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

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Lecture - 04
Solid Waste Generation and Disposal

So, good day and welcome back to class number 4 of the course on Geoenvironmental Engineering. So, today we are going to make a little shift. We have discussed in the first 3 lectures introduction and soil waste interaction and impact. Now we are going to come to the second module which is on design of solid waste disposal facilities that is more on to do with landfills for solid waste. And the next 10 to 12 lectures are going to be on this subject.

So, let us look at the topic one of this module and that topic is the Generation of Solid Waste and its Disposal. So, we will see how solid waste gets generated, what do we do with solid waste, and finally where does it land up and how do these large heaps of a waste look like.

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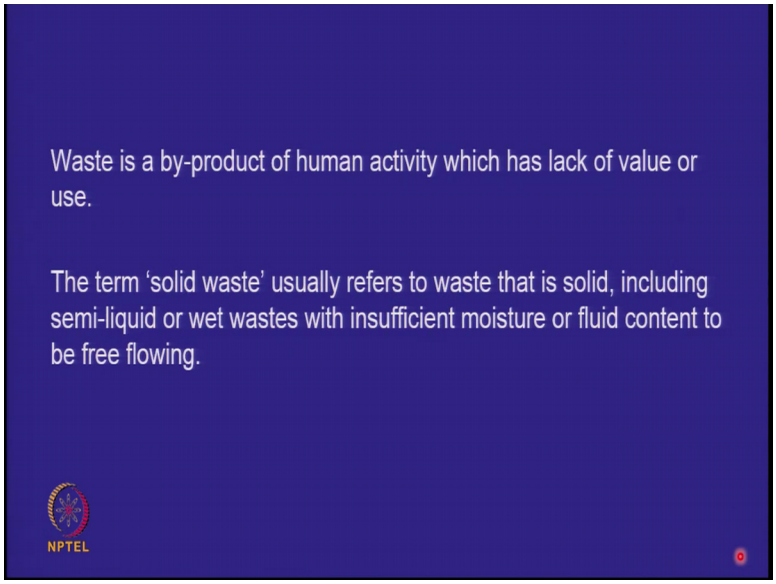

So to define waste; waste is a byproduct of human activity which has lack of value or use; that means, it has no value or use. And therefore, nobody is taking it away to use it for some other purpose and the term solid waste refers to waste that will not move away

from the site where it is deposited, because this question will come to you always is slurry waste solid waste is where to way solid waste. So, the term solid waste refers to waste that is solid that is simple including semi liquid or wet wastes with insufficient moisture or fluid content to be free flowing. So, waste which can flow by themselves then do not come under the terminology of solid waste.

So, we are dealing with all waste which will stay where it was generated or in a nearby area and does not flow away to the nearest drain or river.

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Now, waste can be classified in various ways then if you look at the environmental engineering books it can be on the physical state you may have solid waste liquid waste gaseous waste you may use the original use mining waste food waste. I mean what was the waste derived from mining activities or food activities or you may want to look at the waste as the material of which it is constituted you may have paper waste, glass waste, construction debris waste. This is the material which may constitute the waste sometimes you will find reference to the properties I mean this is combustible waste it might be easy to burn or this is compostable waste. That means, it may be easy to do by the degradation of the waste and convert it into compost or this may be recyclable waste.

So these are some of the terminology is based on properties again sources you may have domestic waste coming from a residential area you may have commercial waste when for example, in Delhi you have commercial centers, you have markets, you have hotels. So,

domestic waste, commercial waste, you can have hotel waste, you can have a market waste, and industrial waste.

Finally, we would be looking at the safety level definition we discusses will earlier waste may be classified as hazardous and non-hazardous etcetera. So, for the purpose of this course we will be looking at waste as per the last definition just 3 levels of waste hazardous being the higher level non-hazardous being the middle level and what is often called inert waste, but what I call construction and demolition waste or that is the lower level of safety.

So we will be looking at 3 levels inert or construction and demolition waste non-hazardous and hazardous waste that is what we will do for the purpose of this course.

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So, quickly I run through some terminologies just. So, that you are able to align with them there are no terminologies then this. So, that you are not confused this agriculture waste which comes from agricultural practices both livestock as well as crop residues this mining waste. I have already done this there may be the overburden from the mining there may be the tailings from the mining or there may be the process waste from the mining. Let me restate this mining waste you dig the soil before you reach the ore is overburden you reach the rock which has got 5 percent of the pure material and 95 percent of the balanced material. So, you crush it and crush it.

So what remains after crushing and crushing is a powder then you send it to a process after the process is over this powder will come out and that we call tailings, but from the process itself which may involve adding liquids adding chemicals the powder is tailings the pure metal or whatever is the mineral that you are trying to take out that would come out and then you would have some third component which may be in the form of a liquid or otherwise in the form of a sludge which would be the process waste. So, you will have the overburden the tailings and the process waste energy production waste locally in India we talk about it as ash there will be many types of ashes, but then you will have fly ash you will have bottom ash and you will have other types of terminologies, but we look at it as energy production waste in the us these are called CCRs coal combustion residuals.

Industrial wastes can be of various types depending on what the industry is producing is it pesticides is it dyeing is it chrome plating is it petroleum or oil based industry a huge variety of waste is it pharmaceuticals so, really a very very wide spectrum of industrial waste; dredging waste. So, if you look at the Nigel of the drain as waste flows as liquid waste flows in a drain the heavier particles tend to settle down at the bottom. So, from time to time we have to clean up the channel. So, that its carrying capacity is not reduced. So, often you will see a dragline or a backhoe cleaning up a drain and this black sediment at the bottom is lifted up and placed on the side now one tends to think that it is kind of very inert sediments, but since it is travelling with waste water it can entrap some contaminants on it.

So, in some of the developed countries dredging waste is not disposed of like inert material, but it is disposed of either as a non-hazardous or a hazardous material. So, we should know what we are meaning organic and mineral wastes from dredging operations construction and demolition waste we have already discussed construction and demolition waste we have already discussed and it can comprise of brickbats concrete even when you are dismantling a road or digging up a road to relate than the a salting material the pipes and the construction debris.

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Very often the waste which you are handling will be sludge from treatment plants this may be from sewage treatment plant or affluent treatment plant in industrial areas.

So sewage treatment plant waste will be very different from a effluent treatment plant waste, but solids from the various sedimentation tanks sludge that is digesters of industrial and domestic waste water treatment plants is treatment plant waste household or residential waste is the waste which comes out from the houses or the residential areas bulk of it is food; there is paper and packaging also important in it is sweeping. So, you get dust you may have it sweeping from the house, but if you are looking at a residential area then it will also be the street sweeping. So, see when you clean a road where does the silt road you put it in the drain storm water drain or does it get collected separately the leaves. So, it may have yard waste etcetera.

