Environmental Geomechanics
Prof. D.N. Singh
Environmental Geotechnology Laboratory
Department of Civil Engineering
Indian Institute of Technology-Bombay

Lecture No. 33
Geomaterial characterization-IX
(Chemical characterization)

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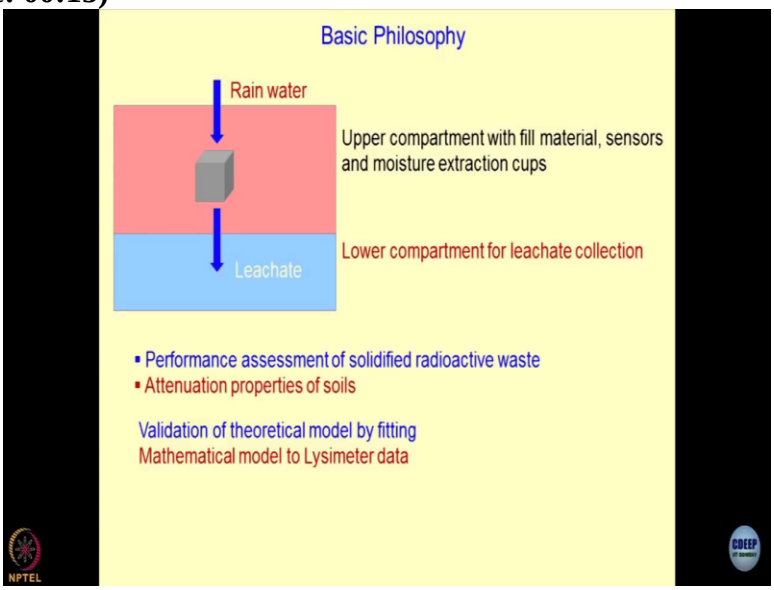

So, in nutshell what is the basic philosophy of lysimeter is truly speaking there are two strata. One is the lower compartment which is the leachate collection system and upper compartment which is filled with the material sensors and moisture extraction systems like cups. And what I can do it, I can find out the how the system is going to behave when I talk about let us say encapsulated nuclear waste because disposal of the nuclear waste has been a big issue and the country wants to become a muscular country in terms of today's social-political situation so, radioactivity and dealing with it has become very important. This is the attenuation property of soils has become very important. So, what I can do is I can take the atomic waste or highly toxic waste encase it in a unit this is what is known as encapsulation. So, I can freeze the entire material contamination into the matrix of cement or sometimes glass. Those of you who are interested read more about how this is done.

So, glass is the best source of encapsulation of toxic waste. Why because glass is amorphous. Do you remember XRD patterns? So, there we were looking for the glassy here, which is more reactive. So glass will not let anything come out of it. Now, when I am talking about this, you should also Google about the salt domes which nature provides salt domes. So, which nature provides and these are the best places to dump the atomic waste coming out of your reactors.

Why? Again the same thing, salt is the most reactive phase, which will not let any species of contaminants go out of it and hence it acts as a best possible barrier system naturally provided. So, coming back to this story, I can take toxic waste atomic waste biowaste encapsulated in a matrix of concrete, cement paste different type of resins, and I can solidify it. Now, the question is before I dump it somewhere, I have to prove that nothing from this unit is going to leach out.

So, this was a project which I dealt with for India. And a very educating work. And this type of modelling we did a real-life situation. And what I did is after embedding it somewhere here in the upper layer, I induced artificial brains and live the system for a certain duration and whatever leachates come, you can analyze. And you can show that the encapsulation which has been done is perfect, nothing will go out. Everybody is happy.

Do you realize the importance of this simple experiment, which was done, I am getting a feel of this, minus this, everybody would have been asking what will be the effect of this material on errant and then they are not let you install atomic establishments. And if nothing of the sort happens, then what will happen? You will always remain in the 17^{th} century. You are deprived of electricity and power and weapons and whatnot, radiotherapy and medicines, so many applications.

So are you realizing the whole cycle, where the science and technology gives answers to the questions which would safeguard the society against the concepts are clear? So, I can design here how much is being retained by the soil, attenuation property or this option studies and everything; I can do beautiful modelling to even see what the effect of temperatures, ambient temperatures after disposal is.

What are the temperatures in the ground, whether thermal cracking of the soil is taking place or not because these are the thermal stresses, chemical stresses, radiation stresses all put together a beautiful example of coupled phenomena. We use this concept to find out the validity of the models which are being used?

