Environmental Geotechnics
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Lecture – 08
Soil mechanics

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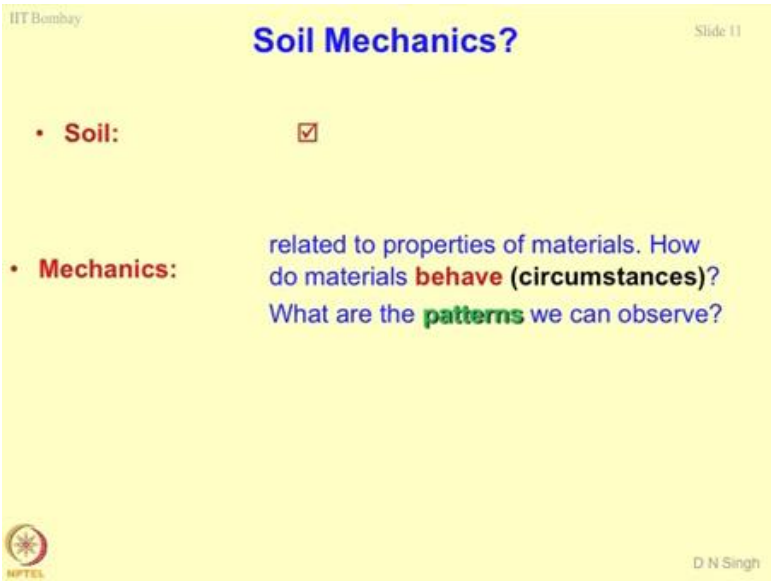

Well let us come back to the Soil Mechanics, the second part is still missing. We have understood a bit of soil, now the question is what is mechanics. So, soil we have understood a bit I would say, how do you define mechanics?

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Ok. To cut it short let us say it is related to the properties of the materials, how do materials behave under circumstances, alright. What else the mechanics would do? They observe the patterns. Any example of patterns in geomechanics? Of course, you are asking what is geomechanics. So, I think it should be clear by now. Geo is nothing but the materials which are naturally occurring and you are trying to understand their behavior and how they react to a given situation.

So, this would be a very crude language of or maybe definition of geomechanics. So, now, the question is what type of patterns you observe. Do you observe some patterns in geomechanics?

Student: Sir for example, types of failures.

Very good that is right. What are these failures?

Student: General shear failure.

Excellent that is right.

Student: Local shear failure.

That is correct.

Student: Shear failure.

Very good that is right. So, what are the in technical way how do you define this patterns? What is the technical name given to this? Shear failures.

Student: Shear failures.

Or shear lines or slip surfaces and so on, clear. So, all these things are nothing but they are the patterns which have been created within the soil mass because of external loading. And when you say within the soil mass all these attributes which we have talked about are in built clear. So, this is the interaction of the external environment and the soil mass both have their own attributes and peculiarities and characteristics. So, what mechanics does? It is nothing but observing how patterns are formed.

So, you do stress strain relationship by doing track shear test or by doing a direct shear test, what is that you are observing there? Sorry?

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You are basically trying to understand how failure takes place. How for a given strain this stress is developed or for a given stress strain develops? So, it is nothing but recognizing what causes are and what effects are. Clear? Now for an example if I take a acid solution and if I pour it on the soil, what is going to happen? If soil is active and if acid is highly concentrated, there should be some reaction going on between the two clear. Now till now we were talking about the patterns which have been created in the soil mass because of the external loading which is mechanical type.

Now, here we are trying to observe what a chemical loading on the soil system is going to do, clear? So, that would be the environmental impact on the system because of some loading which happens to be of chemical form.

So, this is how we can expand the scope of the studies which we have been doing till now. So, again if you ask the question, what is soil mechanics? Basically soil mechanics is nothing but the subset of geotechnical engineering and what geotechnical engineering does? It is basically concerned with the application of civil engineering and technology to some aspects of earth, which may include soil mechanics, rock mechanics and foundation engineering, clear? But this is where the effect of environment becomes very significant.

So, if you can map the effect of environment on to these subjects, this becomes environmental geomechanics. Is this part clear?

