18CV656 CNR Module 3 Part 1 Prof. Srinidhi S U

conservation of natural resource (Visvesvaraya Technological University)

ATRIA INSTITUTE OF TECHNOLOGY
Department of Civil Engineering

Course: Conservation of Natural Resources (18CV656)

MODULE 3

Part 1

AIR

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Module 3: Air and Minerals

Air: Introduction, composition, sources and classification of air pollutants, National Ambient Air quality standards (NAAQS), Air quality index, effects of air pollution on human health. Economic effects of air pollution. Control of air pollution by equipment, smoke and its control. Ozone depletion impacts, photochemical changes.
Minerals and rocks: Minerals, important rock forming minerals like Quartz, Mica, Feldspar and Amphibole, lithification & metamorphism, weathering: physical, biogeochemical processes, erosion, agent of erosion

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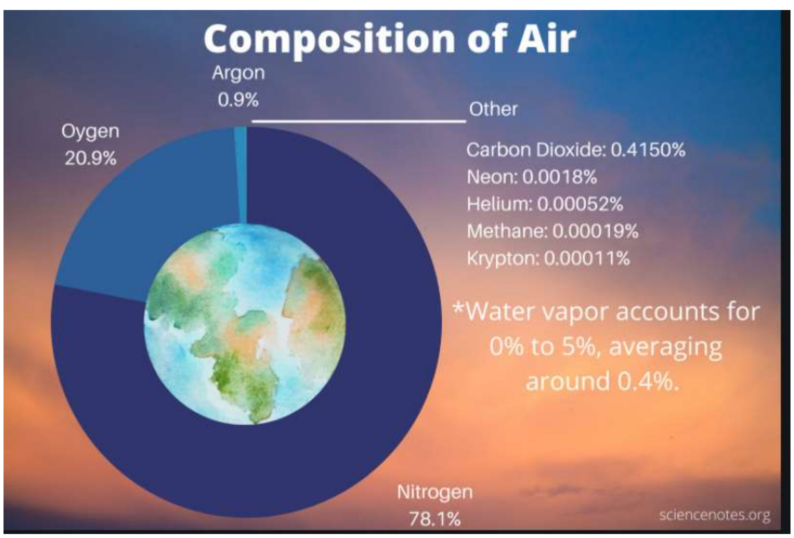
Air

Air is a non-homogeneous mixture of different gases in the atmosphere.



The composition of air refers to the chemical composition of the troposphere. The troposphere is the lowest layer of the atmosphere, extending from the surface to about 12 km or 39000 ft. The troposphere contains about 80% of the mass of the Earth's atmosphere. Nearly all of the atmosphere's water vapor exists in this layer. Just three gases account for 99% of dry air: nitrogen, oxygen, and argon.

Gas	Formula	Percentage (%)
Nitrogen	N_2	78.084
Oxygen	O_2	20.946
Argon	Ar	0.9340
Carbon Dioxide	CO_2	˜0.04
Neon	Ne	0.001818
Helium	He	0.000524
Methane	CH_4	0.000187

Air pollution

Means the presence in the atmosphere of one or more air contaminants in such quantities and of such duration as is or tends to be injurious to human health or welfare, animal or plant life, or property, or would unreasonably interfere with the enjoyment of life or property.

Air pollution may be defined as the

presence in the air (outdoor atmosphere) of *one or more contaminants* or *combinations thereof* in such quantities and of such durations as may be or tend to be ***injurious to human, animal or plant life, or property, or which unreasonably interferes with the comfortable enjoyment of life or property or conduct of business***.

- Air pollutants come in the form of ***gases*** and finely divided ***solid*** and ***liquid*** aerosols.
- *Aerosols* are loosely defined as "any solid or liquid particles suspended in the air"

Air Pollutant

- A pollutant can be solid (large or sub-molecular), liquid or gas .
- It may originate from a natural or anthropogenic source (or both).
- It is estimated that anthropogenic sources have changed the composition of global air by less than 0.01%.
- Examples of "natural" air pollution include:

- Ash,
- salt particles,
- pollen and spores,
- smoke and
- windblown dust

Sources and Classification of Air Pollution

The air pollutants can be classified in many ways as shown below:-

1. **According to origin:**

   The air pollutants are classified into:

   Primary pollutants:

   The pollutants that are emitted directly from identifiable sources produced by natural events (eg: dust storms and volcanic eruptions) and human activities (eg: emissions from vehicles, industries etc.) are called primary pollutants. Eg: smoke, dust, oxides of sulphur & nitrogen, hydrocarbons and particulate matter etc.

