

Geoenvironmental Engineering (Environmental Geotechnology): Landfills, Slurry Ponds & Contaminated Sites
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Lecture - 02
Sources & Impact of Contamination

Welcome to the second lecture of the course geo environmental engineering, today we are going to look at the sources and impact of contamination. But let us just quickly go through what we did last time. So, last time was an introductory lecture, we defined what is geoenvironmental engineering and we said it is a confluence of geotechnical engineering and environmental engineering, dealing with contamination on the ground surface and beneath the ground surface. And we talked about how the lectures for the next 42 hours will be distributed and we said the bulk of the lectures will be on landfill design and design of slurry ponds and the remaining would be on contaminated sites. We also looked at how the evaluation will be done and what are the textbooks which we will follow.

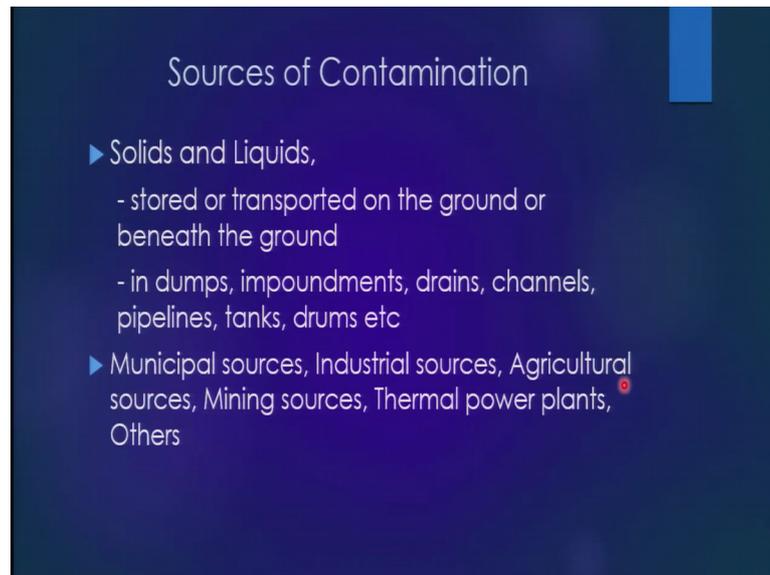
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So, taking off from where we ended last time today let us look at sources and impact of contamination. So, when I talk of sources of and impact of contamination do you remember that I am talking about of contamination on the ground and subsurface

contamination. I am not discussing here contamination of water, contamination of air, which is what is traditionally done by the environmental engineers. So, we look at what happens to contamination on the ground and contamination in the subsurface environment.

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So, what are the sources of contamination? Briefly we had discussed this last time and we are saying the sources of contamination are the solids and the liquids, which are either stored or transported on the ground or beneath the ground. So, as long as a solid material or a liquid material is stored above the ground it is a totally different thing why? When you store something in a bin above the ground you structurally design the slab to take the load of the waste and to also be waterproof; that means, if a bin is above the ground and it starts to be leak then you can actually see drops and droplets of the leachate or the waste water coming out. But the movement you bury it under the ground what happens? You cannot go beneath the base to see what is happening.

So, that is the major difference when solids and liquids are stored or transported on the ground or beneath the ground, they can become a source of contamination primarily, because we should be able to detect leakage. So, such storage may take place in dumps like garbage dumps in impoundments like slurry ponds even drains which are carrying waste water or channels which are carrying waste water or pipelines which are carrying wastewater like sewage pipeline or tanks underground petrol tanks or drums which have

been buried under the ground with some waste, all these can leak and cause subsurface contamination. The contamination can come from municipal sources; that means, all they can originate from an urban environment, they can come from industrial areas; they can also come from the agricultural sources, mining areas, thermal power plants and others. So, we have not covered everything, but these are the major sources from which we do know that ground contamination and subsurface contamination occurs.

So, last time if you recall we were saying that if we have waste we would like to utilize as much of the waste as possible and if I have municipal solid waste I can recycle the metals, I can recycle the glass, I can do composting and get compost, I can also if there is energy in the waste in the form of plastics or paper or rags of cloth we can burn it to recover some energy of course, with proper environmental protection such that the none of the harmful gases go out from the incinerator, but still we would have some waste to be disposed on the ground and this waste then has to be put in a manner in which it does not contaminate the environment. A lot of research is being done that if you have residual waste in the form of ash for example, you have burnt everything and ashes remaining, but we find that the ash has got some contaminants, how do we entrap it in a glassy matrix what is glass what is the main.

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SIO₂.

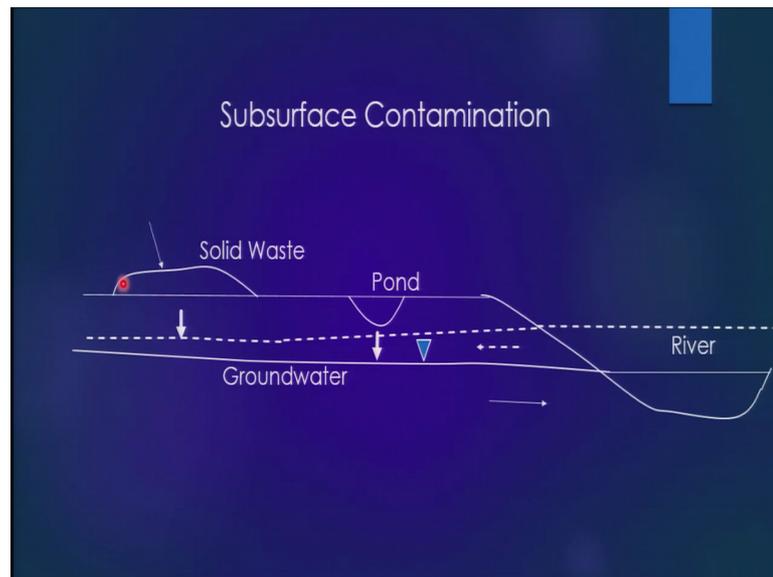
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What is sand?

Student: (Refer Time: 06:10).

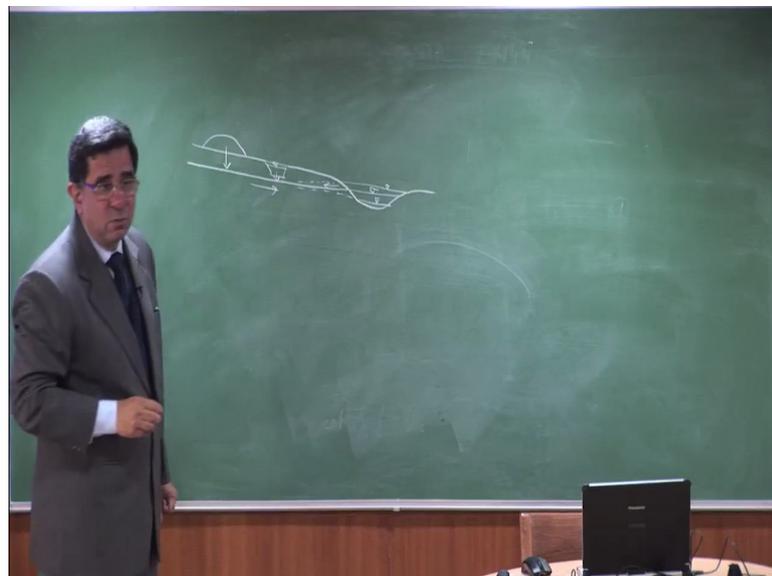
SIO₂ what is ash SIO₂. So, if I can transform the ash into a glassy matrix then I can interact the contaminants in that till we do that we have to still manage the waste which is coming on the ground.

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So, you will recall this diagram which we discussed last time, and just to make one more point.