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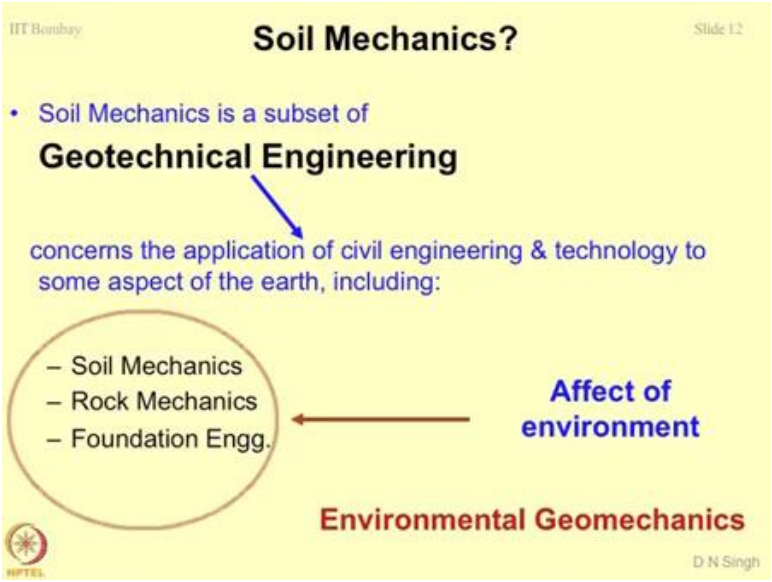

So, we have followed a long path to derive to a point that it makes sense to re study these things by keeping in view how the environment is affecting this structures and that is what the major scope of the subject is. Is this ok? Any suggestions from you point which can be included here?

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Ok. Let us proceed further then you please keep on thinking and if case you have few points to make just send them across to me.

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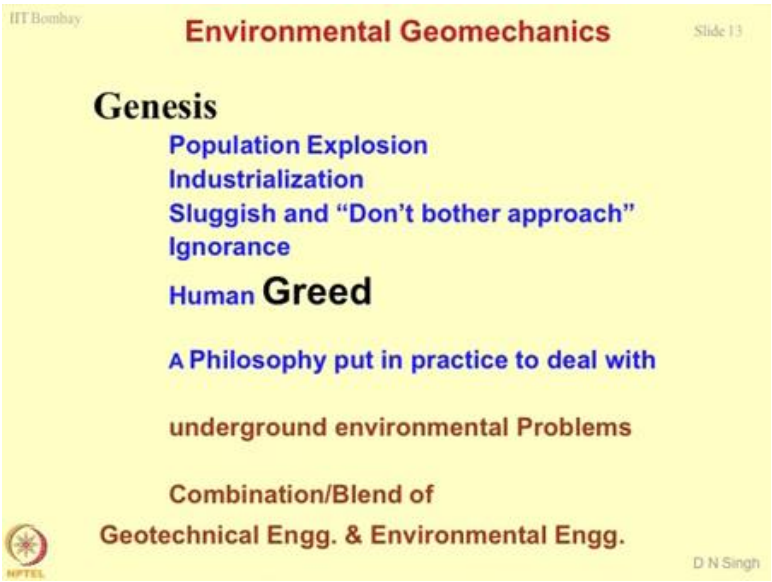

So, let us start formally introducing the subject. The first question is what is the genesis of the subject. Genesis is nothing but what causes this study to initiate or to initiate such studies. The first is population explosion. In what way it is responsible in contributing studies towards environmental geomechanics, any example?

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You require more land for people; now where is the land in city like Bombay, city like Tokyo, Singapore and so on? So, population explosion is one of the major reasons that why people have started talking about the subject. The second is industrialization ok. Let us continue with this the third attribute of this subject is sluggish and do not bother approach. You agree with this? There are so many expeditions every year to Everest. What these people do? They carry along with them so many things. They consume it there; they throw it there. So, Everest has become the highest land fill in the world. All sorts of plastic, utilities, batteries, chemicals, you know heavy elements they all being dumped up there.

So, there is a now there should be some strict rules and regulations against this; plastic, polythene, rubber, waste materials and so on. Ignorance: most of us do not know what

we are doing and what will be the effect of our activities alright. Human greed: what is the greed? Where is the greed involved in?

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That is right. So, everybody wants to extract maximum from the nature. If you can make a building up to second floor basement, the tendency is to go up to 5 floor basement. So, this is how the hydrogeology gets affected. If you go much deeper in the soil mass what you are doing? You are basically affecting the hydrogeology. Agreed? Too much of extraction of petroleum, ores, gases is nothing but the greed.

