Geoenvironmental Engineering (Environmental Geotechnology): Landfills, Slurry Ponds & Contaminated Sites

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Lecture – 01
Introduction

Good morning to everybody. Nice to have you here for the first lecture of the course the Geoenvironmental Engineering, I am Professor Manoj Datta. I have been teaching this course for the last 10 years and over the next 12 weeks, so, we will share common experiences about this course.

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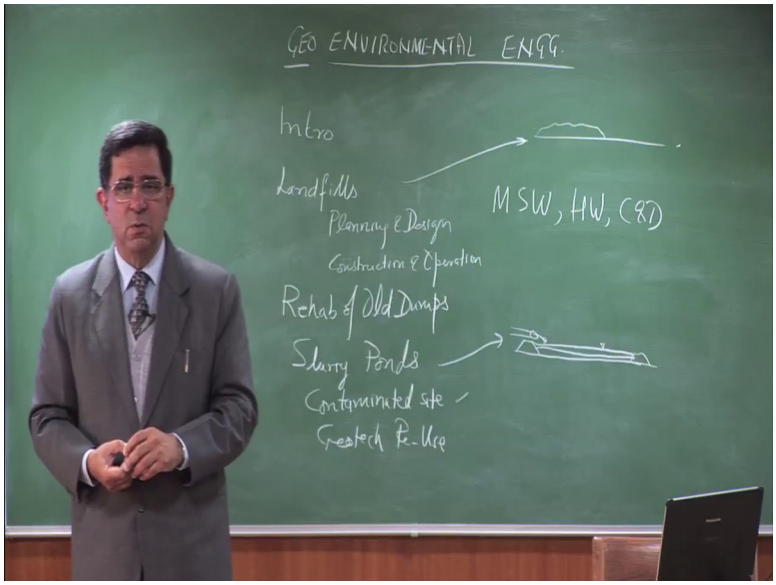

So, let me begin the word geo environment is made up of 2 portions, the geo portion and the environment portion. Geo normally refers to dealing with the earth geological materials and things like that. And environment normally refers to dealing with ecosystem; you must protect the environment such that the ecosystem is not affected.

So, this course is geo environmental engineering. Now in some of the institutes, in some of the colleges in universities and technical institutes, this course is also known by another name environmental geo technology.

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We are doing geo environmental engineering over the next 12 weeks. This course is also called environmental geo technology and if I were to look at the keywords associated with this course. It would be geotechnical aspects of waste disposal, design of landfills, slurry ponds and contaminated sites.

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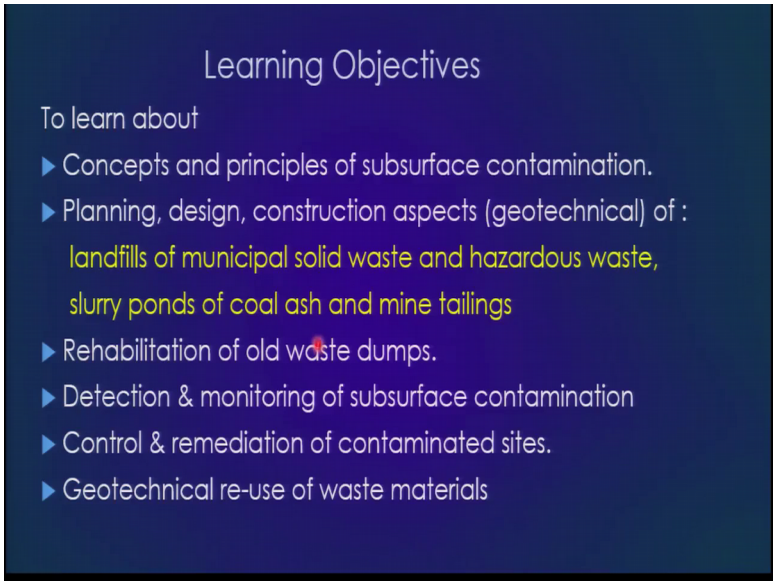

In this course our learning objectives will be to learn about concepts and principles of subsurface contamination. The bulk of the course will focus on planning design and

construction of landfills of municipal solid waste and hazardous waste. As well as design and construction of slurry ponds of coal ash and mine tailings and other slurry deposits.

We will look at rehabilitation of old waste dumps detection and monitoring of subsurface contamination. We will look at what can be do at sites which have already contaminated with waste the what are the control and remedial measures, we can take and what is the geotechnical reuse of waste materials.

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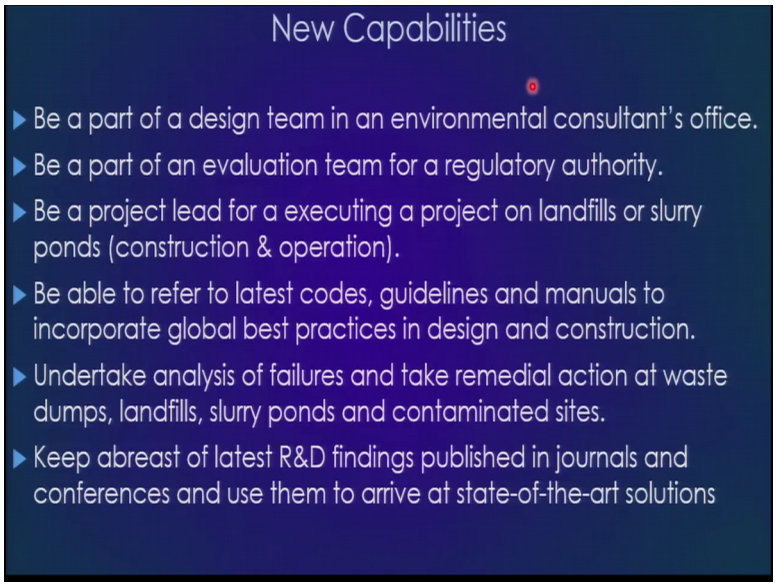

When you finish this course you will have many new capabilities. You can be a part of a design team in an environmental consultant office, with the new knowledge that you acquire here.

In this course you will be able to do design work relating to landfills and slurry ponds. You can be a part of an evaluation team for a regulatory authority. If a regulatory authority is monitoring a landfill you can be a part of the team which goes and does the monitoring program looks at the leachate and the landfill gas and other emissions from landfills and slurry ponds. You can be a project team leader for executing a project; that means, for designing constructing and operating a landfill or a slurry pond. You should be with the knowledge gained is in this course very easily be able to refer to the latest codes whether it is European practice or American practice or Indian practice look at the various codes guidelines and manuals.

So, that in your designs you can incorporate the best global practices for landfills slurry ponds and other waste disposal facilities. You will also be equipped to undertake analysis of failures. I mean if there is a landfill failure or a slurry pond failure you will be equipped, how to analyze the failures and also take remedial action for stabilizing these failures, and also take remedial action at contaminated sites to prevent further spread of contamination from these sites. And finally, you will be able to keep abreast of the latest R and D findings you will be able to go to the journals and the conferences the latest journals and conferences and read articles or what is happening in this area and understand these articles. And you will be able to use the R and D findings to arrive at state of the art solutions for your problems.