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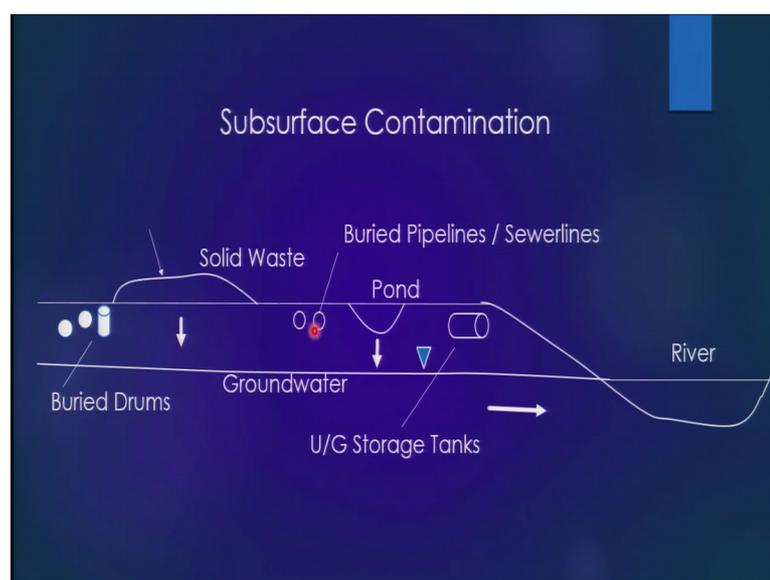
I said last time that cities are next to rivers or some water bodies, and that if I dispose some waste or if I have a pond with some not so nice liquid stored in it, then they can contaminate the groundwater. And I also made a statement that the groundwater flows towards the river, is that a correct statement does the groundwater always flow towards the river.

Well let us look at the ground surface first within a watershed or within the catchment of the river all the ground surface tends to go towards the river because the river is the lowest point topographically. So, this to ground slope is always going towards a river or towards a lake, which is a natural low lying area, what about groundwater? Very often the groundwater will also follow the profile of the ground surface so; that means, the groundwater goes to the river most of the time, but there is one issue that you should be aware of that if the groundwater if the river level rises. So, river can be in flood. So, if the river if the river level rises what happens?

So, during the lean period; that means, during the summer months the water level will fall here and the water table would begin to little lowered as it discharges into the river. During the floods a recharge takes place; that means, the water level in the river becomes higher than the groundwater table outside. So, in such cases the water can flow in this direction as well. So, do remember that flow takes place in both directions, but for bulk of the time the ground water table follows the surface of the land and flows into the river.

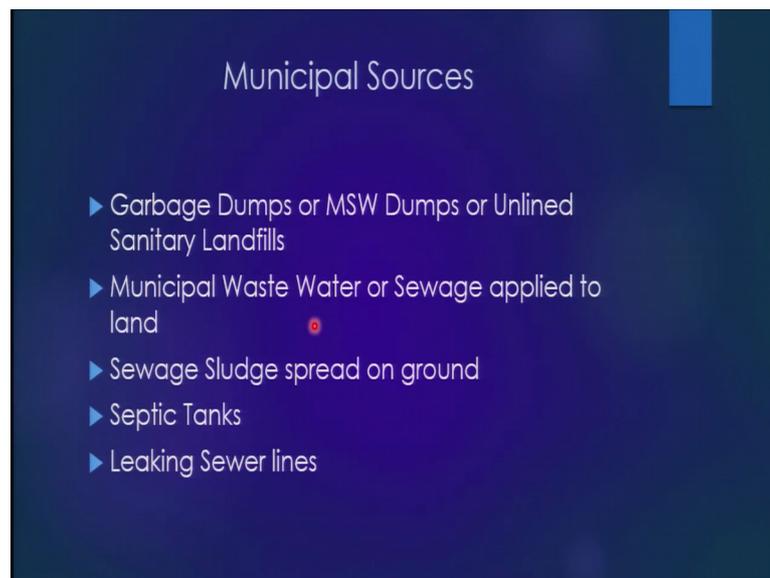
So, this I think is depicted here where the river has risen during the floods and during those periods the groundwater is flowing towards the land and the groundwater table is being recharged by the river, but most of the time it is flowing into the river. So, what we have said now is that subsurface contamination or ground contamination is not only on account of the solid waste or the liquid waste in a pond or the solid waste.

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But if you have buried some drums if there are some pipe lines, if there are some underground storage tanks or any facilities which are underground they can cause groundwater contamination, because most of them leak and the problem is we are not able to detect the leakage or monitor it; we are not able to detect the leakage or monitor it So, let us look at municipal sources what are the municipal sources which will contribute to ground contamination or subsurface contamination.

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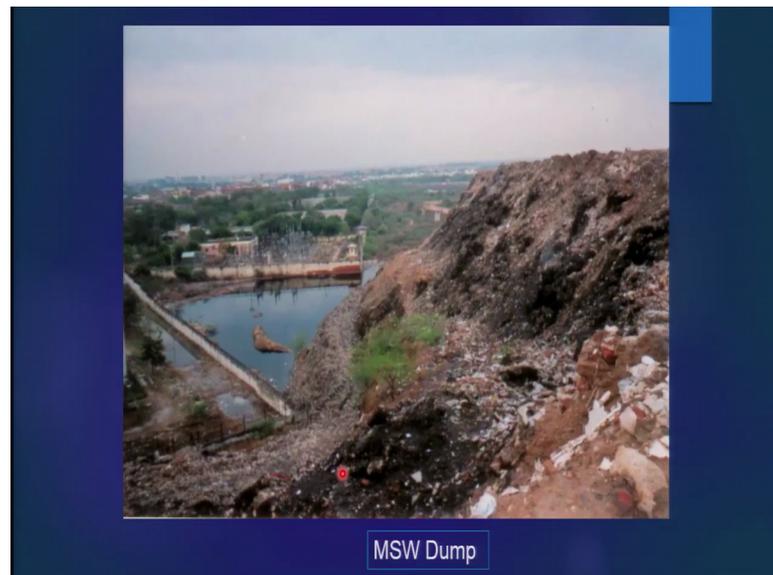


We have already talked about garbage dumps or municipal solid waste dumps or unlined sanitary landfills. We will better define this term later, but sanitary landfills are waste dumps in which the waste is covered with soil on a daily basis. So, these are the old concept that you put the waste on the ground and cover it with soil and it gives the good appearance it keeps the tests and rodents away it reduces the smell, but if the landfill is not having a liner at the bottom or impermeable strata at the bottom it can still cause contamination. Sometimes municipal wastewater or sewage is applied to the land this also can cause subsurface contamination or the sewage sludge coming out of the sewage treatment plant that is also spread on the ground. So, these are also sources of subsurface contamination, septic tanks where the sewage system has not been developed we are cleaning them every once you often, but there also a source and leaking sewer lines.

So, really if I was to go beneath the city if I could be a burrowing animals, you know and then I travel underneath the surface ground surface of the city. So, in drops of liquid

would be coming down from the ground drops of the liquid would be coming down from the ground, if there is groundwater table it will be contaminated if there is no groundwater table of the ground water table is deep below, that liquid gets held by the soil. So, in any case the soil gets contaminated or the groundwater gets contaminated.

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So, this is a nice photograph of a municipal waste dump in one of the Indian cities, you can see a lot of black black stuff here right this is because occasionally there is a fire and you can see some black liquid here, this is what we called leachate which is just piling up and the height of this dump is about 40 meters. So, anybody will know the height of Qutub Minar.

Student: (Refer Time: 13:02).

So, as I said that 40 meters means three fourth the height of Qutub Minar and this dump keeps on rising because we do not have another place to put the waste because in urban environment the space is very restricted. So, this is causing subsurface contamination. Firstly, it is causing contamination of this ground then the leachate is going below so, it is doing some surface contamination.