   Secondary pollutants:

   The pollutants that are formed in the atmosphere by chemical interactions between primary pollutants and atmospheric constituents are known as secondary pollutants. Eg. Sulphur trioxide, ozone, ketones, sulphuric acid, nitric acid, carbonic acid etc.

2. **According to state of matter:**

   The pollutants are classified into:-

Gaseous air pollutants:

These pollutants exist in a gaseous state at normal temperature and pressure. They are carbon dioxide, nitrogen dioxide, sulphur oxides etc.

Particulate air pollutants:

These are not gaseous substances. They are suspended droplets, solid particles or mixtures of the two.

3. **According to sources:**

   Pollutants originate from

   Natural sources:

   These include volcanic eruptions, deflation of sand and dust, forest or wild fires of natural vegetation, sulphur springs, natural geysers, organic and inorganic decays, vegetative decays, marsh gases, cosmic dust, pollen grains of flowers, photochemical reactions, soil debris etc. Wild animals in their natural habitat are also considered natural sources of pollution – decomposition gases, waste

   Man-made sources:

   These include human activities such as industries, factories, urban centres, aircraft, nuclear experiments, automobiles, agriculture, domestic burning of wood and burning of fossil fuels, deforestation, mining, waste treatment plants and power plants.

Sources of Air Pollution - contd

Stationary Sources

- A stationary source of air pollution refers to an emission source that does not move (i.e., power plants, chemical and manufacturing industries).
- Often stationary sources are defined as large emitters who release relatively consistent qualities and quantities of pollutants.

POINT SOURCE

- Point sources include-
- industrial and nonindustrial stationary equipment or processes considered significant sources of air pollution emissions.
- A facility is considered to have significant emissions if it emits about one ton or more in a calendar year.
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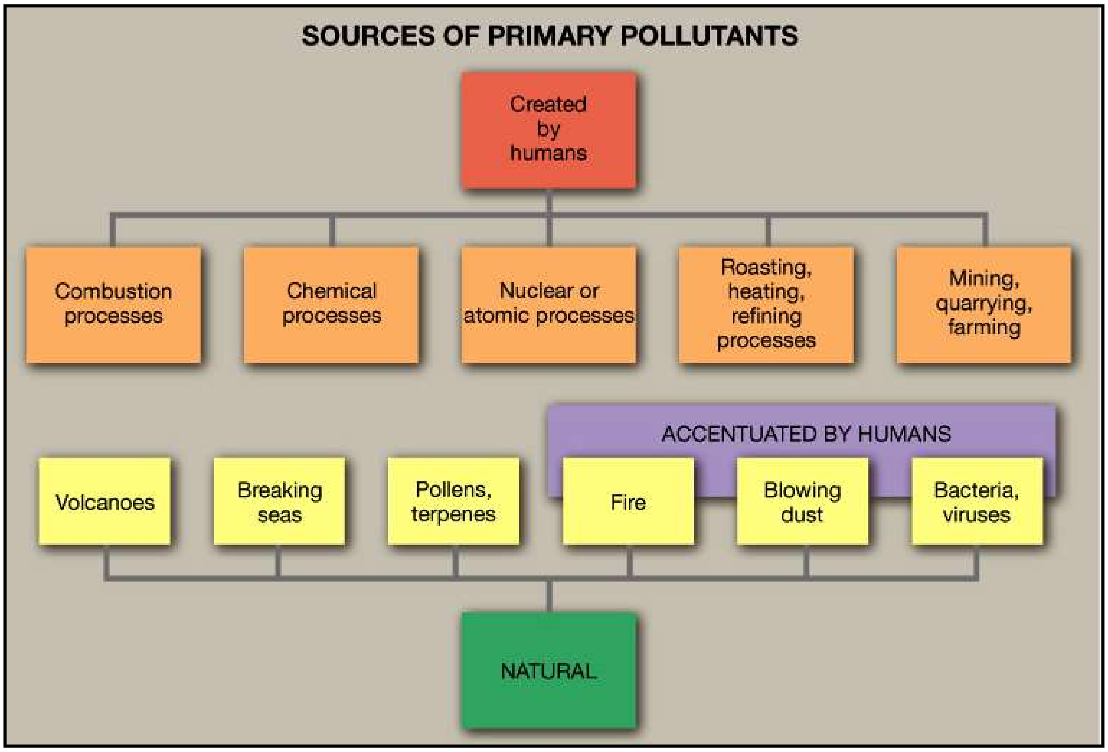
Area Sources

- The term AREA SOURCE is used to describe the many smaller stationary sources located together whose individual emissions may be low but whose collective emissions can be significant.
- Typically area sources are those that emit < 25 tons per year of any combination of hazardous air pollutants, or < 10 tons per year of any single hazardous air pollutant.
  Examples
- locomotives operating within a railyard
- Multiple flue gas stacks within a single industrial plant
- Open burning and forest fires
- Evaporation losses from large spills of volatile liquids
- Area sources that may fall under the “point source” definition are piping leaks, industrial wastewater treatment ponds, rock and quarry operations, and tank farms.



