**Environmental Geotechnics**
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**Lecture – 28**
**Geomaterial characterization – 8 (Pore solution studies – I)**

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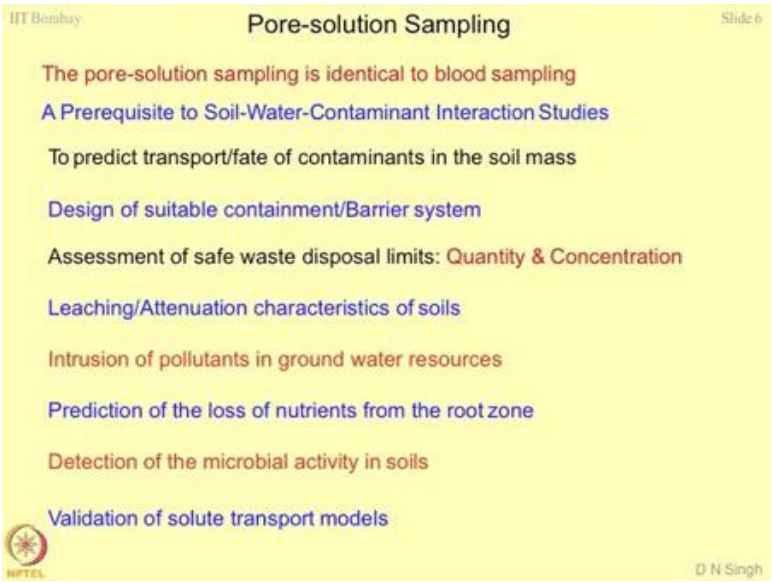


Now, let us discuss with about pore solution sampling. I intend to spend enough time today regarding this particular subtopic, because later on you will realize that this is a very good technique to understand what type of interaction is occurred between soils and contaminants. So, the logic which comes to my mind is that the pore solution sampling is identical to blood sampling of a patient. So, modern day what is happening in our medicine, this is what pathological examinations is all about. Is it not? And then based on blood sampling you diagnose the disease and then recommend some medication observation all those things which we have already discussed.

So, this is the prerequisite for soil-water contaminant interaction studies. You must appreciate one point that there are two perceptions of defining soil contaminant interaction. One is whatever is retained in the pore solution and whatever is retained on the soil grains. Is this clear? When soil is interacting with contaminant, certain fraction will remain in the liquid phase in the pore solution.

Now, these fellows could not get adhere to the soil grain because of whatever. Clear? And the second category is whatever gets adhere to the grains of the soil mass. So, these are two perceptions based on which you can further study soil-water contaminant interaction. So, the simplest form is if you take out the pore solution, analyze what is the concentration of cations present in it and you can say the soil is contaminated to this extent.

The second perspective we will be talking when we will be discussing sorption capacity in the soil mass; that means, what amount of concentration of cations gets sorb on to the material. So, this I will be studying in sorption desorption studies or I will be discussing that. Is this part clear? The best application of this type of studies is to predict, transport or fate of contaminants in the soil mass. Do you agree with the word that fate of contaminants? Normally you go to an astrologer and say what is my fate is it not what is stored in my future. So, why do people use the word fate of contaminants, any guess?

Good you are your logic is good its correct. Transport is a easy phenomena whatever you pour on the soil mass, it simply gets percolated out and as if nothing has happened to the system, you would have been lucky if this type of situation prevails in most of the cases. But truly speaking soil is active contaminants are hyper active. So, this type of situation will not occur so easily. Now this is where you start talking about what happens to the contaminant when they get trapped in the matrix of the porous system.

So, when you use the word what happens, this is nothing but the fate. So, they may decay there, they may multiply there, they may degenerate there, they may do something more wonderful. Now this is what people are trying to understand that what ultimately happens to contaminants when they interact with soil mass.

