility, whereas, if all 3 are together we can do the infrastructural overheads are much minimized if we have all of them in one; however, it will depend on the distances involved.

If you are large municipality or a mega city and your transportation costs are very high then you may not put them in one place then you may put them in 3 separate places, but I would like you to see what is happening now.

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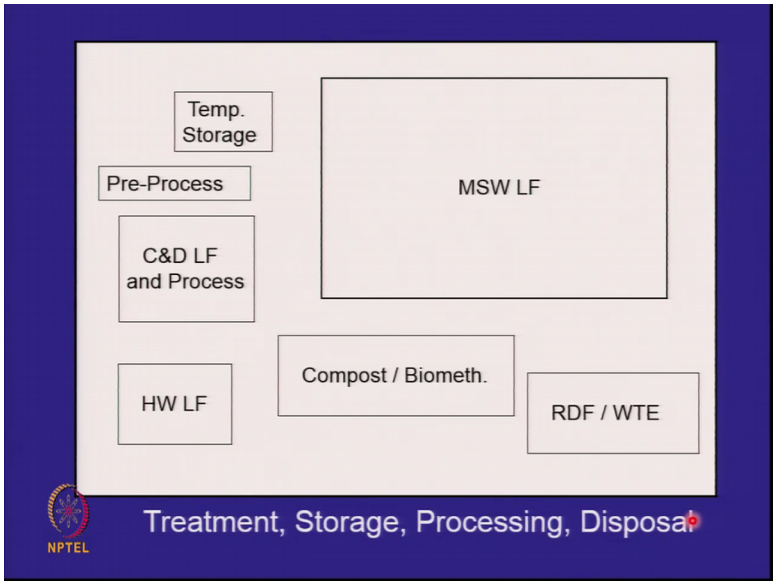

So, if I look at a huge facility that we create see what is happening the municipal solid waste mixed municipal solid waste is here. The construction and demolition waste is here the hazardous waste is here. So, these 3 components is what we saw in the last slide, but what do we have more at this site we have a temporary storage; that means, if the waste is not going into a landfill it has to be preprocessed or if it is monsoon and it cannot be placed you have a temporary storage procedure facility you have a preprocessing unit.

That is what will go where will all the ways to go directly here or will some of it come here after preprocessing. And in addition you may have a composting or a biomethanation plant and you may have a RDF and a waste to energy plant on the same site. So, as the importance of processing and the investments in processing increase this will become smaller and smaller. Because this is now no longer the original municipal solid waste, it this is the rejects from everything it is the rejects from here it is the rejects from here and it is all that which could not go. So, the preprocessing will send some materials.

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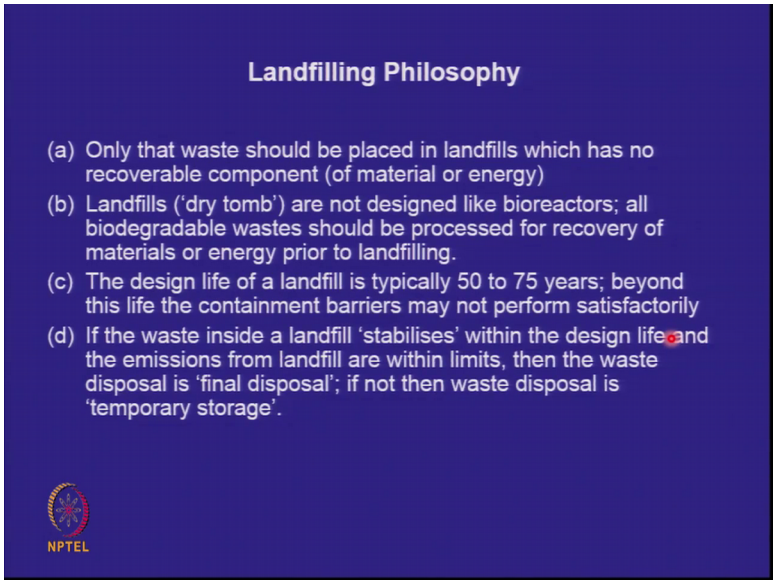

So, this will become smaller with time and these will become bigger with time.

So, just to recall the land filling philosophy which we have done last time only that waste should be placed which has no recoverable component. Landfills will be designed like dry tombs no water in no water out and not. Like bio reactors and the design life will be typically 50 to 75 years beyond which the containment barriers may have to be reexamined and we may have to re excavate the waste and reconstruct it if the waste is not stable if the waste is stable, it can be homogenized with the eco system. So, if the waste stabilizing then the waste disposal is final, if the waste does not stabilize in 50 to 75 years then the waste disposal is temporary storage.

So, last time we said is there any other way of doing this or is this the only way of doing it. So, I asked you to read up about bioreactor landfills. So, would you like to tell me

what you found out, what is the main difference between a dry tomb landfill and a bioreactor landfill?

Student: (Refer Time: 06:30).

So, it is being said that in bioreactor landfills you are recirculating the leach ate and is that all.

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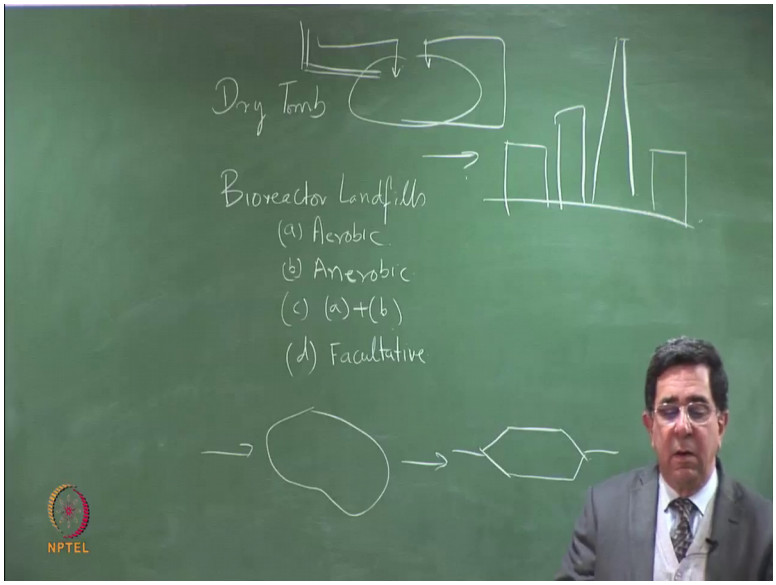

So, there are 4 types let us put them. So, I have talked about dry tomb and you are talking of bioreactors. Incidentally I can recirculate the leach ate in a dry tomb also there that is just one of the leach ate management strategies that you have. So, in bioreactor landfills you said there are 4 types of bioreactor landfills just tell me.

Student: Aerobic and anaerobic.

Student: (Refer Time: 07:30).

Pardon.

Student: (Refer Time: 07:38).

Facultative: so you have to remember that the basic concept of a bioreactor landfill is that the waste which is coming in has got significant biodegradables. What we are saying is that all the biodegradable should go to a composting plant or a Biomethanation plot. So, let us compare this is a bioreactor landfill right with let us say looks something like that. And this is a factory or a close industrial area sorry could close industrial buildings where the waste comes in for other purposes like Biomethanation. So, the bioreactor landfill is an open area bioreactor. Whereas, if you do a thing like containerized Biomethanation or containerized composting anaerobic or aerobic, then you have everything in a controlled environment.