Commercial waste refers to it similar to the household waste, but it is produced from offices shops restaurants. So, that act each commercial activity is relatively more intense. So, if it is restaurant waste it will be a particular type of waste if you have office buildings a lot of stationery and paper will come out of it and if you have shops then you have the type of shops that you have what kind of shops are you having in a particular area that is if it is a fruit and vegetable market then its fruit and vegetable waste, but if it is a cloth market then it is a rags and cloths this is that is coming out bulk from these commercial areas institutional waste then this waste which comes out from the IIT.

So what will it comprise of because we are a residential campus bulk of it is residential waste, but we also have the academic area. So, what comes out of it is like office waste, but our laboratories that is the tricky one, because in all the labs we are dealing with chemicals and though it will seem that it is a very small percentage of the total waste which comes out from IIT, Delhi, the fact of the matter is that some of those chemicals specially the ones which remain inside the bottles. After the main work has been done disposal of these chemicals requires that they be treated as hazardous waste. So, in institutional waste will have different characters coming out from hospitals it will be more biomedical waste or hospital waste comprising of the all the material which is left over after the various surgical operations and everything else including all the medicines.

So they can be pathological and other wastes. So, hospitals research and educational institutions and this waste may have to be treated in a very specific manner biomedical waste is the term earlier it used to be a hospital waste; waste produced during diagnosis and treatment in hospitals microbiological waste and animal waste from experiments.

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So, I would like to introduce you to the term municipal solid waste we discussed about hazardous waste and we discussed about non-hazardous wastes and we said municipal solid waste is non-hazardous, but what in itself is municipal solid waste municipal solid waste is a very heterogeneous mixture of various kinds of wastes and depending on how

you collect your waste that heterogeneity may vary on any end of the spectrum and I will just explain this to you.

This term refers to all the waste collected by a municipality and therefore, comprises of waste from different sources household waste kitchen if you have yard waste means if you have a garden. So, you will have some material coming from the garden in this city there will be commercial centers there will be institutional centers there will be construction and demolition there are park trimmings I mean there are street sweepings. So, it usually excludes agricultural waste mining waste industrial waste energy production waste and dredging waste, but everything else it includes. And sometimes you see if you go to the some of the older sites waste disposal sites, if you do not have a separate industrial waste disposal area where is the industrial waste going to land up.

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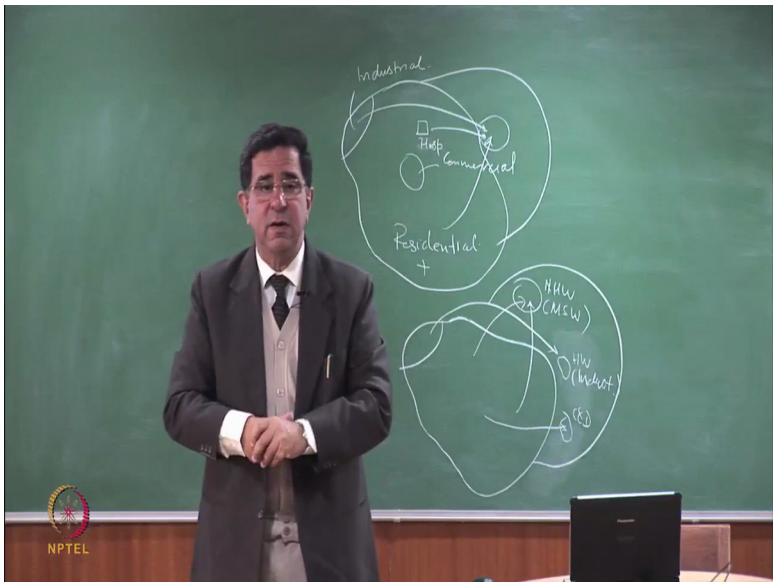

So let us just quickly have a look at this if you look at a city that is the boundary of a city. So, within the city bulk of it will be residential area, but let us take like Delhi where the center maybe cannot place and at one end there might be an industrial area. So, this is commercial area industrial area and yes this is a mix of residential plus various other commercial and institutional areas.

So, I am just trying to show you this example that we are saying industrial waste will normally not be what you call municipal solid waste now suppose this is a city which does not have any coherent waste disposal plan. So, there is one waste disposal site

somewhere which started 30 years ago and we have a site which is here. So, the municipal solid waste will also come here the industrial waste will also come here and sometimes even the biomedical waste it is a big hospital you have when.

So in the older dumps you will find that you will have a mixture of all types of waste the bulk of it will be residential because that is the maximum waste which is coming out every day from the households the others will be small; however, as things that improve the time as things that improve the time. And suppose for the same city you now have 3 lack areas of disposal of course, I am showing this just outside the residential limits, but in many cases these have now been engulfed inside the city limits. But now if I have 3 one I said will do one for hazardous one for non-hazardous and one for the more inert type of material the construction and demolition waste.

So, which is going to be the largest the non-hazardous municipal solid waste or the industrial waste or the construction in demolition waste?

Student: Non-hazardous.

Non-hazardous municipal solid waste so, let me put the sizes in perspective. So, if this is the non-hazardous municipal solid waste I may have smaller sites and that is a different issue whether all sites are at one location or at different locations that we will address later, but what I am now trying to say is that if you have got industrial waste if you go to the industrial hazardous waste disposal site and all your municipal solid waste will go to be non-hazardous waste for municipal solid waste the hazardous waste site for industrial waste and the CND waste will come here.

It of course, depends on whether you have a collection mechanism or not you teller the householder please keep your waste in 3 bins you have to set up a collection mechanism at the moment only one guys comes to collect your waste and maybe he will also have 3 bins then he can collect it, but one bin will fill up every day and the other bin will fill up one tenth. So, what will happen that bin may not go to the site till it is filled up?

So there are different mechanisms for getting these. So, I just wanted to bring to you the overall perspective about the municipal solid waste of waste from a city we have already discussed hazardous waste. So, we will not discuss this any longer, but this is industrial

waste could be hazardous mining waste could be hazardous even institutional waste as I talked could be hazardous if it comes from something about that.

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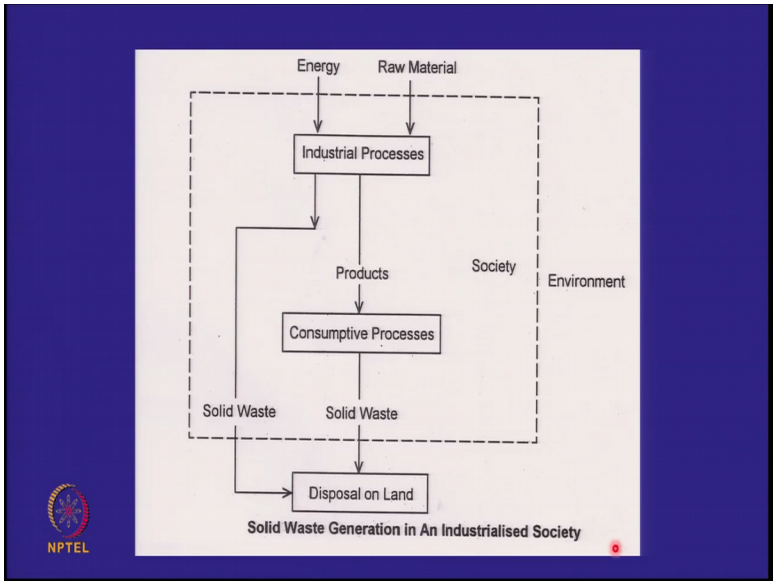

So, if I look at the processes what are we consuming from the environment and what are we giving back to the environment you will find that we are consuming energy and we are consuming raw materials. So, if I want to make any product let us take this table I need draw materials and then I need energy for the manufacturing devices the raw material may be wood and energy before the saw I may have a sewing mill. So, I will need to have energy.

