Environmental Air Pollution

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Lecture 2

Air Pollution Systems

Very quickly, in one minute, let us revise what we did last time. We started with the atmosphere and we said that the atmosphere that we see today was not the kind of atmosphere we started with. Atmosphere changed and changed substantially; changed in such a way that today's life or today's world can be sustained. We also said that one of the important physical parameters for the atmosphere, that was important, was the pressure. We also derived an expression to see how the pressure changes with height. We then looked at temperature profiles. We saw that the temperature indeed changes and changes not in a monotonic function but it changes depending on what height you are in; it may increase, it may decrease, or it may be probably the same. That has lot of lots of implication in terms of air pollution studies and that you will see later, because we have not derived the temperature equation yet. We will leave it for the later part of the course because is not that straight forward as the pressure term was.

If you recall, we had just started the pollution systems and that is what we will discuss. I will continue from where we are left. If you recall I summarised the whole environmental engineering, not just the air pollution, in three letters that was STR - source, transport, receptor. You would really wonder that everything what you doing environmental science, engineering is just within the frame work of this ST and R. I will try to do the same thing in terms of STR.

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So if I start with source... let me draw the source for you. So what you have is some kind of industry; it can be a source. Automobiles can be a source, or whatever you can think of as air pollution sources, even household heating can be a source. There can be many sources; so we need to study the source or sources, if you like.

When you say sources, just saying the source is not enough. What should we know about the source? Its quantity. Now we are trying to characterise the source; what you mean by the source? We should understand its quantity, or somebody might like to say emission rate or something. You also need to say: it is just not the quantity but what are the specific pollutants that we talk about. So you also want to define the pollutants. Thirdly, if I want to really characterise a source, what are the other things that are important for me?

We have a power plant here, [ ] power station; I want to say it is an air pollution source and I want to characterise as a scientist. What else do I need to say about the sources? I need to say at what height it is being released; that is very important. So when we study the source we need to study the height; we also need to talk about physical parameters like temperature and pressure. Sometimes it is important to say the velocity. We are still talking about the source and have not moved to the atmosphere as yet. So these are little things that we can comment on without really reading or without really knowing the air pollution. So this is the source. We will study about the source.

Then what comes next? If I draw the components as we have just discussed and now the pollution starts travelling. So we say the pollution is now travelling. So what happens here? Here is the source; now let us call this the transport. For the transport, what are the important parameters that we need to understand about the transport of the pollutants? Wind speed. So let us say what we need to study and understand here is the wind. Wind in all aspects: wind speed and directions. What else? We need know about moisture and also the temperature of the atmosphere - that also defines many things.

So we need know the wind speed, the wind directions, the moisture and the temperature. When you are putting, let us say for example, a pollutant in the water, and you understand water very well, what happens to the pollutant? It disperses; it gets diluted and what else? It degrades to either chemicals reactions, or biochemical reactions, or sedimentations or coagulations. It changes all the time. So apart from the physical factors that are responsible for the movement or the transport, you also need know, if I can use the word - transformations. It can be physical transformation or chemical transformation.

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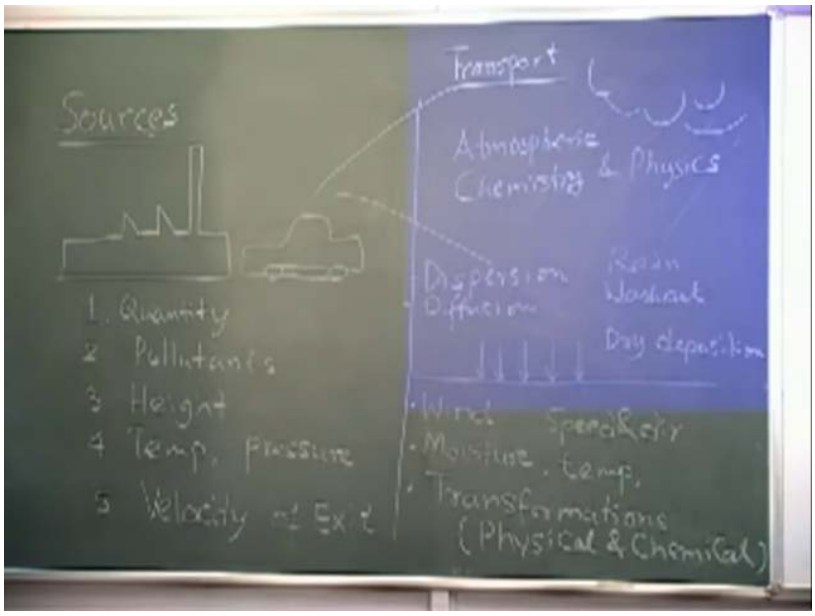

