

**Advance Analytical Course**  
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**Lecture No. # 20**

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Just the way we had been taking about contamination in water and soil, similarly, we have huge problem of contamination in the air and we refer to this as air pollution. So, this lecture I have dedicated mainly to the causatives of air pollution and the main methods that are adapted for the analysis to detect these air pollutants. What is it?

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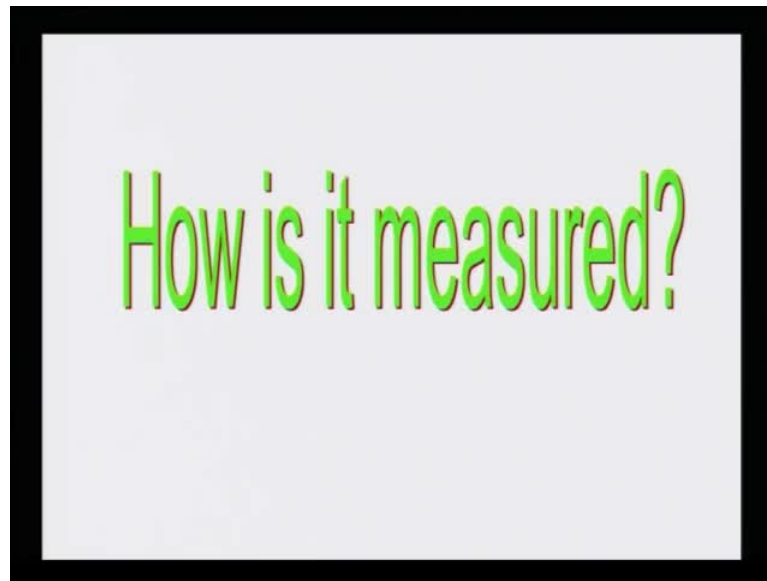


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If we try to look at this problem, any visible or invisible particle or gas found in the air that is not part of original or normal composition will be considered as a pollutant. So, you see how it kind of affects. **Natural - forest fires, pollen, dust storms or it could be through unnatural man made coal, wood and other fuels used in cars, homes and factories for energy purposes could be two causative reasons for causing air pollution.** So, there could be a natural reason or an unnatural reason.


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**AQI: Air Quality Index**

- **Indicates whether pollutant levels in air may cause health concerns.**
- **Ranges from 0 (least concern) to 500 (greatest concern)**

A stylized illustration of a globe showing the Americas in green and the oceans in blue. A thick, yellow, curved swoosh or ribbon-like shape wraps around the globe, suggesting a path or a measurement.

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Air Quality	Air Quality Index	Protect Your Health
Good	0-50	No health impacts are expected when air quality is in this range.
Moderate	51-100	Unusually sensitive people should consider limiting prolonged outdoor exertion.
Unhealthy for Sensitive Groups	101-150	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
Unhealthy	151-200	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion.
Very Unhealthy (Alert)	201-300	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion; everyone else, especially children, should limit outdoor exertion.

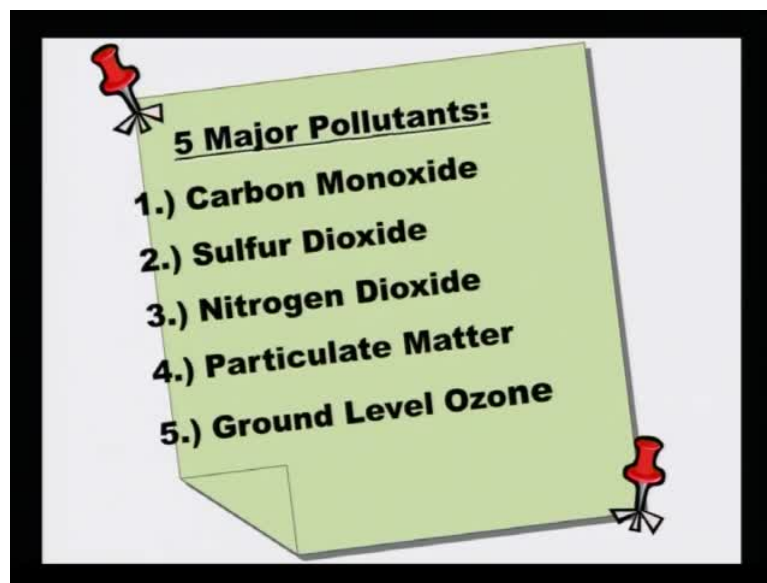
How is it measured? The way it is measured is by air quality index or we will refer to this as AQI - indicates whether pollutant levels in air health concerns; ranges from 0 - least concern to 500, that is, the greatest concern and globally, this is an accepted norm. So, we have air quality and it will be considered good, if it is between 0 and 50 and it will protect our health; that means there will be no health impacts that are expected when air quality is in this range.