So, there are 2 differences controlled and uncontrolled right. And I talked to you about composting last time I said if you do windrow composting and how much time a windrow composting is aerobic. In how much time does the way stabilize? Do you remember that I had said that you can make these long windrows you can turn them over every day? Well I said in weeks the waste will stabilize in weeks right and remember windrow composting is also open and. So, they should put it under a shed it is not contained containerized composting.

So, containerized composting is more expensive. Windrow composting is less expensive, but gives more odor, but in any case we are talking here of stabilization of the waste in weeks. How much time does it is suppose some biodegradable waste comes into a conventional dry tomb landfill? How much time do you think it stabilizes in week's month's years tens of years?

Well, tens of years I can assure you that in a dry tomb landfill in which water is not coming in it you do not have enough moisture to degrade. So, we have in dry tomb landfill the way stabilizes in tens of years. So, for biodegradable should not come in well if you make a bioreactor landfill and how much time does it stabilize. So, it goes from tens of years to years it does not go from tens of years to weeks. So, I am just giving you 2, 3 alternative comparisons one in a closed container facility like this is the waste coming in. We have more control you have control over temperature we have control over humidity we have control over pH we have control over oxygen in a facility like this we can attempt to do control.

But it is not that closely possible there is rainfall it is some kind of an open air facility. Whereas, therefore, the dry tomb philosophy presupposes that everything will go to dedicated facilities which are geared for stabilizing the waste in a particular way, whereas the bioreactor landfill is just a faster way of stabilizing the biodegradables in a dry tomb landfill. So, I can recirculate the leach ate or I can send in air. So, the 2 variables which you are really controlling are sending in water and sending in.

Student: Air.

Air: so if I have a dry tomb landfill and if I take out the leach ate and recirculated or if I get fresh water and recirculated and if I get air and recirculated then it becomes like about a biodegradable; however, control is difficult I mean sometimes people have tried to accelerate these processes by putting in some accelerators you know and the process can go out of control. You may have a lot of heat you may not be able to control all the conditions that you want. So, ideally I mean trying to try controlling humidity here as inside a container.

So, you can control humidity in a container, but you may not be able to control humidity in a landfill. So, bioreactor landfills are good when the waste is. So, intimately mixed that the biodegradables cannot be easily separated from the other components then you might want to send this to a bioreactor landfill; however, if you are doing separate storage at source or even if it is not separately stored at source.

But if you can do pre sorting send bulk of the material to a composting plant or a Biomethanation plant or gasification plant whatever you want to send it because they are more dedicated. And they stabilize the waste faster. So, that is the concept. So, in some guess in some countries bioreactor landfills have come up, but they have still not come up in a very big way.

We still try and use them as an accelerated stabilized landfill, but then remember you are dealing with much larger quantities of leachate. And there are those associated risks that when you deal with larger quantities of leakage you will have larger possibilities of leakage. And you will have larger possibilities of instability of slopes if the pore water pressure inside the waste goes up. So, these are to be traded one of the other at the moment India is following dry tomb philosophy.

But it is open to all other new developments from time to time any question you would have on this because you studied on bioreactor landfills you use if you feel it still better you have got a way the various alternatives that we have. So, remember we have done this already.

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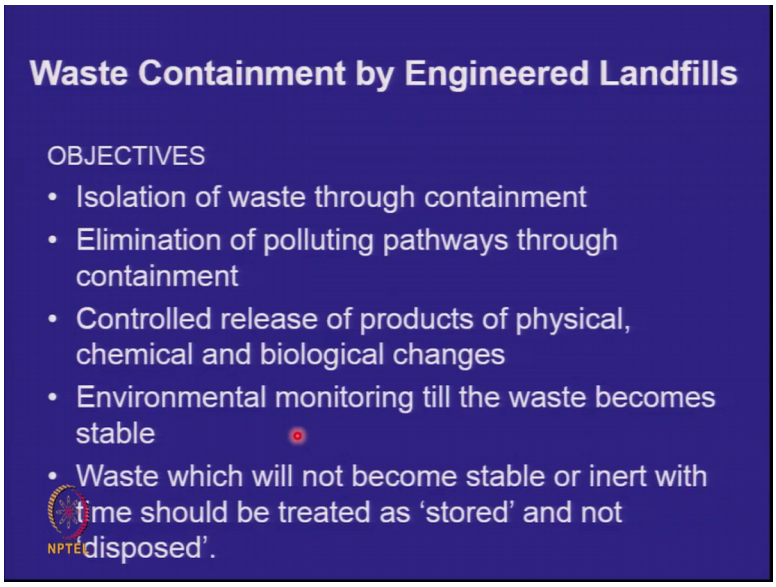

We are isolating the waste through containment. We are eliminating the pathways and we are still through the 2 straws having controlled release. We are not containing it and allowing everything to accumulate inside. So, we are isolate the ways through containment we eliminate all the pathways. We still allow controlled release of products we monitor till the waste becomes stable and as I have said that which is not stable is stored and not disposed.

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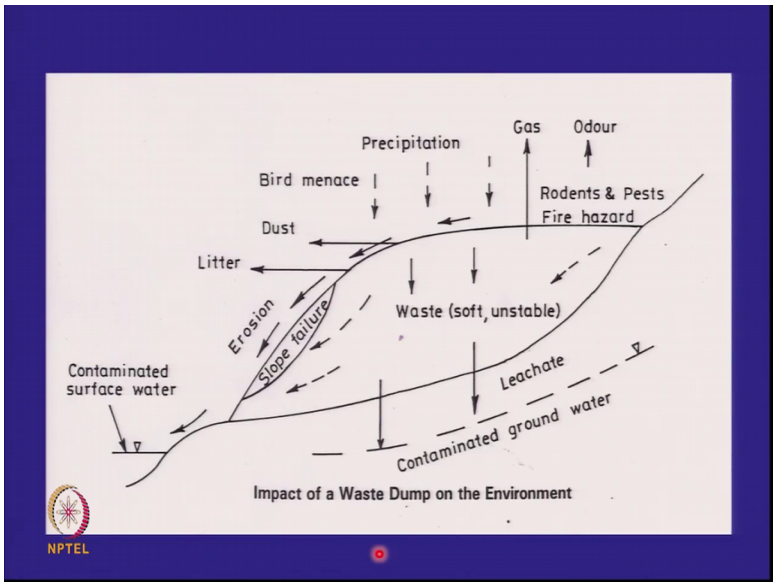

So, this is just an old shot to remember, how much waste dumped contra malas.