Factors that affect air pollution

- Emissions (traffic, industrial, domestic)
- Geography (terrain)
- Weather conditions (rain, winds, humidity)
- Season
- Time of day
- Population density
- Indoor vs outdoor

National Ambient Air Quality Standards (NAAQS)

NATIONAL AMBIENT AIR QUALITY STANDARDS (2009)

Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)	
Sulphur Dioxide (SO_2), $\mu g/m^3$	Annual * 24 Hours **	50 80	20 80	-Improved West and Gaeke Method -Ultraviolet Fluorescence
Nitrogen Dioxide (NO_2), $\mu g/m^3$	Annual * 24 Hours **	40 80	30 80	-Jacob & Hochheiser modified ($NaOH-NaAsO_2$) Method -Gas Phase Chemiluminescence
Particulate Matter (Size less than 10µm) or PM_{10}, $\mu g/m^3$	Annual * 24 Hours **	60 100	60 100	-Gravimetric -TEOM -Beta attenuation
Particulate Matter (Size less than 2.5µm) or $PM_{2.5}$, $\mu g/m^3$	Annual * 24 Hours **	40 60	40 60	-Gravimetric -TEOM -Beta attenuation
Ozone (O_3) $\mu g/m^3$	8 Hours * 1 Hour **	100 180	100 180	-UV Photometric -Chemiluminescence -Chemical Method
Lead (Pb) $\mu g/m^3$	Annual * 24 Hours **	0.50 1.0	0.50 1.0	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper -ED-XRF using Teflon filter
Carbon Monoxide (CO), mg/m^3	8 Hours ** 1 Hour **	02 04	02 04	-Non dispersive Infrared (NDIR) Spectroscopy
Ammonia (NH_3), $\mu g/m^3$	Annual * 24 Hours **	100 400	100 400	-Chemiluminescence -Indophenol blue method
Benzene (C_6H_6), $\mu g/m^3$	Annual *	05	05	-Gas Chromatography (GC) based continuous analyzer -Adsorption and desorption followed by GC analysis
Benzo(a)Pyrene (BaP) Particulate phase only, ng/m^3	Annual *	01	01	-Solvent extraction followed by HPLC/GC analysis
Arsenic (As), ng/m^3	Annual *	06	06	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper
Nickel (Ni), ng/m^3	Annual *	20	20	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

NOTE: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigations.

Ambient air quality refers to the condition or quality of the outdoor air. NAAQs are the standards for ambient air quality with reference to various identified pollutant notified by the CPCB under the Air (Prevention and Control of Pollution) Act, 1981. Major objectives of NAAQS are:

(i) to indicate necessary air quality levels and appropriate margins required to ensure the protection of vegetation, health, and property,

(ii) to provide a uniform yardstick for the assessment of air quality at the national level and

(iii) to indicate the extent and need of the monitoring programme.

Annual standards are basically the annual arithmetic mean of a minimum 104 measurements in a year, at a particular site taken twice a week, at a uniform 24-hourly interval and at either a 24 hourly, 8 hourly, or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. However, there is a 2% chance of exceeding the limits but not on two consecutive days of monitoring.

