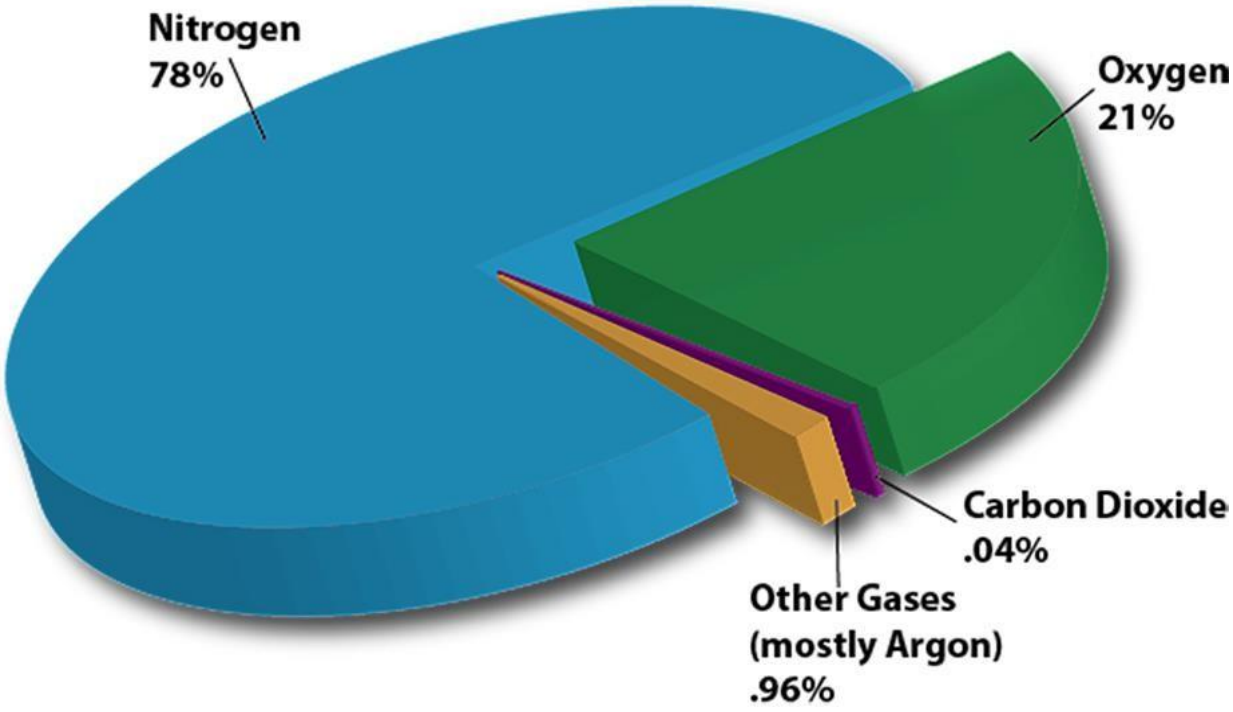
Module: 03
AIR

Introduction

- Air is **a mixture of many gases and tiny dust particles**. It is the clear gas in which living things live and breathe. It has an indefinite shape and volume. It has mass and weight, because it is matter. The weight of air creates atmospheric pressure.
- Air is one of the most important constituent of our environment. Average human being requires about 12kg of air each day, which is nearly 12-15 times greater than the amount of food consumed.
- Eventually , even a small concentration of pollutants present in the air becomes more harmful to human health.
- The introduction of harmful gases, dust particles and intoxicated fumes in the atmosphere more than the permissible limit which might bring harm to living organisms is called air pollution

Compositions of air

- Air is a mixture of gases which makes up the Earth's atmosphere. These gases are colorless and odorless and hence, we can't see them but only feel them.
- The atmosphere is an ocean of these gases. It consists of 78% nitrogen, 21% oxygen and 1 % other gases and water vapour.
- The composition of air does not change as you travel through the layers of the atmosphere. What changes is the number of molecules. The air molecules decrease and become less.
- The moisture content varies from place to place. Arid regions have less moisture content as compared to wetlands.



