NPTEL

NPTEL ONLINE COURSE

Ecology and Environment

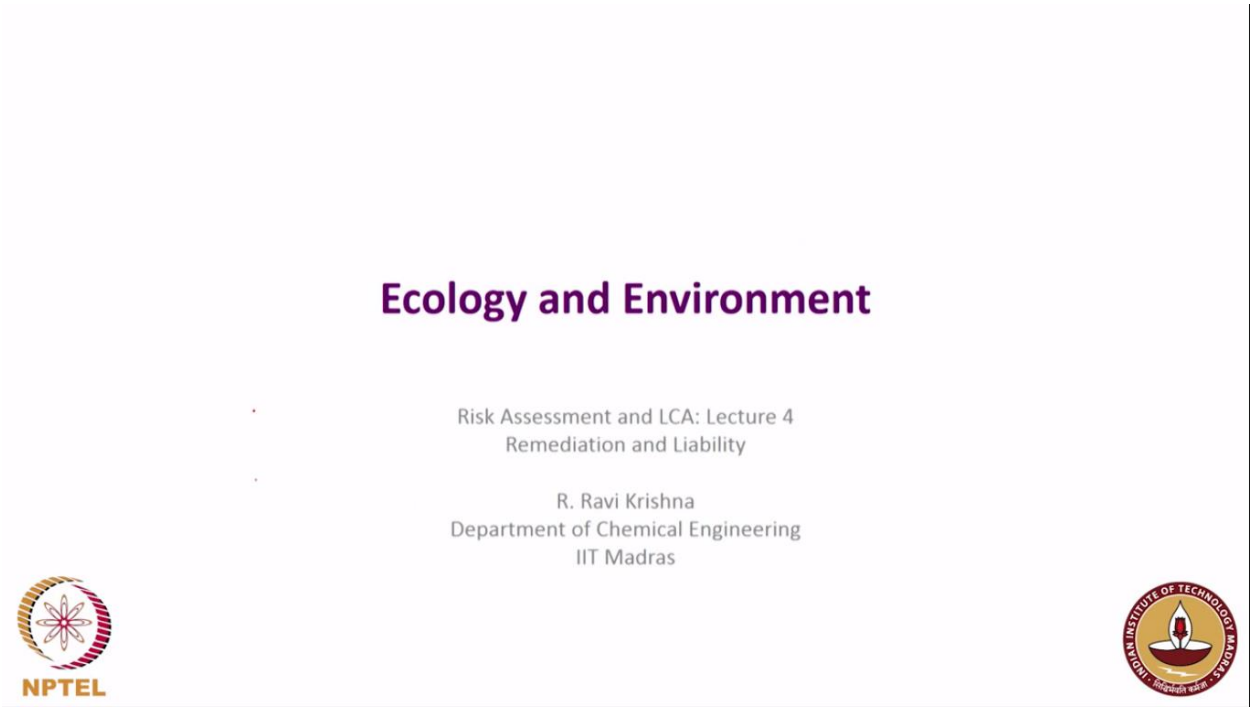
Risk Assessment and LCA: Lecture 4

Remediation and Liability

Prof. R. Ravi Krishna

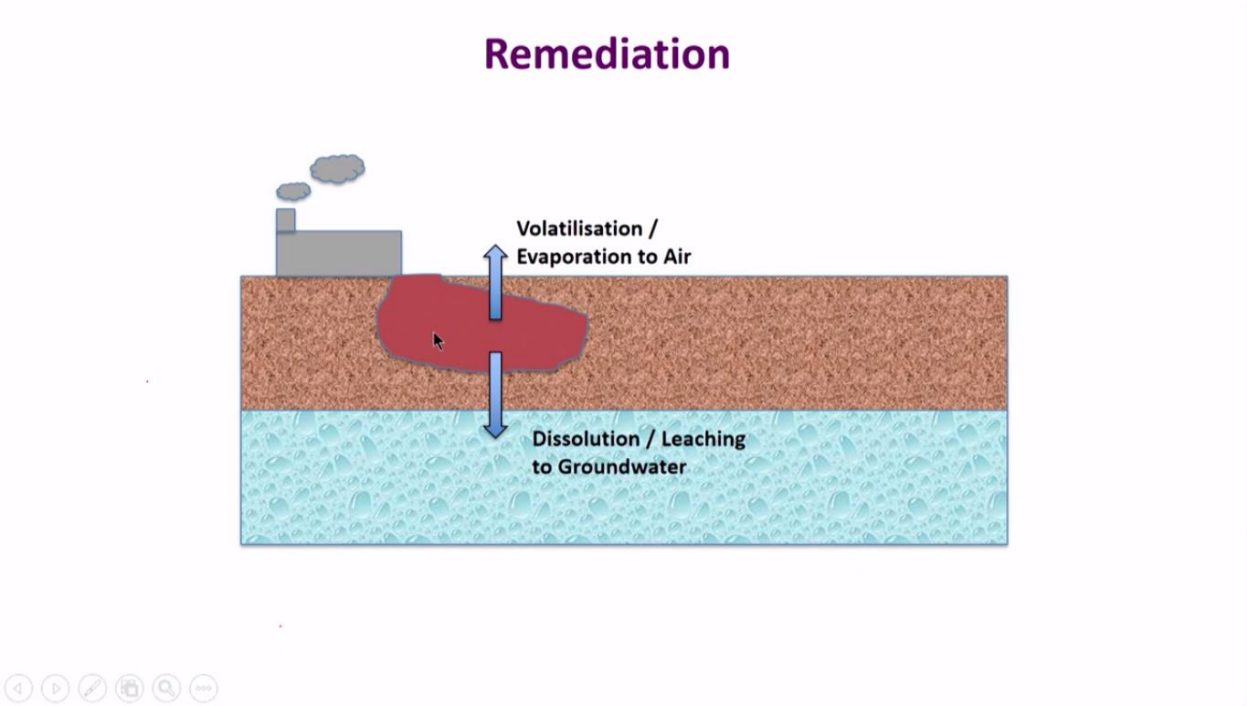
Department of Chemical Engineering

IIT Madras

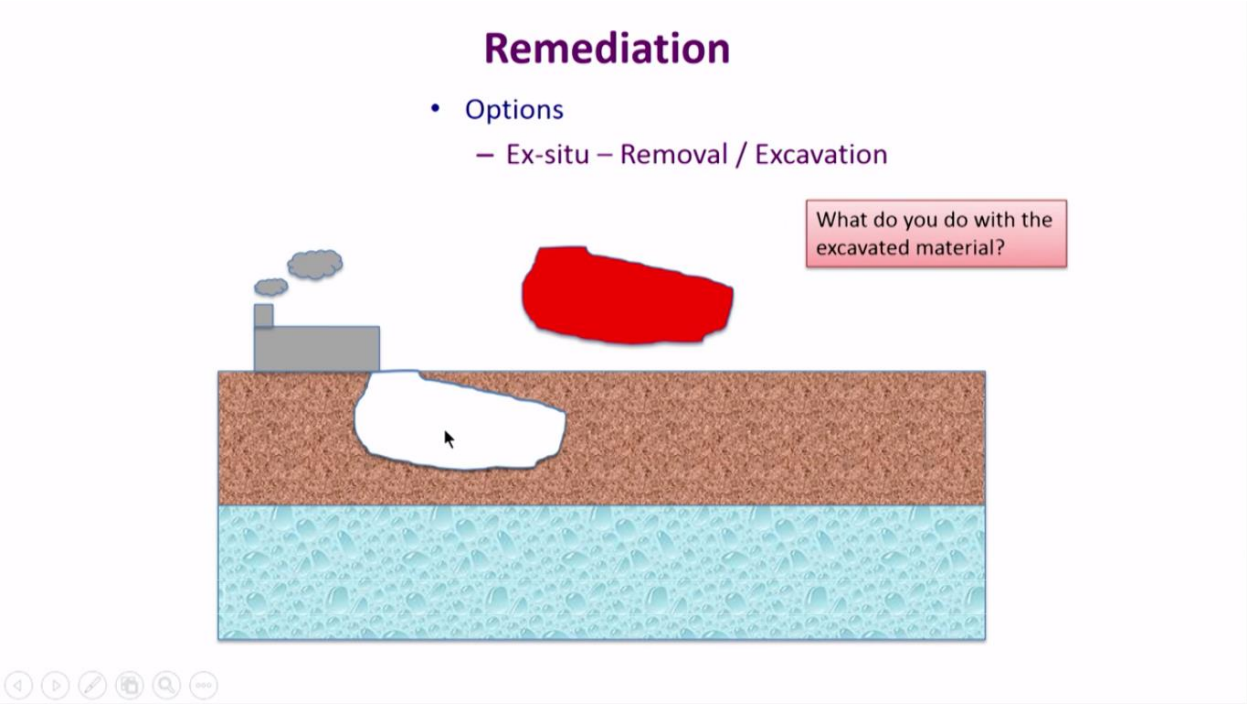


Welcome to lecture 4 of the series of risk assessment and LCA module, the course ecology and environment. In the last three lectures, we discussed various aspects of health risk assessment and the pathways by which contaminants can reach receptors and cause health effects, and we looked at the linkages between different sources and different aspects of our current society where we use different products and different processes.

In this lecture, we are going to look at remediation soil and sediment and some aspects related to health risk assessment related to this. In the last few lectures, we discussed the water and air pollution. Here we are going to talk a little bit about the third aspect of control where we say remediation. It is not really control as the word says remediation is a treatment option something some damage to the environment has already occurred, so we want to rectify it.