It could have an air quality, which is moderate, which will be from 51 to 100 and usually sensitive people should consider limiting prolong outdoor exertion. That means those who are more sensitive should avoid being in this region of pollutants. If the air quality is furthermore unhealthy for sensitive groups, it could range from air quality index of 101 to 150. Active children and adults and people with respiratory diseases such as asthma should limit prolonged outdoor exertion and unhealthy **people**, that is, if there are air qualities which are completely unhealthy, will range in the air quality index as 151 to 200 and that the children, who are very active and adults, who have respiratory diseases must definitely limit their prolonged exertion outdoor. And very, very unhealthy air quality which needs an alarm or alert would be in the range of 201 to 300 and definitely, the active children, adults and people with respiratory diseases such as asthma should limit themselves in their prolonged exertion; everyone else, especially children should limit outdoor exertion.

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So, you see that these pollutants need to be measured and how the measurement takes place? The five pollutants that are: one is carbon monoxide; the second one is carbon dioxide; the third one is nitrogen dioxide; the fourth one is particulate matter and the fifth one is called ground level ozone. So, you see these are the five major air pollutants that need to be measured very carefully.

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**Carbon Monoxide**

- colorless, odorless
- produced when carbon does not burn in fossil fuels
- present in car exhaust
- deprives body of O<sub>2</sub> causing headaches, fatigue, and impaired vision

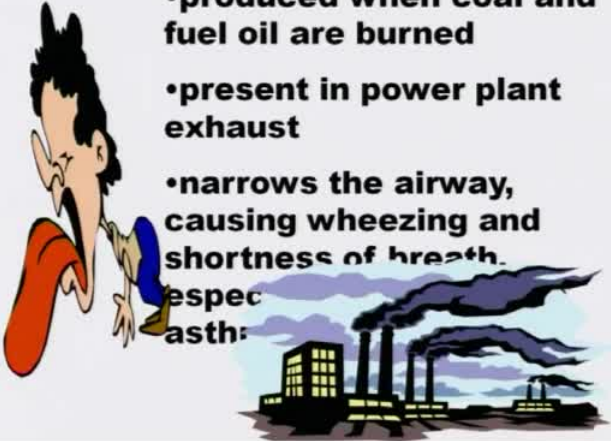


Carbon monoxide - it is a colourless and an odourless gas produced when carbon does not burn in fossil fuels properly, that is, by incomplete combustion of carbon; present in car exhaust, deprives body of oxygen causing headaches, fatigue and impaired vision. So, you see if a person inhales carbon monoxide, the usual symptoms that are visualised are that the person will have headache, will feel fatigue and will have impaired vision; that means there will be a vision problem also associated, if a prolonged inhalation of carbon monoxide is suffered and these comes from various sources.

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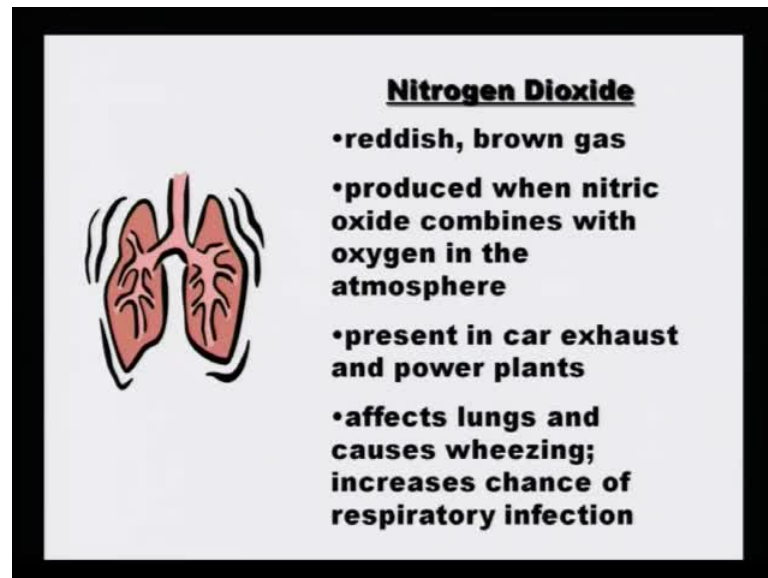
**Sulfur Dioxide**

- produced when coal and fuel oil are burned
- present in power plant exhaust
- narrows the airway, causing wheezing and shortness of breath, especially asthma



Similarly, sulphur dioxide - sulphur dioxide is produced when coal and fuel oil are burnt. So, this is the source which causes the excessive production of sulphur dioxide. It is present in power plant exhaust, and narrows the airway causing wheezing and shortness of breath, especially in those with asthma. So, due to the inhalation, these are the symptoms that arise in a person who has inhaled sulphur dioxide

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Nitrogen dioxide - similarly, by understanding the nature of nitrogen dioxide, its causative and what effect it can cause to a person can be understood. Reddish brown gas Nitrogen dioxide is a reddish brown gas produced when nitric oxide combines with oxygen in the atmosphere.

It is present in car exhaust and power plants and it affects the lungs and causes wheezing and increases chance of respiratory infection. So, these are the after effects of inhalation of carbon sorry of nitrogen dioxide.