Composition of Air

Element	*Volume by %*	*Weight by %*	*PPM(Parts per Million) by Volume*	*Symbol of the Element*	*Molecular Weight of the element*
Nitrogen	78.08	75.47	780790	N_2	28.01
Oxygen	20.95	23.20	209445	O_2	32.00
Argon	0.93	1.28	9339	Ar	39.95
Carbon Dioxide	0.040	0.062	404	CO_2	44.01
Neon	0.0018	0.0012	18.21	Ne	20.18
Helium	0.0005	0.00007	5.24	He	4.00
Krypton	0.0001	0.0003	1.14	Kr	83.80
Hydrogen	0.00005	Negligible	0.50	H_2	2.02
Xenon	8.7×10^{-6}	0.00004	0.087	Xe	131.30

Some other components of air are mentioned below:

- Sulfur dioxide (SO_2) – 1.0 ppm
- Methane CH_4)2.0 ppm
- Nitrous oxide(N_2O) – 0.5 ppm

- Ozone(O_3) 0 to 0.07 ppm
- Nitrogen dioxide (NO_2) – 0.02 ppm
- Iodine(I_2) 0.01 ppm
- Carbon monoxide (CO) – 0 to trace ppm
- Ammonia NH_3) 0 to trace ppm
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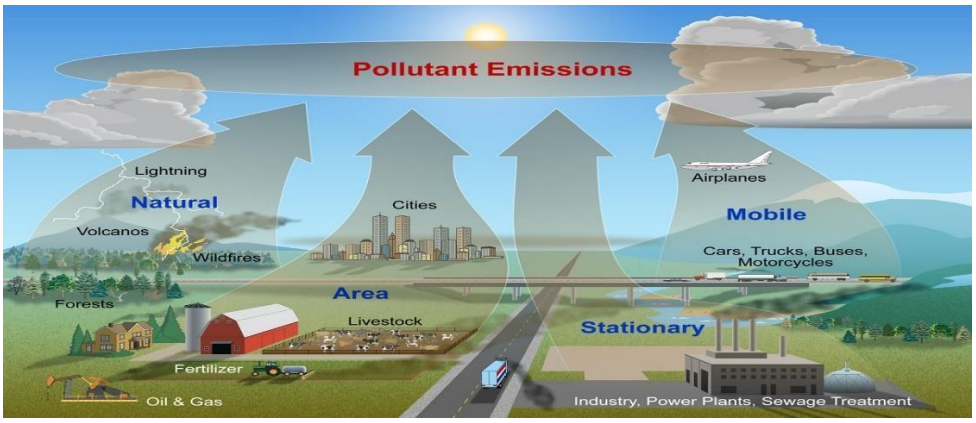
SOURCES OF AIR POLLUTION

Types of Sources

There are four main types of air pollution sources:

- *MOBILE SOURCES* – such as cars, buses, planes, trucks, and trains
- *STATIONARY SOURCES* – such as power plants, oil refineries, industrial facilities, and factories
- *AREA SOURCES* – such as agricultural areas, cities, and wood burning fireplaces
- *NATURAL SOURCES* – such as wind-blown dust, wildfires, and volcanoes



- Mobile sources account for more than half of all the air pollution in the United States and the primary mobile source of air pollution is the automobile, according to the Environmental Protection Agency.
- Stationary sources, like power plants, emit large amounts of pollution from a single location, these are also known as point sources of pollution.
- Area sources are made up of lots of smaller pollution sources that aren't a big deal by themselves but when considered as a group can be.
- Natural sources can sometimes be significant but do not usually create ongoing air pollution problems like the other source types can.

