Geoenvironmental Engineering (Environmental Geotechnology):
Landfills, Slurry Ponds & Contaminated Sites
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Lecture - 39
Environmental Control Measures at Slurry Ponds

Good day to all of you, today we will do our last lecture on slurry ponds and we will address the issue of environmental control measures at slurry ponds.

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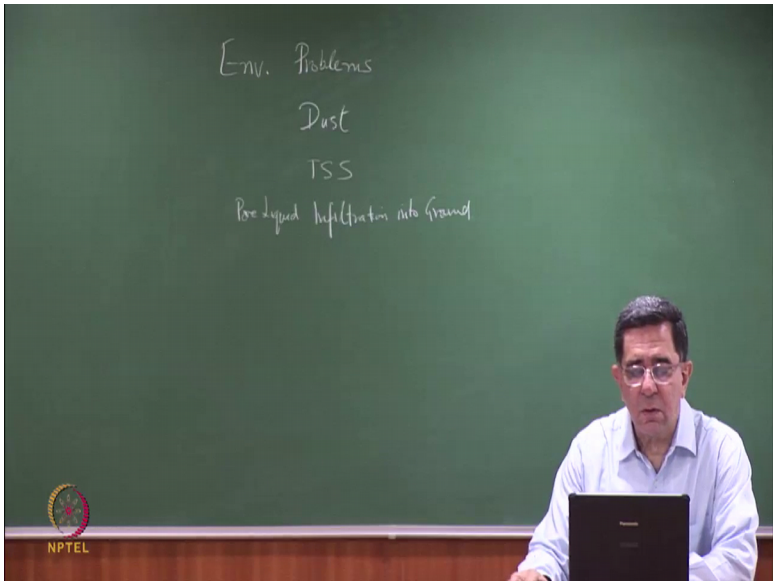

So, in your mind what are the issues environmental issues and environmental problems associated with slurry ponds. So, anybody like to say what are the problems associated with which is the main one which comes to your mind suppose I have an ash pond what is the main issue with the ash pond .

So, if the ash is dry in the dry amongs the there may be dust emissions. So, that is one issue problem any other problem? Environmental problems with slurry ponds we saw that the decanted slurry which normally is either recirculated, but if it is not recirculated it goes back to the water source. So, the decanted slurry is sometime milky in color. So, there is this issue about suspended fine particles, total suspended solids. So, sometimes the total suspended solids was also an issue, any other thoughts which come to your mind or any other issues which you think would influence?

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Well it may in filtrate in to the ground water, but if the water is, in filtration into ground. So, if the leachate or if the pore liquid if the pore liquid is not of good quality then you have an issue if the pore liquid is alright then there may be a another related issues we look at. So, let us see these are some of the factors which comes to your mind in an overall context what are the environmental issues that we look at. So, if you look at an ash pond or a slurry pond we talked about fugitive dust.

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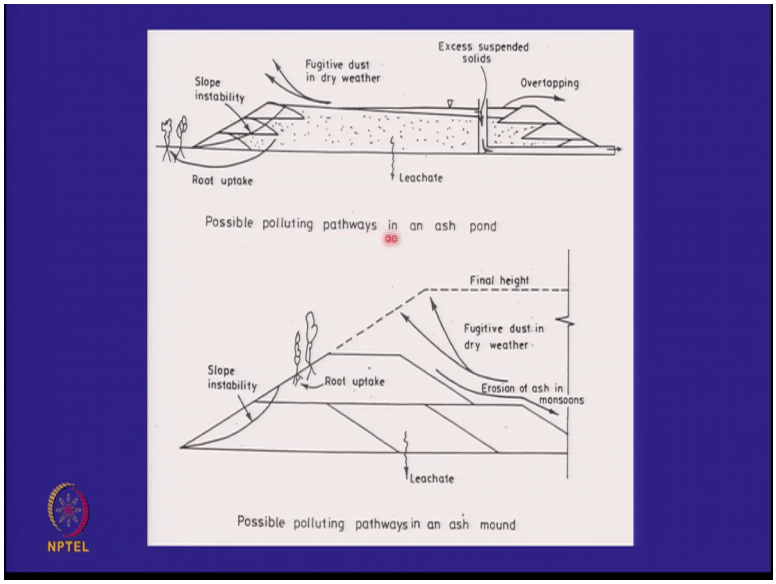

So, the dust is not going to come out from the ponded area, that dust is going to come out from the dry area and a tendency is we should keep the pond as small as possible. So, that the phreatic line is not high that can be a problem, but if you are very close to habituated areas then you might want to run your slurry pond by keeping the water level high. An excess suspended solid in the decanted water is also another problem and somebody said leachate into the ground. Sometimes the concerns are expressed that you know there may be some dilute area salts or material in this. So, one issue is that those will go with the leachate to the ground water table, but more importantly if they also come out then they can affect the crops adjacent to it.

This is not enough evidence to say so, but since this material is not natural material, but more manmade either by burning of coal or by various processes involving crushing of the rock and then chemical additions to extract the metals, sometimes there is a issue that

some of these deleterious material will come out and effect the plant growth or it will be taken up in the roots of the plants. Occasionally we do have the problem of over topping which is more a stability problem, but what is the difference.

Suppose I have a water reservoir right suppose I have a water reservoir. and I have over topping over topping will occur if the spillway capacity is not adequate or if there is a large rain which comes and you are already full up and you do not have adequate free board. Over topping normally occurs when your ash is almost full slurry pond is operating at it is full capacity and you have a huge downpour and your spill ways are not having adequate capacity. So, if I have a water reservoir and it if it overtops the water will come out right it might breach the embankment that will become a liability issue and then it will flood the adjacent areas. So, if water comes out from a reservoir it will flood the adjacent areas right, but eventually the water will flow away along the natural drainage paths. So, temporarily it will flood the fields, but after about a week you go you will find that the water has gone away because all ground has some natural drainage paths taking it somewhere. When over topping occurs with ash the major problem is the water will run away, but the ash will get deposited in the adjacent areas.

Now, it is not so easy to remove the ash because now the solid powdery material as settled down on the ground surface of the nearby areas. So, over topping of slurry has a much longer permanent effect, than over topping of water both may have impact on you know the habitat around it the crops around it, but the permanence that once slurry has come out it has and I have told you slurry can travel several 100 meters and sometimes kilometers. So, if you have say slurry ash has traveled one kilometer or mine tailings have traveled one kilometer, and suppose it is a farmers fields and you have some wheat growing wheat crop growing in it, now what happens? That material gets settled n the wheat crop you if we have to bring back that material by an earth work operation the crop is lost of course, even if there is flooding sometimes the crop will be effected, but at least the water will go away. So, that is the major issue about over topping in slurry ponds.