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**Particulate Matter**

- **particles of different sizes and structures that are released into the atmosphere**
- **present in many sources including fossil fuels, dust, smoke, fog, etc.**
- **can build up in respiratory system**
- **aggravates heart and lung disease; increases risk of respiratory infection**



The image contains two illustrations. The top one shows three blue smokestacks with red tops, emitting a thick plume of blue smoke with small green and yellow particles floating within it. The bottom one shows a pink heart with a white bandage wrapped around its upper left side, symbolizing health issues or damage.

Similarly, particulate matter - the particles of different sizes and structure that are released in the atmosphere. These are small dust particles and they will be floating in the air like colloidal solution. We see that there is a brownian movement in the particles; the same way, very small particles are suspended in the air.


Present in many sources including fossil fuels, dust, smoke, fog etcetera; can build up in respiratory system and it aggravates heart and lung diseases particularly increases risk of reparatory infection. So these are the various effects that are caused by the particulate matter.



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**Ground Level Ozone**

- at upper level, ozone shields Earth from sun's harmful UV rays
- at ground level, ozone is harmful pollutants
- formed from car, power and chemical plant exhaust
- irritate respiratory system and asthma; reduces lung function by inflaming and damaging lining of lungs

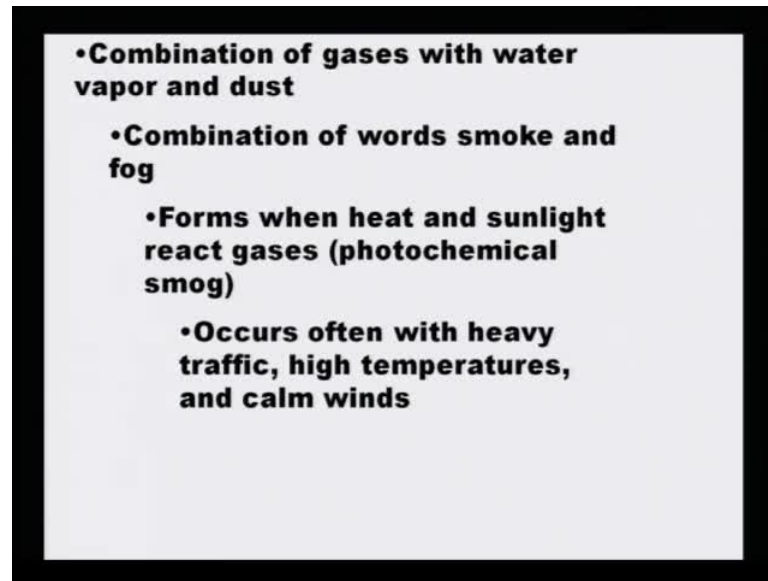


Ground level ozone - how does it help or how does it affect the person who is inhaling this ozone. At upper level, ozone shields earth from sun's harmful UV rays. At ground level, ozone is a harmful pollutant formed from car, power and chemical plant exhaust. It irritates respiratory system and asthma; reduces lung function by inflaming and damaging the lining of the lung. So, it is extremely injurious for the respiratory system and the lung, and it affects the inner lining of the lung.

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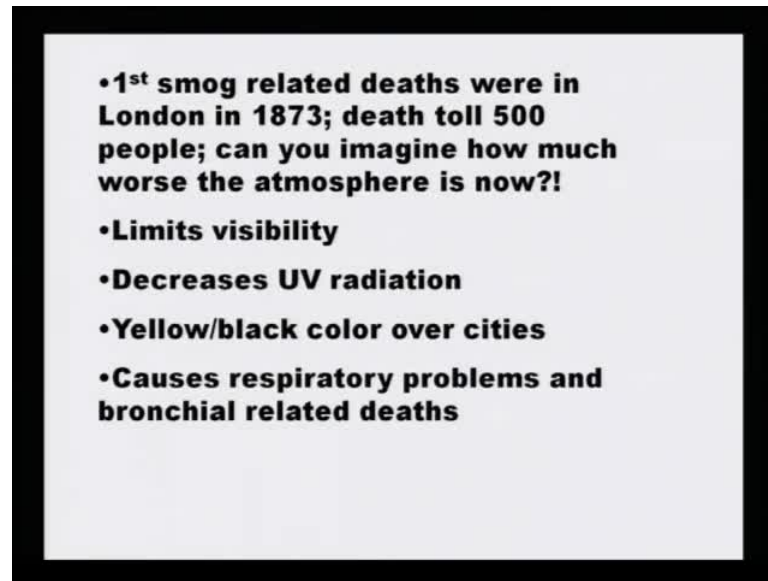


Therefore, these five together form a very dangerous combination, which is called as SMOG. **Combination of gases with water vapour and dust; combination of words with smoke and fog come forms** When heat and sun light react with these gases, photochemical smog is formed. And it occurs often with heavy traffic, high temperature and calm winds. So, these are the causatives of the formation of smog and smog is nothing, but a mixture of these five dangerous air pollutants.

