CH1203 Industrial Pollution Prevention and Control

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Topics Covered

1. Sustainability
2. Environmental Regulations
3. Pollution
4. Air pollution control methods
5. Principles of water treatment

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- Definition of Pollutant and Pollution
- Classification of Pollution
- Air Pollution
- Land Pollution
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Pollution – *Definitions*

Pollutant

- A substance is normally considered to be pollutant
- if it adversely alters the environment by changing the growth rate of a species, interferes with food chain, or interferes with health, comfort, amenities, or property value of the people.

Pollution

- Pollution is the result of action or presence of a pollutant in a part of the environment where it is considered to have deleterious (or harmful) effects.

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Pollution – *Classification*

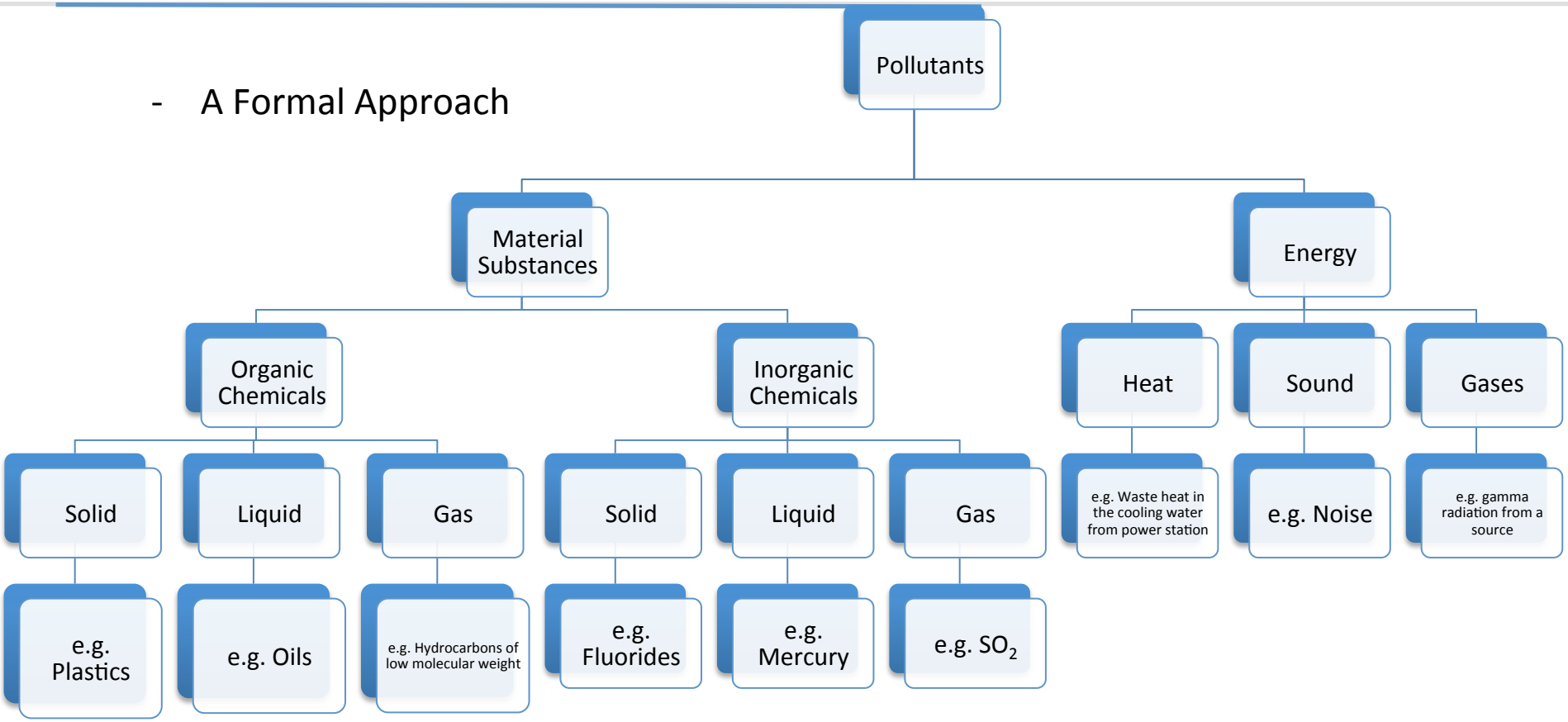
- It is well known that no substance or form of energy is automatically a pollutant as this depends upon its effect which in turn depends on where in the environment it has been liberated.