So, too much extraction from the ground will result in subsidence collapse of the ground and so on. So, subsidence is a very big problem. In India, Mussoorie is the place where too much of mining of lime stone has caused the deterioration of the hills. Thailand is a good example of too much extraction of water drinking water from the ground. So, what happens? The ground settles down. So, this lot of people in geotechnical engineering are studying subsidence of soil they are doing lot of modeling and they are trying to understand. Particularly small islands where the biggest problem is you extract something from the ground in the ground settles. So, what will happen to the entire civilization, construction, buildings and so on. It makes sense?

Student: Yes sir.

So, basically this is a philosophy which is a blend of two things. Underground environment problems and it is a blend of geotechnical engineering and environmental engineering. How beautifully you can blend these two things together, you can select the way you want. So, there is lot of fight going on as far as the subject is concerned. The first question should be that, how this concept came in mind to some people that they should start a new subject as environmental geomechanics. So, it is basically a blending like blending is in our blood, what we do? We blend cement for making concrete with sand, with gravels, with water by putting add mixtures into it and so on.

So, we create a good concrete. So, by blending these two subjects themselves, you can create a good breed which is known as environmental geomechanics. So, you will find that most of the applications are coming from environmental engineering and how to monitor them, how to diagnose them and how to give some prescriptions is falling in the

realm of geotechnical engineering. So, this is where you find that there is a good interface between two subjects.

Like environmental engineers cannot really handle with all the problems with society and the nature is facing. Is it not? But then we have that background and what we have to do is we have to expand this background to the issues or the situations which are prevailing in nature or in the environment. Give you some examples, what is that we try to study in the preview of this subject?

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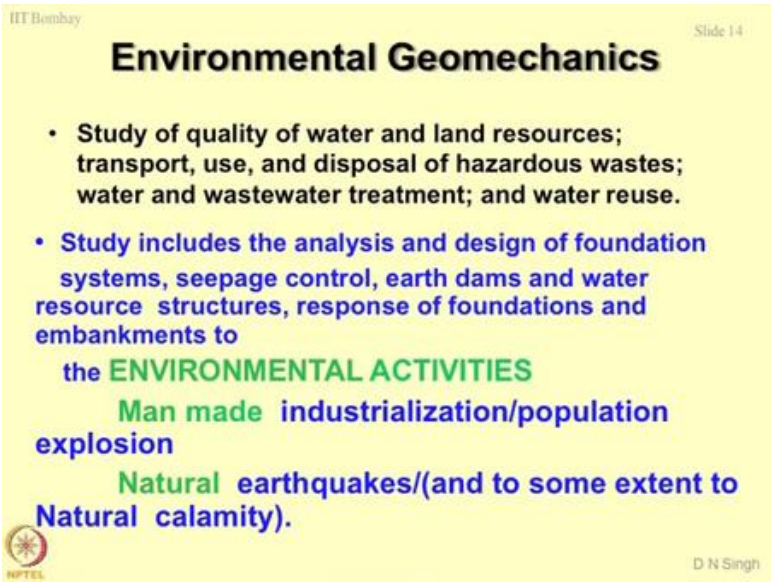

Basically you try to study the quality of water and land resources. Quality of water is also being studied by environmental engineers. Then transport, use and disposal of hazardous, how you are going to safely transport the waste which is generating, how you are going to use the waste and how you are going to dispose the waste are the issues; water and waste water treatment and water reuse. The further studies would lead to you study including analysis and design of foundations, seepage control, earth dams, water resources, water structures, response of foundations and embankments to environmental activities. Some of these activities could be manmade or some of them could be natural.

So, industrialization and population explosion: can you visualize a situation where man made activity may create failure of the dams? Suppose I discharge contaminated sludge on the soil mass and slowly and slowly it goes and gets mixed up with the retained water. So, what these acids are going to do? These acids are going to eat up all the cementitious

material which are present in the soil grains and once that material is eaten up what is going to happen? The system becomes highly pervious. So, every simple negligence having good activity of chemicals is going to cause lot of problems and the failure of the design. Similarly, it may result in washing up of the fines. So, all the fines may get washed out because of the chemical activation or the chemical activity.

So, these are some very minor, but good examples of where an impervious system may become later on a very pervious system because of prolonged interaction with aggressive environment. Then what happens to the shear strength? If the pore structure gets enlarged the shear strength gets affected, clear? The compressibility gets affected; the collapse potential gets affected and so on. So, basically a system which looks very strong today because of its degradation, it may end up in a system which loses its strength, imperviosity, collapsibility and so on and it becomes a material which is not good a construction material. So, these type of alterations can happen in nature and then the biggest challenge is that how we are going to simulate these type of situations in the control environment and once you have simulated them, how we are going to use them for solving real life problems.