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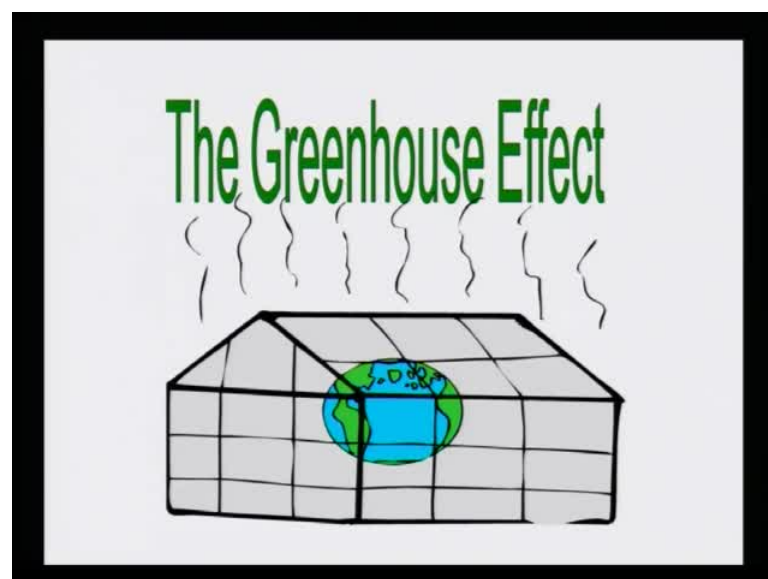


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What are the effects that are caused by the smog? First smog related death was in London in 1873 and death toll went up to five hundred people. Can you imagine how much worse the atmosphere is now? **limits** It also limits the visibility; we are not able to see far of distance objects. It decreases UV radiation. **yellow and black colour is kind of** There is a cover of black or yellow colour over the cities. It causes respiratory problems and bronchial related deaths are witnessed, when there is huge amount of smog. So, that is the kind of its effectivity that one witnesses in air pollutants.

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The other problems that are associated are, the greenhouse effect; that is, there is a kind of a warming that takes place and these smogs then do not let the activity take place in the normal sense. Then there is this global warming. You must have been hearing this word global warming for a very, very long time, but to be able to understand that why there is so much of heat generated at the earth's crust, it is because of this particulate matter; they are able to absorb a lot of sun rays and which is then radiated towards the earth and that causes global warming.

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Thinning of the upper ozone layer - **this causes** the smoke and the carbon monoxide which are released causes the thinning of the upper ozone layer and the UV rays then now start penetrating towards the earth's surface very readily. **Another rain** Acid rains are one another cause that are very, very dangerous. **to the** **The smog and five notorious air pollutants causing acid rains**

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Similarly, there are other indoor air pollutions which are due to the indoor activity. That means, if we are using any kind of heating devices or if people are smoking within the

house or if there is a chimney in the house, it could also add on to indoor air pollution. It is not always that outside there is pollution and inside everything is very clean and nice.

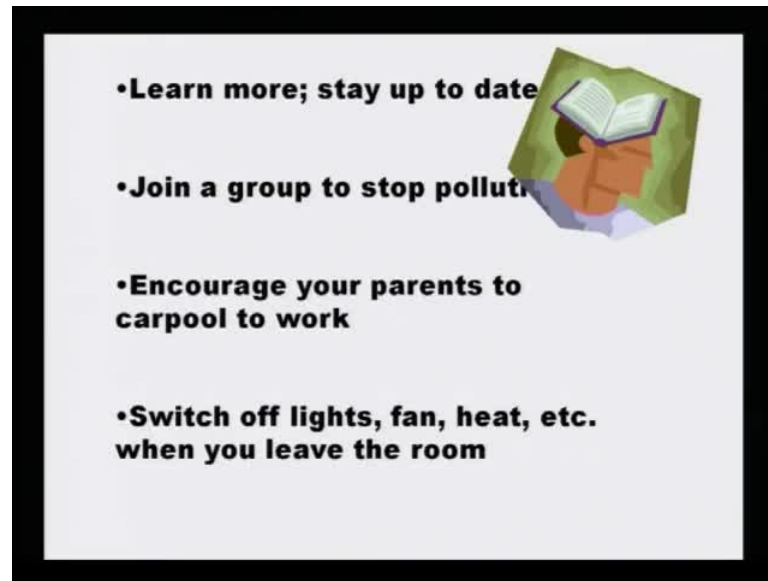
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So, what can we do to avoid indoor air pollution? That is a very important issue because most of the time we remain indoor and it is important for us to then think of using various such activities, where we can aerate our system with fresh air like one should **bike** ride a bike very regularly; tell your friends and family about this pollution and avoid to be in the polluted area. Suppose, if you have to visit an industrial area, try to come out of it as soon as possible so that you do not inhale too much of these pollutants and you are able to save your lungs carefully.

Make sure your parents get pollution check of their cars very regularly because car and automobiles are the ones which are very notorious in creating lot of air pollution. So, if we make the regular pollution checks of the car, it will be seen that the machine is not over exhausted and that the fuels are clean and the exhaust is also not generating very dark coloured mono oxide containing pollutants. And as far as possible try to ride a bus or school bus; that is just a small suggestion; it is not that everybody should go only in school bus and not in cars.

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Learn more and stay update about these. Join a group to stop pollution; that means there should be a societal activity to reduce the pollution or at least be able to understand. Encourage your parents to do a car pool to work so that lesser number of cars are plying on the road at one time; switch off lights, fan, heat and other heating devices within the room, when you are leaving the room. Why, because it all adds on to energy and energy and the dust particle when they get together, they make more dust particles float in the air and cause indoor air pollution.