Classification based on various approaches

- A formal but simplistic approach approach
- A medium based approach
- An ecological approach
- A functional approach

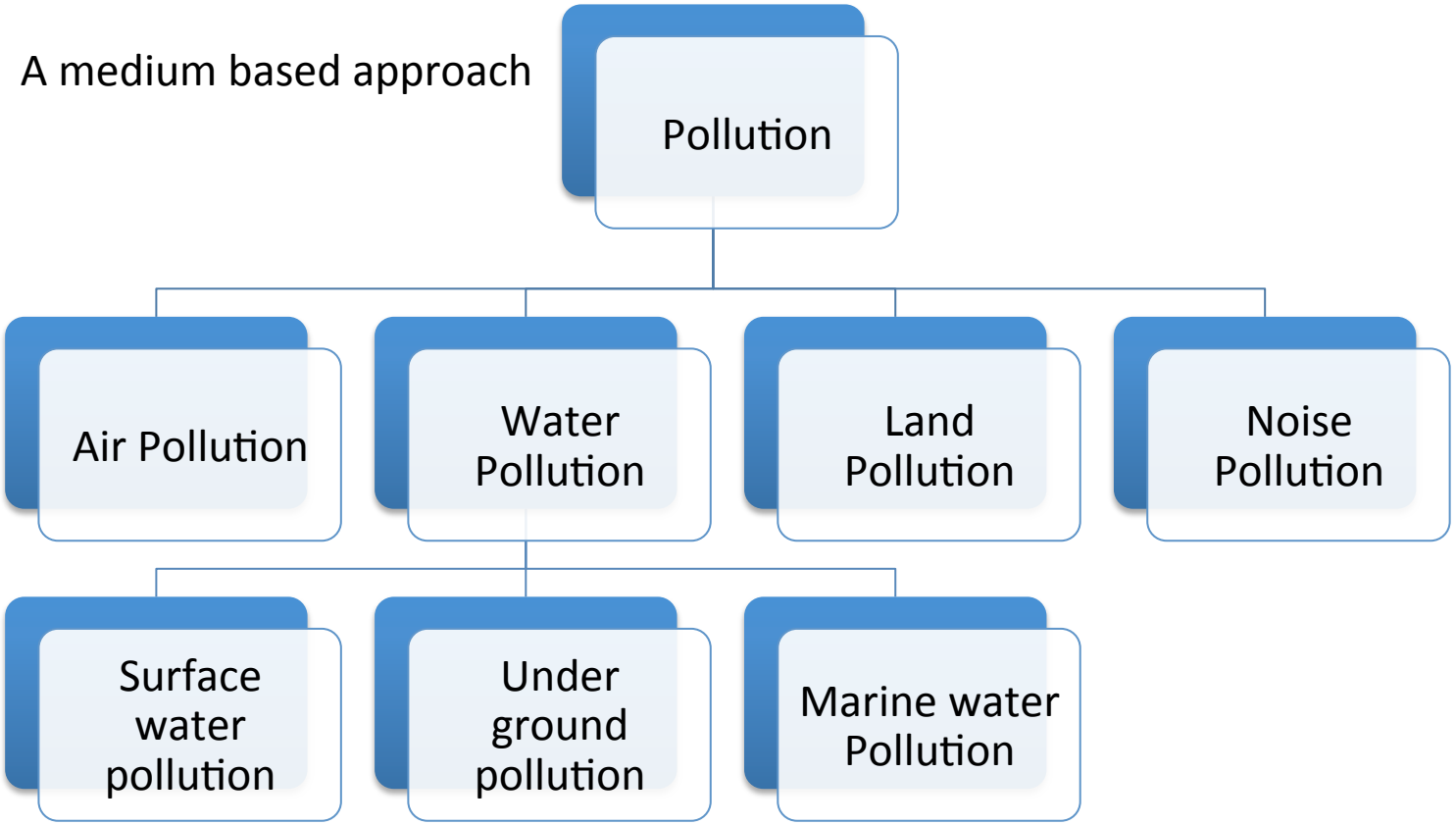
Pollution – *Classification*

- A Formal Approach



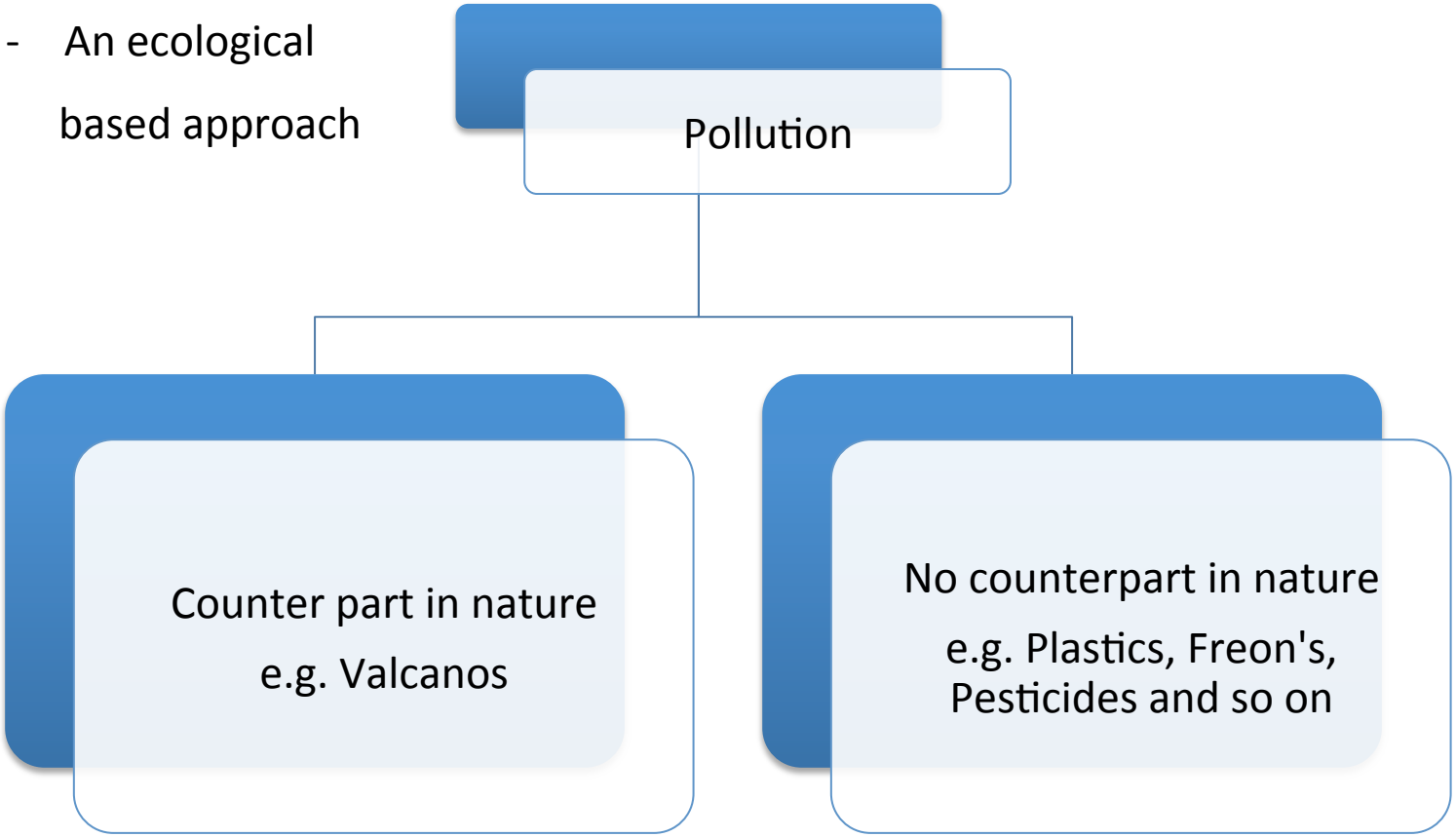
Pollution – *Classification*

- A medium based approach



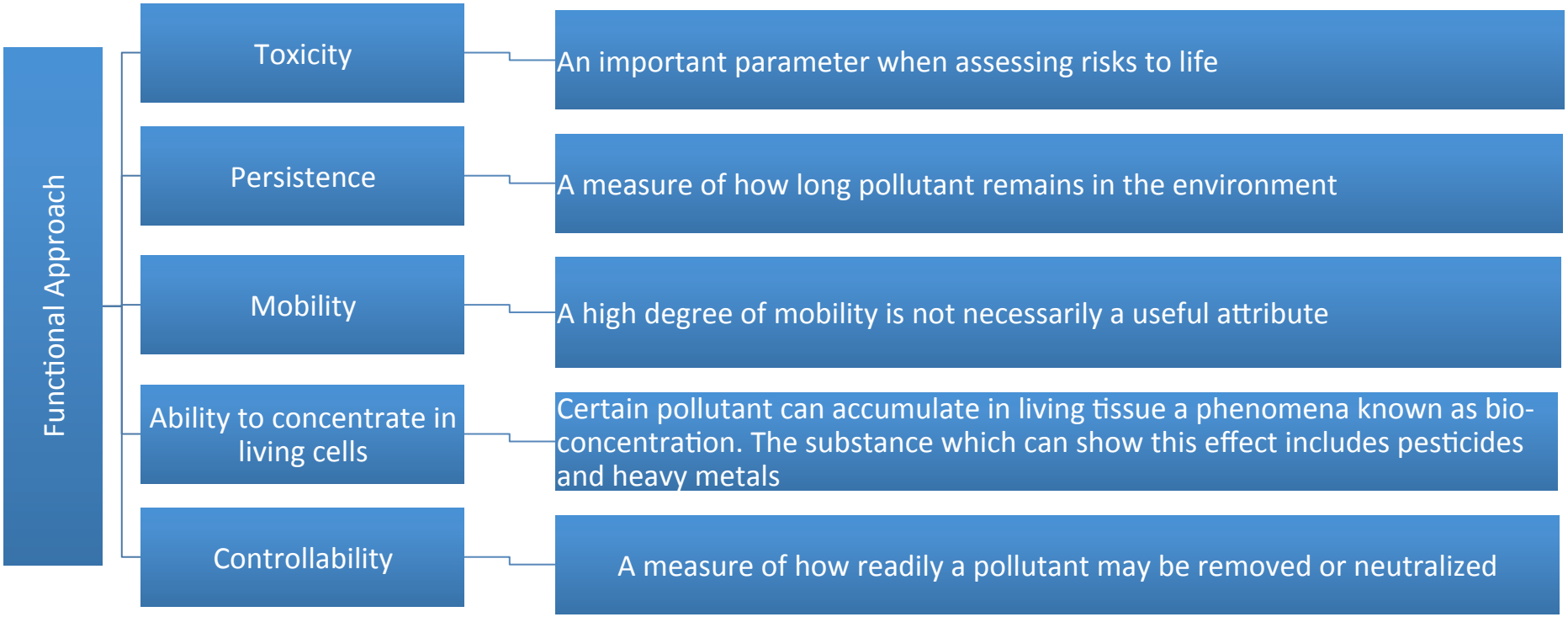
Pollution – *Classification*

- An ecological based approach



Pollution – *Classification*

- The functional approach



Pollution

- In nut shell, two basic strategies may be adopted in pollution control:

① Concentrate and contain

② Dilute and disperse

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Air Pollution

- Gaseous volatile liquid and particulate materials emission by the industries results in air pollution.
- Air pollution can affect the environment or the general population at local, regional, national or global level.

For Example:

- The industry that burns coal and emits pollutants from its boiler exhaust gases that contain sulfur dioxide and hydrogen sulfide may cause serious odor problems in the immediate area as well as materials damage through acids that form upon reaction between the contaminants and water vapor in the air.