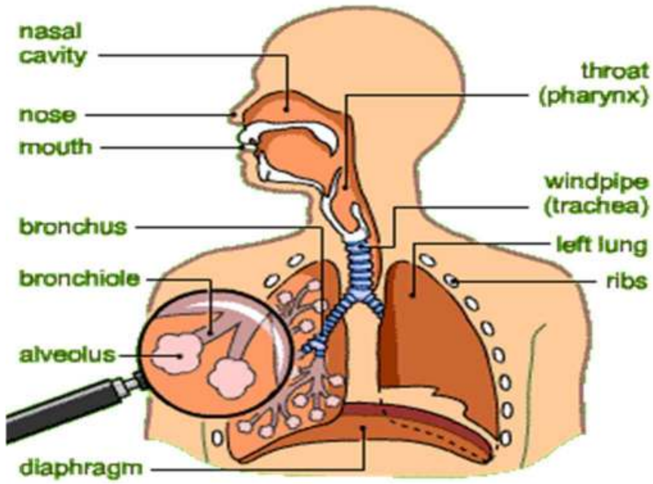
Air Quality Index

The AQI was launched by the Prime Minister in April, 2015 starting with 14 cities and now extended to 71 cities in 17 states. The AQI is a tool for the effective communication of air quality status to people in terms, which are easy to understand. It transforms complex air quality data of various pollutants into a single number (index value), nomenclature and colour. There are six AQI categories, namely, good, satisfactory, moderately polluted, poor, very poor, and severe. Each of these categories is decided based on the ambient concentration values of air pollutants and their likely health impacts (known as health breakpoints). The AQ sub-index and health breakpoints are evolved for eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Lead (Pb)) for which short-term (upto 24-hours) National Ambient Air Quality Standards are prescribed. Based on the measured ambient concentrations of a pollutant, a sub-index is calculated, which is a linear function of concentration (e.g., the subindex for PM2.5 will be 51 at concentration 31 µg/m3, 100 at concentration 60 µg/ m3, and 75 at concentration of 45 µg/m3). The worst sub-index determines the overall AQI.

TABLE 3: AQI CATEGORIES AND HEALTH BREAKPOINTS

AQI	Associated Health Impacts
Good (0-50)	Minimal Impact
Satisfactory (51-100)	May cause minor breathing discomfort to sensitive people
Moderate (101-200)	May cause breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease, children and older adults
Poor (201-300)	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease with short exposure
Very Poor (301-400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
Severe (401-500)	May cause respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases. The health impacts may be experienced even during light physical activity

Effect of Air Pollution on human health



Human respiratory system

Tobacco smoke. Tobacco smoke generates a wide range of harmful chemicals and is a major cause for health illness, which known to cause for cancer. It is well-known that smoking affects the passive smoker (the person who is in the vicinity of a smoker and is not himself/herself a smoker) ranging from burning sensation in the eyes or nose, and throat irritation, to cancer, bronchitis, severe asthma, and a decrease in lung function.

***Biological pollutants*.** These are mostly allergens that can cause asthma, hay fever, and other allergic diseases.

***Volatile organic compounds*.** Volatile compounds can cause irritation of the eye, nose and throat. In severe cases there may be headaches, nausea, and loss of coordination. In the longer run, some of them are suspected to cause damage to the liver and other parts of the body.

Formaldehyde. Exposure causes irritation to the eyes, nose and may cause allergies in some people.

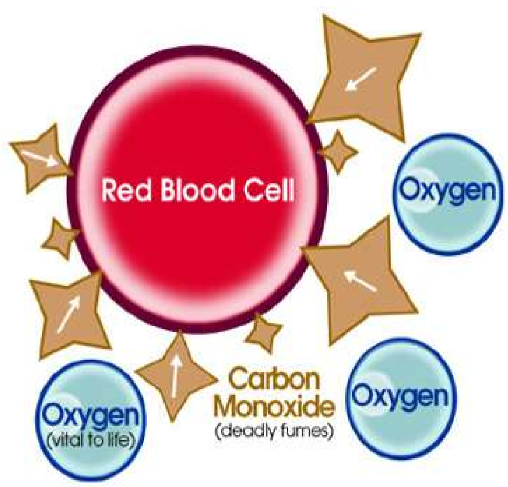
***Lead*.** Prolonged exposure can cause damage to the nervous system, digestive problems, and in some cases cause cancer. It is especially hazardous to small children.

***Radon*.** A radioactive gas that can accumulate inside the house, it originates from the rocks and soil under the house and its level is dominated by the outdoor air and also to some extent the other gases being emitted indoors. Exposure to this gas increases the risk of lung cancer.

***Ozone*.** Exposure to this gas makes our eyes itch, burn, and it has also been associated with increase in respiratory disorders such as asthma. It lowers our resistance to colds and pneumonia.

***Oxides of nitrogen*.** This gas can make children susceptible to respiratory diseases in the winters.

***Carbon monoxide*.** CO (carbon monoxide) combines with hemoglobin to lessen the amount of oxygen that enters our blood through our lungs. The binding with other proteins causes changes in the function of the affected organs such as the brain and the cardiovascular system, and also the developing fetus. It can impair our concentration, slow our reflexes, and make us confused and sleepy.



Sulphur dioxide. SO_2 (sulphur dioxide) in the air is caused due to the rise in combustion of fossil fuels. It can oxidize and form sulphuric acid mist. SO_2 in the air leads to diseases of the lung and other lung disorders such as wheezing and shortness of breath. Long-term effects are more difficult to ascertain as SO2 exposure is often combined with that of SPM.