So, in the end sitting through this 42 lectures, you will be able to acquire these new capabilities.

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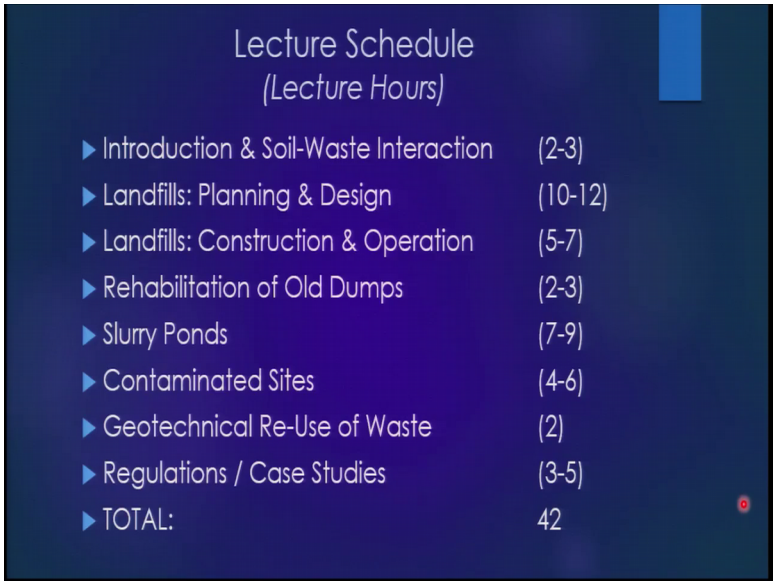

So, as I said this course has 42 lectures. This may not be the precise order of the lectures and at that we will follow, but it gives an idea of what we will cover in the entire course. The correct order is visible on the website of this course. We will spend the first 3 lectures on introduction and the soil based interaction, including todays lecture we will have 2 more lectures. So, we will see what are the sources of ground contamination, what are the impacts of ground contamination. We will see how if you put waste on the

ground, how does it actually impact the subsurface environment. That is through soil waste interaction.

Then a bulk of this course is on landfills. And landfills are you know solid waste disposal facilities. You regenerate garbage in the city where does it go? I thought in solid waste management you must have learnt about use and garbage for composting use and garbage for recycling. But even after you do all that and you must be hearing about waste to energy plants. So, even if you take out all the composed from a garbage all the energy from a garbage all the recyclables from a garbage there is still something left. So, what happens to that that is disposed off on ground.

So, landfills are the facilities in which you dispose of the final rejected material, which nobody else can use and we will be dealing with landfills. And as you can see we will be dealing with planning and design, and we will be also dealing with construction and operation. So, what kind of wastes are disposed off in landfills. Typically, we will deal with municipal solid waste, hazardous waste and construction and demolition waste. As we go along we will find that we will be primarily dealing with 3 types of solid wastes, the garbage which comes out from the houses, the hazardous waste which comes out from the industries and the construction and demolition debri. You know in the city is everybody is either making another story or it is demolishing an old home and making bigger home or making malls. So, all the C and D debri is also being disposed off on the ground.

So, we will look at design of landfills for these types of waste. Then you will also be dealing with rehabilitation of old dumps. As you can see here rehabilitation of old dumps is an extension of landfill design, but the problem is that in a designing a new landfill, you can prepare the site to receive the waste. Whereas, if you have an old dump which is huge like a mountain then the base of the site is not available to you to prepare it for putting the waste. Then we have to do everything on the top. And then how do we tackle an old waste dump which is very large if it is a very small dump you can say all right I will excavate it, I will do something and prepare the ground for receiving the waste, but if it is a huge dump as any of you seen a garbage dump of your city where do you belong the manjana, which city do you belong to.

Student: (Refer Time: 09:53) Guwahati.

Is there a waste dump in Guwahati?

Student: No sir.

Or you do not know about it. Anybody who have seen a waste dump a garbage dump.

Student: Yes, sir.

Who. So, which garbage dump have you seen, Avinash.

Student: (Refer Time: 10:12) is there is our Guwahati city.

Oh she says it is not there in Guwahati city and now you say no, it is there in Guwahati city.

Student: (Refer Time: 10:20)

So do you remember its size approximate size?

Student: Sir no sir there (Refer Time: 10:22).

I mean is it 100 meters wide a 200 meters wide.

Student: Around 200 centimeters.

So, it is about 200 meters into 200 meters is that a rough idea. Yes, mohit you said you have seen a dump where have you seen one.

Student: Sir recently in Hyderabad.

You have seen a waste dump in Hyderabad. So, how wide is it approximately?

Student: Where around 250 meters wide

Well I think I have seen the Hyderabad main waste dump, I think it is about 1 kilometer wide. So, if you look at the base of the dump when I am talking of width, I am not talking of how wide, it is at the top I am talking of high wide it is at the bottom. So, I think it is a much bigger dump. So, anyways what I am trying to say and what is the height of the Hyderabad waste dump.

Student: Sir, around 70 meters yet no sure because it is on (Refer Time: 11:16).

So, waste dumps can be 20 meters, 10 meters high 30 meters high and that kind of heights. So, if we have a huge dump of that height it is very difficult to move the waste. So, and the rehabilitation of dumps, we will be doing what do you do with these old dumps which have accumulated at a site. Then another topic that we will be covering is slurry ponds. What are slurry ponds? If you see a thermal power stations, coal comes to thermal power stations you burn it and ash is generated. So, typically for every a 100 units of coal which comes about 30 5 percent of it is ash.

So, these thermal power stations are producing huge quantities of ash, and the coal is coming on from where does the coal come from at a thermal power station from a coal mine, and we have 3 thermal power stations in Delhi, but the coal is coming from Bihar. So, the ash does not go back, the ash after burning remains at the site where the electricity has been generated. So, this ash has to be then placed in a waste dump, unless it is reutilized. So, to transport ash from the boilers where it is generated to the waste dump, often they will mix the ash with water and transport it in the form of a slurry.

So, 2 major a types of wastes go to ponds slurry ponds, one is coal ash and the other is mine tailings. Suppose I am extracting let us say zinc. So, what do I do I dig up the earth I mine it, and I bring out an ore which is rich. In zinc to take out the zinc from the ore I will crush it crushing crush, after you have crushed by some technique whether it is a gravimetric technique or otherwise the zinc will be separated from the crushed rock. The crushed rock is called tailings and this is also transported from the mine to a waste disposal site in the form of a slurry. So, we will be looking in this course on design of slurry ponds. And that is very different from a garbage dump. Because the garbage dump is not transported in the form of a slurry.