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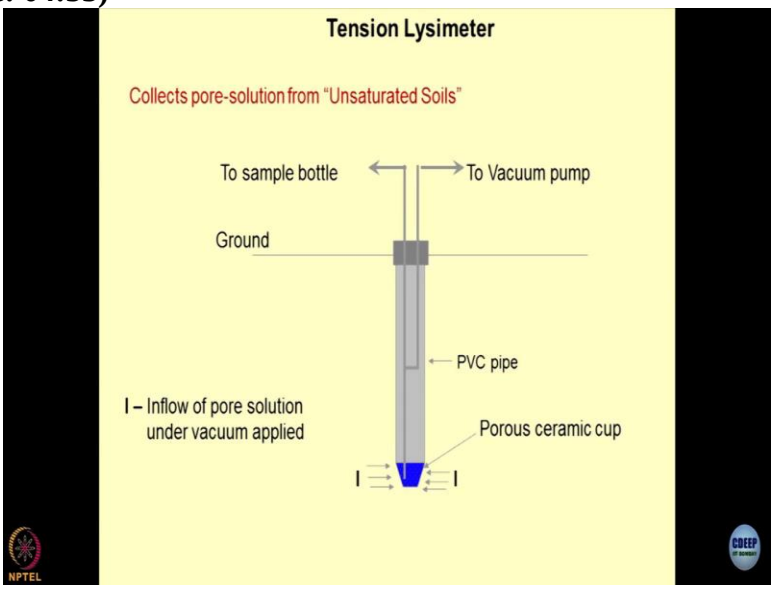

Okay. So until now, we have been talking about the saturated systems of the soils. Zero tension lysimeter. And now I would like to show you how the ancient Lysimeters look like primarily they are used for unsaturated soils where you do not allow ingress of water happening in the soil mass. So, this is how these systems look like these are the last tubes of PVC tubes which are specially designed for these are typically PVC tubes or the glass tubes of different lengths. At the end, there is a specialized ceramic cup which is attached, and this is also known as a thimble.

So, these are the systems which have a specific air entry values. In medical sciences, they use these type of things quite a lot. Most of the research in the environmental geomechanics is being replicated after seeing the human body, and how it functions so, these systems which are normally used in medical sciences are now being used in geomechanics. So, in this tube, there are tube pipes which are inserted, the philosophy is like this that once I inserted into the soil mass, which is unsaturated, leave it for some time apply suction.

So, when you apply suction, the water from the unsaturated soils gets sucked, and the suction should be so modulated that the pore solution comes and sits inside the tube. And once this

happens, you can have another pipe which is connected to the sampling bottle vial, and you can keep some sample that you have collected by applying some vacuum suction. So, this is how the tension lysimeter works. I will show you how it looks like and how it is calibrated and other things.

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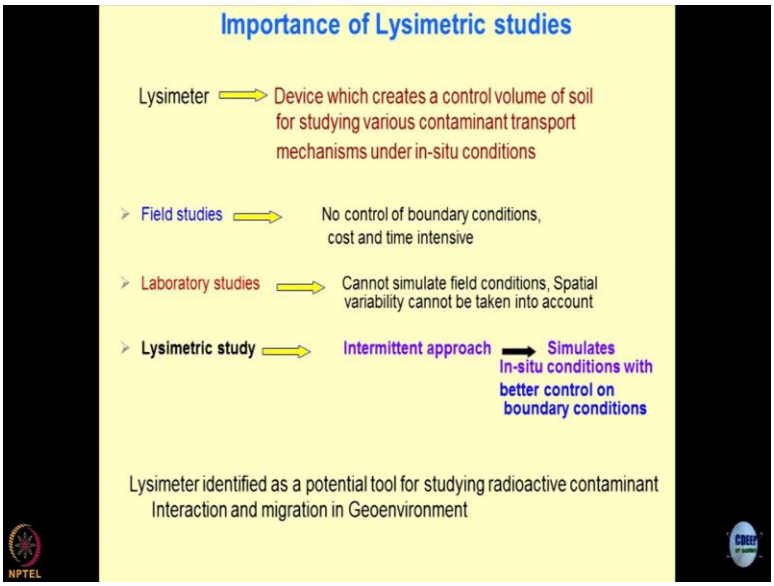

What is the importance of the lysimetric studies this was a project which I did for Atomic Energy Regulatory Board of India and BARC. So, as I said, the lysimeters are basically the devices which create a control volume of soil for studying various contaminant transport mechanisms under in-site conditions. There are 2 types of this field and laboratory studies in field studies unfortunately not much control on the boundary conditions and they are very expensive and very time-consuming.