Air Pollution

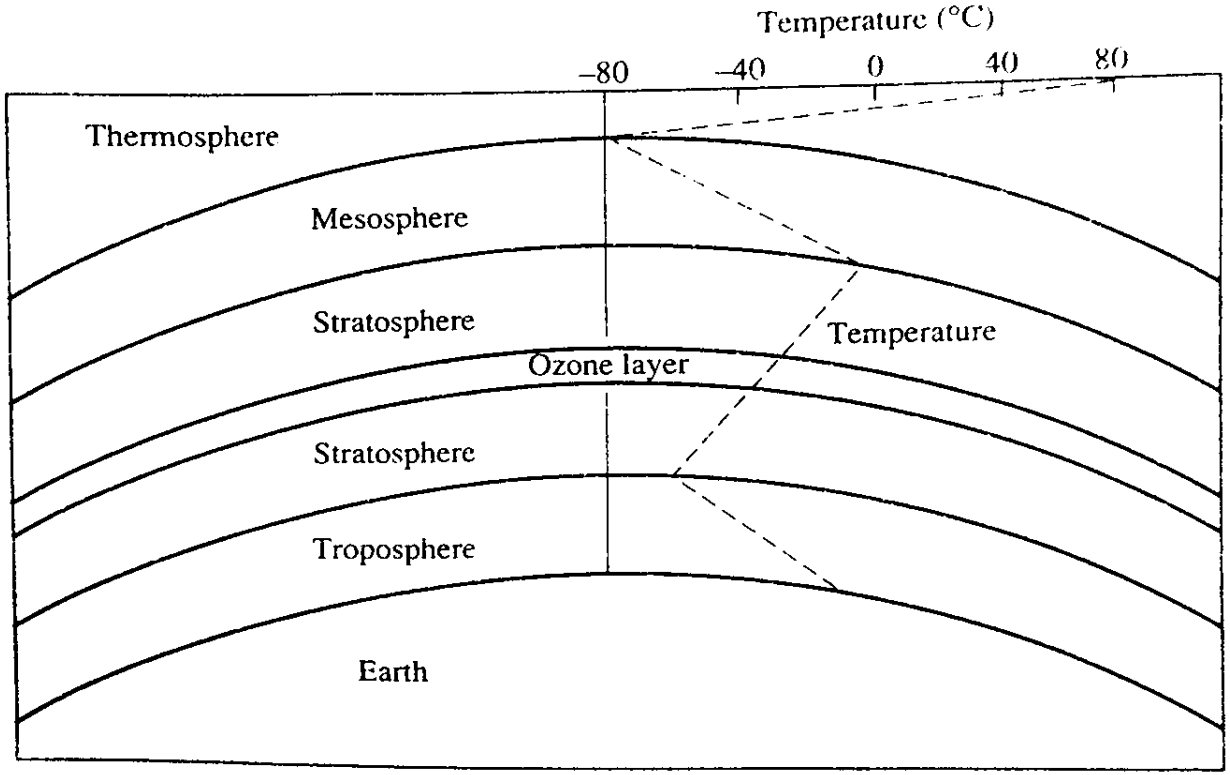
Let us understand the layers of atmosphere

Layers of earth atmosphere:

- The atmosphere can be divided into four distinct layers of contrasting temperature due to differential absorption of solar energy.
    a) Troposphere
    b) Stratosphere
    c) Mesosphere
    d) Thermosphere

Air Pollution

Layers of earth atmosphere:



Air Pollution

Let us understand the layers of atmosphere

Layers of earth atmosphere:

- The layer of air immediately adjacent to Earth's surface is called troposhere.
- The troposphere, ranging in the depth from 16 km (10 mi) over the equator to about 8 km (5 mi) over the poles, contains about 75% of total mass of the atmosphere.
- The air is well mixed because of winds.
- Air temperature drops rapidly with increase in elevation, reaching about -60^{o}C at the top of the tropospher.

Air Pollution

- The layer of air immediately above the troposphere is called Stratosphere, it extends above 50 km.
- Air temperature is relatively constant or even increases slightly with increase in elevation.
- The ozone is of greatest importance to our environmental quality because it contains ozone layer, which protects life on earth by absorbing UV radiation from the sun.
- The ozone concentration is 1000 times greater when it is compared with the troposphere.

Air Pollution

Above the stratosphere we have Mesosphere and Thermosphere, there is little interchange of materials between the troposphere, where the human activity has an impact and these two zones are thus limited to our.

Composition of Earth:

Earth is primarily composed of Oxygen (21%), Nitrogen (78%) and rest Argon, Neon, Helium, Krypton and Xenon.

Air Pollutants

Classification of Air Pollutants

Primary Pollutants

- which are directly released into the air in a harmful form.

