Environmental Geomechanics
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Lecture – 22
Waste: A Manmade Resource – III

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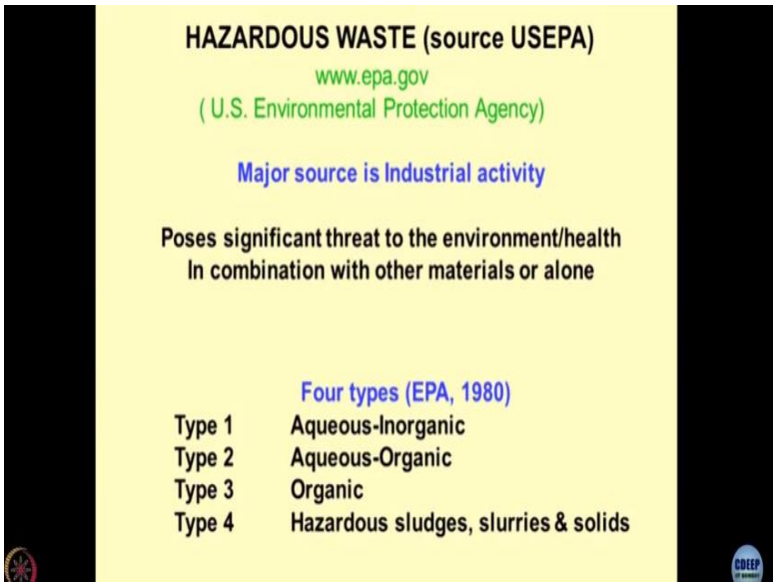

So what are hazardous waste? The source is USEPA I am sure you must be aware of what is USEPA in our distress environmental pollution agency. And if you go to the website, you should go once and try to see what these guys are doing, and you will get a lot of ideas. What you as a citizen of a democratic country can do primary source is industrial activity, and hazardous waste poses a significant problem and threat to the environment and health of flora and fauna in combination with other materials or alone.

These are the four categories of the hazardous list which we usually talk about, and this is as per EPA 1980 are type 1, type 2, type 3, type 4 aqueous inorganic, aqueous organic, organic and then hazardous sludges, slurries and solids. So these are the very wide criteria which have been used to classify the hazardous waste. Now I am sure from my discussion until now you must have realized that a lot of space is posing a big challenge and hazardicity comes because of the attributes which we have discussed today is it not.

Pathogenic activity, radioactivity, inflammability and the expos in nature it could be irritant, it could be getting decomposes quickly it is could be non-decomposable it could be having order in it, it could be infectious. So all these things are adjectives right now. Are you getting this point infectious now somebody asked me a question about how infectious the material is, is there a scale from 0 to 10.

Like in your soil classification system, you have numbers CU, CC, PL, LL, PI, shrinkage limit and all that. So all this has been quantified. But I am sure there must have been a time where everything would have been a philosophy. And then people started working on this, and they generated a lot of data, and then they showed that bring the soil from anywhere in the world. It follows these indices it follows these norms, rules. So I hope I have conveyed the message to you that most of these things are still in the descriptive form.

They do not have the number assigned to them. So where the research has to be done is to quantify these effects. So if somebody says explosivity of the material what the expression index which has to do with the chemistry of the material, composition of the material and so on is. Environmental conditions what pressure, what temperature, what wind velocity this might happen.

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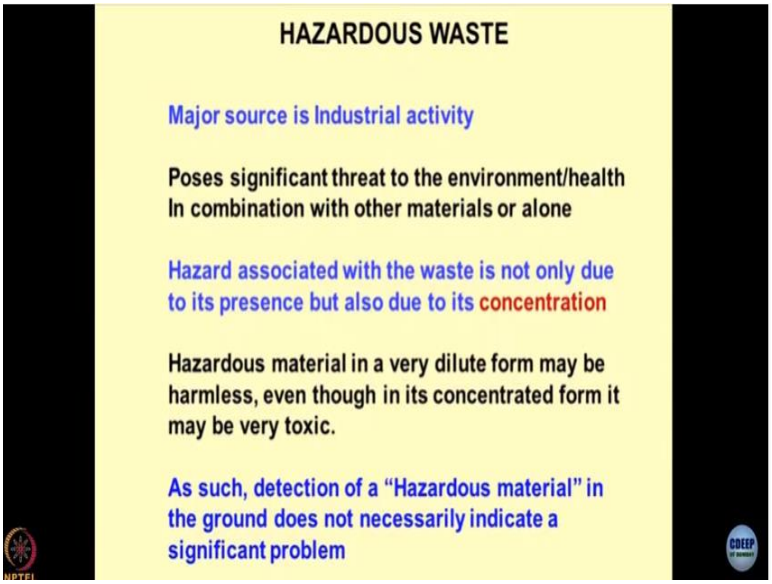

So hazardous waste is the one which is a having the major source of industrial activity and this poses significant health or hazard associated with the environment. There is something known as the concept of concentration. So hazard associated with the waste is not only due to its presence but also due to its concentration. And this is where we talk about a term which is known as hazardicity and toxicity.

When the concentration of the contaminants in the system go beyond permissible limits, they become toxic and as long as they remain within the permissible limits, they are hazardous. So given a chance which one you will prefer hazardicity or toxicity or which one you will think of negotiating with I will prefer hazardicity because toxicity is something which has gone beyond certain numbers certain limits.