Physical transformation should be removable mechanisms. Here what I can say, apart from this thing, is also what is important for me is atmospheric chemistry and let us not forget physics – very important. So, we want to know about both atmospheric chemistry and physics. Then another important thing which happens in the atmosphere and does not happen so much in water pollution, is also [ ]. What do you see when look at the sky in monsoon

time? You see clouds and the rainfall. When we are talking about atmospheric chemistry, we can count the rain also. When I am talking about transformation, you understand through the chemistry; the physics also takes care of the dispersions and dilution. So, this is what we are talking about the transport and to some extent transformation and removal because all this is happening in a large container.

There is something called a constant deposition of the gases and the particles on the surface. This is the rain, I find again the rain washout; this is you can say dry deposition (Refer Slide Time: 00:10:16 min). This is all happening. We need to understand this; we need to be very thorough with this. This is a transformation and this is the wind speed, wind direction. Apart from this, there are also the two Ds which are very important: dispersion and diffusion; that also are important things that are happening.

The part of the study which decides the diffusion, dispersion, movement of air and how the air travels, how the atmosphere is behaving in terms of the movement of the air – that study is called meteorology. In a way, we are also studying atmospheric chemistry and physics, but in addition to that the other science that we will try to understand, which has more to do with wind speed, wind direction and the transport of the wind, which includes the clouds and rainfall. The study of atmosphere in term of dynamics of the atmosphere is what we call meteorology. We should not forget the general terminology of the atmosphere which is dealing with wind speed, wind direction, the pressure, the cloud formation and things like that is called meteorology.

You see already in the air pollution, you have becoming very interested this theory. We need to know processes because you cannot understand the source unless you understand the processes in the industry. You also need to the know chemistry part, you also need to know the physics, you also need to know the meteorology and you also need to know the how the pollutant solution move to the rain. It can be a very big course.

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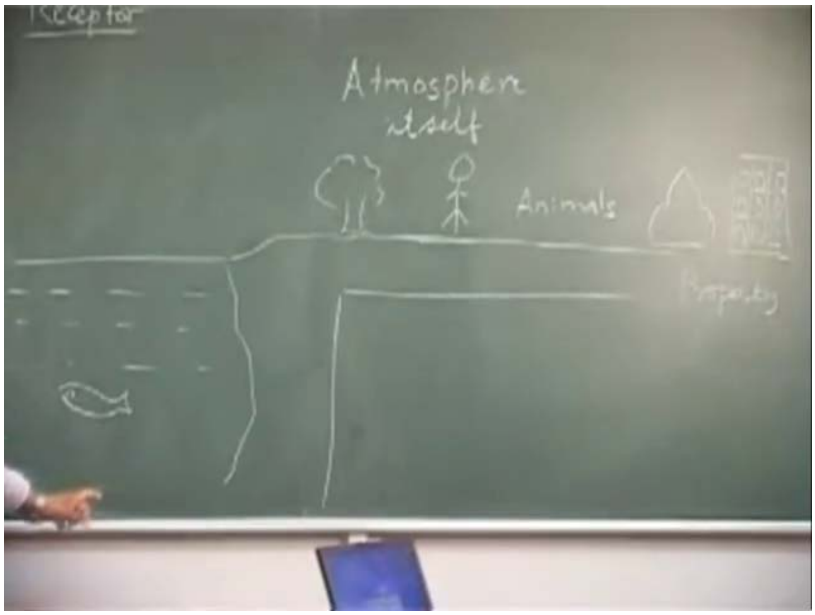

So finally where do we go? Remember what I said S, T, R. R was receptor. So let us talk about the receptor. We are still, in a way, defining the course. Receptor can be water, can be aquatic life in the water, they can be trees and plantations and things like that, they can be crops, they can be all ecology if you like. There is one person sitting very smartly here; this is a man. So you have this, you have this and we have, I cannot draw such a good picture, so let us say animals (Refer Slide Time: 00:13:50 min). You have everything. There can be aquatic ecology, there can be trees, plant and crops, and let us not even forget that we have other things which can be affected by the air pollution. Other than the ecology what else can it affect? It can affect the human being, it can affect the crops, it can affect the tress; it can affect the aquatic system – air pollution we are talking about. What else can if affect?