So, these are the man made activities where the industrialization population explosion is responsible for contamination and the effects to the geo environment what about the natural phenomena? See natural phenomena earthquakes and all sorts of natural calamities are responsible for this too much of flooding, landslides, tsunamis and so on. So, the realm of environmental geomechanics is basically increasing day by day. I hope you can understand because when we put both the activities together that is manmade activities and the natural activity the sky is the only limit.

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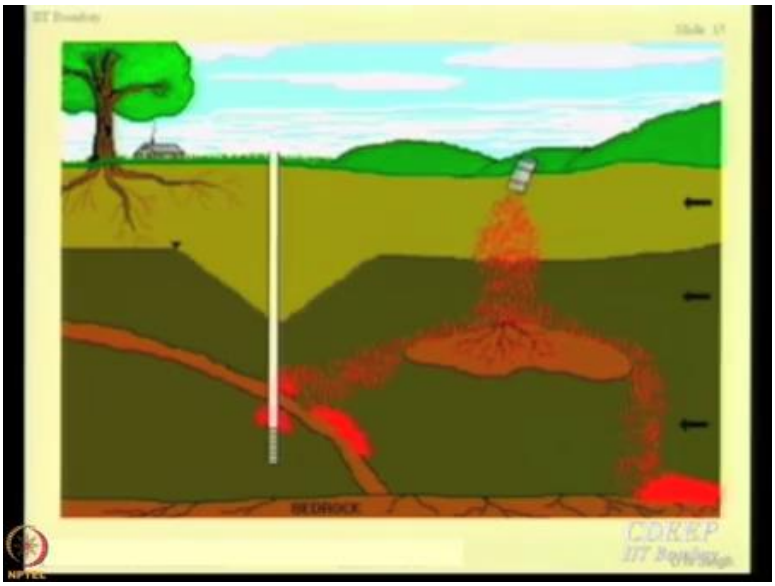

See this is a practical scenario which I think should give you some idea about what is happening in day to day life.

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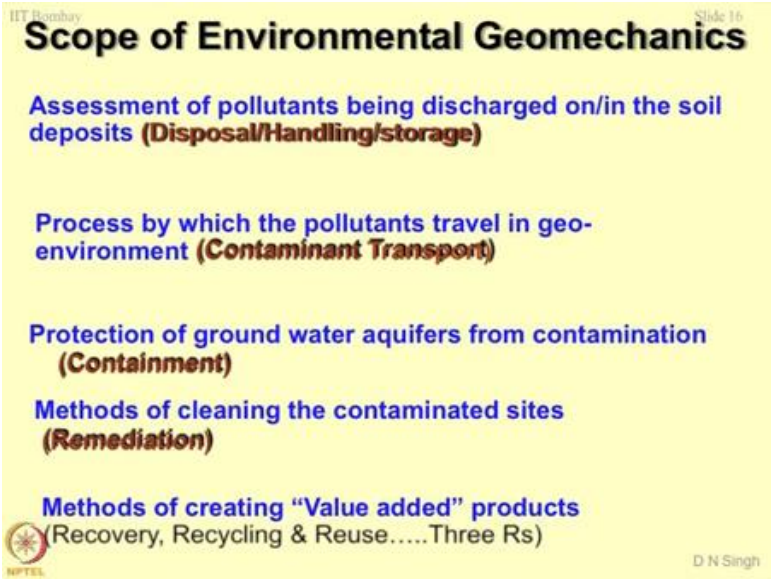
This has happened very fast. So, if you want to enjoy this further just a minute ok. I think alright see what I am trying to show here is that this is canister from which the waste is being disposed off in the porous system. So, this is the atmosphere or the biosphere and anything below the ground surface is biosphere, geosphere and this is what is the main concern to all geo technical engineers. So, when you are dumping this waste, this waste starts percolating in the soil mass. So, this is one type of soil, this is second type of soil this happens to be an aquifer which is highly fragmented and then somewhere you have bedrock which is a hard rock.