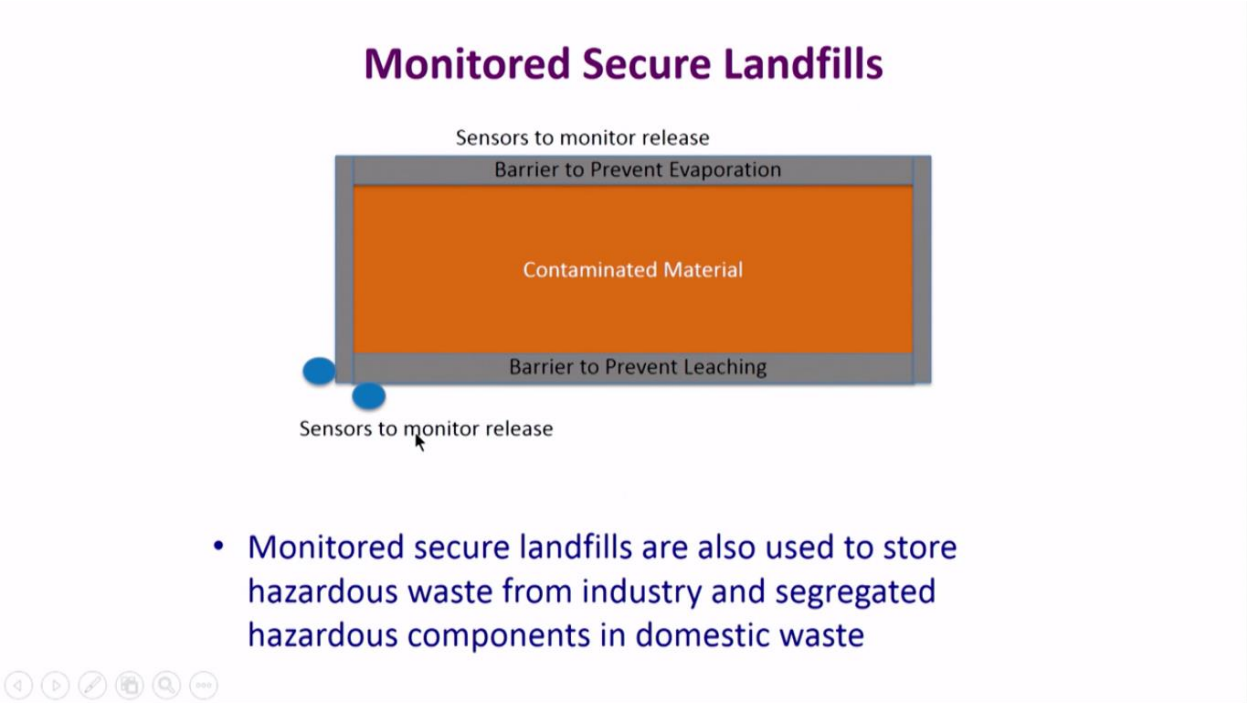
So, we look at remediation first from a soil pollution perspective. So, let us take this example in this schematic where we have this is a soil system. We have a small set of contamination here, and from this, there is a possibility of evaporation of this chemical through the soil to air, and there is also a possibility of leaching to the groundwater by dissolution. So, if this kind of thing and we look at this particular scenario where there is this is occurring in a perimeter of a factory or some processing facility where there is nothing here. It is all open ground.



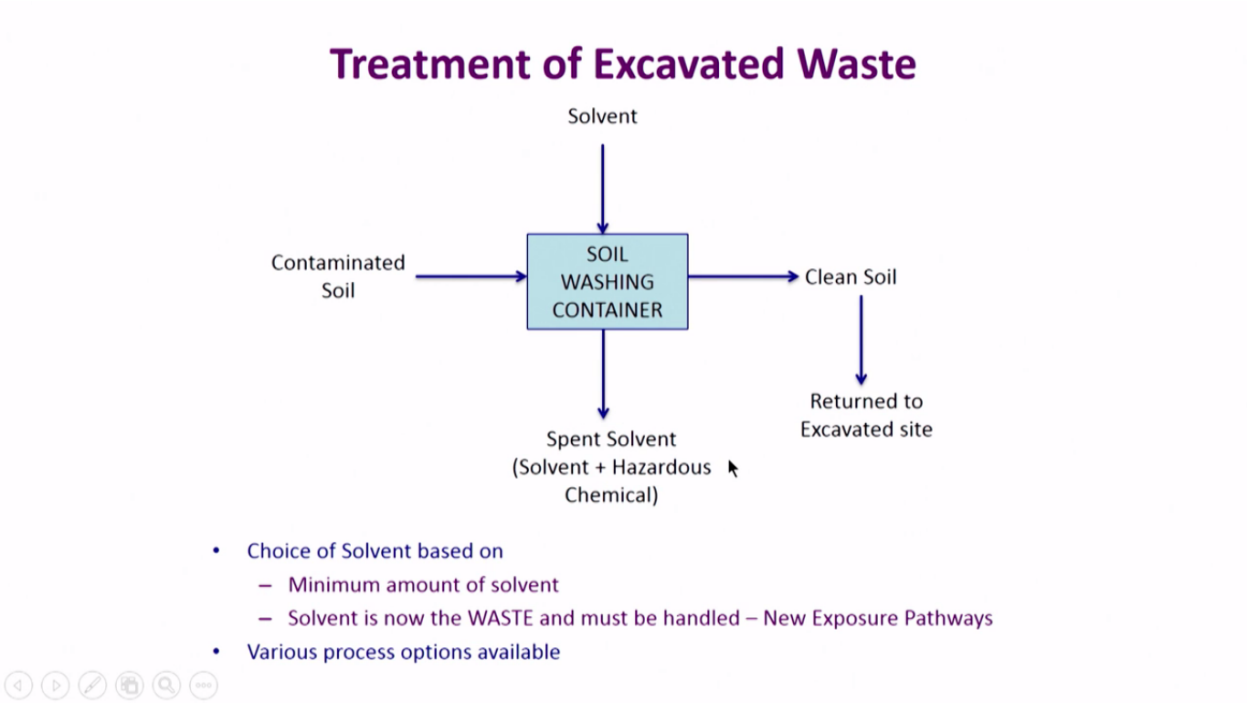
So, there is a possibility that exists we can do what is called as an Ex-situ option. We can remove the option that we have is that of removal of this entire contaminated zone. So, we take it out by excavation and then there will be a gap here that will be filled up with any clean material or a filler or anything that we want to do, and it is possible to do this. I have shown it schematically here.

