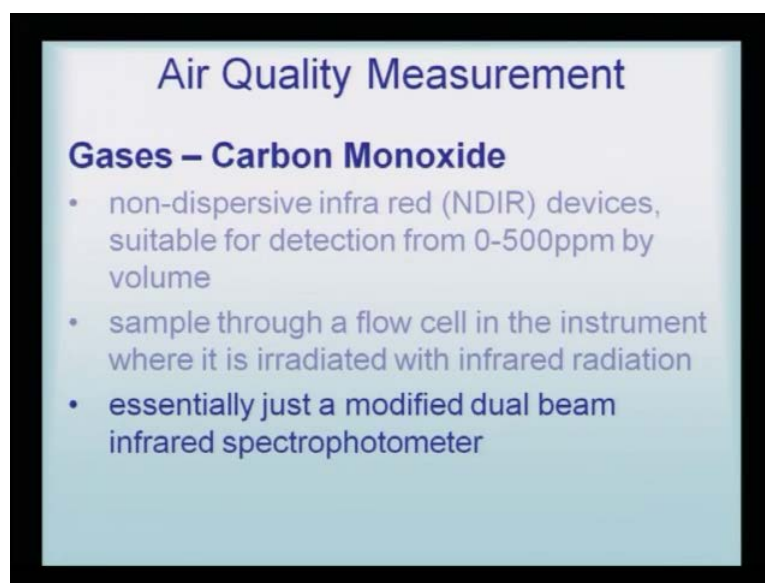


Advance Analytical Course
Prof. Padma Vankar
Department of Chemistry
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Lecture No. # 22

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Air Quality Measurement

Gases – Carbon Monoxide

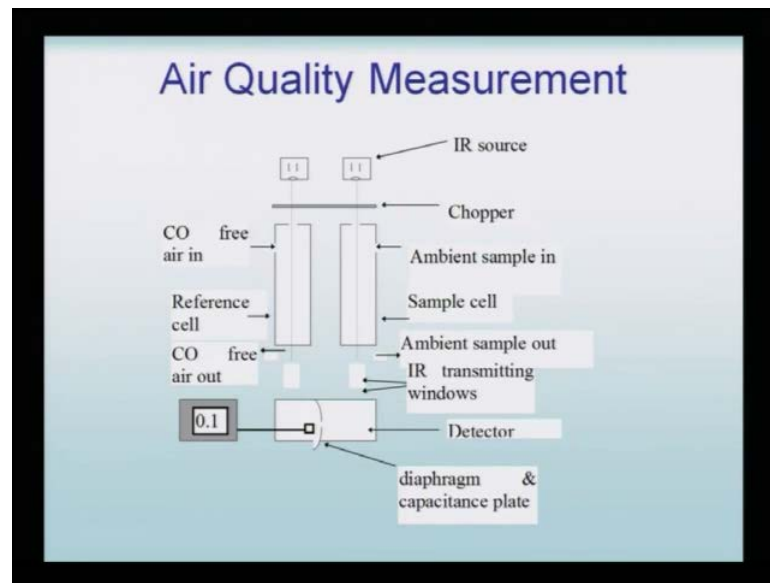
- non-dispersive infra red (NDIR) devices, suitable for detection from 0-500ppm by volume
- sample through a flow cell in the instrument where it is irradiated with infrared radiation
- essentially just a modified dual beam infrared spectrophotometer

Continuing with the air quality measurement, the analysis of carbon monoxide has to be done in another very specific manner - non-dispersive infrared (NDIR) devices, are most suited for detection of 0 to 500 ppm by volume. So, this has completely new method. The SO_x and the NO_x could be done by UV method, but carbon monoxide requires a non-dispersive infrared device.

Sample through a flow cell in the instrument, where it is irradiated with infrared radiation; that means, if this gas is particularly infrared light sensitive, whereas the other two gases were UV sensitive.

Essentially, just a modified dual beam infrared spectrophotometer can do the needful. So, if we have a carbon monoxide sample, we can analyze it on a double beam infrared spectrophotometer.

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This is how the instrument looks like. There is IR source, and then, two beams are made to pass; there is a chopper which puts only one type of IR radiation into the device; and carbon monoxide free air is passed through one, and through the other one, the ambient sample is passed; so they go parallel, and there is a reference cell, and then it is passed on to the detector, and there is a diaphragm. So, finally the analytical spectrum is derived from this kind of measurement device.