The question is who sets these limits? Pollution control boards clear or the agencies which are doing statistical analysis. So if these types of industries are running in this area and these type of sludge is being disposed of what type of diseases prevailing in the nearby township clear. And then if I make a model out of this sometimes when you get a chance, please check on net biodiversity analysis.

So there was a time when geotechnology has never talked about these terms. I hope you can realize bio is something which geotechnologists has never bothered about. And diversity also we never bothered about, but I am sure now these are the terms which are becoming contemporary in our practice of the subject.

So biodiversity talks about what I discussed just now. There is an industrial activity, and I would like to know what is the influence of this industrial activity in the surroundings and these surroundings could be x, y, z, t you remember long back we discussed all these things. So this is where based on the statistical models and the agencies, environmental agencies, the numbers which they describe become guidelines or permissible limits and anything beyond that becomes toxic unwanted and less than that is hazardicity.

So this is what I have written here. Hazardous material in a very dilute form maybe harmless even though in its concentrated form it may become very toxic. Most of the medicines is a good example. They are toxic, particularly you overdose, but if you dilute them, they are curative as well as hazardous also. So there might be some side effects, but they might be curing your disease.

So as detection of hazardous material in the ground does not necessarily indicate a significant problem. I can live with a hazardicity but not with toxicity. These are very conceptual things but very abstract thinking. So as I said, what you need to do is you have to quantify these statements prepare guidelines to help pollution control boards make society better.

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Okay so let me continue with this sources of hazardous waste nuclear power plants municipal solid waste landfills, chemical and primary metal industries, paint and dye manufacturing industries, mining industries, paper and pulp industries. Most of the geotechnical engineers were dealing with the geomechanics are very closely associated with industries. Nuclear power plant I have discussed quite an in detail MSW also I have given you some idea chemical and primary metal industries. You can understand that ultimately the sludge is an issue.

Paint and dye manufacturing read on the internet that how this industry got affected because of the NGT order or maybe Supreme court order or high court orders. So these are the topics in

which the judiciary gets involved directly with the issues. Why? Because they are controlling the laws of the land and one law of the land also is that behave in a manner that nobody else gets affected because of your activities.

Do you ever wonder what paper and pulp industry are doing here in this list? Because the paper and pulp industry produces a lot of sludge. The more and more you wash the paper with acids and different chemicals you produce a lot of sludge, and the sediments which come out of the paper and pulp industries are equivalent to the silt which is normally used in geotechnical engineering construction or for different infrastructure activities.

I have discussed a lot about the mining industry also. Similarly, battery and cell industry so I am sure nickel, cobalt, bismuth, cadmium these are the heavy elements which are causing a big problem to the present day. Safeguarding of the geoenvironment as far as the gadgets are concerned. Yes, these are required, and they are fulfilling the requirements.

The leather industry I am sure you must have come across that the leather is also a big issue, particularly the type of leachates it produces and the contamination which it causes of the geoenvironment. So big list electroplating so the more and more electroplating you do the spent fluid, spend fluid is the one from which you have taken out the metals. So when you are doing electroplating.

And then the question is where to dispose it becomes liquor of certain anions or cations when you do electroplating, so when you do electroplating, basically cations go onto the electrodes or bangles and all whatever you are trying to electroplate that will become a cathode on which cations will go and get deposited. So all anions remain in the solution and hence solution becomes a very concentrated anionic solution chloride ion let us say.

So most of the industries are facing this problem that after the processing has been done the sludge which comes out of very high and any concentration what to do with it and then they approach you to solve this problem. Do you realize so the concentrations would be 40000 PPM,

50000 PPM extremely high concentrations and you are supposed to give a solution to these issues? It becomes interdisciplinary work.

"Professor - student conversation starts" Leather industry like in Kanpur tanneries sir is there any subsequent like significant improvement in their work and right now after so many of the years they are near the Ganga river that is why I am asking about the tannery specifically. Correct, so you are quite knowledgeable you are aware of what is the situation. There is a central leather institute also in the country as go to the webpage and see what they are doing where it is located check it and visit their website and see what type of innovative things, they are doing into the leather industry because leather brings a lot of foreign revenues to a country.

Apart from the revenues which local market also provides textile industries, you must be aware of. There were so many judgments given by the courts on the closure of the textile industry. Why Jaipur is a good example where the Kota print used to be dye printing used to be the main issue and it contaminates the ground water extremely. So there was a threat way the leather industry was banned. Similarly, the dyeing industry was also banned, but for an environmental geotechnologist this should not be a solution to a problem.

Banning is not a solution. What should have been done? The solution should have been provided so that nothing untoward happens to the geoenvironment. Now, this is what engineering is you take a specific case and solve this problem. And say this is the solution which I am giving to the society hospitals and pharmaceutical companies. I hope you can realize it is a big challenge on how to deal with the hospital waste bio-waste the cancer cells which are removed in the hospitals. Who knows where to dispose and how to incinerate them. Correct so these are the challenges.

Pharmaceutical companies the sludge they are producing, and they are disposing of this is a good example of hazardous waste you can add onto this list. This list is never-ending "**Professor - student conversation ends**".

