

Energy and Environment Science

L-T-P-C: 2-0-0-2

Syllabus:

Unit – 1 [4 Hours]: Present Energy resources in India and its sustainability:

Energy Demand Scenario in India, Different type of **conventional Power Plant**, Advantage and Disadvantage of conventional Power Plants, **Conventional vs Non-conventional power generation**.

Unit – 2 [4 Hours]: Basics of Solar Energy: Solar Thermal Energy; Solar Photovoltaic: Advantages and Disadvantages, Environmental impacts and safety.

Unit – 3 [4 Hours]: Wind Energy: Power and energy from wind turbines, India's wind energy potential, **Types of wind turbines, Offshore Wind energy**, Environmental benefits and impacts.

Unit – 4 [4 Hours]: Biomass Resources: Biomass conversion Technologies, Feedstock pre-processing and treatment methods, Bioenergy program in India, Environmental benefits and impacts; **Other energy sources: Geothermal Energy resources, Ocean Thermal Energy Conversion, Tidal Energy**.

Unit – 5 [4 Hours]: Air pollution: Sources, effects, control, air quality standards, air pollution act, air pollution measurement; **Water Pollution:** Sources and impacts; **Soil Pollution:** Sources and impacts, disposal of solid waste. **Noise pollution**

Unit – 6 [4 Hours]: Greenhouse gases effect, acid rain; Pollution aspects of various power plants; **Fossil fuels and impacts, Industrial and transport emissions impacts**.

Energy and Environment Science

Unit – 5 : Pollution

Unit – 5

1. **Air pollution:** Sources, effects, control, air quality standards, air pollution act, air pollution measurement
2. **Water Pollution:** Sources and impacts;
3. **Soil Pollution:** Sources and impacts, disposal of solid waste.
4. **Noise pollution**

Unit-5, Class-1 “AIR POLLUTION”

Coverage

1. Introduction
2. Energy ,Environment and Climatic change
3. Air pollution and Types
4. Air pollution Sources
5. Effects
6. Controls
7. Air quality standards,
8. Air pollution act,
9. Air pollution measurement

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Faculty & Accredited Energy Auditor (AEA 091)
Dr. P.Dharmalingam , B.Tech (Hons),PGEM, MS, Ph.D

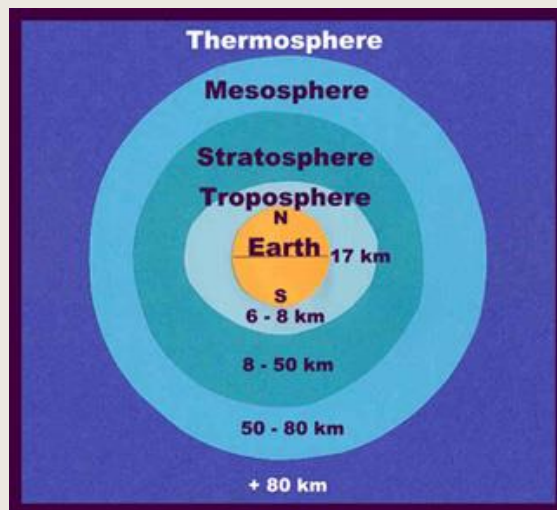


- **Executive Director, EnSave Consultancy & Training P Ltd**
- **Former Director & Head, National Productivity Council**
- **Accredited Energy Auditor (BEE,GOI)**
- **Certified ISO 50001 –EnMS Auditor**
- **CMVP & Green Building Professionals(Graha)**
- ❑ **35 Years of Energy Auditing experience in India & Abroad**
 - Conducted 450+ Energy Audit in Industry & buildings
 - Trained 15,000+ engineers in energy efficiency –India
 - 16 years experiences in conducting preparatory training for EA/EM BEE exam
 - Developed 300+ certified energy auditor in Iran, Nepal, Fiji, APO,UNEP ,Egipt, Ghana
- ✓ **Co-author of BEE Energy Efficiency Exam Guide book**
- ✓ **16 years experiences in conducting preparatory training for EA/EM BEE exam**
- ✓ **Established Practical Energy efficiency Centre @NPC Chennai**
- ❖ **Recipient of AEE's Asia Subcontinent Energy Professional Development Award,USA.**

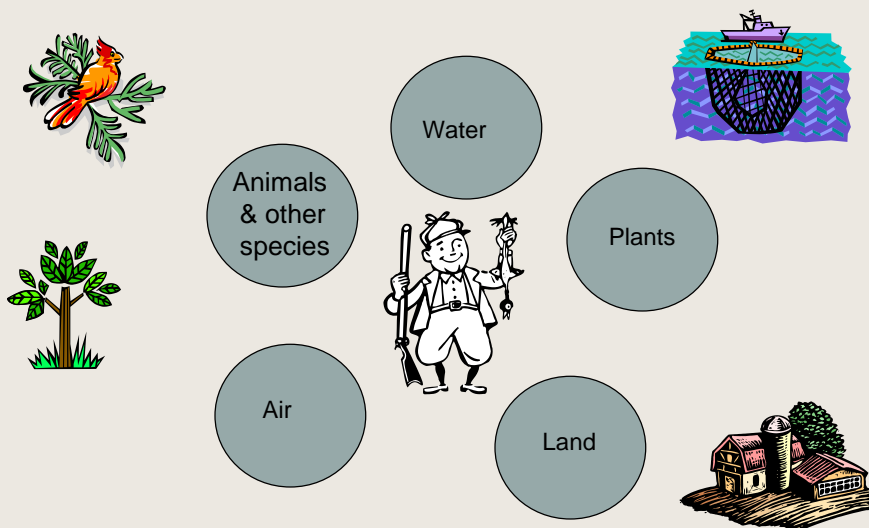
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What is Atmosphere?

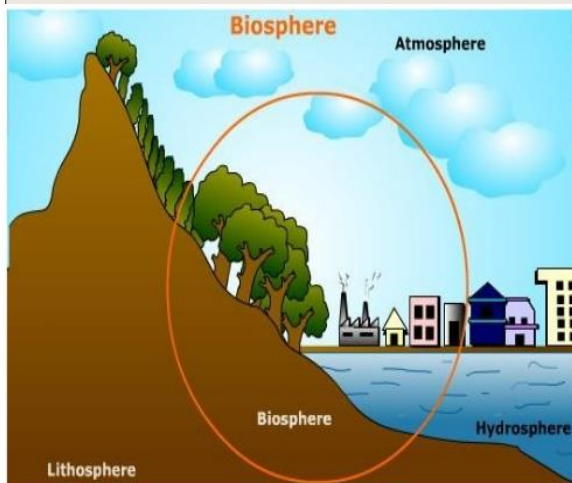
- Atmosphere is the life blanket of Earth.



What is Environment?