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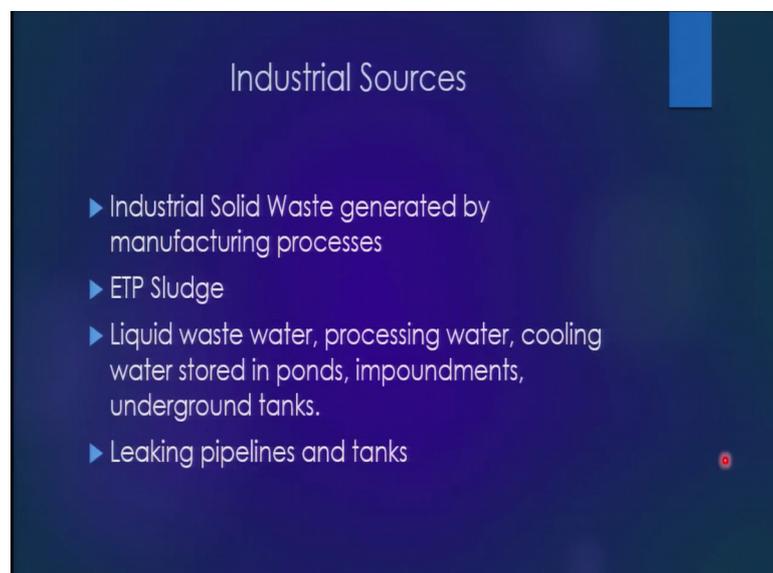


So, this is one city this is another city looks the same very much similar height this is about 20 meters that you can see the human being. So, how many meters is this guy.

Student: (Refer Time: 13:46).

So, you can just sort of multiplying as many number of times as we want to get the height of the dump, and that is the kind of leach ate which is slowing out here it is flowing is very close to a water body, you can see this water body and therefore, it is contaminating both the water body and the soil beneath it.

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So, I will come to industrial sources later, but what we are saying is that as long as I start to typically what happens dumping of the way starts in a low lying area, why because it is low line one feels that if I dump some waste in it.

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It will come to the ground level, but it is not be an I source, then what happens once waste starts to accumulate here and waste keeps on coming in from the city unless you have alternate facilities then this waste starts to gradually rise. So, this may be the history of a waste dump and if I have rain.

Since it will be a low lying area the water will pound up at the bottom right we will have leach ate, but there are many other things associated with the dump it is will be bad order those of you who are aware that what happened recently in Bombay? The Deonar dump caught fire. So, there is a lot of smoke that in that reason the schools had to be shut for ten days because a lot of smoke was emanating from the dump. So, the dump may cause a lots of problems it can be leach ate is one of them bad smell is another smoke from smoldering fires is another, they do produce greenhouse gases we look at these, but this is the this is the source of contamination if you are looking at industrial sources.

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So, industries are also producing they are also producing liquid waste they are producing gaseous waste and they are producing solid waste. And as I have already told you the more I restrain the liquid waste and the gaseous waste, the more both of it comes to the ground along with the solid waste which is coming out because gaseous waste will cast the ash and bring it to the ground, liquid waste will go to the effluent treatment plant, and it will give the sludge all of them becomes solid waste.

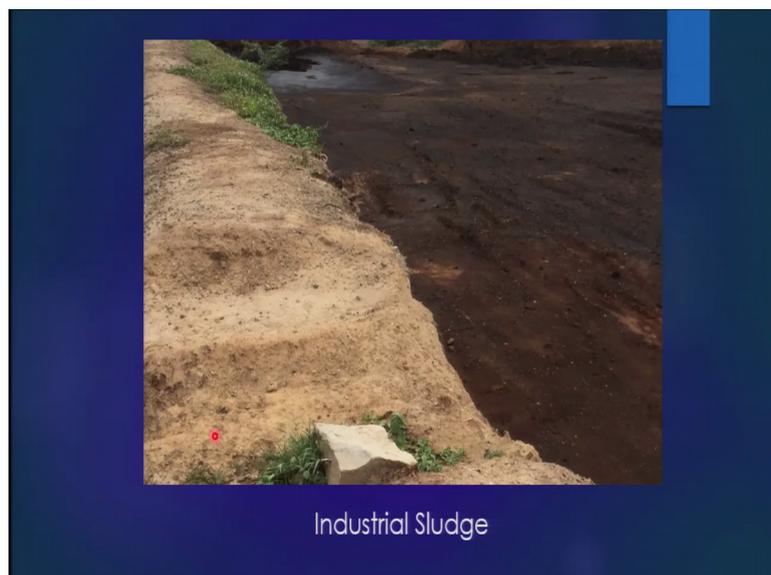
Now, typically in urban environments you earmark an industrial area so that you know you are able to promote the industry. So, in a city you will have an industrial area so; that means, a lot of industry is concentrated in that area. So, one of the ways of managing the waste of the industrial area is to set up common facilities, common effluent treatment plant that means, from all the industries let the effluent come to a common treatment plant and it can be treated there. The problem is the complexity if in an industrial area you have one type of industry say textile industry or you have oil paste industry, then you can treat the effluents together. But if you have heterogeneous industries somebody is making pesticides somebody is doing drawing colors somebody is doing chrome plating then you have wastages of very different nature and most of the effluent treatment plants common effluent treatment plants have not worked well in India, in industrial areas which have got different types of industries. So, just like you try and manage the affluent in a common facility, industrial areas also tend to manage their waste now in a common

facility called a TSDF and is basically a storage and disposal facility storage and disposal facility or a central storage and disposal facility if the TSDF stands for.

So, if I send it to a common facility, in India we call this treatment storage and disposal facility. When you will go through the regulations you will see that the ministry and the central pollution control board wants that for a cluster of industries have a TSDF where you can treat the hazardous waste if it is very hazardous, you can store it temporarily and finally, you can dispose it. You store it if you can find the reuse for it you can send the waste to them.

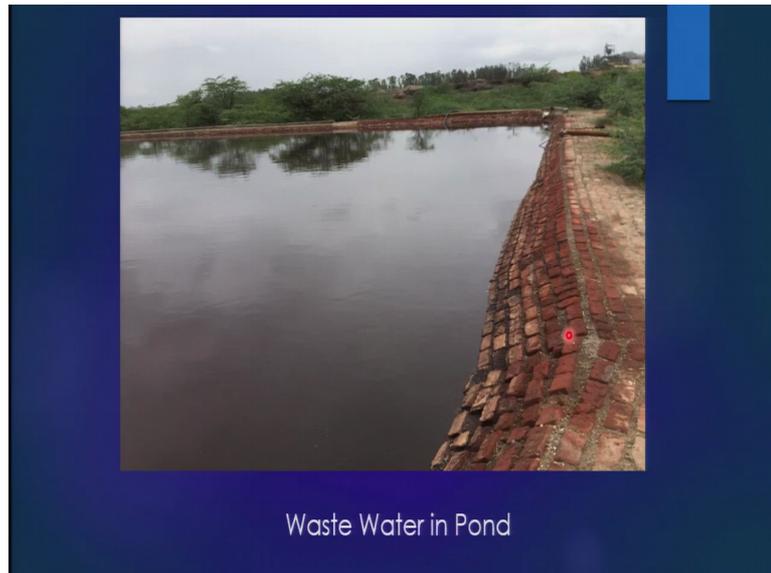
So, what we find here is industrial solid waste generated by the manufacturing processes comes to TSDF the ETP sludge effluent treatment plant sludge which is different from the solid waste generated by the manufacturing process that also comes to the disposal site, both of these are solid wastes which can affect the subsurface environment. Even more potent or liquid wastes as long as they are stored above the ground and now there is a big move by all pollution control boards asking industries to store all effluents above the ground, but most of the old places you will go you will find tanks, you will find ponds, you will find the underground storage tanks. So, liquid waste water or liquid processing water even cooling water when it is stored in ponds impoundments and underground tanks this can slowly leach into the ground and of course, leaking pipelines and tanks.

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So, the solid waste the liquid waste stored and the transporting elements which are used also you can contribute to on the subsurface pollution. Here is a photograph of a sludge being disposed of by an industry in an excavated area, the same industry is also keeping it is wastewater in a pond.