So, once we remove it, we have various options that now we can work with. So, what do we do with the excavated material? So, what we have now done is we have transferred the contamination from this area to this mass of soil which something has to be done and the different options that we have for disposal of the excavated material. We have to worry about it and think about it a little critically because this is now a new waste material. It is not in its original form, but it is still waste, and new exposure pathways can also form from here.

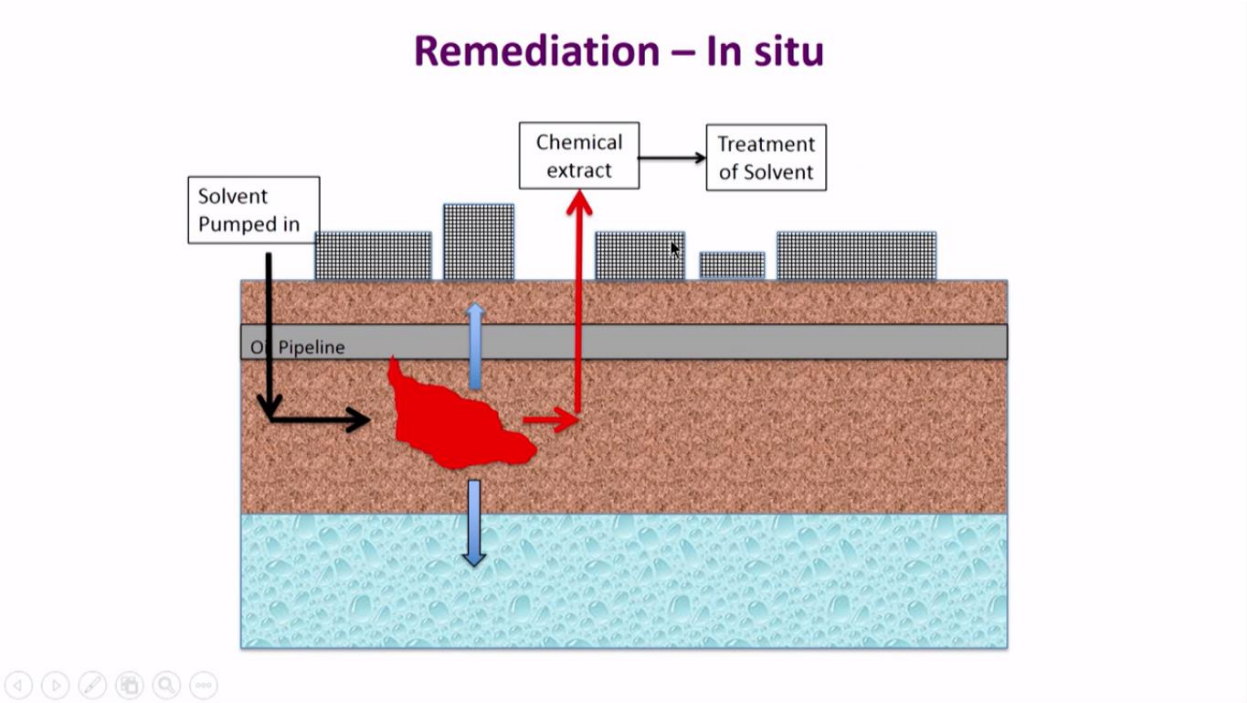
So, it is hazardous it has a chemical that you do not want in the soil, and so forth it can cause damage wherever it is. So, where do you put it? And one of the most common refrain, one of the most common comment from people in our communities is it "not in my backyard." So, this is a very common phrase in places where remediation has been attempted. Is that where do you, if you dig up a large amount of contaminated soil in some area and where do you put it and so wherever you put it there is going to be some somebody who is not going to like it because of this new exposure pathways and so what can be done? The obvious option is in nobody's backyard. So, nobody's backyard means we do not want to put it anywhere. So, what do we do? So, we put it, one option is to do what is called as a monitored secure landfills. The word landfill is a is a generally loose used term where you put solid material into a pit in the ground, and that is it. So, the word secure here means that it is now well designed such a way that it does not allow the usual exposure pathways and therefore it is contained, and the other option is to treat the contaminated soil, to remove the materials from the soil and clean the soil.



So, monitored secure landfills are schematically they look like this. So, this is the contaminated material. It is there is a hole that is dug in the ground, and you have barriers that are placed on all the sides on both in the bottom, the sides and as well as in the top to prevent, in the top to prevent evaporation, in the side and the bottom to prevent leaching. Because if there is some chemical that is here and that chemical will release if the if the container breaks, usually it is secured in a container, but if for some reason due to pressure or something it breaks it will still be contained inside this chamber. And we have sensors both on the top and bottom to monitor if there is been any release. So, we look at leaching, but, whenever it rains if there are leaks in this thing. So, over a period of time what has been observed is that secured landfills do have because they are made by made by us there are no absolutely fail-safe materials. They are always likely to have some failure at some point in time; how long in their usage time this will happen is the question that people try to answer in landfill design. And it has to be monitored from time to time in order to. So, they have strict barriers which does not allow leaching which means rains, the rainfall is not allowed to percolate inside, therefore, it cannot leach any chemical. Despite all these protections, people are still a bit not so trusting of monitored landfills, but I think this is one way in which we can engineer a containment facility, and this is done for a large amount of hazardous waste which we do not know how to treat, or we do not want to treat for economic reasons. The other option is to clean the soil.