  Example: Carbon monoxide, Hydrocarbon, particulates, Sulphur di-oxide and Nitrogen compounds.

Secondary Pollutants

- which are modified into hazardous form after they enter the atmosphere due to chemical reactions.

  Example: Petrochemical Oxidants and atmospheric acids.

Air Pollutants - *Classification of Air Pollutants*

Pollutant	Sources	Characteristics	Effects
CO (Carbon Monoxide)	CO is produced when organic material such as gasoline, coal or wood are incompletely burned	Colourless, odourless and Non irritating poison	It will quickly cause death at quite low concentrations Inhaled CO will attach to haemoglobin in the blood, reducing the capacity of blood to carry oxygen to tissues resulting in head aches
Hydrocarbons	Petroleum based fuels and remenants (uncombustibles) of fuels that did not burn completely Major sources are automobiles followed by refineries and its allied industries Synthetic organicchemicals that includes BTX, formaldehyde, vinly chlorides, phenols, and trichloroethylene	Volatile organic compounds, odorous and toxic	Contibutes towards carcinogenic (health related problems) Impacts ozone layer

Air Pollutants - *Classification of Air Pollutants*

Pollutant	Sources	Characteristics	Effects
SO_2 Sulfur Dioxide	Burning of sulphur containing fuels (Coal and crude oil)	Colorless, corrosive gas	Respiratory irritant and a poison It can react in the atmosphere with ozone, water vapour and forms H_2SO_4 Causes damage to the construction materials and metals
Particulates	Unburned stationary fuels, automobiles and industries (sugar, paper, power and so on.)	Small pieces of solids dispersed in the atmosphere and constitute the 3rd largest category of air pollutants. E.g. dust, ash, shoot and smokes	Respiratory problems, carcinogenic-health related issues and smog formation

Air Pollutants - *Classification of Air Pollutants*

Pollutant	Sources	Characteristics	Effects
Nitogen Oxides (NOx	Primary source is the automobile engines Combustion of coals Oil or natural gas	Highly reactive gases formed from oxidation of nitrogen in air during combustion	Smog formation Nitrogen Oxides can react with water forming HNO_3 and contributes to acid rain problems
Photochemical Oxidants	Volatile organic compounds (or) aldehydes or Nitrogen oxides	Products of secondary atmospheric reactions driven by solar energy Strong oxidant	Eye irritant, damage lung tissues and chlorophyll in plants
Lead Mercury and Cadmium	Gasolines containing tetra ethyl lead (added to reduce engine wear) Ore smelting Inceneration of wastes	Silvery white metal And it can react with H_2S	Carcinogenic related issues

Air Pollutants – *Effects*

- Smog formation
- Photochemical smog
- Acid rain
- Global warming
- Green house effect

Air Pollutants – *Effects (Smog)*

Smog formation

- The term “smog” comes from a combination of words “smog and fog”
- Smoke was produced by the action of fog with high concentration of fly ash or shoots or smoke particles

Photochemical smog

- Photochemical smog is the result of interaction between nitrogen oxides and hydrocarbons under the influence of sunlight
- These reactions produce a mixture of photochemical oxidants peroxyacetal nitrate (PAN), ozone, acrolein and so on.

Air Pollutants – *Effects (Smog)*

- Automobile exhaust is the major source of photochemical smog
- Automobile gas has large amount of NO
- $N_2 + O_2 \longrightarrow NO$
- $2NO + O_2 \longrightarrow 2NO_2$
- $O_2 \longrightarrow 2O\bullet$
- $O_2 + O\bullet \longrightarrow O_3$

$NO_2 + \text{UV radiation} \longrightarrow NO + O\bullet$

Air Pollutants – *Effects (Smog)*

Overall reaction

$$NO_2 + \text{UV radiation} + VOC + O_2 \longrightarrow NO + O_3 + PAN + \text{aldehydes}$$

Air Pollutants – *Effects (Acid Rain)*

- Smog problems usually affect a relatively limited region.

- An industrially based problem that often affects larger region is that acid deposition, more commonly reffered to “acid rain”.

- Acid rain is rain that is more acidic than the normal because it contains sulphuric acid (H_2So_4) or Nitric acid (HNo_3).

