NPTEL

NPTEL ONLINE COURSE

Ecology and Environment

Risk Assessment and LCA: Lecture 3

Transfer of Pollutants in the Environment

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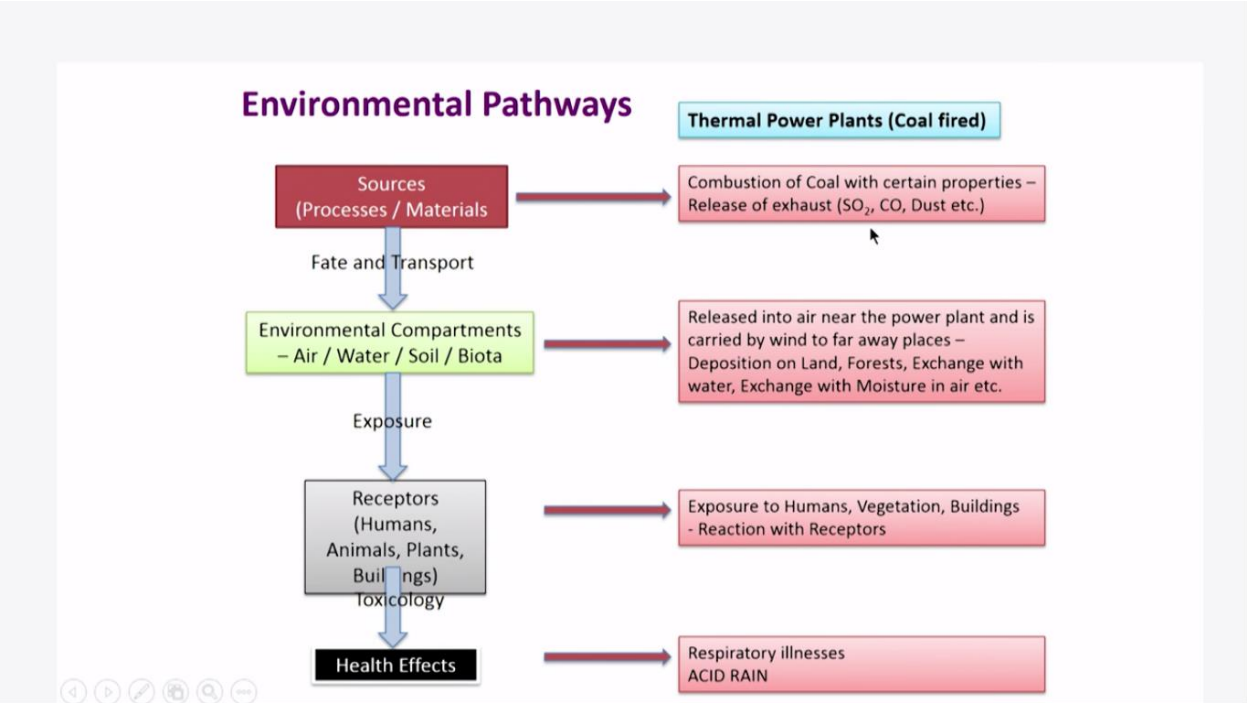
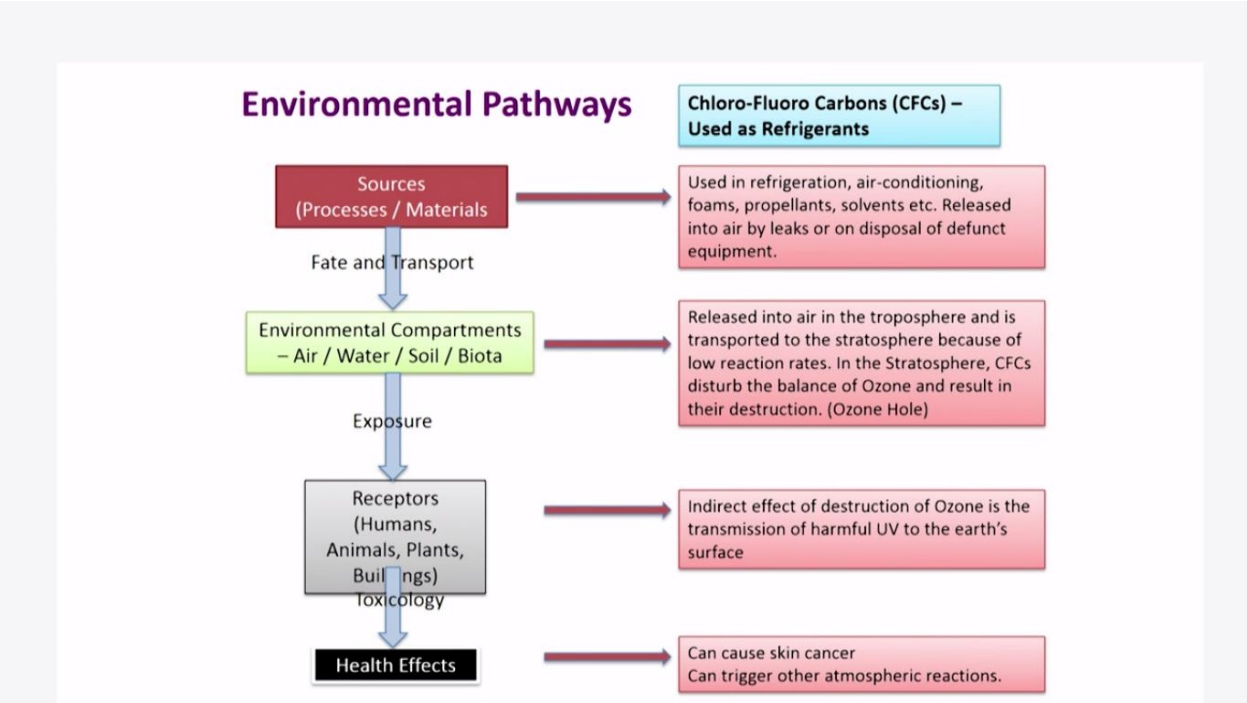
Hello. Welcome to the third lecture in the series for risk assessment and LCA in the ecology and environment course.