So, this becomes a very interesting phenomena to study and to capture. Similarly, if you are let us say setting up a power plant or industry or nuclear power station, the first question is that how far I should draw a boundary so that you know population should be within this limits. How to determines this? There has to be some mathematical modeling there has to be some in-situ observations to be conducted so that you can define that yes upto 25 kilo meters from this point onwards, there should not be any populace because this is the danger zone.

Now this is where actually people talk about prediction of transport of contaminants. So, these are two very interesting sides of the coin I would say, where most of the time people try to understand either a transport mechanism or they try to understand what happens to the contaminant and the porous system because of this interaction. So, it is a very wide topic very wide topic. So, here you can create four type of situations; passive soil passive contaminants, active soil active contaminants and the combination ok. So, this is what our friend Srinivas is trying to do. Is he here? I cannot see him.

Srinivas, you agree with this? This is what you are trying to work on. It is a pure philosophy. He is trying to conceptualize and conceive this idea and then show in numerical terms that yes, this type of interaction can be captured not photographically, but mathematically. Another good application is that it should be a very good methodology to design suitable contaminant and barrier systems whether your barriers and containments are working properly or not.

So, you think of a situation that below every containment or a barrier system, if you can take a dose of the leachates or whatever is coming out and if you analyze it and if you see that the concentrations are alarming that means, your barrier system is already failed. Just like your blood sugar going very high, what doctor does, immediately cautions you do not do this, do not consume sweets and so on. Immediately you have to take some actions to stop this type of transport out of the leachate facilities or the landfills.

So, this is where actually safe disposal limits come in the picture. The basic question which I had in my mind when I was when I started my studies on this topic is that, how do these disposal limits are quantified, how these guidelines are prepared, is it not? So, basically it is based on observation or based on experience. So, all the guidelines are based on experience or the observations in terms of quantity and concentrations of the leachates which are coming out of the system.

Now incidentally this can also help you in determining the leaching properties and attenuation properties of the soil. So, leaching is nothing but if you add fresh water to the soil mass whatever free ions may come out of this is leaching. So, this is leaching out of the elements from the soil matrix. Normally this type of thing will happen when soils are heavily contaminated alright then only leaching will take place. So, the second thing which we were talking about is the attenuation characteristic of the soils.

So, attenuation characteristic of the soil what it indicates is that, whatever contaminants you are poring on the soil sample they remain captured in the soil mass; attenuation alright stopping property of the soils. Now these type of studies will also very significant and useful when you talk about intrusion of pollutants in the ground water resources. What is the dose of the contaminants which is migrating in to the refresh water supply? So, some of you or may be some other researcher, they are trying to understand the ingress of salt water in the fresh water supply.

So, the best thing is you sample a pore solution and then see what type of chloride ions are present in the fresh water supply and whether you require some containment of the barrier system to stop this type of process. Prediction of the loss of the nutrients from the root zone: so, you can think of devising some instruments or may be electronic circuitry, where the moment nutrients leach out from the root zones, there should be a sort of a alarm system.

Now this type of alarm system is also placed below the landfill liners. So, the moment concentration of the leachate increases this the alarm and then you get enough time to correct this. Detection of the microbial activity in the soil what type of microbial degenerations are taking place in the soil mass, this can also be checked. Microbial activity will normally decompose the soil mass and once the decomposition takes place there could be some elements which will leach out of the soil matrix.

So, this is how the microbial activities can also be studied in the soil with the help of pore solution sampling techniques. And the best thing you can do is you can validate the solid transport models particularly mathematical models. The biggest question is the type of mathematical models which are being used by the professionals whether they are accurate or not. Clear? Now this is where the question is how to select the parameter which are going to be in the mathematical models. So, for getting these mathematical model parameters you have to conduct some field instrumentation or laboratory instrumentation then whatever results you are getting from the mathematical models you can always check by observations in-situ observations. So, this is a very hot topic for research you know in the 21$^{st}$ century and then if your models are not matching with the field observations, the critical commentary, what is why it is so, happening and in what way the mathematical model should be refined or in what way the detection technique should be refined?