Total eco system we have covered that; apart from that, it is still not quite part of the eco system but it has very strong influence or strong effect of the air pollution. One is of course the climate. Sometimes the pollution can affect the way we have seen how the atmosphere changes with time. We are in a situation, where we recognise as a scientist that the atmosphere, the secondary atmosphere, who knows that slowly we may have been going into a tertiary atmosphere, we know why things are changing, why ozone has been disturbed, why CO_2 and methane levels are going up. We are changing the atmosphere, so receptor can be atmosphere itself.

Atmosphere itself can be receptor, which is this, and it gets affected. If that gets affected, everyone will be affected; atmosphere itself is changing. Apart from there is still something which is very important in terms of the effect of air pollution and that must be taken as the receptor.

What is in Agra? Monuments. See monuments are not part of the ecology, or the buildings, or the property. Everyone talks about the effect of air pollution on Taj Mahal and how we are spending lots of money to save Taj Mahal. So let us not forget monuments. I can say receptor is also building or in general term let us write – property; even that is affected.

So when we are talking about the receptor, we are not just talking about a human being or a plant or a tree, but everything that can get affected from air pollution; effects which are started, transformed, still reaching to the receptor. The simple objective of air pollution or any air or any pollution control is not quite worry about this (Refer Slide Time: 00:17:23 min) but worry about this .If there was no trouble here, who cares what is being emitted there. If there is no problem here, who cares how it is transformed and transported or being removed or not. Objective or the goals are very simple. It always difficult to achieve that goal but objectives are very simple. The objective of air pollution or water pollution or soil pollution is simply to safe guard the receptor, so that the bad effects, so that the ill effects of the activities which you are doing are under insignificant or tolerable.

So what is the system you talking about. So this entirely covers the receptor. Interestingly, this just not the effect on the building but say that it is it is causing the corrosion or the erosion of the building and things like that, but what is even more important, as the economists would like to say, the value of the property is also affected because of air pollution. You might have a very beautiful a bungalow or a mansion, a high-fi mansion; suppose that mansion is located in area which is highly polluted; your evaluation of building now will drop. So in that economic sense, not in the scientific sense, we can also say that even real estate is affected by air pollution. What my objective here? It is to safe guard. The whole purpose of the study air pollution or any pollution for that matter, or the degree you are trying to get, is to save or safe guard the receptors from the ill-effects of air pollution. That is the objective.

Now you understand that the process people will tell you what process is, what the emissions are and things like that. These are some people with a chemistry background and some people

with the meteorology background. Who are people who can tell more about these things? More about these facts? Let us talk about who can tell in a better way how man will be affected because of air pollution. To some extent people in medical science; experts in toxicology, they can say how if you exposed to such and such level of particulate matter, you will probably have bronchitis or some lung disease; some body who is more into it is likely to say: you were exposed to it or even if we are exposed to benzene you are likely to get leukaemia at a later age or something, the cancer generally happens at a later age.

This is another science that will decide as to what is effect of pollution and you may need a personal expert on the materials who will say what is effect on the Taj Mahal. There may be another person who will say the effect on some other kind of building which are not made of this thing. Somebody might need another expert in aquatic ecology who can tell you the deposition of the pollutants and what will happen. You may need a botanist, plant pathologist if you like, to tell you something about this one. So what I am trying to say is that the receptor or receptors needs more expertise and we are into an arena of inter-disciplinary subject.

What I will do now with this System of Air Pollution is we will try to define air pollution. I needed this background to define what air pollution really is and the definitions become important. Definitions have some... I do not want to use the term - legalistic value; definitions have a very standard written explanation of the subject. This is why we need very standard definitions, so that we are not talking vaguely about this subject definition. Life is full of vagueness and things like that but definitions are very clearly written. I think you will recall the definitions of the [Wellesley] for that matter what you read in class ninth or tenth; that is standard. The definition of the civil engineers you know; definitions of influence line, I do not know if you have studied it, it is a very standard definition. The teacher would expect that you write every word properly when the definition is asked. So what we will do is try to define the air pollution.