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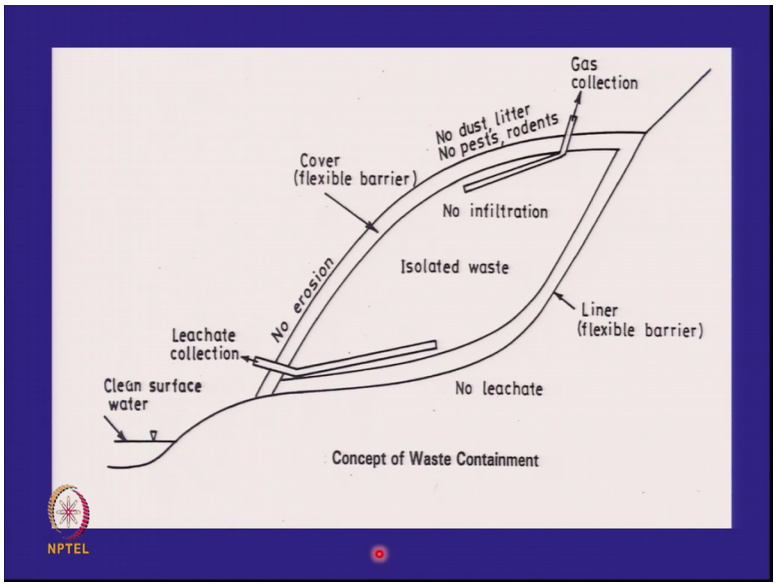

And that is the philosophy, and we said that if you have these 7 components a liner system a leach ate collection system.

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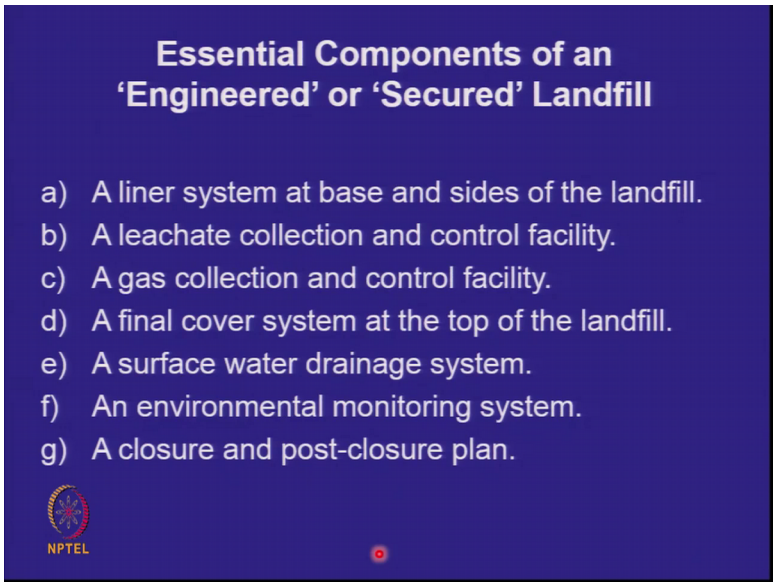

A gas collection system a final cover a surface water drainage system and environmental monitoring system and a closure and post player plan you have an engineered or secured or a scientific landfill.

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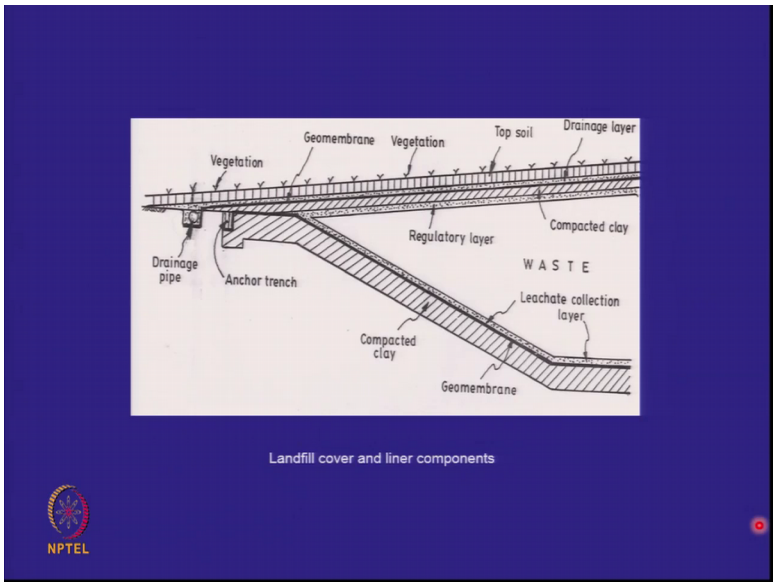

And this is what it looks like in it is true component form.

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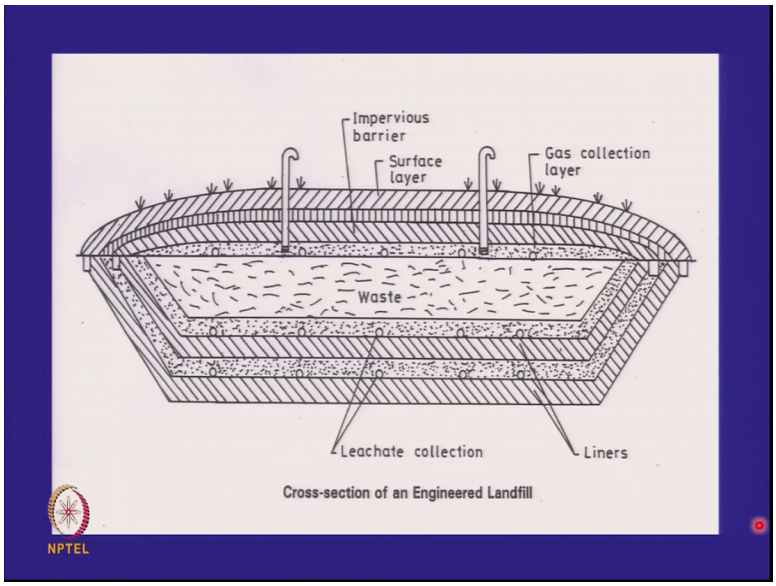

And if you look at an exaggerated view of the cover and the liner here, so of course this waste actually several meters or tens of meters high and these are only a meter or two, but this is an exaggerated view to show that it is got many components the covers and the liner are multi component systems.

So, the first question is; what is the design life of a landfill. And just to address this issue the design life of this building is 75 to 100 years. So, the larger I make the design life of a landfill the more area I need. You say I want to make hundred year landfill you have to calculate the waste that will come out you will have to calculate what percentage the waste will be reaching the landfill and you will come up with a huge area. So, typically landfill can be designed for the same design life as a building; however, often that much area will not be available; if that much area is not available what is the correct a kind of an idea of the size of a landfill.