Though we did some of the field studies and laboratory studies also cannot simulate the in-situ stresses because once you retrieved the sample, the in-situ stresses cannot be simulated. Another problem is you cannot simulate the real matrix of the soil or the file structure, which was the line in which was in the real-life situation. Another issue that special variability cannot be taken into account because the sample sizes are very small in laboratory studies.

So, under these circumstances, the lysimetric studies can be utilized as an intermittent approach, and I can simulate in-situ conditions also by controlling the boundary conditions. So, you may say that this is a sort of one type of a solution which I get by doing lysimetric studies.

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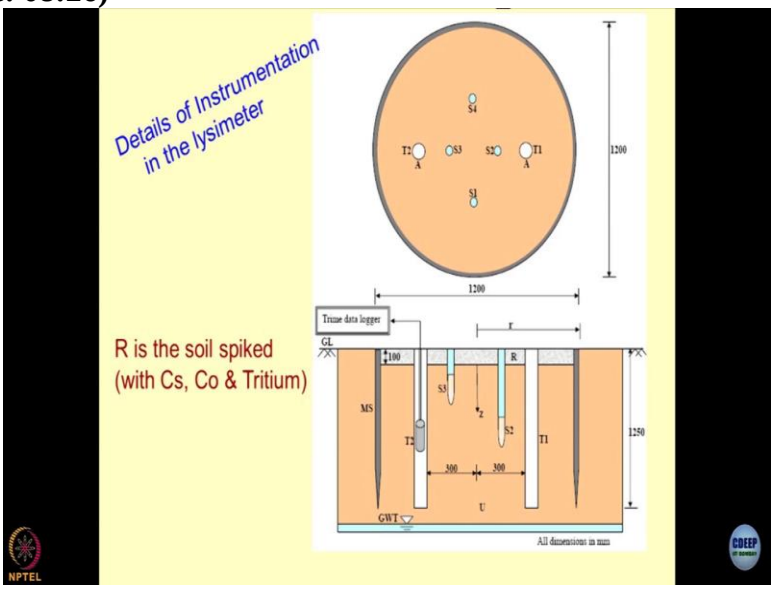

So, this is the case which I was talking about what type of instrumentation has been done at a place where the atomic waste is dumped in India. So, what you see over here is a stainless steel ring of 1.2-meter diameter, and this was about two meters long. This ring was not two meters long; this was also 1.25-meter length you can see from here. So, this was inserted into the ground by pressing it from the top the way the piling is done. So, inside the soil mass becomes a control volume, and it does not get influenced by the outside surroundings.

Now, as far as the instrumentation is concerned, what you are observing is that there are two cubes T1 and T2. So, these are the PVC tubes which were installed after the sample was created. These are known as TDR cubes, time-domain reflectometry tubes, and what you are observing here is a TDR probe. This is what is known as time-domain reflectometry probe, and this is used for profiling the moisture content from top to bottom of the zone of interest and the type of volumetric moisture which you obtain from here.

Remember this is volumetric moisture to get from the TDR probes can be utilized to profile the variation of groundwater regime in the sample; this is the groundwater. So fluctuation of the water table can also be captured when you use arterial. So if you blow from top to bottom, and

you could try to create a moisture profile, these type of groups are very useful. Why to because we wanted to see the spatial variation within a small group and they were installed at different radial distances at different depths.

So, this is a typical tension lysimeter on it. And what I have shown here is a thimble which is made up of a specialized ceramic cup which has a peculiar air entry value. So, this is the setup which has been created. Now what is normally done is we remove the top 100 mm of the soil and replace it with sand. And this sand is utilized as the source of contamination which is going to migrate through the soil. By using these type of setups, we could study the caesium cobalt and tritium these are the ratio mixture which we use to study their interaction with the soils. Why these radioisotopes were used because these radioisotopes are present in the sludge which comes out of the atomic reactors. So this is what actually you wanted to study. So, the choice is yours you can use a different combination of the radio nucleus.