Biosphere

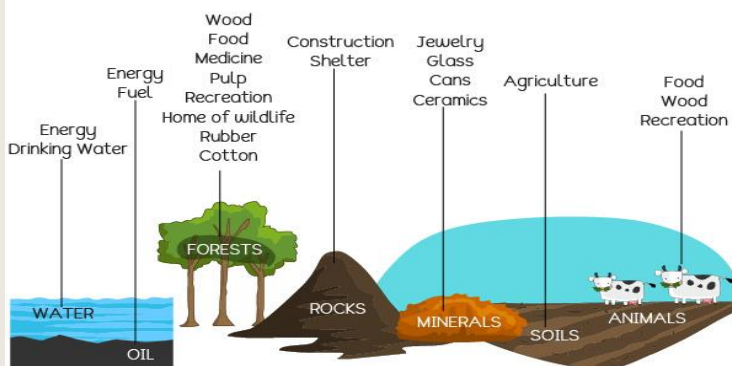


It is the entire interconnected ecosystem of earth
Air, land, surface water where life occurs

The biosphere is the portion of the earth that supports living things. It includes living and non-living things.

2. Natural recourses

What are the Natural resources?

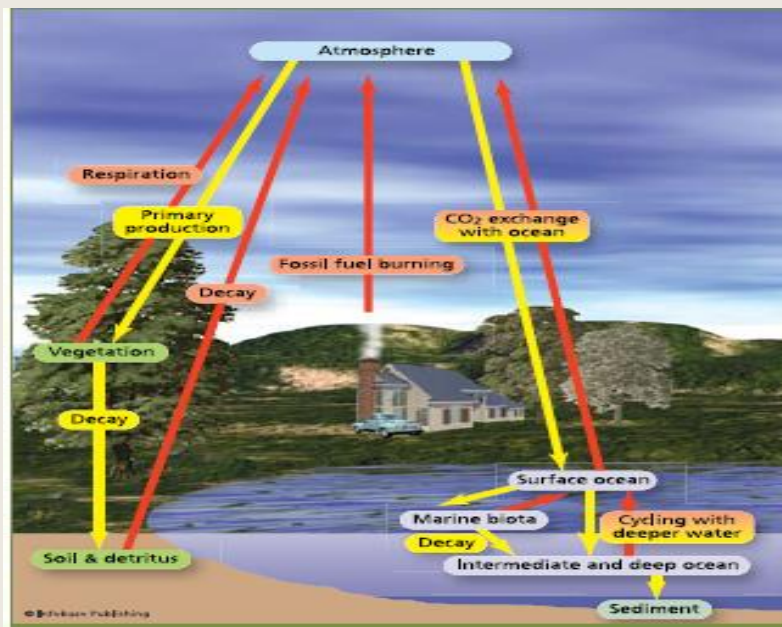


Resources may be **solids, liquids, or gasses.**

They may also be **organic or inorganic.**

They may also be **metallic or non-metallic.**

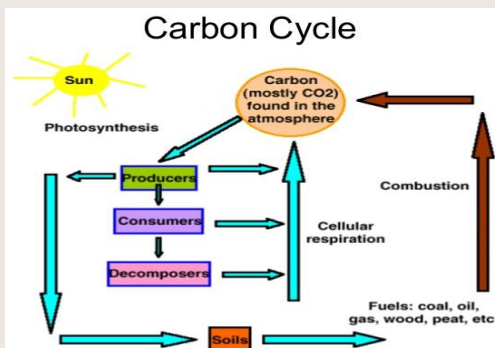
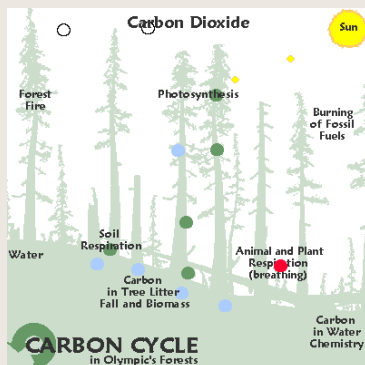
They may be **renewable or non-renewable**



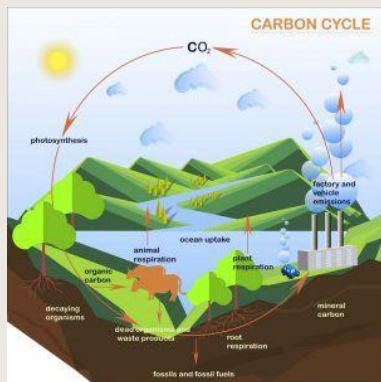
The carbon cycle, showing inputs of carbon into the atmosphere (red) and outputs of carbon from the atmosphere (yellow).

3. Carbon cycle and Energy resources

The carbon cycle or CO₂ cycle is an **important part of everyday life**. Due to the abundance of carbon found in all elements of life, including animals, rocks, air, water, and more, the cycle of carbon is one that is constantly moving and changing due to the ever-changing nature of the things.



Why is the Carbon Cycle Important?

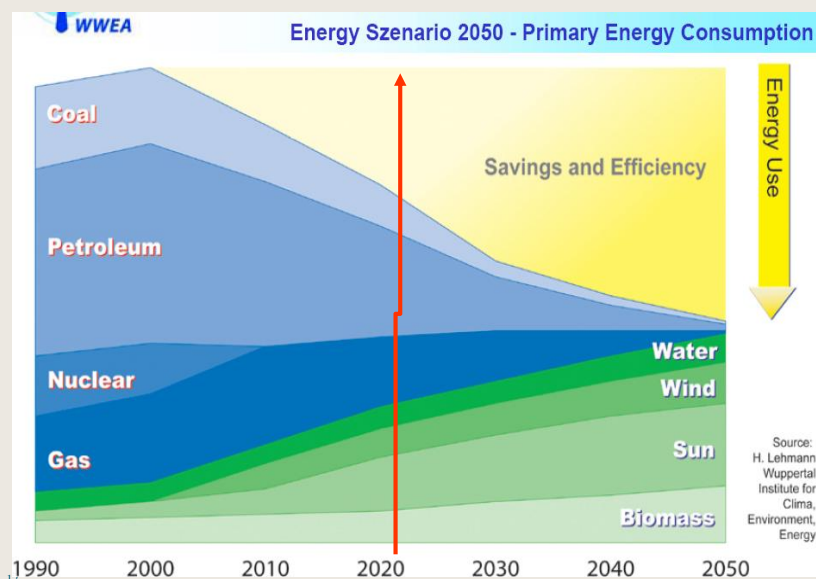


- The carbon cycle, under normal circumstances, works to ensure the stability of variables such as
 - ✓ **Earth's atmosphere,**
 - ✓ **the acidity of the ocean, and**
 - ✓ **the availability of carbon for use by living things.**
- Each of its components is of crucial importance to the health of all living things – especially humans, who **rely on many food crops** and animals to feed our large population.