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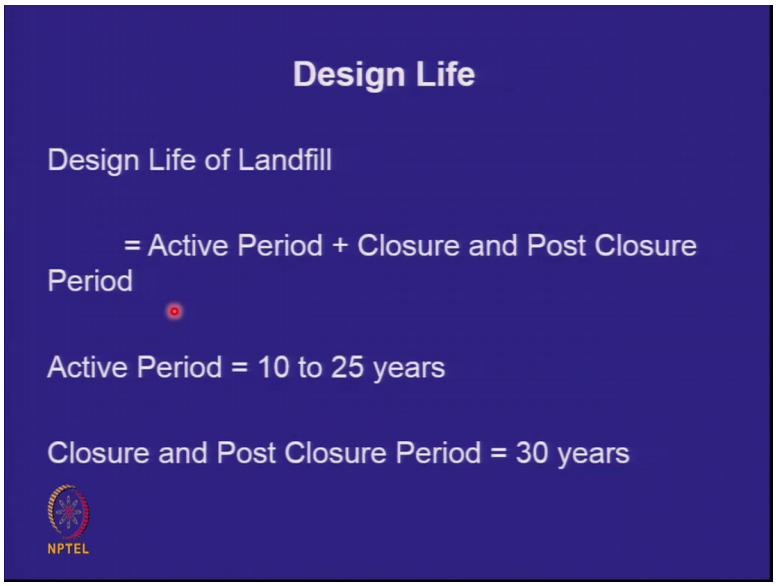

So, the design life of a landfill is the active period when the waste is being filled plus the closure and post closure period. After you have filled the waste and you have no longer you are putting the waste on the site the site is not closed, because the whole thing is still undergoing chemical reactions. So, you have 2 periods the filling period and the closure and post closure period for which you have to take very intense care of the site. Typically, the active period is 10 to 25 years typically the active period is 10 to 25 years. And the closure and post closure period is typically 30 years you tend to intensively monitor the site. So, if you have a 25 year filling period and 30 years post closure you are having a site which is having a total span of design life of 55 years or a 40 years.

Now, can the active period be smaller you say I have got a very small piece of land can I design the landfill for 3 years. Well sure you can design it, but it is very expensive the smaller a landfill becomes the smaller a landfill becomes all the facilities have to remain the same. You have to still have an entrance gate you still have to have a weybridge about the waste which is coming in, you still have to have fencing, and you still have to have monitoring wells and air monitors.

So, all those expenditures are fixed and you just say I will go off the site in 3 years and then you have to monitor that side for if you are going to do an engineering design you have to monitor it for the full time till the waste becomes stable.

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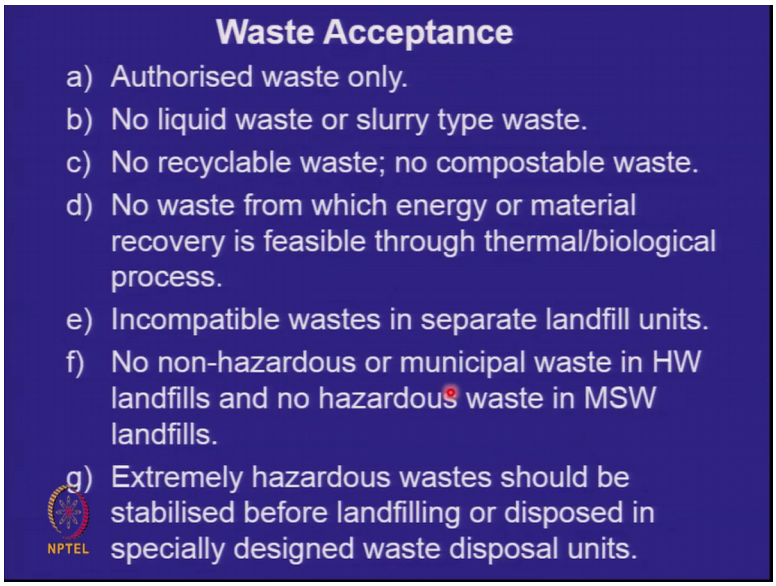

So, typically a site which is less than 10 years is a kind of an uneconomical or unviable site; so better to have sites which can have an active to active period of 10 to 25 years. And remember depending on the type of landfill you will have a acceptance criteria. So, you cannot go and dump any waste on any landfill. Only authorized waste will be accepted and no liquid waste or slurry type waste will be accepted at a landfill. You can have thick viscous sludge which will not move on it is sludge slurry type waste means lean slurry; that means, a lot of water, if you have a slurry type waste which is a lot of water you have to d what are that and bring it in the form where it will not move.

So, authorized wastes only no liquid or slurry type waste can come in landfills are not designed like ponds no recyclable and no compostable waste should come to the landfill. Only that which is so, intimately mixed that none of the plants are going to accept it should come no waste from which energy or material recovery is feasible through the thermal or the biological or any other process should come to the landfill. If you are having a hazardous waste landfills you get waste from different industries and fires and explosions at hazardous waste landfills are not unheard of.

So, if you have incompatible wastes one which will ignite the other or a reaction then you have to store them separately in separate landfill units. You cannot store municipal solid waste in a hazardous waste landfill and a hazardous waste in a municipal solid waste or a nonhazardous waste landfill. Why? Hazardous waste landfills have more

stringent liners and covers. So, if you start sending nonhazardous material there, you are wasting capacity because the per ton cost of disposal is much higher.

Similarly, a nonhazardous waste landfill is not designed to tackle the hazardous waste, because the impact of leakage of hazardous wastes is much more than the impact of leakage of nonhazardous waste. So, either way you cannot do both. So, nonhazardous waste municipal waste in hazardous waste is not a la hazardous waste landfills I not allowed and vice versa. And as I have said you can have extremely hazardous waste, the 2 issue handle this one is that you can stabilize it and then you can landfill it. Or you have to go for a specially designed waste disposal facility.

Suppose I have got a hazardous waste x. How do I stabilize it I can encapsulate it, I can put it in our lead container I am just giving you the examples? And then this encapsulated waste can be placed in landfill which is so, permit is it; however, if it is nuclear waste you cannot even do that. If you have very hazardous wastes, then all countries are expected to have a very hazardous waste disposal site which is deep underground in the rock and that is where the waste should go. So, it is like one country may have one or 2 such sites whereas, municipal solid waste landfills every municipality will have to have one hazardous waste landfill every municipality.

Student: (Refer Time: 21:55).

Those which are big industrial areas will have hazardous waste landfills and they will. In fact, receive the hazardous waste from the areas around it, it becomes like a regional landfill. So, typically a state may have 2 3 or more hazardous waste sites. Gujarat is very industrialized it has many hazardous waste landfills. Whereas, Punjab Haryana here they may have one or two, but all big towns will have a municipal solid waste natural. So, we have to be clear that when we are going to place waste we must be very cautious about the site that we select. One is area should be available.

You know between farming between housing between industrial activities you may have very little options where you can place your landfills, but still if you have 2 3 options. And typically we are talking of a distance of 50 kilometers from the source we were earlier used to say landfills must be within 25 kilometers of the source. So, that the transportation costs are not high, but now as available sites are decreasing you are also willing to send waste 50 kilometers away.

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So, within 50 kilometers if you have a bunch of sites then you have to go through a site selection process. And what it involves will do this in greater detail in a later class, we have to select a site with greatest protection to the environment at low cost and with public acceptance the most difficult problem is with public acceptance. Nobody wants to have waste in their backyard and what is that called.

Student: Nimby.

Nimby not in my backyard you can send the waste anywhere else, but do not send the ways to my backyard.