SPM (suspended particulate matter). Suspended matter consists of dust, fumes, mist and smoke. The main chemical component of SPM that is of major concern is lead, others being nickel, arsenic, and those present in diesel exhaust. These particles when breathe in, lodge in our lung tissues and cause lung damage and respiratory problems.

The importance of SPM as a major pollutant needs special emphasis as

a) It affects more people globally than any other pollutant on a continuing basis.

b) There is more monitoring data available on this than any other pollutant.

c) More epidemiological evidence has been collected on the exposure to this than to any other pollutant.

Economic Effect of Air Pollution

Air pollution already affects human health, agriculture and leads to a range of other impacts. These impacts are projected to become much more severe in the coming decades. Rising emissions of air pollutants are projected to lead to higher concentrations of particulate matter (PM2.5) and ground level ozone. In several regions of the world, average concentrations of PM2.5 and ozone are already well above the levels recommended by the WHO Air quality guidelines. The market impacts of outdoor air pollution, which include impacts on labour productivity, health expenditures and agricultural crop yields, are projected to lead to global economic costs that gradually increase to 1% of global GDP by 2060.

The projected increase in concentrations of PM2.5 and ozone will in turn lead to substantial effects on the economy. According to the calculations in this report, global air pollution-related healthcare costs are projected to increase from USD 21 billion (using constant 2010 USD and PPP exchange rates) in 2015 to USD 176 billion 2005 in 2060.

By 2060, the annual number of lost working days, which affect labour productivity, are projected to reach 3.7 billion (currently around 1.2 billion) at the global level.

The most dangerous consequences from outdoor air pollution are related to the number of premature deaths. This report projects an increase in the number of premature deaths due to outdoor air pollution from approximately 3 million people in 2010, in line with the latest Global Burden of Disease estimates, to 6-9 million annually in 2060. A large number of deaths occur in densely populated regions with high concentrations of PM2.5 and ozone, especially China and India, and in regions with aging populations, such as China and Eastern Europe

The annual global welfare costs associated with the premature deaths from outdoor air pollution, calculated using estimates of the individual willingness-topay to reduce the risk of premature death, are projected to rise from USD 3 trillion in 2015 to USD 18-25 trillion in 2060. In addition, the annual global welfare costs associated with pain and suffering from illness are projected to be around USD 2.2 trillion by 2060, up from around USD 300 billion in 2015, based on results from studies valuating the willingness-to-pay to reduce health risks.

• Policies to limit air pollution emissions would lead to an improvement in air quality, reduce risks of very severe health impacts, and, if properly implemented, generate considerable climate co-benefits.

Other effects are corrosion of metals, soiling and eroding of building surfaces, fading of dyed materials rubber cracking, spoiling or destruction of vegetation effects on animals, as well as interference with production and services

Building materials are corroded and disfigured by air pollutants. Smoke and aerosols adhere to stone, brick, and other building surfaces to produce unsightly coatings. Sulphur dioxide and sulphur trioxide in the presence of moisture can react with limestone ($CaCO_3$) to form calcium sulphate ($CaSO_4$) and gypsum ($CaSo_4$, $2H_2O$). This acid converts limestone into a water-soluble bicarbonate, which is then leached away. Staining of building stone by sulphur compounds and particulars requires additional cleaning expense.

Paints

Areas of high pollution require more frequent painting. Air pollutants may damage the protective coating and by exposing the underlying surface to attack.

Textiles

Sulphur oxides cause deterioration of natural and some synthetic textile fibres. The most common form of permanent damage to textiles has been the deterioration of nylon hose.

Rubber

The main affected areas are the side walls of tyres and various forms of electrical insulation. This type of damage is caused by ozone.

Leather

Sulphur dioxide causes leather in lose much of its strength and ultimately disintegrate.

Paper

The small amounts of metallic impurities in 'modern' paper accelerate the conversion of absorbed sulphuric dioxide to sulphuric acid, in the presence of moisture.

Glass and Ceramics

During a long exposure for three years, porcelain enamels showed a change in their surface appearance. Moisture and atmospheric pollution by acidic substances seems to have played a major role in surface degradation.

Electronics Industry

Air pollutants cause thin insulating film to develop on contacts resulting in open circuits and malfunctioning of the equipment.

Vegetation

Damage to vegetation as a result of air pollution is a very important aspect of economic loss due to air pollution.

Intangible Loss

Another very important economic repercussion of air pollution is the intangible loss due to great damage to art objects throughout the world including our county. For example, effects on the Taj Mahal (Agra), Sri Channakeshava Temple (Belur), and Parthenon (Athens).