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Air Quality Measurement

Gases – Non-methane H/C

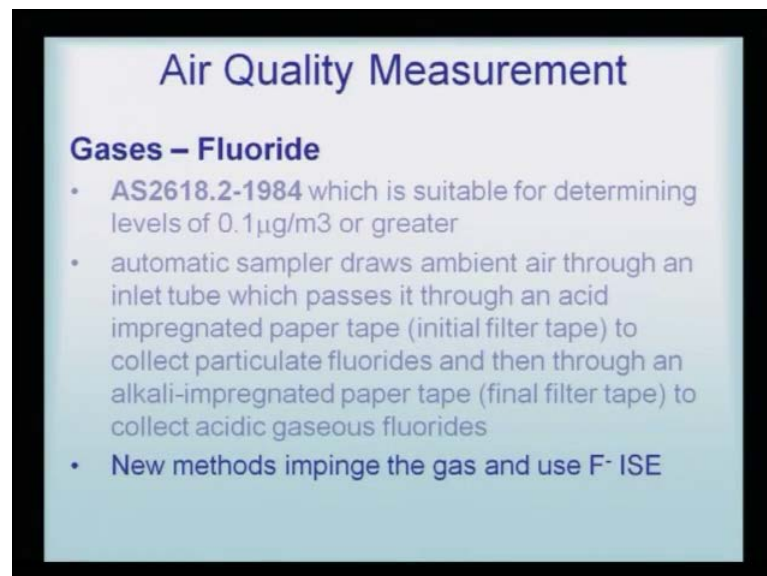
- essential to discriminate between methane and other H/C's, as it is the only hydrocarbon that naturally occurs in large amounts in the atmosphere - remember those cows & termites!
- feed a continuous stream of gas sample into a GC with a FID
- hand held field gas chromatographs now available which allow sampling and analysis to be done in the field – eliminating sampling error

Non-methane, that is **H/C**, that essentially to discriminate between methane and other HCs, as it is the only hydrocarbon that naturally occurs in large amount in the atmosphere. So, you see, it is quite important to be able to analyze not only the carbon monoxides, the SO_x, the NO_x, and the ozone, but also sometimes, some other pollutants need to be analyzed. And therefore, there should be detecting devices to analyze the same.

It requires a feed to continuous stream of gas sample into a GC with an FID. So, such methane or methane type of gases, can be directly analyzed on a gas chromatograph, with the flame ionization detector - FID detector.

Hand held field gas chromatographs now available, which allow sampling and analysis to be done in the field, eliminating any sampling error. See, now-a-days, because if such gaseous pollutants are found in the factory areas or in certain areas, there should be very handy gas chromatographs, which can be taken on-site and so they are held in the hand; so, they are called hand held field gas chromatographs, which then allow the sampling and the analysis on the spot, and so, there is no error of the sampling and any other contaminant coming in the process.

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Air Quality Measurement

Gases – Fluoride

- AS2618.2-1984 which is suitable for determining levels of 0.1µg/m³ or greater
- automatic sampler draws ambient air through an inlet tube which passes it through an acid impregnated paper tape (initial filter tape) to collect particulate fluorides and then through an alkali-impregnated paper tape (final filter tape) to collect acidic gaseous fluorides
- New methods impinge the gas and use F⁻ ISE

Even fluoride, can be one of the other air pollutants, which I did not mention so far. Why? Because, only under certain conditions these other pollutants, that I am going to mention now onwards, have been noticed in the air quality; nevertheless, there has to be