You know then this becomes a two-sided problem. So, one side you try to modify mathematical models and the parameter estimation. So, this becomes a very challenging task.

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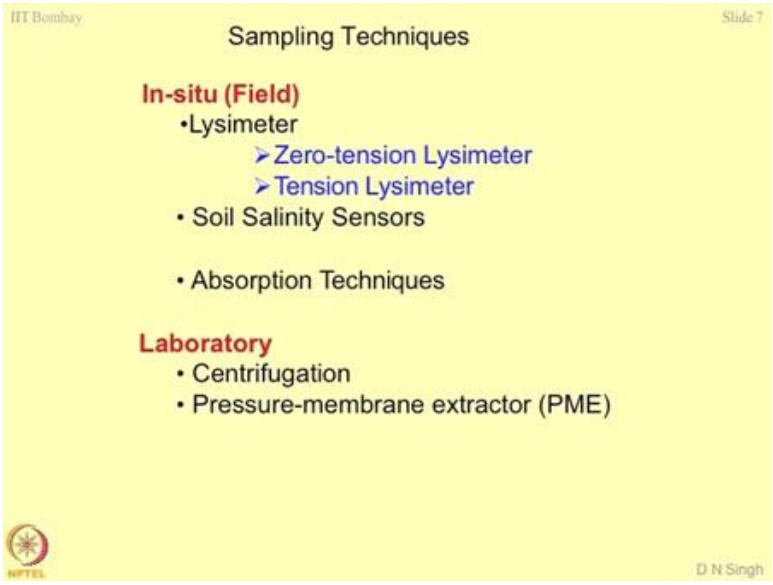


Let us discuss a bit about sampling techniques. The first category of sampling techniques is in-situ or the field and the second broad category is laboratory alright. So, in in-situ techniques normally we go for lysimeters. I have discussed this in previous lecture. I had shown you one or two slides today I will be discussing in details, how lysimeters are designed, how they are installed and ultimately what is the basic idea of doing the lysimeters studies; that means, to collect the pore solution. And the moment you have collected the pore solution you know what is the extent of contamination and what is the extent of soil contaminant interaction which has already gone through.

So, when we talk about lysimeters there are two categories of lysimeters. One is zero tension lysimeter another one is tension lysimeter. In your perception what is meant by zero tension lysimeter and tension lysimeter and what is the difference between the two? Yes, please Sneha, Sangeetha, why is the word tension being used there? Ravi? Some guess at least.

You are very close, very good, please think again and answer. You are very close that something is applied to collect the pore solution that is right. Now what is that you are going to apply?

Student: May be some suction.

Very good. So, suction; that means, depending upon the state of the soil there could be either free drainage which happens mostly in saturated soil mass or if the soil happens to be unsaturated, there you have to apply suction to collect the samples. You are quite close very good, Binel and Jan.

When you talk about in-situ instrumentation sometimes soil salinity sensors are also used. So, these sensors basically tell you how saline the soil mass is, is it not? So, again your electrical conductivity will be different for soils which have more salts in them. So, if you do a if you perform a test let us say in Rann of Kutch where you have mostly brackish water, where the electrical conductivities will be very high as compared to normal water.

So, this is where you can easily find out that soil solution has more of chloride ions or salts and hence the conductivities are very high alright. Sometimes absorption techniques are also used. I will cover these techniques bit in details in todays lecture. As far as laboratory is concerned, we normally talk about centrifugation technique to drain out water from the soil mass and then most common technique is Pressure Membrane Extractor, PME. You apply some pressure, you squeeze out water from the soil mass, whatever pore solution gets collected analyze it by ICP, ICP-MS or by atomic adsorption spectro photometer. Is this ok? So, broadly we have two categories; one is field another one is laboratory.