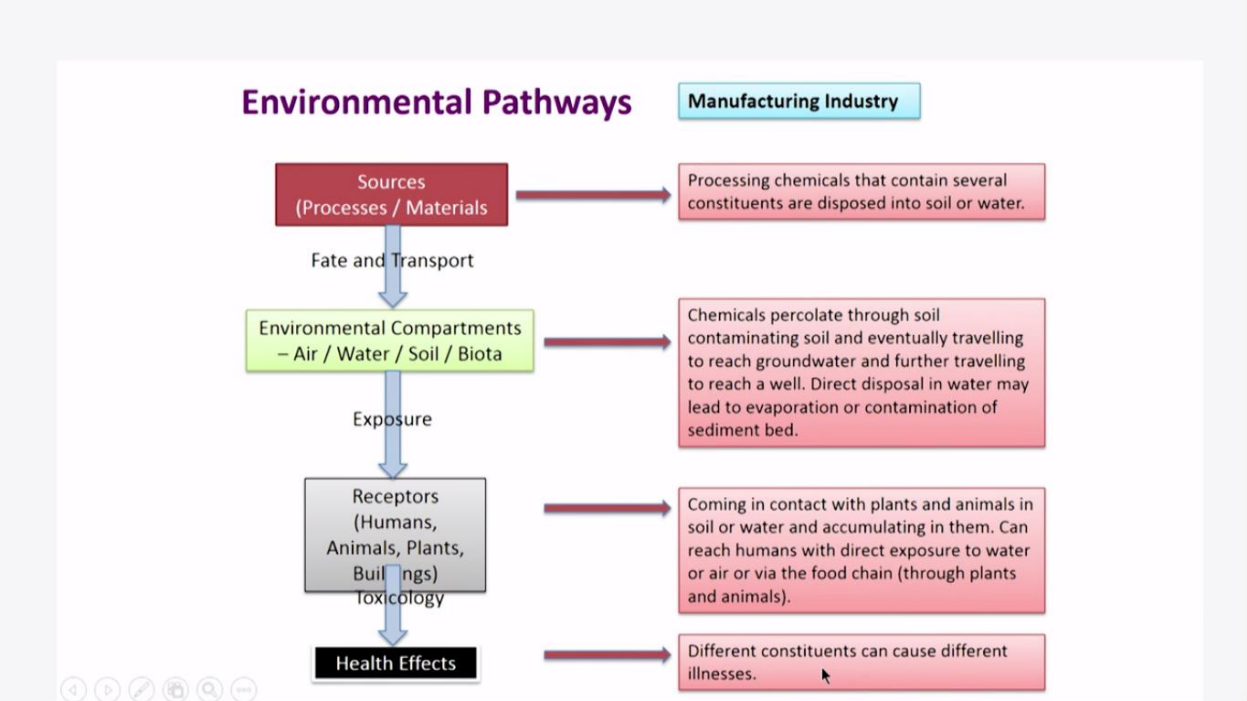
In the last lecture we looked at transport of chemicals from the source into the environment and to receptors and different scenarios in which it can happen, and some simple mechanistic ideas about that. We stopped at a point when we pose this question; can we do anything about these health risks? And we look at the different options we have and where we can intervene. Before that, we look at some examples of what we call as the sources and what are their effects.

So, in this we have a series of the pathway of the pollutant from the source to a receptor in terms of health effects is given here and corresponding to this I will give you a few examples. For example, at thermal power plants are coal-fired we have the sources, combustion of coal results in the emission of certain exhaust gases and particulate matter and these are transported, released into the air, and they are dispersed and transported into the air. And there are different processes that happen, one of them is deposition, the exchanges with the land as well as in water. So, this is well-known as people have measured the rate at which materials can transfer from air into a phase such as water or land, and we also see that there is an effect on vegetation. So, that is one effect.

And when it comes into the environment, and you can get exposed directly to human beings through air or through vegetation, or it can react to buildings. So, there is instances where several buildings have had damage; monumental buildings and then there is this big case, and eventually there is an effect. So, one of the more common effects seen here are respiratory in nature for this particular source. There are also another big category of effects, which is acid rain, which came into prominence because of the acidic nature of the rainwater, because of interaction between the pollutants SO_2 and water vapor droplets of water in the atmosphere, and this pertains to the chemistry of the sulphur oxides with water and what it does to the pH of rainwater, the acidity of rainwater.



The other example, one can look at is a very classic example that is used in atmospheric long-range atmospheric transport, is that of chlorofluorocarbons or CFCs, which were used as refrigerants, air-conditioning, foams and in propellants and various applications. And it is released into air as a result of the usage or as a result of leaks or incorrect disposal or defunct equipment during that time you throw away the compressor and the fluid. So, things gets released into the environment. And it is transported into the to the stratosphere, and we saw that yesterday in the in the graph there, and there it reacts with ozone and results in their destruction. That is the ozone hole. Indirect effect of this destruction of ozone is a transmission of UV onto the earth's surface, and therefore it has effects and can cause cancer and other atmospheric reactions.