CLASSIFICATION OF AIR POLLUTION

Air pollutants are classified as

1. Primary pollutants and
2. Secondary pollutants

- Primary air pollutants are emitted directly into the atmosphere by the original source. carbon monoxide, nitrogen oxides, particulate matter, sulfur oxides, and volatile organic compounds.
- Secondary air pollutants are formed because of reactions between primary pollutants and other elements in the atmosphere, such as the ozone, which is formed when hydrocarbons (HC) and nitrogen oxides (NOx) combine in the presence of sunlight; NO2, which is formed as NO combines with oxygen in the air; and acid rain, which is formed when sulfur dioxide or nitrogen oxides react with water.

Particulate Pollutants	**Gaseous Pollutants**	
1. Lead 2. Fly Ash 3. Metallic Oxides 4. Nanoparticles	5. Carbon monoxide (CO) 6. Carbon dioxide (CO2) 7. Chlorofluorocarbons (CFCs) 8. Ozone (O3) 9. Nitrogen oxide (NOx) 10. Sulphur dioxide (SO2)	• Volatile organic compounds (VOCs) • Benzene • Ethylene • Biological pollutants • Asbestos • Radon

Particulate Pollutants

- The particles that pollute the air by being suspended can be defined as particulate pollutants.
- These particles are results of some anthropogenic processes like vehicles, industries, construction sites/activities, etc. or natural sources like pollen, volcanic eruptions, natural gaseous precursors, etc.
- Their size ranges from 0.001 to 500 micrometers (μm) in diameter.

Nanoparticles (NP)

- Nanoparticles have diameters less than 100 Nanometers (**10-9**).
- NP is responsible for the formation of dust clouds, Ozone depletion, environmental hydroxyl radical concentration, and stratospheric temperature changes.

Fly ash

- Fly Ash is particles of oxides and other heavy metals. The majority of them are aluminum silicate (in large amounts), silicon dioxide (SiO2), and calcium oxide (CaO).
- Thermal power plants are a major source of Fly Ash pollutants.
- Its deposition in agricultural fields can cause heavy metal contamination of crops and vegetables.
- The Ministry of Environment and Forests has made it mandatory to use Fly Ash-based products in all construction projects, road embankment works, and low-lying landfilling works that are within a 100 km radius of Thermal Power Stations and mine-filling activities within a 50 km radius of Thermal Power Stations.

Lead

- Lead is one of the most hazardous heavy metals.
- Lead can cause serious damage to the human body like:
    - Nervous system damage
    - Digestive issues
    - Kidney damage
    - Impacts on intelligence
- Hence, Lead was banned as an additive to fuels and other products.
- Lead mixed with water and food can create cumulative poisoning.
- It has long term effects on children as it lowers intelligence.

CAUSES OF AIR POLLUTION

Air pollution is caused by solid and liquid particles and certain gases that are suspended in the air. These particles and gases can come from car and truck exhaust, factories, dust, pollen, mold spores, volcanoes and wildfires. The solid and liquid particles suspended in our air are called **aerosols**.

1. Vehicle Exhaust Fumes.

The number one source of air pollution in city environments is vehicle exhaust fumes, which happen to release high amounts of carbon monoxide. It’s no surprise then that carbon monoxide also happens to be the largest air pollutant in the United States.

- Millions of vehicles are operated on a daily basis in the US alone, each one leaving its own carbon footprint on the environment. This is why hybrid and fully electric vehicles are making a splash in the automobile marketplace.
- People are looking to rely less on fossil fuels to power their cars, leading to less toxic emissions into the environment.

2. Fossil Fuel-Based Power Plants.

- In addition to vehicle exhaust pollution, fossil fuels also present a wider scale problem when they're burned for energy in power plants.
- Chemicals like sulfur dioxide are released during the burning process, which travel straight into the atmosphere. These types of pollutants react with water molecules to yield something known as acid rain.
- This is one of the reasons that alternative energy sources, such as nuclear, solar, and wind are being explored in greater detail. They tend to release much less pollutants into the environment to produce equivalent amounts of energy.