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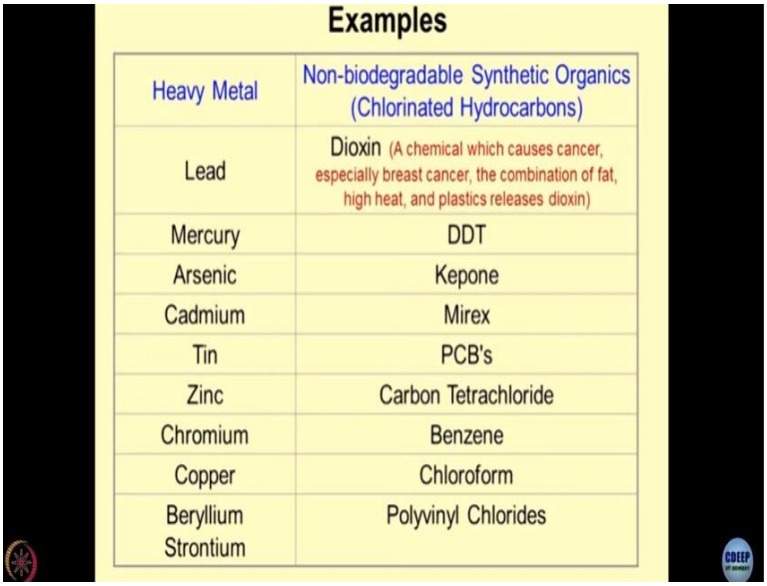

Some of the examples of heavy metals I have written over here and how do they influence and what form they are obtained in different gadgets utility items I have listed over here so let Mercury, Arsenic, Cadmium, Tenzing, Chromium, Copper, Beryllium, Strontium. These are the heavy metals which are checked, or which are tested in drinking water and the sludge which are being disposed of.

And on the right-hand side, I have shown what the potential utility items where you might be having this are. So somewhere must have read a few years back that the kids in India are not supposed to get exposed to the toys from a certain country you came across these type of things very good, so you are aware of what is happening? So somebody wants to be forming these rules and regulations. Is it not long been there was a case against a company which used to make shoes?

So imagine your foot barefoot is always in contact with the soul of the leather. And if these souls are made up of PVC what is going to happen as a scientist, how would you analyze this problem? It is a contact mechanics problem. So you have a high chloride concentration in the PVC which is migrating into the blood vessels in your body.

So non-biodegradable synthetic organics, chlorinated hydrocarbons and in what form they are available I have written over here. Lead, Dioxin, Mercury, Kepone Arsenic, Cadmium, Mirex.

PCB boards which you have in your electronic gadgets. They have Tin and leachable zinc, carbon tetrachloride, benzene, chromium and different type of polyvinyl chlorides which might be having Beryllium and Strontium.

So once you enter into this realm, you have to understand that a complete diagnostics of the soils where these type of manufacturing activities are being taken up has to be done. If they are contaminated, they are to clean them up and if there as a potential of contamination, you have to stop it and then this becomes a big issue for the nation and the society. Is the scope becoming clear that what are your activities, and this is where you have to use advanced instrumentation tools to detect or the facts are?

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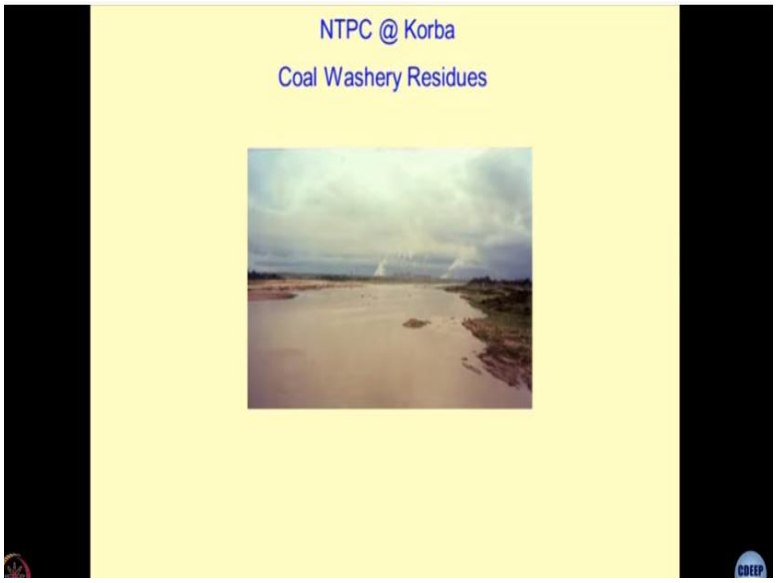

Okay so moving on to a real-life example. Some of you were very eager to know what is happening in the world. I will share my experience with a project which I did long back at NTPC CORBA I am sure you must be aware of what is happening at CORBA NTPC is the main unit over there, and they produced a lot of electricity for the country. But when they produce electricity for the country at the same time, they are producing a lot of fly ash and its a big question on how to deal with this fly ash in a better way.

Now what I am going to talk about here is not the fly ash but the coal which is used to run these four units of NTPC, and I was in involved by an Australian company here which were running

the coal washery. So if you see from a distance, this is NTPC plant, and a lot of emissions are taking place in the environment. And of course, they may say that everything is safe because now they might have put back filters on the dust collection systems to clean up the emissions.