Now the question is very simple. So when can we accept that concentration of the pollutants which are emitted from the source has to be zero or can that be zero? Can [SO_2] be zero? You go can you go to the cleanest part of the earth, you go on to the north pole or south pole you will still get the some SO_2, CO_2, there is some lead, there is some chromium, there is some cadmium, some organic compounds and some of the levels of benzene you can find there provided you are able to measure it. We are not taking about zero pollution. So what

will happen is that at some point there has to be some level that has to be acceptable or at least some level on which the effects are almost not there.

We are not talking about zero concentration but we are talking about level at which you know the effects are tolerable. So we try to define that. Now we are talking about more of the control part. We are trying to say if this what is the thing and we know the objective and then once you know the objective, you should try how to achieve that objective. To achieve this objective you must say how to protect them, what level of the pollution that you will protect them. You do not want to overdo it; you are all engineers, you want to protect the ceiling does not fall in but then in the process you do not want to overdo the design on the columns. You do not want overdo the size of the slab, the thickness of slab, so there is something in all walls which is tolerable, with this one we have no problem. We are trying to define air pollution, not in terms of the source, not in terms of the transport, but in terms of the impact oo the receptor.

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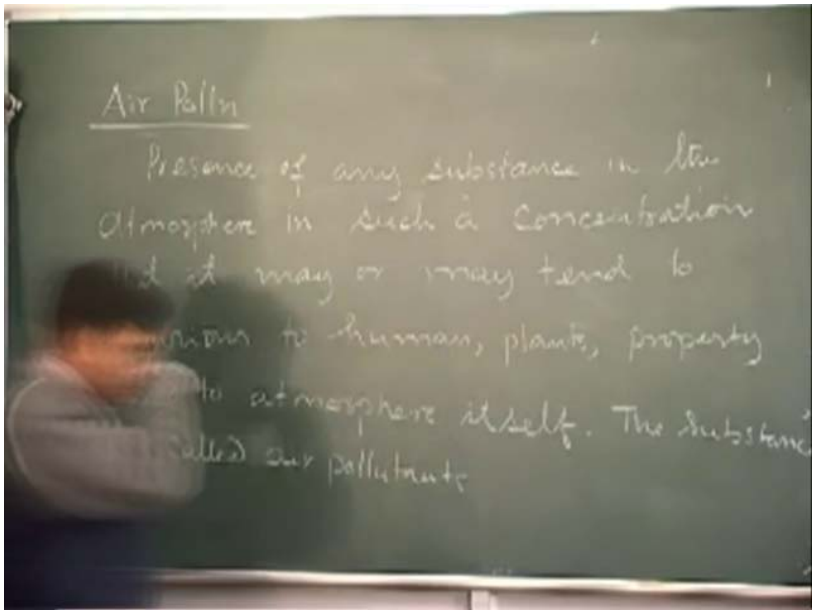

I will try to give you a standard definition for air pollution, which I will have to write unfortunately. To go through this background, is to reach a logical definition of the air pollution. So we say air pollution is the presence of any substance - solid, liquid or gas - in the atmosphere in such a concentration that it may or may tend to be injurious to humans, animals, plants, property or to the atmosphere itself, is referred to as air pollution and the substance as air pollutant. The definition is a very tricky thing; you have to write the right

words. This is something very close to what you will get. I will read it through and send it to you through email. The presence of any substance - you can correct that to solid, liquid or gas; we are trying to be very clear. The systems which were such concentration exist and that is called as the air pollution.

Now the focus suddenly shifts to the receptor. We are now trying to understand some kind of control. What is the key word here in the definition? What is the most important word or words that you can think of? Concentration. The whole thing is focused around this little thing - concentration. All our efforts are focused on this. For the time being we have forgotten the source, we have forgotten the meteorology and we are suddenly focused on to this thing because my objective is also focused on this point. If I am achieving this concentration, I do not care what the sources are, what is the meteorology, what are the transportation systems, and what are the other things? So suddenly the focus becomes concentration.