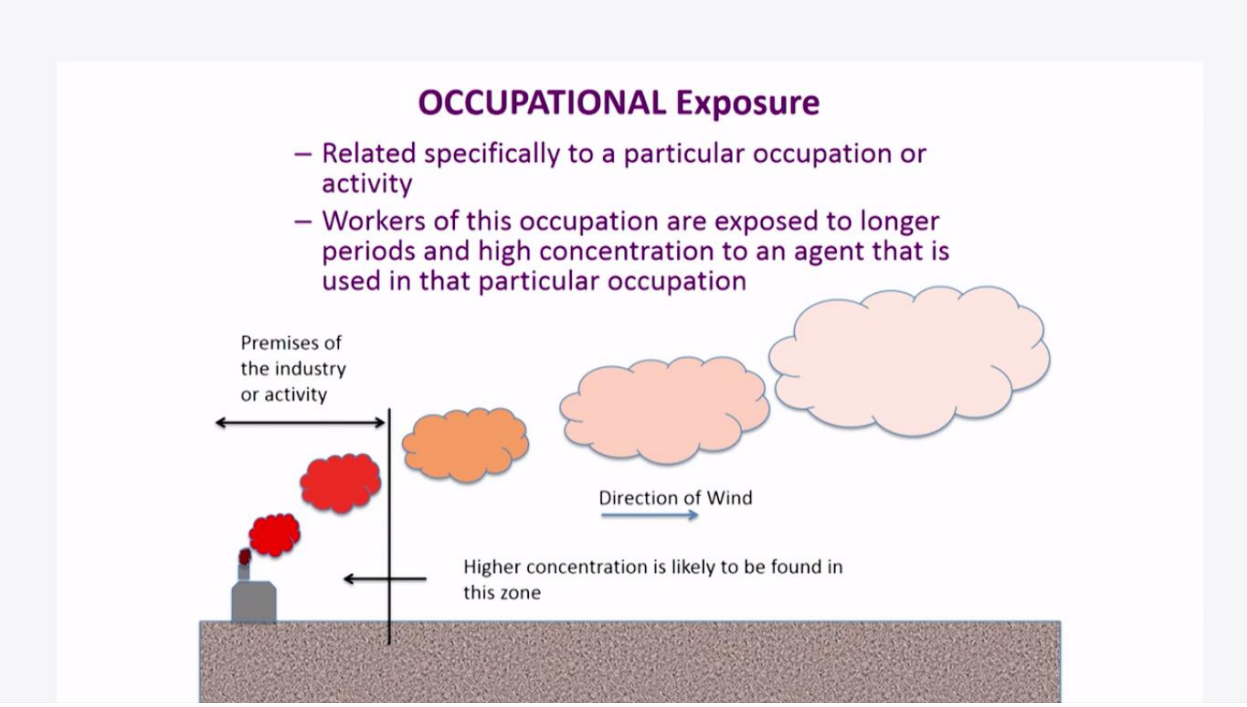


The third example is a generic example that for any manufacturing industry we have processing chemicals, several processing chemicals that are used in the industry and as a result of which there is a waste stream. In every industry has some waste stream and which may be released into water or soil or air and if they are released into the soil, they percolate into soil contaminating the soil and eventually traveling to reach groundwater and further traveling to reach a receptor through a well. And direct disposal in water may also lead to contamination of sediments as we saw yesterday. And this one can come directly into contact with the – receptor can come directly in contact with the water or air with the water and then or with other plants and animals which come through the food chain. So different constituents depending on what is being released it can cause different illnesses.

There is a category, it is a very loosely defined category of events that one is concerned about. What is this called as a planned or registered and the term is used very loosely here but what it means is that there is a known manufacturing facility or a factory or a plant which is making a product. Everybody knows about that. The government knows about it. Everybody knows. It is not a clandestine activity or vehicles on the roads which are registered. So, you can go and count the number of vehicles on the road by looking at the data of the Road Transport Authority. They can tell you how many vehicles are there and what type and all that or consumer goods sold in the market. These are events, or these are planned activities and planned products and processes as a result of which we can look at the emissions or the pollution that can come out of these things. It is known. So, one can really understand that, and one can plan for it. One can account for it.

What cannot be accounted for is accidents which are events that are not supposed to happen in the normal course of things but in all the planned and registered activities there is a possibility of an accident happening. For example, there is an explosion, or there is a spill on land, on water or underwater. So there are several examples of oil spills on land, or a ship carrying it breaks, and oil is spilt on open sea or underwater pipeline carrying oil, spills oil and we have a big problem on our hands if that happens. And there are leaks, leaks of pipelines which is an accident and then there is, of course, forest fire which some cases is natural sometimes it is human-made. So, these are one set. And there is also another set of events which are unregistered which means that there is activities like open burning. So, in the current context, open burning of garbage is not allowed by the Indian regulatory agencies such as the Central Pollution Control Board, but you see it happening from time to time at different scales, very small scale to large-scale people burn waste, organic waste. Sometimes they also burn things like plastic, and there are issues with doing that, and that can cause a pollution specific to the burning of plastic and cause different ailments over a period of time, and then dumping of waste or hazardous material on public

regulated land or water. So, this is this is similar to what when you see people there is a garbage dump, and people go and do not go and throw garbage in it, they throw it outside. So, it is equivalent of that, and this can happen. So, these are the three kinds of events that one must keep in mind when we plan for this kind of things but we cannot plan for unregistered event, but we can definitely plan for accidents. What we call as emergency management, response management. So, this is a worst-case scenario and should be planned for, and this is definitely should be planned and designed when we come to the environmental management.



So, other couple of other terms that are very specific to exposure when it comes to a source. One is this is called as occupational exposure. Occupational, we looked at exposure in the previous two lectures, exposure which is related to a particular occupation or activity it is called as occupational exposure. For example, there is an industry, and within a certain distance from the industry, which is say the perimeter of the industry, you are likely to find very high concentration. For example, you go to a construction site, in the construction site you are likely to see a lot of crushing happening or work with cement. There is a lot of pollution there. Usually, you see that the area is confined. They cover it up with some kind of a barrier so that the dust does not go out but people who are working inside are exposed to that dust. So that is called as occupational exposure. So, this occurs in every field. Anybody who is working with a chemical is likely to be exposed to a very high concentration than people who are outside.

So, as you can see this is based on a slide we saw yesterday. There is a certain region within the distance away from the source that the concentration is likely to be high, and beyond that it reduces. So, this is this zone within this zone you are likely to have an occupational exposure standard, and away from it, we call it as, it is far away. It is not under the influence directly of this particular plant.

OCCUPATIONAL Exposure

- Examples of these are those working in
  - Hazardous waste management facilities
  - Chemical manufacturing facility
  - Road laying services
  - Construction and demolition services
  - General manufacturing industry
  - Cleaning services
  - Emergency response services (including that of fire, chemical spill etc.)

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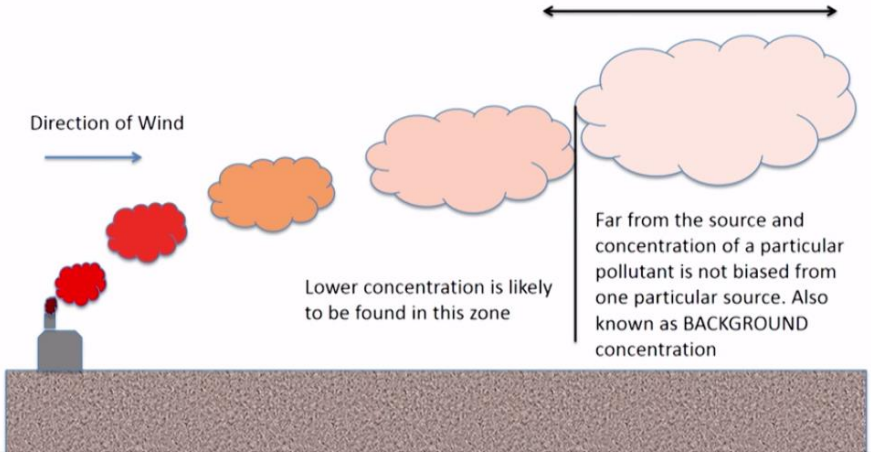
Occupational exposure examples are all this and what I mentioned in terms of construction and all that. So, there are different types of occupational exposures. There are some examples of them.