Air pollution control devices

Air pollution control devices are a series of devices that work to prevent a variety of different pollutants, both gaseous and solid, from entering the atmosphere primarily out of industrial smokestacks. These control devices can be separated into two broad categories - devices that control the amount of particulate matter escaping into the environment and devices that control acidic gas emissions. It is important to understand that the extraction methods for each specific type of pollutant can differ, so the only the major methods are discussed. Although complex, these devices have shown to be effective in the past with the overall levels of emissions for many pollutants dropping with the implementation of these control devices.

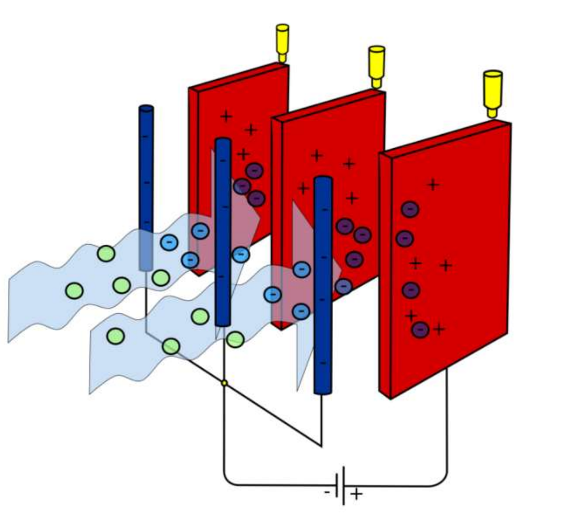
Control of Particulate Matter

Specific machinery is used to remove particulate matter from flue gases. Much of this separation uses physical means of separation and not chemical separation techniques simply because particulate matter is large enough to be "caught" in this manner. Below are some of the basic ways that particulate matter can be extracted.

1. Electrostatic Precipitators
2. Cyclone Separators
3. Fabric Filters

1. **Electrostatic Precipitators:**

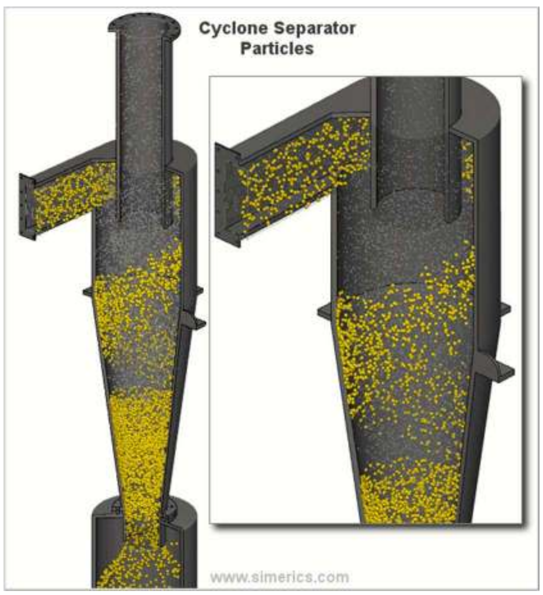
An **electrostatic precipitator** is a type of filter that uses static electricity to remove soot and ash from exhaust fumes before they exit the smokestacks. Unburned particles of carbon in smoke are pulled out of the smoke by using static electricity in the precipitators, leaving clean, hot air to escape the smokestacks. It is vital to remove this unreacted carbon from the smoke, as it can damage buildings and harm human health - especially respiratory health.

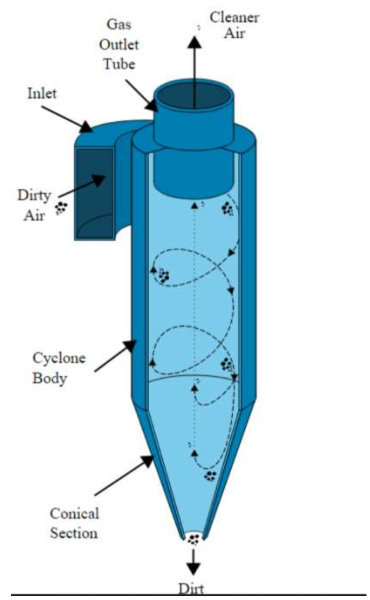


A model of an electrostatic precipitator using metal wires as the negative electrodes and large plates as the positive electrodes