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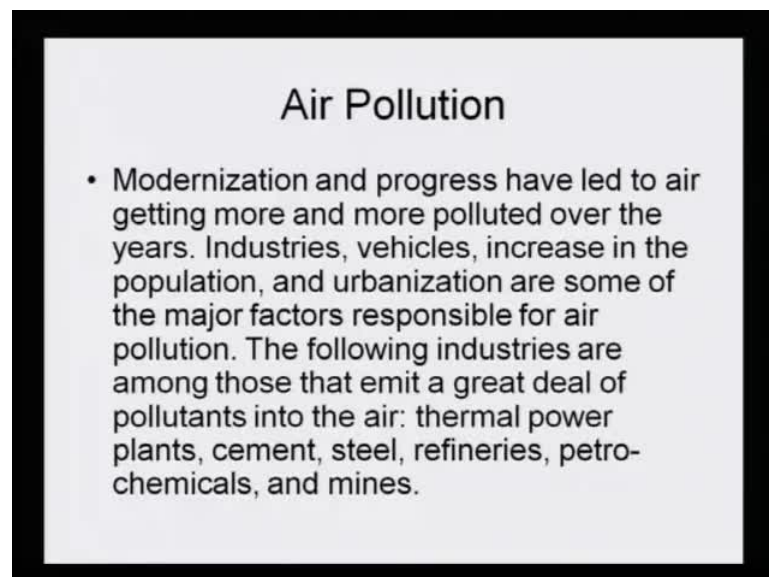


So, therefore, we have only one world and do you want to really save the world or do you want to destroy is the question that needs to be answered. Why, because we are living in the air; we have to breathe the air. If the air is polluted, it will cause a lot of problem for **ourselves** and that is why the awareness for air pollutants and their analysis is very, very important.

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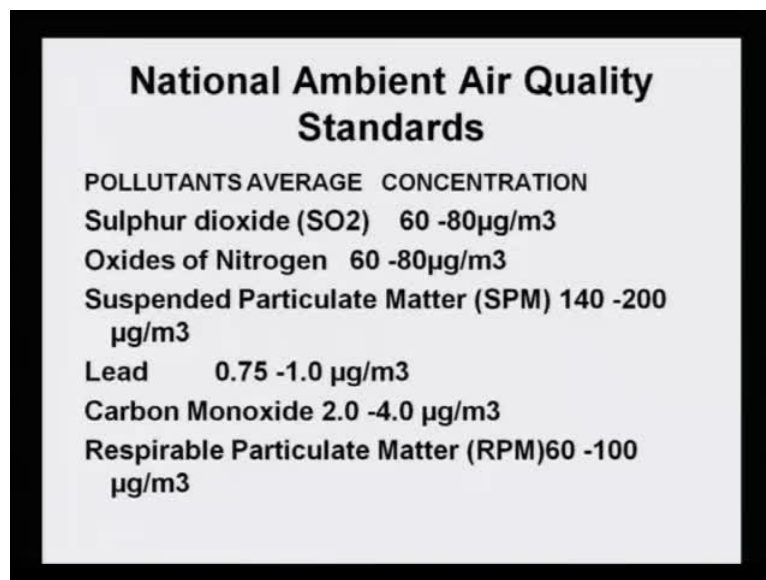
We will see a little more detail about what are the air consisting of and which are the major pollutants. We did take a look at the five notorious pollutants. That is carbon



monoxide, nitrogen dioxide, sulphur dioxide, particulate matter and the general ozone - thinning of the ozone layer. Air pollution - modernization and progress have led to air getting more and more polluted over the years. Industries, vehicles increase in the population and urbanization are some of the major factors responsible for air pollution.

The following industries are among those that emit a great deal of pollutants into the air: thermal power plants, cement, steel, refineries, petrochemicals and mines. You see it is these industries which create a lot of air pollution and these industries which add on to the air pollutants are mainly thermal power plants, cement factories, steel factories refineries, petro chemicals and mines.

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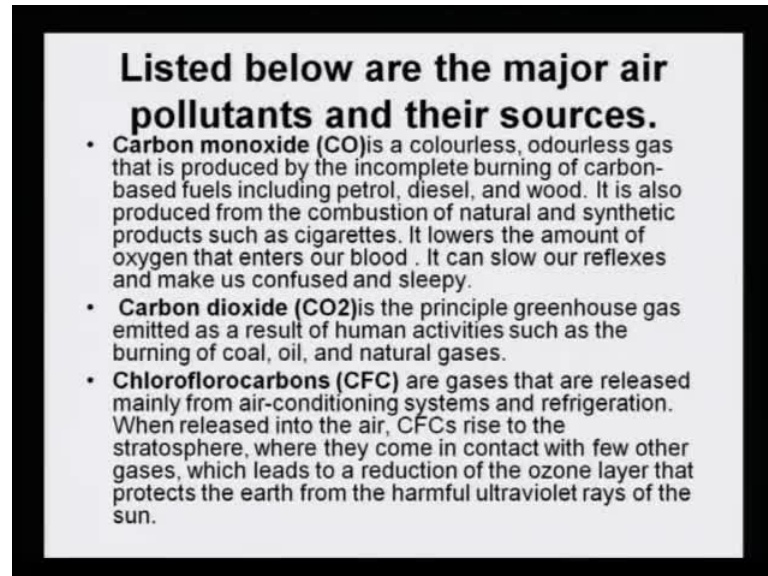