If I am doing disposal in the dry manner then of course, there is larger problem of fugitive dust emissions and there is also problem of erosion from these slopes during the monsoons, till the final cover comes. Once the final cover comes then the problem of erosion is not there is there a problem of erosion in the pond in the slurry pond well we are making these embankments and they have a cover soil and you are suppose to have a vegetative growth on it. So, erosion is not a major problem in pond if your embankments

are well designed, but in dry placement these slopes are exposed till it reaches the full height and there can be erosion and there can be fugitive dust all other aspects are similar.

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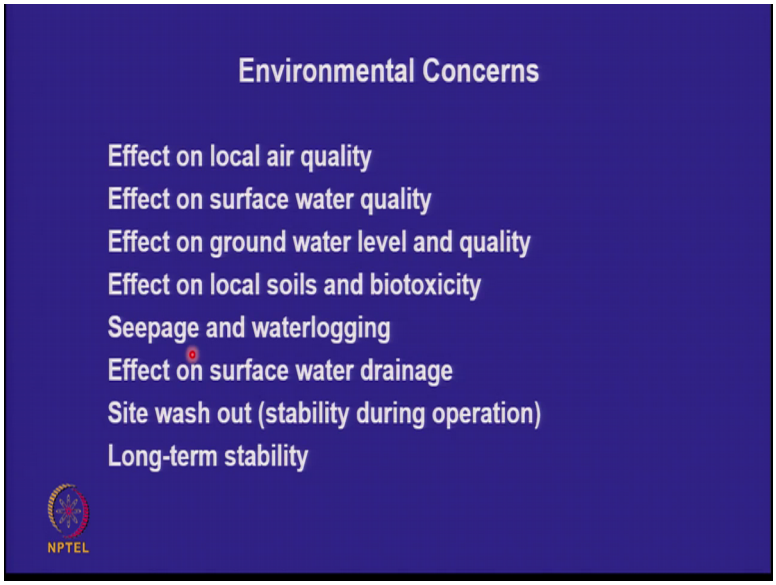

So, if I want to address the environmental concerns I have these few issues, effect on local air quality because of dust effect on surface water quality because of total suspended solids, effect on ground water level and ground water qualities.

So, these are two issues which are separate if I have got deleterious material or if I have got contaminants in the water if the poor fluid quality is not good, then I can effect the ground water quality, but the other issue is I will I may also sometimes effect the ground water level and that also may have it is own associated problems. If the dust is taking away ash what is the effect on local soils and biotoxicity? Occasionally you will have im I mean last to last year there was this big news item that the upper (Refer Time: 08:53) in himachal were being effected by ash from a nearby plant what was happening was that during the pollination period the ash particles was settling down on the plants and that was effecting the pollination conversion of the flowers into fruit.

So, while it looks very in aqueous is a very mild things small amount of dusts, but in an area which is not having dust in the past if you start creating a environment which has small particles floating around it can effect. So, it can affect the local soils or biotoxicity. You are the issues of seepage and water logging because you are creating a pond, you may sometimes effect these surface water drainage pattern of the area just like in landfills

if you are making your pond in low lying area, normally the low lying area is a drainage path for of you know flows in high rain fall months.

So, we have to take care of that site washout or over topping is of course, an important issue and finally, long term stability. When you and I are have walked of the pond, the plant has started stopped operating who is going to look after it for 100 years 200 years 500 years.

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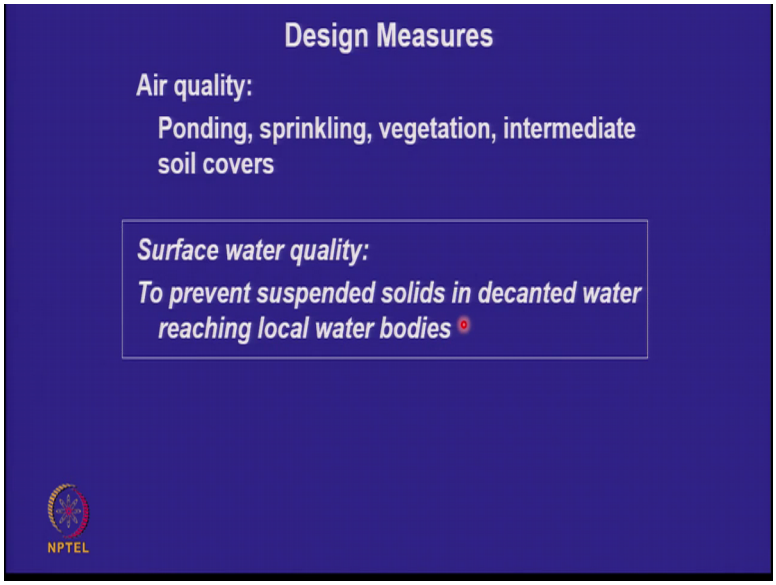

So, let us address this, first question is how to prevent fugitive dust emission during dry summer months and it simple you can do ponding. So, if you are in area where the dust is causing a problem you have a road highway next to the pond and you get these huge dust emissions or you have some houses nearby.

So, you can increase your ponding as long as you are having excess water supply; that means, do not operate the pond in the summer months at low level increase it, and keep the majority of the ash submerged. One can also say I can sprinkle, but sprinkling is 24 by 7 sprinkling is very very costly you know exercise, and it is power dependent. So, I have not seen sprinklers which can keep the dusts (Refer Time: 11:06) 24 by 7. You may do sprinkling in you know while you are there you may have automated sprinklers ideas to keep the dust down, but 24 7 sprinklers I think on any area I have not seen. Of course, when the pond reaches it is top level then you should grow vegetation on it either by putting a soil cover and vegetative growth or if even on that material the shrubs can grow

then please accelerate that vegetative growth. Because any form of vegetative growth will be a dust control measure and of course, sometimes you might want to use intermediate soil covers, that means you have a material which is going to go to 15 meters high, you can build an expenditure that after every five meters ill put in an intermediate six inch soil cover.