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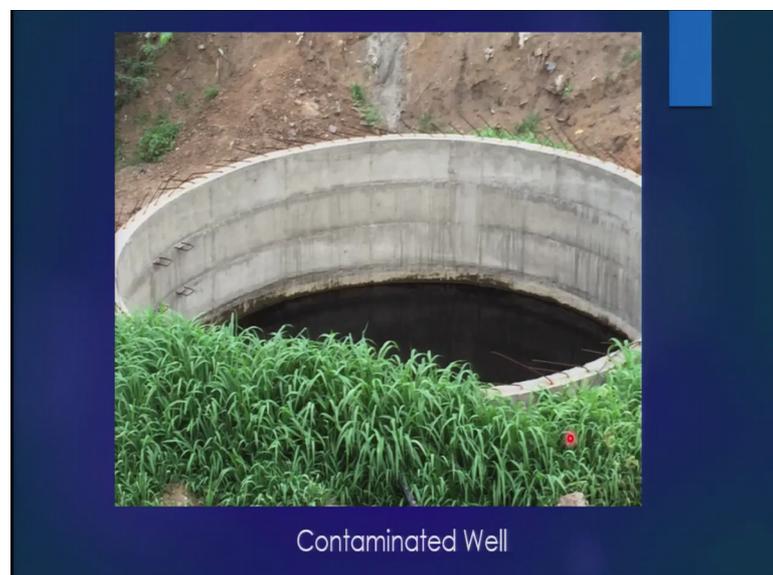
Now, there are specifications as to how do you lining this wastewater pond so that the leachate does not go into the ground. But if you do not follow them very rigorously some leakage of the other will occur and you can see the quality of the brick lining that we have here. it may be underlined by clay or other impermeable elements, but the quality has to be done very well.

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If I look at this, this is an industrial area and this is temporary storage of the processing fluid beneath the ground.

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And when this happens you may have a situation like this, this is a well a groundwater well and this got black water in it because the water has leached from wastewater pond or from a sludge and reached this well.

So, municipal solid waste you saw the kind of leach ate look black. So, the learning is that you have a lot of black liquid around right occasionally it may be light brown

occasionally it may be dark brown and occasionally it may be black, but you get a lot of color and you get and you know you are drinking of your tube well, you have even a very light tea colored liquid coming the tubule will be closed you would not drink because you know that is got a contaminated. Even if it has got a harmless color in one of the industries you went it was just like a sugar you know, caramelized sugar is brown I do not know whether you understand the word caramelized sugar brown sugar.

So, actually the color was coming from caramelized sugar. So, you should drink it nothing would happen to you, but it is brown water is brown I cannot serve it to my guests I cannot drink it any which way. So, ever the other source which is a diffused source please understand is agriculture.

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Diffuse means because we apply fertilizers soil amendments pesticides to a large area. So, as long as these are within limits that means, there is no excess fertilizer there are no excess soil amendments, and there are no excess pesticides, they are supposed to remain on the crops and within the boundary, but unfortunately we are not able to regulate this that this is within the limits and this is exceeding limits.

So, when the rain comes these will all go off into the nearest drain and once there in the drain which is always full of water they will reach the subsurface. So, these are not point sources these are surface sources, and only when they are in excess do they cause do they get washed to the nearest drain and they are getting we are getting the contamination. In

many agricultural practices you have animal husbandry for example, make producing units meat producing units. So, there also the processing as well as the dead animals as well as the droppings of the animals all of them have to be treated very carefully otherwise they can become a source of contamination.

So, we do not see it, but you know if you go to a poultry farm and you have x 100 or x 1000 hens anything which is a concentrated animal activity has a trade off on to the environment beyond it. Where do you dispose the characteristics, how do you do you incinerated do you bury them the animals which got sick. So, these are also reaching the ground and finally, food processing units which you can just take as equal to any industrial units, food processing units are say same thing as a chemical processing or a biochemical processing unit. So, they also produce the same thing which we had discussed earlier.

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The next at source which is important is the mining source, how many of you are familiar with mines or how many of you have visited a mine you which mine.

Student: (Refer Time: 25:41).

Was it an open mine or a closed a deep below open. So, what kind of a size did it have? If I use to make you sit on an aero plane and ask you to look down. So, they have excavated something now from the ground. So, what is the size of the excavation in plan.

Student: (Refer Time: 26:05).

Two kilometers in length, and how much in width?

Student: (Refer Time: 26:09).

Oh that big a pit and how deep is it approximately.

Student: More than 200 meters.

More than 200 meters or 100 meters. So, here is somebody who has visited in Dunbar the coal mine which you should sit on an aero plane you will find that it is plant size is one kilometer into two kilometers, and at the deepest point it may be more than a 100 meters deep. So, what are we doing there? We are digging out first the earth at the top and then you come to a coal seam and we dig out the coal is that what is happening right and we are using this coal and we are sending it to thermal power plant for example, maybe it is coming to our Badarpur thermal power plant in Delhi. So, from Dunbar you get coal you put it in a train, you send it to Delhi at Badarpur power station, we burn the coal and what happens ash is generated we all get electricity ash is generated ash does not go back to Dunbar to fill up that cavity that we have created and the ash accumulates.

So, there two issues here one is what are we doing at the mining site and the second is what are you doing at the thermal power plant site. So, the mining site can always say that I am sending my coal to Delhi I am not producing any waste, but does the process of excavation cause a problem in your mine, do you think if I make a cavity which is say 1 kilometer by 1 kilometer in a 100 meters deep, what is your immediate concern. Please remember that to reach the coal I may have first dug out the soil and the rock for about 50 meters is that correct or was the coal seam more at the surface, was the coal deep below or at the surface.

Student: (Refer Time: 27:58).

Right. So, I may have removed soil which was 50 to 100 meters. So, what do you think are the environmental issues here? All mines may not be opencast mines some mines you can just go deep below and work underground and the oh you may not want to remove the overburden. So, you have to actually do the costing here.

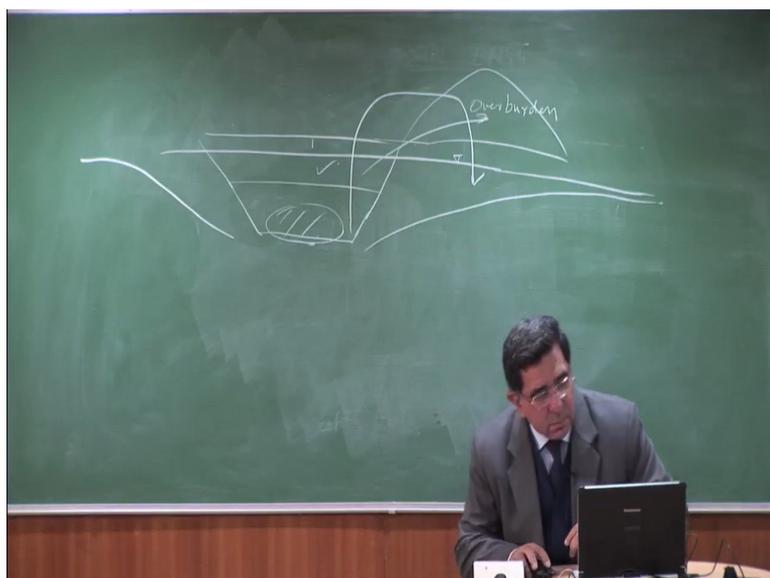
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So, here is mother earth ground surface here it has a resource that we want to remove, there two ways of doing it one is you do this and the other is you do this.

So, when this is limited in depth then you will do an opencast mine, and when you are it is very high in depth in hutti gold mines for example, you are 2 kilometers inside you are not going to do a opencast mine . So, and we are discussing an opencast mine and what do you think it does when we have an operation like this.

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This is just a conceptual diagram please do not think that this is a actual depiction of a mine. So, first problem is I remove all this overburden, where does it go? I put it on the site somewhere maybe it comes here. So, this is called overburden; some of it as we dig along will put place back in the same area, but we will have a large cavity. So, what is happening, one is we are removing overburden is there anything which is going to happen when you make a deep excavation like this.

Student: Unstable slopes

Unstable slopes. So, we will make them flatter slope stability problem he says when you are going to go 100 meters below, you want to excavated at one is to one. Firstly, it will be rock. So, you can do steep slopes, but if you cannot we can make them flatter what is the one major environmental change other than the fact that you have used two kilometers by one kilometer area and used it for bringing out coal which we need what is the one major change that we have caused.