So, far what have we discussed we have discussed. If I have ground, I can put waste on it like municipal solid waste. So, that becomes a situation where you have to design a landfill. If I have the waste coming in the form of a slurry, how do you think I store slurry on ground. Slurry will come to you in the form of a pipe, let us say an 8 inch diameter pipe. So, should I bring the pipe and start disposing the slurry here what should I do.

Student: Excavate it.

You should excavate it that is a lot of cost.

Student: (Refer Time: 14:58).

So, you took you have to create a kind of a pond, whether by excavation or whether by putting embankments.

So, maybe what I do is, I will pick up some soil from inside and I will make an embankment. It is like making an artificial lake because the slurry is full of water. And then what happens? I send the slurry the slurry spreads in the form of water and what happens? The particles which have been mixed with the water settle down. So, my tailings or my ash will settle down here, and I will have water here and finally, I can recirculate the water. So, how do you design a facility like this how do you design a facility like this, how big is it? Typically, a slurry pond may be 1 kilometer by 1 kilometer in base area. And to what height can it go? When they are there are ponds which are going as I as 20 to 30 meters or even more. So, that is part of this.

The next topic which we looked at is the topic of contaminated sites. What are we going to cover in contaminated sites? So, far we have been talking of solid waste we have been talking of slurry waste, but a contaminated site is on which any waste has been disposed. It can be liquid, it can be slurry, it can be solid. It can be in a drum, it can be sludge, it can come in a truck. So, if you have a site on which if you have a site on which something has been disposed off for a long period of time or for a short period of time. Let me say there is an industrial area from which chromium sludge is coming out. The chromium sludge is like a thick slurry and they are using some abandoned area for disposing of the sludge or the slurry. Then gradually with time something will happen to the subsurface environment.

So, contaminated site maybe because an underground tank is leaking which is the most often liquid which is stored in underground tanks; Petrol. We have how many petrol stations do you think Delhi has? 5 10 hundred thousand well it will be between 100 2000. So, each petrol station does it store the petrol above the ground or under the ground. Why not above the ground?

Student: (Refer Time: 18:09).

Pardon.

Student: (Refer Time: 18:14) more danger.

They are more danger that is there is an explosion or if there is an external event it can spark something in any case. So, the world over all the gasoline and the petrol is stored underground. If it leaks it goes into the ground. So, that becomes a contaminated site.

So, a contaminated site is one in which some contaminant has been released in any form. Solid, liquid, slurry, even volatile organic compounds, such sites have also to be first identified. They occur a lot in industrial areas. You know you are an owner you started an industry it did not work out after 4 years, you want to sell. Now law requires that you have to if you make this deal from one owner to another, the land which you transfer should not be contaminated. And this means you have to detect whether there is any contamination. And if it is contaminated you have to monitor it and you have to remediate it.

So, that is a total different topic in comparison to this solid waste disposal facilities finally, we will look at geotechnical reuse of waste. You can see this, in this what are we targeting. What we are trying to say is, when we create these mounds of waste we are using good fertile land. They become an eyesore. We are going to remain therefore, the rest of your life it is a solid waste. So, can we reuse it? Which industry has a large volume reuse of materials or which sector has large volume reuse of materials or use of material let us say.

Student: (Refer Time; 20:27).

Power sector produces the waste. What will it do with the ash? Power sector is using coal it is giving you electricity, but ash is coming out what will you do with the ash.

Student: (Refer Time: 20:45).

Yeah. So, the only thing that is happening a lot in this world is cities are rising vertically. You can only rise vertically if you are getting some material to become to make the cities. So, what is the traditional material with which we construct the how where by which these cities go up vertically.

Student: Concrete.

You concrete may be steel may be world, but many natural materials are used. In the production of concrete what is the material that is the most significant portion. Cement?

Student: (Refer Time: 21:23).

So, cement is a small portion of concrete, but fine aggregate coarse aggregate water. So, basically again these are natural materials which are being utilized. So, for cities to go up we have 2 dig materials. To make the bricks we have to dig the soil and burn it in the kilns to make the bricks. So, as cities go vertical we use large volumes of soil and aggregate. So, one of the thoughts is, can we reuse waste in this industry. So, geotechnical reuse is not for construction of buildings. Geotechnical reuse is for the purpose of earth works. Please understand, we are all do you use soil for earthworks in abundance, 3 locations if you have a low lying area. You want to raise the ground level then you need earth, if you are not going to use it from well far you will start digging up from nearby, and bringing that or that does not serve any purpose, because where you are digging you are making that low.

So, for filling low lying areas then making embankments, in Delhi for examples earthwork where is the maximum amount of earth work taking place can anybody guess, where lot of earth work is taking place in Delhi. Every time you construct a flyover there is an approach at embankment you know how high is the flyover.

Student: 40 (Refer Time: 22:31).

40 meters is too high it will 70 meters is qutub minar.

Student: (Refer Time: 23:15).

So, it is more like 10 meters. So, we have a road which is at ground level and you have a flyover which is at 10 meters high and you have to make an approach embankment. So, to make the approach embankment you need soil. So, in Delhi a lot of earth is used for making the approach embankments for these flyovers. So, currently what do we do? We go outside Delhi we look for barren land and there is no ownership or nobody is interested in it we buy the rights and do earthwork, but all the barren land is gone. Or it has become low lying because we have been excavating from there, then you go to the farmer and said will you sell me your fertile land so that I can make a approached

embankment for a flyover in Delhi. So, our farmers said no this is my livelihood then you may go to a place, where there is waste lying which has soil like properties which is not hazardous. And then you have a win situation a thermal power plant may have a waste which is of no use to them you may be able to get a waste which is soil like provided you then check it is geotechnical properties and then you can use it.

So, in geotechnical reuse we will look at such kind of applications, where are we going to substitute soil with such material. And final topic is regulations and case studies. Regulations and case studies will not be covered as separate topics in this course, but will be refer to time and again when we discuss the other topics. So, you know everything relating to contamination and pollution is regulated by the central pollution control board. So, from time to time the ministry of environment and forests and the central pollution control will bring out these regulations which you have to follow. And they also bring out guidelines which are guidelines, but are not the law, but they give you a framework that we they expect this minimum guidelines to be followed.

So, we will look at regulations and guidelines published by mostly we look at the Indian regulations, but also maybe you will go back and look at some international or global regulations, which is a big environmental agency whose regulations are very popular.

Student: US (Refer Time: 25:57).

US cpo then us environmental protection agency. Then we also have European regulations. So, we will also try and see what is happening in some of the other countries. We will also look at some case studies about these materials. So, case studies will relate to landfills some slurry ponds in which IIT Delhi has been involved.

So, we will share those experiences with you, and if time permit is we will look at a little bit on geothermal energy and other associated subjects. So, any questions at this stage which come to your mind? No questions, then let us continue. So, if you go to google and puncheon environmental geo technology or geo environmental engineering or landfills all the keywords that I have given you or you will come up with 50 60000 books.