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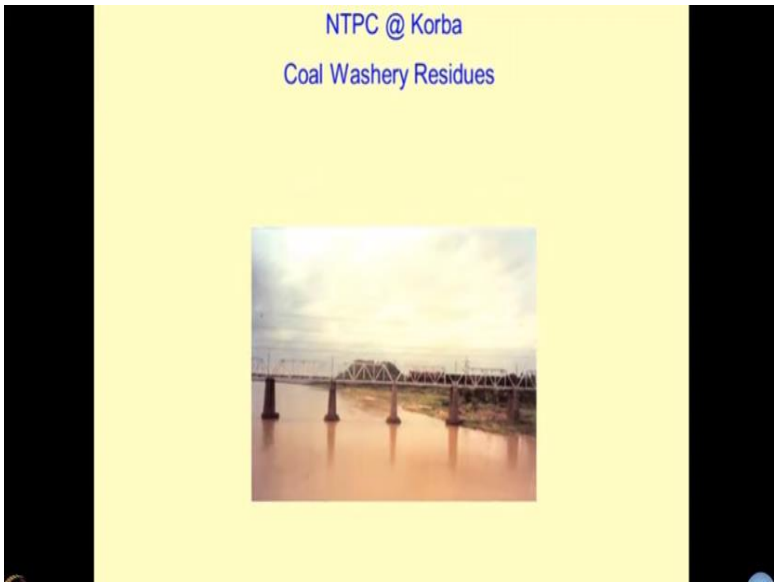

I intentionally took this photograph I wanted to show you this is a railway bridge in which railway wagons are moving. The train is moving and in the background is you will see that there is a big hill which had been created by human activities and these Hills are several in numbers in the Raipur Corba regions because these are the mining overburdens that you are discussing long time back.

Okay, this could be the stack of the coal which is unused which is not of the good grade to get incinerated easily. Were we talking about the calorific value of the coal hardness or the coal all right? So if the coal is not good quality, there is no point in taking the industry because it cannot be incinerated. It will not provide you with proper energy. So one of the concerns is that the height of these hillocks which are manmade is increasing and we will discuss this in details.

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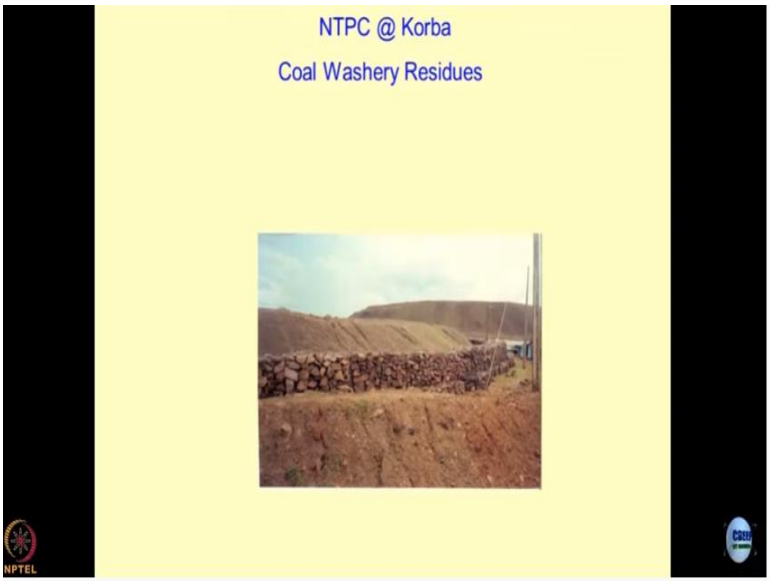

This is how they store the washery residues. These are coal residues which have been stacked multilayer system. And the mandate given to me was how to utilize these materials? Because unless you create a storage space, the coal which is coming out of the open cast mining cannot be generated.

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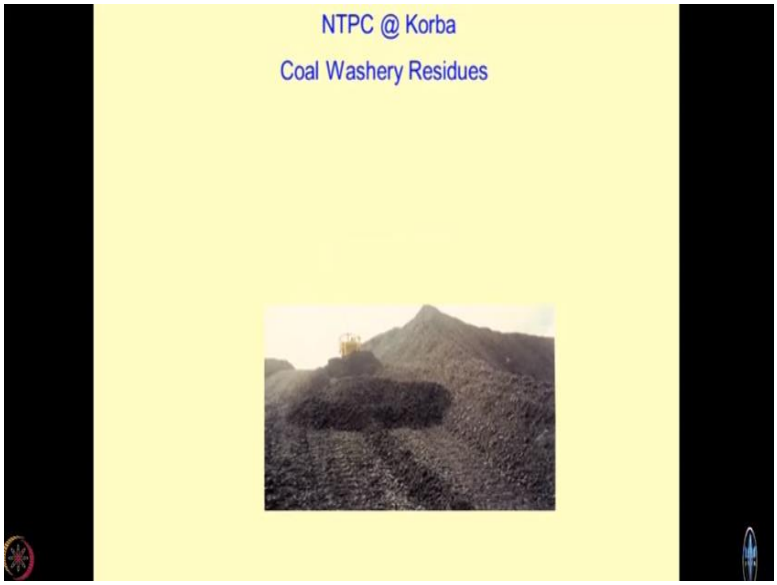

So these are the residues from a closer picture you realize that I am quite at a height it must be about 35, 40 meters high where these type of road system is created to bring the old residues after washing and to stack them over here. So this becomes a multi-tiered system.