3. Exhaust from Industrial Plants and Factories.

- Similar to exhaust being released from vehicles, heavier machinery located inside big factories and industrial plants also emit pollutants into the air.
- Industrial plants can be found pretty much everywhere in the world, so the spreading of air pollution is basically global.

1. **Construction and Agricultural Activities.**

- On a daily basis, dirt and dust is kicked up into the atmosphere from excavating and demolition type construction activities.
- Switching the focus to agricultural activities, ammonia is a frequent byproduct that just so happens to be one of the most dangerous gases in our environment.
- There are also plenty of nasty chemicals that get placed into the atmosphere from pesticides and fertilizers, which are being used at increasingly higher rates.

1. Natural Causes.

- When people think pollution, they almost always blame other people. Let's not forget that the Earth is one of the biggest polluters itself, though.
- Volcanoes, forest fires, and dust storms are nature-born events that dump massive

pollutant	common sources	maximum acceptable concentration in the atmosphere	environmental risks	human health risks
carbon monoxide (CO)	automobile emissions, fires, industrial processes	35 ppm (1-hour period); 9 ppm (8-hour period)	contributes to smog formation	exacerbates symptoms of heart disease, such as chest pain; may cause vision problems and reduce physical and mental capabilities in healthy people
nitrogen oxides (NO and NO_2)	automobile emissions, electricity generation, industrial processes	0.053 ppm (1-year period)	damage to foliage; contributes to smog formation	inflammation and irritation of breathing passages
sulfur dioxide (SO_2)	electricity generation, fossil-fuel combustion, industrial processes, automobile emissions	0.03 ppm (1-year period); 0.14 ppm (24-hour period)	major cause of haze; contributes to acid rain formation, which subsequently damages foliage, buildings, and monuments; reacts to form particulate matter	breathing difficulties, particularly for people with asthma and heart disease
ozone (O_3)	nitrogen oxides (NO_x) and volatile organic compounds (VOCs) from industrial and automobile emissions, gasoline vapours, chemical solvents, and electrical utilities	0.075 ppm (8-hour period)	interferes with the ability of certain plants to respire, leading to increased susceptibility to other environmental stressors (e.g., disease, harsh weather)	reduced lung function; irritation and inflammation of breathing passages
particulate matter	sources of primary particles include fires, smokestacks, construction sites, and unpaved roads; sources of secondary particles include	150 µg/m^3 (24-hour period for particles <10 µm); 35 µg/m^3 (24-hour period for particles <2.5 µm)	contributes to formation of haze as well as acid rain, which changes the pH balance of waterways and damages foliage, buildings, and monuments	irritation of breathing passages, aggravation of asthma, irregular heartbeat

	reactions between gaseous chemicals emitted by power plants and automobiles			
lead (Pb)	metal processing, waste incineration, fossil-fuel combustion	0.15 µg/m^3 (rolling three-month average); 1.5 µg/m^3 (quarterly average)	loss of biodiversity, decreased reproduction, neurological problems in vertebrates	adverse effects upon multiple bodily systems; may contribute to learning disabilities when young children are exposed; cardiovascular effects in adults

2. Household Activities.

- Forget about outdoor pollution. What about the pollution that takes place inside our own homes?
- Common household chemicals, notably bleach, without proper ventilation is a primary source of indoor air pollution.
- Smoking tobacco through the use of cigarettes and cigars also releases toxic pollutants into the air.
- It's often easier to think of outdoor pollution as the primary danger on a wide scale level, but don't dismiss the little everyday activities that also impact our health.