AMBIENT Exposure

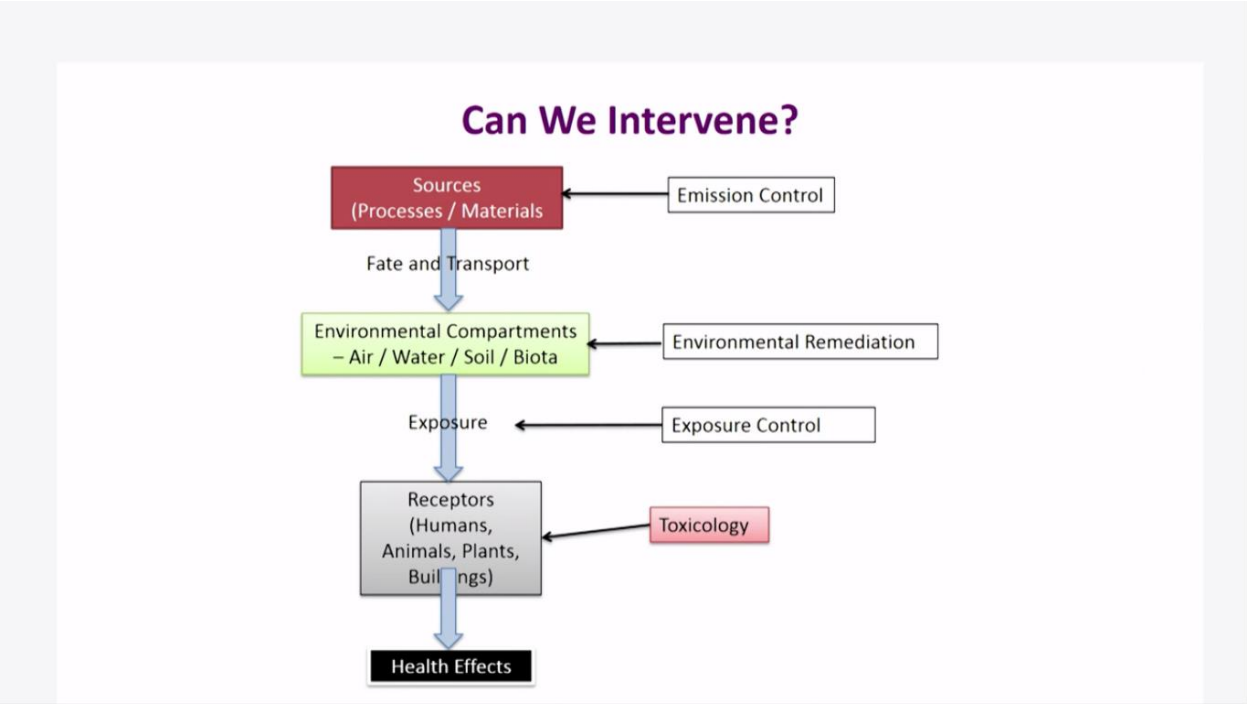
- Not associated with any specific occupation or activity
- Related to a person walking on the street away from any specific activity



Ambient exposure, on the other hand, is something that is not associated with a specific activity. So, anybody who is walking on a street and know does not have anything to do with any activity, and that person is exposed to what we call as an ambient concentration.

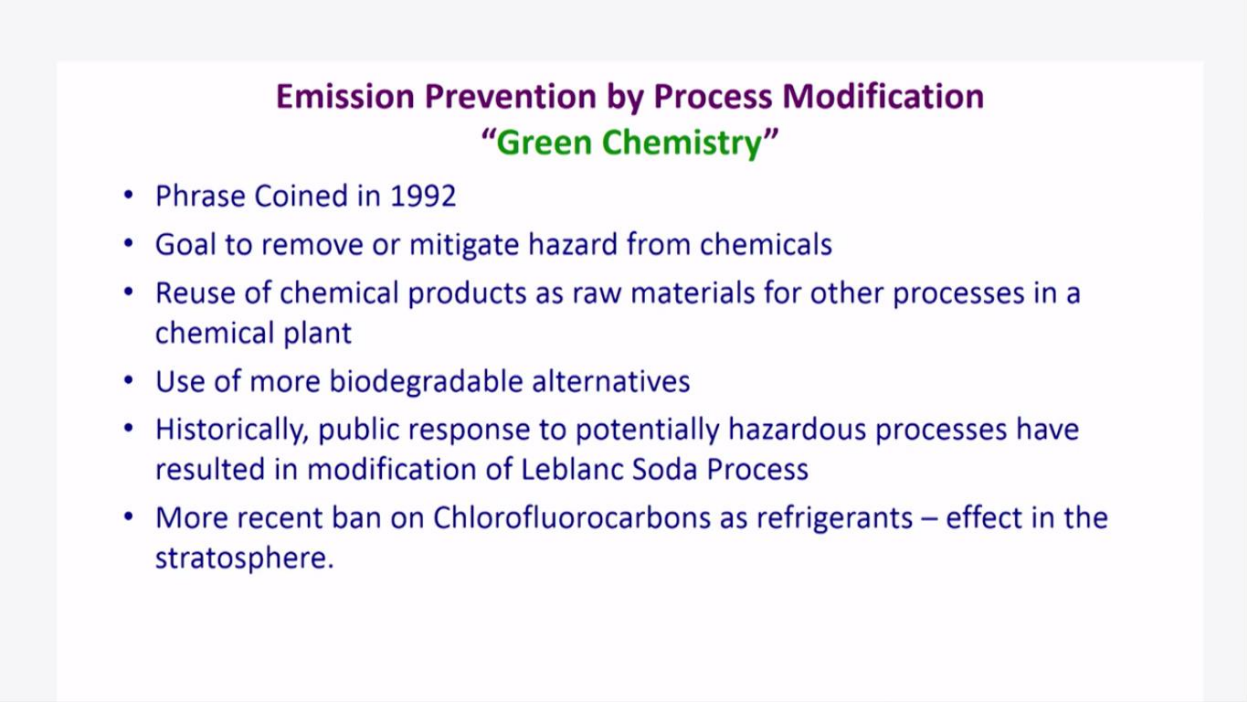
So, our focus in as a society is to maintain concentrations of chemicals below a certain level in the ambient zone. So, this is here in this same schematic we are talking about this, and it is very far away from the source. So, it is also known as background concentration. So, what we call as the background is specifically not related to any activity. For example, if you are standing next to an automobile you are exposed to emissions from the automobile, but you are standing very far away from it, you are standing in a playground that is a kilometer from a road you are exposed to something, but this something is a background concentration. So, this background concentration can increase over a period of time if the amount of pollution released into the environment keeps on increasing.

So, this is similar to what we – to the concentration of CO_2, the background concentration of CO_2 or the average concentration of CO_2 in the atmosphere we are talking about CO_2 and methane in terms of greenhouse gases and global warming. This is what we are talking about. We are talking about an average concentration across a very large region that is increasing, and this increase occurs slowly over a period of time and this is what we are worried about, and we are also -- so these are two things specifications that and people differentiate between these two.