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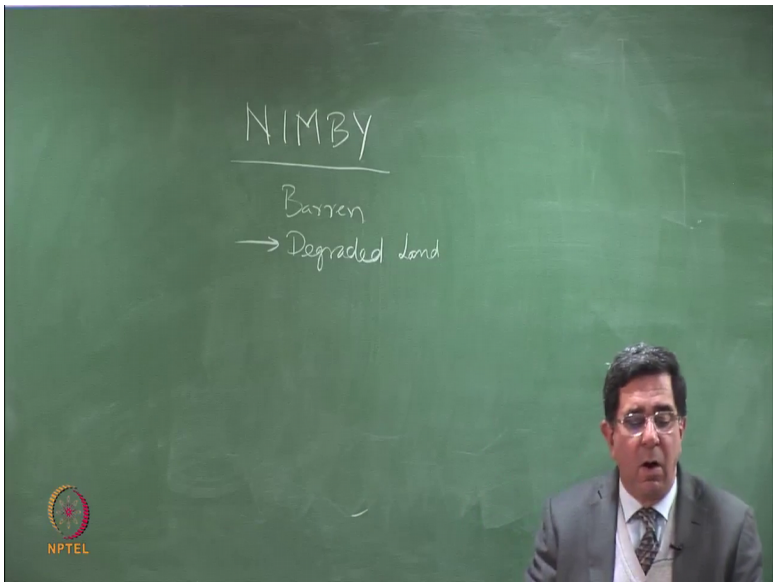

So, the biggest thing we have to overcome and everybody is now very enlightening, the villagers are enlightened there is a key do not send the waste of the city to our village or near our village why should you live in your own waste, you are generating the waste. So, typically this is a big problem now in the country. However, the solution to this is always either barren land or already degraded land. That means, land where waste has been traditionally disposed off in the past, may not be in a proper manner right, but then once waste is already being disposed and you go and tell the people now where now we are going to do in a more engineered manner it will look green after and you show them the other landfills then they say oh this is good, but if you go to a new site a green field site then you have a problem.

So, typically when you are doing site selection look for barren land away from and look for degraded land. Already land this the simplest or the highest is land which has already been used in the past for dumping all kinds of industrial waste or municipal waste. So, suppose you have a bunch of sites, suppose you have a bunch of sites and say 2 3 then also you have to still come up with the best site. So, for that you have to do a site selection methodology, where you have to you know balance multiple parameters we are talking of protection of environment low cost and we have to therefore, consider some attributes which you can see we are lo we are talking about let us say I have 2 sites in one place the groundwater table is 2 meters below the soil another place the ground water table is 20 meters below the soil.

So, the immediate bell which rings is then look the 2 meters site the place where the groundwater table is 2 meters below the ground should be avoided. Because if there is any leakage ground water will become immediately contaminated, and if this is 2 meters or 3 meters and it is drinking water, then already there will be hand pumps in that area. So, people will be using it all the time.

So, such parameters; that means, receptor para receptor related parameters, how many people are adjacent to that site pathway related parameters where is the groundwater table, where are the drinking wells where is the river source related parameters. Are you having a large waste dump or a small waste dump and waste management attributes? So, these are the 4 sets of attributes which have to be considered decision making is not simple decision making has to be a multi parameter approach.

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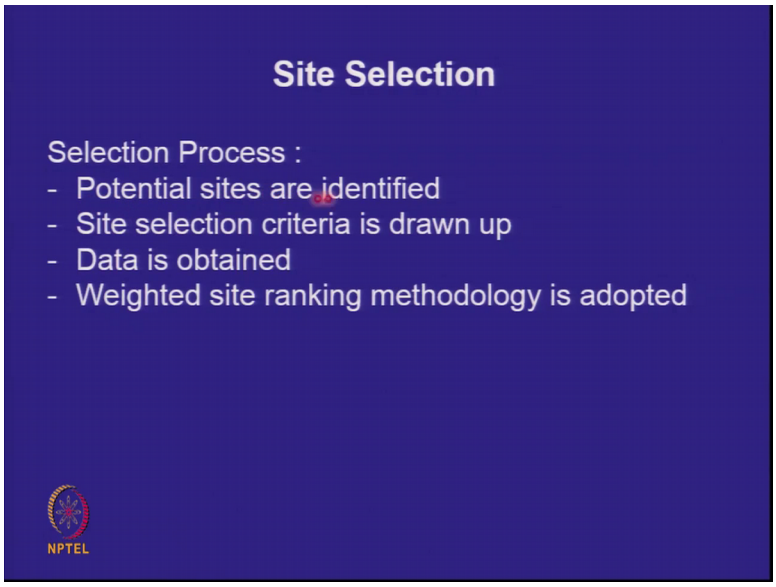

So, potential sites are identified site, selection criteria is drawn up and a weighted site ranking methodology is adopted. Now the central pollution control board has one rated site ranking methodology there are more site ranking methodologies which are available in literature. We will do the rated site ranking methodology in a later lecture.

So, we identify the sites if there is only one site available the choice is hardly there. And you have to set up criteria what is important to you and the people obtain the data, you can make decisions in the absence of data. What is the type of soil is the pervious sand or is it impervious clay? So, some the decisions are fairly obvious and then adopt this, but

for us broad locational criteria is already there as to the minimum distances from critical facilities.

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So, when you have a landfill which has to be located at a site you will check all these. It should be at least 200 meters away from a lake or a pond more than hundred meters away from a river. If it is in a floodplain; that means, that the area gets flooded, then you have to make a protective embankment all around it because you cannot have your landfill being submerged and unsubmerged.

That means, the whole thing gets filled with water while it is operating you have to be 5 me, 500 meters away from a highway 500 meters away from a residential colony 500 meters away from a public path you cannot be inside a critical habitat or inside a wetland or inside the coastal regulation room because of bird hit is you should be 3 to 20 kilo meters away from an airport. I think the Indian regulations are much more stringent they are talking about being 20 kilo meters away, you should be 500 meters away from the nearest water supply tube well the groundwater table level should be at least 2 meters below the base and other factors.

So, in all this you what you are saying is these are the safe distances minimum acceptable guidelines. And please see I have put 500 meters from my perspective, while rivers get flushed every year during the high flows during the monsoons the rivers the high flows. So, contaminants tend to get washed out, but lakes and ponds especially if

the lake is being used for drinking water purposes, they do not get cleaned up all that often. So, best to keep the 500 meters away if you are using those lakes and ponds for drinking water supply. So, you adopt this locational criteria after that if you have a bunch of sites.

Then you have to do a weighted site ranking methodology having identified some sites you have to do site characterization, and you need a lot of data you need a lot of data.

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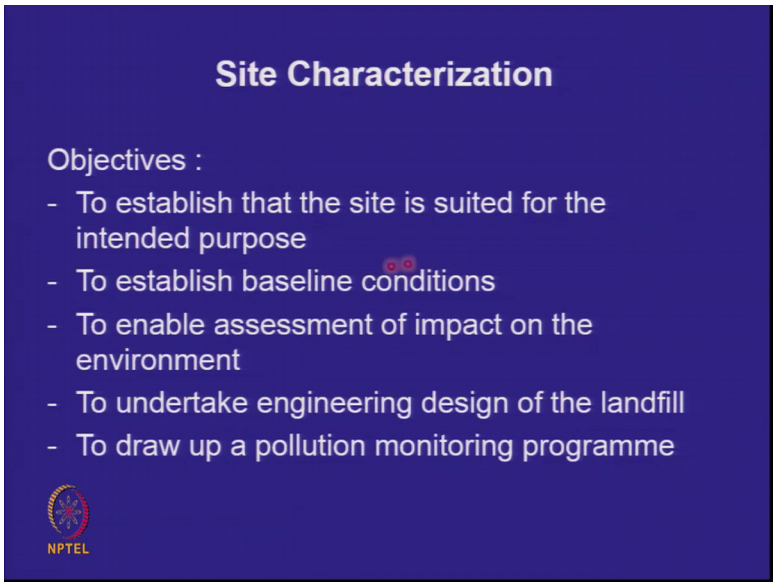

So, basically you have to establish that the site is suitable. You have to establish the baseline conditions because you are always going to monitoring. So, what was it before and what did it become after you have to do IA environmental impact assessment report for getting the clearance to do the design.

