Environmental Geomechanics
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Lecture No. 31
Geomaterial characterization-VII
(Chemical Characterization)

We have been discussing geomaterial characterization, and we have talked about physical characterization, morphological characterization, geotechnical characterization, mineralogical characterization and some part of chemical characterization which I have been talking about. And the whole emphasis is to give you an idea about that why these type of characterization schemes are important in the contemporary practice of geotechnical engineering and environmental geomechanics and what is state of the art on the subject.

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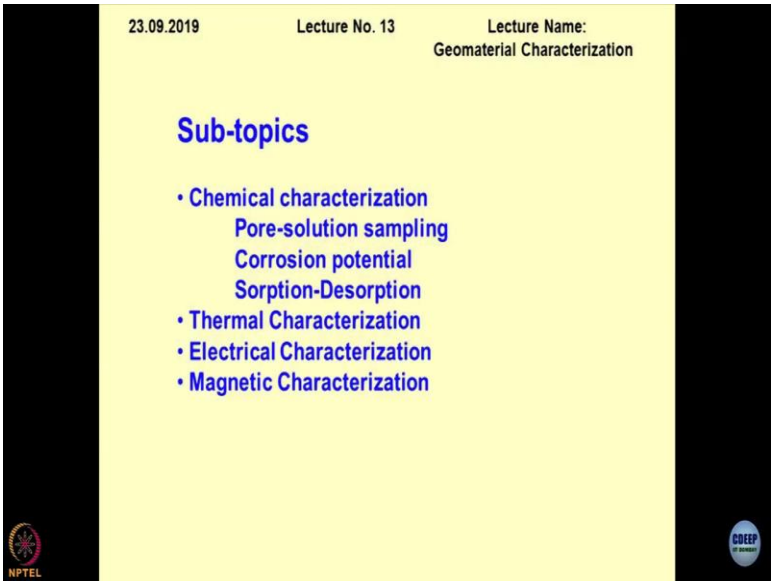

So, in continuation with that what I have been discussing in the previous lecture, I will be touching upon chemical characterization in details today. The obvious reason is that the chemistry of the material is becoming very, very important to understand what is the state of the material, including the human body? Most of the assessment of the status of the human body or the geomaterials is being done based on this chemical examination.

So, under the head of chemical characterization, we will be discussing quite in details about the pore solution sampling, which in my opinion is identical to the blood sampling, which I have been telling you since several lectures there is an analogy between the way the medical practitioners, they diagnose the human body based on the fluids which can be retrieved from the body. Similarly, we can make the diagnosis of the materials by retrieving the pore solutions from this.

This is a very contemporary thought in professional practices of these days where the intention is to treat the system, and when I say a system, this is the geomaterial system based on the early diagnosis, and the application of the chemical characterization is best defined by the corrosion potential of the soils. In today's world, this subject has become very, very important as I cited last time also all the buried structures in the soils have to be in contact with the severity of the soil and hence the corrosion of the buried structures because of the aggressive soil import environment is becoming very important.

And hence I will spend some time describing what is the corrosion potential of the materials and based on this; the classification scheme has been developed. We will also be talking about this option the sorption-desorption mechanisms, which is the easy way to quantify how geometrical contaminant interaction occurs. And this is a very contemporary thought, where any type of interaction with the material of any contaminant in the gaseous phase or the liquid phase can be quantified by studying the sorption-desorption mechanisms.

Then, of course, we will move on to thermal characterization followed by electrical characterization, and this would be followed by the magnetic characterization, and that would be a very comprehensive discussion on environmental geomechanics.