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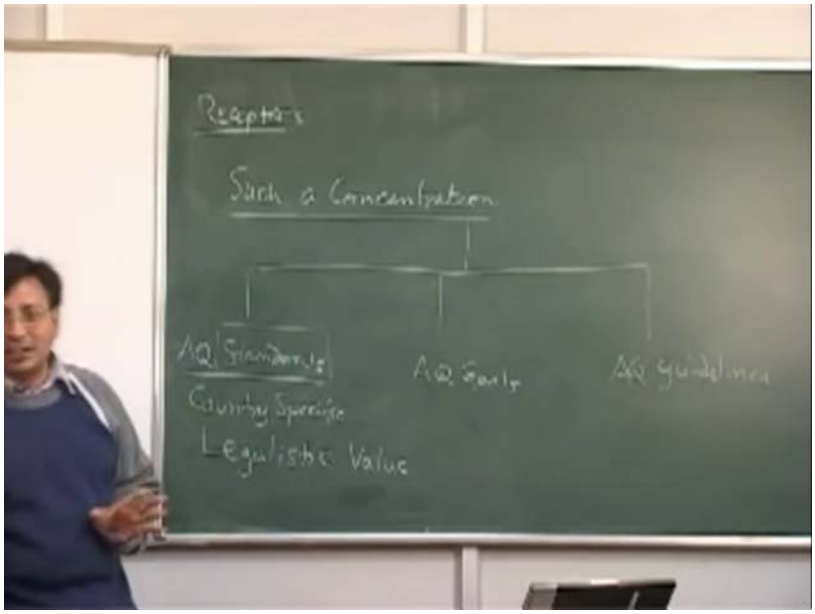

What I am trying to say is that if I achieve this concentration that means the air pollution is within control or it is fine. If it is not within that such concentration, I need to do something else; I need to do control at the sources or something. The entire air pollution management if I can call it centres around this concentration. Everything that you want to do at source, all measurements you want to do, the meteorology you want to study, is all centred around this little concentration. This is what is defined as or called many names. We will say what the

names are: sometimes we call it air quality because of air quality standards; some body may like to call it air quality goals; some people call air quality guidelines. Now the focus suddenly has shifted to that thing. You can just imagine we are not talking so much of science but we are talking more of the management. Everything is centred the around these numbers.

There should be lot of thoughts, lot of energy, lot of understanding that goes to fix this numbers because the rest is determined by this. So air quality standards are very important. We will discuss that in a moment. Who should define the air quality standards? The basis we know. Where do we go for the basis? We go to the toxicologist, we go to the people with the medical sciences, we go to the people who have studied the air pollution and health effects. That is a different thing but when we talk about the standards it is country specific. As a nation I decide I want to bring down the levels to such and such level and that will be my legally binding value. It can be country specific. How to derive at the quality standards, we will see today or tomorrow. This can also be country specific (Refer Slide Time: 00:34:38 min). What I want to define, make a difference is, when you look the word - standards - the moment you see this one, it as it as a legalistic value, it is a law; it is a standard. When you talk about the goals and guidelines, if you know the Indian constitution you can almost draw the similarity to these standards as the fundamental rights and suppose you have the guidelines, then the guidelines will be equivalent to directive principles.

With the constitution of India you see the fundamental rights that is what is the government has to provide you with it and directive principles is something that the government will try to get you. So the whole thing is centred around here but then planning can also go up to this thing. So that is what the difference is (Refer Slide Time: 00:35:44 min).

Have you heard about WHO, water quality standards or something? Remember one thing the WHO cannot give the standards, this is a misnomer even if sometimes you find it written in the books it cannot give. Who is WHO? WHO cannot give you legalistic binding values. The laws always pertain to that country. It is our prerogative what laws we want to fix. WHO can give only the goals or guidelines. So that is why always never ever use the word WHO standards. Say No to WHO standards, but Yes to the guidelines.

