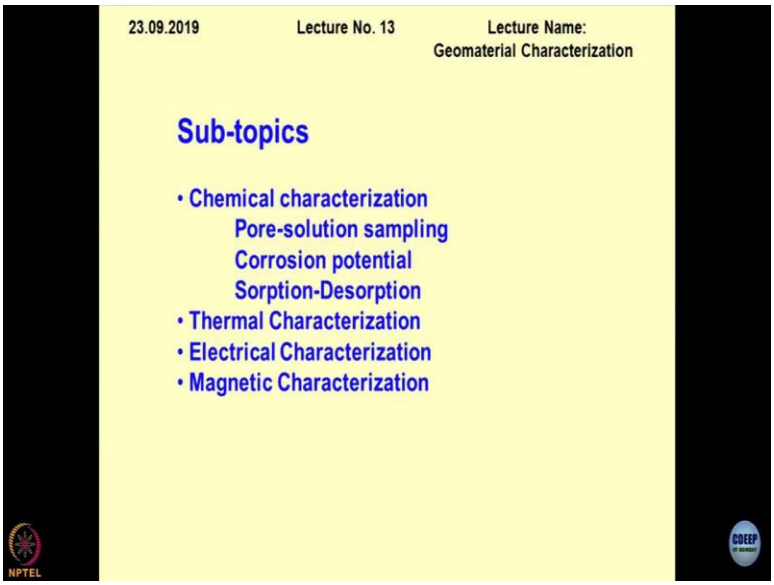
Environmental Geomechanics
Prof. D. N. Singh
Environmental Geotechnology Laboratory
Department of Civil Engineering
Indian Institute of Technology-Bombay

Lecture No. 34
Geomaterial characterization-X
(Chemical Characterization)

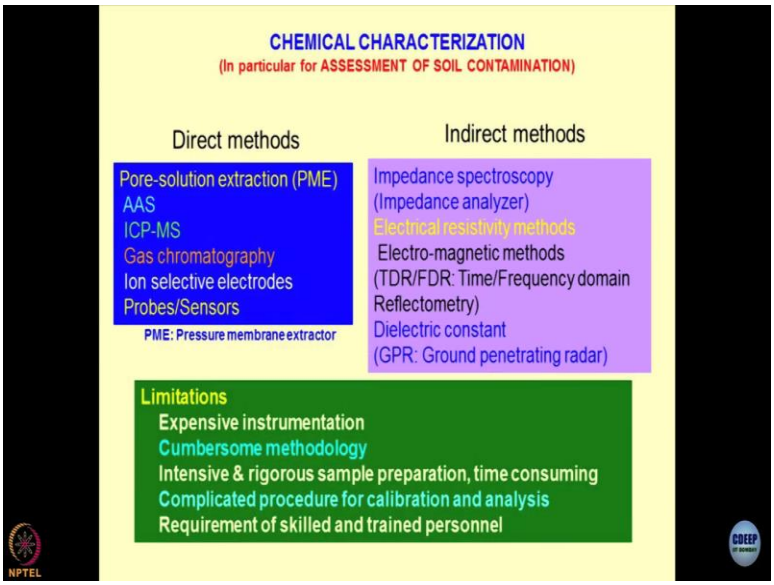
The previous lecture we have been discussing the chemical characterization the pore solution sampling and how these pore solutions can be utilized for characterizing the geomaterials.

(Refer Slide Time: 00:28)



Today I will be discussing one more technique of what is defined as soil washing. And this also is a technique to create pore solution by wash the sample with an adequate amount of water, and I can create a pore solution, and I can characterize the geomaterial. I will continue with a discussion on corrosion potential of soils today, and maybe sorption desorption will come later. This will be followed by thermal electrical and magnetic characterization.

(Refer Slide Time: 01:04)



There is an interesting technique of characterizing science based on their chemical characteristics. Particularly if you want to assess what is the level of contamination of the soils, soils may get contaminated because of anthropogenic activities. One of the interesting techniques to find out the definition of soils it is washing. It may so happen that soils may get contaminated because of several natural phenomena or anthropogenic processes.