So, can we intervene? And the answer is yes we can intervene in multiple places. So, we know this pathway. We know the source. We know where it is going. We know what it is going to cause, and we can intervene in a couple of ways. One is emission control which means that we can stop it at the source okay, and the second is if we can not stop it at the source we at least stop a receptor from getting exposed to it. So, this is an easy part and the third case where you are not

able to stop the source, but it is in the environment already, and this happens specifically in the case of soil or sediment pollution where it is directly not coming to you yet, it does not come to you yet. It has not, you have not been exposed to it, to the agent but it may come to you at some point in time in the future. So, then you have to look at something to remedy that situations. It is called environmental remediation.



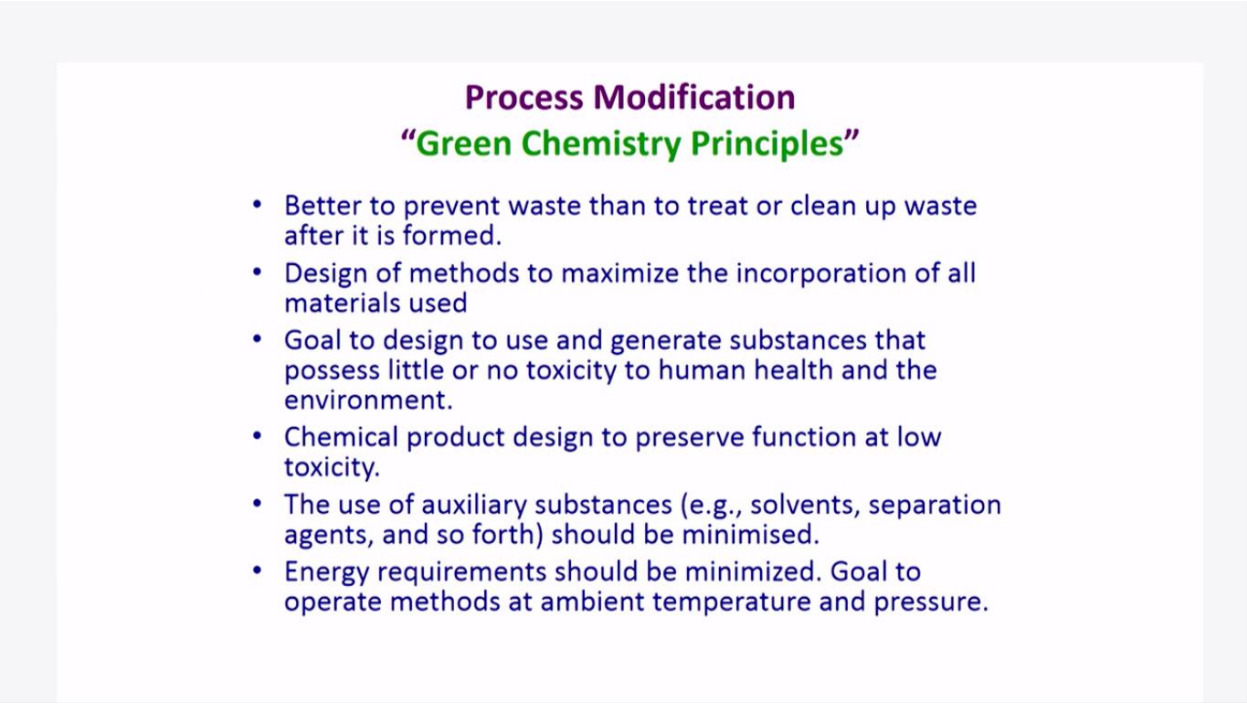
And we look at emission control first. The first methodology that one can do for emission control is by prevention completely which does not mean that we stop the process. That is a drastic method which has consequences for economic and social aspects of sustainability. So, this is where we have the term - sustainability takes an important connotation here because we then as technologists have a role to play in trying to devise methodologies where we can still sustain the economics of the society by looking at alternative ways of producing things. And this which may be a bit more expensive, a bit more difficult to do than the original method that was sought after but it is eventually on the whole sustainable.

So, this term called green chemistry and by extension what is called as a green process, these are all terms that were coined in the last few decades. The idea is here to opt adopt processors which mitigate hazard from chemicals and this can be done in various ways and one of the more commonly seen approach is to use biodegradable alternatives because one of the concerns that we have is the accumulation of a chemical in the environment and the case in point is plastic. You have all seen a lot of attention that is paid to plastic of different kinds, accumulation of plastic in our society in different forms, in the form of complete products such as mobile phones or computers or anything or to plastic bags which is there which is found everywhere all around us and so on so. There is regulation from different governments in different states that you cannot get plastic bags unless you pay for it and you cannot throw them away here and there and so on so forth to try to discourage people from using more and more plastic. And so, when

plastic was formed, was invented whenever it was invented in the around 50s, 60s it became a big industry at that time. People did not envisage the idea that plastics will be there and the idea of plastics not being able to degrade very easily was not a very serious point at that time because there was no resource crunch, there was no pressure on the population for space and other things. In India places like India, we have other pressures of space where options for disposal and all that is very less. So, we see the effect a lot more than a few other countries.

So, this is -- so we see a reaction to this increase in plastics in ways in which say we want to use biodegradable alternatives. We do not want to use plastic we will use some other options. So, this is this is an example of that and the ban on chlorofluorocarbons as refrigerants because they were causing bad effect in the stratosphere resulted in people looking for alternatives. So, we have – we need refrigerants, and people look for other refrigerants.