<b>National Ambient Air Quality Standards</b>	
<b>POLLUTANTS</b>	<b>AVERAGE CONCENTRATION</b>
<b>Sulphur dioxide (SO<sub>2</sub>)</b>	<b>60 -80µg/m<sup>3</sup></b>
<b>Oxides of Nitrogen</b>	<b>60 -80µg/m<sup>3</sup></b>
<b>Suspended Particulate Matter (SPM)</b>	<b>140 -200 µg/m<sup>3</sup></b>
<b>Lead</b>	<b>0.75 -1.0 µg/m<sup>3</sup></b>
<b>Carbon Monoxide</b>	<b>2.0 -4.0 µg/m<sup>3</sup></b>
<b>Respirable Particulate Matter (RPM)</b>	<b>60 -100 µg/m<sup>3</sup></b>

National ambient air quality standards - we have an air quality index that is AQI, but that is set up by the national ambient air quality standards. Pollutants, their average concentration; what should be their average concentration? Sulphur dioxide should not be more than 60 to 80 microgram per cubic meter; oxides of nitrogen again, should not exceed the limit of 60 to 80 microgram per cubic meter; suspended particulate matter or particulate matter because they are suspended in the air, should not exceed the limit of 140 to 200 microgram per cubic meter and the content of lead, that is a notorious heavy metal should not exceed from 0.07 to 1.0 microgram per cubic meter. Carbon monoxide should range between 2 to 4 microgram per cubic meter and respirable particulate matter, that is, the RPM should not exceed 60 to 100 microgram per cubic meter. So, this should

be the ideal air quality and this has been set up by the national standards of every country.

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**Listed below are the major air pollutants and their sources.**

- **Carbon monoxide (CO)** is a colourless, odourless gas that is produced by the incomplete burning of carbon-based fuels including petrol, diesel, and wood. It is also produced from the combustion of natural and synthetic products such as cigarettes. It lowers the amount of oxygen that enters our blood. It can slow our reflexes and make us confused and sleepy.
- **Carbon dioxide (CO<sub>2</sub>)** is the principle greenhouse gas emitted as a result of human activities such as the burning of coal, oil, and natural gases.
- **Chlorofluorocarbons (CFC)** are gases that are released mainly from air-conditioning systems and refrigeration. When released into the air, CFCs rise to the stratosphere, where they come in contact with few other gases, which leads to a reduction of the ozone layer that protects the earth from the harmful ultraviolet rays of the sun.

Listed below are the major air pollutants and their sources. We just learned some sources, but we will go into little more detail to understand. **the listed.** Among the listed air pollutants are, carbon monoxide is a colourless, odourless gas that is produced by the incomplete burning of carbon based fuels including petrol, diesel and wood. When there is an incomplete combustion, the carbon does not get converted into carbon dioxide completely. What it does, partially carbon monoxide is formed and partially carbon dioxide is formed and this carbon monoxide is then causing the air pollution. It is also produced from the combustion of natural and synthetic products such as cigarettes.

It lowers the amount of oxygen that enters our blood. **If we inhale carbon monoxide, it kind of restricts the oxygen to get into the system and when oxygen is not going into the system, the entire metabolic functioning which takes places with the help of oxygen and the reason why we respire is that we take in oxygen and we exhale out carbon dioxide is not functioned properly.** It can slow our reflexes and make us confused and sleepy. So, these are also the side effects of too much of inhalation of carbon monoxide.

Carbon dioxide is the principle greenhouse gas emitted as a result of human activities such as burning of coal, oil or natural gases. Now, **this also,** too much of carbon dioxide

can also create green house effect. So, that also should be avoided because it becomes like a pollutant.

Chlorofluorocarbons (CFC) are gases that are released mainly from air conditioning systems and refrigeration. When released into the air, the CFCs rise to the stratosphere, where they come in contact with few other gases, which leads to a reduction of ozone layer that protects the earth from the harmful ultra violet rays of the sun. Now, what role does chlorofluorocarbon play? Although **they** these gases are used in air conditioning because they are very good coolants and by **the rarefaction** the contraction and rarefaction of these gases, the air condition machine is made to work and the cooling effect is observed, but when these gases get leaked out into the atmosphere, they rise up to the higher stratosphere and there they combine with other gases. As a result, the ozone layer is getting depleted and the UV rays from the sun start penetrating on the earth there by causing global warming. So, that is what is the cause. When CFC is leaked and CFC then combines with ozone to cause this kind of global warming effect.