So, when you dispose this waste it goes and interacts with all the layers which are present in the subsoil; that means, the type of soil which is present is very important. These arrows basically depict the water table whether there is a moment of water or not. So, basically because of the presence of this water the tendency of this system is to get disperse too much we will talk about this subsequently. It may so, happen if there is a fault or fracture present in the sub surface, all this waste may go and get concentrated over here and if you drill a tube well or a bore well for drinking water supply, the entire activity may come into this and it may be hazardous to the society.

So, this shows that what is that should be covered when we talk about environmental geomechanics. Now where we are going to use the concept of geomechanics? As we discuss sometime back the mechanics is nothing but the observation of patterns. So, what is that we are going to observe here? How this waste goes, interacts with this soil mass, how this waste goes, interacts with this type of soil mass when water table is moving is standing is present or not present if fractures are there or not clear and so on and what are attributes of the waste.

So, attributes of the waste we will discuss slightly later, but of course, attributes of the waste would be what type of chemicals, what is their concentration, what is their reactivity. If you are talking about radioactive waste, the attributes would be half life period. The waste which may not be a real hazardous waste today may become hazardous after 50 years because of its half life period of 50 years.

There could be a waste probably the half life period is 25 years, 50 years, 25 years, 5 years and so on. So that means, these are the attributes which become very important when you are trying to study how this system is going to get affected. Is this clear?



So, let us talk about the scope of the subject. The very first thing is that we try to study or we try to assess how to dispose, how to handle, how to store the waste which is coming out of the industry. Now this step is known as disposal, handling and storage. So, this is the assessment of pollutants being discharged on or in the soil deposits. Sometimes you tend to throw the waste on the surface itself most of the industries are doing this, but

sometimes depending upon the hazardousity of waste, it becomes necessary that it should be disposed off quite deep into the ground.

So, that's why I used the word both on and in. So, this is the first step; what type of waste you are producing, how you are going to handle it, how you are going to store it, how you are going to dispose it. Now once you have gone for this activity what happens? The interaction of the waste starts with the environment. So, the process by which the pollutants travel in geoenvironment and what is this process known as?

This process of traverse of contaminants in geo environment is contaminant transport. So, any waste which is disposed off subsequently will start interacting with environment let us say rain water and then that liquid phase will penetrate into the soil mass or the rock mass and will produce another challenge contaminant transport. So, as an engineer what we should do? We should keep on observing or we should take some steps?

So, the idea is we would like to stop this spread of contaminants in the geoenvironment. This is what known as protection of ground water aquifers from contamination and this is also termed as containment process. That means, how can I contain the migration of waste into the geoenvironment, how can I cut off this process.

The ideal situation is where you are disposing off something on the ground or in the ground and nothing moves into the geomaterial; that means, there is no contaminant transport, but that is not possible. Because this is a trait of the contaminant, it is going to react with the soil mass, it is going to react with the water table and so on. So, how you are going to contain it? If you cannot contain then what you should do?

You should remediate the lands which are contaminated. So, this is the fourth step or the fourth scope normally we call it to study the method of cleaning of contaminated sites. Mostly environmental engineers are associated with this type of work, geotechnical engineers are now adopting it, but truly speaking it does not fall in the realm of pure environmental geomechanics.

What is left in this series? Sometime back I think somebody was talking about three Rs. So, another challenge is the methods of creating value added products out of the waste which is being disposed off. So, this is where we talked about the recovery, re cycling and re use these are known as three Rs. Sorry?

Student: Recharge of water.

Recharge of water ok. So, this becomes, no but we are talking about actually is the waste here. So, from the waste can I recover something? Can I re cycle the waste? Can I reuse the waste? Now based on this principle there is something known as RCRA; RCRA is its basically the act to recover sorry, it is not that Resource Recovery Conservation Act; Resource Recovery Conservation Act. So, how would you recover a certain utility item from the waste? So, on this also some people are working. Basically these are the five steps which will create good scope for the environmental geomechanics.