So, that the dust is now the ash surface area is not exposed. This intermediate soil covers works more when you are using ash as the construction material in embankments, then you do not want to leave very large patches of the ash expose in a dry condition. Surface water quality we have a dresses issue how we prevent suspended solids in the decanted water from reaching local water bodies. See if the size of your pond is correctly designed then the finest particle will settle and you will have clear water coming out the problem comes when the size of the land available to you is smaller than the design size.

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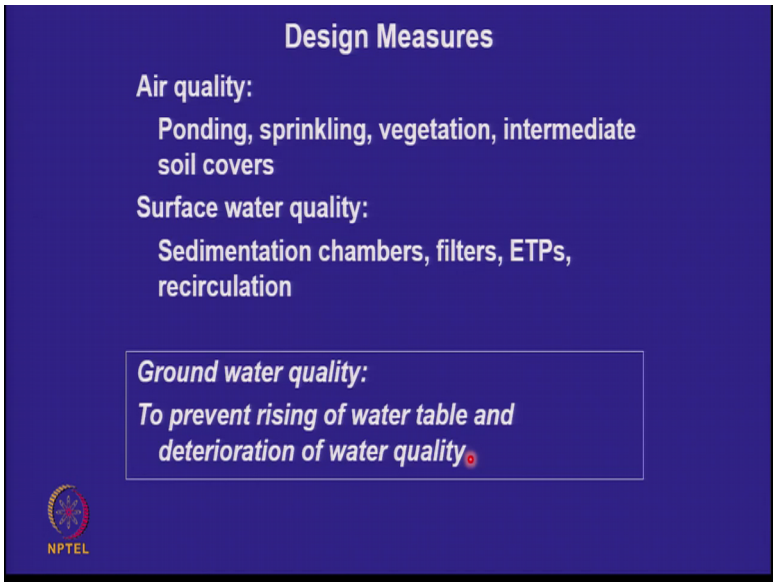

Then you have a tendency for the coarse particles to settle, but certain set of particles will pass out. And really for that either we need additional sedimentation chambers or we talked about filters last time filters which becomes choked and which have to be periodically cleaned, all we can actually make a end of the decanting pipe and a treatment plot where you flocalate all these fines and deposit them. That is very expensive and of course, finally, you re circulation means that you are not releasing any water into the body into the surface water body nearby. But re circulation you can do for a limited period of time the material instead of getting built up in the slurry water and eventually you have to

do a blow down or you have to release something, and at that time you will have to need all these alternatives.

So, even today sometimes when I walk to an ash pond, I am often seeing when the pond is full you see when the pond is when the ash is down, then even if the vertical even if the horizontal travel time is not adequate, you can close the lower ports. So, that the water level also raises and therefore, there is a time or horizontal travel and a time for the vertical raise. So, you can have more retention time, but when the pond is almost full then you are not able to hold anymore water.

So, that is the time when you find the emissions becoming high. In terms of ground water they have two issues one is preventing the raise of the water table and the other is the deterioration of the water quality. And if I look at the issue of raise of the water table, I ill I just want to (Refer Time: 14:45) if you make slurry pond in an area where there has never been a water reservoir in the past, your water is coming either from a canal or from a river it may be 20 25 kilometers away and now have made this pond which is like you have created a lake.

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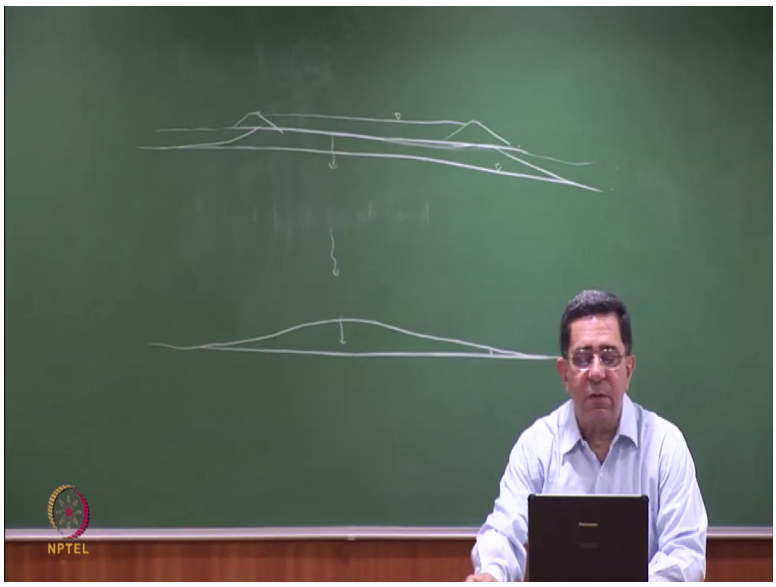

So, may be in the original site the water table is deep bellow into the water table is deep bellow, and you create a ponded area and remember this is going to work for 25 years, you are going to have water most of the time in the pour 25 years. So, if there is no barrier to downward flow; that means, not impermeable soil a very low permeability soil

then this water will tend to flow down. Some will be held some will reach down and if a lot of water is flowing down, this water table may become something like that. There may be a mound of water the water table may raise a little bit in this area because lot of water is coming eventually it will just flow away when the pond is stop functioning water table will come back to it is original position if my water table is here to begin with, then I have to be very conscious of the problem because then this water table and this will get interconnected. The water table raise may be like that and this water table may rise. Now as long as water table raise is beneath the pond it is fine, but if the lateral permeability of the soil is high the water table raise may start to extend beyond the pond.

In I am not talking of the seepage water which is through the embankment; I am talking of the water which is going down. Now when this water table raises sometimes it brings up the salts from the bellow which would not in the crop zone, route zone of the crops up and that sometimes has a effect on the production of the crop output. In some cases it may be very good; if you are in a water deficient area what have you done you are started giving more water to the area. Assuming that the water quality is not effected the farmers around you are happy, there is more water in the tube wells they are more water in the irrigation wells.

So, that is good for them you are in an area where water table is already a plenty and close to the ground surface, you are doing the opposite effect they do not want more water they do not want the water table to come higher, but we are making it go higher. So, this causes the water able to raise it can be beneficial in a water scares area it can be a problematic you know high water table area.