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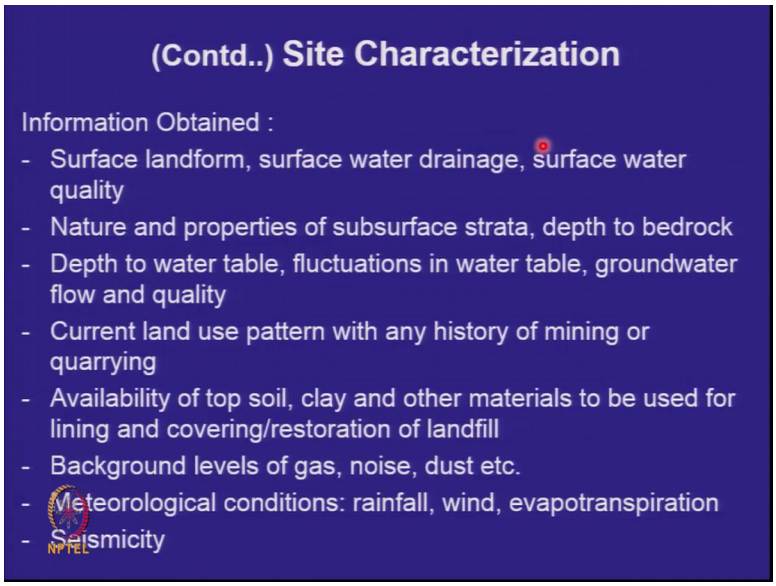

We need the site characterization and to do the monitoring program, we need the site characterization. And So, this is an important step for us. And it is not simple you have to have the following information. Surface land form, topography, drainage and surface water quality. Sub soil properties, depth to bedrock depth to water table fluctuations in water table what is the direction of groundwater flow and what is the quality.

Current land use pattern with any history of mining or querying are there any underground openings availability of topsoil clay and other materials to be used for the landfill. What are the background levels of gas noise dust etcetera, which you are going to later monitor and the metrological, conditions rainfall, rain evapotranspiration and seismicity? So, this is the bunch of data that you need for a good landfill design. And with this once you have characterized it landfill design is easy.

So, if I look at the first thing is; what does a landfill look like in plan. And fundamentally landfill comprises 80 percent of the area which is going to be used for placing the waste and 20 percent of the area which is going to be used for other facilities.

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So, whatever area you have 80 percent of the area is likely to be used, so placement of waste and 20 percent for others. Now this is only when you are placing the waste in that area. If you are going to make a composting plant in that area if you are going to make waste to energy or RDF plant, then they will be taking up much larger space and this area which is being used for storage of the waste will be decreasing with time. In any case you will have offices, laboratory, workshops you will have treatment facilities you will have fencing greenbelt roads, you will have temporary areas for holding the material and you will have environmental monitoring facilities.

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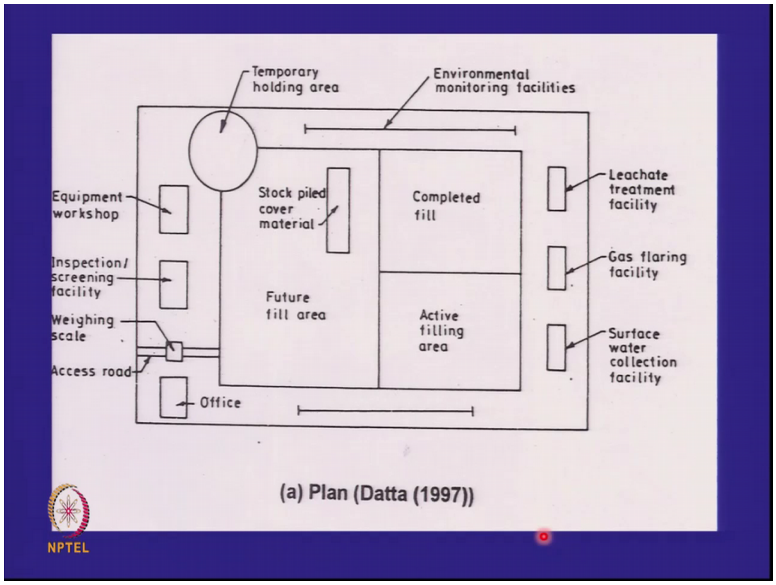

So, in a very simplistic manner I had like to say if this is a rectangular area, which is available to you this is what is going to be covered by the landfill temporary hold. So, this is where the landfill will come this is temporary holding area equipment workshop inspection facility weighing scale the road comes from here there is a working office and hit the inspection and screening facility means you have the laboratories here.

And when you collect the leach ate it goes to a leach ate treatment plant, when you collect the gas it goes to a gas flaring unit, when you collect the surface water it goes to a surface water collection unit and then you will have environmental monitoring facilities.

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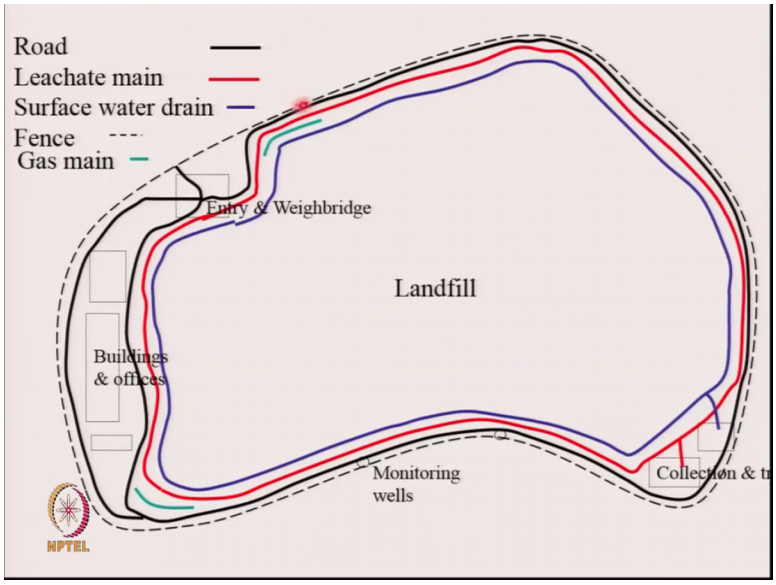

So, this is a nice kind of diagram which tells you what it looks like or in other ways shape may not be rectangular and this is what the landfill will look like 80 percent of the area where the waste is going to come.