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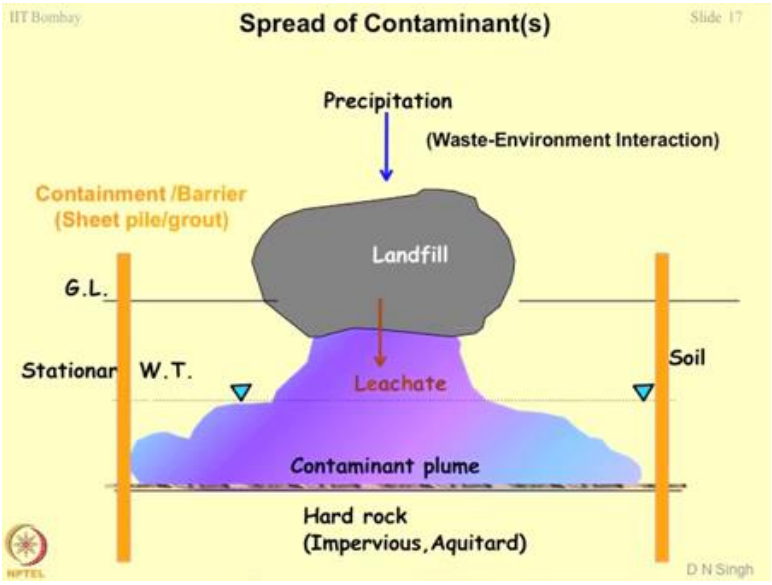

Now you think of a situation like this where the spread of contaminants is going to take place. Suppose if I create a land fill on a ground and there is a stationary water table in the soil mass and this is followed by hard rock impervious material which is aquitard. Now, when this landfill material interacts with precipitation, now this is where actually you have waste environment interaction starting. So, waste is interacting with the environment and the rains what will happen? The leachates will produce. So, whatever leaches out of this landfill or the waste material is known as leachate and what this leachate is going to do?

This leachate is going to create a plume. So, this is what is known as contaminant plume. Now because the water table is stationary here the chances of this plume spreading out are less and again this will also depend upon the type of leachates. Suppose this leachate

happens to be very dense as compare to water in terms of density and viscosity. So, the chances of this leachate getting mixed up with water are less and what will happen? There will be a stack formation. Now if you rotate this figure by 180°C, what will happen? This becomes a scenario where pollutants are being discharged from a chimney. So, then all this is happening in air. So, the medium gets replaced by air, the soil gets replaced by air and this is stationary wind, there is no flow of wind; clear?

Now, the challenge is how to stop this process? How the ecosphere or geo sphere does not get affected too much, what I should do? You have dispose of the waste here, the waste is interacting with water, the leachates are formed, leachates are migrating into the system. The third step is containment, put the barriers ok. So, what is that you are trying to do? You have isolated this much region from the rest of the geoenvironment. So, you can use some sheet piles, you can use some barriers, you can use some grouts and so on. So, that this activity remains confined in the system, this is one of the techniques. So, this is what is meant by containment.

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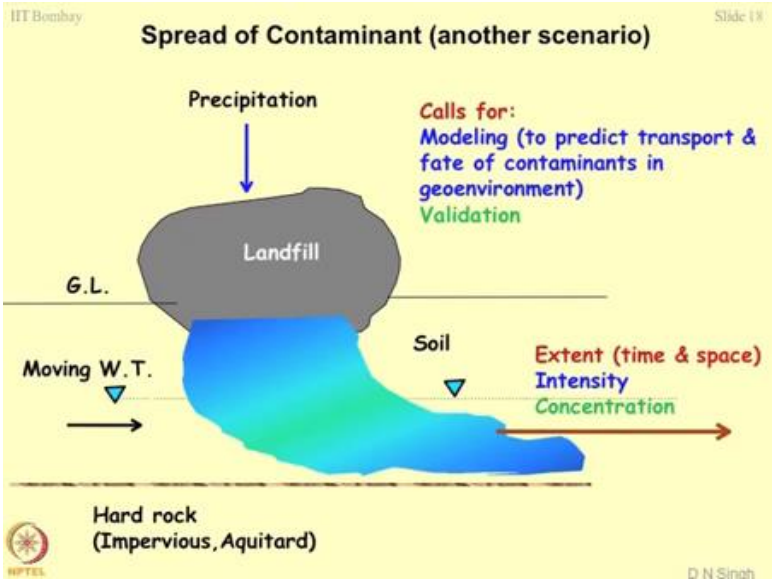

However, if the situation is like this, that the water table is moving then what happens? This entire leachate plume has a tendency to migrate downstream. So, you will be happy with this situation or the previous situation? Which one is more friendly to engineers or the society or to the environment?

Student: Previous one.

Previous one. So, let us go to the previous situation. Would you like formation of this stack continuous formation of this stack? Then we will be sitting on a volcano. So, you keep on dumping the waste over here ultimately what will happen? This whole area will become like a volcano on which the system is standing, it may erupt any day. So, though it looks to be very charming and easy to handle truly speaking it should be avoided and it should follow this type of situation, but then what is going to happen?