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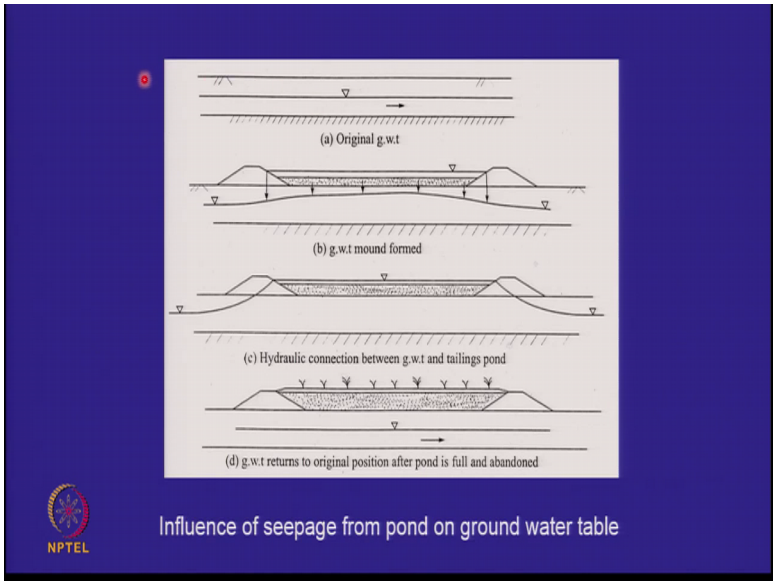

So, the one thing that we have to realize is, as you will see here that if this is the original ground water table this is the original land, I have come and made my ash pond or slurry pond, my water table has re reason it has become connected. So, after sometime when the ash pond or the slurry pond ids not being operated though there will be no water, you will put a soil cover you may put some vegetative growth on top and then the water table will return to it is original position. But for this intervening 10 15 25 years you can have some effect of the raising thw, local water table and that you have to take into account.

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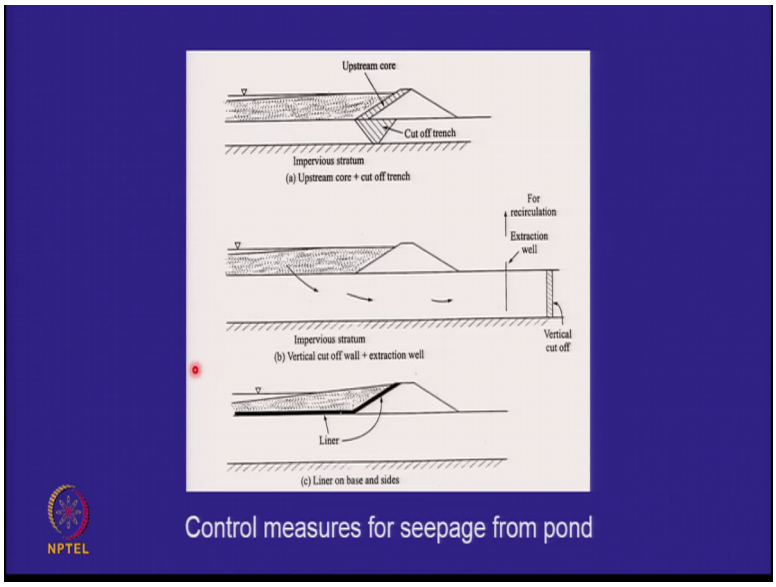

So, what about the quality before we look at the next issue what about quality? Water quality will depend on the slurry water, that is are you getting treated water, are you getting raw water from a river is the river water itself in the summer months having high contaminants. Now normally the water that you get for the purpose of making a slurry or for the purpose of chemical processes may not be a very high quality water. So, then what you are doing is you are picking up the water making a slurry, and depositing it on land.

So, if the water quality used for making the slurry is bad, then it can impact the ground water quality. Tother house no no inflow water was good, but my tailings had some residual chemicals and those chemicals are now mixing with the water and going down. So, this is a very waste material specific problem, for a long time there is been a huge debate that does the ground water quality get effected by burning ash, by burning coal and using the slurry technique of depositing the ash, does the quality of the liquid in which the ash has been mixed with the water does it effect the ground water table. And there have been so many studies which show no no there is no effect. If there is an effect it may be because the original water quality was itself bad more recently in the us they have started saying that no in a few cases they have seen rise in some specific heavy metals round ponds which have been in operation for several years. So, there are marginal increases beyond the acceptable limits of some heavy metals in the US which have been reported. So, this aspect has to be studied very carefully.

If you are using mine tailings what are the processes, you have to do the toxicity characteristic leachate procedure, that the ash or the mine tailings should not have anything, which can leach out and then see how it effects the ground water table. So, the only way to stop the ground water quality and the ground water level from being effected is by putting a liner at the bottom ok and please understand.

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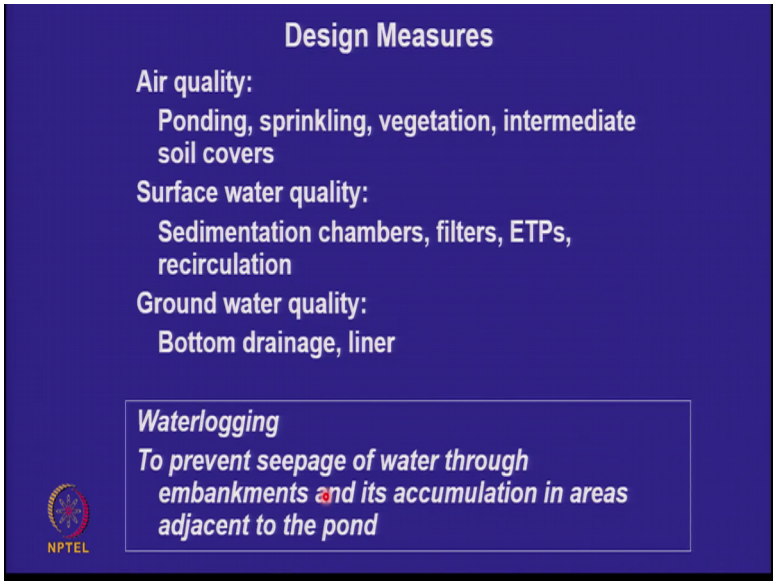

I can do three things, I can say that my leachate is coming down, I already have an impervious stratum here I can put a cut off trench and an upstream clay core and constrain this water in this area this is one approach. The other approach is let this water come out as it tries to go beyond the embankment I can put a vertical cut off valve and you will be doing this in the next few lectures and I can do a extraction well, and I can put it back here; that means, the effect of this water is not going to extend beyond this valve and the last is let me not allow the water to get out. So, this is the best and is while I while the word use is liner it means it is has to have bottom drainage also and liner because otherwise I told you incremental raising is very very difficult.