I think anthropogenic processes all of you understand this could be the influence of the industrial activities which are going on vigorously everywhere in the world. And the natural processes could be I am sure you must have heard about the oozing out of arsenic in certain part in the country particularly in the eastern part of the country, where the arsenic comes out of the ground and contaminates the water, and this is an environmental effect on the soils, and soils leach out arsenic.

So what I am trying to say is that the soil contamination could occur both naturally as well as anthropogenically. And if you want to establish what is the level of contamination of soils. These techniques which I am going to talk about today would be very very useful. We have been working on the concept of a soil pollution index. This is the quantification of how much the polluted the soil is, and why I am trying to quantify the soil pollution or soil contamination is because of the simple fact that as a geotechnical engineer, environmental geotechnologist, I will like to decontaminate the soils later.

And when you decontaminate the soils, this process is quite a time consuming as well as cost-intensive. So, in today's world, everything is cost-oriented, time-oriented, and you cannot use qualitative terms just to define the soil is contaminated. The question which industries ask you is, what is the level of contamination? And how much time and effort it would take to decontaminate the soil. So, with this pretext, I will start my discussion on how would you assess the level of contamination of geomaterials or the soils there are two techniques which are normally used and these techniques.

Direct techniques are the direct methods and indirect methods, and then a big series of direct methods which are available in the literature people have been working in this area. The first one is the pore solution extraction. Which I was discussing in the previous lecture, you can take out a sample of geomaterial, it could be concrete, it could soil it could be rocks, and you can place it in a pressure membrane extractor, which I showed you last time, you can apply a certain amount of pressure through the compressed air.

And in the process, the pore solution comes out and this pore solution can be analyzed by using atomic absorption is a spectrophotometer, which I showed you when we are discussing the chemical characterization or this can be analyzed by using ICP-MS inductively coupled plasma mass spectroscopy. So, depends upon what is the level of accuracy you want, AAS is less accurate. It is normally used up to PPM levels parts per million of the concentration of the contaminants ICP-MS is used for PPB or PPT levels parts per billion or parts per trillion levels.

And then people are using gas chromatography also particularly to identify the level of contamination which is a form of a volatile organic substance; a gas chromatograph has become necessary equipment in modern-day geotechnical engineering laboratories because you would like to ascertain the level of contamination of the soil before you start doing conventional test including the specific gravity liquid limit or particle size distribution.

Then we have different types of ion-selective electrodes in the market, which are very useful to find out what is the level of contamination of the geomaterials. There are different types of probes and sensors which are nowadays being used and developed. And this is where

geotechnical engineers like me would like to collaborate with people from nanosciences, nanoelectronics metallurgy departments, physics professionals, chemical engineers, biotechnology is microbiologists and so on.

Because these are the guys who give inputs to a designer who could design a sensor for a specific purpose, so, gas sensing is state of the art right now, liquid sensing is the state of the art right now solid form of contaminants in the soil is also a very, very state of the art thing in the present scenario. So, all the phases of the matter can be detected by using the sensors. There is another series of tests which falls under the category of indirect methods.

And this is where we have done a lot of work in our field by utilizing the impedance spectroscopy by employing an impedance analyzer. So, those of you who have some interest in electrical engineering, electronics engineering, you might have come across this equipment which is impedance analyzer or impedance spectrometer. So, what we do is we check the response of the material in a very wide range of frequency of current AC. So, we will talk about the discussion between what type of current should be utilized DC or AC. What are the advantages and disadvantages?

And this is sort of a third eye for me; I hope you understand what the meaning of the third eye is something which is not visible, but you can look into a matter, and you can realize what is happening. So, in any closed control volume, if I want to see what is happening inside without opening up the system to the atmosphere, I would like to see what is happening inside the material. What is cooking up inside, we are using these concepts for even detection of the hydrates which gets formed in the sediments where Bhini is working on and in fact and Ganaraj who is trying to work on the neutralization of heavily polluted soils by different techniques; even Jasmine is working this area by air purging by acid purging or by different types of reactive gases when they are purged into the system. So, impedance spectroscopy, as I said, is becoming a non-destructive technique to establish the mechanisms which occur in the porous media. And I will give you some exposure to how this is being used.

