**Environmental Geotechnics**
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**Lecture - 01**
**Overview I**

**Keywords:** Geotechnical Engineering, Environment, contaminants, waste

Myself, I am D. N. Singh, Professor in Department of Civil Engineering. I started my career in 1994, and I am continuing doing research and academic work quite profusely. You can write down my email address which is dns@civil.iitb.ac.in

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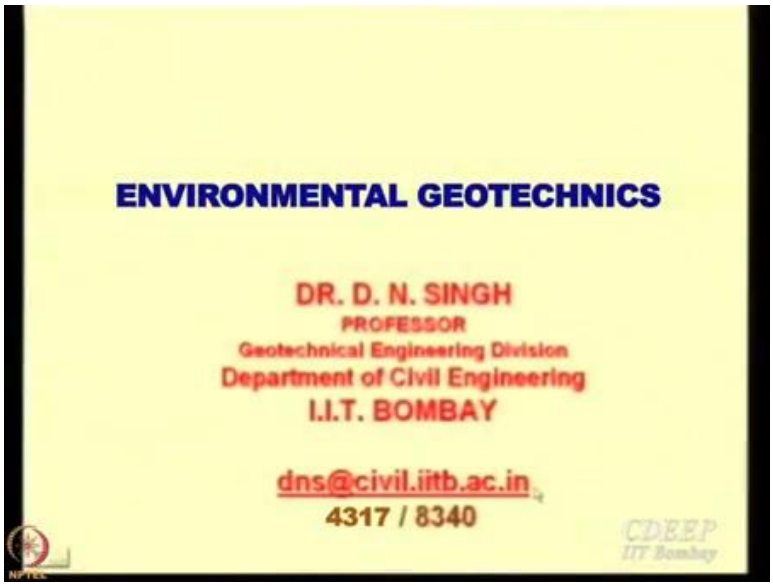


Try to sort out most of the queries in the classroom or you are most welcome to communicate to me through email.

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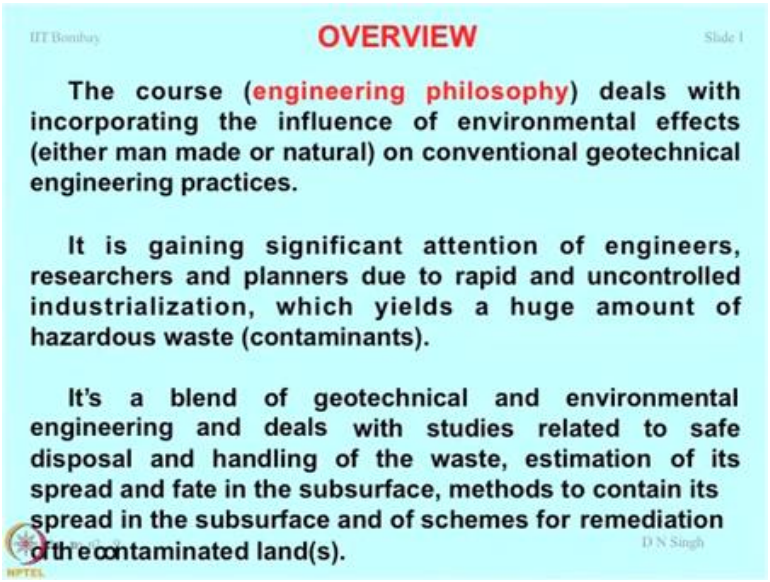


Let's start with the over view of the course. This course normally I define it as a philosophy and that too the engineering philosophy, basically deals with the incorporating the influence of environmental effects, in bracket you must be noticing that I write either manmade or natural on conventional geotechnical engineering practices. The basic idea is I tried to draw a simulation between what is happening in the nature and how the simulation can be done in laboratory by using different methodologies and techniques which are known to human beings or technocrats.

Now, again I would like to emphasize on the word philosophy, you will find this course lightly unconventional. It is not a very stereotype of a course where you expect me to give you lot of equations and solving the problems by inputting the parameters, I am sorry that is not the whole idea of this course. And slowly and slowly you will discover that this course has been developed over the years. Particularly, by assimilating the information which has been given to me by my own students.

So, it's a very interesting way in with this course has evolved and the journey continues everyday, every thesis, and every dissertation is a learning experience for me particularly and I thank my students for guiding me properly. So, this course is gaining significant attention of engineers, researchers and planners due to rapid and uncontrolled industrialization which yields a huge amount of hazardous wastes or the contaminants which normally we used as a connotation rather than talking about the hazardous waste.