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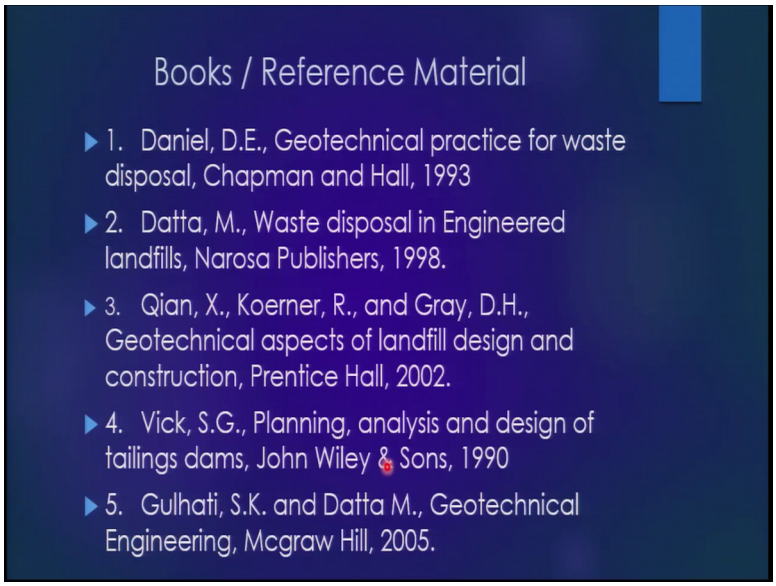

So, these are only some of the books that are recommended, but the first book that is David Daniels book, this is the bible from where geo technique environmental geotechnics started. And this is what we will follow for bulk of the course is what we will follow for bulk of the course.

The book on the waste disposal in engineered landfills this is been authored by the by me and came up in 1998. It is more suitable for Indian conditions and design of landfills not for everything else. And quin and koerners book is more recent for landfill design, the details of landfill planning and design. As far as slurry ponds are concerned there is only one book you will come across a lot of conference proceedings on ash on tailings dams tailings impoundments, but to be written in the form of a textbook this is a old book by vick it discusses the subject very well and this is what we will used for the purpose of our current class. And gulhati and Datta is an undergraduate come post graduate level book which has 6 chapters on geo environmental engineering, but their elementary chapters they can be used as your starting points for this course.

So, these are the textbooks that we will follow you are welcome to read up many more books.

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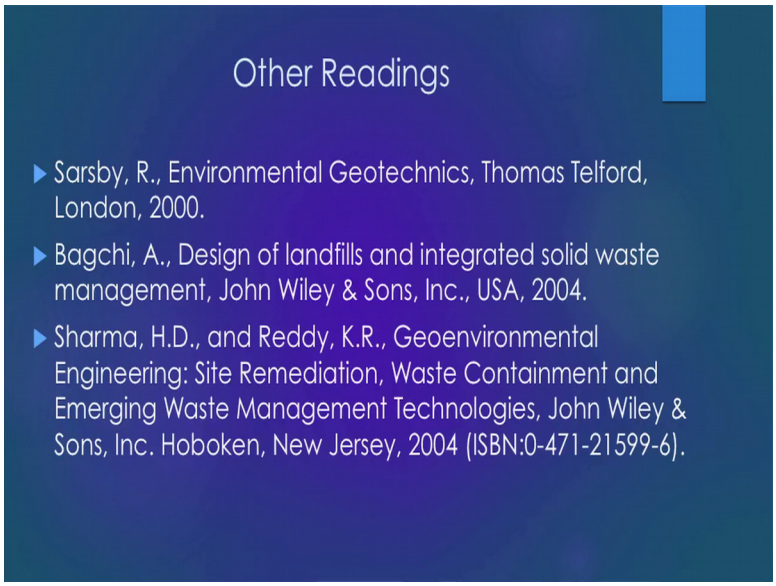

This book on environmental geo technology by sarsby, there are books on landfills by bagchi and by reddy and Sharma, and there are many other books. So, you are welcome to get the flavor from those books as well. All of you are expected to learn about waste characterization. So, suppose I come and give you a material let me assume I have got some little bit of powder in my hand. I do not even know whether it is hazardous. So, let me say all right, come take this please take, come it may be hazardous, take now go back. So, the question is I have handed over some powder to you. Now what is it waste characterization deals with answering the question what is in your hand?

Student: Sir, it is a waste powder.

It may be talcum powder it is.

Student: (Refer Time: 30:05).

So, the only thing you can tell me when I give it to you in your hand is what is it is color and whether it is fine or worse. So, everything else you have to do for characterizing it. So, waste characterization means how do you discover a material which is powdery in nature is it soil, is it ash is it talcum powder is it hazardous is it nonhazardous is it inert is it has it got a biological component is it biodegradable, is it food waste maybe you can smell it also and say sir this is not smelling very good quite clearly it has an organic content. So, therefore, it may not be the best.

So, you will have to learn about how to characterize waste. We will give you the introduction here, but you will have to self learn about it. So, let me again try to put this in a nutshell.

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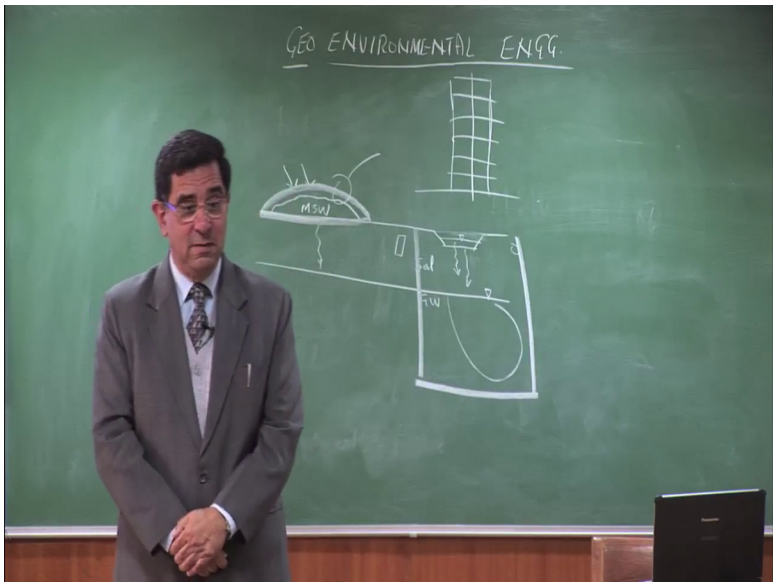

Geo environmental engineering or environmental geo techniques deals with contamination at the ground surface and beneath the ground surface right. It deals with contamination at the ground surface and beneath the ground surface; the contamination can occur if you have solid waste. Then contamination can occur if you are storing some waste liquid in a pond. It can occur your buried pipe line. It can occur in a buried storage drum. So, there can be different sources and we will do that in the next lecture.