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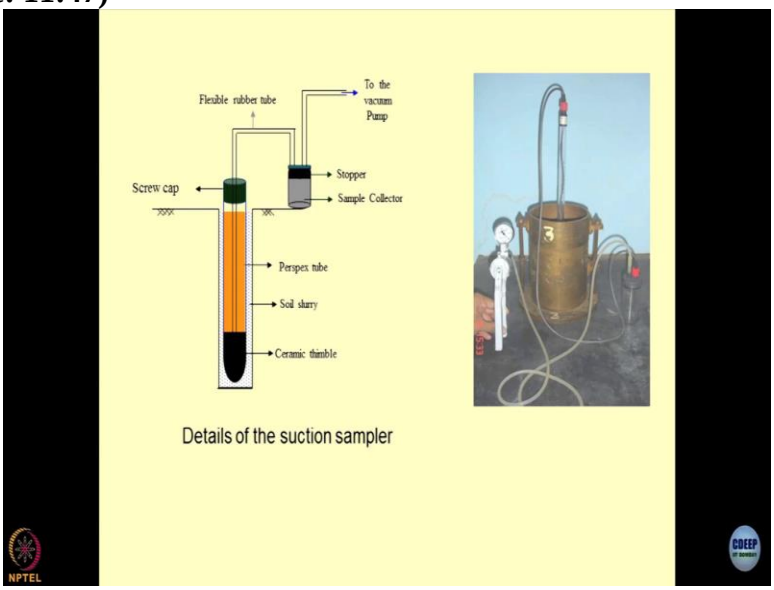

This is how the suction samplers look like. We train them in a CBR mold to see whether they are working all night or not. And then when you apply suction pore solution gets collected.

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Just to show you how the activities are done in the field. This is how the whole system has been created the two SS tubes are fitted for suction samplers are fitted; these are the cubes which are connected to the suction samplers. Now, you can see that we are giving, this is the strontium crimson red colour is the typical colour of the strontium radionuclide and then we leave this whole thing for rainfalls to come.

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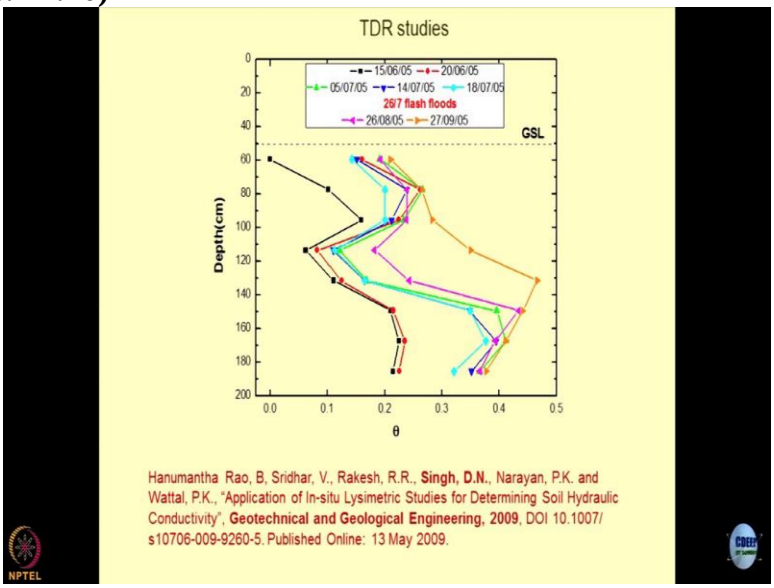

This experiment which was very expensive, was done during the flash floods off. You can see here the externals going completely from 15 June and 2 July and then came to the flash floods off what is this July 2005 these glass tubes are broken, and they got flooded, but we got good data there is none which we did and analysis. Area studies are normally done to establish the

variation of soil moisture in the entire domain, and particularly, this is the groundwater variation which causes this type of profile this could be because of the percolation due to the rains also.

And this takes care of the evapotranspiration because on this accident if you remember the soil sample is exposed to the environment. So, evapotranspiration, percolation, fluctuation of groundwater table everything is taken care of. So, this is a very comprehensive set up which has been done if you want to read this outcome of the study you should refer to this work which we published in geotechnical and geological engineering application of in-situ lysimetric studies for determining soil hydraulic conductivity under field conditions.

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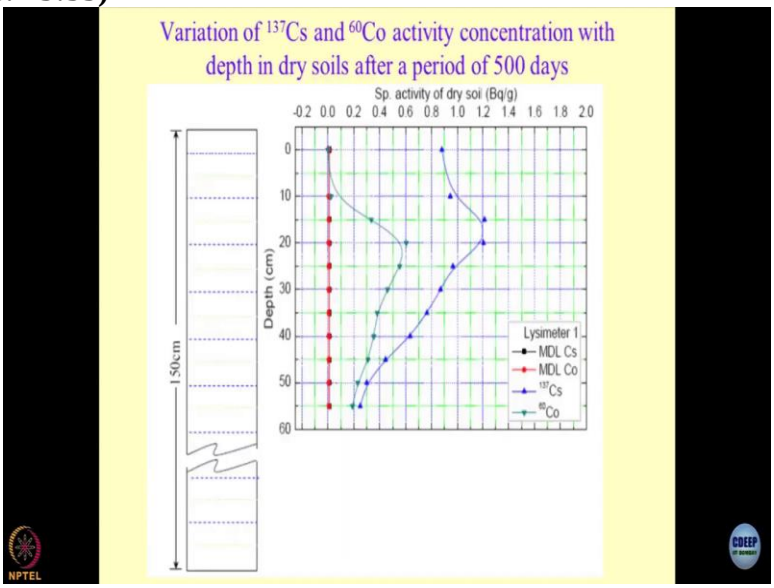