How you define a contaminant? Jain

Student: It is how is it harmful to a body or is it harmful to the nature.

Yes, very good. Can you, dissect the word contaminants and define it further, or what is the literal meaning of the word contaminants?

Student: The substance which make the something not useful.

Ok, next.

Student: The substance which has a tendency to contaminate other things like contaminate.

You are trying to find out the definition of contaminant itself.

Student: Yeah.

Yeah.

Student: Like which has the hazardous effects on both nature and also human life.

Student: Pollutants we can say.

Okay. Yes please, Sarika.

Student: Sir, contaminants are the substance which disturb the characteristics of the substance can say and results in some hazardous waste like that.

Good next.

Student: I think contaminate is something which when comes in contact with normal those standard qualities will be changed when this contaminant will be mixed, so that will be creating harmful effects both for the environment and to the human beings.

That’s right next please.

Student: It is like a substance which not only affects the mankind, but also it gives it is hazardous effect on environment also.

Good next one.

Student: The contaminants are those materials which can be which can be manmade substances or by naturally also and it causes a harmful effect to the environment.

Good.

Student: Contaminants are basically any toxic and they affect the quality of environmental.

Yeah. So, most of you most of you understand what is the meaning of what contaminants. So, my life and my job becomes very simple whatever you have defined these are the traits of contaminants you are right. In the simplest possible words, a contaminant would be a foreign material or a foreign body which tries to what; it spoils the basic characteristics of a system. All right.

Well, so what we will do is we will try to study this statement again. It is gaining significant attention of engineers, researchers and planners due to rapid and uncontrolled industrialization. I hope you will agree. this is what is going on currently in the country and all over the world. And this phenomenon leads to a huge amount of generation of waste because wastes are not needed, unwanted, we term them as contaminants. All right.

Now, as far this subject is concerned it's a blend of geotechnical engineering and environmental engineering, and basically deals with studies related to safe disposal and handling of the waste estimation of its spread and fate in the subsurface, method to contain its spread in the subsurface and some schemes which you can derive for remediation of the contaminated land.

So, what you will notice is the scope of the study or the subject is too much. What I will try to do here is I may not go in to the details of each and every step which I have talked about here, I will just try to give you the basic idea about what is the genesis of the subject which we are trying to study and what are its applications or implementations. But truly speaking, all these thing should be borne in mind when we talk about the subject and that is why I say the overview of the subject deals with so many facets.

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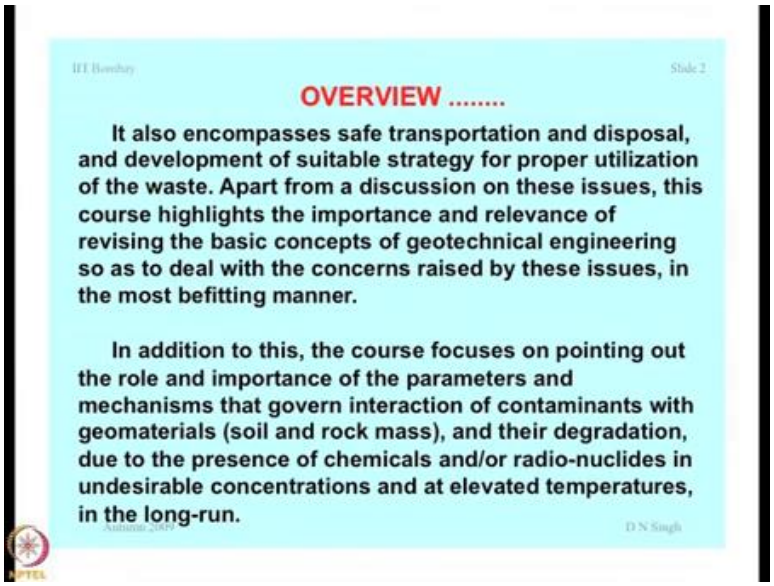


This subject also encompasses safe transportation and disposal, and development of suitable strategy for proper utilization of the waste. Now, this is where the concepts of recycling, reuse, reapplication of the waste is coming in focus these days. Apart from a discussion on these issues, this course highlights the importance and relevance of revising the basic concepts of geotechnical engineering, so as to deal with the concerns raised by these issues in the most befitting manner. This is something very tricky, and this is where actually I spend most of my time in explaining that how the two concepts one is which is slightly I would say old concept is going to get modified by the new concepts, or the neo concepts which we put into the practice to solve most of the problems which we are dealing with in day-to-day life.