So, purely from the point of view of affecting the ground water both in terms of the ground water table level as well as in terms of the quality, you are safe if you use the liner with the bottom drainage. However, it is expensive because the size of these ponds is huge two kilometers by 2 kilometers. So, that is a very expensive bottom barrier that you have to create. But they have no options at the moment there is a (Refer Time: 23:01) guideline saying you must put a liner at the bottom does not give the details of the liner. So, people will put some thin plastic sheet, to meet the ministry of environment. And forest guidelines in the US now they are now specifying the requirement of liners the bottom drainage rules are just come out in October 2016.

So, really if you are looking at ground water quality as well as the ground water level bottom drainage and liner is a good thing. Even if we have taken measures that the

ground water will not raise we still have some times the issue of water logging. And water logging is normally due to the seepage from the embankment not from the base it can be enchanted from the base as well, but if you do not collect your seepage water properly and do not connect it to a surface water drain then what will happen is, suppose in plan I have a rectangular pond, in some area the water may start to seep out and collect outside and that causes water logging.

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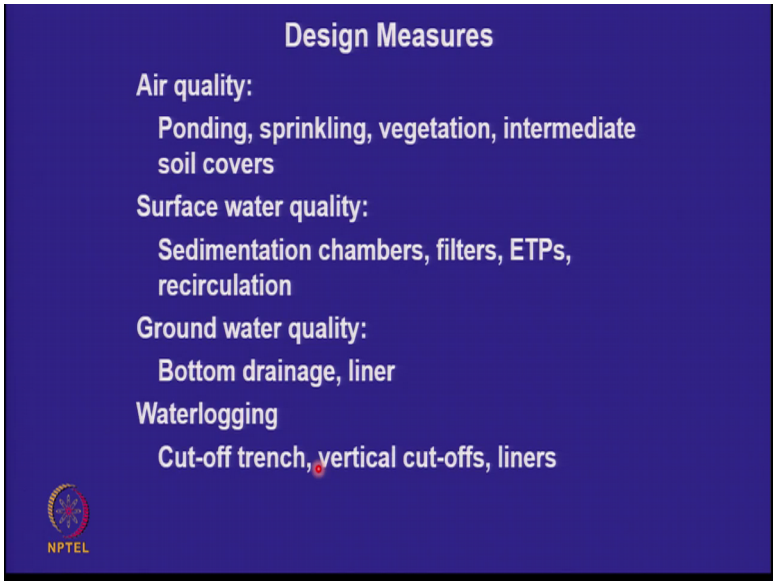

So, to prevent water logging best to have cut off trench which I showed or vertical cut off valves liners of course are the best solution. But in any case we have surface water drain or the interceptor drain outside the embankment, should be able to take away this water an connect it to the local drain from which the water flows away. So, efficient collection of the seepage water is important, and measures that nothing from the bottom comes to the sides are also important. And we have done this surface water drainage issue blockage of the surface water drainage path that if we are in a low lying area to we normally do not consider this, but we have to make diversion channels.

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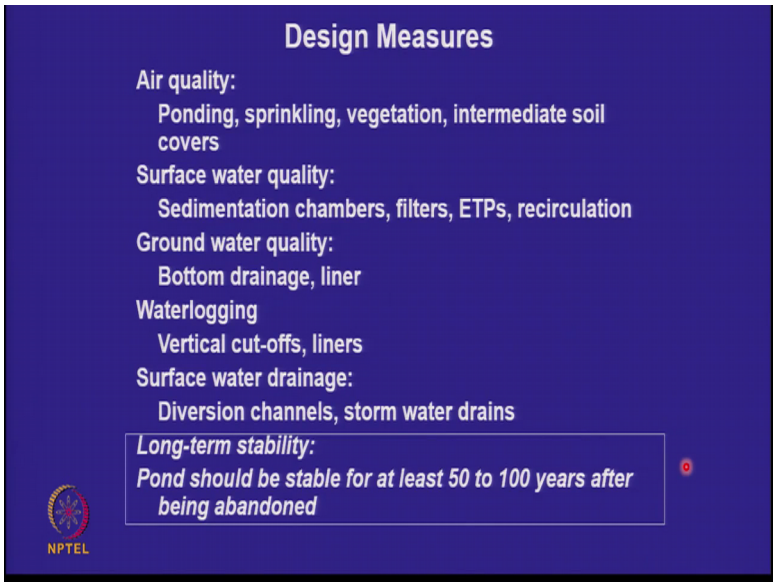

So, if I am in a low lying area let us say I have a concave upward shape and of the elevation of the ground on one side is higher on the other side is low, and you have made your pond or a land fill in between. If I do that I have to give channels at the side so that the water which comes from behind during the rainy season, is not stopped by this whole mass of waste disposal facility that you have created, but it should be able to go from the sides bypass this and meet this in the front. So, we have to create alternate flow paths so, that there should be no ponding of water behind it.

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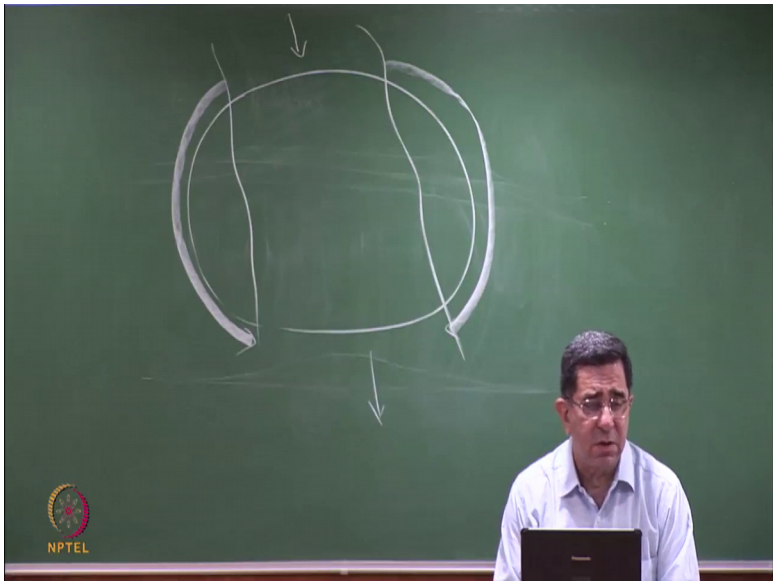

So, if I am looking at a plan let us say this is a low lying area and I have used this area for the purpose of creating a pond or a land fill. Now when the flow comes there will be ponding of water behind it, instead of that I need to have alternate paths in the form of channels. So, that this flow continuous uninterrupted and does not cause ponding upstream of these facility that we have created. Finally, we would like to address the issue of long term stability I have made a pond with all these measures that you have talked about here. The only question is have you bothered about long term stability? Long term stability means when human intervention stops I do not have a maintenance engineer on it for life, or I am not going to have maintenance engineer there for a 100 years or 150 years. When the facility what you have created now is the topographical height you know you went up going higher and higher by the upstream method there was no topographical high in that area before you make the embankments you put some vegitarive grass, you go away no body regrets the grass the grass becomes to dry up. So, you must have something which is stable for at least 50 to (Refer Time: 27:43) 100 years after being abandoned.