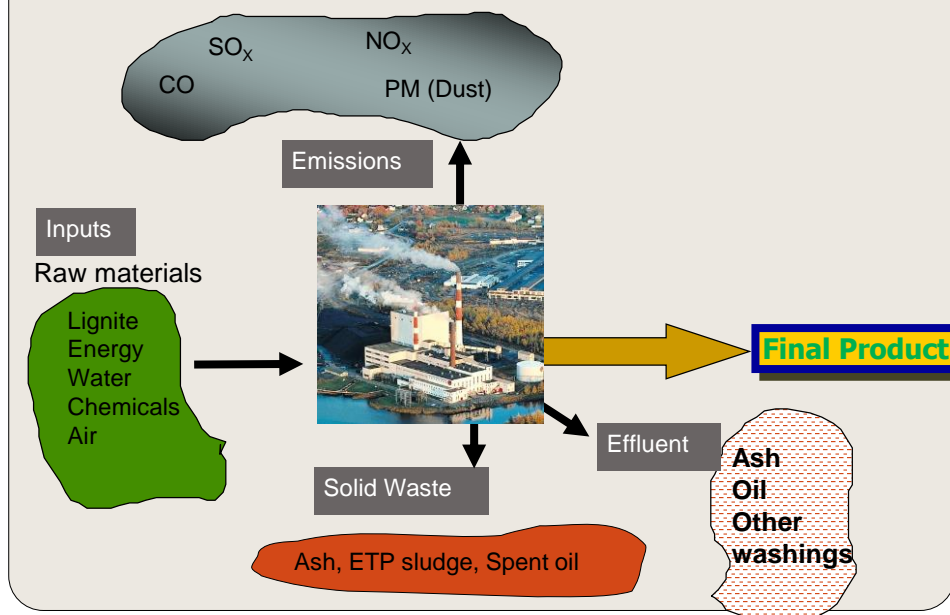
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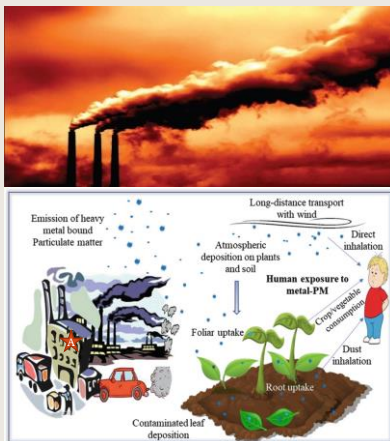
Energy USE



How Pollution is caused



4. Energy ,Environment and Climatic change

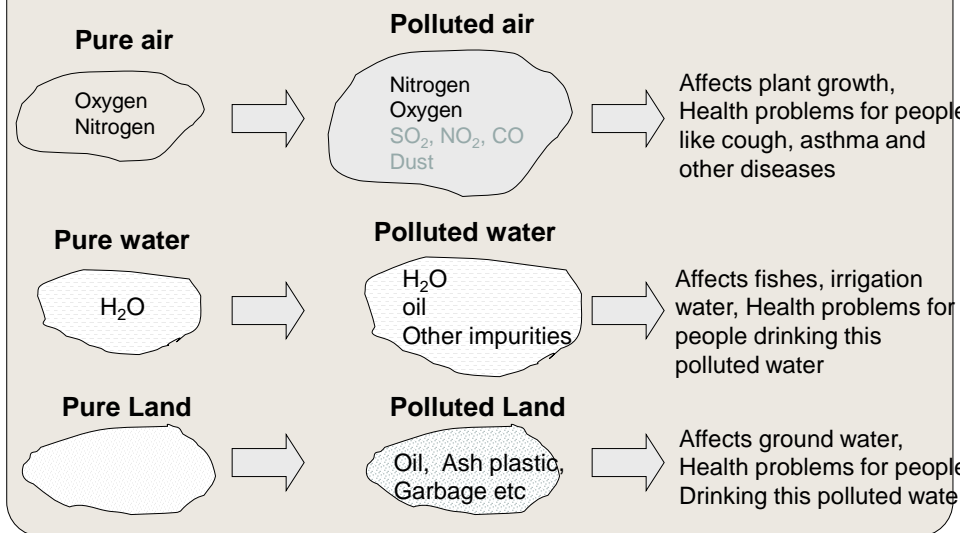


□ The principal emissions causing impact on the air environment are particulate matter (dust), Sulphur oxides, nitrogen oxides, and carbon monoxide.

1. **Particulate matter** - Generated from the combustion of solid fuels like coal, lignite, biomass etc. (**ash content**)
2. **Sulphur oxide (SO_x)** emissions mainly occur from combustion of oil and coal due to **sulphur content**.
3. **Nitrogen oxides (NO_x)** emissions are also associated with fuel combustion and air
4. **SO_x and NO_x** emissions lead to acid rain which is a trans-boundary environmental **issue**
5. **Carbon dioxide** is a major contributor to global warming and climatic change though **it is not consider as pollutants**.

What is pollution?