2. **Cyclone Separators**

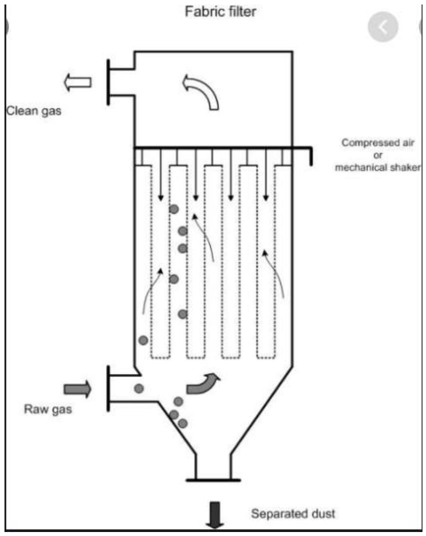
A **cyclone separator** is a separation device that uses the principle of inertia to remove particulate matter from flue gases. In these separators, dirty flue gas enters a chamber containing a vortex, similar to a tornado. Because of the difference in inertia of gas particles and larger particulate matter, the gas particles move up the cylinder while larger particles hit the inside wall and drop down. This separates the particulate matter from the flue gas, leaving cleaned flue gas.





3. **Fabric Filters**

Fabric filters are one fairly simple method that can be used to remove dust from flue gases. In some gases they can also remove acidic gases if they utilize basic compounds. This method simply uses some sort of fabric - generally felt is used as a woven cloth would allow dust to make its way through - is placed so that flue gasses must pass through it before exiting the smokestacks. When the gas passes through, dust particles are trapped in the cloth



Gas Control

More intense chemical methods of separation are generally required to separate polluting gases from the flue gas. However, this extraction is important as many acidic gases in flue gas contribute to acid rain. Below are some of the basic ways that gases can be extracted.

1. Scrubbers
2. Incineration
3. Carbon Capture

1. Scrubbers

   Scrubbers are a type of system that is used to remove harmful materials from industrial exhaust gases before they are released into the environment. These pollutants are generally gaseous, and when scrubbers are used to specifically remove SOx it is referred to as flue gas desulfurization. There are two main types of scrubbers, **wet scrubbers** and **dry scrubbers**. The main difference is in the type of material used to remove the gases. By removing acidic gases from the exhaust before it is released into the sky, scrubbers help prevent the formation of acid rain.

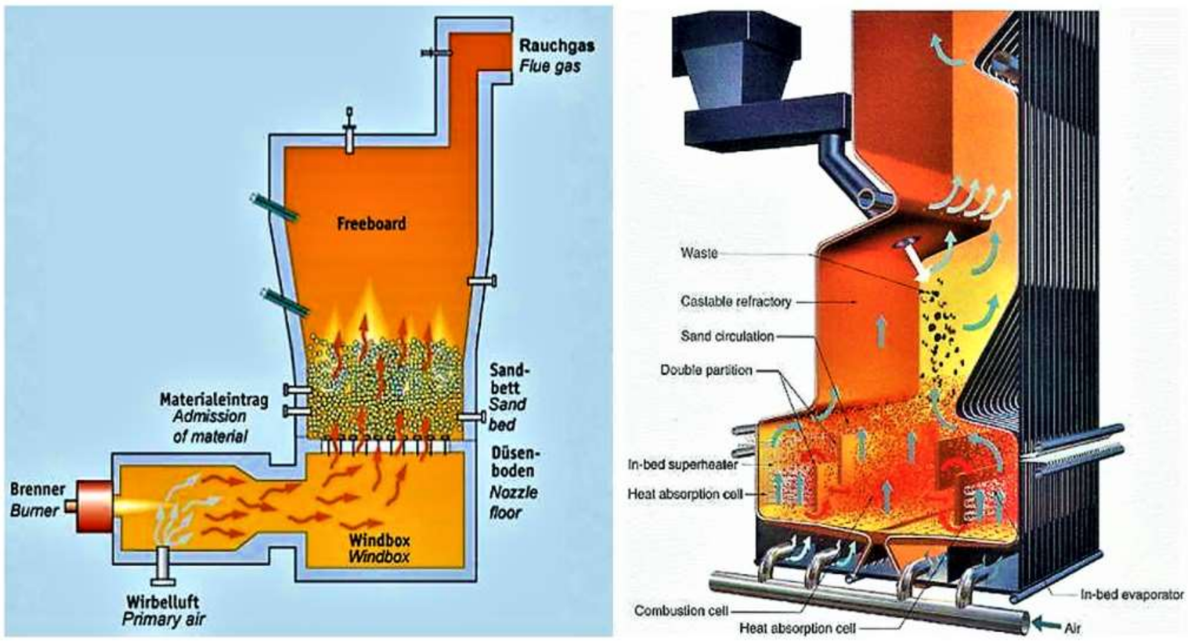
There are two main ways to scrub pollutants out of exhaust, and they are:

- **Wet Scrubbing**: The removal of harmful components of exhausted flue gases by spraying a liquid substance through the gas.
- **Dry Scrubbing**: The removal of harmful components of exhausted flue gases by introducing a solid substance to the gas - generally in powdered form.