So, the first part of this course is all about design of a facility where we are going to put the waste. So, totally or philosophically how would you go about this problem. If a let us say just assume that this is all on sand right, this is municipal solid waste will municipal solid waste contaminate the sand, will municipal solid waste contaminate the sand? That is the first question. Yes, or no?

Student: Yes (Refer Time: 32:23).

Why it will walk into the sand.

Student: Will have some leachate.

It will have some leachate, where will the leachate come from? I do not know what is leachate, but you use the term. You mean to say it will have some liquid with the liquid will have some contaminant. So, will the waste physically go and intrude into the sand no. So, it will need a medium to transmit the contaminant from the waste to the soil. So, perhaps what is saying is, if you have waste and if rain falls on the waste, then it might go and contaminate the soil right. Because then it will percolate through the waste and contaminate the soil, but what about this? This is liquid waste and suppose it is got some (Refer Time: 33:21) will go recently to Pune and there was some waste water which was being stored in a pond. And it had some dark color and then people are reporting now they are they are seeing dark water in their wells.

So, this can percolate unless you design. So, I am trying to now get to this. So, when I know that this can contaminate the ground and this can contaminate the ground how will I design what will be my design philosophy?

We have to restrict the movement of the contaminant from the waste to the surrounding environment. So, the philosophy is that we have to do something, in terms of engineering, which prevents the contaminant to move out from the area in which the waste is stored right. So, the first part of this course on landfills deals with this philosophy. It deals with this philosophy. The second part of the course on contaminated soil sites deals with the philosophy that if contaminate has already gone into the ground or it is already there on the ground, and you know normally beneath the soil you will have a groundwater table. So, it is possible that the soil will get contaminated and the groundwater inside the soil will also get contaminated.

So, the second part of the course wants to know how much of this has got contaminated. You have to detect it you have to quantify it and then if it has got contaminated what should we do, how do we remediate it, how do we reverse it or if not reverse it prevent it from spreading more because reversing it may be very expensive. So, again as an engineering as an engineer how what would you do to this? As an engineer what would you do to this? We would like to put a have you input this beautiful containment structure here, we would like to do something like this. So, that it does not travel of the site.

So, the entire engineering can we do this can we put something like this under the ground? Is it costly? Is it doable? And what is this? What is this material? Is it concrete? Is it steel? Is it soil? Is it bitumen? Is it polymer? Is it geo membrane? What is it? Is it or is it a combination of that? That is what this course is all about that. Can we design facilities which will not impact or harm the environment, and if some subsurface contamination has already taken place then can we do something about it can we quantify it and can we do something about it. So, that is the part of what we are doing here.

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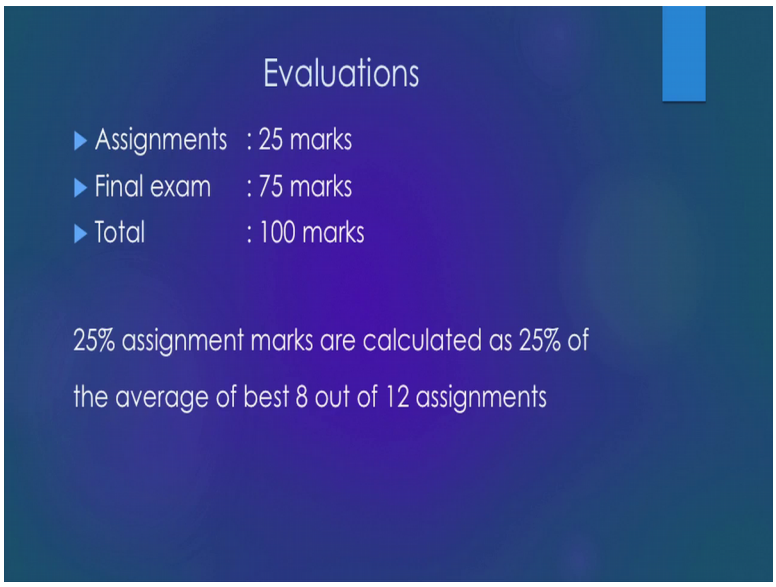

So, we will have some evaluation as usual there are a hundred marks up for graphs you can always get hundred out of 100. And so, since there is significant self learning components the assignments will have 25 marks. So, then let us quickly do 3 or 4 more a slides.

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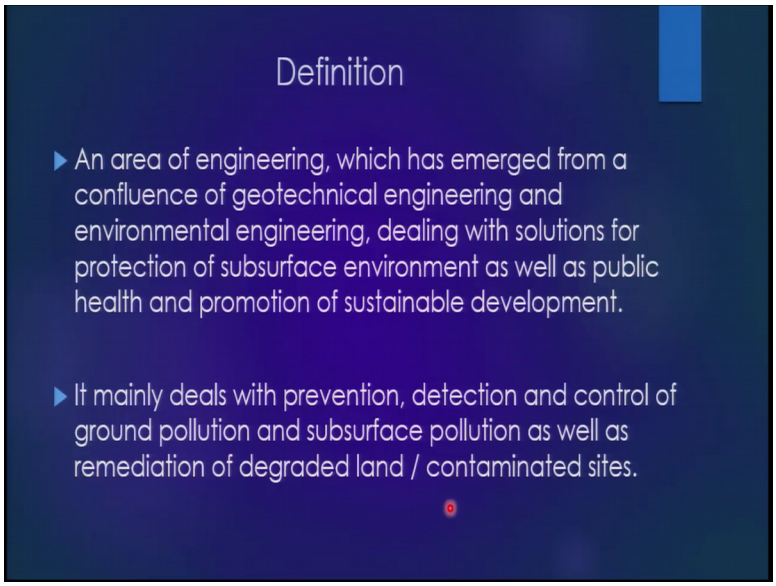

And let us first look at the definition of geo environmental engineering. As I said in the beginning it is a confluence of geotechnical engineering and environmental engineering, dealing with solutions for protection of the subsurface environment, as well as public health and promotion of sustainable development.

So, basically we are going to do the engineering of protection of the ground or the subsurface environment, and of course, promotion of sustainable development by protection of public health. So, it mainly deals with prevention of subs of ground pollution and subsurface pollution that is in the new facilities which you are going to design you have to be able to underwrite, just like a make a structure. Are you underwriting as a civil engineer that this that this building, that we are in what is the life of this building? I think I am in a 5 story building or something like that. So, what is the design life of this building.

Student: 50 years

50 years are you certifying that it lasts for 50 years. Yeah?

Student: (Refer Time: 38:47).

Yes, or no.

Student: (Refer Time; 38:56).

If you do not, I would not hire you to design my building you have to design a building and construct it and be ready to stand in the code of law and say that this building will.

Student: (Refer Time: 39:04).

Yeah and if it falls I am responsible for it. Whether there is a hurricane an earthquake a tsunami a tornado, whatever flood what else extreme events. If it despite any of that you have to be able to design it and say it will last for 50 to 100 years.