Student: Dispersion.

Sorry?

Student: Dispersion.

No pollution control boards are going to nab you. Because you have industry here and then what you are doing? You are contaminating the entire thing downstream. So, somewhere here I might be having my industry. So, why should I get affected? Because of your activities and foolishness. So, I am going to lodge the complaint. So, what is going to happen? In order to stop this process, the industry has to be stopped, clear? So, that mean this is where actually you have to see what is the extent of spread of the contaminants this situation is always a ideal situation. Why? You are nullifying the affect of the leachates which are coming out of the land fill ok.

This is another perception difference may be and then what you have to see is, what is the concentration, what is the intensity and what is the extent, when we talk about the extent we talk in terms of time and space. So, down the stream at a given time after how much distance what should be the concentration of contaminants and this calls for modeling. So, what is modeling? Modeling is nothing but to predict the transport and trait of contaminants in geoenvironment and then you have to do validation of this.

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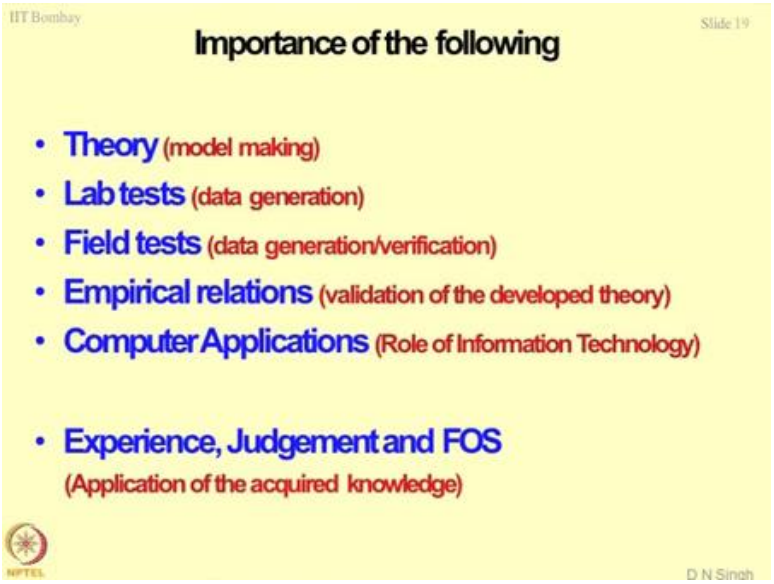

So, this is almost the entire activity would be. Some of the important steps here would be is this part clear or not you have followed this? I switched over to the next slide thinking that there is no time. So, what we are trying to do here is, we are trying to estimate how much concentration would be reaching down the stream after a given time at a given distance and then what is its intensity what is the concentration and so on.

So, this is where several steps come into the picture, you have to make a theory and this theory should be nothing but a model. So, what are the attributes of the model? The attributes of the model are there is a source and there is sink. So, source happens to be the industry which is producing waste or the pollutants, and the sink happens to be the porous media in which the pollutants are going to sit or get disposed off.

You have to do some lab tests and these lab tests the basic idea of doing this lab test is that you are trying to generate data. What is this data? This data is nothing but the attributes of the porous system in which the waste is being dumped and the attributes of the waste. Then you need to do some field test. Why should you do field test? To check whether your model is working alright or not.

So, this is the data generation for verification purpose. Then sometimes all these exercise may lead to some empirical relationships and these empirical relationships will be used for validation of the developed theory. This is ok? And sometime what you do? You use

some finite element based packages finite difference based packages and so on that is the computer applications. So, this is where the forecasting comes into the picture.

After 50 years at a distance of 5 km what should be the intensity of waste? So, this is where the role of information technology comes into the picture. And the last, but not the least would be the experience and the judgment. What is meant by FOS? Factor of Safety. So, what is the factor of safety you want to adopt? Under no circumstances the concentration at a given point should go beyond permissible limits clear. So, this is very important and this comes from your judgment or this may come from your experience. So, most of time pollution control boards what they are doing? They have lot of experience, they have judgment and they work within a certain specified factor of safety.

So, this is where application of the acquired knowledge comes into the profession. So, this is what I wanted to cover in today's lecture. I hope the basic introduction part is clear and the scope of the subject is also known to you now, and this should give you a fair idea about the activities in which this profession takes you further.