This is how established the movement of caesium and cobalt is in an active form, and we did the modelling for 500 days, the whole purpose was to design the repositories where the waste is being dumped and how the whole system behaves, how much is getting sorbed onto the soil mass at a given depth. So, these type of studies become very useful when you design the repositories where the waste is being dumped.

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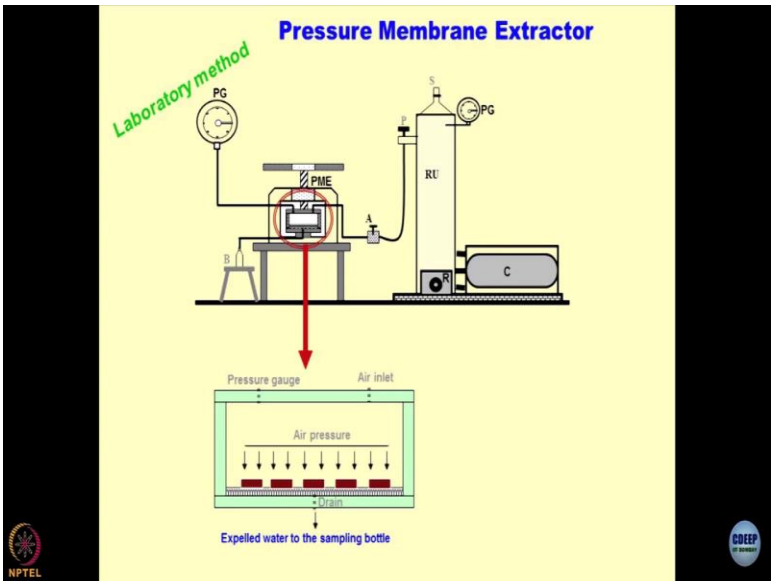

Now, this is another instrument which was fabricated by one of my master student Dr Vikas Thakur now he is a professor at NTNU Norway. So, this is the system which was created. Now, what you are seeing observing here is that this is the control volume where I can keep the sample, and this is connected to a pressure retention unit and pressure retention in this connection to a compressor.

So, with the help of the compressor, the pressure is built up in the tension unit, and this pressure of air can be used to pressurize the sample in the pressure membrane extractor. So, rather than using the water in the cell, the sample which is kept here is being pressurized with the compressed air and why it has been done answering your question. Now you are seeing a situation where the fluid is compressed and just percolating through the sample.

So it displaces the core solution which gets connected into the boil which is kept over here. So if you look at the shoulder view of the pressure membrane extractor, this is how it looks like. It is a chamber where the bottom portion is connected to a drain. And on the drain, we keep a percolating material, mostly a geotextile on the top of this we keep a cellulose acetate membrane. Cellulose acetate membranes are used for a lot of treatment of the human body, particularly the filtrations of different type of fluids.

Membrane technology is a big subject in chemical engineering, so, to create a membrane which will function at a certain pressure for certain types of contaminants or ions, a good example of membrane technologies is the ROs which you are using or the water filters that you are using. So, when the air is the inlet, what happens, this air pressure acts on the samples of the soils which are kept in small these are the rings. So, they are open from both top and bottom.

And what we do is we keep the filter paper on the top of the filter paper we keep the ring, and we pore the soil slurries in the rings, and we place them over here. So, when you apply air pressure, the pore solution comes out, and that is collected in the bottles. So, this is a pressure membrane extractor. This was done by our cells, but now in the market, you will find that commercially available pressure membrane extractor is available.

These are primarily used by the guys who are working in unsaturated soil mechanics or the guys who are working in a biomedical engineering or agricultural scientists, those who are very much interested in uptake capacity of the soils and plants and those who are working in the field of nutrition, ingress and loss from the soils. So, this type of equipment can be utilized quite easily.