Environmental Geotechnics
Prof. D. N. Singh
Department of Civil Engineering
Indian Institute of Technology, Bombay

Lecture – 10
Soil contamination

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Which one is more severe Solid waste or Liquid waste or Gaseous waste? If you talk about the severity of the waste, how would you grade them; which one is going to be most severe; solid waste liquid waste or gaseous waste? In my opinion solid. Why? It remains there for a pretty long time. So, it is a botheration for everybody for a prolonged duration. A liquid waste can always be diluted and gaseous waste will become much more dilute at the moment you put it in the environment all right.

So, that is why everybody talks about solid waste disposal, not the liquid waste and gaseous waste.

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So, this is a big challenge, how to deal with the solid waste and how to manage it. Well, this is a situation which I have taken from Baku-Oil Field, one of my friends happens to be working for a company in Baku. So, one day he sent me this email and asked me to say a few words about this photograph; what is your opinion; what is happening here? These are all oil rigs ok. So, the moment you produce oil, what happens to the soil? It becomes contaminated because of the oil spill or slicks. Can you identify this pillar over here or this post?

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There is a lamppost here and this is a street on which you are driving. What is this unit? Any guess?

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You are quite close to it, but not correct. It is oil-well. So, think of a situation that oil wells are located on the road this is what Baku is. Is it not? So, every 100 meters, you will find a oil-well and you may fall in your garden periphery or it may be on the road; it may be anywhere. Now, the issue is the more and more oil you extract from here, the chances are that this oil will spill. The whole idea of showing you these slides is at these places where the oil production is too much; they are also suffering with severe problem of soil contamination.

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Look at this classical photograph. What is your impression about this photograph, though I have written here Soil Contamination?

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Sorry.

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That is right. This is oil slick and because of oil slick, what has happened there is no vegetation on the ground and this extent could be in 100's of meters to kilometers. Now,

the biggest challenge if somebody appoints you to clean up this soil so that this soil mass can be used for some vegetation and developmental work construction work and so on.

So, what would be your approach? When your clothes become dirty, what do you do? You wash them.

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Sorry.

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No, leaching is something different, but you could not prevent that; so, this type of situation already occur. Now, what is that you are going to do here, if I employ you as a client sorry my consultant, if I ask you I want to develop the entire land for civil engineering purpose or rehabilitation work; what is that you are going to do?

Student: Chemical Treatment of soil

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Well good. So, that is one of the techniques. The question is which chemical, you will be using? The amount of chemical required and ultimately even if you use the chemical, where you are going to dispose-off the sludge? So, you will be removing soil oil from the soil, but then somewhere you are going to dump it. So, this situation becomes tricky, challenging. Look at this figure again, you find lot of shining surface. What is your guess? The surface will remain as it is or it will subside slowly and it will become clean automatically. Oil is lighter than water or heavier than water?

Lighter than water.

So, this will always remain here. So, given a chance if you leave this set up like this, this land is gone for all productive purposes. It cannot be utilized. So, you have to do some engineering here. Clear? Now, this is becoming a big issue in environmental geotechnology. The moment these type of lands are getting exposed to any spills or slicks or oil contamination, all the properties get changed ok. So, there are a lot of studies done by people to study what is influence on shear strength characteristics of oil contaminated soils.

But the logic says if oil is present in the soil mass, the soil mass will not be able to mobilize the complete strength again shearing. So, this type of studies are becoming interesting for which simulation is required. Any other guess? Yes, you are your guess was correct that you can use some chemicals. Anything else apart from using chemicals, which can be employed over here to get rid of this type of situation?

Student: Inundation or excavation

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City like Bombay, where you are going to put the soil which is coming out of inundation or excavation, not inundation. In fact, even if you inundate, what is going to happen the oil will form a surface on the water column.

Student: Sir, as it loads we can easily collect all the water (Refer Time: 06:07).

That is true, it is very easy to discuss it in a classroom on a piece of paper, but truly speaking, doing it in field is not so easy. Then, what we should do? Soil washing is a good answer. You can wash the soil, but then this is a very tedious task. We require millions of tons of water to wash the soil and again, the problem is the sludge which is generating how to deal with that. So, a primary problem becomes secondary or tertiary problem. So, these are the issues which are involved with these type of scenarios.

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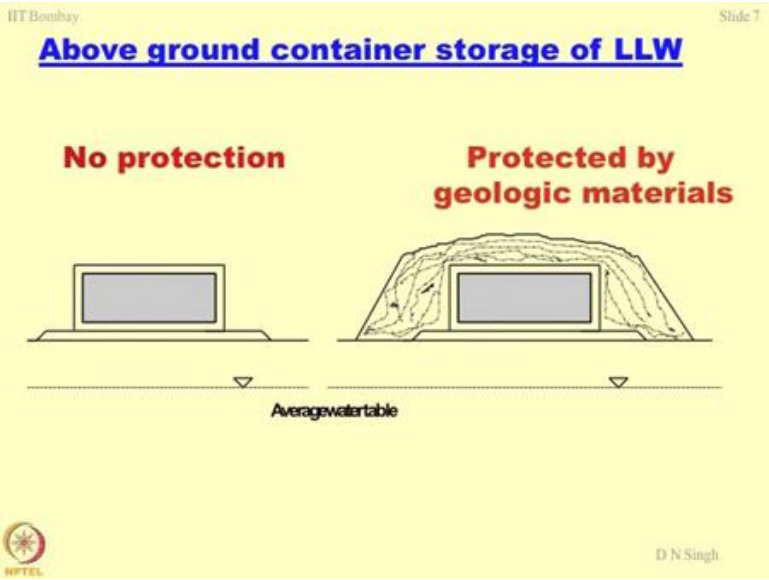