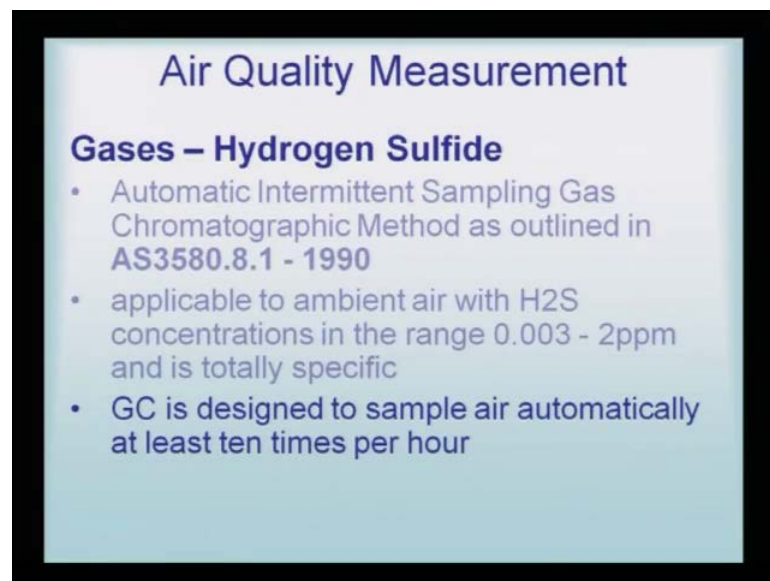
a testing protocol ready to able to analyze these. The first one was methane; the second one is fluoride contamination.

There is an Australian method called AS2618.2, which was released in 1984, which is suitable for determining the levels of 0.1 microgram per cubic meter or even greater.

Automated sampler, draws ambient air through an inlet tube, which passes it through an acid-impregnated paper tape - initial filter tape - to collect particulate fluorides, and then, through an alkali-impregnated paper tape - final filter tape - to collect the acidic gaseous fluorides. So, there are two types of filters, and these tapes are one-by-one impregnated with these different species of fluorides, and total gaseous fluoride is then evaluated.

New methods impinge the gas, and use another type of fluoride detector, which is called F-ISE.

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Gaseous hydrogen sulfide also, when it is in high and toxic quantity, can be a very serious air pollutant. Automated intermittent sampling gas chromatographic method, as outlined in AS3580.8.1, which was released in 1990, is the method for analysis or is the device for an analyzing the hydrogen sulfide.

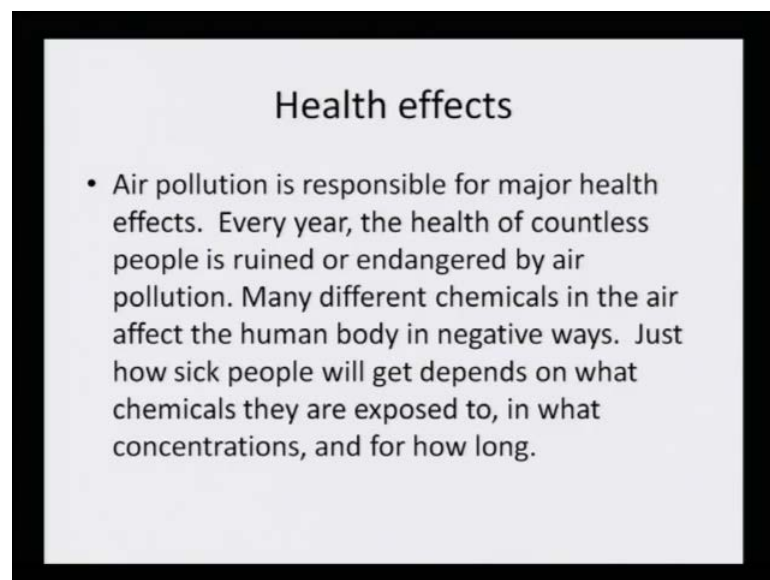
Applicable to ambient air with H₂S concentrations in the range of 0.003 to 2 ppm parts per million and it is totally very, very specific for hydrogen sulfide alone.

GC is designed to sample the air automatically, at least 10 times per hour. So, this kind of dedicated GC machines will collect the sample every 10 hours, in every 10 hours it will collect the sample, and go on analyzing it and generating the data.

So, with this we have come to an end of one set of analytes. So, you saw the particular kind of pollutants in air were the carbon monoxide, the NO_x, the SO_x, hydrogen sulfide, methane, and fluoride, and not to forget that lead also was one of them.

Coming to the effects of these air pollutants, some more information needs to be given to you, because these have some very serious effects.