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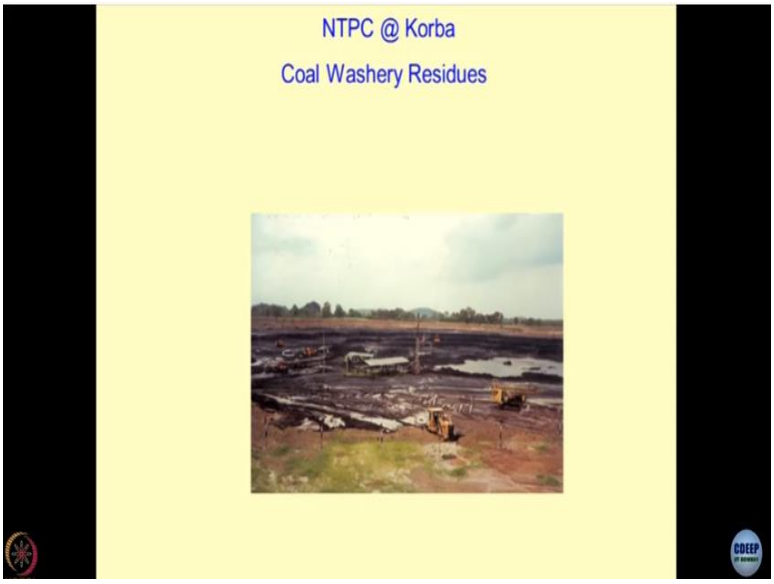

This is a typical open cast mine. This is one typical manmade mountain overburden which has been created at a quite distance from the mine. And if you see from this point onward this is the ground, and from here the cutting has started, and this is the first seam of the coal, and so on, we have created ventures of the coal, and this is how the coal is extracted.

So open casts mining we are doing a project right now at Banegaon in Nagpur. It is a very challenging project discussing and starting the discussion that the deeper you go the big issue is how to stabilize the slopes of the granular material which could be 40,50 meters high. And unless you stabilize this mining operation cannot be done. There are several challenges. So as I said long that its not only the mining engineer's domain it is mostly geotechnical engineer's domain and they give you all sorts of guidelines and we are trying to work on this problem.

Apart from this, the biggest issue is this being a sedimentary deposit and that it will be bodies or the surface of the water being very nearby. This water discharges into the mines, and hence it becomes tough to do the stability analysis of the cuts because of excess sewage.

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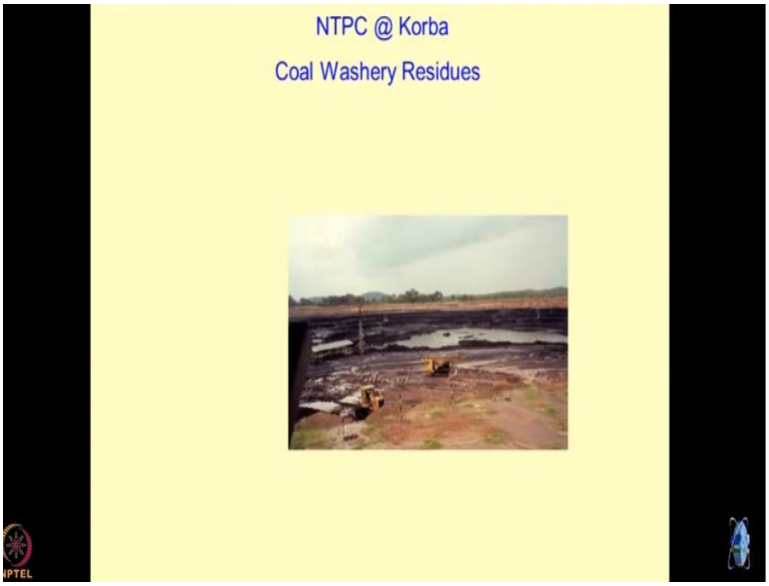

This is another close look for how the benches have been created and how coal is being taken out. And imagine what my intention was. At one side you are doing mining you going extra deep inside the ground. On the other side, you are creating mountains of overburden material. Both are hazardous, but mining has to be done for the sustenance of the nation. How long will you be bringing coal from other countries and you are losing on a lot of foreign exchange.

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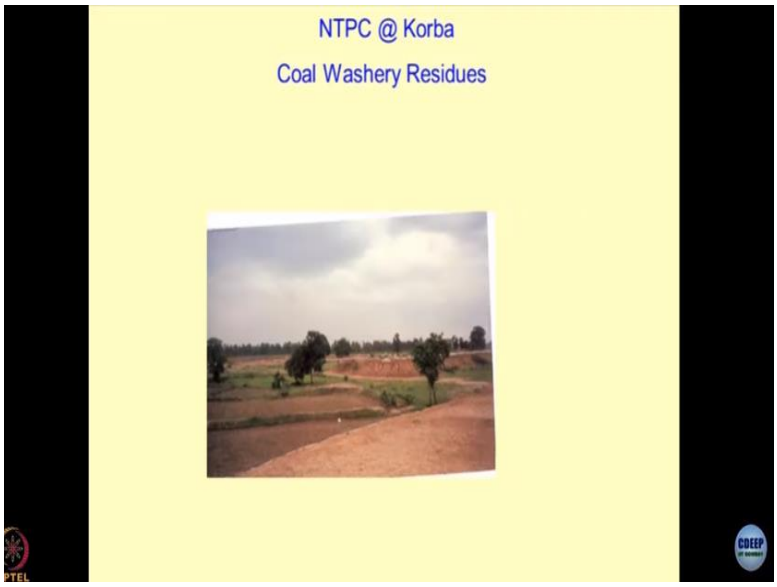

So incidentally what I have shown over here is that this is agriculture land and then the idea was to utilize the millions of tons of the gold residues for clearing some infrastructure.