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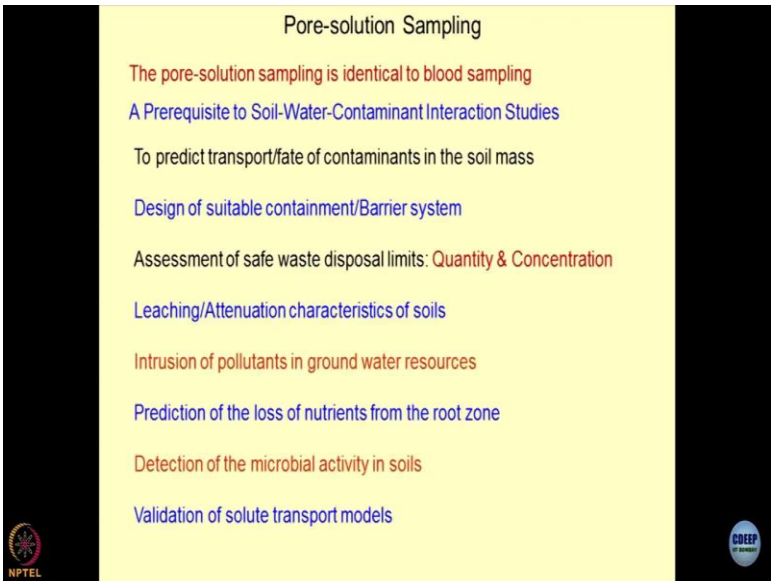

So, to begin with, when we talk about the pore solution sampling, as I said, the analogy is same as the blood sample or for that matter, any fluid which is from the body and this is a prerequisite for soil water contaminant interaction studies, and this is where the focus is, in today's world, most of the industrial activities are polluting the geosystems or geomaterials. So, and most of these issues are becoming legal issues.

The warnings are being sent, notices are being sent, and if under no compliance, even the closures are being offered are being sent to the industries. I hope you understand these words are quite big, and they are an extremely difficult situation for an industrial setup to handle. Basically, pore solution sampling helps in predicting the transport and fate of contaminants in the soil mass, or even the rocks also. Why have not toured it because it is easy to study things in the soil because of the relative less denseness of the matrix or the porosity that higher as compared to the rocks?

So, when we talk about the transport of contaminants in the geomaterials or the porous media the second question comes, what is the fate of the contaminant, how long it is going to survive in the porous media, or it might multiply also depending upon the situations which you might be observing that prevail in the geosystems? So, contaminant transport and determination of the fate of contaminants is also becoming very contemporary, most of the time nuclear industry, thermal industry, thermal power industry, pharmaceuticals any type of manufacturing which you take

would require, the technical guidance in terms of these steps, which would form the environmental impact analysis also.

So, we have discussed sometime back about the containment system and the barrier systems. So, the best would have been if I would have contained the things by designing good barriers in the soil mass so that the contaminant does not spread into the entire geomaterial or the porous media. So, this is their pore solutions can help you in understanding whether the containment and the barrier systems which have been designed or installed or functioning or not.

So, this topic as I said, is more of practical ideas and execution-oriented. And if you check on the net a lot of activities are being done under the realm of pore solution sampling and contaminant transport. This exercise will also help us in determining what the safe limits of the disposal of contaminants what should be the quantity and what should be the concentration of the contaminants which should be discharged are.

So, in other words for solution sampling also helps you in deriving the guidelines which should be adopted by the industries for disposal of contaminants in the general you are aware of leaching and attenuation characteristics of soils. So, leaching is a phenomenon where the heavy metals or several species which might contaminate the environment, come out of the waste matrix and then they transport into the porous media or geomaterials. Attenuation is the reverse process attenuation is something which is the capacity of the porous media to not allow migration of contaminants to occur.

So, this is a sort of an inherent property of the geomaterial by which the geomaterial would not let the contaminants migrate from one place to another place. So, it could also be termed as retardation capacity, retardation characteristics of porous media that means, the porous media is so active chemically that image in a species of chemicals which is passing through the porous media and get sorbed onto the porous media itself, it will discuss these things around.

So, as it environmental geotechnical engineer where the jobs are where the challenges are, these are the topics in which industry requires your support and help. So, you design a barrier system

which is attenuating the contaminants that would be a statement of the contaminants are leaching out of an investment is that is known, but how can I stop this process? That is very good, but if I cannot stop this process, what type of porous media I can create through which contaminant transport would not occur so easily.