Student: (Refer Time: 30:30).

What do you mean by proximity of groundwater? So, if the groundwater was the 20 meter depth what did you do when you did a 100 meter excavation?

Student: (Refer Time: 30:44).

You lowered the groundwater, if you lower the groundwater what will happen all around. Suppose the groundwater was here we will not going to the technology of how you lowered it, but I have lowered the groundwater when I lower the groundwater what will happen? Maybe this is the drawdown curve I will have I will be pumping out the water know all the time. So, the region will witness a depletion in the groundwater. So, all the farmers I am not talking of the one kilometer by two kilometer area, now I am talking about the 10 kilometers on either side of that great cavity that you fraught. So, the water will go into that cavity. So, the land becomes gets affected because the groundwater goes down.

So, ideally what should we be doing? Ideally we should be maintaining the groundwater and maybe we should be from an environmental perspective remove the water and put back the water. So, that this part of the water is not affected that is what happens when

the metro does excavation in Delhi, it removes the water from the excavated portion, but beyond 50 meters it cannot deplete the groundwater. So, there are extraction wells and then there are injection well at 50 meters why because if you deplete the groundwater the buildings were begin to settle.

So, basically we need to keep the groundwater at it is original position which is a fairly complex techno technological activity. So, there are two in two things which are happening; an overburden is being placed and groundwater is being lowered. So, mine overburden is one problem, huge amounts of mine overburden are placed mountains, but this is mountains of crushed and excavated material. So, if your mountain of crush in excavated material dust will fly when the rain will come the water will carry away the suspended particles and go and deposit it in a nearby lake or a nearby river wherever the water is going.

So, these overburden mounds have a problem and then as I said in the case of a coal mine, the coal is virtually in a very pure form right, but if you have a metal mine let me say I am taking out zinc. So, the over may have only 5 percent zinc, 95 percent will be the rock in which the zinc it. So, we will crush the rock and. So, we will get mine tailings whichever in the form of a fine powder and these are large quantity slurry wastes which are deposited. So, on the top of the ground and then of course, we also have mine processing liquid waste. If I am doing the extraction of zinc from the or it is just not a physical separation, I take the rock and I crash it and crush it and crash it and crush it and crush it now it is fine it is crushed, what is the specific gravity of zinc and what is the specific gravity of rock; specific gravity of soil.

Student: (Refer Time: 34:33).

Specific gravity of rock.

Student: (Refer Time: 34:36).

Same same and we are talking of the specific gravity of the solid matrix; 2.65, 2.7, 2.8 specific gravity of metals 5, 6, 7. So, I have separate I have crushed and crushed and I have two sets of materials one is heavier one is lighter. I am not saying just by crushing you can separate them no I cannot separate the very fine particles the very fine particle has got 80 percent zinc and 20 percent rock still sticking to it then you do some other

process, a chemical process a separation process. So, that will give you mine processing liquid waste. So, you will get the crushed rock as tailings and you will get mine processing liquid wastes and when the tailings will come out will they have any zinc in it. Let us say the original ore had 5 percent zinc when the crushed tailings will come out will they have 0 percent zinc

Student: (Refer Time: 35:38).

Maybe it may be 0.1 percent, it may be 0.2 because you cannot remove everything and if it has led then maybe the tailings are also hazardous classified as hazardous. So, tailings will have some residual metal.

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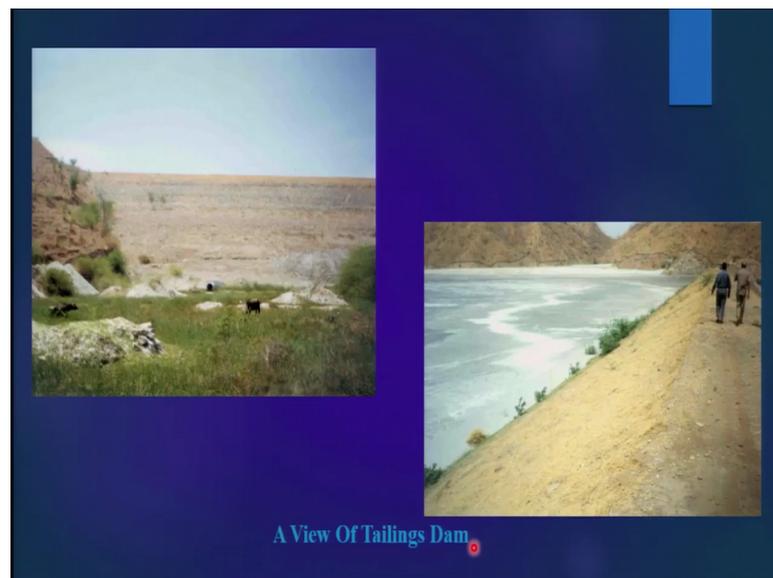
And then. So, let us have a look here what mining does to an area this is not a below ground mine this is an above ground mine. This is a shot from a magazine called the sanctuary and this is an iron ore mine in the south of India, and these are the original these are the hills and all of them have the ore, and this is what we are doing these are the processing units, and what is happening to the tailings? This is a 100 meter high dam like a water reservoir can you see this? And behind that you think this is water this is all the crushed rock part of the crushed rock is overburden which is somewhere else which I do not have a photograph of, but the crushed rock which went through the processing unit is in the form of tailings this is like powder sand silty sand sandy silt, and this is 100 meters

high and this distance is about 4 kilometers, through the 4 kilometers like a water reservoir.

So, this can cause the impact the environment and this can impact the environment the subsurface environment. As geotechnical and your environmental engineers we want to always bring back thin ground to it is original condition I cannot of course, bring back all the over here, but I would like that this looks like this eventually, in that what I want to do and that is a whole topic of rehabilitation of mines which we are not going to get into which we are not going to get.

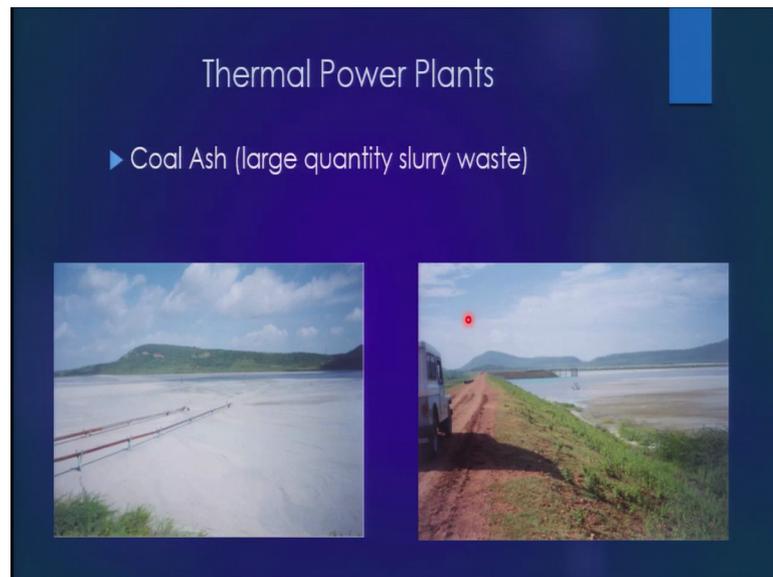
But some of the problems associated with this because this is all a geotechnical design the design of the dam, how do you raise the dam that we will be handling in this course.