So, there is a contaminated soil, it goes into a soil washing container, and you add a solvent, and the clean soil that comes on it can be returned to the excavated site, original site and this clean material goes back there so that you do not have to buy a new material. You clean it so you can treat it on site and put it back. So that is economically viable, and this spent solvent of course now is a new waste. It is a new waste stream, and so this has to be treated, and whatever technology is available for us to treat it we have to use it. The question here is a choice of solvent that we use. So, if you can look at it, the analogy here is similar to that of washing clothes, washing machine something like that where we are trying to remove dirt and oil and grime from clothes. We use a detergent. So, a solvent that very small amount of solvent that needs to be used so that we are minimizing the amount of the mass of the solvent that contains the hazardous chemicals. So, we are taking say thousands and thousands of cubic meters of soil and then we are removing all that contaminant into a very small volume. So maybe a drum maybe you can take 10,000 meter cube of soil and contain all the wash in maybe a thousand liters. So that is a – it is a very large reduction in the volume of waste that you have to now manage either store it, and then this can be put it in a landfill if you do not want to treat it and there are various options for treatment that are available.



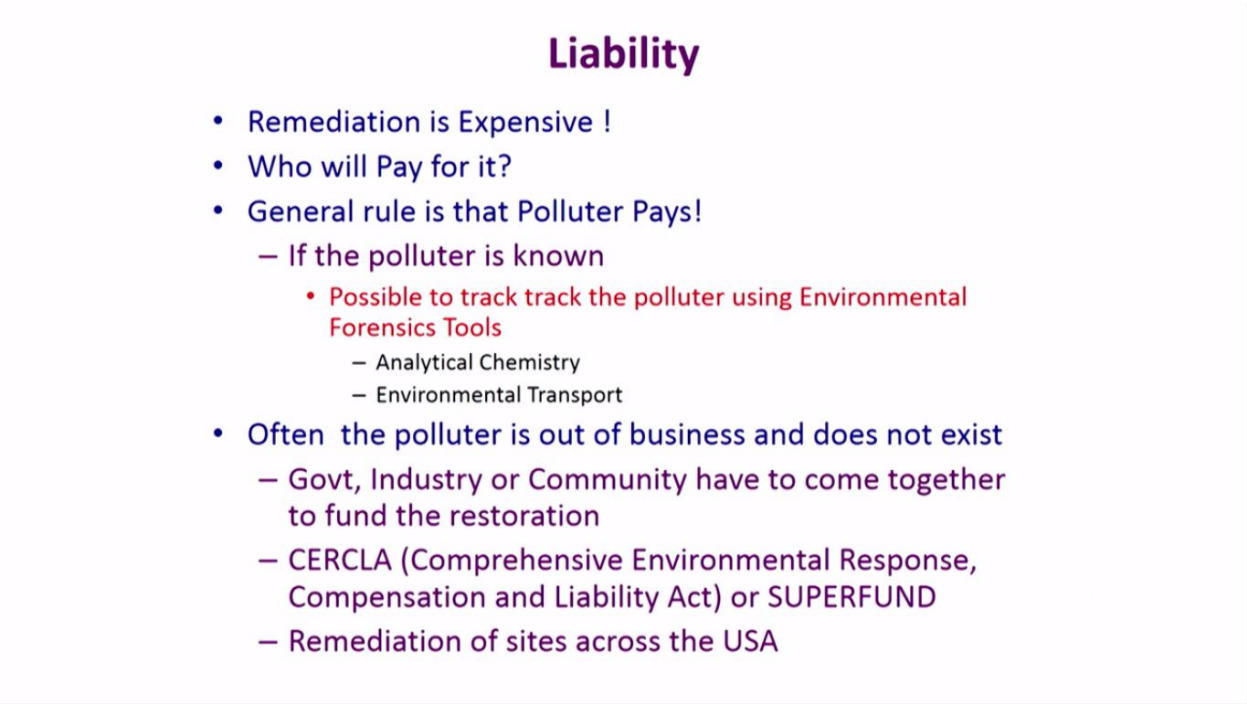
The other scenario of soil remediation is in this kind of case where there is an oil pipeline that is running in the soil. So, this is a very common scenario, but on top of it we do not have an industrial setting we have residential or commercial buildings and therefore excavation, if there is a leak in from the pipeline which also results in pathways of exposure, excavation is not possible because you have these buildings here which are residential or commercial. They have been built, and this is quite often this is a case, and you cannot do anything about it. So, so one has to then device in-situ options where you do not have to – everything is in place and treatment is done in place. So, this is one of the examples of an in-situ option that you pump the solvent in through a network of pipelines here, flush it across the zone here, and pull it out. And this extract that is pulled out is a similar to the extract that comes from the soil washing container in the previous slide and then we have to treat the solvent. So, this can be done either on-site, or it can be taken and done it separately and elsewhere.

So in all this process, there is again a secondary risk that is posed, because of these processes and the and the– if you do not want to disturb the commercial and residential activity of these people living here then you have to take extra pains, extra care to all the more. Take care of health risk assessment a little more than what you would in the previous case where excavation is possible in an industrial site where the exposure is going to be something which is similar to occupational exposure as we talked about earlier.