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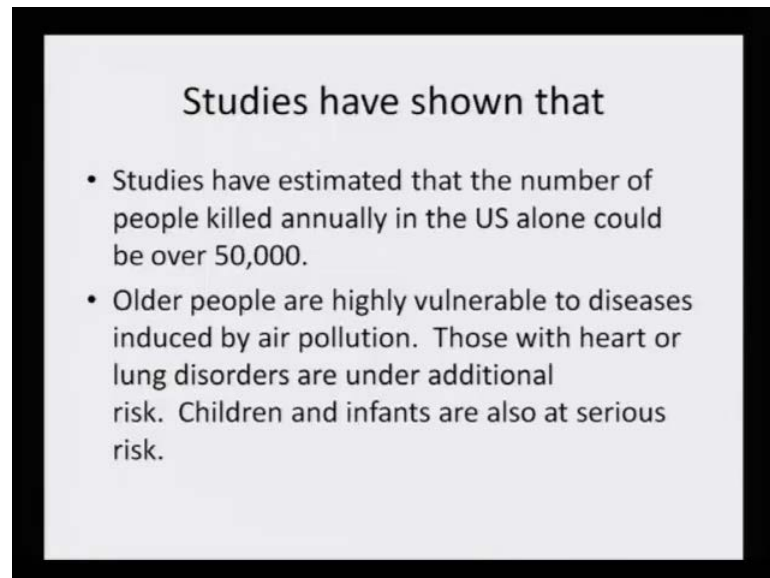


Air pollution - what kind of health effect, can it cause? Air pollution is responsible for major health effects. Every year, the health of countless people is ruined or endangered by air pollution. Many different chemicals in the air, affect the human body in negative ways. Just how sick people get, on what depends that what is the kind of chemical atmospheres they are exposed to, in what concentration, and how long have they been exposed.

You may have noticed, that people who live in slums, who do not have very good aeration in their small hutments, and who burn charcoal or who burn wood for cooking purposes - actually a lot of carbon monoxide is just spread in their hutment. Now, all the family members are inhaling that carbon monoxide, and they tend to fall sick more often,

than people who are living in houses, where they have good exhaust system and these unwanted gases are removed. And in even higher restaurants and other public places, you would have found that they have very strong **evacuating exhaust everywhere fitted**, so that all the unwanted gases are thrown out into the atmosphere and the indoor air quality is maintained at a very good level.

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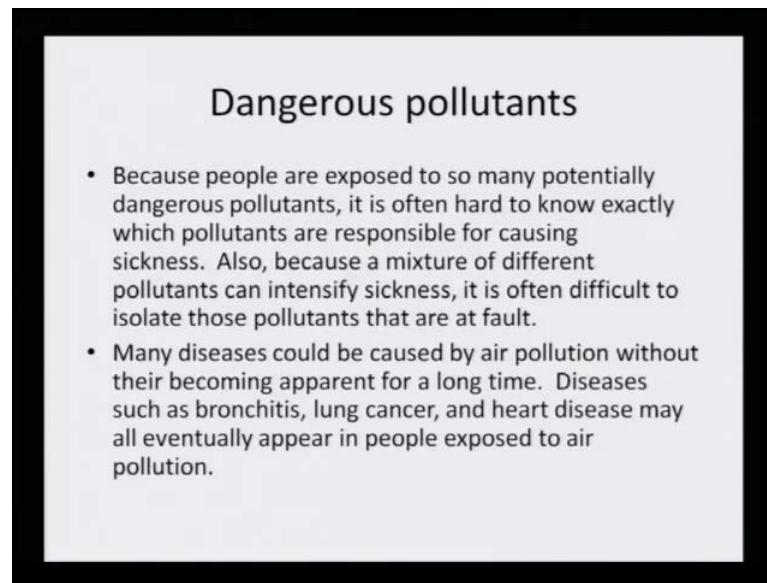
Studies have shown that

- Studies have estimated that the number of people killed annually in the US alone could be over 50,000.
- Older people are highly vulnerable to diseases induced by air pollution. Those with heart or lung disorders are under additional risk. Children and infants are also at serious risk.

Studies have shown that, a number of people are killed annually not only in our country, but even in U.S, **and alone in U.S about** 50,000 people die simply because of air pollutants.

Older people are highly vulnerable to diseases induced by air pollution. Those with heart or lung disorder are under additional risk and children and infants are also at serious risk. And that is why, it is very important to maintain ambient air quality, to be of reasonable order, and not having too many pollutants. Particularly for older people, it is very risky, because already their body has a low immune system, and in that, if more and more toxins are incorporated by inhalation, then it will definitely cause in culmination of some diseases. Similarly, children and infants, who again have lower immune system or their immune system has not developed to a certain stage, they also have very serious risk.