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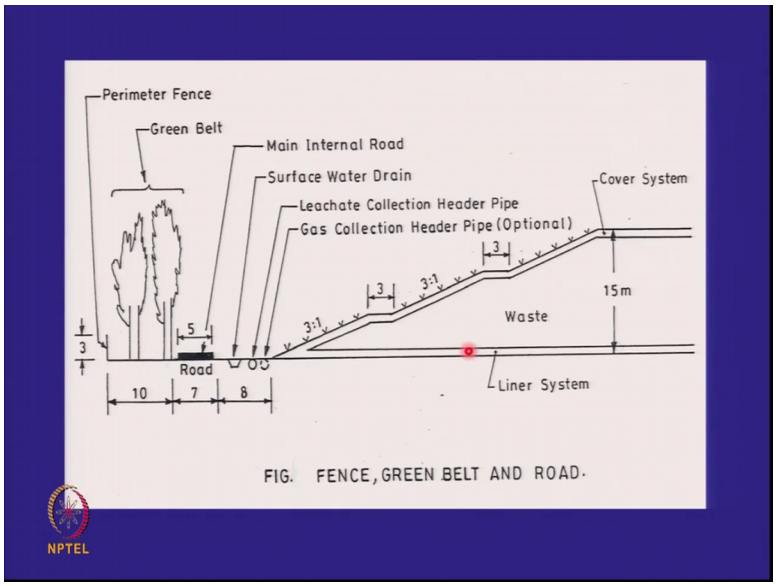

So, you can have many other buildings all around the perimeter you will have a fence you will have a road and if I just want to look at it like this. So, you may have a fence here then you may have a mandatory requirement of a greenbelt you like a road all around the landfill. So, that you can inspect it and on top of the landfill and you will have this leach ate collection gas collection surface water collection facilities which can go to the plants and then you may have a landfill around it. So, that is what it looks like in plant.

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So, you will get land not the way you want it, but you will get the land as it exists. So, you can have a shape like this, at one place they are giving land like this that is adjacent to a railway track in Faridabad. We got a land like this in the hedge in Gujarat, we have a land which looks like this all this is counted towards your landfill, you will get the land as it is available not as you desire because you are trying to find out the land which is acceptable to the people around.

So, all these you have to then design your facilities, but remember the thumb rule is that typically 80 percent of the area will be used for placing the waste. Maybe if you have only landfill then it will look like this, but if you are going to put up other plants as well then you will have to then you will have to earmark those areas suppose with time what will happen to this maybe with time when the modern landfill is set up in another area then, that is your landfill what I am talking off is where only waste is being put, but more and more we are having situation where the other facilities in the hierarchy of waste management we are making more and more subsidies for the other. What is the problem with these very narrow areas area looks great I can give this as a very narrow strip for what is the problem with the narrow strip, well if you have a wide base then your landfill goes up and looks like this?

Now, you make the base very narrow and make it very long what happens, the slopes come and hit each other and you cannot get to a higher height. So, if you want to make high landfills you read larger base width of the shorter dimension or the shortened area. In fact, here what we did was we remember this was hardly any area: so this all the preprocessing and the treatment facilities came here, because we needed more base width and the landfill only came here. In the narrow area areas, you can put the stuff is drilling have to go very high and you can use that area appropriately.

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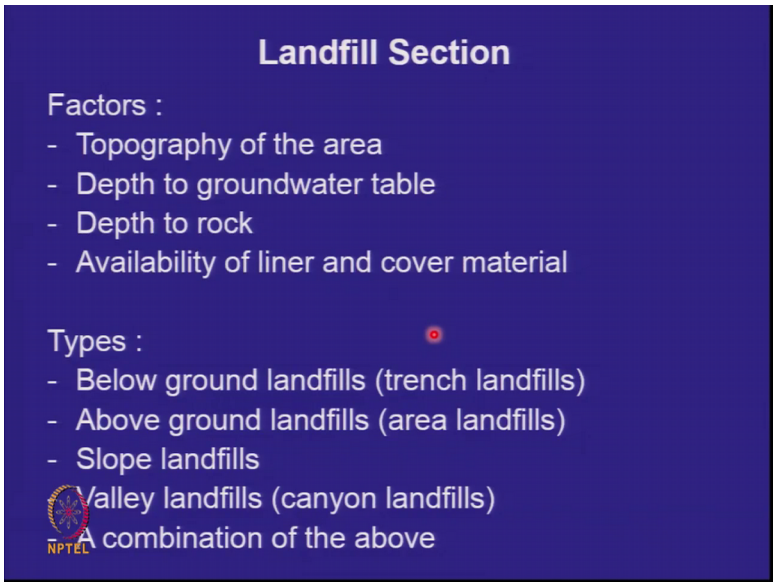

What does the section look like? The landfill section will be dependent on the topography of the area. And as I said it will depend on the depth to groundwater table and depth to rock. And you can have below ground landfills; you can have above ground landfills, sloping landfills, valley landfills and combinations of the above.

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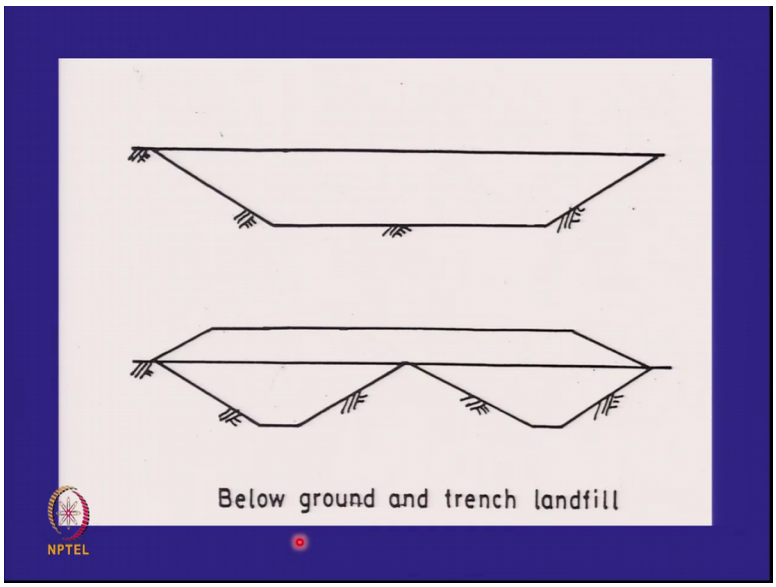

So, I will run through this quickly that is a below ground landfill. And that this was nowadays used very little this is called a trench landfill and it has a part of an above

ground landfill on it. So, these trench landfills are not used because you are losing the space. So, now, all of them will become like this.