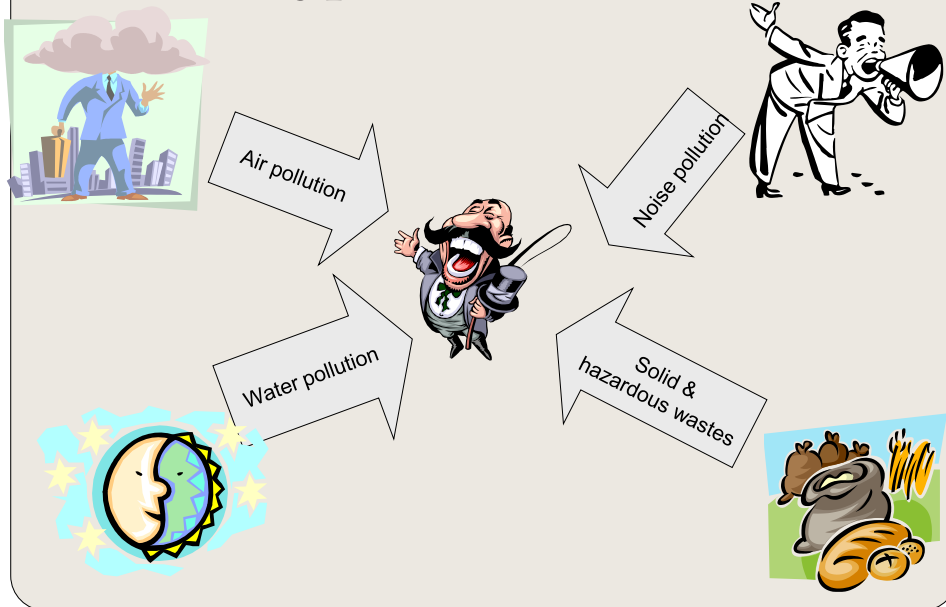
Undesirable elements in the Environment



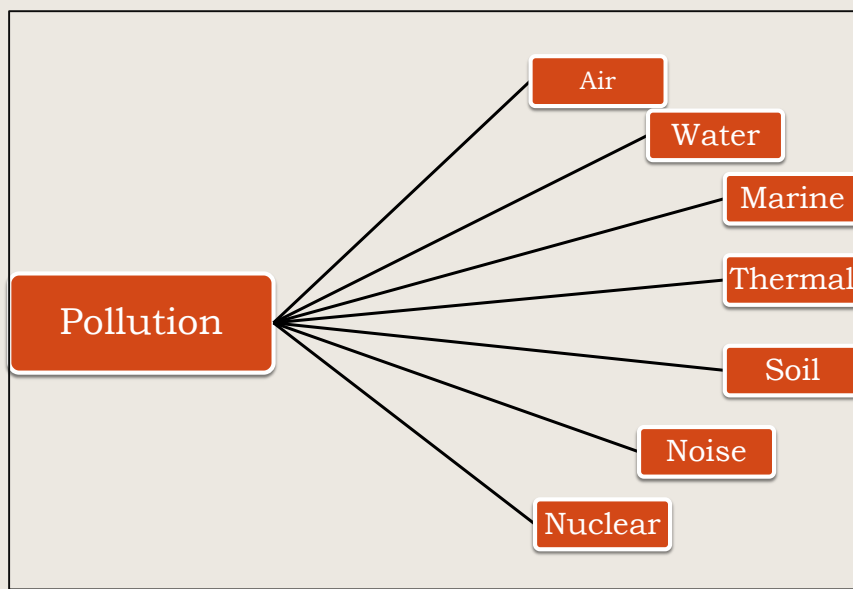
Definition of Pollution

- ❑ When **Harmful Substances Contaminate the environment** it is Called Pollution.
- ❑ It can be defined as any undesirable change in the physical, chemical, biological characteristics of any component of the environment which can **cause harm to life and property**.

Types of Pollution



Types of Pollution



Air pollution



Pollution from All sectors

Air....

- Air supplies us with **oxygen which is essential for our bodies to live.**
- **Air is a mixture of** nitrogen, oxygen, water vapor, carbon dioxide and inert gases.
- **Human activities can release** substances into the air, some of which can cause problems to humans, plants, and animals.

Natural Composition of Gases

Dry Air Expressed in Volumes	
• Nitrogen (N ₂)	78.1%
• Oxygen (O ₂)	20.9%
• Argon (A)	0.9%
• Carbon dioxide (CO ₂)	0.035%
• Others	0.065%

Others : Neon (Ne)
Helium (He)
Krypton (Kr)
Hydrogen (H₂)
Xenon (Xe)
Ozone (O₃)
Radon (Rn)

Definition

- **Air pollution** : An atmospheric condition in which certain substances (including normal constituents in excess) are present in concentrations which can cause undesirable effects on man and his environment.

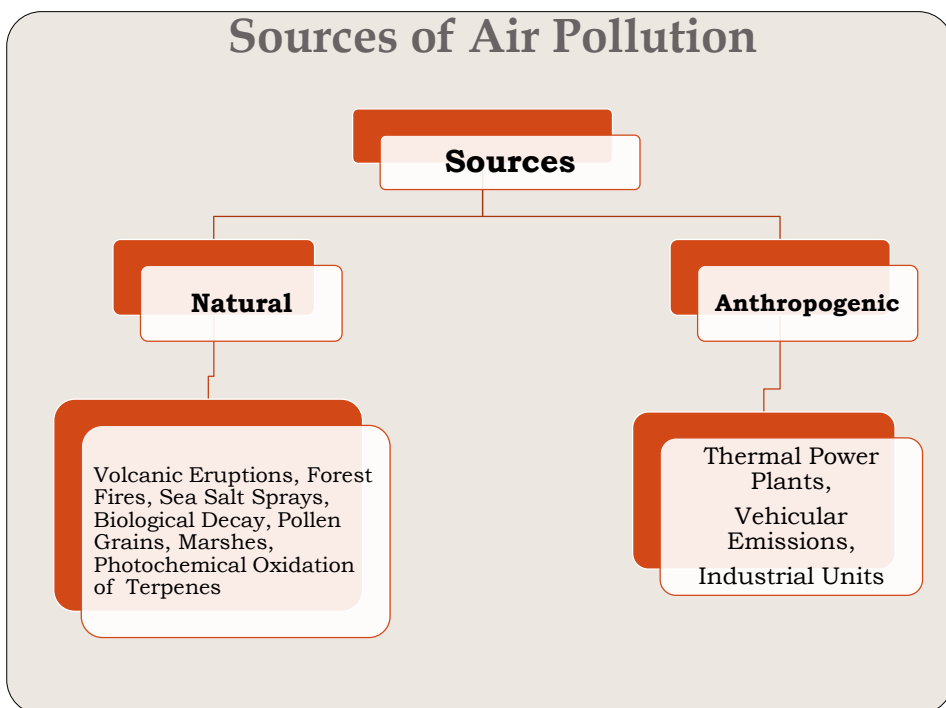


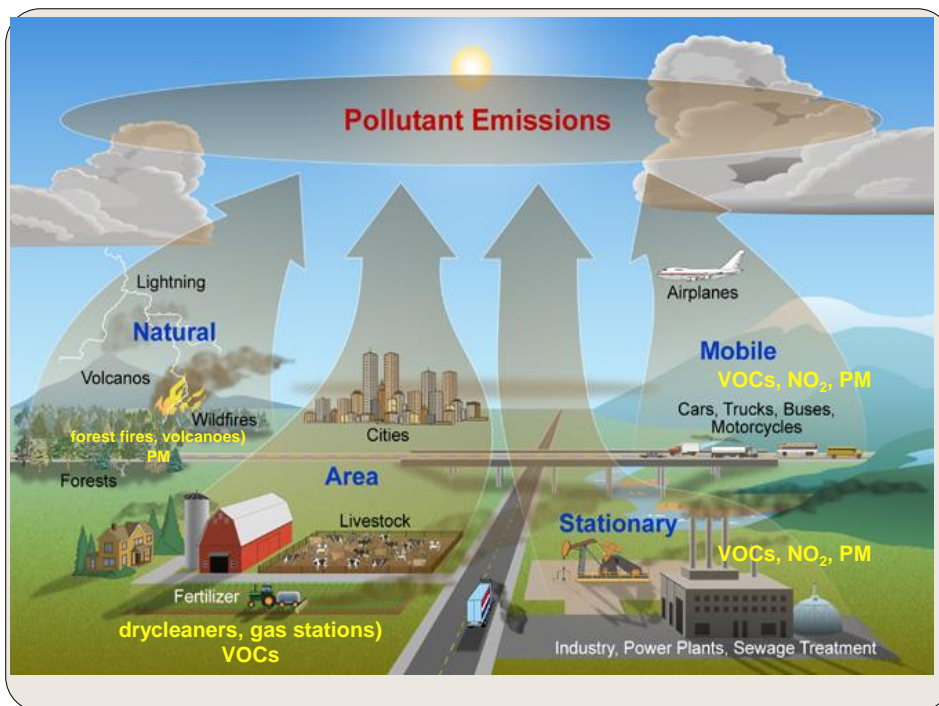
They are in the form of

1. **Gases** (Nox, Sox, CO, VOC);
2. **Particulate matter**(dust, smoke, fumes, etc)
3. **&Radioactive** (rado-222, Iodine-131, etc)