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Dangerous pollutants - because people are exposed to many potentially dangerous pollutants, it is often hard to know exactly, which pollutants are responsible for causing sickness. One cannot pin point, whether by inhalation of one type of pollutant it has caused or culminated in one type of disease; there is no direct correlation. However, it also does not always appear in just one quantity; it will be always a mixture.

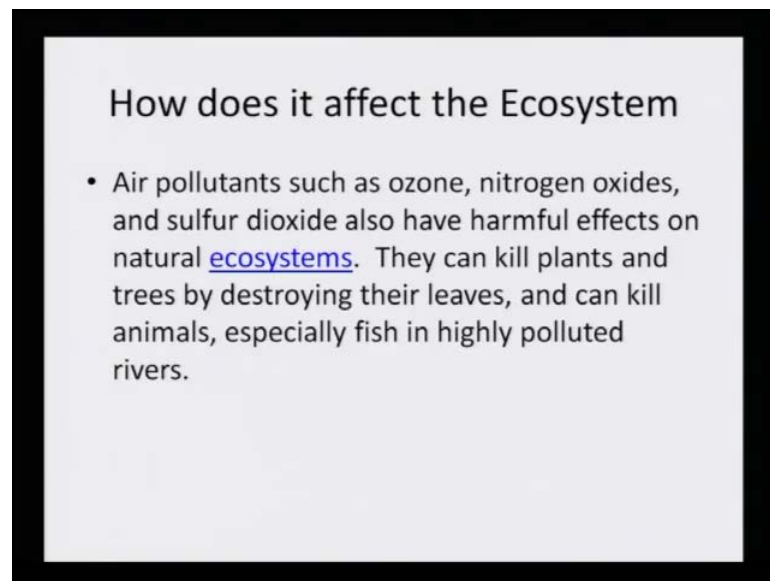
Air quality when we are talking, if we are talking of air quality being bad, that means, it may have carbon monoxide, it may have methane, it may have fluoride, it may have NO_x, it may have sulfur dioxide, it may have ozone or it may have all of them. So, it could have either or all. So, that is why it is very, very difficult to be able to pin point, which particular air pollutant has been the causative of a particular sickness. Also, because a mixture of different pollutants can intensify sickness, it is often difficult to isolate those pollutants that are at fault. Now, it is very difficult, a particular disease that has been noticed in an old person - is it because of one pollutant or the other pollutant, it is impossible to be able to diagnose that.

Many diseases could be caused by air pollution, without their becoming apparent for a long time. Diseases such as bronchitis, lung cancer, heart diseases, may all eventually appear in people exposed to air pollution. Now, you see, due to prolonged inhalation of polluted air, it slowly and slowly effects the body system; it is not that today you have inhaled some bad air and tomorrow you will have lung cancer; it is a long-drawn

process, a slow process, where the toxin or the particulate matter or the NO_x, Sox, they are slowly getting adsorbed in to the body, and when they reach a threshold level, they start creating a toxic effect on the metabolic system; and that is where the disease starts appearing. And in many cases, particularly the heart disease and the cancerous stage, there are no apparent symptoms.

So, the symptoms appear when the disease has almost reach 80 or 90 percent of its advancement stage. So, at that particular time, when it starts showing its effect on the exterior of the body or when it makes it apparent, it is too late for any kind of corrective measures. So, that is why it is important to keep the air quality as clear and pure as possible, by continuously monitoring these gases from time-to-time, so that they can be a corrected and removed, and therefore, not be the causative of some dangerous diseases.