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### More pollutants

- **Lead** is present in petrol, diesel, lead batteries, paints, hair dye products, etc. Lead affects children in particular. It can cause nervous system damage and digestive problems and, in some cases, cause cancer.
- **Ozone** occur naturally in the upper layers of the atmosphere. This important gas shields the earth from the harmful ultraviolet rays of the sun. However, at the ground level, it is a pollutant with highly toxic effects. Vehicles and industries are the major source of ground-level ozone emissions. Ozone makes our eyes itch, burn, and water. It lowers our resistance to colds and pneumonia.
- **Nitrogen oxide (Nox)** causes smog and acid rain. It is produced from burning fuels including petrol, diesel, and coal. Nitrogen oxides can make children susceptible to respiratory diseases in winters.
- **Suspended particulate matter (SPM)** consists of solids in the air in the form of smoke, dust, and vapour that can remain suspended for extended periods and is also the main source of haze which reduces visibility. The finer of these particles, when breathed in can lodge in our lungs and cause lung damage and respiratory problems.
- **Sulphur dioxide (SO<sub>2</sub>)** is a gas produced from burning coal, mainly in thermal power plants. Some industrial processes, such as production of paper and smelting of metals, produce sulphur dioxide. It is a major contributor to smog and acid rain. Sulfur dioxide can

More pollutants - lead is present in petrol, diesel, lead batteries, paints, hair dye products. Lead affects children in particular. It can cause nervous system damage and digestive problem and in some cases, cause cancer. So, you see that we have talked about unleaded petrol. Earlier, the petrol was not purified and lead was allowed to pass and when this lead went into the combustion machine of an automobile, it would come out with the

lead oxide or some form of lead in an half combusted or completely combusted state. As a result, it created a lot of metal pollution in the air. So, this is one such heavy metal which is found in the air and the effects are very, very serious. Why, because it causes directly attacks the nervous system and it also attacks the digestive system. So, for some children it has been also a causative of cancer. That is why the sourcing of lead in the atmosphere must be curbed and it comes from petrol, diesel, lead batteries, paints, hair dyes and many other such sources.

Ozone - occurring naturally in the upper layers of atmosphere, this important gas shields the earth from the harmful ultra violet rays of the sun. However, at the ground level, it is a pollutant with highly toxic effects. Vehicles and industries are the major sources of ground level ozone emissions. Ozone makes our eyes itch, burn and water. It lowers our resistance to cold and pneumonia. So, you see if there is too much of ozone in the atmosphere, even that can cause a lot of problem. It ideally is a boon, when it is at the upper layer of the atmosphere and this important gas actually shields the earth from the UV rays of the sun. However, at the ground level, it is like a pollutant and with very high toxic effect because it reacts with the vehicular and industrial pollutions, and then it kind of creates a lot of itching in the eye, burning and then watering of the eye.

Nitrogen oxide or Nox - because there are a variety of nitrogen oxide and so, all put together will be referred as Nox; causes smoke and acid rain. It is produced by burning fuels including petroleum, diesel and the coal. Nitrogen oxide can make children susceptible to respiratory diseases in even winter. So, what Nox does? It creates smog and acid rain. Why, because it has a tendency to react with water and to form dilute nitric acid; that is why it is called acid rain.

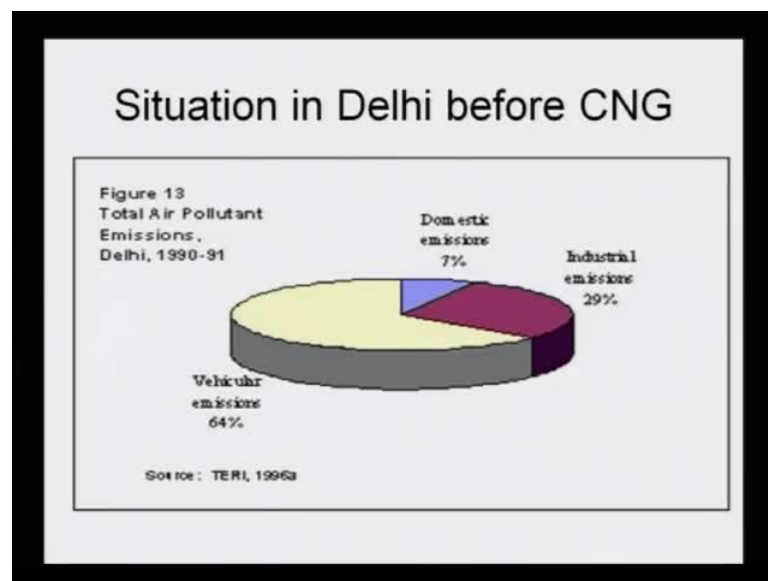
Suspended particulate matter or the SPM consists of solids in the air in the form of smoke, dust and vapour that can remain suspended for extended periods and is also the main source of haze, which reduces visibility. The finer of these particles, when breathed, can lodge in our lungs and cause lung damage and respiratory problems. So, as the name suggests, it is suspended and particulate - very fine particles, which are floating in the atmosphere and these are there, and when they are inhaled, they get clogged into the lungs and they cause lung damage and respiratory problems. Another thing, they also because the atmosphere is not clear, it is suspended with these particles and there is a yellow or a black colouring which is over shadowing, there is a visibility problem; long

distance objects cannot be seen, if there is too much of smog or suspended particulate matter.