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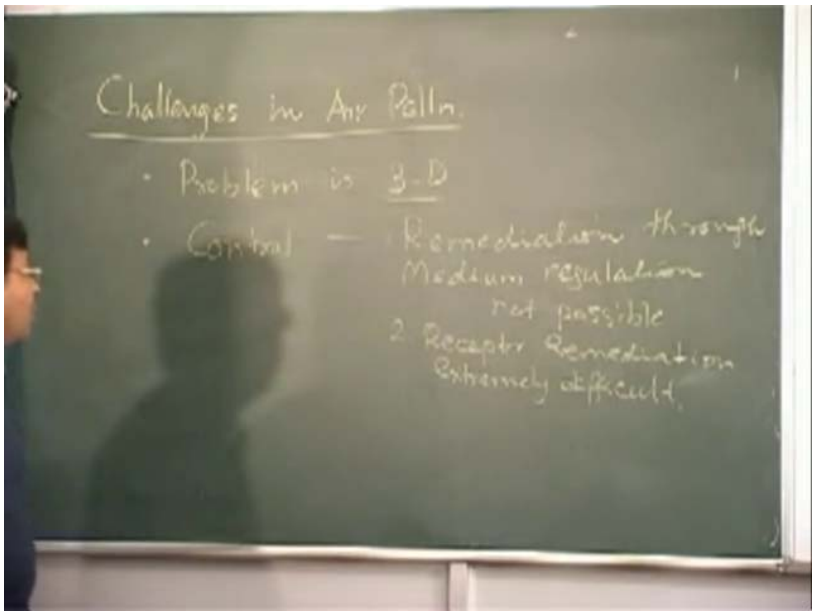

If you compare water pollution, noise pollution, soil pollution, we have to see what the challenges are. Air pollution is something you can never model as one-dimensional or two-dimensional. The problem is always three dimensional, more complex and very challenging. Ground water modelling; I do not know if you know about ground water modelling; how do we model ground water? A very common way to model ground water is one-dimensional with the transport of the water and the pollutants. Of course, some people do a two-dimensional model.

A one-dimensional modelling of the ground water, gives the ground water movement as well as the transport in vertical direction is pretty good. How do we model the pollutant transport in the region? Two-D; largely generally Two-D. Whereas, in air pollution all models you will see will be three dimensional models and that is the challenge when we are talking about the air pollution.

Let us talk about control. Let me put a question to you: I want to improve the water quality in the river Ganga or Yamuna. What possible options do I have? Treat the waste water. What else can I do? Ground water recharge. What you are saying is suppose we have putting lot of water into the ground water, the ground water in will back flow towards the river and the river quality will improve. It means I can think of putting more water or some kind of dilution or it is possibly by man made efforts. So control at source. So you can also manipulate the water quality by providing more dilution water. You can construct a dam; we all do that.

When there is a lean flow, when the pollutant levels could be high, what I will do is to do a little more discharge and then as a result the water quality will improve, my fish will survive.

So what I am saying is that the medium of the transport can be controlled or can be regulated; water harvesting, to preserve the water. So water harvesting is possible but can I do air harvesting? Impossible! I cannot stop the air and say to clean environment today, I will hold on the air in this room, tomorrow it is going in to be dirty and flush it out with the clean air. So when it comes to the control in terms of the air pollution, I will say the regulation or change or control or I should use the word - remediation - through an air medium regulation is not possible. I cannot regulate the air and if the air is bad, it is bad; people die. How do you save yourself from the dirty water? What are the other ways you can save yourself from the dirty water or polluted water? By boiling it. So that little treatment at the load level for air is not impossible but it is difficult. You can buy water bottles. It is a clean way of saving yourself. It is very difficult, for ordinary people, to be carrying a cylinder on your back and doing a normal operation. If I can use the words - direct receptor remediation is extremely difficult. We are talking about the challenges that we face in this.

The problem with the air pollution is that the effects are instant. This means that you cannot avoid the air and then you will see immediately the effect. Something like what happened in Bhopal. Suppose this had happened in terms of the water pollution; suppose the MIC had gone into the water system, I do not think the disaster would have been that big. Not many people would have died very quickly. We will say the water supply is contaminated, please do not drink this water. Then immediately information can go, people will not drink the water. We can predict that people down stream of such and such place should not use the water, but here we cannot do anything as people will have to breathe the air. The effects are again instant and therefore air pollution study or air pollution control or air pollution management becomes very challenging. The effects are instant or acute. What will be the fourth thing? Solutions cannot be delayed and you have to act quickly. Let us talk a little bit about the human biology. You will be surprised that some of the effects of air pollution are irreparable; whereas with water, the infections of water can be treated through antibiotics and things like that. But if the damage is to, let us say the lungs, you can not revive it but you have to live with that problem all through life.