So, the basic aim of the study which we are going to do is to get some solutions to the problems which exist in nature, and which are of severe importance to the mankind or the society or the nation or the world as such. In addition to this, the course focuses on pointing out the role and importance of the parameters and mechanisms that govern interaction of contaminants with geomaterials. Now, this would be a slightly new word or terminology for you. Most of the time, we talk about interaction. How two things are going to you know communicate with each other. Now, this is what is the meaning of interaction is literally.

So, most of the time I would like to bring you back or your attention to the fact that how we are going to simulate the interaction of two systems, one could be a contaminant, another one could be a porous system or a geomaterial. So, truly speaking, enough emphasis is given here to understand how a porous system is going to interact with contaminants.

Now, when you talk about this type of interaction if the interaction happens to be prolong, the tendency of the system is to get degraded. So, this is where the second step comes into the picture, after interaction, the interaction or prolonged interaction in leads to degradation. So, the degradation due to the presence of chemicals or radio-nuclides in undesirable concentrations and at elevated temperatures in the long-run.

So, when we will discuss about the attributes of the contaminants what we will notice is that apart from the chemical activity, a contaminant can have radioactivity associated with it or concentration of chemicals and that too at elevated temperatures. So, you think of a situation where you have three components of or three attributes of the contaminants like temperature, too much of radioactivity, too much of chemical concentration and how these three parameters are going to influence the interaction of this contaminant with a porous system which happens to be geomaterial.

Now, interestingly this interaction can be defined or can be quantified with the help of concepts of mechanics. So, the study which we have done till now related to soil mechanics in geotechnical engineering using them as the base, I will add on the top bit of concepts related to how to model a certain mechanism. So, this becomes environmental geomechanics; that means, we are going to study how the influences of environmental factors can be encompassed or studied or can be imbibed in the system in the most you know unique way or in the most appropriate manner.

So, here few words are very important as I said the first one is interaction; the second one is prolonged interaction may result in degradation, and the attributes of the chemicals or the contaminants, where we talked about three things concentration temperature radioactivity and so on. And of course, we talked about these phenomena to take place in a prolonged manner that is the long-run.

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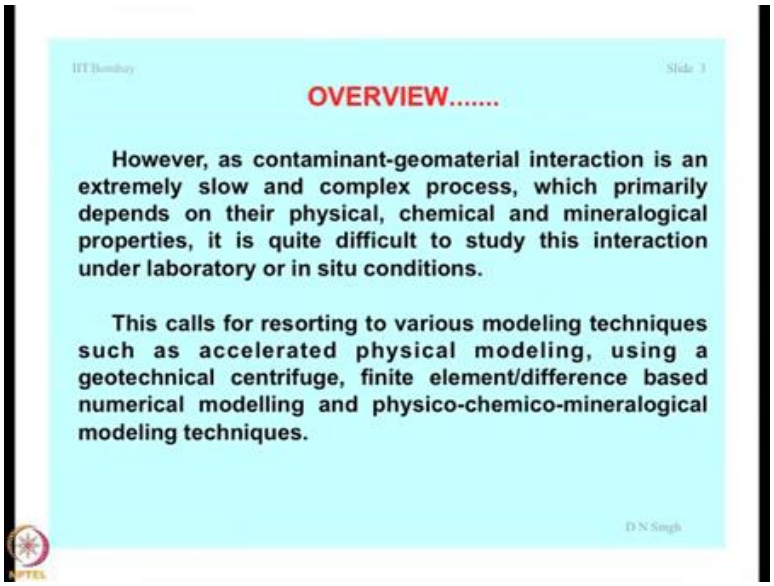


However, as contaminant-geomaterial interaction is an extremely slow process and a complex process and this primarily depends on the physical, chemical and mineralogical properties of the system, it is quite difficult to study this interaction under laboratory or in situ conditions. These are some new words which I am finding over here. I hope the contaminant-geomaterial interaction part is clear to you.

Now, when we talk about this interaction, it is a very slow process. Even if you talk about the migration of water which is nothing but the seepage or hydraulic conductivity. The hydraulic conductivities of geomaterials are very very small, $10^{-7}$, $10^{-8}$, $10^{-12}$, $10^{-14}$ m/s and so on.