- Originating from SO_2 and NO_2 in the atmosphere.

- The acidity can also cause from acids associated with the particulate matter in the air.

- The acids may reach materials on the earth by settling as wells by the particulates being incorporated in the rain droplets.

Air Pollutants – *Effects (Acid Rain)*

- Atmospheric acids can naturally occur (valcanos, vegetation abd lighting) but must derive from coal burning and use of internal combustion engine.

- Electric utility or power plants account about 70% of the aanual SO_2 emmisions and 30% of NO_x emissions in the united states.

- Overall more than 20 million metric tons of SO_x and NO_x are emitted into the amosphere in the US each year

- The SO_x and NO_x produced can react with water vapor in the air in the presence of oxidizing agents (Ozone, hydrogen peroxide and hydroxyl ions) to form sulfuric and nitric acids.

Air Pollutants – *Effects (Acid Rain)*

- Burning petroleum based fuels (gasoline, diesel, kerosene and so on) can produce acid rain.

- Unpolluted rain usually has a pH of 5.6.

- Dissolution of Co_2 from the atmosphere, which reacts to form Carbonic acid (H_2Co_3) in the Water droplet.

- $CO_2 + H_2O \longrightarrow H_2Co_3$

- This acidity can be quickly neutralized and usually has negligible impact.

Air Pollutants – *Effects (Acid Rain)*

- The average pH in rainfall in the north eastern part of the United States Ontario areas are impacted by the burning of high-sulfur content coal between 4.0 and 4.5. Extreme cases the pH can be much lower.

- A rainfall pH of 2.1 was recorded in 1969 in News Hampshire, an area that burns very little coal is affected by airflow pattern from industrial mid west, where high sulfur was burned.

Air Pollutants – *Effects (Acid Rain)*

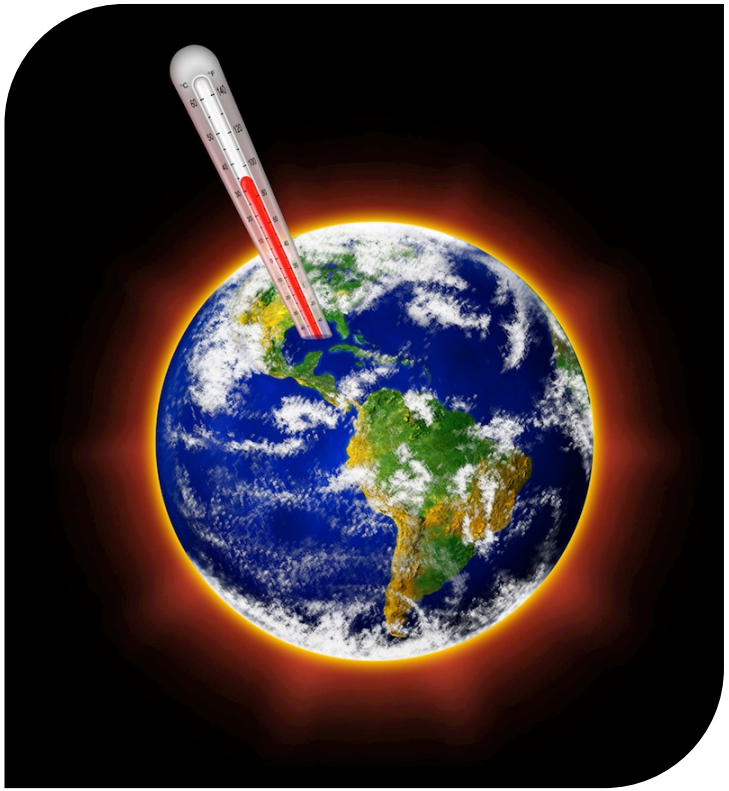
- Improved sulfur recovery at combustion facilitates and also new ways to reduce the amount of coal needed by the industry is required to reduce the acid rain caused by air pollutants.
- Increasing the use of recycled materials while reducing the reliance on energy-intensive processes such as smelters, aluminum, pulp and paper mills will also reduce the air pollutants
- Enhanced pollution prevention activities could go long way towards minimizing the acid rain

Air Pollutants – *Effects (Global Warming)*

- Global warming
- Industries releases gases containing CH_4, NO_2, and CO_2 which increases level of green house gases
- Trees absorb CO_2 and maintains CO_2 balance in atmosphere
- However, human beings are cutting trees for roads and buildings leading to deforestation.
- Deforestation leads to CO_2 imbalance imbalance.
- Layer of green house gas becomes thicker.