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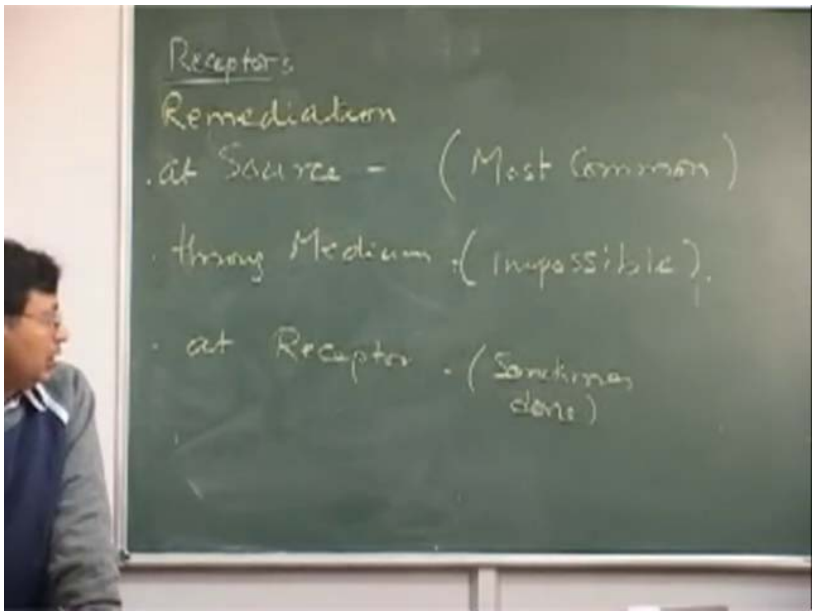

In a way, what I have said to you in terms of the remediation; the remediation can be of three types - at source, through medium, at receptor. Remediation at source is most common for air pollution. Through a medium is impossible, more or less; for air pollution and remediation at receptor is done sometimes. (Refer Slide Time 00:46:10 min).

Why I want to introduce to you receptor remediation is that receptor remediation has become a very standard practice; also to try remediation at the receptor. Take for example the Taj Mahal. What has been done for Taj Mahal? You probably will not be aware, but you know all traffic and transport which is very close to Taj Mahal that has been stopped. A specific green belt and the forest have been designed about the Taj Mahal. The land was acquired through Supreme Court orders. Now we have the beautiful forest that has come up very close to the Taj Mahal. So in a way what are we doing? We are doing a receptor remediation. One of the common things to do in the receptor remediation is to design a green belt. The technical word for the green belt is shelter belt. Why I am talking about this is, this has really been tried and there are some improvements in the air quality is some areas.

The people from Delhi they always have lots of influence and all the big people are there. What they are saying is that there is lot of pollution that is coming from Rajasthan in terms of the desert storms from the Thar desert. So we should build a green belt at the border of Haryana and Delhi. This is another study of other pollutants and there are dynamics and

thesis on this. There is lot of research on that so that we can prevent the transport of the pollutants.

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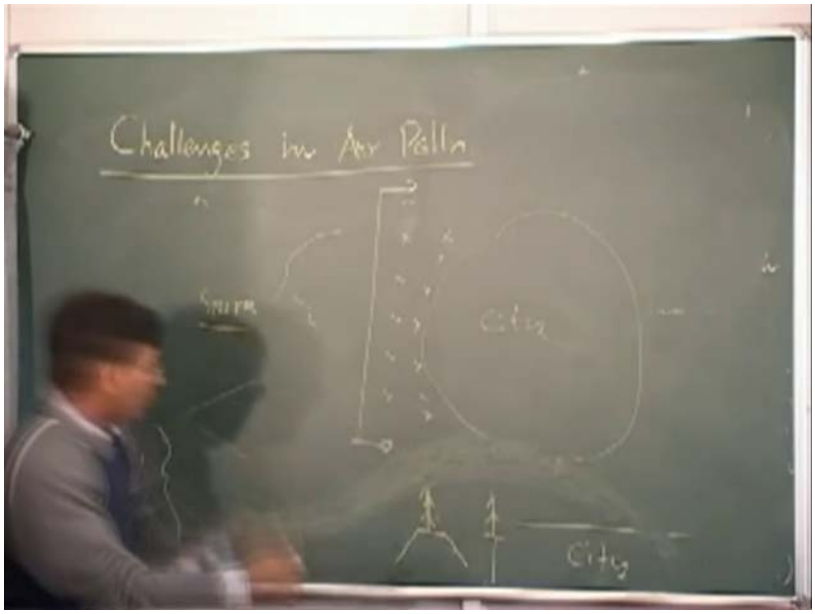

This is not a filter. Generally what they do is, suppose this is your city or locality or residential colony or whatever, and here is the source (Refer Slide Time: 00:48:40). You have some kind of tall trees here; or suppose if you want to see all of them scientifically, if I take a section, you will find that there can be an embankment like this - a railway line and then there can be tall trees. Then there could be another belt for the shelter or the some more trees.