And then slowly and slowly we will see that there are few mechanisms which are going to be much slower than this mechanism or the mechanism of seepage of water or a fuel to the system. Diffusion is one of them. So, there could be a situation where diffusion takes over the seepage process or advection process. I hope right now you might not be able to envisage that what type of situation this would be, but just to give an example for the for the for the sake of completeness. If you think of saltwater migration or saltwater intrusion, where the contaminant transport mechanism is mostly going to be a diffusion process not the advection process. So, this is where actually we talk about extremely slow processes which are very complex in nature. And which primarily depend on the

physical properties of the system, chemical properties of the system and mineralogical properties of system.

Now, this is a very holistic approach which we are talking about that means, till now people have been talking about only physical characteristics, forgetting what is the chemical characteristics and the mineralogical characteristic of the contaminant-geomaterial system. Though it is a very difficult task, but then this type of interaction has to be simulated first in the laboratory, so that the generalized models can be developed, and hence we can prove what is going on in the laboratory whether it is commensurating with the facts of the phenomena which govern in the nature.

So, this is where actually we require different modelling techniques. So, certain part of the course, I will be devoting on studying or telling you how to model these mechanisms by adopting the latest techniques such as accelerated physical modelling, I am sure you must be doing a course on centrifuge modelling also which is nothing but accelerated physical modelling using a geotechnical centrifuge, finite element difference based numerical modelling techniques.

And another new concept is if you want to study how a geomaterial gets degraded over a period of time because of its interaction with the contaminants, we can talk about the physic-chemico-mineralogical modelling. So, this would be something very interesting and unique which I would like to cover in this course. Any questions?

How it is going, it's all right [FL].

Student: Sir, there is one question. Now, here you said that basically degradation of the geo material, but in conventional geotechnical engineering. We study soil stabilization, so where we add something so, can we say that these concepts of this environmental geomechanics also they have the genesis from the soil stabilization that is the positive effect. Now, we are studying basically the negative effect of this material.

It is a very good question, again a very thought provoking question. Any answer from the audience here, Seema? It is a philosophical question; so, it requires a philosophical answer. One capsule of medicine is a medicine, but more than a certain dose becomes a poison, I do not know whether it is correct to this analogy or not. When you talk about stabilization, the concentration of chemicals which you are in putting in the system are

controlled. But when we talk about interaction of contaminants with porous system, the concentration and the hazardousity of the waste is beyond control.

So, I hope you can now correlate the things if the doses are controlled it is a stabilization process; well, monitored process is going to meet to a good stabilization process. However, if the concentrations and attributes are quite you know extreme or very high, then what happens in that case, this becomes a case of environmental or geomaterial degradation. This is what is to my knowledge. Any addition to this?

Yes, please. you like to add something please feel free to interact. Your interaction is very important than the contaminant-geomaterial interaction.

Student: I also want to one more question I want to ask, that is I understand I mean we have used the word physic-chemico-mineralogical modelling techniques. I understand physico means it refers to the characterization of soil that tests we do, but what type of test we generally do for chemico and mineralogical modelling, how we do that? Just a brief.

So, Seema's question is that what is essentially meant by physic-chemico-mineralogical modelling techniques. Everybody understands what is meant by physical characterization of the material that is you first work out the particle size distribution, specific gravity, surface area, shape of the particles, angularity of the particles and so on. So, this is very well understood phenomena in geomechanics all of you must have done experiments to classify the soil. Your classification schemes are based on physical classification only.

You come out of it a bit when you talk about Atterberg limits, it's a add on to the physical process. How?

You add water to soil all right, and then you try to understand what is the activity of the minerals which are present in it. So, this is where the importance of minerals comes into the picture. I will be talking about the mineralogical characterization of materials also in this course a bit.

Normally, we conduct X-ray fluorescence techniques which we known as XRF and XRD to find out the chemical composition of the soil mass or the geomaterial or mineralogical composition by conducting XRD. That is X-ray diffraction technique. I will be

discussing about these things. Some of the other chemical attributes of the material can be determined by conducting test like pH measurement in the pore solution, or cationic exchange capacity that is CEC, or zeta potential of the soil mass and so on, anything which I missed out.

So, normally, we talk about pH, cation exchange capacity, zeta potential of the soil of course, sulphate chloride which are present in the system and so on. So, basically what we are trying to do is, we are trying to work on a model which talks about the totality of the material properties that is the physical properties, chemical properties and mineralogical properties.