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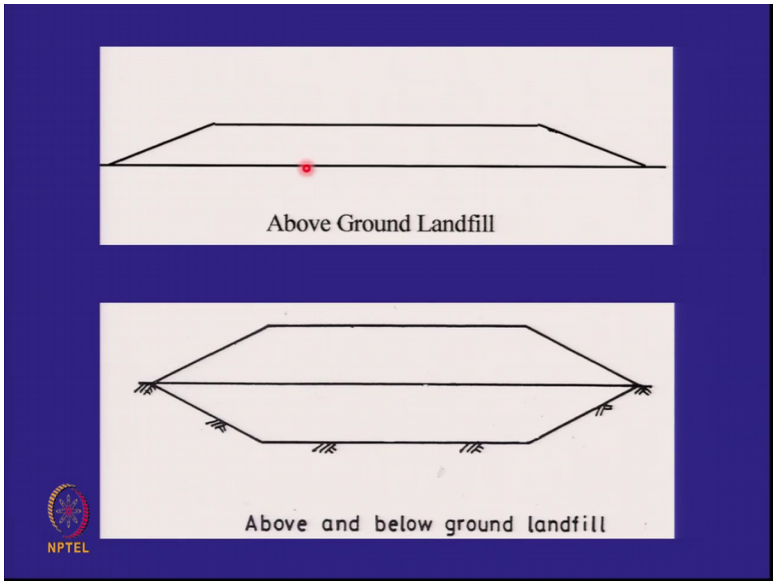

So, I have an above ground landfill, when will I have an above ground landfill when I want to do everything by gravity my leach ate should come out by gravity, or when the rock is near the surface or when the groundwater table is very close.

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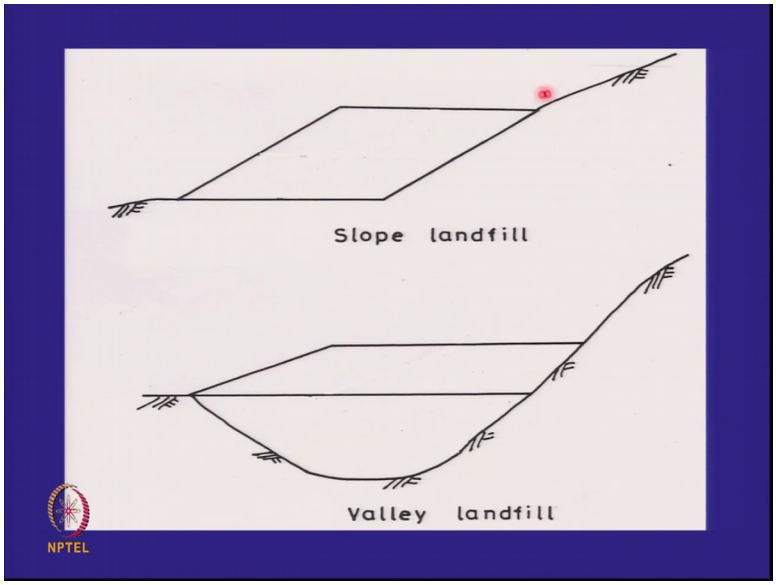

And the other options are due and above and below ground landfills together. Yet another option is to do it on the sides of hills this is a side slope landfill. If your topography is

sloping and if you are in a hilly region you cannot go and adopt these. If you are in a valley or flat ground you can adopt these, but if you are not in a flat ground if you are on sloping ground then you have to adopt this this is a slope side slope landfill.

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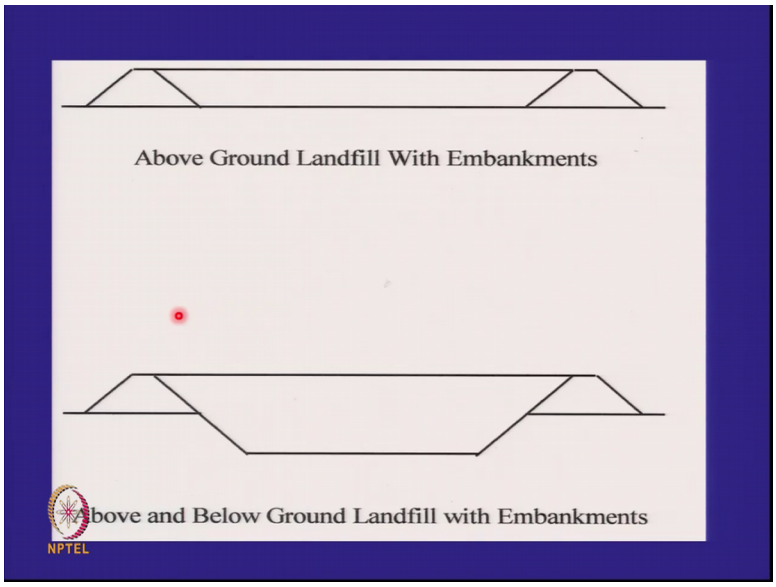

And this is a valley landfill sometimes you will make above ground landfills using embankments. In the hope that these can be steep slopes and not very flat slopes as far away slopes. So, you may often come across such cross sections where you have taken out the soil from the inside to increase the capacity this soil you used to make the embankment and that soil comes here and you can accommodate larger waste in comparison to this here you are getting the waste from outside here you are getting the waste from outside.

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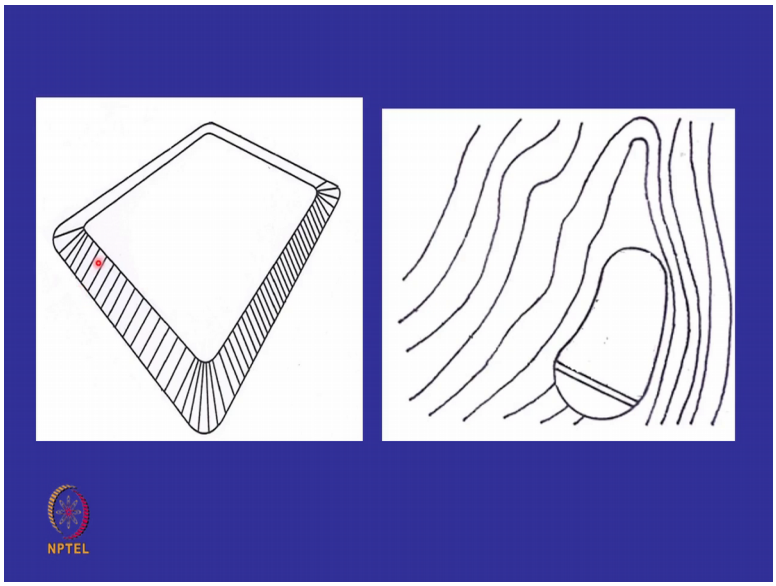

The landfills we will look at like the area which you get this is something on a flat ground. So, you have an above ground landfill maybe it is above and below this is what you can see from the top and when I talk of a valley landfill in a hilly region this looks very much like a dam across the 2 mountains. So, to be able to store some water behind it to create a reservoir, but this is actually filled with solid waste. So, you can create a valley landfill in the area. So, depending on the situation we will have different sections above below and other types of sections.

So, I have shown you in the last few minutes what do landfills look at like when you look at them from the top and what do they look like when you slice them open you seen the sections they can be very variable. And we said topography depth to groundwater table and depth to bedrock if both are high you are going to be above the ground, if you have sloping ground you can only make a sloping or a valley type of landfill and area the planer view depends on what area you get you cannot decide what type of area that you want.

So, we will stop here today you can digest all this information that has been given to you, and we will continue to now look at insight in the inside space, I have this area I have section what does it look like from inside and what are the various components of design. So, we will stop here.

Thank you.