So what we take all the time from the environment is energy and raw materials and energy comes from burning coal or burning diesel nowadays from solar power, but our energy can come from hydro electric power, so, basically energy in the form of electricity and raw materials as the principal constituent of what is going to be utilized. So, a product may have raw materials from 15 sources for example, I do not know an automobile a car it would have inputs from thousands of sources the metal the sheet metal for the body the upholstery the springs the steering. So, so we take energy and raw material and then we these are inputs to an industrial plant. So, the industrial plant will produce a product, but it will also produce waste.

So the solid waste starts to get generated at the industrial plant level then the products are actually packed they are packaged I cannot give you hundred percent pure product you

want a shampoo I have to put it in a bottle I cannot. So, once I have a product; it goes to the consumer and that is the city that is the city. So, products are consumed and waste is produced and these wastes it tends to be disposed of on land.

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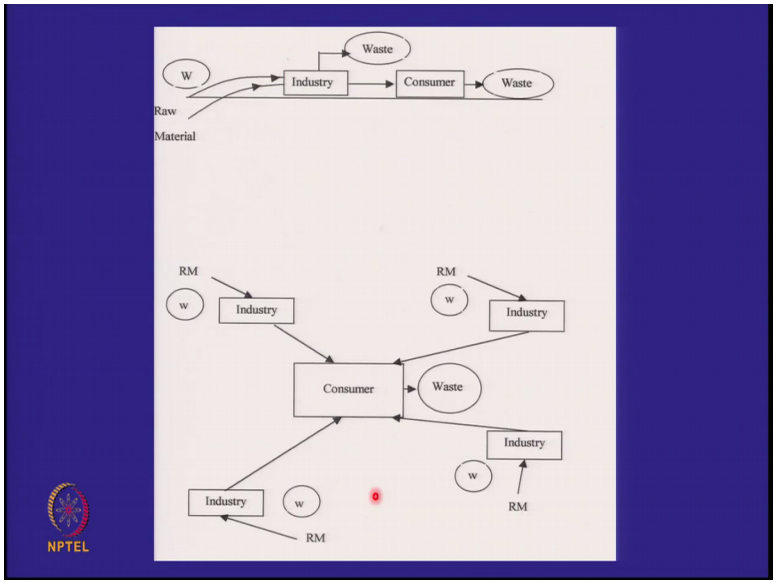

So, we consume energy and raw materials and we dispose the waste on land where is the raw material coming from raw material may come from the surface of the earth from beneath the earth it can also come from the atmosphere and an industry maybe at one location and the consumer maybe at another location. I am sure if you just look at a beverage like Coke or Pepsi then the plant of where the Coke is manufactured is at one location and its being sold all over the city.

So the raw materials will come from the mother earth either on the surface or deep below the industry which produces the product. Let us take for example, electricity coal comes from deep below it goes to a thermal power plant the thermal plop or power plant burns the coal the ashes deposited adjacent to the power plant the electricity goes in transmission lines to the consumer and in the case of electricity there may be no residual waste, but if there was any other product.

For example, if I was manufacturing biscuits then my biscuits should be in a packet the consumer would eat the biscuits and the waste would come up and that is going to be placed on the ground and if you look at it is in plant a city may be getting products from thousands of industries. So, thousands of plants around different geological settings

somebody is giving electricity somebody is giving you cars somebody is giving you biscuits someone is giving you beverages they all come to the city when we consume them we get waste.

So when you when you traveling into Delhi at about 10 o clock in the night or later then you have to stand at the border or the boundaries of the city and see how many trucks are coming in every day. So, what kind of trucks you will get there will be cars and some trucks which are being taken to the car supplies you see a lot of cement coming in road construction going on you get lot food coming in for all of us. So, the city keeps on getting keeps on getting and all these trucks brought empty they do not take back anything with them the cement came in a cement bag did the truck take the cement bag away now. So, they all tend to leave the packaging material in the city itself.

So this table is let me ask you a question we have talked about mining industrial municipal which waste do you think is the maximum in quantity which waste in India for example, what is the waste we are producing maximum municipal solid waste seems to be lot of garbage around all the time on there some other kinds of waste which would be more. So, I just now compared municipal with industrial and construction demolition waste.

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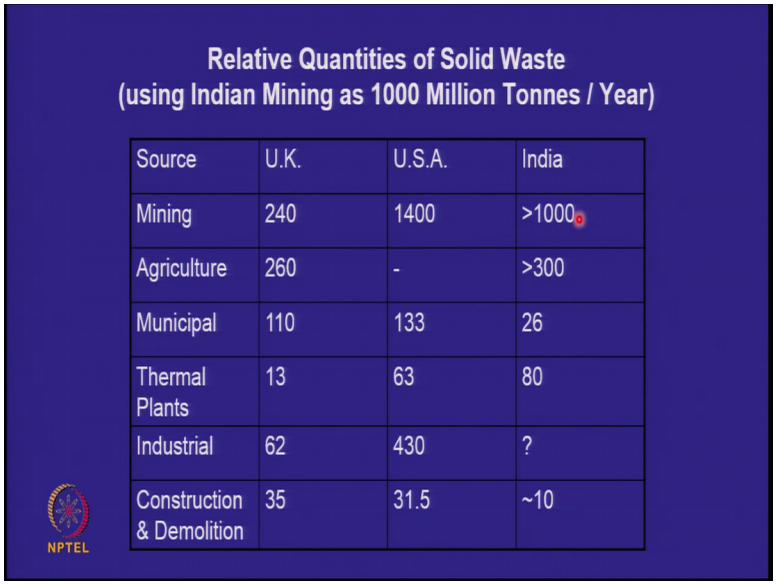

So, municipal is locked, but if you look at a national perspective let us first look at India these are not absolute values these are not get today we are producing thousand million

tones this is just using this as a thousand and what is happening in the other countries at a particular point of time. So, this is not the annual production today I think thermal power plants may be producing a 120 million tons of ash this is when I use mining as a 1000. So, the biggest waste that is coming out is mining and the second biggest waste that is coming out is the agricultural waste agricultural waste may not appear to be such a major visual issue because it is diffused on land in the rural areas all the plant cuttings and everything is diffuse.