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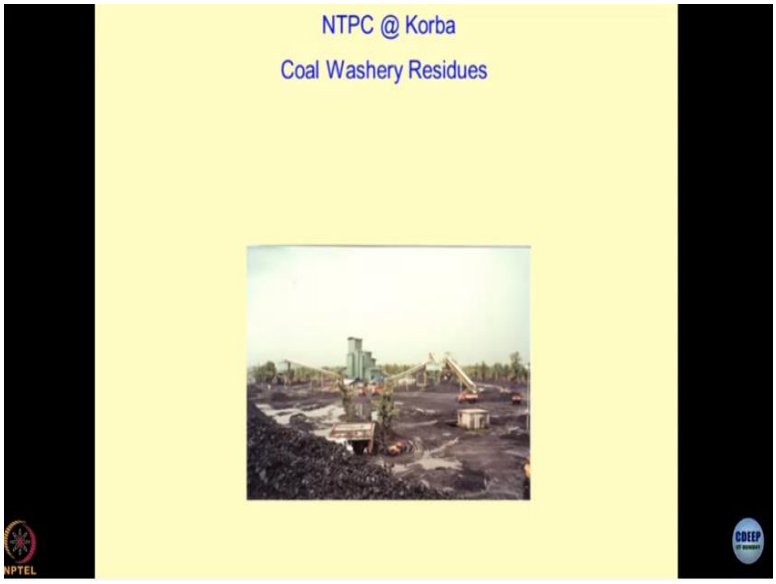

This is a good example of how old residues get stacked at the coal washery unit; washing of coal is a chemical process. Sometimes you have to wash it with acids. Sometimes we might ever be treated with a different type of steam curing. Sometimes you have to give a treatment of different chemicals to get rid of impurities in the coal and so on.

One thing you should realize is that today's geotechnical engineering is not mastering only one subject because then the problems become very limited, and the scope of your activities becomes absolutely limited. Instead, what society wants and looks up at you is they want a solution to the problem. So you have to learn in the process lot of subjects and the concepts so that you can give a good solution.

So you have to learn a lot of chemical processes why coal is a residue. You have to ask these type of questions when you go to the sites and meet people before you can solve the problem. Because ultimately the question is how to utilize this material which is of no use to the washery. So unless I have created a similarity between this material and the natural aggregates which are existing, I cannot go ahead with the solution.

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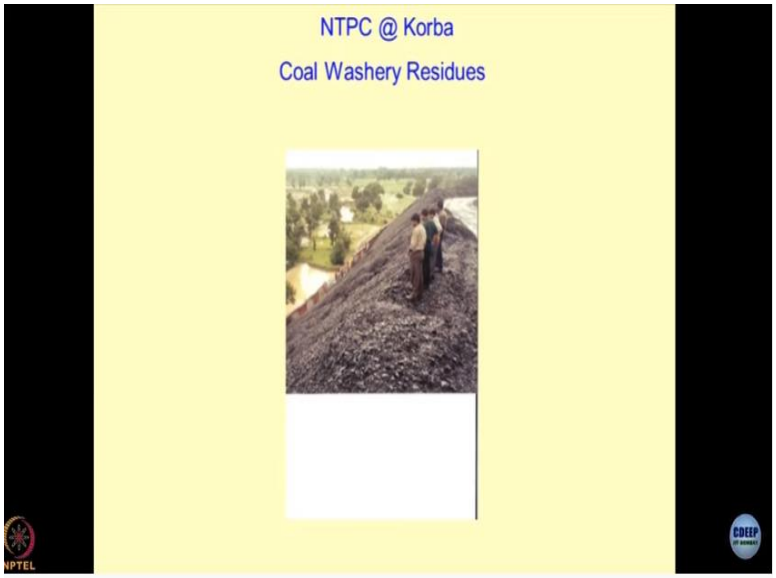

This is how it looks he is Dr. Naidu one of my Ph D scholars who is the faculty now at IIT Chennai and the next one is Dr. Kolay who is now a faculty member at university of Carbondale close to Chicago. So these are the people who are associated with this project and this gives you a very clear idea about the washery is somewhere here, you are stacking the coal residue, and this is the road which I was talking about to take the material to create a second point of the storage.

The huge areas like there have been few acres of land and the heights would be this level itself is about 20 meters and then each of the flights would be 10, 10, 15 to 10 meters or so on. Imagine the magnitude of the problem. This is one of the coal washeries in the country.

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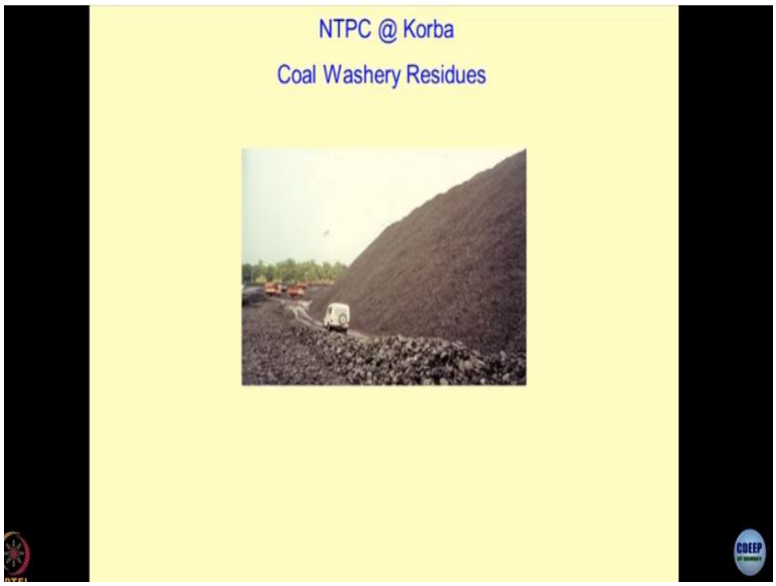