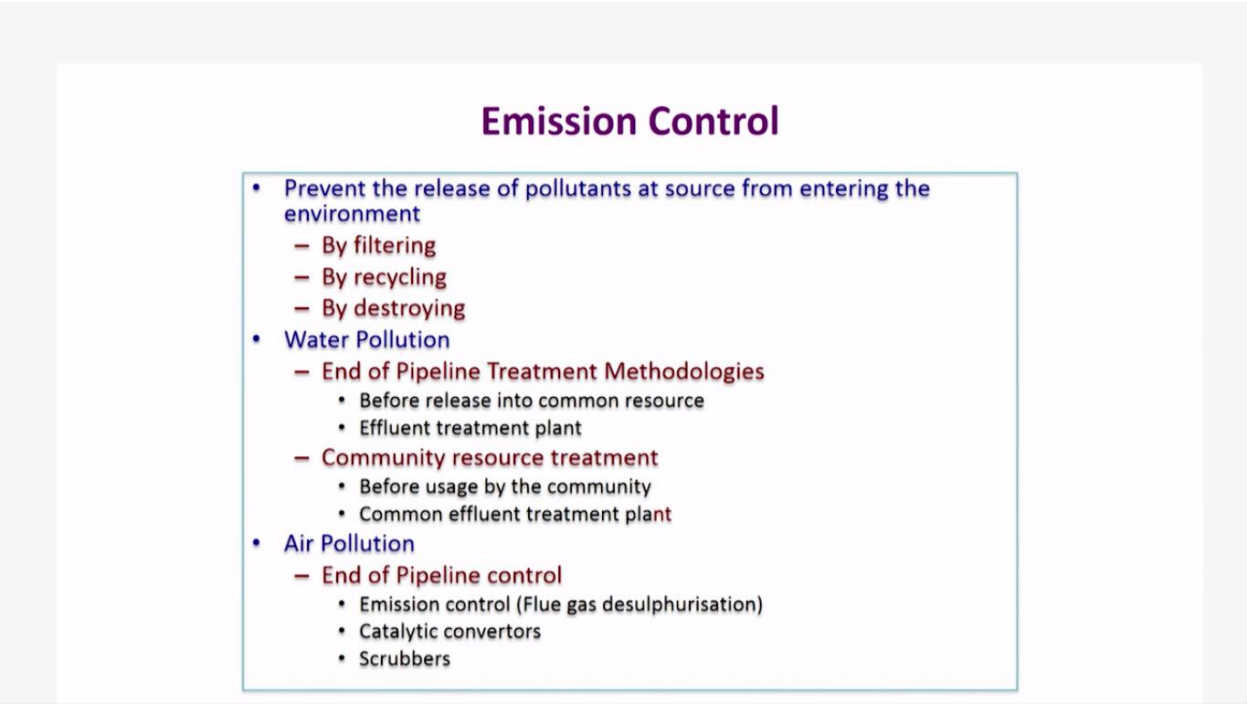
Now there is a – the idea is to get something, and that is better from an environmental perspective. It does not mean that an alternative has zero effect. Every alternative has some effect if not here in the way in which the current methodologies has an effect, it may have an effect in some other sphere, and one has to investigate that thoroughly in before coming to a conclusion. So, automatically no option becomes a perfectly green option. There is always a shade of some effect there, and one has to investigate as engineers and scientist one must be aware of that and then provide options for society so that they can use a better option if available.



And one of the goals here is again energy, and we have not talked about energy really in this course. We will talk a lot about it in a different module is linked to environment in some case because some of the energy production methodologies involve the release of materials that are harmful to the environment not from a health perspective but from a climate change perspective also. So, energy requirements or energy also is cost. It is amount cost that is involved in doing it.

So, these are all very intricately linked, and this is where I think one should appreciate and recognize the inter-linkages of the different arms of sustainability that there is no single clean solution or there is no single absolute solution for it. You still have to optimize it with the other two angles of sustainability, the economics and the society in general.

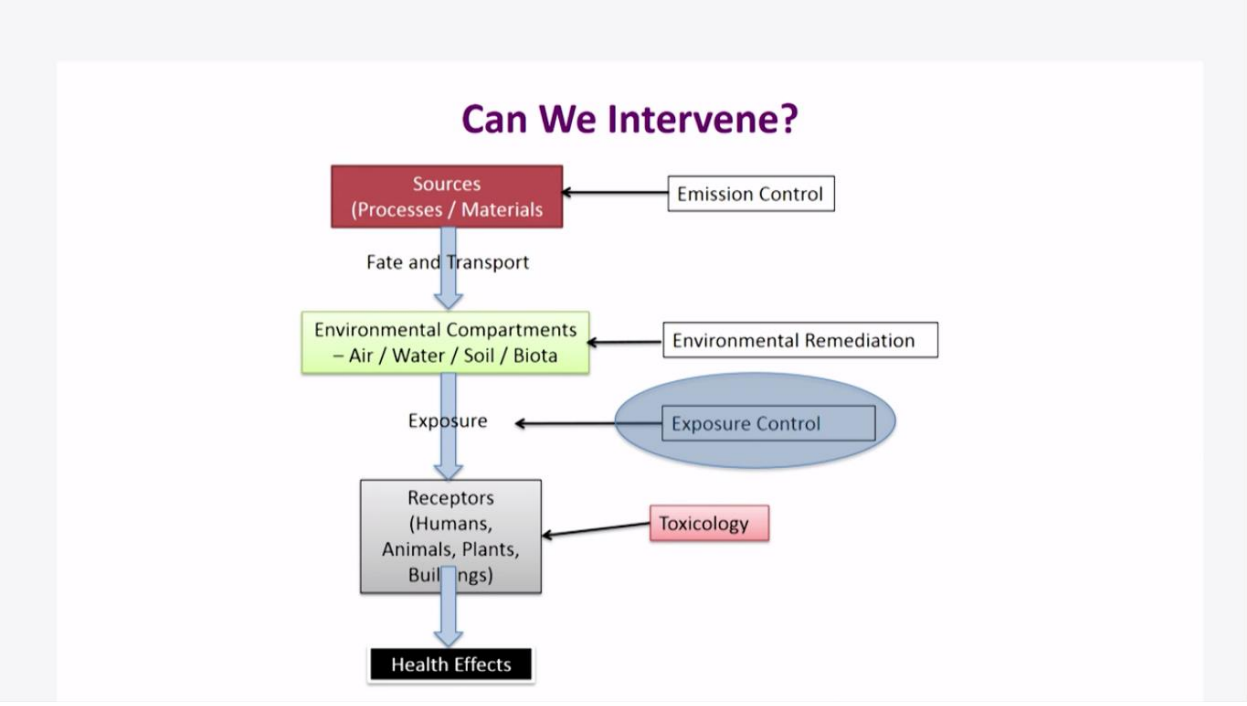
And continuing on this there are other options that one can use. We will come back to this a little later when we talk about design and the lifecycle assessment. So, the other option of doing emission control is if you cannot change the process if it is not possible to change a process, there is no alternative, for example, if you have, so right now the big example is automobile, automobile.



So, we use petrol or diesel as automobile's fuel or LPG or CNG, and they all have different emission profiles. They all emit something SOx, NOx or the unburned hydrocarbons and particulate matter. And so, the idea is now we do not want to use any of these fuels, one, that is process change, a green process is that lets use electrical vehicles. Okay. So electrical vehicles do not emit anything because they - it does not work on a combustion principle. But right now, we do not have an electrical vehicle that is available in the market for price that all of us can afford. So, it is still in that phase of development research and development. So, we are still stuck with fuels using fossil fuels. Then we can not just throw our hands and wait there, but we do control, emission control. So, there people have devised methodologies by looking at catalytic converters and other method. All car companies have big research wings where they look at the of getting methodologies by which they can control the particulate matter and the other emissions that are coming out and so you have this different ratings of Bharat V, Bharat VI, Euro V, Euro VI and so on. So, we have we have different listings that is implemented by the industry and by the government.