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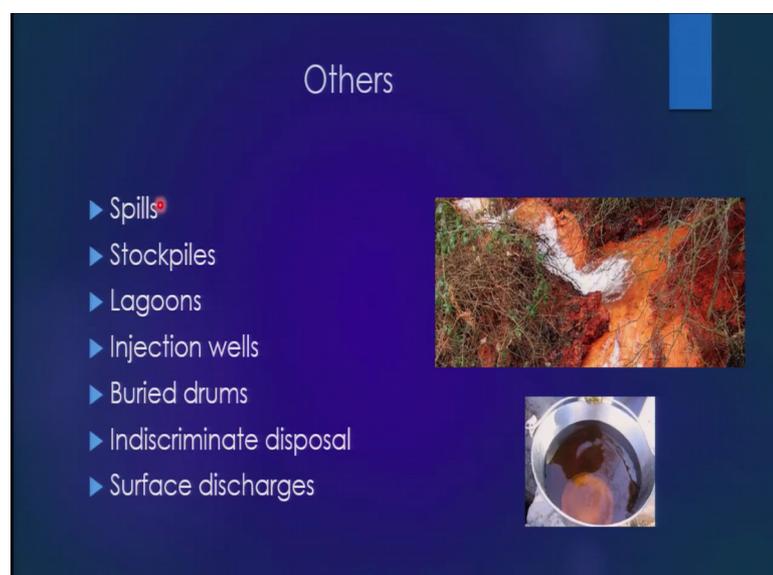
This is another tailings dam this is about 40 meters high and that is the lead zinc tailings behind the dam.

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Then the another source of a lot of solid waste is the a thermal power plants, they produce a lot of ash I told you coal ash. So, somewhere here is the thermal power plant it is not in the photograph here, but this is the ash pond created looks very similar to the tailings which he saw here know here, and slurry pipelines bring in that ash they are coming out here this is the embankment and this is the water which is then being decanted. So, we have about one 80 to 100 such ponds in the country with several million tons of ash accumulated behind them, and then you can have other sources of ground contamination spills.

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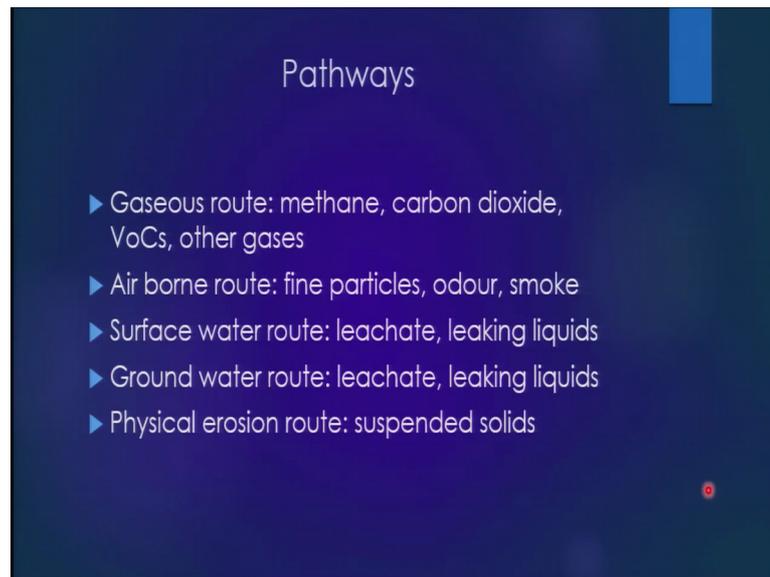


You have a tanker which is carrying something it has an accident it spilled something. Stock piles your temporary stockpiling some including coal you want to stockpile something you do not have a covered shed. So, it is like being stockpiled in the open and it will stop lagoons like ponds where we are storing material.

In the past the industry used to be a make used to inject their waste water into the ground using injection wells, nobody thought about it (Refer Time: 39:30) this will pollute the groundwater eventually, and now they are no longer allowed, but this is a reality of the past that we did not have a river nearby, we did not have a drainage channel, we used to inject the wells into the ground; and say oh we are injecting it into impervious strata it would not spread from that area buried drums indiscriminate disposals you can see here chromium sludge indiscriminately just put on the surface and that is the color of the water very nice iced tea color maybe lemon tea whatever you like to (Refer Time: 40:07) and surface discharges.

So, these problems are there they are not very visible air pollution is only present we can see it all the time, we can smell it all the time. Water pollution you go to the river Yamuna it becomes very evident you look at the Nigel grade drain all these water pollution problems become evident. Ground contamination and subsurface contamination is not visible and all these things which grow into the ground do not travel at a very fast rate. So, did not spread very fast. So, they are there they are moving gradually, in some of the locations they will spread rapidly in others they do not.

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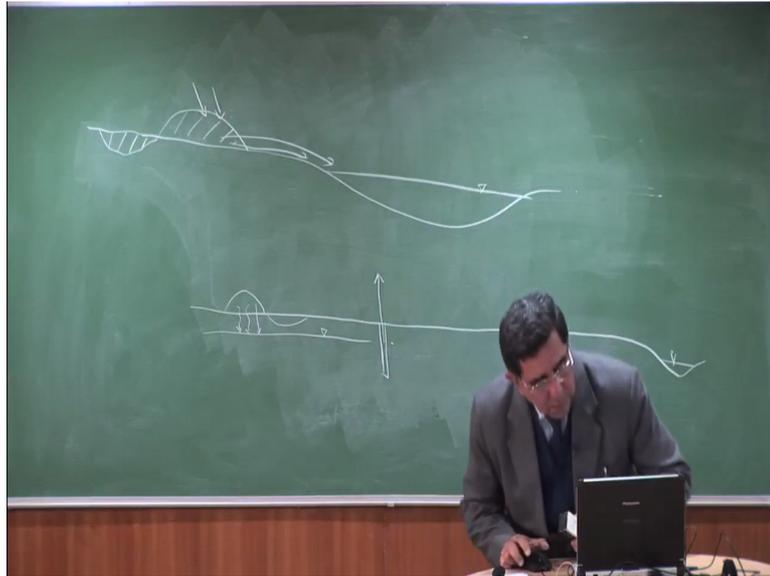


So, what are the pathways these are the sources how does the contaminant go from the source to you, order the contaminant bother you I have got a mound there of garbage lying in okhla [FL] why should it bother me. So, you can have various routes by which these contaminants can travel, you can have the gaseous route the predominant route is the leach ate and the surface water please do remember when I am just putting you can have the gaseous route in many of the municipal solid waste dumps huge amounts of methane and carbon dioxide are being produced. And these if the dumps are below the ground low lying area, then the methane can even travel into the soil and pollute the soil and affect the crops nearby. In any case the methane is coming out and it is a greenhouse gas and it is affecting the environment, similarly as I said many of the petrol stations have buried tanks and the volatile organic compounds are leaking into the soil and the soil is getting contaminated.

The other airborne gaseous or airborne route is the route of dust air erosion and air transport. So, it from various sites including ash ponds, including tailings ponds, including mine overburdens including municipal solid waste fine particles of dust are carried by the wind and deposited in the nearby areas. So, we are living nearby one of these occasionally in the dry months you will find [FL] because why because the ash from the ash pond or the dust is coming and depositing over your building. God is kind monsoons will come and it will wash away the building, but imagine there was a news item in Himachal that we find us particles were beginning to affect the pollination of the

apple orchards. So, to a building which are non biotic and not alive it does not matter if a dust particle comes and you wash it away, but if it starts to sit on the leaves and the flowers of the plants then you have an issue there even if it is a very thin layer. The surface water route best demonstrated many cities have lakes and the lakes are also their drinking water resource.

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So, god forbid if you have not located your dump dumping site properly whatever industrial waste or municipal waste or and you have something here or something underground I do not know solid or liquid, the tendency is that the ground is sloping towards the lake and will you get surface contamination or will you get groundwater contamination here; what kind of contamination do you suspect I think I have gone outside the limit, but nevertheless if this is clay if the soil is clay what will happen when the rain comes will the water go into the soil or will it travel along the slope of the ground.

Student: (Refer Time: 44:34).