I hope you can realize now the magnitude of the problem. Had it been some embankment I would not have bothered much about it, but this is carbon material is it not. The chances of this metal catching fire during summers are tremendous. Methane formation is taking place because of coal, so flashpoint is their organic material, and you are stacking it like this. It is a hazard to store this material in your premises clear.

It could be inflammable and hope you can realize from the size of this car what is the height of the slope we were talking about. Now the question is, what are you going to do with this material?

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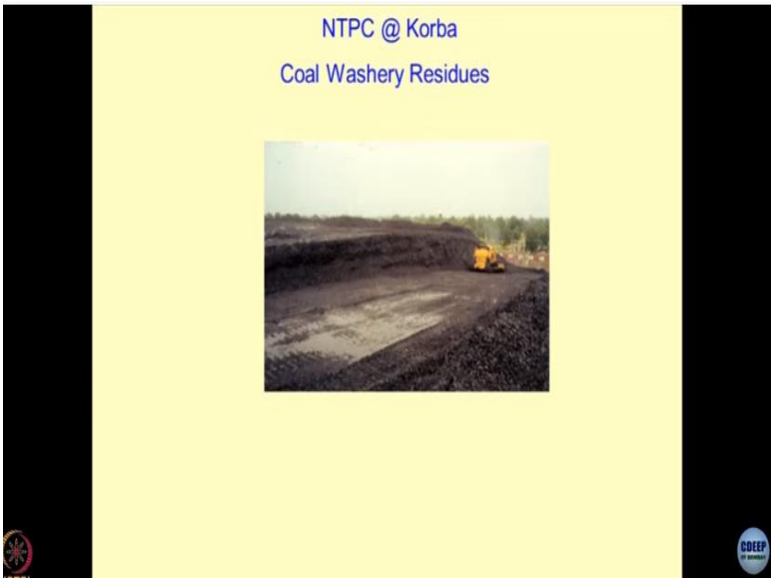

And another beautiful picture of how do they manage these storage areas and how do they create further storage of the materials. So you have to learn all these things. Management of the heaps of industrial byproducts and the waste material which is coming out.

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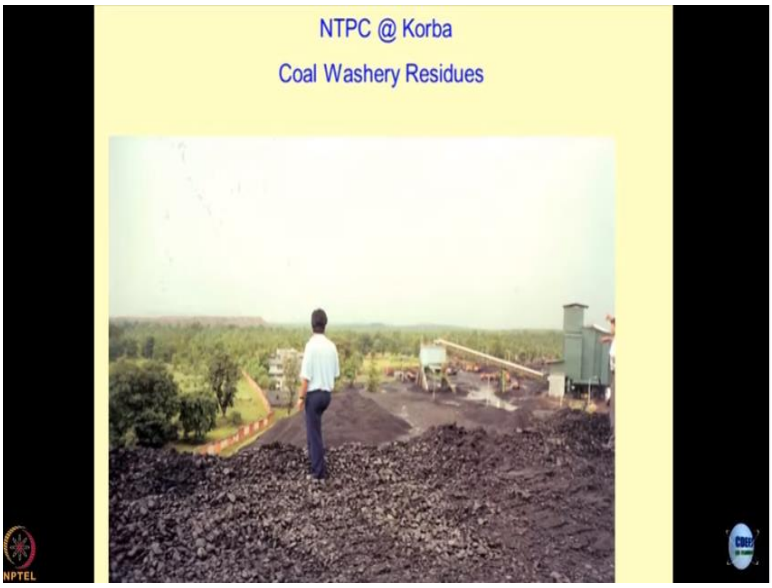

Another picture I wanted to show the manmade system like coal washery residues on which Dr. Kolay is standing. In the background, you can see the manmade hillocks overburden when you remove the topsoil and stack it somewhere look at the whole area. This is a plain area near CORBA, but it looks like a very hilly terrain because most of these are made up by mining activities. I hope the statement of the problem is clear to you and the importance of the problem is clear to you.

Now if geotechnical engineers cannot solve this problem who else will be solving? This is a big question. Only thing is the material has got changed. You have been doing slope stability analysis of silty frictional material. C- phi type of soils clear here the material has been changed. The rest of the problem remains the same some of the reviews.