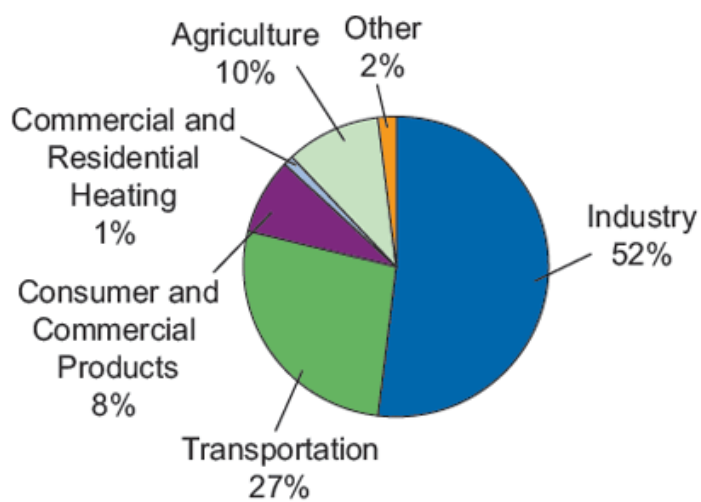
Classification of Air Pollutants

- Air pollutants may be **particulate or gaseous**.
On the basis of origin they are divided as
- **Primary pollutants** ---- Are emitted directly from the point source. e.g. : **CO, NO₂, SO₂**
- **Secondary pollutants** ---- formed by interaction of primary pollutants
e.g. : **Smog, Ozone** etc

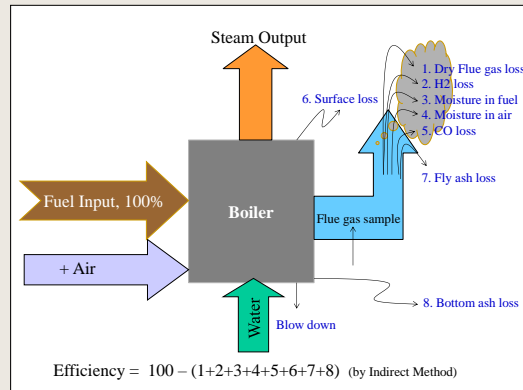




Sources of Emissions of Air Pollutants



Air pollution from our plant-Boilers



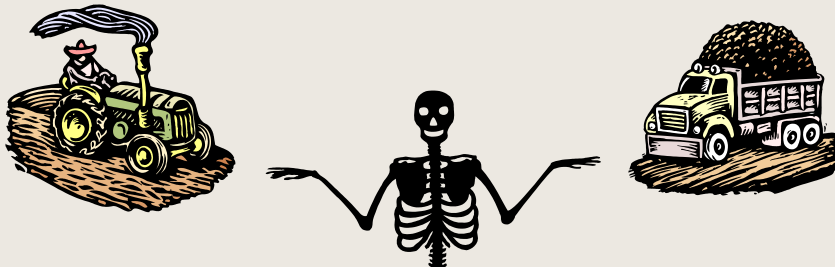
- Carbon monoxide, Carbon di-oxide from boilers
- Nitrogen oxides from boilers
- Sulphur oxides from boilers
- Dust generation/Ash dust from boilers
- **Can you think of any other ?**



Pollution problems

- Air you breathe = **10 Cigarettes** every day
- More than ***40,000 people die*** every year due to air pollution
- No. of patients with **respiratory diseases** and **allergies** has **doubled** in the last five years
- Child death has increased

Dust in air affects lungs..



Sulphur and Nitrogen oxides cause Acid Rain

- Caused by release of SO_x and NO_x , which mixes with water vapour to form acids
- Effects
 - Acidification of lakes, streams and soils
 - Release of metals, washing away of nutrients
 - Killing wild life
 - Corrosion
 - Asthma and chronic bronchitis

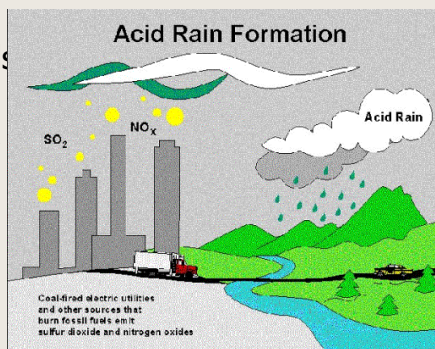
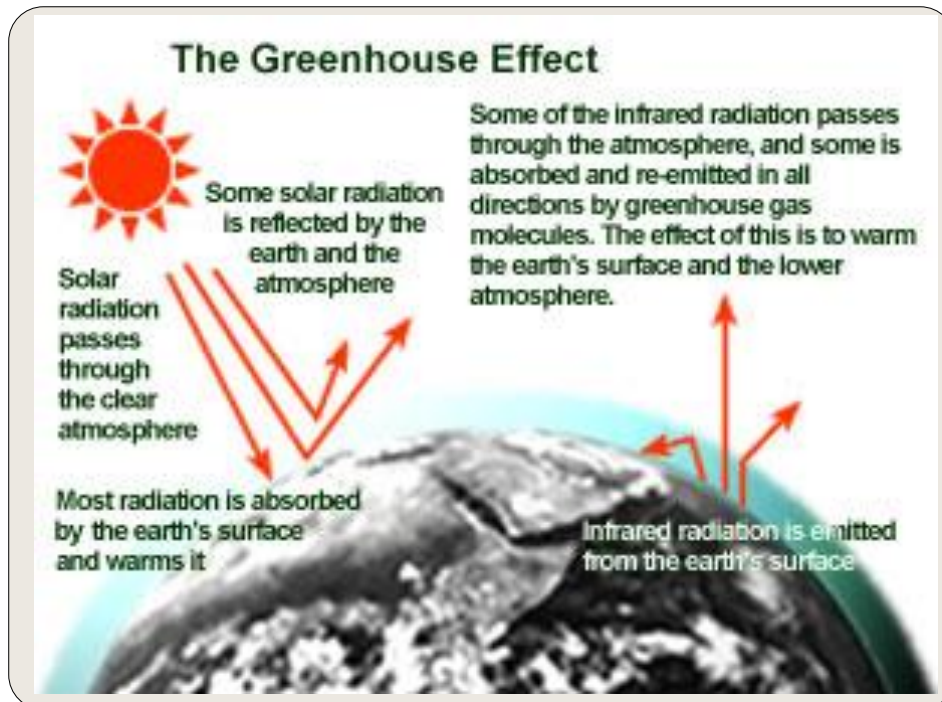