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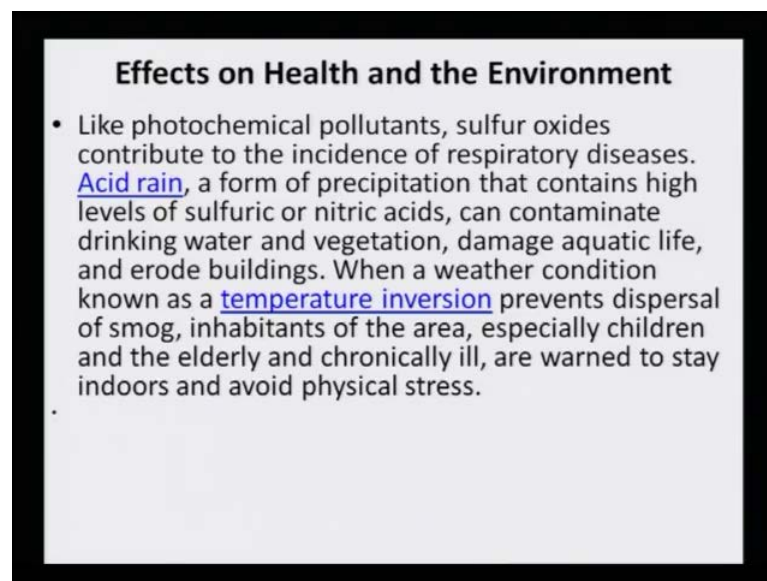
How does it affect the ecosystem? It is not that only human beings are being affected if there are air pollutants. Air pollutants such as ozone, nitrogen oxide and sulfur dioxide are also having harmful effect on the natural ecosystem. They can kill plants and trees, by destroying their leaves, and can kill animals, especially fish in highly polluted rivers.

You see, because all living beings are subjected to some form of respiration, and if the respiration does not take place normally, it is going to affect that particular part of the eco system in one way or the other. And the more sensitive the plant or the animal is, the higher will be the **affectivity**; fishes are known to be very, very sensitive and they take

oxygen from the water, and if this oxygen is not pure, obviously, their respiration will get affected very drastically. So, the water in which they are residing, must have very pure quality oxygen, and there should not be any water-borne or air-borne pollutants, which can disturb their respiratory system.

Similarly plants, as I told you they also respire through their leaves. If there is, the air pollutants are present, that means, there will be a loss of oxygen that should be reaching the leaves for the stomachic cells to open and take up the oxygen. So, what will happen, that instead of the whole of oxygen entering the plant leaf through the stomachic cells, it would be the air pollutant and the oxygen together entering it. The air pollutant will then start doing its toxic effect in the leaves, and subsequently, the leaves will shrink and die, and that will affect the oxygen content intake of the tree or the plant.

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Effects on Health and the Environment

- Like photochemical pollutants, sulfur oxides contribute to the incidence of respiratory diseases. [Acid rain](#), a form of precipitation that contains high levels of sulfuric or nitric acids, can contaminate drinking water and vegetation, damage aquatic life, and erode buildings. When a weather condition known as a [temperature inversion](#) prevents dispersal of smog, inhabitants of the area, especially children and the elderly and chronically ill, are warned to stay indoors and avoid physical stress.

Effects of health and the environment – so, as time and again I have told, that it has a very drastic effect, a very bad effect on not only human beings, not only plants, but also other animals. Like photochemical pollutants, sulfur dioxide contributes to incidence of respiratory diseases. Acid rain, a form of precipitation, that combines high levels of sulfuric or nitric acids, can contaminate drinking water and vegetation, and it can damage aquatic life and erode buildings. When a weather condition known as a temperature inversion prevents dispersal of smog, inhabitants of the area, especially children and

elderly, and chronically ill, are warned to stay indoors to avoid any kind of physical stress by the intake of these bad gases.