So, this is there in all the sectors. So, we do not have - we cannot prevent the pollution from occurring. We at least control it from entering the environment, and so we filter, we recycle, we take it back and put it back into the process and do not allow it to come out by innovative management of the process itself or we have to destroy, we destroyed so chemicals cannot be destroyed completely. They do not go into – they do not become zero. They convert to something else. It does convert usually to carbon dioxide and water or ammonia or some such thing which has a less impact on health than the original waste product, might be, but it has some other impact. So, in the case of if you burn the waste by incineration, it is technology that is controlled, use is acceptable in some cases. Incineration will produce carbon dioxide and if you convert all the wastes to carbon dioxide then there is an issue of reducing greenhouse gas. So, as I said earlier, there is no absolute perfect solution for it. It is only better solution, and then we have to make a decision whether this is better than that. So that assessment has to be done, but options are available.

So, we also have water pollution end of pipeline treatment methodology. This is the general term that is used. It is end of pipeline, and before it enters the environment and so before release, we have treatment technologies. We have effluent treatment plants. So, community resource treatment where we have a large section of industry which they can pool their resources and make a common effluent treatment plant before it enters, the water gets out of there. So many of the corporations, industry now have a zero-waste management plan. This is sometimes implemented by the government, sometimes the corporations themselves have adopted it as a methodology to both save resources as well as to help in the efforts towards making it a more sustainable environment. And so all these are possibilities. So, the other option of intervention can occur through what we call as exposure control.



So, it is already out in the air, and this happens in air and water. What can we do? So, we can protect ourselves by using safety equipment.

So, here for exposure control, it comes now exposure control now has two particular methodology, particular sections. One is occupational hazard. So we have, we saw earlier in this in this lecture, we have a very large significant section of population who are working somewhere, and at their place of work there is some occupational hazard. And so safety is, now becomes a big issue which is -- so safety is usually seen as fire safety and electrical safety and all that but we call it as environmental health and safety. And this is becoming a big thing and part of all corporations, all major industries have this section, safety and environmental health. And one has to invest in safety and personal protection devices. These devices are depending on what the operation is, it can vary from having filter masks, masks for vapors, mask for particulate matter. And you see people, you can go and see images on the internet, where you can see, if you look for safety equipment you will see a whole range of safety equipment and starting with the helmet, where the helmet is obviously protection device. But these for the exposure pathways that we have discussed in this class mainly the inhalation and the ingestion, we need safety equipment and the safety is integrated into the design. So whenever a new building is designed, one needs to take into account.

So, for two reasons, one is normal operation and business as usual. Where, in the normal operation you have exposure, that is one. Second, a very important part is emergency response. So if there is an unexpected activity like a spill or an accident or a fire, one needs to quickly react to that. And so that has to be integrated into the design and it is in the best interest of corporations to do this because there is an issue of liability both to the workers as well as to the general public. And the other issue is, if there is -- if the employer does not provide for safety equipment and if the workers fall sick there is loss of productivity. That is the monetizing aspect

here that if you have loss of productivity and most of the companies if they lose worker hours then there is loss of productivity and there is loss of income, there is loss of revenue for the company. And so therefore in a way in the investment that they make on safety of their workforce is a good investment in the long run. And there are other social aspects to this which we won't go into deep, but you can look at things around that. There are some aspects, some operations in our society where there are certain social issues where safety is still – we still need to get to the point where we enforce all these safety issues irrespective of the kind of operation it is.

In ambient environmental safety what people look for is inexpensive pollution control technologies. For example, water filters, this is one of the main concerns that we have is that we drink water we do not know if it is safe. So, many of us do not drink tap water, some of us do drink tap water but many of us in general, I have in the last 20 years or, so I have not seen people drinking tap water because they are not sure if the tap water is clean and for various reasons. Maybe it is clean, and nobody wants to take the risk. So, we have either water filters or we buy filtered water, and so this is an exposure control in some sense, and we also use safe food. We have – we would like to know where the food is coming from and how it is being cooked and all that all that is intuitive, and we have clean air.

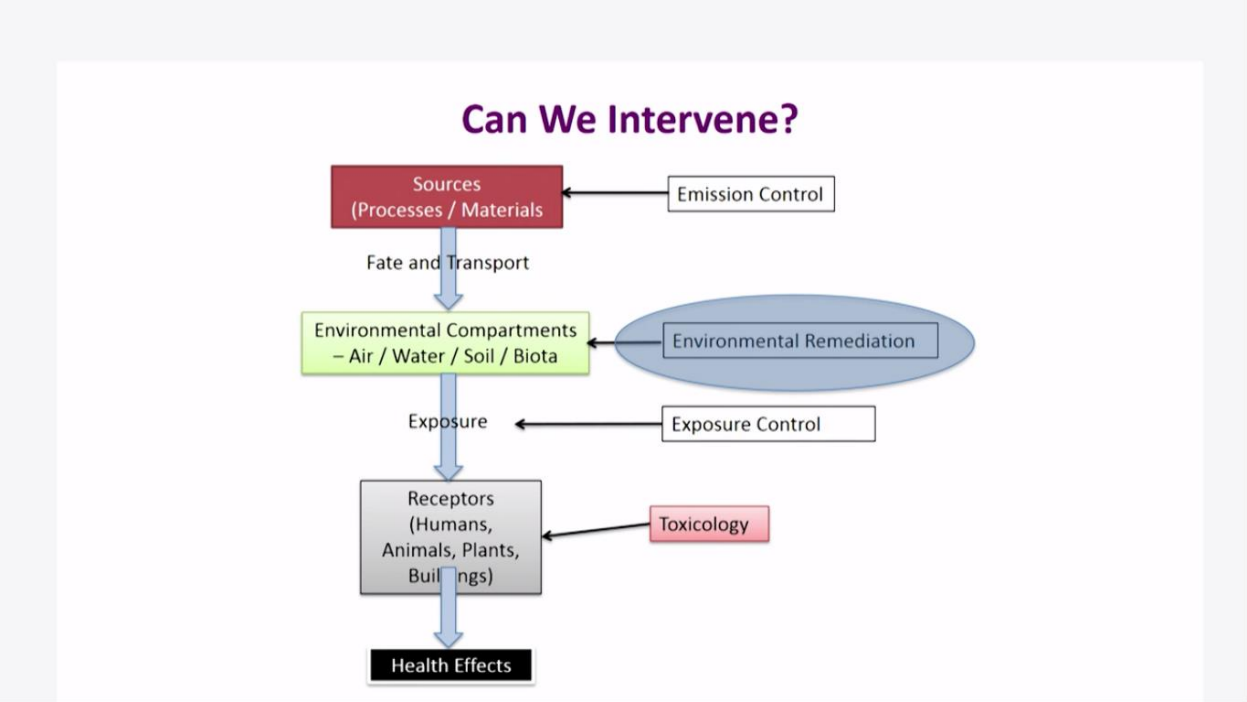
So, clean air is something which we have lesser control over than the other two because air is everywhere, it pervades everywhere, unless you are sitting in an air-conditioned hospital, or air-conditioned office where the air is purified if it is purified for example hospital air is purified. It goes through a very rigorous purification system, the air conditioning system because it is – it does not come under ambient, it comes under occupational this thing because there are patients and there are other activity going on in a hospital, and therefore the risk of air pollution