So, some of the logistical difficulties in in-situ remediation is accessing the waste can be a problem as we saw in the previous site, and waste that can the extracted must be treated on site, and then we also have to take care of preventing new exposure pathways. So, we try to create solve one problem, and in the process, we create newer problems which are equal or greater in magnitude for exposure then we have a problem. So, this is quite commonly the criticism that comes to remediation, people are overzealous and remediating something, and this is where risk

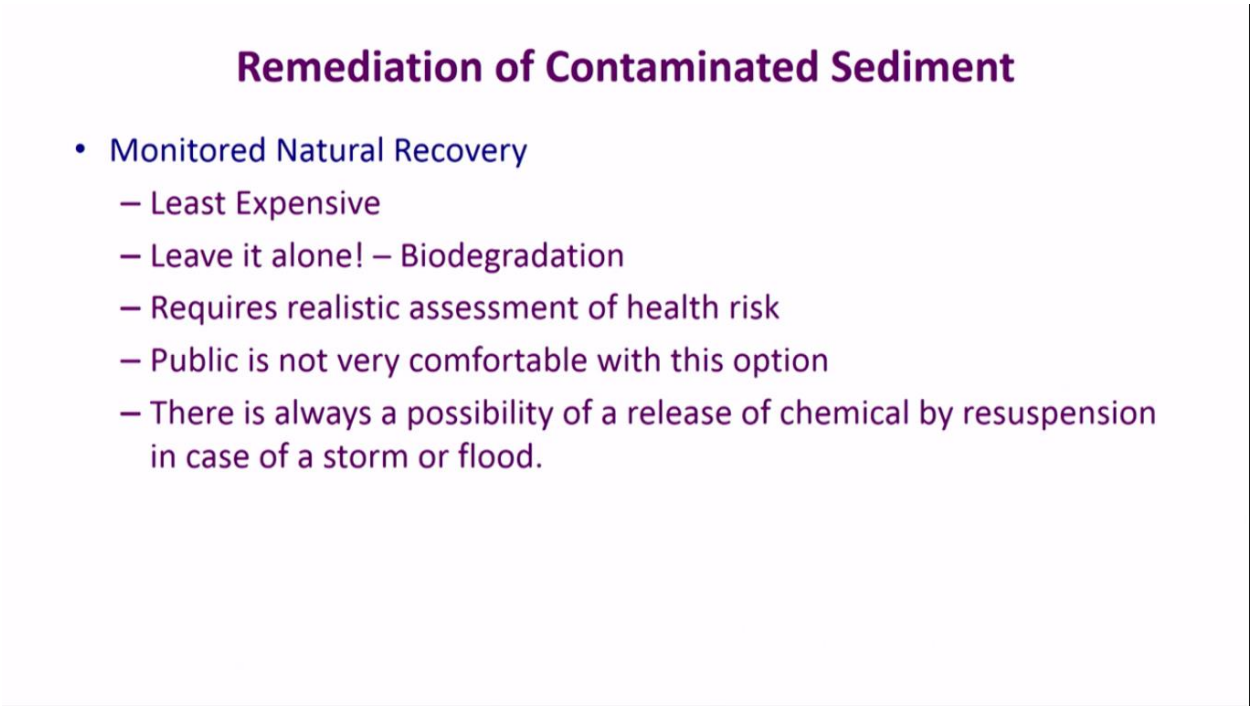
assessment comes to very important use in making these decisions whether to do something and how to do something.

And the other thing this also gives us some insight into locating or sighting of hazardous material processing away from residential place. For example, we will definitely not want to have an oil pipeline running below a residential area. So, with given that if you have it then we have to have safeguards in place where remediation is possible, and this is something that one has to take care at the time of planning, at the time of urban planning this has to be done very judiciously otherwise there is going to be problems later on. So, this comes as part of the design, and so this is a very common problem because one of the things that we see is that for 20-25 years back we have industrial estates associated with cities which are far away from the city, which are about 20-30 kilometers from the city. So as the urban area, the metropolitan area has grown and many of these cities now the industrial estates are surrounded by residential area. So, the original design of segregating these places where exposure to common public is minimized is now not an option because people have built houses around. So, either you have to re-engineer or retrofit these companies with safety equipment that meets the standard for ambient exposure, or they have to be closed and relocated elsewhere. So, and this is a question that goes into urban planning, and so we see this holistic approach that is necessary in order to do anything in our society.



Now we come to the issue of liability, and the main reason for liability is this remediation is expensive. So, if you can imagine if I have to excavate a thousand, a very large amount of material and this cost is going to be prohibitive. So, who will pay for it? See the general rule is that the polluter pays if the polluter is known. So sometimes there are a lot of industries in a given area, and we see contamination in the soil, and it is possible to track the polluter using

what we call as environmental forensic tools which include analytical chemistry and the transport of pollutant. We saw some of it in the previous few lectures, and if the polluter is known then we know sometimes it is very clear. But oftentimes if it is historical contamination, which means that it has happened several decades ago, and the polluter is out of business or does not exist anymore, and then others have to get in, and industry or government have to come together to fund the restoration. One such example of that is what is called a CERCLA in the United States or it is also called as a superfund. It is called a Comprehensive Environmental Response Compensation and Liability Act and a large number of sites have been where -- so this is a comprehensive, this is a fund that is that is created by the government with the industry and the community, and then they fund this common these things.