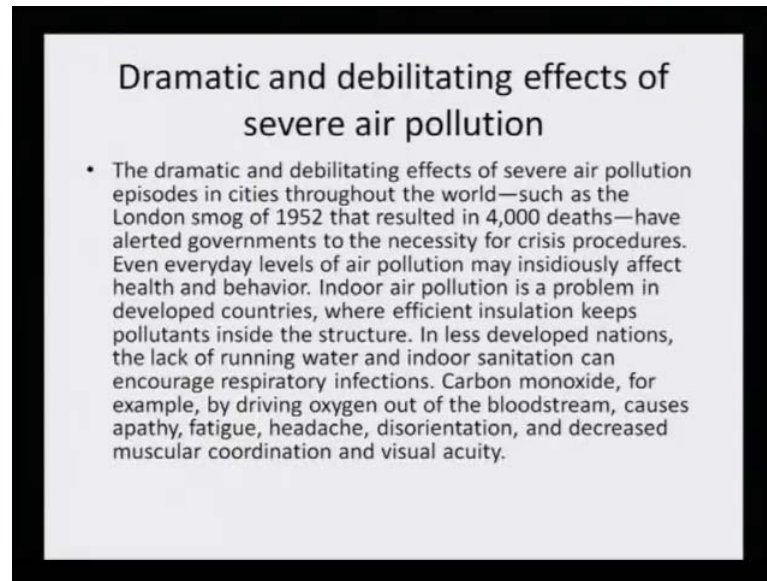
Now, these gases - sulfur dioxide - it is a photo chemical; that means, it reacts with UV light and get sensitized, and therefore, it creates a lot of respiratory diseases, problems, in people who are chronically ill or those who are elderly, and therefore, they are subjected to physical stress due to inhalation of too much of sulfur dioxide. This sulfur dioxide, if it is in higher quantity, and if rains have taken place, the sulfur dioxide and the nitrogen oxides, then react with the rain water to form dilute sulfuric acid and nitric acid.

Now, when they come down, they seep and **leach** through the ground, the soil, into the ground water. So, they also contaminate the drinking water, and if these acid rains are very, very corrosive, then they will also start corroding the vegetation. Suppose, you have put plantation, and the plants are in their tender stage, and at this stage if acid rains come, they will simply char the plant, the saplings of the plant, and it will just be dead and gone.

So, this also affects the tender vegetation, because acid rains are highly, highly corrosive, and they damage aquatic life, and they also damage our buildings, because this acid rain can corrode, and will react with the exterior of the buildings, and start creating holes in either the surface or on the walls.

And as what I mentioned, that the smog condition can get reversed. And I gave you that theory of, if it is at winter evening and if it is a summer evening, what will be the condition of smog. Smog is nothing but an accumulation of all these different types of air pollutants put together; so, they make a kind of a cloud just above the earth surface. If the earth surface is very heated up, they will raise up; if the earth surface is cool, as what it is in winter days, it will all be very close to the earth surface, and therefore, it will create a lot of inhalation problem, because it will be like a shadow just above the earth at the level at which we are standing.

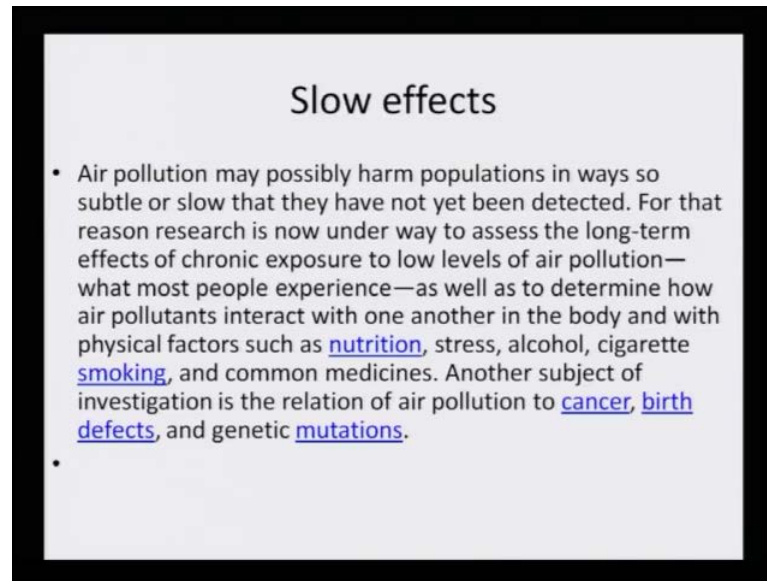
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Dramatic and debilitating effect of severe air pollution - the dramatic and debilitating effects of severe air pollution episodes in cities throughout the world have been known - such as, once in London, the smog of 1952, resulted in death of 4000 people - have alerted governments to the necessity for crisis procedures. Even everyday levels of air pollution, is a problem in developed countries, where efficient insulation keeps pollutant inside the structure. In less developed nations, the lack of running water and indoor sanitation can encourage respiratory infections.