There are cities are concentrations of human beings and therefore, the waste is building up and therefore, it is very much visible to you, but typically please see that what we think is a huge amount of waste is very small in India in comparison to the mining in agriculture, but the impact is important and in comparison to 26 industrial waste maybe 10 percent or 15 percent and construction and demolition waste maybe 30 percent, but thermal power plants are producing more with so. And if you look at the US again just see, so, it is an industrialized country I have look at this much larger than this.

Then UK again municipal is more than industrial India has more population. So, how come US and UK are producing more municipal waste though they coming out from residential areas well per in an industrialized the more industrialized the society one human being will produce more waste per capita waste production is much more. So, that is why you will find that this is the kind of the situation that you have let us go forward. Now as I told you the waste can be chemically active biologically active or physically active.

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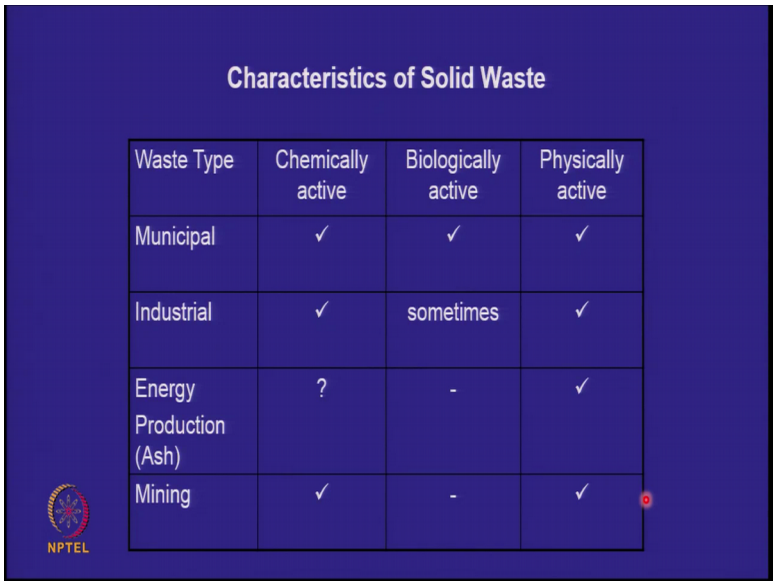

And let us look at municipal solid waste quite clearly it is chemically activate all your salt in your food is going into the leftover food is going into the dustbin and sodium chloride is mobile. So, its chemically active your food itself is biologically active and physically active they will be fines there is all kind of heterogeneity.

So the municipal solid waste exhibits all 3 properties industrial waste is industry specific. So, if you an industry which is mainly dealing with inorganic products then it will be chemically active, but may not be biologically active and physically active yes because it will have the particles which can move away, but if you are in an industry which is having organics and bio products then it will be biologically active.

So, bulk of the chemical industry does not necessarily produce biologically active waste my experience with hazardous waste landfills recent years has been that most of the waste which comes in is inorganic hazardous waste and if there is organic hazardous waste is the tendency to burn it in incinerators and only send the ash to the recycle energy production waste like be talked about ash; ash is definitely if its biologically not active it is coming out of the burning of coal is physically active it has fine particles it creates dust it suspended particles go into the water is it chemically active this is debatable.

So there are some issues about heavy metals coming out from over a long period of time from huge ash dumps there both sides of both points of view that there are heavy metals,

but there are they are beneath or within the limits, but there is another point of view that there are heavy metals and they gradually accumulate with time and are harmful to the environment. The mining waste typically is chemically active and physically active not the overburden the overburden waste may not be, but the tailings and the process waste would be chemically active and physically active.

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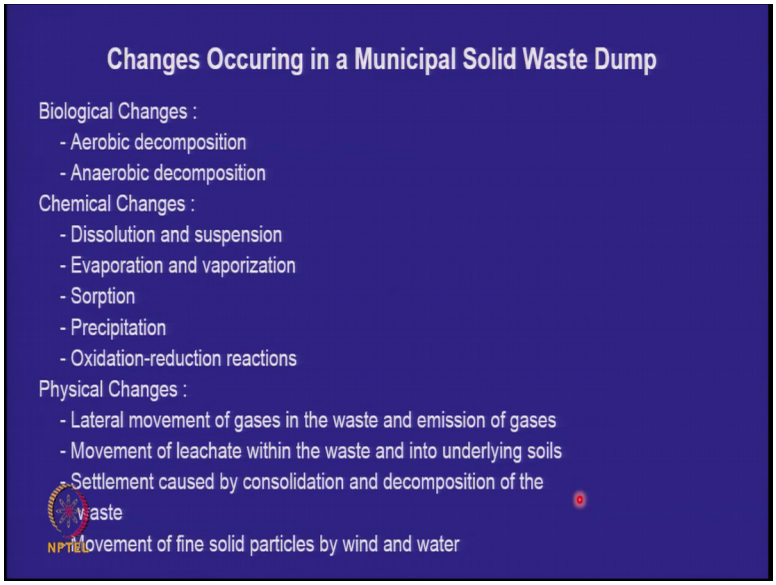

And if you have a municipal solid waste dump within the dump when you put all this waste you have all kinds of you know reactions taking place anaerobic and aerobic decomposition in the presence of air and oxygen in the absence of oxygen I all you talked about dissolution evaporation sorption precipitation all this will be happening and physical changes movement of gases movement of fine particles settlement of the waste these are all occurring in the waste dump.

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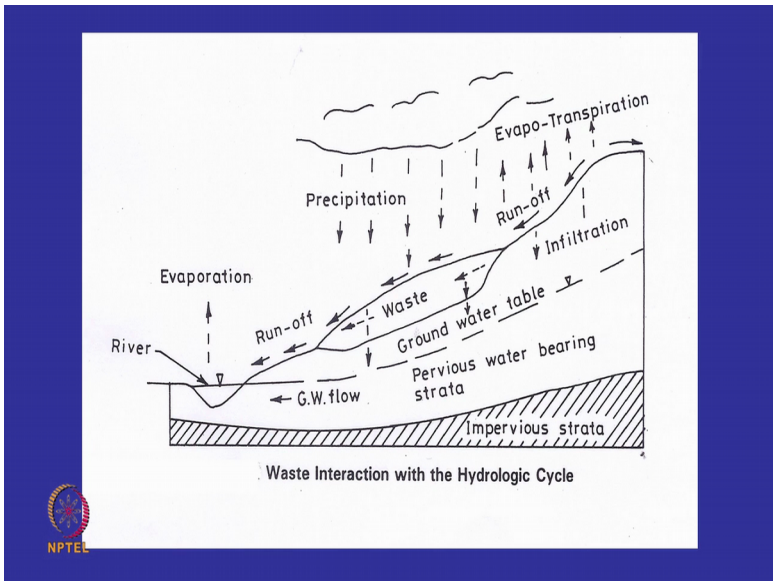

And when we take this waste and put it on land we have discussed this; this waste becomes a part of the hydrological cycle rain water will come to that area and all kinds of associated problems will be there.