Correct. So, if it is clay then. So, surface runoff on impervious soils on sloping ground next to a lake, it is a reality in this country several lakes are polluted because the dump is close to the lake. If you are on the pervious soil then the situation changes then the situation is the water tends to go down or it can be a combination of both. So, if you are very far away at IIT how far away are we from a water source, how far is IIT from a

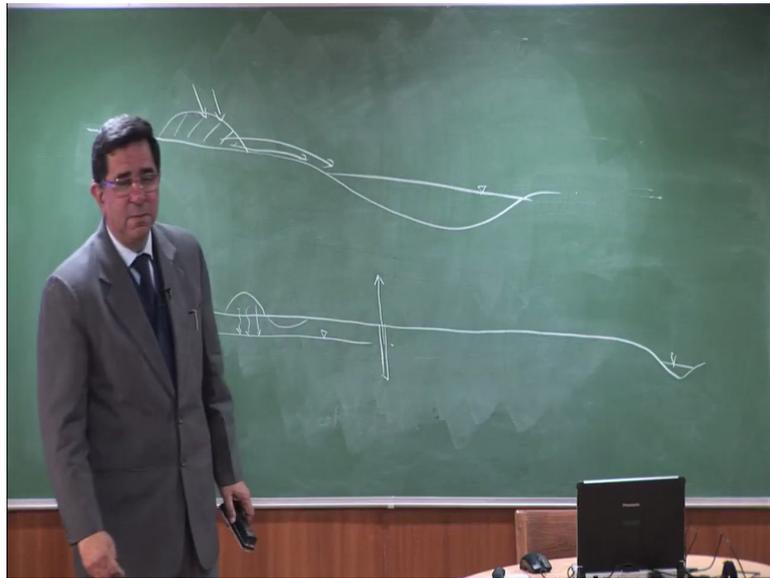
water body do we have a lake nearby you no the nearest freshwater body is the river Yamuna.

Student: (Refer Time: 45:30).

How many kilometers.

Student: (Refer Time: 45:34).

(Refer Slide Time: 45:40)



It is closer to ccri then it is to IIT Delhi. So, it 10 kilometers away, in such a situation that is a totally different situation, what is likely to happen what kind of soil are we sitting on in Delhi.

Student: (Refer Time: 45:59).

Its loose well sandy silt silty sand; it is not your silt we call it Delhi silts sometimes erroneously, but if you were to give it an engineering classification it is silty sand sandy silt. So, it a permeable soil and an impermeable.

Student: (Refer Time: 46:14).

So, the answer is right there staring at you in the face, that if you are setting impervious soil and if the groundwater is not be below then your rout is and god forbid if you have a

tube well or a pump here which extracts the water then you are going to receive it, two similar dumps, but in different situations.

So, let us look at the pathways once again with this context, you can have the surface water route the leachate and the leaking liquids can travel along the ground surface, hopefully before they reach if the source is very far away it will evaporate because you do have evaporation all the time or you can have the groundwater route or it can be both. So, either way here also the ground is going to be sloping towards the river Yamuna. So, the groundwater table is going towards the river Yamuna. You can also have a physical erosion route. So, a gaseous route, a liquid route and a physical erosion route; that means, the first question is if I put any waste on the ground solid waste on the ground in the form of a powder, will it go into the soil on its own right I put talcum powder on gravel on boulder redeposit, let us do the extremes first what is the size of boulders.

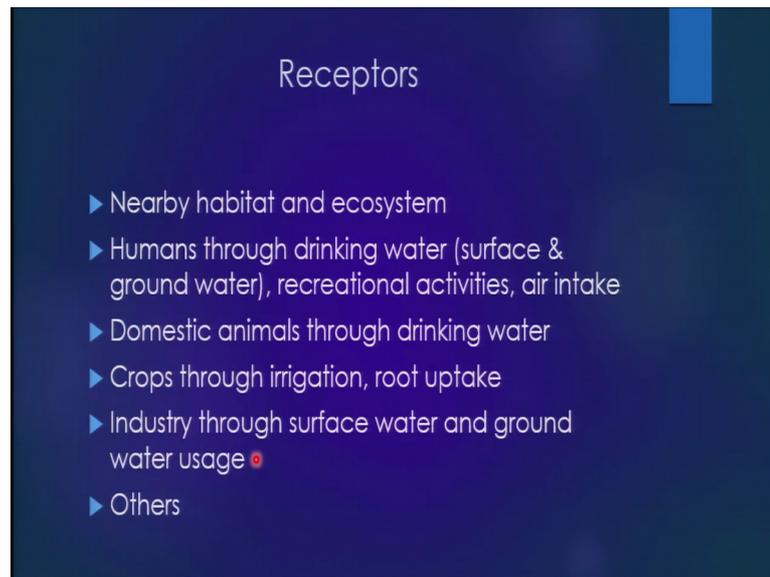
Student: (Refer Time: 47:56).

Thirty centimeters let us say boulder redeposit now I am going to help I will store talcum powder on top of it what will happen? The talcum powder will go into the voids of the physically it will travel. So, for fines not to physically travel into the soil, the filter criteria between the waste and the soil must be met otherwise some of the fines will go physically with the water into the white space of the soil below, and not very far may well travel over maybe 30 centimeters half a meter, if there is a very large difference if the soil is clay and your waste is coarse to coarser nothing will go from one into the other.

But physical erosion route the fines of the waste can travel with water and reach from one point to another. How far can they travel? If you look at the failures of some tailings dams and ash ponds, they can travel a kilometer or two kilometers, but that is impossible, but in a dam there is water and there is powder or soil or tailings, and when the breach in the embankment takes place then this slurry travels like viscous fluid, and in some cases has traveled as much as a kilometer or two from the location of the breach.

So, there are physical pathways as well. So, gaseous routes, airborne routes, surface water groundwater route and physical erosion pathways; who receives who why are we.

(Refer Slide Time: 49:45)



So, bothered they are going let them go well receptors who are the receptors of the contamination, the biggest problem is if this habitation nearby. If human beings are using this then the nearby habitat and the ecosystems. So, to the humans it the contaminant can reach them through drinking water, our water supply comes from the rivers and the lakes so that surface water or many cities rely on groundwater extraction, if you are doing swimming and boating and having recreational activities in your lake then you can be affected because if the pollutants are traveling, and humans can also be affected by the air intake. If we are living close to a waste dump and there are airborne particles this entire issue about smoke and smog in the winters with the glass wall landfill got fired this time is an issue of air pollution.

So, animals can be affected; if we are using water for irrigation purposes then crops will uptake whatever contaminants are coming the routs can uptake it, and it can come into the food chain industry uses the surface water and groundwater. So, if there are some contaminants it can affect the quality of the water being used by the industry. So, everybody here is a receptor if their sensitive environment they can be affected. So, these are the ways in which we can be effective and let me see.

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Impact

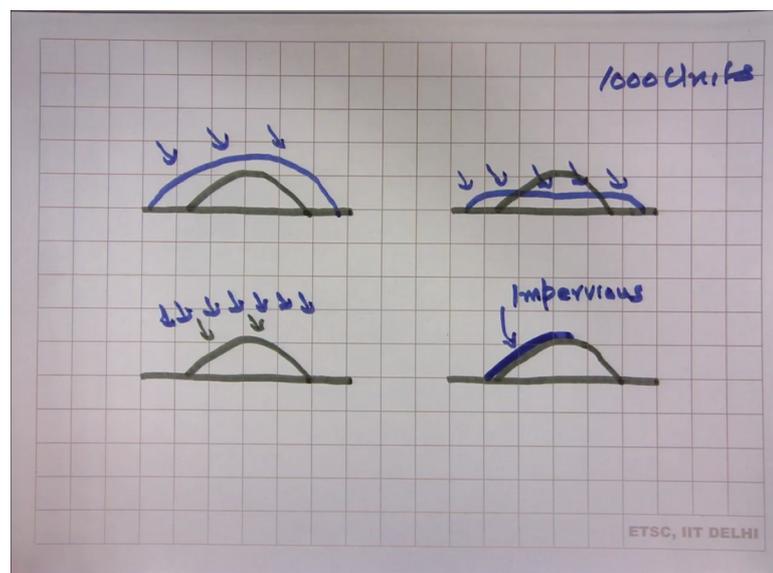
- ▶ Larger the source,
- ▶ Shorter the pathway,
- ▶ More the receptors,
- ▶ Greater is the impact



I will come back, but I would like to say the following what about the impact. Simply stated the larger the source the bigger the problem, the shorter the pathway the more quickly it can reach you and the more the receptors; this photograph for example, shows you that there is a way stump there is a Google earth shot and there are people living all around it these are houses some sheds some houses some residential area.