Or the third definition could be, I would like to create a porous media which would attenuate contaminant transport. So, these are the three different types of issues which you might be coming across. Then, of course, everybody is concerned about natural resources like groundwater. And we do not want our groundwater sources to get contaminated because of the industrial activities. But unfortunately, this is what is happening.

So, pore solution sampling is also going to help you in taking proper measures so that the groundwater reservoirs or the resources do not get contaminated. In today's world of electronics and sensors, it is very easy to monitor and protect the underground facilities by installing sensors that discussing subsequently; there is another interesting area where some of us are working. And we supplement our knowledge to the individual scientist who does not have much practice of dealing with the porous media.

So, one of the challenges which environmental geomechanics professionals are facing is how to predict the loss of nutrition from the root zone because of over-irrigation. So, over-irrigation leads to loss of nutrition also. So, all the nutrition which are present in the soil might get detached, and this system might be equivalent to leaching of nutrition from the porous media. So, this type of situation has to be avoided.

Another situation which people might talk about is the microbial activity and this movement and the soils. So, where are the locations where the colonies of the microbial activity that are harping or surviving in the soil must that can also be detected by pore solution sampling, the technical term given to this type of activity and the studies related to microbial detection in soils could be under flushing of bacteria?

So, this is a topic on which a lot of research is being done beyond contaminant transport. Now, researchers are interested in finding out how microbial activity gets flushed out from the soils. So, it might be having both aspects you would like to stop the microbial flushing for maintaining the good health of the soil. At the same time, when the activity becomes very high, you like to flush it out of the soil mass to maintain the balance.

So, it depends upon how engineering is being done by a certain professional; I hope you can realize that the application of these concepts could be several and tremendous. Then, of course, the pore solution sampling is done for validation of the numerical modelling course, which have been developed by people and which are available in the market. So, there was a time when people were doing mathematical modelling for all the phenomena in geomechanics.

And then later on some good sense prevailed to researchers, and they started questioning how good or bad these numerical modelling, algorithms are, or the software are. So, there is a big group of people who are working on the validity of the software itself. And that is the reason sometimes I always say you have to use the software as very carefully because the knowledge is limited which has gone into the development of the software's and what is happening in the world is at least few 10s of years ahead of the information. So there is a mismatch of the timescales itself in the mathematical models and questions. **"Professor - student conversation starts"** Yes, native bacteria are the microbes that are always there in the soil. And like whenever we are dealing with it, is it safe to assume that like in the given time span, they would not be having any effect on the soil structure itself, where we are constructing or if they are native, only native microbes for a given timescale of 30-40 years?

So it is a good question what you are asking there, what is the impact of the native bacteria on the porous media, is it? This is the general question. And I think from day one, I have been highlighting that the chances are that either these bacteria would upgrade the system or they will degrade the system. So up-gradation means there could be some cementation which might occur because of the microbial chemical process which might prevail in this porous media. **"Professor - student conversation ends."**

A good example of this would be precipitation because bacteria have a tendency to change the pH of the pore solutions also inside the geomaterials. And there are metals which would not be in the soluble form corresponding to a search and certain pH values. So, if these type of things happen, the pores are going to get clogged because of the precipitations of the salts. How are another scenario could be that this bacteria might become up the porous media itself and hence might induce a lot of secondary or tertiary porosity in the system that's the voids? What I was thinking was there with this one for not Sofia, as long as its formation like now suddenly if we are assuming that it might eat up or like is it unsafe assumption like millions of years, your assumption is your thinking processes well. The only change you have to make nothing in processes that you are talking about the situation which is prevailing before the soil came in contact with the contaminants.

And the chances are when the soil and the bacteria come in contact with the external agencies like contaminants; the growth might get aggravated because many times these contaminants would act as a nutrition to the bacteria. Right. What you are thinking is correct. So the native bacteria would have been living there or colonizing over there since several years that is fine. But then the ingress of contaminants might change their characteristics. So you have to think of this situation. So this creates a very different context altogether, I am sure you must have realized.