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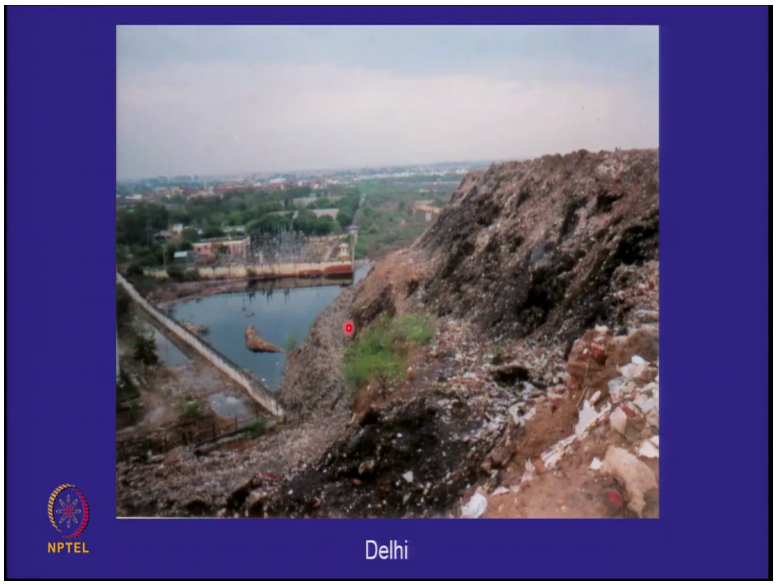

So I am going to revisit this journey: we had in the beginning in the introductory class look at some waste dumps and look at the kind of scenarios which exist in the country we have already looked at this slide this is a municipal solid waste dump in Delhi.

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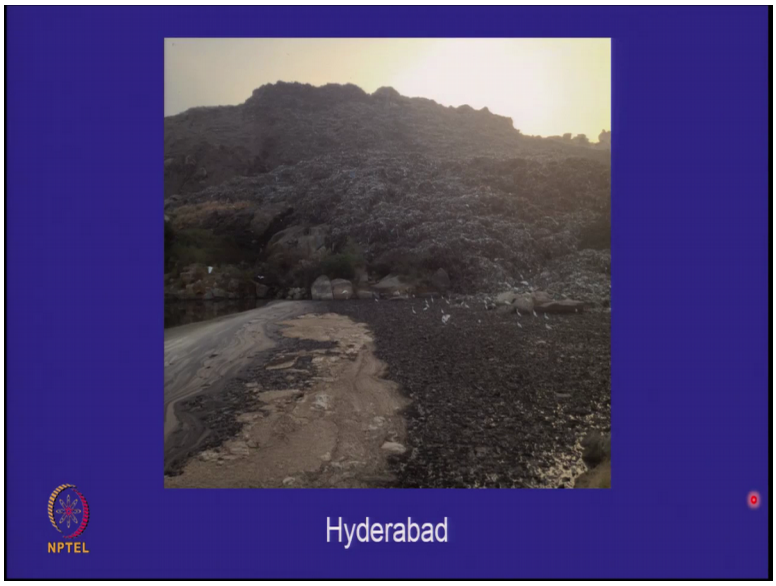

This is photograph of the municipal solid waste dump in Hyderabad and this is the photograph of the municipal solid waste one of the municipal solid waste dumps in Mumbai.

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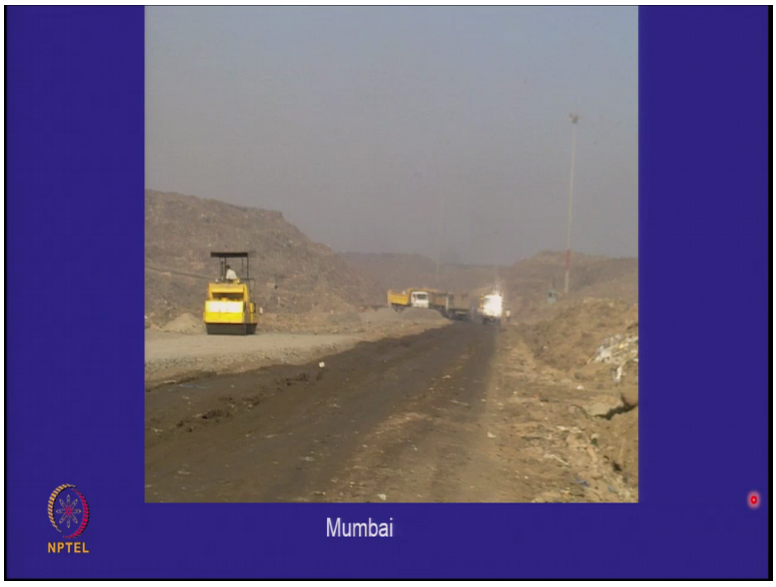

So, please understand a huge city like Delhi or Mumbai will not have one disposal sites they may have 2 to 3 or 4 disposal sites. Whereas, the smaller cities will have one disposal site why if you have a big city like Delhi what is the size of Delhi I think 40 kilometers or 30 kilometers by 30 kilometers it is like the width and the length.

So what happens is if you have to travel diagonally from one end and trend the ways to the other end you may have to travel 50 kilometers. So, you may have 2 3 dumps east west north south which might have developed over the period of time.

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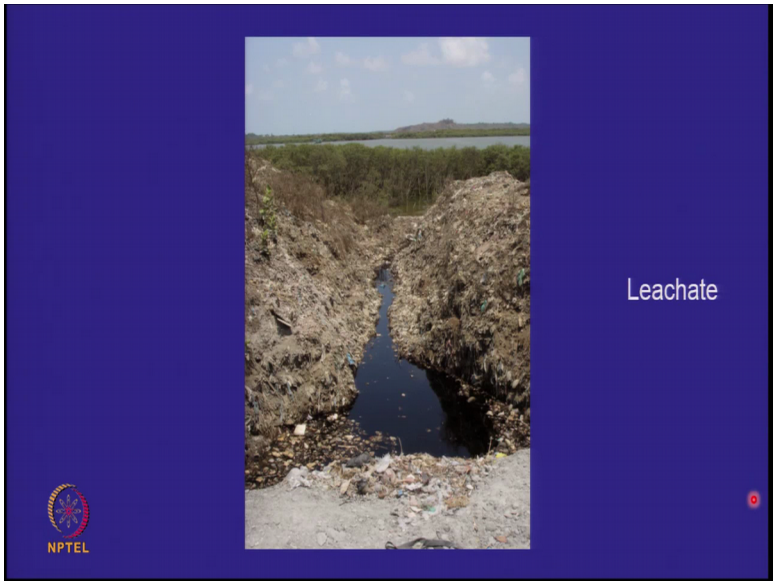

That is Pune for you that is Ahmedabad that is Kolkata Dhapa and we have already discussed this you will find Leachate coming out.