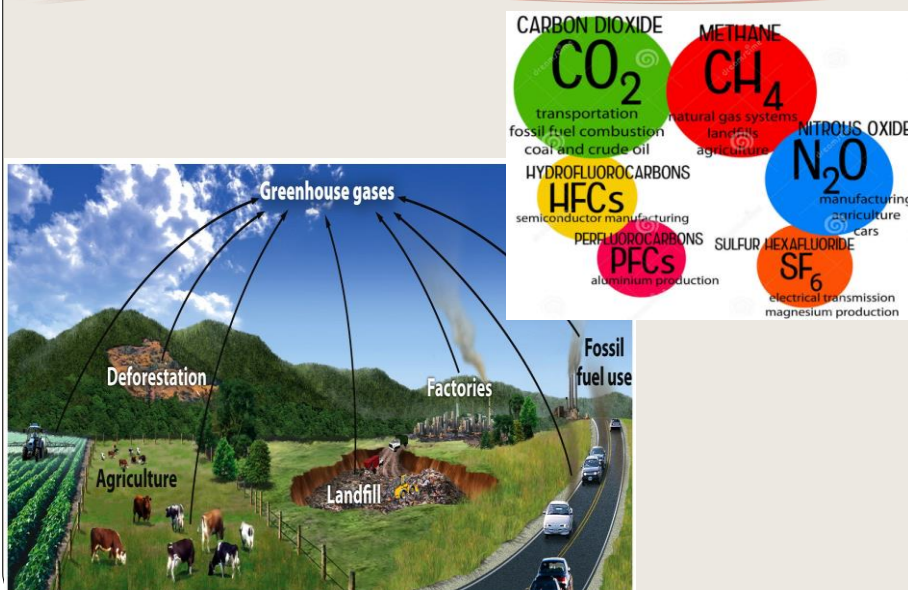
Figure 1.16



CO₂ causes Global Warming

- Global temperatures increased by 0.6°C in 20th century and expected to rise by about 5.8°C by 2100
- CO₂ from fossil fuel combustion, methane and nitrous oxide emissions through agricultural activities are responsible
- Sea level is expected to rise up to 88 cm by 2100 - flooding in coastal areas
- Displacement of people, changes in cropping pattern, changes in rainfall, reduction in agricultural yield and threat of food shortage looms large

Green House Gas – Major Causes



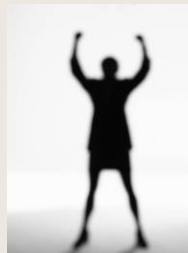
Criteria of Pollutants

Name of the gas	Characteristics	Source
Nitrogen dioxide (N ₂ in air is oxidized); No _x sum of NO, NO ₂ , other oxides of N	Brownish gas irritates the respiratory system originates from combustion	Burning fuels including petrol, diesel, and coal
Ground level O₃ (primary constituent of smog)	Reaction of VOC + nox in presence of heat +sun light	Vehicles and industries are the major source
Carbon monoxide	Reduces bloods ability to carry O ₂	Produced by the incomplete burning of carbon-based fuels & natural and synthetic products such as cigarettes
Carbon dioxide	Principle greenhouse gas.	Emitted as a result of human activities such as the burning of coal, oil, and natural gases
Sulphur dioxide	Precursor to acid rain along with Nox	Formed when fuel (coal, oil) containing S is burned and metal smelting
Chlorofluoro carbon (CFC)	Ozone depletion	Released from air-conditioning systems and refrigeration.
Lead	Cause learning disabilities in children , toxic to liver, kidney, blood forming organs	Present in petrol, diesel, lead batteries, paints, hair dye products, etc
Particulate matter (PM 10 & 2.5)		

Effects of Air Pollution

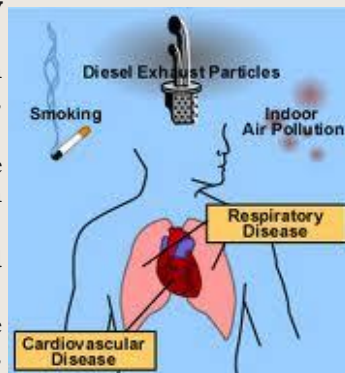
Air Pollution affects???

1. Human health
2. Animals
3. Plants
4. Materials
5. Environment



Effect on Human health

- Main problems are related to **Respiratory Track** - Asthma, hay fever, allergic diseases.
- **Irritation of the eye, nose and throat.** In severe cases there may be **headaches, nausea,** and loss of coordination.
- Prolonged exposure can cause damage to the **nervous system, digestive problems,** and in some cases cause **Lung cancer.**
- It **lowers our resistance** to colds and pneumonia.
- **CO** has affinity towards Hb which cause disturbance in transportation of Oxygen, impairing our concentration, slow our reflexes, and make us confused and sleepy.
- **SO₂** in the air leads to diseases of the lung and other lung disorders such as wheezing and shortness of breath.
- Chronic respiratory disease, lung cancer, heart disease, and even damage to the brain, nerves, liver, or kidneys. **Effects of Arsenic, Asbestos, Mercury, Benzene**



Effect on Plants

- Pollutants enter through stomata
- Destroy chlorophyll and Affect photosynthesis
- Cuticle(Wax Layer on Leaves) is lost
- Necrosis – Damage to Leaf Structure
- Chlorosis - Loss/ reduction of Chlorophyll
- Abscission - Dropping of leaf
- Epinasty – Downward curling of Leaf
- DEATH



Effect on Animals and materials

- Corrosion of metal surfaces, fading
- SO_2 & water form H_2S – corrosion as well as disfigurement of statues made up of limestone or Marble
- Air pollutants mix with rain water and increase acidity (Acid Rain) of water body and kill fish.
- Ozone causes crackling of rubber



Effect on Environment

1. **Visibility**
2. **Pollutants in the presence of sunlight produce photochemical Smog**
3. **Emission of Green House Gases tend to Global Warming**
4. **CFC's cause Ozone Depletion**

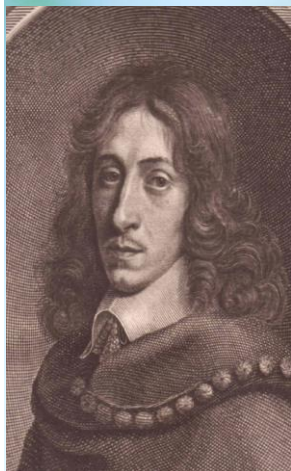
Air Pollution is **not** a new problem

- **In ancient Babylon** (circa 1754 BCE), one of Hammurabi's codes (no. 232) specified **compensation for another's property damaged by your smoke.**
- **Many ancient Egyptian mummies** have evidence of **smoke induced lung disease** as do more recent mummified remains of Vikings.
- Edward I "Longshanks" (1239-1307 CE), **King of England from 1272-1307 CE banned burning "sea coal" while parliament** was in session under penalty of death.

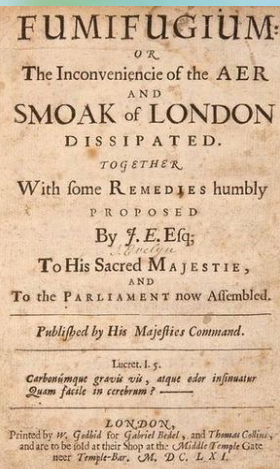


Fumifugium (1661)

John Evelyn (1620-1706 CE)



Alamy.com



Theehp.com

Written by John Evelyn an English aristocrat and father of the "English Garden" to King Charles II of England.