So, one is the top surface we have to put soil on it and do vegetative growth, and the other issue is also on the sides, any measure of vegetative growth which is assisted by irrigation will not survive. So, all vegetation has to become self generated vegetation; that means, the local shrubbery and the local vegetation has to be put in position. The only last thing that is bothersome is that the material that you have deposited between the embankments y the upstream or the downstream that is the soft or a loose material

hydraulically deposited should we densify it, before we move on or should we loose it loose that is the only question.

So, densification is not easy or cheap, but if you remember your ground improvement techniques insitu densification of course, grained soil those silty sands and sandy silts you have a few alternatives you remember those alternatives impact compaction, vibro flotation compaction, piles blasting idea is I have created a mass 1 kilometer by 1 kilometer say 20 meters high which is relatively loose, if I do not densify it the top surface will eventually become settle with time. So, one is to have adequate convexity in the closure.

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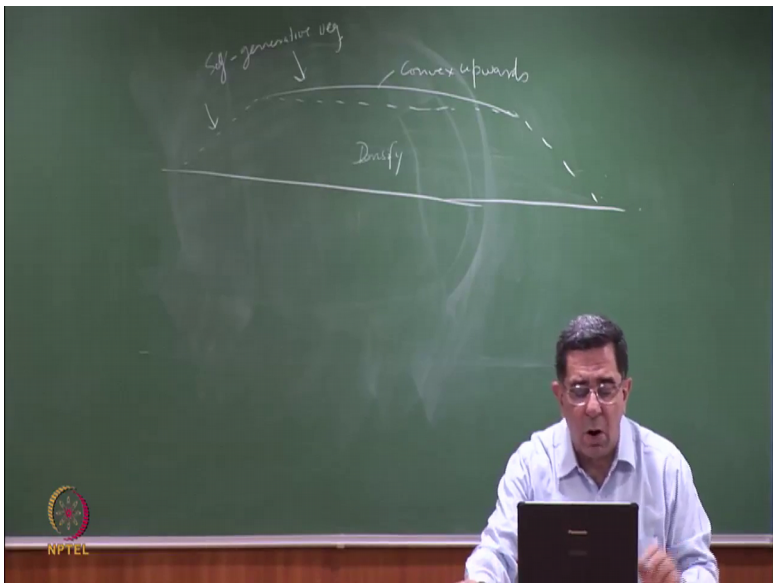

So, a final profile is like this. So, I should give adequate convexity at the top. So, that this always the surface water is running away, and the other question is should I densify. If you can why not and as I said it should be self generative vegetation. So, long term stability implies densification self generative vegetation or rock fill, if you cannot get suppose (Refer Time: 30:35) aired area dry aired area Rajasthan and you do not have self-generative vegetation there.

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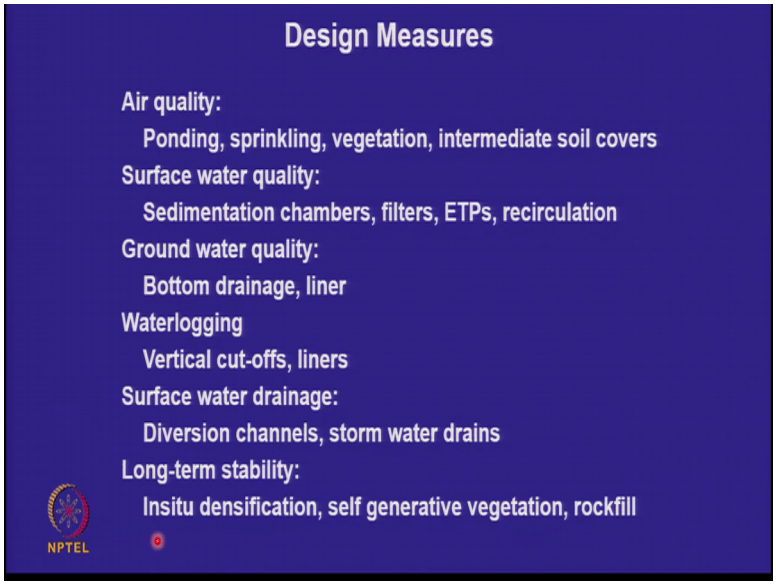

Then you might have to put a rip rap or armor a hard material which does not blow away which does not have erosion.

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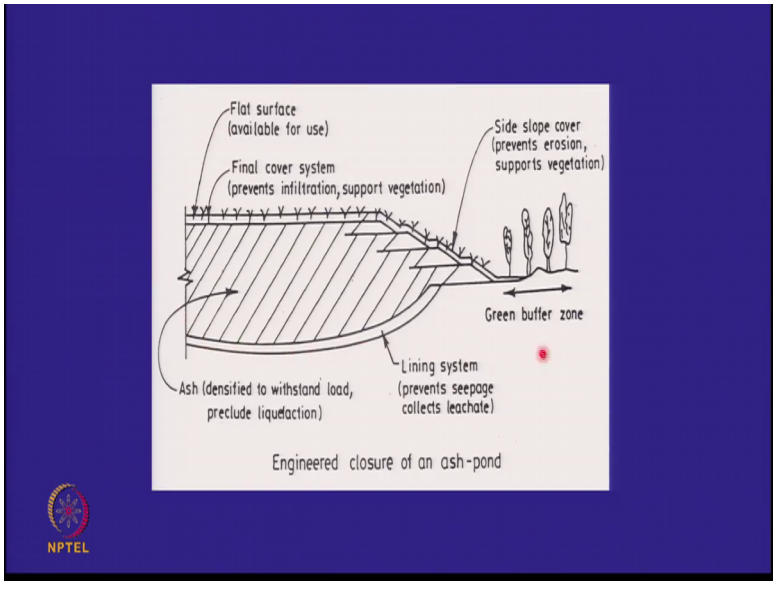

So, eventually an engineered closure of a slurry pond a liner and a drainage material here, these are your upstream raisings, you had the soil cover on it you have to have a vegetarive growth, you have to have a soil cover on the top, you have to have vegetarive growth, you have to have densified. If you intend to densify he cheapest and the method for densification is blasting because blasting is like creating artificial vibrations and

densifying, it will not be uniform.