Air Pollutants – *Effects (Global Warming)*

- Global warming



Air Pollutants – *Effects (Global Warming)*

- Thicker layer of green house gases traps more heat results in average temperature of earth and earth becomes hotter and hotter. This is called “Global Warming”.

Air Pollutants – *Effects (Global Warming)*

If we don't take steps to reduce global warming., it will lead to loss of human lives, plants and animals.

Steps to reduce global warming

Plant more trees

Reduce, reuse and recycle

Use less hot water

Turn off electronic device when not in use

Spread awareness.

Air Pollutants – *Effects (Green house effect)*

- The sun rays warms the earth through its rays.
- A part of the sun's rays is absorbed by earth.
- A part of the sun's rays is reflected back in space.
- A part of the reflected rays is trapped by the Green house gases (NO_x, CH_4, CO_2)
- These trapped radiations (or rays) of the sun warm the earth

Air Pollutants – *Effects (Green house effect)*

- Consider a nursery where plants covered with glass roof.
- In a green house (Nursery) the suns heat can come in but cannot go out.
- The trapped heat warms the green house and becomes very hot inside.
- This trapped heat helps in controlled growth of plants.
- In a green house sun's heat can come in but cannot go out.
- The traped heat warms the green house.
- Similarly the gases (NO_x, CH_4, CO_2) trap sun's radiation, the earth would be very cold place where we wouldn't survive
- Thus, trapping of heat to keep the earth warm is called "green house effect".

Air Pollutants – *Effects (Ozone Depletion)*

- In the mid -1970's, scientists became concerned about the possibility that chemicals emitted into atmosphere could react with ozone in the upper atmosphere and reduce its concentration there.
- Ozone plays an important role in the stratosphere, absorbing all a small fraction of the harmful ultraviolet radiation from the sun.
- As the ozone absorbs ultraviolet light, it is split into an oxygen molecule and an oxygen radical
- Ozone + UV radiation $\longrightarrow$ $O_2 + O\bullet$

Air Pollutants – *Effects (Ozone Depletion)*

- Recombination of oxygen radicals and oxygen molecules allows ozone to be reformed, available to absorb more UV radiation:
- $O_2 + O\bullet \longrightarrow O_3$
- The ozone prevents the UV radiation from reaching earth's surface, where it could cause skin cancers, mutations and cataracts in human or other living organisms
- It was estimated that 1 percent loss in ozone can result in a 2% increase in the amount UV radiation reaching earth, which could cause about 1 million extra human cancers per year worldwide if no protective measures are taken.
- Research has strongly implicated chlorofluorocarbons, as the primary cause of ozone depletion in the stratosphere.

Air Pollutants – *Effects (Ozone Depletion)*

- At earth surface CFC'c are nearly inert, but when impacted by uv radiation in the upper atmosphere, the CFC's release chlorine atoms.
- CF_2Cl_2 + UV radiation $\longrightarrow$ CF_2Cl + Cl_2
- The chlorine atom then quickly reacts with an ozone molecule, breaking it down to oxygen:
- $Cl\bullet + O_3 \longrightarrow ClO + O_2$
- Ozone protects us from uv radiations reaching us by absorbing the radiation and breaking into an oxygen atom and an oxygen radical.
- The oxygen radical and oxygen molecule can then recombine to form new ozone molecule, available to absorb more UV radiation.

Air Pollutants – *Effects (Ozone Depletion)*

- However, if CFC's are present, the ClO produced upon the reaction of the chlorine atom and the ozone can react with oxygen radical forming more chlorine atoms that react with more ozone.
- $ClO + O\bullet \longrightarrow Cl\bullet + O_2$
- In addition to producing chlorine another Cl atom, this reaction removes the oxygen radical, forming it from recombining with an oxygen atom to form and ozone molecule
- It was estimated that 1 chlorine atom can destroy more than 100,000 ozone molecules before finally being removed from the stratosphere.

References

Global Warming

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Green house gas

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