So, if you are going to design a facility to prevent subsurface contamination, you have got to certify that it will perform for the design life of what we people deal with 50 to 100 years is what we deal with and you and you have to be totally responsible for it if it leaks. So, that is what we will do in this course that you will learn how to design these facilities. So, that they do not leak for the next 50 to 100 years right. And then of course, also the solutions for the detection and control of the pollution, and what we please note 2 words that those are being used as well as the remediation of degraded land. Once a land becomes polluted you cannot sell it from one owner to another till you bring it back to same level as original condition.

So, there are very stringent norms in the developed countries for degraded land or land which have undergone contamination. In India these are just being formulated. And there are many sites in industrial areas, where the original owners have closed the industry and the ground is polluted and a new owner will not buy it you know in we have these industrial development areas. And these industrial development areas a new owner will only buy that the land is clean he do not have to have the liability of trying to clean up it is very expensive exercise cleaning of contaminated sites is a very expensive exercise.

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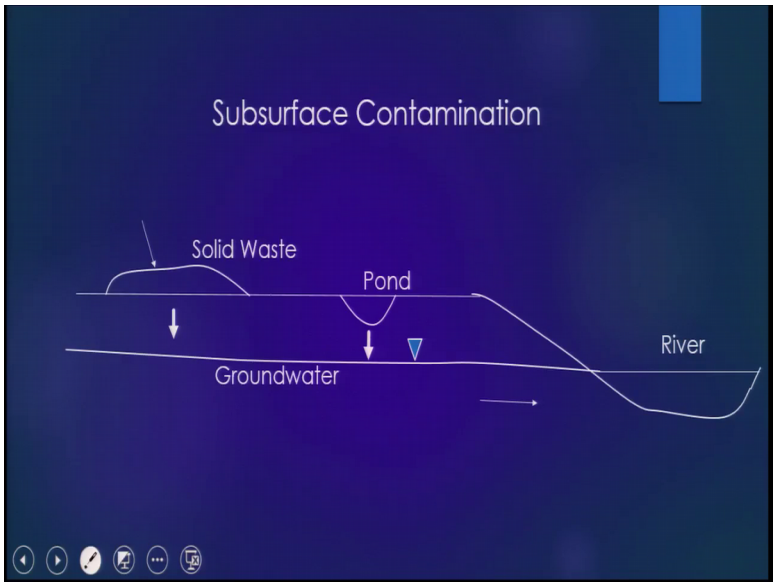

So, this we have already discussed, if you have solid waste and if there is rain it will contaminate the soil and it will contaminate the groundwater. If you have a pond if the pond has got drinking water if it is a lake do not bother me, it. In fact, acts like a recharge for the ground water, but if it has got wastewater and you have just put a notional liner I will do brick lining. So, brick lining is as impervious as the number of joints it has and every brick has a joint. So, it is it is virtually going to contaminate the groundwater and then this contamination will flow and normally the groundwater is flowing to a nearby river normally see if you look back in time civilization as it developed cities only came up.

Student: (Refer Time: 42:24).

Near rivers of the banks of rivers because that is where the water walls and that is where the groundwater was close to the ground surface. So, you could put in a hand pump to take out the water.

Now, that we are able to transfer the water by pipes through very large distance (Refer Time: 42:40) living areas which do not have a permanent source of water, but mostly cities will either a river or a lake nearby. So, let us look at a city which does not have a river or lake nearby let us not go to Rajasthan. So, I have lived in what I have lived in Chandigarh this is a lake nearby and the Ganga river. I have lived in Delhi which was the river Yamuna, nearby I have lived anywhere else I have lived in a place called nangal in

Punjab which are the huge the river (Refer Time: 43:02) there were a subtle pass next to it.

So, does your city have a river nearby matt gauhati has a river the Brahmaputra what about where do you come from phiros.

Student: (Refer Time: 43:16).

Where is that?

Student: (Refer Time: 43:18) Assam.

So, you must be having some rivers flowing by because in a hilly area you will always have some watershed. Anybody lives in a city which does not have a water source right next to it within 20 kilometers. So, most of us do realize that there is a water source therefore, there will be a water table unless you have depleted it and therefore, this is a problem.

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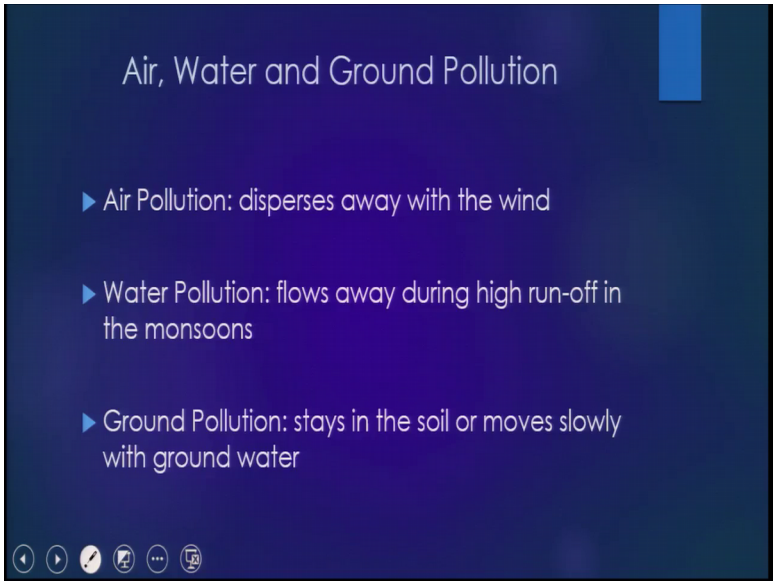

So, I would like to end by talking about air pollution water pollution and ground pollution, because we are only dealing with ground pollution. Air pollution is visible; smog is visible or it is smellable. Even if it isn't it with a rare odorless contaminant which will be there, but there are they can be gases which are odorless and colorless the one the great tragedy we had which get gas tragedy we have.

Student: (Refer Time: 44:19).

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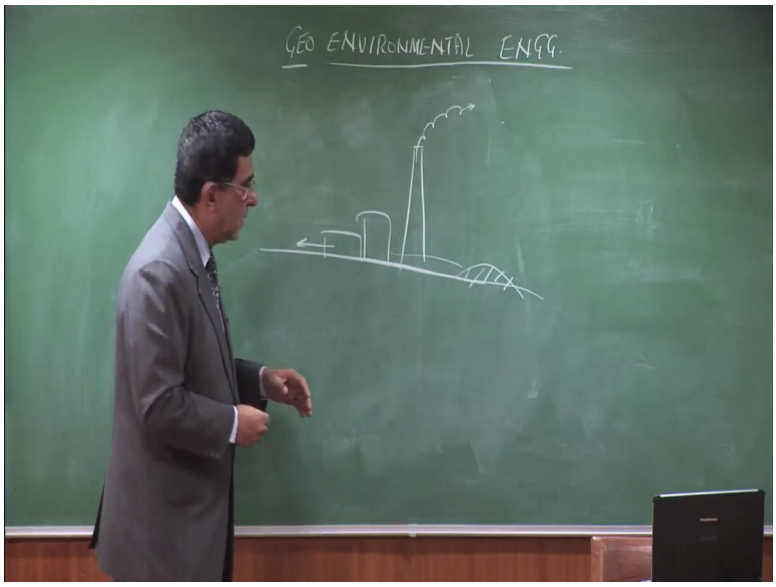

Yeah so, but in any case the thing with the air pollution is that pollution does not stay at that point. If you have a chimney and there is some bad stuff coming out of it, let us say this is some industry and then something is coming out of it, not too good dark black clouds and stuff like that, but it is not going to stay there it disperses with the wind and when they close it for the night come next morning it is gone. And some liquid will also come out liquid waste. So, if liquid waste is coming out of my industry, I do not want to treat it what will I do? I have taken a pipe outside my boundary wall, and I will I will if there is nobody living next to me I will say dispose. So, if I dispose the waste on my adjacent plot what happens to that water waste water liquid.