biological particles that are is higher. So they have a purification system, and so there is a wide variety of masks and filters for both water and air pollution. So, you see people standing on the road walking on the road covering their faces with handkerchiefs and masks. Wearing masks sometimes it is inconvenient, and in a place where it is very hot and very humid it becomes extremely difficult for people to manage, and they have to walk on the roads and therefore they have to have some kind of device that is both convenient and inexpensive. And that is the other thing. And so, as a technologist one needs to evaluate and provide inexpensive air pollution devices and a lot of these are already there in the market. Corporations make them, and I think it is – we are trying to make it much more cheaper and for everybody to use.

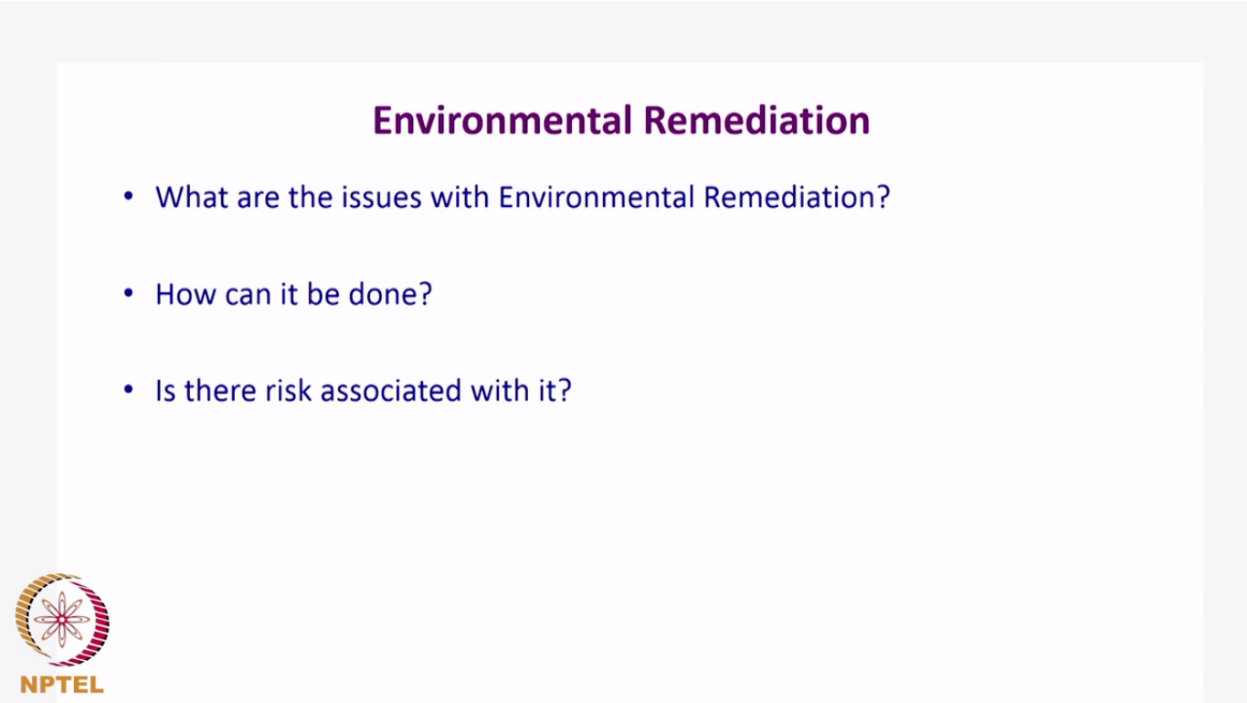
So, what happens if there is damage done to the environment already. So, examples of this are historically contaminated soil. So, what happens is people do not realize, if somebody does not realize, that there is a leak happening, or people do not know if there is for lack of any other information the chemicals have been dumped, or in as in the case of Bhopal, near the old Union Carbide site there is a factory that has been abandoned because of the accident in 1984. The accident does not – did not cause the contaminated soil, but there is a lot of stockpile of chemicals that were there. It is a manufacturing facility, and nothing was done to it. So, it slowly some of there was damage, physical damage and lot of it enters into the soil, and there is a lot of serious problems that are happening because of this and not because of the original accident that has its effects, yes but there is a follow through of this because of the site. It was not taken care of, and that that I think has – can cause these kind of things. And also, sites near old landfills and disposal sites historically what we say by historically is decades, we are not talking about one year or two years we are talking about decades and historically contaminated sediment again as I mentioned when we talked about contaminated sediments, sediments are not in view. They are underwater so people do not know what is going on unless they measure, or they see some

symptoms in the water and so by the time they see a symptom, and they realize what is going on it is probably a few decades contaminated sediments have existed.

So, a very prominent cases the river Rhine in Europe goes through Germany and a few other countries and then river Hudson in the United States, and we have river Ganga a lot of industries around Ganga, and there is a lot of focus on the cleanup of river Ganga. But river Rhine has been cleaned. It used to be a lot of chemical companies around that, and it was remediated. It was cleaned up. We will talk a little bit about some of the options that we will take one case study or at least the general principles behind doing such kind of remediation. And we also have contaminated marshlands. This is very common. So, marshlands or Estuaries are there, and Estuaries are inland lakes a very large number of them in India as well, and there is a big very delicate ecosystem there and because they - if they are in any close proximity to any commercial activity there is a very good chance that they are all contaminated.



So, we intervene in under those conditions also in what we call as environmental remediation. So environmental remediation is a term that is used for correcting, for fixing the mistake, fixing a problem.



So, as the term suggests or the world itself suggest. So, we – in the next lecture we will look at what are the issues with environmental remediation? What are the options first? And then we look at what are the issues? And how can it be done? And there are other issues because it has been done already done. So, we have a question of liability in this. So, we will look at in the next lecture; we look at liability and some of these issues related with remediation and which are legal in nature and what are the terms that people usually look for in this kind of systems and if there is any risk associated with it. Remediation itself as I mentioned, no process is free from effects. So, we would like to see what are the effects of some of these processes.

Thank you.