Now, let us come to some situations, where waste is being disposed-off on the ground. Are you aware of this type of situations; can you think of where this type of disposal is being done? I have shown a water table over here and a ground surface and on ground surface, there is a direct disposal of the waste unit and I have written above sorry a is missing above ground container storage of Low Liquid Waste or Low Level Waste.

See this type of practice was being adopted by some of the nations. India was also one of them that whatever waste comes out of the atomic units, put it in a canister and this canister is made up of lead (Pb) so that no radioactivity comes out and then, disposed it directly onto the ground. But then, I think you can realize this is situation where no protection is being given to the waste unit or the canister. This unit is free to react with the environment from the top from all the sides and groundwater table, particularly fluctuates; it will enter through the base.

It will contaminate the system and then, subsequently what is going to happen because of repeated drying and wetting of this metal, it may crack. So, once this cracks or it may disintegrate. So, once it disintegrates, what is going to happen? All the activity will come into the environment and hence, contamination will take place. So, to avoid this type of situation, what people have resorted to is they have gone for geological materials that means, you cover this system with the help of some geological material. What type of geological materials can be used to create a barrier like this? These are nothings but barriers.

So, the question is what type of mineral should be used to create a barrier system and what should be their functionality and how would you check that whether the system is behaving all right or not.

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Radiation is one of the attributes of this unit; temperature, chemical activity, thermal stresses, chemical stresses will be too much; mechanical stresses are not going to be so much here by the way. That means, you require a shield over here which cuts off this unit from the environment, but how it has been done?

It has been done only by cutting off this unit from the environment in the form of precipitation. But it still this unit is exposed to water table. So, if water table fluctuates,

the tendency of this water is to seep into the system and disintegrate it further. So, this is sort of a partial containment. But better than definitely this scenario, where no protection was used for this units ok. Now, if you try to analyze the material property which is required to create this type of a geological barrier, this is where a lot of mechanisms are involved.

The first thing is this system should not consolidate of its own. Clear? The second is it should not allow any water to move inside. Third, whatever gases are formed from the base should go out easily, otherwise this becomes like a bomb and it may explode at any time. The third thing is it should act as a coolant to the waste which is frozen inside; otherwise, again what will happen because of thermal stresses, the body of this unit may crack disintegrate and so on. It should be shockproof.

When you are compacting the system using rollers or whatever, they should be shockproof and ultimately, the material which you are using in this type of protection should withstand the temperature flux and chemical flux. So, when it comes in contact with this type of unit at elevated temperatures, your material should not disintegrate. Now, this forces you to think of alternative materials and this is where I had maybe given you some idea in the first or second lecture, where you can use synthetic minerals. So, synthetic minerals are being used mixed together with the soil mass to create a barrier system where nothing will percolate out of it.

And when you say nothing percolates out of it, definitely water and air and the radiation should be contained and so on. So, these are the challenges I had. I hope this is clear. Anything else, it comes to your mind? Shiv Prakash?

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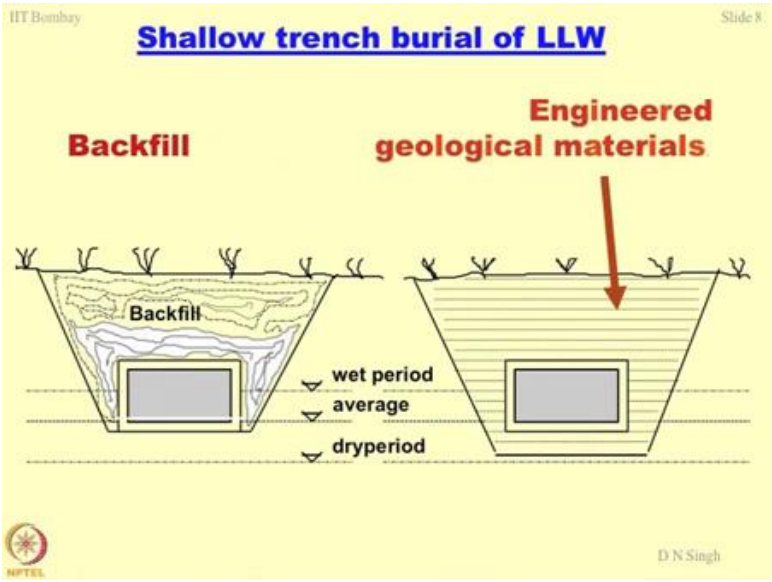

Let us proceed further. But suppose if the intensity of the waste happens to be a bit more and it cannot be dumped directly onto the ground, then what you are going to do? You are going to dump the waste inside the ground surface or below the ground surface.