So, do not think that after blasting you are going to get very uniform compaction when you are going to build buildings on it or when you are going to build any structures on it you still have to locally densify that zone by vibrio (Refer Time: 31:49) or compaction piles or whatever you want to, but as a mass if you want to densify the material then do blastings. So, that this mass remains stable later on. So, what you do to this will depend on where you are you know there is an ash pond of ntpci of at Badarpul in Delhi the land prices are huge.

So, the real estate industry wants that land, you have already reached the final height it is at an elevated height of about 20 meters on the top, surface area at let us say that it is 1 kilometer by one kilometer everybody say I can build a building. So, you say no no it is on loose deposite 20 meters deep. So, they say. So, what will put a 30 meter deep pipe, but ill densify this because the cost of land is. So, very very high near to delhi. So, for those ponds or those waste disposal facilities which are not hazardous; because on hazardous material people are very reluctant to allow usage at the top, but those which are not hazardous, you are able to take insitu densification measures because the land value goes up whereas, that may not be possible in a remote pond which nobody else is going to use for real estate tomorrow. So, actually the measures that you take are dependent on the additional value add that you will get and how you will use that pond later for what purpose.

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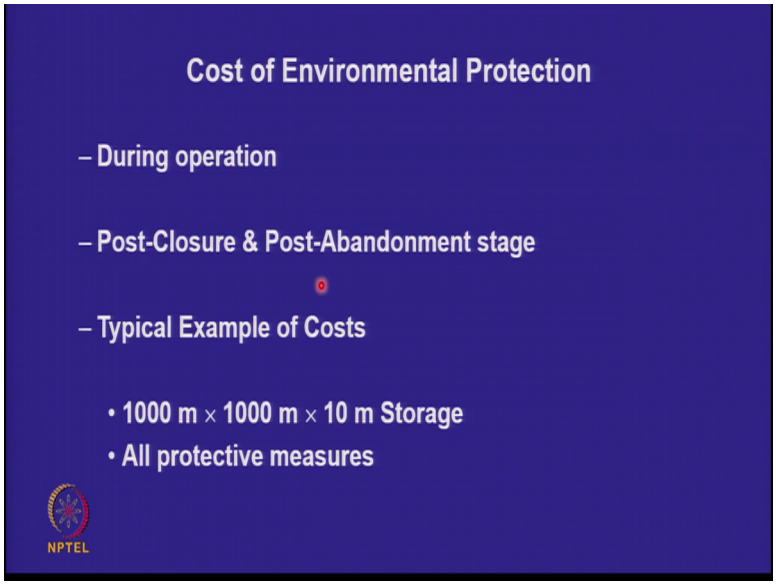

So, remember that there is a cost of environmental protection, during operation you have to protect it because after the operation the water is gone. I mean unless you made the mistake of leaving it finished in a concave upward or a flat section, which would settle with time at the center. So, that if you leave it concave upwards by mistake when the rain comes it will all accumulate at the center of the pond. When it accumulates at the center it will go down into the pond and again you can have a artificial water table inside it. That if you have done a good closure, then after the closure there is going to be no water in the pond. Firstly, it is topographical high. Secondly, it is convex it is got a earth cover and vegetarive growth water will run off it.

So, stability is not going to be a major issue, but during operations stability is always going to be major issue, during operation total suspended solids in the decant is going to be an issue. So, environmental measures during operation are different from the environmental measures post closure and post abandonment just for a minute. Think that the vegetation does not survive suppose you have put some grass even a local grass, but for some reason the vegetation does not survive.

So, vegetation goes and the soil cover gets exposed even that is fine, but if rain fall starts cutting gullies into the soil cover right aggressive gullies and you are not there to maintain it, if you are there to maintain it fine then the gullies will eventually expose the ash inside and that becomes the problematic because ash is highly erodible, and then it will start to come into your water ways. So, we have to keep all these into account.

So, if I look at a one kilometer by one kilometer into10 meter high storage, and if I see what is the cost of disposal in a slurry pond verses a municipal solid waste land fill verses hazardous land fill. Which one do you we are not doing transportation cost, once the material arrives at site which do you think will be the least costly? Slurry disposal verses hazardous waste disposal verses municipal solid waste non hazardous waste; that means, you are talking of the cost of spreading and compacting the material, cost of liner cost of cover final systems. So, just see I there are some relative prices which his was studied I mean on 2005, you see when you have slurry waste it spreads by itself.

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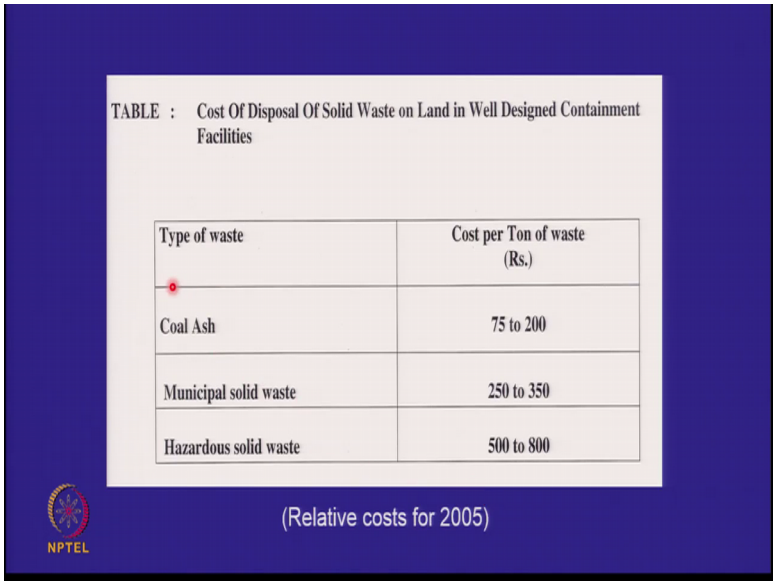

So, you do not have dossers and compactors which are running on the surface. So, that is a power of gravity flow water is used for spreading the ash. So, therefore, ash disposal even if it has a liner and a Basel drainage, is relatively less compared to municipal solid waste which has to be spread and compacted, and less than hazardous solid waste which has to have a double liner.