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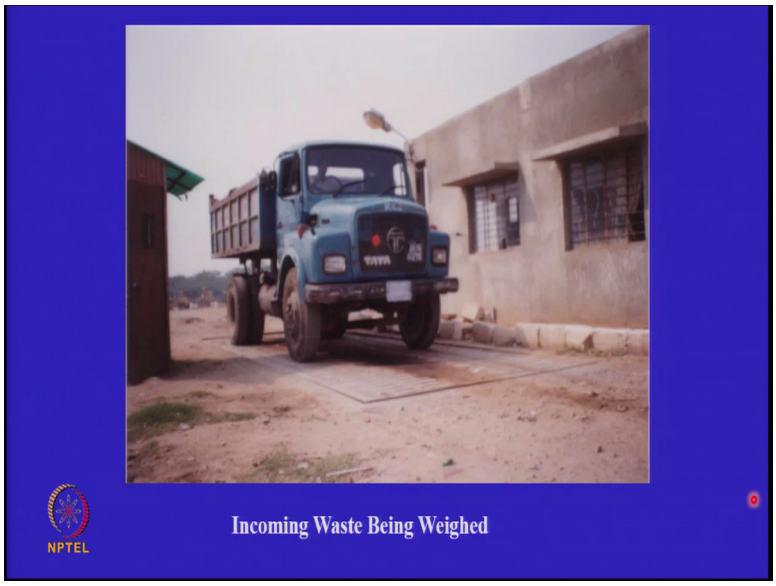

So, if you go to if you go to a waste dump you go to a waste dump you will find they all have way bridges. That means, you are always measuring the weight of the truck coming in with the waste and the one which is going out to see how much waste is arrived.

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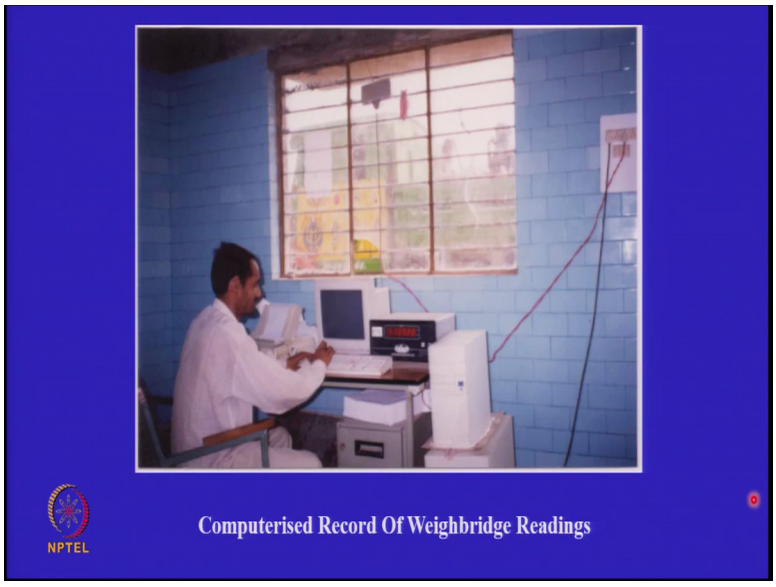

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And the computerized recording system and this just shows you the frenzy of activity on a waste dump these trucks are coming in these are unloading this is spreading.

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This is unloading of a municipal solid waste these are the dozers which are spreading the waste which has come.

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And these are people who are doing sorting on the site these are rag pickers they have been all kinds of litigations in the court, because the non-government organizations do not like human beings doing this. And often the court has said that there should be no rag pickers, but what they do is they remove some of the recyclables from the waste.

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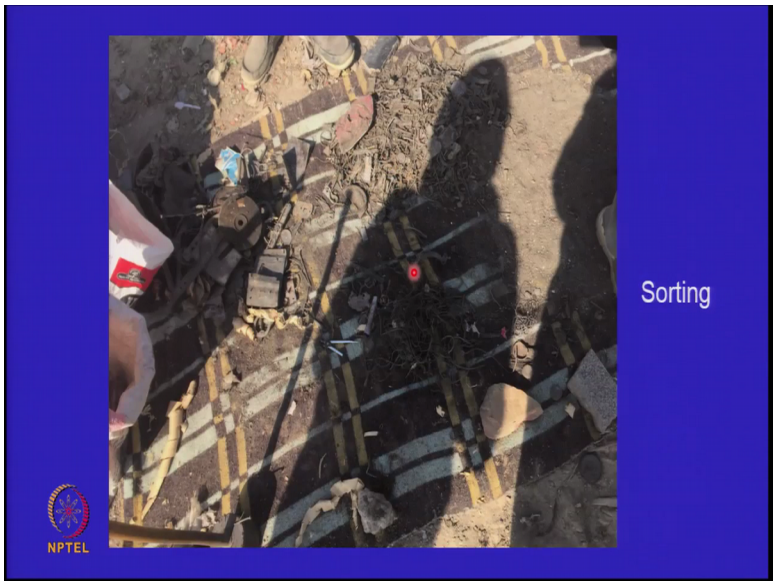

This is the kind of recyclables they will take out wires metal whichever whatever has value and then these rag pickers where you will see there will be on the way site and you can see this these will all be recycled.

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So in a sense rag pickers and the [FL] which comes to your house to pick up your newspaper and the other waste they are all recyclers human recyclers the only issue is are we putting their health at risk while you are allowing this the courts do not take kindly to this they do not want rag pickers to be working on the landfill side there are accidents

there are heavy earth moving equipment which is moving and also there are cuts in other kinds of things.

So, there has been a just going back and forth about if you take them of the landfill then 10 percent of the material which they are taking away remains in the landfill. And so our [FL] system in the rag picker system is an efficient, but not so desirable recycling system the in the in the hierarchy of things the [FL] is better because he is dealing with waste from your house. But those who are working in the landfills come from the lower state of society and not all landfills are like dumps this is a modern landfill which is coming up in India you can see there is a liner system we will discuss this.

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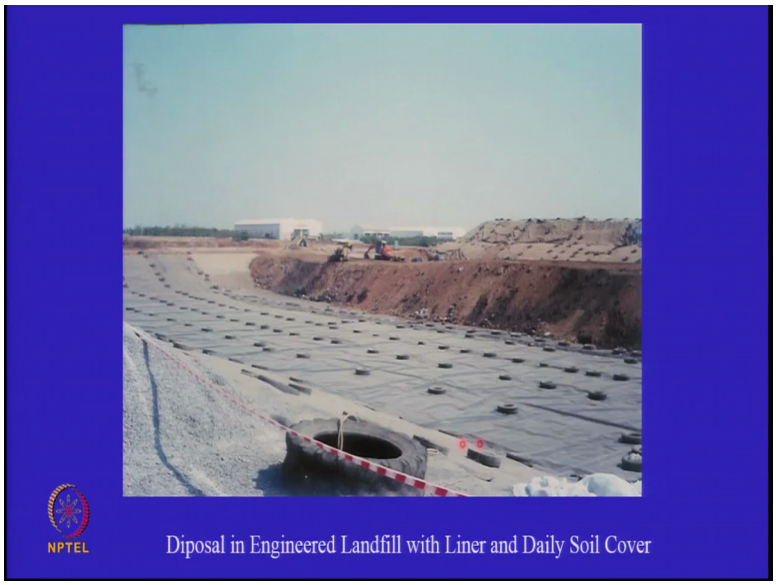

And you can see the waste is covered with soil and whatever is exposed is also covered with an impervious cover.