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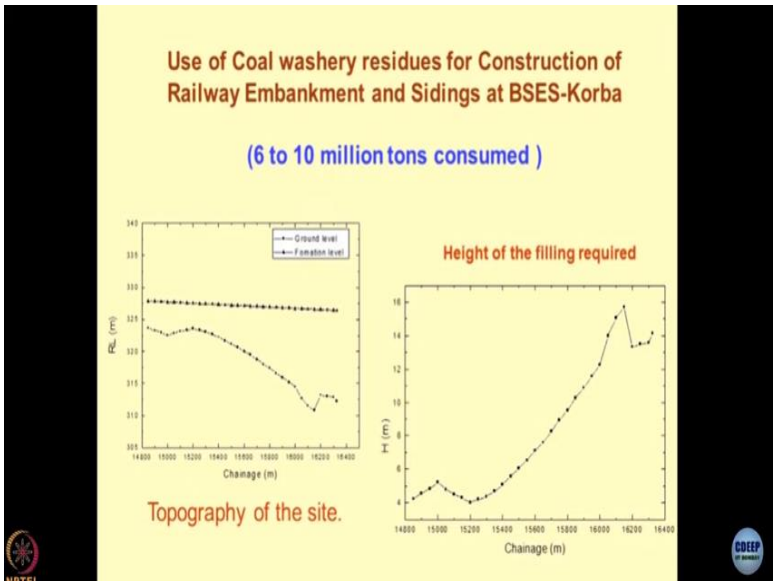

So this is just to tell you what the solution was if you see this is the valley of the land this is an existing ground level and this is the formation level for the railway track that they wanted to construct. So in nutshell, they just wanted to create a railway siding so that the operations become simple. But soil is not available in the nearby area. And what you have is the industrial byproduct. And now the question is can I use this industrial byproduct which happens to be coal washery residue to create an embankment on which railways can lie.

So if you realize this is you will see that the height of the filling which was required to get this gradient of the formation for railways to ply was 16 meters huge height clear. And in the process, we consumed about 6 to 10 million tons of the residues is a substantial amount.

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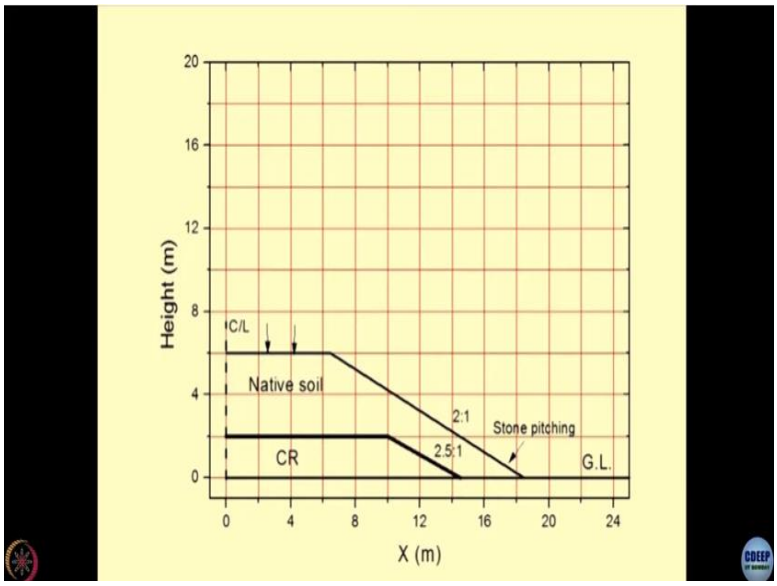

The rest of the things are simple. I mean you do slope stability analysis, but the question is from where you will get parameters, we were discussing some time back somebody has asked what software that is being used. So software could be the same, but the question is now the soil has been replaced by the coal residues. So you have to perform all the tests on coal residues to get their fundamental properties unit, weight, density, compaction, flakiness and then a water absorption, capacity, impact durability, and so on.

You have done all these tests apart from all the series of the conventional test what you need to think about is the instability it may get ignited because of fire migration of methane gas into it a degradation of the material. So oils are less prone to degradation as compared to organic matters like coal. So I'm sure you must be realizing now the conventional subject has been topped with a lot of interesting questions.

How would you model the little properties then substitute those properties and give a solution? So this is the first cross-section which I tried to work on. But what I realize is that if I have to cut off the coal as dues which are encased over here, I have to use a lot of native soil. And as I said native soil is not available because no villager is going to give you the soil for creating embankment, they lose the land that too fertile land. So this did not work out.

So what we did we kept on increasing the volume of the coal residues which can be packed in the embankment and reduce the cover of the native soil. But still, people are greedy. So when they saw that this type of solution work, they said why do not you increase the CR volumes and reduce the native soil for them? But I am sure now you realize that this is a railway track. So most of the impact loading is going to come on the coal residues. And they are fragile materials as compared to soil.

So if there is no sufficient cover of what is going to happen, there will be an impact-induced degradation of the material. You must have studied in your transportation engineering course. So you have to provide a proper cushion so that the CR does not degrade because of that the railway impact. But there has to be a sufficient amount of native soil cover so that the free supply of oxygen to coal residues gets cut off.

Otherwise, what will happen they will degrade very fast, and there is something known as methane formation because of the decomposition of the coal. So these are the challenges. I hope you realize those are problems which are very simple. But when you have to start doing this from point zero, it becomes challenging. So this I did in very early career, and from here I learnt all these adjectives which I use now in my professional career.

Degradability. Durability clear applicability of the material. So all these series started when we were working on this problem. Of course, the client was very happy when I gave him this final solution that you can use so much volume of the material in the as an embankment followed by a very thin layer of the soil which is required to make a good embankment. So I hope you can realize that this is how engineering can be done. And when you are giving a solution, what changes in the way of looking at the material.

So similarly, I remember I did another project near Vallarpadam in Kerala where I did a lot of things. So my material got changed, but I created a complete bypass for the entire Cochin city. And this entire material came from the sea. Now, this is the engineering and technology which cannot be taught in one day. So you have to sit down and learn to analyze and then think of a solution.