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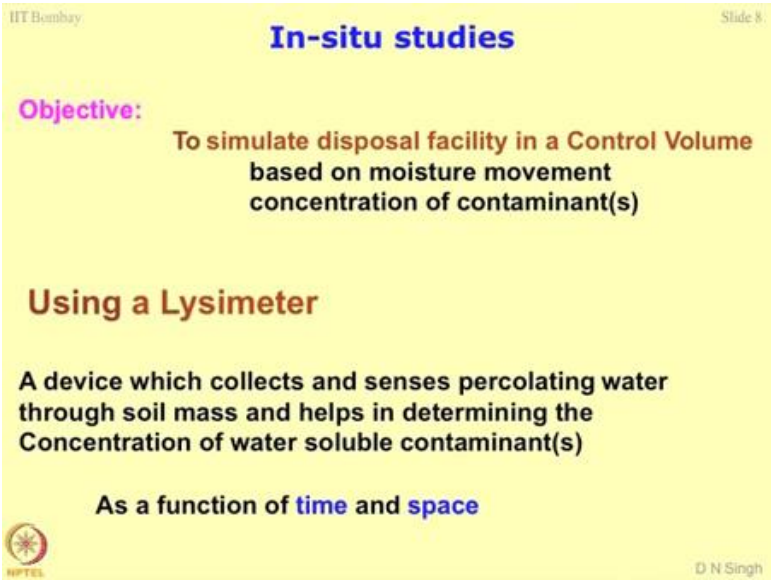



Let us start with the in-situ studies basically lysimeters are designed for in-situ studies. Agricultural scientist were the first to use lysimeters. But slowly and slowly we have encroached upon their expertise and hopefully you will understand that why we have entered in to this field; we means geotechnical engineers. The basic objective of these studies is to simulate disposal facility in a control volume. What is a disposal facility? Disposal facility is nothing but a repository where the waste is being dumped alright.

So, the basic intension is to find out guidelines, what should be the proper dose which should not be crossed otherwise the ground water, the soil will become contaminated and there will be an impact on environment directly. So, what we are doing is we are trying to simulate disposal facility in a control volume. How waste should be disposed on the soil or in the soil in the best possible manner so that it does not hamper the atmosphere sorry environment. Now when you are doing this hope you will agree the fact that moisture movement is the biggest culprit, because the waste will come in contact with the water and then along with the water the species of the contaminants will get leached out and they will migrate into the soil mass contaminating the geoenvironment.

And the second issue is the concentration of the contaminants, what is the concentration which is getting leached out. Now this is where environmental geo technique technology has to play a very important role. Suppose if I tell you that your disposal facility happens to be located in the heart of the city. Clear, you do not want to any chances that they

should not be any moment of moisture from the system and there should not be any concentration of contaminant moving out of the facility clear? So, this is where a geotechnics of landfills, liners, geo textiles, liners, systems, GCL and all these comes into the picture.

So, this is where geotechnical engineering takes over what has been done by agricultural scientist. Their primary aim was what should be the dose of the pesticides or the fertilizers which should be used so that excessive leaching does not takes place into the geoenvironment. So, the obvious answer is if you want to do in-situ studies the best thing is you create a lysimeter. One more thing I want to tell you at this stage is the lysimeter can also be replicated in the laboratory at a miniature level.

Of course, it will have its own limitations, but yes you can take the same soil from the In-situ, you can remold it to the same conditions and you can do the study at a smaller level or volume level. So, what is the lysimeter? Lysimeter is a device which collects and senses percolating water through soil mass and it helps in determining the concentration of water-soluble contaminants ok. The meaning of the word lysi is nothing but whatever secretes out or whatever move out and meter is nothing but the one is which is going to check this or measure it.