**Carbon sorry** Sulphur Dioxide is a gas produced from burning coal, mainly in thermal power plants. Some industrial processes such as production of paper and smelting of metals produce sulphur dioxide. It is a major contributor to smog and acid rain. Sulphur dioxide can lead to lot of health problem related to lungs.

Now, one thing needs to be understood that both nitrogen oxide, that is, the Nox and the Sox, that is, sulphur dioxide are in gaseous form and they are formed from the burning of coal or diesel or petrol and they both then cause the creation of smog. Once the smog is formed, when the rain falls on it, **kind of** because both are acidic in nature, they react with water; one forms sulphurous acid and sulphuric acid, and the other one forms nitrous acid and nitric acid. So, that is why they are very corrosive in nature.

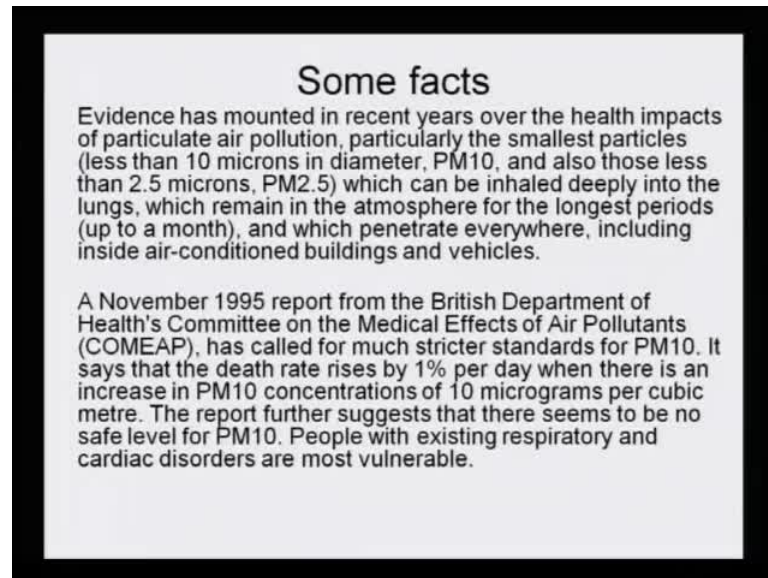
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If one tries to look at the situation of one particular city, in Delhi for example, the situation of the CNG is that there are so many, if one tries to understand why CNG needs to be introduced, why petroleum and petrol or diesel are not the ideal vehicular substance, then one would understand that the total air pollution that was estimated in the year 1990 to 1991 was found to be due to vehicular emissions and the domestic were only 7 percent, whereas industrial emissions were 29 percent. So, these are some of the statistics laid up by TERI in 1996. This study shows that what is the causative? The

causative of major air pollution then becomes coming from vehicles and vehicles are using petroleum and diesel. So, that is why CNG was introduced and that it emits the least amount of these pollutants and thus is ideal for vehicular emissions.

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Some other facts - evidence has mounted in recent years over the health impacts of particulate air pollutants, particularly the smallest particles; that is, the less the particles that are less than 10 microns in diameter - PM10, as what it is referred and also those less than 2.5 micron, which is referred as particulate matter 2.5 - PM2.5, which can be inhaled deeply into the lungs and which remain in the atmosphere for the longest periods up to almost 1 month and which penetrate everywhere including inside air conditioned buildings and vehicles. So, you see there have been evidences that these particulate matters are very, very notorious and they can reach even, the you know air conditioned rooms and the double walled rooms because they are so small that with any kind of little opening, the particulate in PM10 and PM2.5 can reach everywhere.

A November 1995 report from the British department of health's committee on the medical effects of air pollutants, that is, COMEAP has called for much stricter standards for PM10. It says that the death rate rises by 1 percent per day, when there is an increase in PM10 concentrations of 10 microgram per cubic meter. The report further suggests that there seems to be no safe level for PM10. People with existing respiratory and cardiac disorder are most vulnerable. So, you see that this PM10 of the entire class of

particulate matter is extremely notorious and needs to be addressed. Even 1 percent rise per day can cause a huge loss and that is what makes it a very dangerous air pollutant.

So, with this, we have come to an end of this very important topic of using pollutants, understanding the pollutants and to be able to understand what are the machines that can be used for these analyses and as I told you that GC is the only machine and GCMS of course, is the other machine that can be used for the analysis of these pollutants, particularly the Sox, the Nox and the carbon monoxide because they are collected in different areas of the most polluted areas of a city.

These canisters are collected at different times of the day and then taken to an analytical laboratory. The canisters then are transferred through cold trap distortion method on to the GC column for the analysis and that is how you must have seen in many big cities there are places, where it says the air quality index and then it says it has carbon monoxide this much, carbon dioxide this much, Nox this much, particulate matter this much.

So, this data is actually generated from the fact that these particulate matter, Nox, Sox, carbon monoxide are analyzed through a GC machine. We have dedicated enough time on the GC and the gaseous sample transferring devices. So, you will be able to appreciate that GC is the answer for the analysis of Sox, Nox and carbon monoxide.