So we are also now into this area where all this is taking place as I said I show these dumps outside the city.

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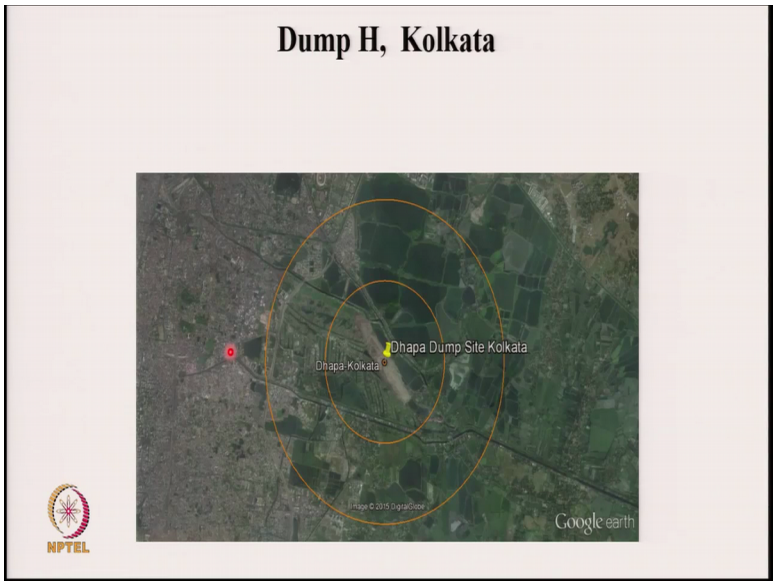

And if I look it Kolkata from this is a why this is about 3 kilometers this is a dump site that is varies Kolkata. So, the dump site is away from the city.

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However if you take a closer view the dump site is right next to these wetlands. So, this is the dump site and these are the wetlands. So, it may not be impacting human beings, but it is impacting the wetlands.

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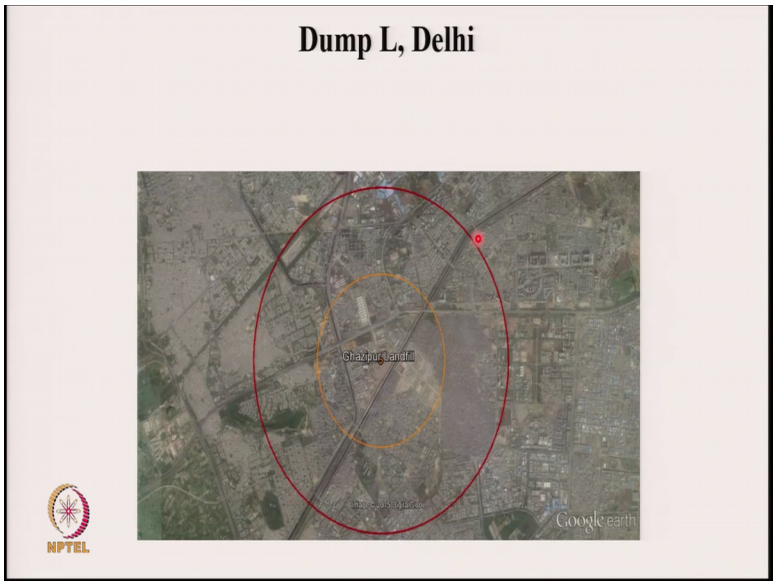

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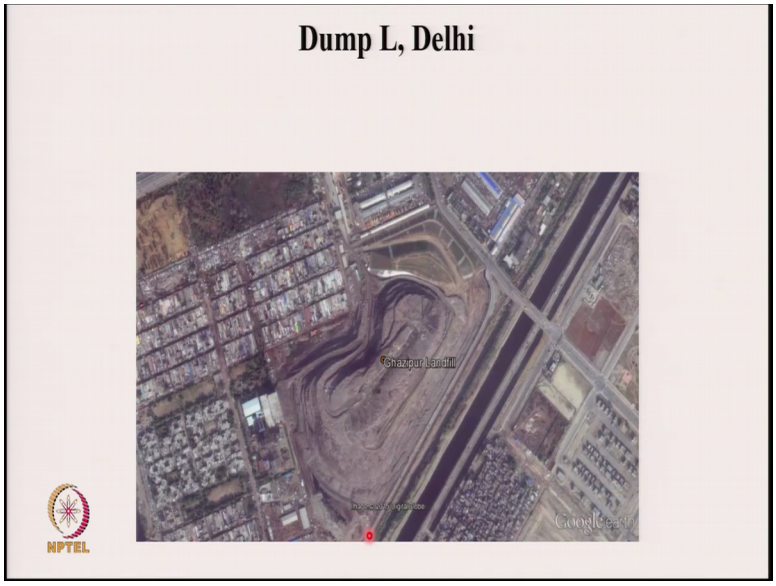

If you look at Delhi this is one of the landfills this whole area is Delhi I mean the small, small, small, small houses take a close of you. So, here the dump is always it.

So what has happened the cities have grown around the dumps the dumps are outside the city and eventually what we find is that as the city group this boundary encapsulated. So, when that has happened; the dumps have come into the landfills.

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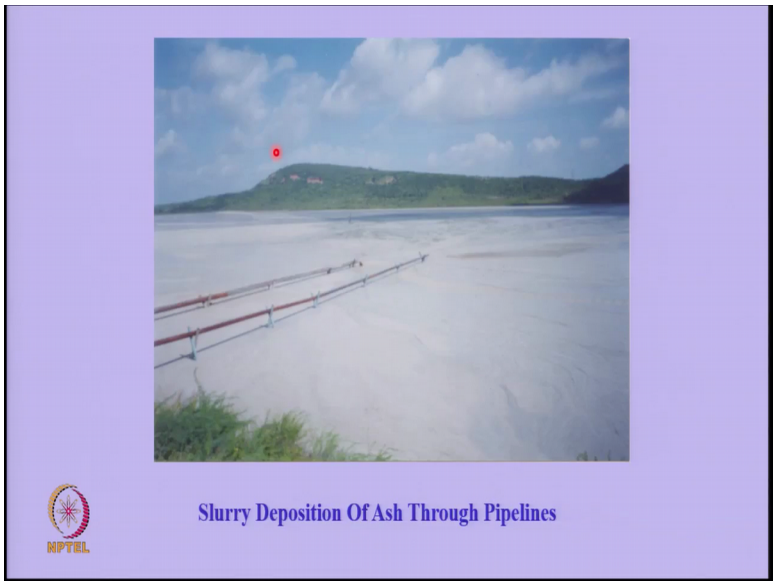

Other than municipal solid waste we have already discussed this is ash being deposited, but you can see this is dry ash and there is water here but.