VARIOUS POLLUTANTS CAUSING AIR POLLUTION

- The EPA has identified six pollutants as "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels.
- These six pollutants are carbon monoxide, lead, nitrogen oxides, ground-level ozone, particle pollution (often referred to as particulate matter), and sulfur oxides.

particle pollution

- The particles that pollute the air by being suspended can be defined as particulate pollutants.
- These particles are results of some anthropogenic processes like vehicles, industries,

construction sites/activities, etc. or natural sources like pollen, volcanic eruptions, natural gaseous precursors, etc.

- Their size ranges from 0.001 to 500 micrometers (μm) in diameter**.**

NATIONAL AMBIENT AIR QUALITY STANDARDS OF INDIA(NAAQS)

- The NAAQS set by the CPCB are applicable to the whole country. The CPCB draws this power from the Air (Prevention and Control of Pollution) Act, 1981.
- These standards are essential for the development of effective management of ambient air quality.
- The first ambient air quality standards were developed in 1982 pursuant to the AIR ACT.
- Later, in 1994 and 1998, these standards were revised. The latest revision to the NAAQS was done in 2009 and this is the latest version being followed.
- The 2009 standards further lowered the maximum permissible limits for pollutants and made the standards uniform across the nation. Previously, industrial zones had less stringent standards as compared to residential areas.
- The compliance of the NAAQS is monitored under the National Air Quality Monitoring Programme (NAMP). NAMP is implemented by the CPCB.

The current standards (2009) comprise 12 pollutants as follows:

1. Particulate Matter 10 (PM10)
2. Particulate Matter 2.5 (PM2.5)
3. Nitrogen Dioxide (NO2)
4. Sulphur Dioxide (SO2)
5. Carbon Monoxide (CO)
6. Ozone (O3)
7. Ammonia (NH3)
8. Lead (Pb)
9. Benzene
10. Benzopyrene
11. Arsenic
12. Nickel

Pollutant	Time Weighted Average	Concentration in Ambient Air	
		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
Nitrogen dioxide (NO_2), $\mu g/m^3$	Annual 24 hours	40 80	30 80
Particulate matter (< 10 µm) or PM_{10}, $\mu g/m^3$	Annual 24 hours	60 100	60 100
Particulate matter (< 2.5 µm) or $PM_{2.5}$, $\mu g/m^3$	Annual 24 hours	40 60	40 60
Ozone (O_3), $\mu g/m^3$	8 hours 1 hour	100 180	100 180
Lead (Pb), $\mu g/m^3$	Annual 24 hours	0.50 1.0	0.50 1.0
Carbon monoxide (CO), mg/m^3	8 hours 1 hour	02 04	02 04
Ammonia (NH_3), $\mu g/m^3$	Annual 24 hours	100 400	100 400
Benzene (C_6H_6), $\mu g/m^3$	Annual	05	05
Benzo(α)Pyrene (BaP) – particulate phase only, ng/m^3	Annual	01	01
Arsenic (As), ng/m^3	Annual	06	06
Nickel (Ni), ng/m^3	Annual	20	20

AIR QUALITY INDEX

- An air quality index (AQI) is used by government agencies to communicate to the public how polluted the air currently is or how polluted it is forecast to become. AQI information is obtained by averaging readings from an air quality sensor, which can increase due to vehicle traffic, forest fires, or anything that can increase air pollution. Pollutants tested include ozone, nitrogen dioxide, sulphur dioxide.
- Public health risks increase as the AQI rises, especially affecting children, the elderly, and individuals with respiratory or cardiovascular issues. During these times, governmental bodies generally encourage people to reduce physical activity outdoors, or even avoid going out altogether. The use of face masks such as cloth masks may also be recommended.
- Different countries have their own air quality indices, corresponding to different national air quality standards.

- Think of the AQI as a yardstick that runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 or below represents good air quality, while an AQI value over 300 represents hazardous air quality.
- For each pollutant an AQI value of 100 generally corresponds to an ambient air

concentration that equals the level of the short-term national ambient air quality standard for protection of public health. AQI values at or below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is unhealthy: at first for certain sensitive groups of people, then for everyone as AQI values get higher.