Normally, this type of disposal is up to few 10's of meters, not more than 10 to 15 meters. So, you dig out a trench place this unit and then, cover it; backfill. The property of the backfill remains same as what we have discussed in the previous slide, where you are designing materials which are going to be good isolators. So, what you have done here. You have isolated this unit from the environment, but unfortunately again if water table fluctuates, the tendency of this water table is to penetrate into this unit and then, attack on the waste disposal unit and again, leaching takes place; contamination takes place.

So, this scenario again requires rethinking. So, what we can do is we can go for this type of situation, where the waste is confined from all the sides in the geological material and these geological materials are engineered. So, when you say engineered that means, compaction has been controlled; the mineralogical properties are taken care of; their chemical properties are taken care of and you assure that this system will withstand temperatures, high temperatures, high radiation effects and so on. This is a better unit as compared to this unit that means, this happens to be a better disposal technique as compared to the techniques which we have studied earlier is this ok.

Basic aim is to cut off this unit from the environment from all the sides, the best possible way you can do. So, this leads to the basics or the concepts of designing a landfill. So, if you can cover the entire unit by putting a geotextile in the base in the sides and then later on you can cover it by making a top cap. The entire unit becomes a sealed unit nothing is going to disintegrate further and going into the environment.

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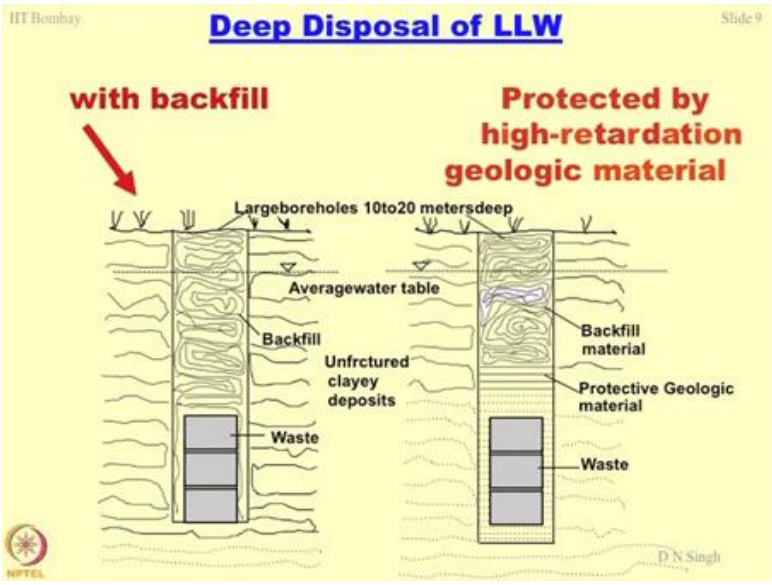

Well, this is the situation where you talk about very deep disposals in some few words are missing here; I do not know how. This is deep disposal of low liquid waste, where you have to go into the geological repositories; go quite deep and put these units in the hard rock.

So, the rock in which the system is going to be placed should be unfractured or it should be a clay deposit. Now, this is what is known as repositories characterization scheme. I mean you take the samples; I was showing you some samples when you came to the lab on previous day. Take out soil mass of the rocks and then, check whether these are candidate, good candidates are not for disposal units. So, then the logic is same. In this type of bore holes, you fill up from the top and make it an engineered barrier so that now what is the big challenge in designing this type of a facility?

When you are dumping these units one over the other, there may be a cracking; there may be disintegration; there can be a mechanical damage. Earthquake can cause all of damage here or suppose, if you have fractured system, what fractured system will do?

The water table flow will be too much and that water flow interacts again with these waste units corrodes it and then the entire environment may become contaminated. So, these are the challenges which are lying ahead you know to the geotechnological engineering professionals.

How to dispose the waste particularly which is of very high intensity and then, how to safeguard it? Now, can you can you model this type of situation? Can you think of the attributes which are required in modeling this type of situation? First is fractured rock mass ok. So, hydraulic conductivity of fractures or the fractured rock mass then, the system starts leaking or the leaches generate. So, disintegrability of the system; in this system goes into the environment; contaminant transport into the fractured rock mass.

What are the attributes of contaminants here? Chemical species, their temperature and they could be of radioactive type. So, radioactive isotopes, we have chemical concentration and temperature effects. This migration could be in a fractured rock system, unfractured rock system, a clayey soil, non clayey soil with water flow, without water flow all right. So, these are the attributes which require modelling.

So, again to remind you what modeling will do? We like to see if this type of facility is created somewhere; what will be the impact of this facility on the geoenvironment, say at a distance of few kilometers after few years or vice versa all right. So, this comes under environmental monitoring program or impact analysis.