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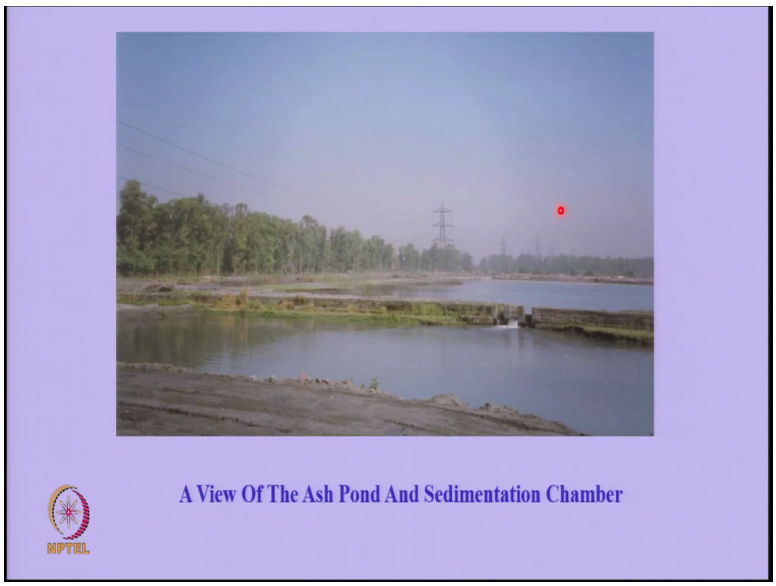

In another power plant you will get ash like this; this is a pond with a sedimentation chamber the ash a lot of extra water as you can see.

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And this is in a Visakhapatnam once again this whole place is like a lake with ash they all have their own implications which we will see later, but this is the kind of waste that we are dealing with.

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And there is only one place in India where ash is being deposited in a dry state and that is a mound nearby Delhi and this is a conveyor belt which brings ash this is not the ash on the conveyor belt this is a for the photograph seems to suggest, but this is a boom spreader. So, ash comes here it travels up this and then it makes conical placement.

So this is this boom spreader was first facing this way and that is the mount that it created.

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You can see how the mount has risen over time and attempts to vegetative because ash will also fly off a lot and cause environmental pollutions around you.

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This is a view of our chalk mound again a dry disposal of chalk again powder.

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This is a process fluid coming out from ledging tailing process. So, it is slurry; it is in put in a pond. So, this is basically going to deposit it is called the Jarosite process fluid and this will impact the environment.

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And there talk to you there is issue about tailings dams the tailings dam as you can see here you have made a dam and behind that like a lake you have a created; created a pond here the mine tailings have been collected.

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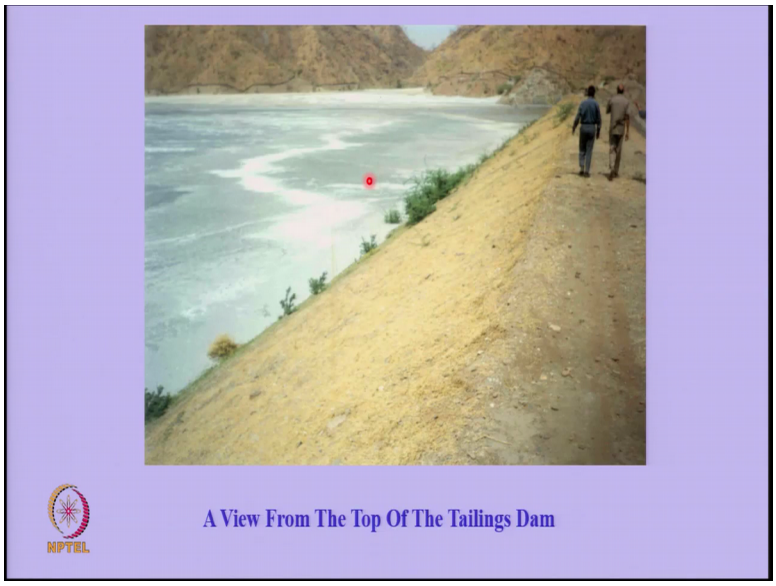

So we are dealing with all these waste disposal facilities and these are accumulating at the site our aim is to tackle them scientifically our aim is to tackle them scientifically. So, that we do not harm the environment. So, all our focus is going to be how to design these facilities. So, that they do not harm the environment.

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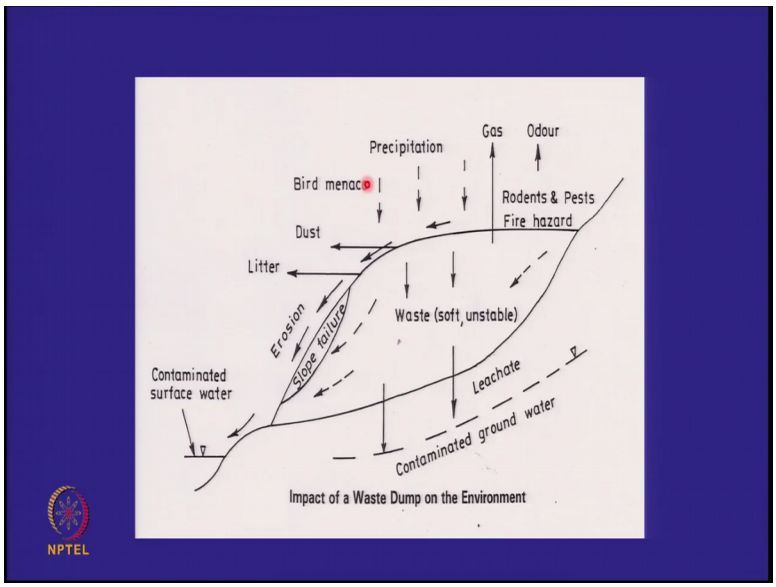

When you deposit something you have. So, many problems if you look at a municipal solid waste dump we will discuss these, but from a dump, it is not a single pathway the source is one, but there innumerable pathway is bad odor gas bird menace which are

hitting the plains dust litter erosion slope failures and contaminated surface water contaminated groundwater we have to look at solutions from an engineering perspective for these problems for the waste dumps that become a part of the hydrological cycle.

So at this stage we will stop and we will continue to see how we tackle this in a scientific and engineering manner, but if you have any questions that if you would like to have some clarification I am open to questions clearly speaking the waste that we put on the ground one attempt can be to make it a part of the bigger system the other attempt can be to encapsulate the whole thing in a kind of a boundary which does not allow its interaction with the outside ecosystem. So, we will see what methodologies or philosophies that we follow in the subsequent classes the other issue of course, is can we have no waste can be become a 0 waste society.

Student: Yes.

Yes and no. So, we will discuss that in the next lecture.

Thank you.