This is your city or area (Refer Slide Time: 00:49:25 min). So what will happen is that the pollutants are travelling like this. Some of them they might go through that but largely what will happen the moment there are disturbance these pollutants or the gases or the flow will react with the obstruction. What was the reaction to the obstruction? They will try to climb the obstruction; we all know about that. Then as a result they will eventually they have to come down and follow the same stream line as this one and there will over pass in this setting. You might find little problem about visibility but you see this one is an over pass. These things are also designed.

So what I am trying to say here is we will not do so much in the course but we should see the possibility of the receptor and receptor control. We can design the shelter belts, so there is a lot of studies, lot of research going on as to how to design. Some people even talk about the

spacing of the trees and the height of the trees, and some people are even talking about the species of the trees that could be planted. That is another arena of research.

But this is possible; this is impossible; most of the things we should talk later in the course (Refer Slide Time: 00:50:48 min). Now can you comment on something about the pollution control at the source? So the philosophy of the air pollution control is to reduce the emissions of the pollutants from the source, so that its impacts are less than the desired concentration at the receptor. We do not want to make zero pollution; we do not want to close down the factory; we do not want to stop everything, but what we want to say is to reduce pollutant emissions to a point such that no noticeable adverse effects associated with the pollutants exists at the receptors of our interest. This is the philosophy of the air pollution.

Now tell me, who will tell whether the emissions are there, whether the impact is within the nominal region or impact is within the safe regions or impact is not within the safe region? Who will say that? and how can we say that?

We understood the objective; the objective is to safe guard the receptor, bring down the pollution level to the lowest concentration. We also talked about the controls which are possible to us. Who will tell us how much control is to be done? This is the job of the air modellers. Emission quantity is Q; so they are the one that try to give the Q which can be an array; why array? There can be many sources: automobiles, house heating, cars. The modellers will look at this emission; look at the transport changes and what is happening; what is the concentration that is observed.

So the observed concentration must be, while we are designing the air pollution, less than air quality standard. If we are done that one, we have done the pollution control, we have met the objective and we have done a fantastic job. This is what all air pollution engineers try to observe and if I can use the word standard, I will define the standard as we go a little bit more. This is the objective as well as the philosophy and to do this one we need to understand this, we need to understand this and we need to understand this and who can provide this understanding is the air pollution modeller. (Refer Slide Time: 00:53:45 min)

So the modeller should have a reasonably good idea of this, very good idea of this and some idea of the impact and that is how this is done. So sometimes observed is model calculated, or sometimes it can be measured or monitored also.

This brings us to the concept of the air pollution measurements. Our objective is to make sure that this what is happening, so you do the measurement or either you do the modelling. You can do modelling for the existing sources, modelling you can do for the future sources and you can use this information of your modelling and science in planning citing of the industry.

We will stop here. What I tried to do today is to give you a little feel of the air pollution system, what are our objectives, what you want to achieve, more in terms of the philosophical and some reasoning, not so much of science and technology. We will go that back and forth, we will talk about the different things depending on how we are doing it. Eventually at the end of this course these things would be interconnected and that will be at the later stage.

We will talk about the making of standards in the next class. This is very important because this is the key word, such a concentration, so standard is important because everything is centred about the standard. There is lot of discussions to give you a little feel that in US ,for the example, they are fixing the standard and sometimes it takes four years to fix the standard, five years. The reviews are huge you know and India has also tried to do something similar so that because of that if you get that number wrong, its implications are huge. If you get the number wrong, you can destroy the eco system, you can kill the people and if you get the number too conservative you can destroy the industry. We do not want to do that, we want do a good job. So that fixing of the standard is very important, rest of course is engineering, technology and things like that.

We are talking at the philosophical level; we will stop here and we will continue whenever we have the next lecture.

Thank you very much.