Blamed the poor air quality of London on the burning of sea coal

Proposed substitution of wood for coal for domestic heating in the environs of London



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Major 20th Century Air Pollution Events



Meuse Valley 1930 (listserve.com)



London Killer Fog 1952 (wija.com)

- Meuse Valley, Belgium (1930)
 - 65 deaths due to **thermal inversion (flouride)**
- Donora, Pennsylvania (1948)
 - 20 deaths due to **thermal inversion**
- London, England (1952)
 - "Killer Fog" resulting in ~4000 deaths
 - **Sulfur Dioxide and other compounds**
- **Bhopal, India** (1984)
 - ~4000-22,000 deaths and ~575,000 injuries
 - Industrial accident (**methyl isocyanate**)



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WHY IS AIR QUALITY IMPORTANT?

- Millions of people are exposed to unhealthy air every year.
- Ozone and particle pollution are the two most widespread air pollutants of concern.
- Everyone can be harmed by unhealthy levels of ozone and particle pollution - especially people with asthma, heart or lung disease, older adults, children and teens, and people who are active outside.



Particulate Matter: Size Matters

Size is important to the behavior of PM in the atmosphere and human body and determines the entry and absorption potential for particles in the lungs.

Particles **larger than 10 μm** are trapped in the nose and throat and never reach the lungs. Therefore, particles 10 μm in diameter or less are of most concern for their effects on human health.

Particles between **5 and 10 μm** are removed by physical processes in the throat.

Particles **smaller than 5 μm** reach the bronchial tubes, while **particles 2.5 μm in diameter or smaller are breathed into the deepest portions of the lungs.**

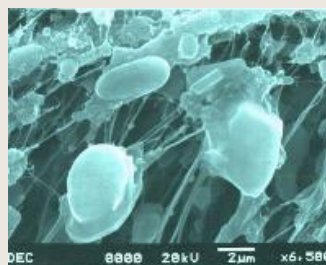
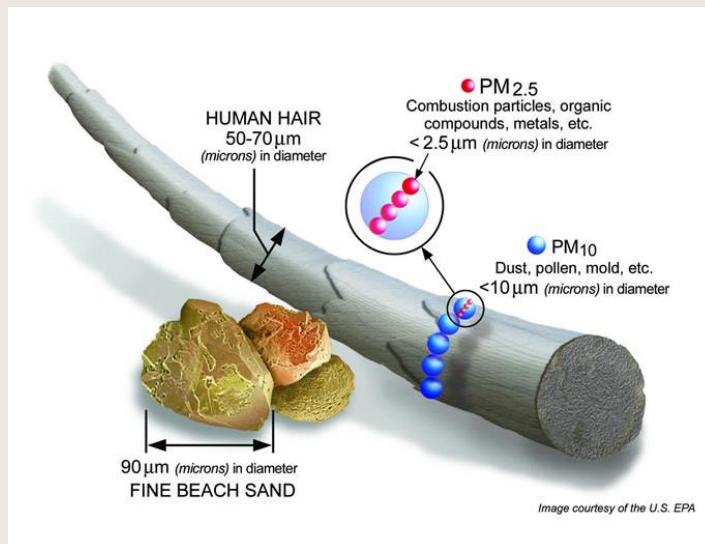


Image: PM2.5. By D. Hershey. From New York State Department of Environmental Conservation, <http://www.dec.state.ny.us/website/dar/baqs/micro/two.html>

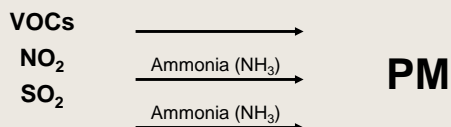
PARTICULATE MATTER: WHAT IS IT?

A complex mixture of extremely small particles and liquid droplets.

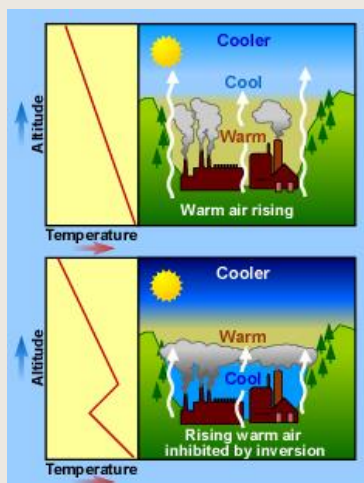


Where Does PM Originate?

Sources may emit PM directly into the environment or emit **precursors** such as **sulfur dioxide (SO₂)**, **nitrogen dioxide (NO₂)**, and **volatile organic compounds (VOCs)**, which are transformed through atmospheric chemistry to form PM.



The Role of Inversions



Source: <http://www.epa.gov/apti/course422/ce1.html>

An **inversion** is an extremely stable layer of the atmosphere that forms over areas.

Temperature inversions trap pollutants close to the ground.

These inversions involve layers of hot air sitting above cooler air near ground level. When particles accumulate in the air layer, they are **unable to rise into the atmosphere** where winds will disperse them.

GROUND-LEVEL OZONE (O_3)

- Ozone is a primary component of smog.
- Ozone is not emitted into the air.
- Ozone forms when nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react in the presence of sunlight.
- Ozone levels can be high in urban and rural areas.

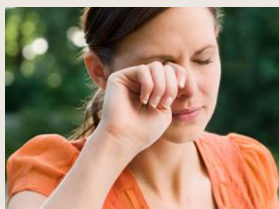


WHAT CONTRIBUTES TO OZONE POLLUTION?



- Motor vehicles
- Power plants
- Factories
- Consumer & commercial products
- Fuel combustion processes

Ozone and particle pollution



Can cause eye, nose & throat irritation



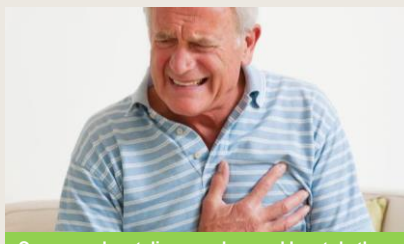
Can cause coughing & difficulty breathing



Can trigger asthma attacks



Can affect the development of children's lungs



Can cause heart disease, abnormal heart rhythms, congestive heart failure, stroke, & premature death

What Adverse Health Effects Have Been Linked to PM?

- Premature death
- Lung cancer
- Exacerbation of COPD
- Development of chronic lung disease
- Heart attacks
- Hospital admissions and ER visits for heart and lung disease
- Respiratory symptoms and medication use in people with chronic lung disease and asthma
- Decreased lung function
- Pre-term birth
- Low birth weight

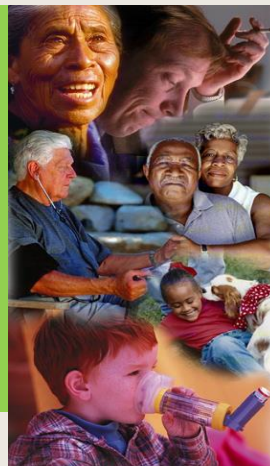
The doctor says particle pollution...

- Aggravates lung disease including asthma
- Aggravates heart disease including congestive heart failure
- Resulting in:
 - More premature deaths
 - More admissions to hospitals
 - More trips to emergency rooms
 - More visits to doctors' offices
 - More school and work absences
 - More symptom days



So Who's at Risk?