Incidentally, material scientists have used impedance spectroscopy to defining the face change in the material, particularly for the allies. And this concept can be extended in the geomechanics. If I want to see what is the state of the material like soils? When they are exposed to supercritical temperatures, particularly in the frozen zones, and at very elevated temperatures, there is a wide range of activities that you can do. The second one is the electrical resistivity method, where you can find out the electrical resistivity of the geomaterial has to relate to the porosity of the medium.

And I am sure you will realize that porosity is a term which is very, very important to geotechnical engineers because all the mechanical properties and engineering properties of the geomaterial will depend upon the porosity and the shear strength, the compressibility the consolidation the volumetric deformation, swelling, shrinking, whatever so, everything can be related as a function of the porosity and electrical resistivity gives you a good methodology to measure the porosity and the alterations in the porosities which are happening inside the system because of physical, chemical, electrical, mechanical, biological mechanisms. There are some electromagnetic methods which are being used in the contemporary society of the world. These are known as TDR and FDR probes very state of the art things, which we have used for finding out the in-situ moisture content and the soils and the MSW and the landfills these type of studies have been done by my ex-students, Agnes and Dr Patel, and now, we are extending these studies through Arif and others.

So, as the name reflects TDR and FDR are time, and frequency domain reflectometry and these are the techniques which are used for determining the in-situ density and in-situ moisture content volumetric not that the gravimetric. So, gone are days when people used to bring the samples to the laboratory to determine the moisture content as simple as you can understand that why this has been written off this technique because the chances are that you are disturbing the sample.

Number 2, it is very difficult to preserve the moistures in the sample for a pretty long time productions on the problem really wants to measure in-situ, then the application of dielectric constant is being made for finding out the fundamental behaviour of the geomaterial and level of contamination also, and this is where ground-penetrating radars have been used by people. So,

this is state of the art on the subject. What I suggest is to follow this discussion, you should go through the papers which are written by my students.

And most of this matrix has already been covered in our laboratory. So, there is nothing new that becomes a routine exercise. So, this is just to tell you that already, these techniques have been mastered, and they have been shown to be working in the field as well as in the laboratory. However, they caution that both these techniques or the methodologies have their limitations. First of all, these are the expensive instrumentation and very cumbersome methodologies though they appear to be very simple, even in the direct methods, the preparation of the sample is quite cumbersome, very expensive.

And indirect methods, the gadgets which are used are very expensive. So, intensive and rigorous sample preparation has to be done, which is time-consuming, and there is a complicated process which is involved related to the calibration and analysis of the results. And for both the techniques will require skilled and trained manpower or the personals. So, these are the limitations, but this is the future of the subject because most of the consulting houses and the business houses they are looking for experts who can give them quick answers or who can give them the solutions as far as the monitoring of a process is concerned, can we use all these methods for any kind of soil or any particular division is there?

I knew somebody who asked this question, and that turned out to be you. So, a very difficult question to answer. And particularly if you read the papers, which are written by Social Lakshmi, these techniques are not universal. So, now, you are going into the intricacies of these techniques. And I think these techniques have to be evolved in such a manner that people should know their limitations and their shortcomings, but there is no harm in trying all the techniques together and then putting on a scale and seeing them how do they compare with each other.

So, a quick answer to your question is if you have organic soils chances are that indirect methods will not work. Why? Because impedance measurement is mostly dielectric based and dielectric constant of organic matter is difficult to define. Another issue is that the organic matter will keep decaying. So, all these parameters will depend upon the exposure conditions and the time when

you measure these properties, which itself is a question mark will come to this but do I read a lot there is journal known as sensors.

And if you follow the IEEE journals on sensors, this is the modern-day geotechnical engineers eyeing their publications because of a simple reason that electronics and geotechnical engineering they are quite handed in gloves. And unless we work together, we can solve these issues. Remember, the soils which are contaminated that are not the right place for humans to access are you getting this point, so suppose if I tell you an example with a pH of the soil is 12 or 13. The first question is, how would we access the site? How would you take all the samples?

There could be a situation where the soils are emitting fumes. So, you have to take a lot of the cautions I hope you can imagine anyone when you are accessing these type of sites, a lot of precautions have to be taken so that you face fewer health hazards. And the sampling becomes another issue. Are you getting the point? So, it is a very big theme of discussion. Anything else? But I am sure you will realize that this is where the challenges and this is what people like we should be taking up.