So, the cover and the liner of the hazardous solid waste predominant the cost, typically in 2005, the rate for hazardous waste disposal was about 500 to 800 rupees per ton, the rate for municipal solid waste disposal was two without land costs please note and the cost of disposal of the ash was lower. So, slurry ponds have low cost of disposal, but there are so many issues associated with availability of water and re circulation of water.

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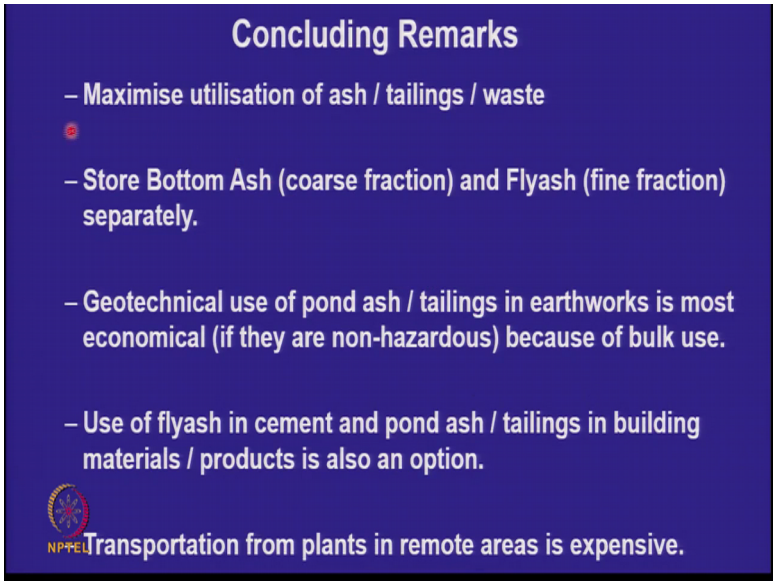

So, in the end I would like to say the following that, the first mantra is minimize wastes. So, just remember go back to your integrated solid waste management principles, maximize the utilization of ash or tailings or waste can everything be used. As soon as the material becomes characterized as hazardous waste please understand this, suppose you have a mine tailings and it is mostly crust rock it looks it is soil like material, but it has something which is sitting on the surface which is leachable and by the TCLP test it becomes classified as hazardous material you cannot use it,you cannot use that without stabilizing it. So, as long as the material is non hazardous we are basically dealing with silty sand and sandy silt we can use that in earth works.

So, maximize the utilization of ash or tailings or wastes to the extent possible, geo technical use of pond ash tailings in earth works is the most economical you know people say I can use that in cement, I can use this material to make bricks, I can use it to make blocks everything fine, but you want to use 10 lakh cubic meters of ash or 10 lakh cubic meters of non hazardous tailings. The simplest is maximum utilization in embankments. So, water what embankments do you usually construct? Road embankments or we fill low lying areas or we may have a lake embankment. Road embankments are the one which use the maximum amount of material for the purpose of earth works. So, you can use it, but your pond has to be close to the road you cannot say alright sir I am making a road from Delhi to (Refer Time: 38:47) can I get the ash from say 500 kilometers away. No then local contractors will say my local soil is cheaper the cost of transportation is very high.

So, nearby your waste disposal areas utilization in earth work is the actual way of keeping environmental costs control measures to a minimum. So, always invest the maximum in utilization even if we have to pay a little it is better than creating these huge ponds. So, maximize utilization of waste never makes waste, again we go back to our mantra from integrated solid waste management that, if you are producing fly separately and bottom ash separately do not mix them together to form a slurry. Because then you cannot get them individually you can still use it, but if both are kept separately one can be used as sand as a drainage media the other can be used for other applications.

So, keep the materials stored even if you are not utilizing all of them keep them stored separately. Geo technical use should be of first choice, in many of the daily metro construction projects where these stations had to be made a lot of earth filling had to be done for the daily metro and in those stations as well as in the tracks a lot of fly ash used from the local ponds Badapo Indraprasta we emptied out the ponds the whole pond was emptied out in in utilizing this ash, but they were nearby. If these ash ponds has been lying say 200 kilometers away, we would not able to get the ash in unless it was still cheaper than local soil.

So, use of fly ash in cement and pond ash tailings in building materials is also an option, but they are value added products. If you want to use fly ash in cement what do you need nearby the fly should be nearby to the cement plant, again this you cannot get fly ash from 500 kilometers away and put it into a cement plant 500. So, the proximity of the pro production unit to where the waste material is lying is important and please never use the materials if by they are classified as hazardous only use them if they are clearly classified as non hazardous it is your responsibility as an geo technical engineer to ensure that the material that you are using is classified as non hazardous and always remember transportation from plants in remote areas is an expensive exercise.

So, what you will find is if you look at the map of the country those ponds slurry ponds which are close to urban areas urban areas with high density populations their material is being used very often and those which are sitting in remote areas there is no utilization. So, you have a thermal power plant which is in Rihand or in Vindyachal verses a thermal power plant which is in Delhi utilization of ash in Delhi so very high, and the utilization of the Rihand power plant is so,very low, unless by any chance cement plants are sitting right next to you in those remote areas as well.

So, with these I think we have come to the end of the discussion, what we have learnt is that to keep the environmental impact minimum have an envelop which pre prevents the emissions, whatever emissions come out if they are decanted water please ensure that there are no total suspended solids, if the emissions are in terms of ground water contaminants then please put a liner and do not allow them to escape untreated eventually.

You know both is look the same landfills and the pond, but sometimes do remember that if you were to do a hazard risk analysis, then depending on the material which is being dispose the waste. The same size the same quantities if the hazard risk is higher then the measures will be more stringent, and the hazard risk is lower the measures may be less stringent that will come out from a more detailed analysis of the type of wastes that you are dealing with. So, any questions? Then all the bests and we will start I think a new topic in the next class will be talking of now remediation of contaminated sites we have not address the issue of contaminated sites sites which have been contaminated by a flowing sites, which have been contaminated by leaking drums we look at that next time and see how is geo technical engineers what is our role in remediation of control measures at such sites.

So, have a good day all the best.