Figure 1. A chemical scrubber.[1]

2. **Incineration**

Incineration is used to convert VOC emissions into carbon dioxide and water through combustion. The incineration generally takes place in a specialized piece of equipment known as an afterburner, which is built to create the conditions necessary for complete combustion (such as sufficient burn time and a high temperature). Additionally, the incinerated gas must be mixed to ensure complete combustion.



The scheme of a fluidised-bed incinerator. There are two types of technologies: bubbling bed (left) and circulating bed (right) technology Source: EISENMANN (n.y.) and GEC (n.y.)

3. Carbon Capture

   Carbon dioxide can theoretically also be captured and stored underground or in forests and oceans to prevent it from entering the atmosphere. **Carbon capture and storage** refers to the process of capturing this carbon dioxide and storing it below ground, pumping it into geologic layers. This process is rarely being used, but is talked about extensively as a way to limit greenhouse gas emissions leading to climate change.

Ozone Depletion

- Ozone layer is an umbrella 24 km [15 miles] from earth surface, an essential component of the stratosphere that absorbs short wavelength ultraviolet radiation from the sun, heating the gases of the stratosphere in the process.

- This is the reason temperatures rise with increasing altitude in the stratosphere, and also the reason life was able to move out of the oceans and on to the land, evolving into the diverse biosphere we know today.
- World ozone day is celebrated on Sept, 16 of every year. Stratospheric ozone is measured in Dobson units [DU] named after G.M.B Dobson who pioneered the study;
  [I Dobson unit = 0.01 mm thickness of stratospheric ozone],
- Average ozone thickness in stratosphere is 300 DU, & when it falls below 200 DU, it's considered as Ozone hole. It is thinnest around equator and thickest near poles.

Causes of Ozone Depletion

- Ozone depletion is caused by the release of chlorofluorocarbons (CFC's) and other ozone-depleting substances (ODS), which were used widely as refrigerants, insulating foams, and solvents.
- Although CFCs are heavier than air, they are eventually carried into the stratosphere in a process that can take as long as 2 to 5 years.
- When CFCs reach the stratosphere, the ultraviolet radiation from the sun causes them to break apart and release chlorine atoms which react with ozone, starting chemical cycles of ozone destruction that deplete the ozone layer. One chlorine atom can break apart more than 100,000 ozone molecules.

Effects

- Effect of ozone hole include cataract, genetic mutation, constriction of blood vessels, reduced crop yield, leukemia, breast cancer, damage to crop, aqua culture, etc.,
- The higher energy UV radiation absorbed by ozone is generally accepted to be a contributory factor to skin cancer. In addition, increased surface UV leads to increased tropospheric ozone, which is a health risk to humans. The increased surface UV also represents an increase in the vitamin D synthetic capacity of the sunlight.
- It should be deduced that the above impacts are not due to exposure of Ozone but due to the UV rays that have reached the earth surface through the ozone holes. One important

health hazard is Snow Blindness [photo keratosis], i.e., inflammation of cornea (outer coating of eyeball).

- The most common forms of skin cancer in humans, basal and squamous cell carcinomas have been strongly linked to UVB exposure. Another form of skin cancer, malignant melanoma, is much less common but far more dangerous, being lethal in about 15% - 20% of the cases diagnosed.

Control Measures

- The results of 18-year study of the ozone column over Antarctica [1st spotted, 1979] showing that the ozone column had decreased from 1957 to 1985, a 35% decrease.
- This report led through several regulatory steps to the Montreal Protocol, an international agreement signed by 139 nations, banning the production of CFCs by the year 2000.
  In 1978, the use of CFC propellants in spray cans was banned in the U.S. In the 1980s, the Antarctic "ozone hole" appeared and an international science assessment more strongly linked the release of CFCs and ozone depletion. It became evident that a stronger worldwide response was needed.
- In 1987, the Montreal Protocol was signed and the signatory nations committed themselves to a reduction in the use of CFCs and other ozone-depleting substances. Since that time, the treaty has been amended to ban CFC production after 1995 in the developed countries, and later in developing. Today, over 160 countries have signed the treaty.
- We can't make enough ozone to replace what's been destroyed, but provided that we stop producing ozone-depleting substances, natural ozone production reactions should return the ozone layer to normal levels by about 2050.
- It is very important that the world comply with the Montreal Protocol; delays in ending production could result in additional damage and prolong the ozone layer's recovery.
- Control mechanism stresses on replacement of the banned chemical by ammonia, steam, helium etc.