So, in this context, we also look at remediation of contaminated sediments. So contaminated sediment is something that is there underwater as we had mentioned in the last lecture and one of the cheapest options is to do what is called as a monitored natural recovery. In the previous few slides, I had mentioned that sometimes if you if you find contamination in a given site, perhaps one of the options is to leave it there because it may not cause as much damage to risk, health risk. If you leave it there rather than disturb it and doing anything can sometimes be worse than not doing anything. But this is not universally true, and it is also a very uncertain. It leads to a lot of uncertainty, and therefore the public cannot handle it.

So, in this particular option of what is called as a monitored natural recovery we leave it alone, but we do not leave it alone it. We monitor what is going on. We monitor how much of chemical is coming out of the water, out of the sediment into the water and we hope that bio-degradation will occur over a period of time and it requires a realistic assessment of health risks and one cannot cut corners here because we are not doing anything with the hope that the measurement of

concentration in the water is below the limits of health risk limits that we estimate using toxicology tools. The public is usually not really comfortable with this option and that is one of the major reasons why people do not look at this. This is an option that is very convenient and easy for the person the entity who is liable for cleaning up a particular waste site. So, the reason the public is not very comfortable is that there is always a possibility of release of the chemical by resuspension. If the mud in the sediment gets churned up for whatever reason and one of these reasons can be a storm. So we see that once in a while we hear a big storm, storm of a century or storm of the decade that comes through and churns up sediments and takes big bunches of large section of sediments and puts it downstream and it churns up the water and the water gets contaminated and it can also go to the floodplain and the floodplains get contaminated, soil gets contaminated and so on.

So, a whole array of secondary effects are triggered and therefore people are not very comfortable. People are also not comfortable because there is a possibility of human intervention, you know some accident and therefore the other option people look at is remedial capping or barrier. This is a relatively expensive in-situ option. It is not as cheap as a monitored natural recovery because something has to be done. In this case what we are doing is like a landfill we are putting a barrier at least on the top. So, we are covering up the contaminated zones so that it does not allow as easy of transport of the chemical into the water. We are putting a barrier on top of it, and the capping design is based on you can use different materials like sand or any engineered material which have different properties, and there is lot of these things have been done, and this again is done on the basis of health risks because this barrier will not last forever. So, it will get used up over a period of time it will get saturated and it will allow material to go through but it may allow it at a very low rate and that low rate is probably sufficient to manage the health risk and this has to be again based – this has to be on the basis of a realistic assessment of health risk.

Logistically sometimes in certain areas you can use it without any problems but someplace like navigational channels or harbors it is difficult to put a barrier because this barrier will then obstruct navigation and therefore can result in the destruction of the cap and further damage.

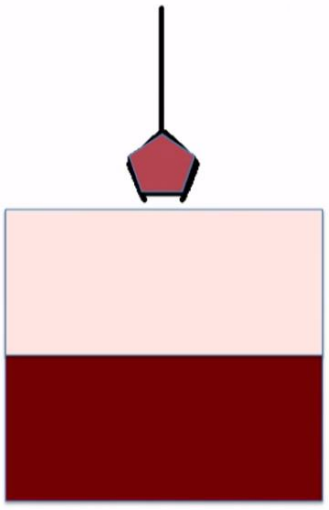
Remediation of Contaminated Sediment

- Remedial Capping (Barrier)
  - Relatively Expensive in-situ option
  - Design of capping materials based on realistic assessment of health risk
  - Logistically, suitable in certain cases
    - Not suitable in places such as harbours or navigational channels
  - There is always a possibility of a release of chemical by resuspension in case of a storm or flood.

So, of course, there is always the possibility of this big storm coming and destroying the cap and the sediment below.