Student: (Refer Time: 45:31).

Pardon.

Student: (Refer Time: 45:38).

I do not think so, because what happens to all rainwater which falls on the ground the

Student: (Refer Time: 45:52).

Yeah. So, the tendency is to first to runoff in the natural slope direction. Yes, it will percolate maybe a little bit a few centimeters or a few inches, but the tendency of water

is to run to a low lying area. The low lying area is normally a drain which runs to a river that is the even it low lying areas.

Student: Yes, sir.

So.

Student: (Refer Time: 46:16).

You put no it rains what happens the water does not stay there, and if you after the rain if you dig beneath the ground if you think that you will find that water one feet below the ground, it is not going to be there the water drains off and goes to these low lying areas and these drains then eventually connect to the larger drain which takes it to the river Yamuna.

So, what happens is when you have liquid pollution pollutant coming out of a boundary, it will eventually find it is way to a waterway, eventually. If a lot of it is coming out. If not a lot of it is coming out it will partly evaporate partly go into the ground, but again that does not stay there. If there is a natural depression yes a bad smelling point will be formed. And then the factory will stop throwing the thing there because they will be getting their own pollutant back through the poor smell and stuff like this, but what happens to solid waste? You put solid waste and what happens? It just remains there it does not vanish will it vanish in a year or what about 10 years some.

Student: (Refer Time: 47:27) biodegradable parts (Refer Time: 47:36).

Some biodegradable part of the garbage may degrade it will become. So, I put up heap it will become smaller, then what will happen? Some of it will erode with wind and water, but that mound will stay there. And eventually it will become flatter and flatter because the rain will keep on making spread to spread in that area, but it would not go into the Indian Ocean from here. So, solid waste ground pollution; that means, you put water also on the soil the topsoil becomes waste water on the soil. The topsoil becomes polluted then it just does not go anywhere, it just stays there. Or it goes into the ground pollutes the ground and travels with the groundwater, but the velocity of the groundwater is much slower than the velocity of the surface water. So, do not expect groundwater to travel several kilometers in a day. That is the biggest problem about ground pollution. So, when

I put solid waste here I have a real problem, it just is not and I keep on producing more waste and the mound keeps on becoming bigger and bigger and bigger.

If you have gaseous waste, you can treat it. Firstly, let the thermal power plants used to give a lot of smoke. Then you put electrostatic precipitators. Now you can hardly see the plume, but what is being captured in the electrostatic precipitator, where does that go. So, when you treat gas when you scrub it when you treat it either a sludge will be formed or a solid will be formed electrostatic precipitators capture all the fine ash. It goes to the ground, if you have liquid waste use in please make an effluent treatment plant. What does the fluent treatment plant do? It has to capture the contaminant somewhere and then allow the clear or the good quality water to move up.

So, what happens, there is a pipe then effluent treatment plant from the other side trumps out clean water. What is being generated by the effluent treatment plant? Sludge. And what do you do with the sludge land application. So, the contaminate is there still there in the sludge.

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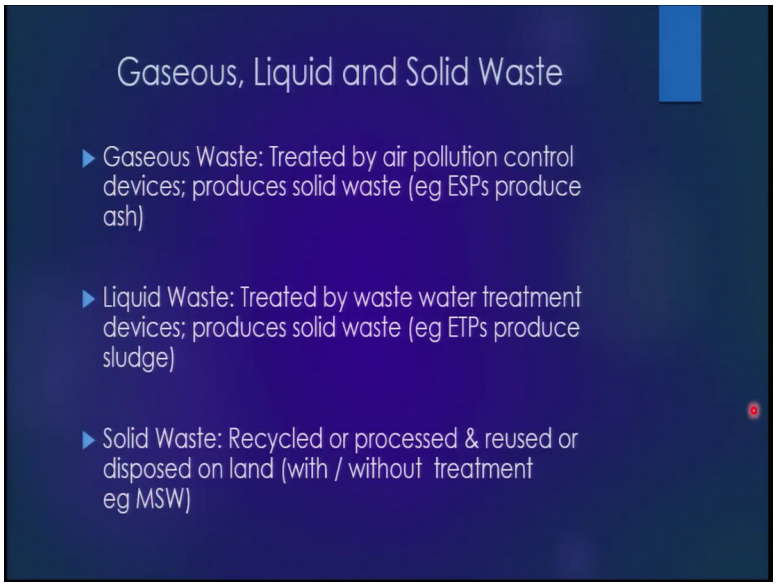

So, solid waste if you see, gaseous waste treated by air pollution control devices produces solid waste. Example electrostatic precipitate, precipitators produce ash. Liquid waste example effluent treatment plants produce sludge. All of this is disposed on land. So, the solid waste we either try to recycle it or we try to process it or we try to reuse it

after processing, but finally, it is disposed on land and it tends to remain there for a long time.

So, again philosophically what would you do with solid waste? You could recycle it you have resize suppose we will say we will take out the plastics we will recycle it, fine. We will take out the composed fine. Then next we will take out the metals in the glass and everything which is reusable fine, still something remains then next then dump it, but really? We would like to convert that material into an inert glassy matrix. So, that nothing comes out from it. So, therein lies the biggest challenge, that can we convert a solid waste into a glassy matrix in which the contaminant remains embedded and does not get released to the environment.

So, currently we do not have a solution for that. The people keep on talking of a process called vitrification or some kind of an institute classification where I will get 2 electrodes and apply thousands of volts of electricity and zap it and it will become glass. So, that probably is the future, but currently all the waste, which is not used remains on the ground right. So, geo environmental engineering is a interdisciplinary, area nobody wants to deal with solid waste, it is a 3 phase matrix solids, liquids and gases. Only geotech people have been handling we are handling 3 phase or 2 phase.