Another part of your question should have been that why these properties are so important to be studied. Now, if you remove the chemical and mineralogical aspects of the geomaterial it becomes a passive soil. So, what is the difference between a clay with kaolin and a clay which is having more of montmorillonite or bentonite in itself, that means, chemically they are different and mineralogically they are different. So, this is why actually it is important to study the overall properties of the geo materials and then try to see how these properties are going to attribute their impact on you know the answers which you are trying to get. Is this ok? Yes, please.

Sorry.

Student: What are the agents which can accelerate the interaction of geomaterial and contaminants.

Yes, please. Again very good question he is asking, your name please.

Student: Shiva Prakash, sir.

Shiva Prakash; Shiva Prakash is asking a question that what are the parameters which may accelerate this interaction. How would you behave when the temperatures are very high outside?

So, you just understand that we are the living entity, soil is also a living entity rocks are also living entity in a geological time frame. And all of us behave in a similar manner whether it is exposed to the temperature, humidity or the pressure. So, any phenomena

any interaction which takes place in this world which happens to be a physical phenomenon has to be guided by temperature, pressure and what else humidity.

Now, if you keep these things in parameters in your mind, you will and go back to the rock cycle, how soils are formed. So, this gives you an easy answer to understand that because of humidity, because of weathering the soils were formed, is it not. So, all these interactions will get influenced by the parameters, temperature, pressure, humidity, activity of different types which are available in nature like as a civil engineer we never bothered about the bioactivity which is present in the soil mass.

We always believed in taking out of sample, bringing it to the lab, remoulding it. And then doing the modelling and getting some parameters which failed miserably when you do a modelling in the nature or in the field. Why, because we have ignored there the effect of bio activity, the microbial activity, the climatic conditions which are going to exist and so on, it is a big list. So, I will try to answer these questions slowly and slowly, but please excuse me because as I said the course happens to be so big and so large. It is very difficult to covered in one core, one semester. So, you keep on asking the question the best way is I think in most of the doubts for both of us can be cleared.

Ok, is this with you or you have another doubt?

Yes, please.

Student: Sir actually you have mentioned that physio, chemico and mineralogical modelling techniques right, sir like the chemico like come like, that means, the water content present in the soil and all like they will be altered when they have interaction with a like some hazardous materials and all. But how will this physical characteristics of the soil be affected by those, like actually they will be generally affected by like the shapes, size and the angularity they will be affected due to that pressure conditions and weathering and all, but how will they be affected by.

Very good question; one part of the question you already answered. The second part is in the simplest form how shape is going to attribute to the activity of the material, what is the difference between sands and clays. When you say surface area of sands is very less and surface area of clay minerals is very high ok.

I hope this answers your question that means there is a very distinct relationship between the physical attributes which happens to be a surface area or specific surface area of each mineral and each material, in fact, each fraction of the soil also clear.

This is one of the answer. The second answer would be what does the specific gravity of the material?

Shape. Ok. So, if shape is or if the particle size is very small, this specific gravity is going to be more. Similarly, we talk about porosity and so on which will fall in line slowly. I hope this answers your part of the question. Ok, What was the second part of your question?

Student: Like will they be getting affected by this.

Chemical action also.

Well, the chemistry is the mother of all sciences people say so, when you talk about the chemical attributes, you must have noticed in your food plate you like to have different types of variety, why, something is sweet, something is sour, something is salty something is less salty, something is spicy. What is this? This is nothing but the chemical compositions are different, clear.

Student: Yes, sir.

And if you take them together it affects your digestion system. If you do not take something in proper proportion, something is going to get affected. Similarly, you think of the soils which are made up of pure silica. Now, silica is a passive material, it's not going to react with anything. So, you keep on pouring any amount of contaminants on the silica then net result would be not much, it will not get affected much.

However, if you take clays which may have a different composition different oxides different mineralogy and if they come in contact with chemicals you will notice slowly and slowly when we discuss these issues which come under the sorption desorption techniques that they have a great affinity towards chemical species. All right. A good example of this type of a question or good answer to this type of a question would be, why do you use some typical clays as a cleansing agent for your body? Good example is multani mitti. It is nothing but bentonite why do not you use sands for cleansing your

skin. So, sands will give you more scrubbing effect while the clay has more cation exchange effect.

So, what it does is, it takes out the cations from your body in the form of sweat and what is sweat so it is nothing, but all the chemicals which has oozing out of the skin. So, this is a good example of how physico chemical mineralogical interactions are going to govern the overall process of waste coming in contact with geomaterials. Yes please, any other question doubts? If you do not agree please tell me know and you answer someone can take the charge of answering the questions.

Ok.