Carbon monoxides, for example, by driving oxygen out of the blood stream, causes apathy, fatigue, headache, disorientation, and decreased muscular coordination, and visual acuity. So, you see that, you know, we have developed a life style which has created all these problems, and we need to understand, as to how to check, because having gone through these problems - like in 1952, 4000 people died just because of a very severe smog. And then, there was felt that there is a necessarily to immediately make a corrective measure and to remove people from those kind of pollutant sites. **to analyze**. And therefore, it was felt that throughout the day, there should be some kind of monitoring in highly polluted industrial areas, in areas where there are **vehicular traffic very high**, those are the places which are very susceptible for high air pollution.

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The slide is titled "Slow effects" and contains a single bullet point. The text of the bullet point discusses the subtle and slow effects of air pollution, mentioning research into chronic exposure to low levels of air pollution and its interaction with physical factors like nutrition, stress, alcohol, and cigarette smoking. It also mentions the relation of air pollution to cancer, birth defects, and genetic mutations.

What I have been talking about - air pollutants do not show an immediate effect; it is not that today you inhale carbon monoxide and tomorrow you will just fall sick; it is a gradual, but a slow poison.

Air pollution may possibly harmful population in ways so subtle and slow, that they have not yet been detected. For that reason, research is now under way to assess the long-term effects of chronic exposure to low levels of air pollution - what most people experience - as well as to determine how air pollutant interacts with one another in the body and with physical factors such as nutrition, stress, alcohol, cigarette smoking, and common medicines. Another subject of investigation is the relation of air pollution to cancer, birth defects and genetic mutations.

Now, you see, that it is a huge area; an area which is not even well understood. Why? Because we know that air pollution harms the population; we also understand that it is a slow process. But what is causing what, and how is it effecting in the metabolic system, how the chronic exposure and slow levels of air pollutants, can actually make so much of a drastic difference in the health condition of people, is yet to be determined and understood completely. And how is it related to a lack of nutrition or if a person is taking too much of alcohol or they having cigarette smoking simultaneously or taking too much of medicine, because this is a whole bunch of different class of chemicals - so, how are these chemicals interacting among themselves? How is this air pollutant being controlled

by the other chemicals that are present in the body, is still not a subject, which has been completely understood.

However, it is completely understood by the fact, that these air pollutants can slowly cause cancer, and they can cause birth defects in the fetus, and can even be a possibly causing or be a mutagen. So, mutagenic activity, carcinogenic activity, all can be witnessed.

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There is a Montreal Protocol - a recently discovered result of air pollution, are seasonal holes in ozone layer, in the atmosphere above the Antarctica and the Arctic, coupled with growing evidence of global ozone depletion. This can increase the amount of ultraviolet radiation reaching the earth, where it damages the crops and the plants, and can lead to skin cancer and cataracts. This depletion has been caused largely by the emission of chlorofluorocarbons (CFCs) from refrigerators, air conditioners, and aerosols.

The Montreal Protocol of 1987, required that develop nations sign an accord not exceeding 1986 CFC levels. Several more meetings were held in 1990 to 1997, to adopt agreements to accelerate phasing out ozone depleting substances. Now, this is a very serious and recent problem. And we have heard the terms global warming, the ozone layer getting depleted, and the UV light coming directly from the sun to the earth's surface, thereby causing a lot many more cases of skin cancer and cataracts. It is all because there is an ozone layer on the stratosphere of the earth and that prevents from the

UV light to come directly to the earth. So the vegetation, the human beings, are protected from these excessive UV light. However, because of the use of the chlorofluorocarbons, that is the CFCs, which are being used in refrigerators, air conditioners and aerosols, any amount of it when it leaks, it goes to the stratosphere, reacts with the chemicals that are present there and depletes this ozone layer. So, it is highly reactive to ozone, and so it removes the ozone, which is protecting. As a result, the UV light penetrates into the earth surface more readily.

So, it was felt in this Montreal Protocol, there has to be a limiting factor for ozone; because, earlier ozone was not one of the air pollutant; it was not in that category, only after this determination, that ozone is getting depleted by CFC - chlorofluorocarbons - it was felt that there is a necessity to measure the ozone content also, and that, the CFC levels also need to be checked in the air quality.

So, with this, we have come to an end of this air pollution, the air pollutants and the various measurement devices for specific air pollutant such as, carbon monoxide, carbon dioxide, nitrogen oxides, sulfur dioxide, methane, fluoride, lead, and many other air pollutants, including the chlorofluorohydrocarbons.