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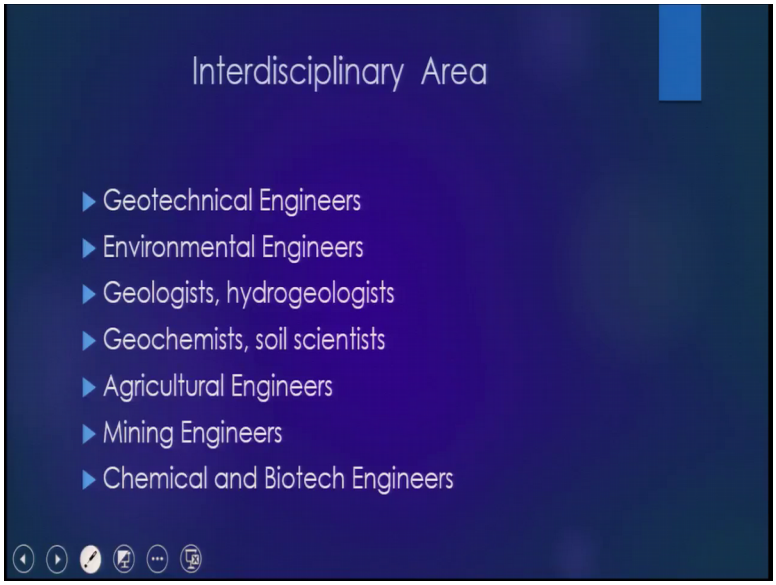

Student: 2 (Refer Time: 52:30).

Well we deal mostly with saturated soils because that is the weakest condition. So, that is a 2 phase media, and if you deal with dry soil that is also a 2 phase media, but if you deal with partially saturated soil or unsaturated soil then we are used to dealing with 3 phase. So, we need the inputs in this area of the geotech people the environmental people all the contaminants, we are not very familiar with everything relating to flow, hydro geologists in the geology. If you are dealing with agriculture, you need to know about the balances. So, you need geochemists soil scientists and agricultural engineers.

We need mining engineers because we dig a lot of things out of the bowels of the earth from deep below. For example, at hutti gold mines the ore will come from maybe 1 to 2 kilometers below, then it will be crushed and then it will come out as tailings and in that tailing there will be some chemicals. Because your aim is to take out the gold and whether use of fast flotation process or a chemical separation process you will add something to that. And then what is remaining is the waste and that has to be exposed to bilinear and finally, chemical and biotech engineers, if we are dealing with municipal solid waste I mean municipal solid waste is very heterogeneous mix. So, we need to have these people.

So, that is what the complete geo environmental matrixes, we are only in one end of it, but we are the only guys who can drill holes who can take samples in 3 phase media and therefore, we are better placed than others to be able to address this issue. So, I just went to the website and I have looked at a punched in groundwater contamination.

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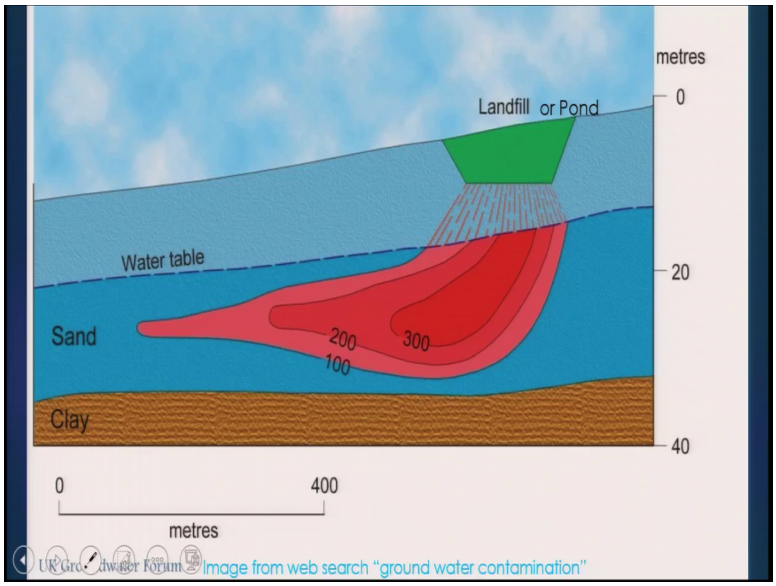

And I found I am just going to share 2 images with you. And this, with these images are attributed to the UK groundwater forum. So, if I have a landfill or a pond. Eventually it is going to come below the contaminant which is there. And you will have contours of concentration and you can get to know how the contaminant travels with time.

So, this is in our domain we can look at this, but as I have told you the distance of travel may typically not be several kilometers, but it may be a few 100 meters or maybe a few 1000 meters.

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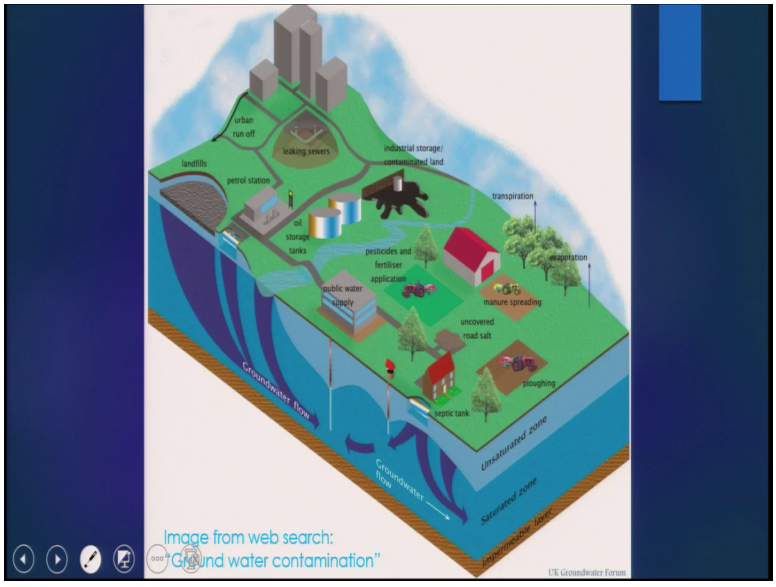

And if you look at the a city if you look at a city as a whole or as a place you can have subsurface contamination from landfills, from petrol stations from industrial areas, from septic tanks, the manure and the pesticides which you have putting will go to the river or to the drain and that drain. And suppose you have a tube well which is taking out the water for water supply purposes, when we are the recipient whether a tube well is extracting this water for water supply. Or whether it is extracting it for irrigation purposes it draws all those because you have a drawdown curve it draws all those contaminants towards itself. And that is where it impacts public health. And that is why it is so, important to address this.

So, just to summarize we have just introduce ourselves to the topic of geo environmental engineering. And what we are going to cover in the next 42 lectures. And I think you now have a fair idea that we are going to look at design of new facilities. We are going to see what we are going to do old to old dumps when we are going to see how we tackle contaminated sites. Over and above that we are going to treat slurry ponds separately from a municipal solid waste hazardous waste and construction and demolition waste dumps. So, next time we will look at sources of contamination and their impacts.

Thank you.