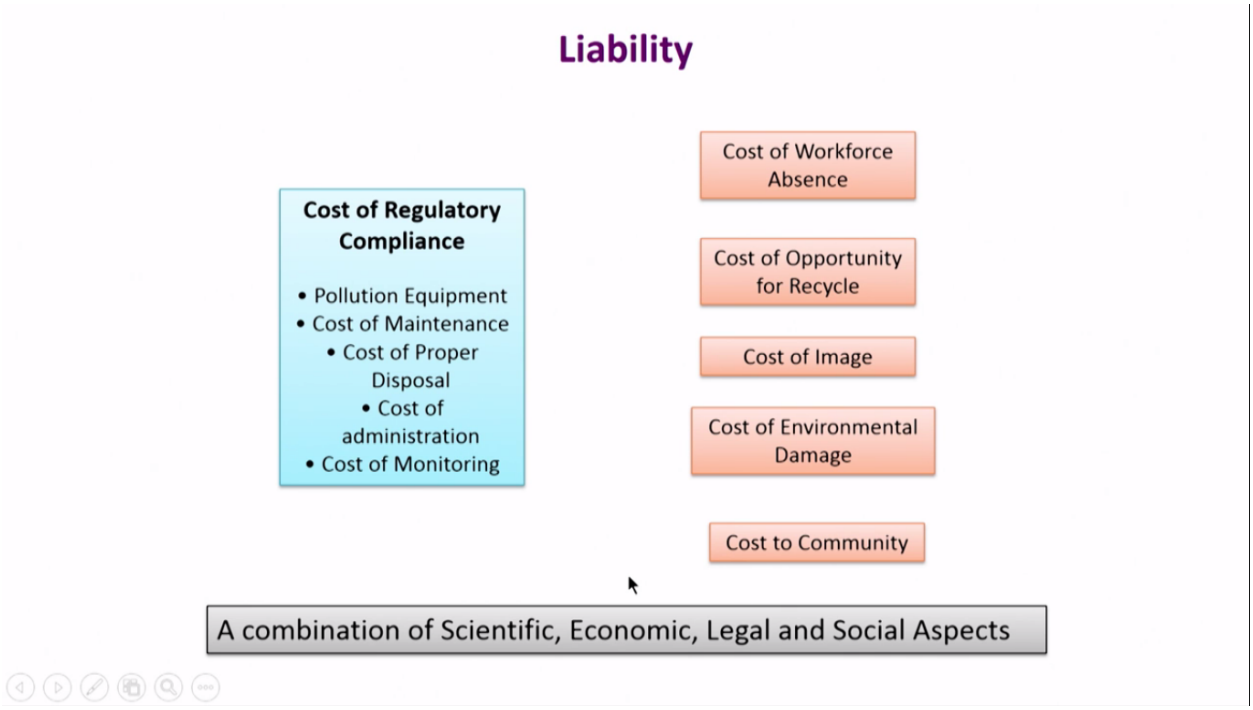
Remediation of Contaminated Sediment

- Dredging
  - Most Expensive option
  - Removal of contaminated sediment and relocation
  - Since it is an invasive process
    - Can result in resuspension of sediment
  - Dredged material has to be kept stored somewhere
  - Secondary pathway of exposure that must be assessed for health risk



So, the third option is called as dredging. Dredging is the removal of the contaminated sediment from the site and relocating it. It is the most expensive option because it involves a lot of work and a lot of post-processing and it is an invasive process and therefore can result in other secondary effects, and so we look at the small schematic here. Dredging is done by a mechanical device which goes into the water picks up the sediment and comes out and puts it somewhere. So, it is like an excavator except that it is underwater. So, look at this animation it goes in, picks up the material and comes up and what happens in the process is when this happen, when you do this it will result in a resuspension of the sediment and the water can get dirty, really dirty and this is a secondary effect.

So, in the first case, you have left the sediment in there, and it is contaminated, but the rate of release is certain value, and it can cause a certain health risk but by doing this you may be increasing the health risk both the air pollution and water pollution, and therefore this is a problem. So, this is one of the reasons why you know if you do dredging you have to be careful about adding on secondary effects. That is one problem. Secondary problem is the dredged material which you have removed now have to be kept somewhere, and so this is again the same problem, not in my backyard problem. So, this is an issue that one has to take care of and while doing all this, you have to again worry about secondary pathways. For example, if I put it on to a barge and do a lorry or a truck and carry it somewhere, it is open, you have to worry about closing it and taking it somewhere and again depositing it somewhere where it is again likely to cause leaching, and so there is a whole set of other options that you have to look at.



So, coming back to this concept of liability. When we talk about liability, we are talking about a cost. We are talking about the cost that the person who is responsible, the polluter pays philosophy has to bear. So, in the overall philosophy of liability if you do not want to have – people have liability because they have not taken due diligence in the process, in their original

process where they are supposed to have kept some safeguards, and they are supposed to have done something right, and they have not done it. So, what we call as regulatory compliance. If you do not do regulatory compliance, you are liable to any damage that occurs to the environment. So, there are arguments that are placed that if you do this, maybe you won't have any liability. You do – you invest in pollution control equipment, you maintain all your pollution equipment, you take care of proper disposal and cost of the administration and monitoring and auditing and everything correctly. If you do not do this, you have other costs which are not obvious straight away. You have of course you are liable to damage but then you are also the regulatory agencies try to monetize the lack of regulatory compliance in these categories that are listed in the in the right hand side. This is cost of workforce absence. So, in the case of safety for example if we do not have safety equipment for worker exposure it can lead to loss of workforce due to illnesses and all that and that is a cost to the company and you can also lose an opportunity for recycling material.

So, if you do not want to release it in environment and one option is recycle it within your process and that is a – it is an added benefit and asset to the company, and that is – if you are not invested in that, then you lose the opportunity of doing that. You obviously have a cost of image. So, if somebody comes to know that your corporation is polluting and there is a lot of media coverage, and there is a lot of campaigns against that corporation, and this can happen. This we have seen it happens so many times and there is a cost of image and people go on record asking people to not to use certain products because it causes a certain environmental damage. Then you also have the cost of environmental damage itself, in the sense this there is some contamination that occurs and that is a cost. So, you have to pay that. The liability is directly linked to that cost of environmental damage and the cost to community. And these are all – these are all, cost to communities is a vague thing but sometimes the community and the workforce is all the same. So, you will have some, and there have been cases in history where this has been very serious, and that companies have gone out of business because of this because they have not thought about all these things when they are designing the process.

So, it is a combination of scientific, economic, legal, and social aspects liability and scientific is only one part of it. So, one of the things that people have to keep in mind with all these other things when they are designing a process or a product in a particular corporation.

So, in the next lecture, we will review a case study in which some of these issues will again come up, and you will see an application of this coming up in a scenario that you can relate to based on lectures that we have had so far.

Thank you.