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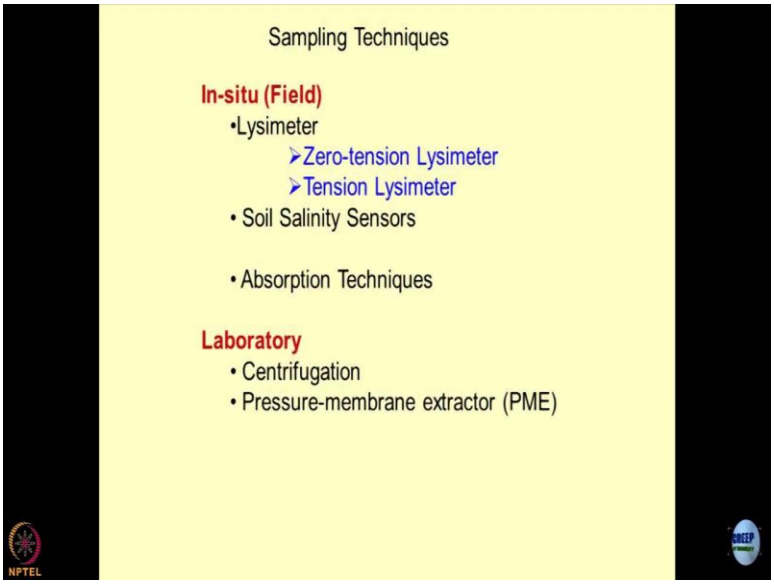

So let us move on to the details of the sampling techniques. Broadly, these are defined or classified in two groups. One is the In-situ which is the field. Another one is a laboratory which is the ex-situ techniques. Under In-situ field conditions or when we have to take the samples from the sites, lysimeters are used lysimeters are the setups which were used for measuring the discharge or percolation.

So word Lysimeter corresponds to seepage or percolation. So Lysimeter is a system which measures percolation in the soil mass. So, these lysimeters could be designed both in the laboratory as well as in the in-situ condition, and I will show you some examples of what I did for the Atomic Energy Regulatory Board of India. This was a unique experiment, which we did. Sometime back I will share this with you, and I will show you how this whole thing was conducted.

So these lysimeters could be either zero tension Lysimeter tension corresponds to suction. That means the Lysimeter. When they are used for saturated soils would not exhibit any suction and hence, they are known as the zero tension lysimeters. However, there could be tension lysimeters also the soils are unsaturated or partially saturated. So, the challenge would be to take out the pore solution from the size which are not fully saturated, and this is where tension lysimeters are utilized.

There are some soil salinity sensors also which are used for sampling of the pore solution. And there are some absorption techniques also which have been used since long, but they have become outdated in the sense because they are not very contemporary. However, as far as laboratory sampling techniques are concerned, centrifugation is the simplest thing you take the sample in a glass tube or in a control volume and centrifuge it at a very high speed.

So, when I say centrifugation is not at 50 G or 100 G to 200 G is going to be millions of G values. So, the RPMs would be of the order of 1 lakh RPM, 5 lakh rpm and so on. So, these are the ultra-centrifuges which are used for taking all the solutions from the soil mass. And this is an interesting technique which has been used by us also, and a lot of people are using to drain out the pore solution from the samples, particularly in-situ samples which are brought to the lab and

then you can fit them in setup, and you can spin them in ultracentrifuge to expel the pore solution.

There is another interesting device which is being used in the market by people, and it is known as pressure membrane extractor PME. I will discuss this, how the pressure membrane extractor works, and how the pore solution sampling can be done. Apart from this, I can use some fluid displacement methods also by putting a fluid of certain density which is higher than the density of the pore solution in the soil mass and then by density separation techniques, I can force the lighter fluid to come out, but these are very tricky methods. Sir, in the laboratory, what we do for saturated and unsaturated soils. Lysimeters can be designed in the laboratory environment also. So, it is only a matter of the dimensions. So, my field lysimeter would be running in a few meters, and laboratory lysimeters could be as small as centimetres. Fine. The mechanism and the concept remain, and we will talk about this and tension sensors can also be utilized to derive the pore fluids. I will talk about this.