So; obviously, if anything is coming out from this it is going to impact this area, a simple thing like bad odor it can be affecting everybody around this area.

(Refer Slide Time: 52:38)



So, let me try and articulate this a little better. So, if I am saying larger the source then let us see there are 4 situations, all the waste dumps are of same size the first statement is that if the waste dump is larger obviously, the impact will be larger because you have more surface area from which the bad order can spin, more surface area on which rainwater can fall and therefore, make more leach ate. But suppose I have the same waste dump with the same quantity; let us say the waste dump is 1000 units.

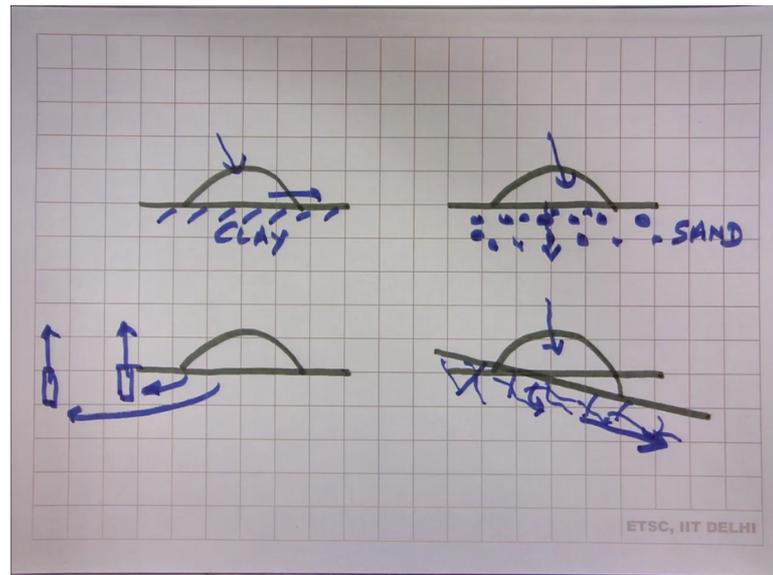
However it is display the way it has been placed is different. So, purely from leach ate point of view which source is going to have a greater impact.

Student: (Refer Time: 53:55).

Yeah the one which is spread more because the rainfall will be let us say 100 mm, it will have to be multiplied by the surface area over which the water is falling. Now if the same waste dump is coming down in height, but is being spread more than the area over which it is spread is more and quite clearly the leach ate which will be formed by this dump will have greater impact. I have to waste dumps of the same size same shape, which source is going to give me more trouble right question is this in Rajasthan or is it in Bombay. If it is in Rajasthan the total water which is going to fall on it is very less because Rajasthan is an arid area it does not get a lot of rain, if it is in Bombay it is going to get more rain. So, those same waste dump in a different location we will get different impacts, so the same.

So, quantity is not the issue, the quantity the surface area the amount of rain. So, in if in Rajasthan you are having this much rain, in Bombay we will have. So, this will produce mod leach ate and finally, a waste dump which is partly covered suppose the waste dump is still operational, but it is partly covered with an impervious cover. Quantity of waste is the same, but I have an impervious cover so obviously, a waste dump which has been partly covered with soil we will have lesser impact than a waste dump which is not covered at all. So, this is the way in which the size of the source impacts the environment what about the pathway.

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Same waste dump in four locations, and I am only looking at groundwater contamination now as I said if I have clay.

Student: (Refer Time: 56:24).

Impervious; if I have sand here, but here to the ground. So, clay and sand same size the source is the same, but the pathway is different. Two locations in one case the groundwater extraction tube well is here and in another location it is. So, the source is further away from this well. So, the pathway is longer. So, this pathway is longer this pathway is shorter. If my waste dump is in rock how will I treat it is an impervious or pervious? For quite some time we know that rocks are impervious or they are pervious.

Student: (Refer Time: 57:50).

Yeah. So, the issue is always about fracture, if they are fractures joints fissures are the pervious or impervious?

Student: (Refer Time: 58:01).

Are the more pervious than clay?

Student: (Refer Time: 58:05).

Yes.

Student: Yes

Are they more pervious than sand.

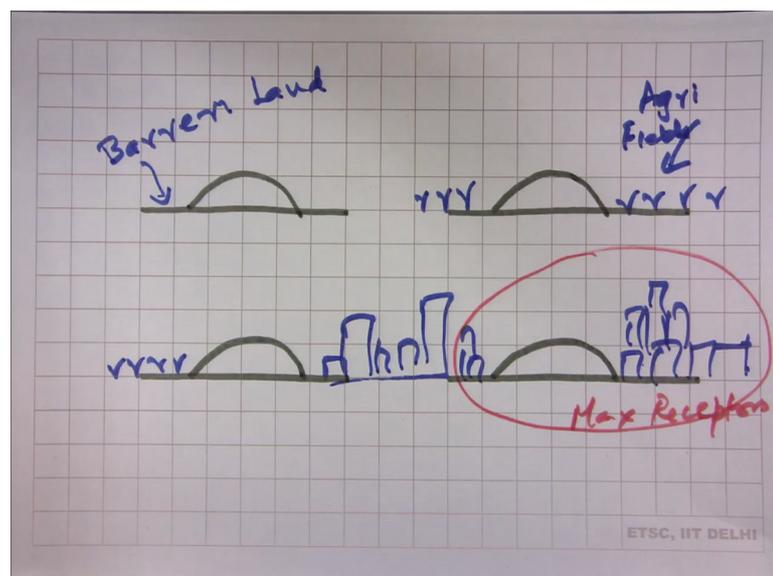
Student: (Refer Time: 58:12).

Depends on the size of the fractures, but some of them can have very large size structures. If you have rock on the surface it can also be inclined hill slope gentle slope. So, the moment you have an inclined slope your hydraulic gradient is up. So, instead of the ground being like this, you have let us say ground like this and let us say this is your waste on same quantity, but now the rock is got fissures cracks and what happens rain falls it is gets into these cracks and then travels along these cracks.

So, competent rock is impervious, but we rarely have competent rock on the ground surface, we have fractured rocks on the ground surface. So, many a times you will find that shorter pathway not because the distance is less if the well, but because the permeability is higher and finally, we talked about source, we talked about pathway let us talk about receptors same.

Student :(Refer Time: 59:40).

(Refer Slide Time: 59:41)



Same size of the dump same soil conditions underneath. This dump is sitting on barren land this dump in the middle of agri fields agricultural fields, this dump to a outskirts of

a city and this dump has sitting on all sides. Same dumb same size same subsoil same rain, but look at the receptors maximum receptors here. Larger the source shorter the pathway, more the receptors greater impact and whether it is a dumb or a pond it holds. So, if you look at it historically waste dumps or waste ponds were first kept outside the cities far away 2 to 3 kilometers. The city is continued to grow because population does not stop they go vertically and they go horizontally, and then the city will reach the dumps and then they went around the dumps and then dumps became part of the city and for that I go back to the slide which I was showing you.

If I say if I look at the slide it is the statement larger the source shorter the pathway more the receptor greater the impact. If I look at the slide you see the landfill here and the houses all around it and with these situations it is there in Delhi, it is there in Bombay, it is there in all the major cities of the country and these have a great potential. And now the Deonar landfill fire in winters caused shutdown of schools for several days the smog in Delhi a month ago was attributed to the landfill fire at Melasma landfill these are beginning to impact the way we live and there was a court judgment at all landfill fires should be put out, but these fires are not like fires on the surface you can bring the fire tender and the dump is 20 meters deep, you extinguish the fire on the surface and the fire continues to smolder inside and it requires special action.

So, we will stop here today we have seen the sources of contamination and their impacts, and we will continue the discussion later, but I am open to any queries or questions that you might have or anything that is bothering you. Any issue any problem which you have felt in your city relating to dumps or even with ponds or any contamination issues then in the next class we will take up the interaction of the waste with the soil to assess how contaminants from waste travel through the soil in the subsurface environment.

Thank you, have a good day.