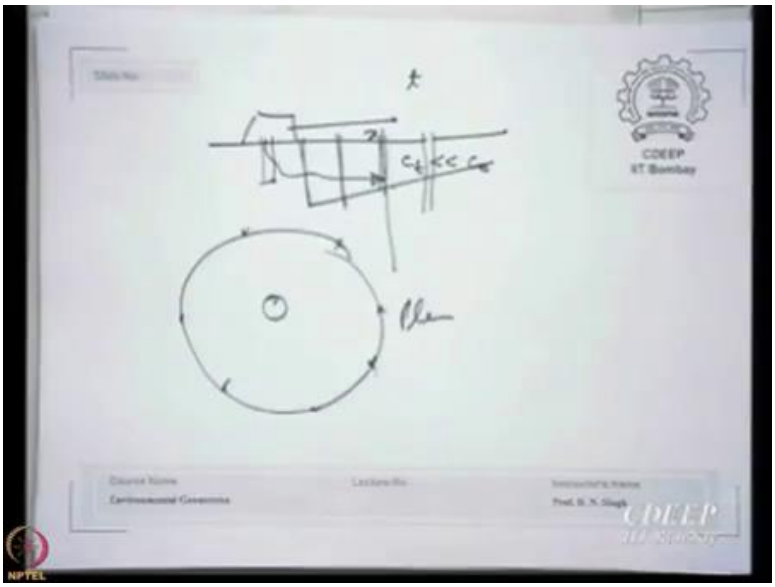
So, it is a device which collects and senses percolating water through the soil mass and helps in determining the concentration of water-soluble contaminants. There is a limitation whatever is soluble in water will only come out and whatever is not water soluble will not come out. And the basic idea of doing the study is that I want a solution in the time space domain. A good example of where which I should sight over here is when you solve consolidation equation you solve this equation for pore water pressure as a f(x,t).

So, at a given depth after a given time, what is the pore pressure which is still remaining in the sample? The same thing I can modify I can replace U by the concentration and my question is if there is a facility where the waste being disposed, what is the concentration at a certain distance at a given time and this concentration has to be less than the permissible limit of the concentration. Then your facility can work very well and everybody is going to be happy with you. This can be reverse problem also. At a given

time what is the concentration at a given distance what is the concentration, I hope you can understand this point.

Whatever pore solution is coming out, yes.

Take. (Refer Slide Time: 20:35)



See this the facility and something is leaching out of this. I want to find out at a given time at a distance of x what is the concentration $C_t$ and this concentration should be much less than the permissible limit. I have several ways of doing this; either I can check the concentration at this point itself by using a lysimeter, I can do a bore log over here take sample of the soil make their solution again test what is the concentration that is one of the ways this is a destructive method.

I can device another technique by using a probe I can find out what is the concentration at this point at this point at this point at this point and so on. So, I will be having a concentration profile like this, agreed? So, this will be for a given time, I can do it in a domain of distance. At a given distance how the concentration is changing, so, that also I can find out. So, that becomes a reverse problem.

Student: Concentration (Refer Time: 21:42).

It changes according to the scale.

Student: (Refer Time: 21:49).

Ok

That is right correct there could be special variation of the concentration that is right. So, again you have to normalize these special concentration variations and then you have to come up with a representative number most probably. So, here whatever variation is because this is going to happen in plan, in the whole domain; so, this is the plan. I can find out concentrations all over and then I can go for some normalization and averaging of the values. So, the basic idea is I should get some concentration which is representative at a given distance, even if I know the concentration at this point, I can use some mathematical models to check what is the concentration at this point. So, this becomes a very good mathematical modeling problem.

Now, again the question is for doing this type of mathematical modeling how you are going to generate the input parameters and that is a challenge, this is what most of the hydrogeologist are doing. So, they go for different bore logging, they collect the water sample, soil course and they generate from both the perceptions what is the concentration of ions presents in the water as well as in the soil sample.

This becomes a holistic modeling exercise. Is this ok? Any other point which comes your mind? So, ultimately what we are doing right now is we are trying to understand a phenomena, we are understanding the physics of the phenomena, then slowly and slowly all these physics part will take helps from the mathematics to do the modeling so that answer to a real life situation can be obtained that is the philosophy. It is clear?