- People with heart or lung disease (including asthma)
 - Conditions make them vulnerable
- Older adults
 - Greater prevalence of heart and lung disease
- Children
 - More likely to be active
 - Breathe more air per pound



How do I know if I am breathing unhealthy air?

- **Check the Air Quality Index (AQI)**, a color-coded system for reporting air quality conditions.
- The colors in the AQI indicate how clean or dirty the air is. When the air quality is unhealthy, you can take actions to protect your health.



What Color is Your Air Today?

What do you say?

AQI color code	Who is affected?	What is the significance?	What action should people take?
Green	–	Air quality is good	Enjoy activities
Yellow	People who are unusually sensitive to air pollution	Air quality is a concern for people who are unusually sensitive to air pollution	People unusually sensitive to air pollution: Plan strenuous activities when air quality is
Orange	People with heart or lung disease (including asthma), older adults, and children	Air quality is unhealthy for people in sensitive groups	Sensitive groups: Cut back or reschedule strenuous activities
Red	Everyone, especially people with heart or lung disease (including asthma), older adults, and children	Air quality is unhealthy for everyone	Everyone: Cut back or reschedule strenuous activities Sensitive groups: Avoid strenuous
Purple	Everyone, especially people with heart or lung disease (including asthma), older adults, and children	Air quality is very unhealthy for everyone	Everyone: Significantly cut back on physical activities Sensitive groups: Avoid all physical activities

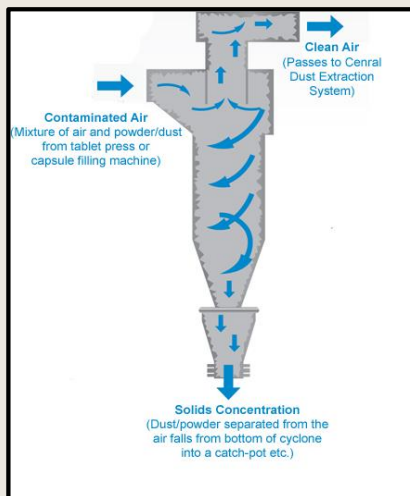
How can we minimise air pollution in our plant?

- Reducing energy wastages
 - We burn less fuel
 - So less SO₂, NO₂, CO₂, dust etc
- Wetting lignite to make fines stick with larger lumps
 - Dust generation will be reduced
- Working with face masks in fuel preparatory and boiler section
 - We can protect us from dust
- Any other suggestions ?

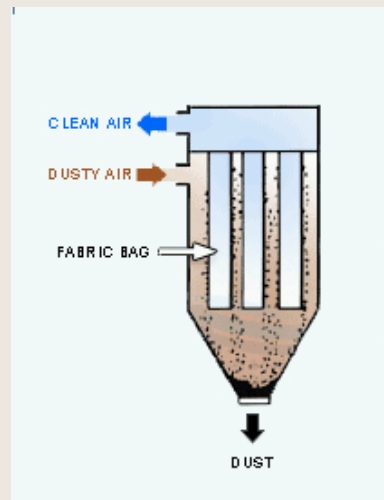
Control of Air Pollution

1. Proper air pollution control devices in industries
2. Using low sulphur coal
3. Regular engine tune up, replacement of old more polluting vehicles
4. Using mass transport system, bicycles etc
5. Shifting to less polluting fuels
6. Planting more trees
7. No to FIRE CRACKERS in Diwali and other occasions

Pollution Control Devices



Cyclone Separator



Bag House Filter

NATIONAL AIR QUALITY MONITORING PROGRAMME (NAMP)

- **Central Pollution Control Board** is executing a nation-wide programme of ambient air quality monitoring known as **National Air Quality Monitoring Programme** (NAMP).
- The network consists of three hundred and forty two (342) operating stations covering one hundred and twenty seven (127) cities/towns in twenty six (26) states and four (4) Union Territories of the country.
- Under N.A.M.P., four air pollutants *viz.*, Sulphur Dioxide (SO₂), Oxides of Nitrogen as NO₂, Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM / PM₁₀) have been identified for regular monitoring at all the locations.
- The monitoring of meteorological parameters such as wind speed and wind direction, relative humidity (RH) and temperature were also integrated with the monitoring of air quality.

The **Air (Prevention and Control of Pollution) Act**, 1981

Responsibilities

- ☹ Obtain “**Consent to Establish**” prior to taking any steps to establish any industry, operation or process or any treatment and disposal system which is likely to discharge effluent/emission
- ☹ Obtain “**Consent to Operate**” prior to commencing operations of any industry, operation or process or any treatment and disposal system which is likely to discharge effluent/emission
- ☹ Apply for **renewal of “Consent to Operate”** before the expiry of validity period, as specified in the consent granted earlier

How the Poisons in the Air Affect You

Lead: ● ●

A toxic metal that's present in normal petrol and in the air as fine particles. Can affect the central nervous system, cause renal damage and hypertension. Children are three times more at risk than adults.

Suspended Particulate Matter ● ● ●

Particles of dust and carbon, coated with toxic gases, all emanating from factory emissions and vehicle exhaust. They coat the lungs. Cause respiratory infections, persistent cough and throat irritation. Aggravate asthma.

Carbon Monoxide: ●

Colourless and odourless, it comes from petrol vehicles, mostly two and three wheelers. Reduces the ability of blood to carry oxygen. Exacerbates heart disorders.

Polycyclic Aromatic Hydrocarbons (PAHS): ●

Unburnt from diesel engines. Cause drowsiness, eye irritation, cough and are suspected to be cancer causing. There is no such thing as a safety level for PAHs.

Sulphur dioxide: ●

Colourless gas that is a part of diesel exhaust and factory emissions. Affects upper respiratory tract. Causes bronchial problems, nose blockage and a hacking cough.

Benzene: ● ●

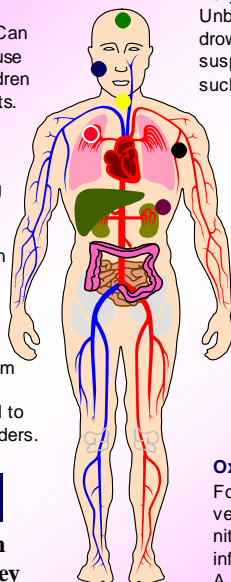
Cannot be seen, it's part of unleaded petrol and is emitted from catalytic converters. A known carcinogen, it has been linked to lung cancer and leukemia and is said to damage the central nervous system. No safe limit: there just shouldn't be any benzene around.

Oxides of Nitrogen: ●

Formed during fuel combustion in motor vehicles and power stations. Convert to nitrogen dioxide, which leads to bronchial infections, clots, headaches and eye irritation. A recent spurt in fibrosis cases in Mumbai has been traced to these pollutants.

Areas Affected

- | | |
|---------------------|---------------|
| ● Lungs | ● Brain |
| ● Respiratory Tract | ● Kidney |
| ● Nose/Eyes | ● Entire body |



Thank You

Save energy and water for Sustainable Life



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