- The AQI is divided into six categories. Each category corresponds to a different level of health concern. Each category also has a specific color. The color makes it easy for people to quickly determine whether air quality is reaching unhealthy levels in their communities.

AQI IN INDIA

- The National Air Quality Index (AQI) was launched in New Delhi on September 17, 2014, under the Swachh Bharat Abhiyan.
- The Central Pollution Control Board along with State Pollution Control Boards has been operating National Air Monitoring Program (NAMP).
- There are six AQI categories, namely Good, Satisfactory, Moderate, Poor, Severe, and Hazardous.
- The proposed AQI will consider eight pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb) for which short-term (up to 24-hourly averaging period) National Ambient Air Quality Standards are prescribed.
- Based on the measured ambient concentrations, corresponding standards and likely health impact, a sub-index is calculated for each of these pollutants. The worst sub-index reflects overall AQI. Likely health impacts for different AQI categories and pollutants have also been suggested, with primary inputs from the medical experts in the group.
- The AQI values and corresponding ambient concentrations (health breakpoints) as well as associated likely health impacts for the identified eight pollutants are as follows

AQI Category, Pollutants and Health Breakpoints

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 –1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

EFFECTS OF AIR POLLUTION

Air pollution can cause a variety of environmental effects

- Acid rain
- Eutrophication
- Haze
- Effects on wildlife
- Ozone depletion
- Crop and forest damage
- Global climate change

Acid rain is precipitation containing harmful amounts of nitric and sulfuric acids. These acids are formed primarily by nitrogen oxides and sulfur oxides released into the atmosphere when fossil fuels are burned. These acids fall to the Earth either as wet precipitation (rain, snow, or fog) or dry precipitation (gas and particulates). Some are carried by the wind, sometimes hundreds of miles. In the environment, acid rain damages trees and causes soils and water bodies to acidify, making the water unsuitable for some fish and other wildlife. It also speeds the decay of buildings, statues, and sculptures that are part of our national heritage. Acid rain has damaged Massachusetts lakes, ponds, rivers, and soils, leading to damaged wildlife and forests.

Eutrophication is a condition in a water body where high concentrations of nutrients (such as nitrogen) stimulate blooms of algae, which in turn can cause fish kills and loss of plant and animal diversity. Although eutrophication is a natural process in the aging of lakes and some estuaries, human activities can greatly accelerate eutrophication by increasing the rate at which nutrients enter aquatic ecosystems. Air emissions of nitrogen oxides from power plants, cars, trucks, and other sources contribute to the amount of nitrogen entering aquatic ecosystems.

Haze is caused when sunlight encounters tiny pollution particles in the air. Haze obscures the clarity, color, texture, and form of what we see. Some haze-causing pollutants (mostly fine particles) are directly emitted to the atmosphere by sources such as power plants, industrial facilities, trucks and automobiles, and construction activities. Others are formed when gases emitted to the air (such as sulfur dioxide and nitrogen oxides) form particles as they are carried downwind.

Effects on wildlife Toxic pollutants in the air, or deposited on soils or surface waters, can impact wildlife in a number of ways. Like humans, animals can experience health problems if they are exposed to sufficient concentrations of air toxics over time. Studies show that air toxics are contributing to birth defects, reproductive failure, and disease in animals. Persistent toxic air pollutants (those that break down slowly in the environment) are of particular concern in aquatic ecosystems. These pollutants accumulate in sediments and may bio magnify in tissues of animals at the top of the food chain to concentrations many times higher than in the water or air.

Ozone depletion Ozone is a gas that occurs both at ground-level and in the Earth's upper atmosphere, known as the stratosphere. At ground level, ozone is a pollutant that can harm human health. In the stratosphere, however, ozone forms a layer that protects life on earth from the sun's harmful ultraviolet (UV) rays. But this "good" ozone is gradually being destroyed by man-made chemicals referred to as ozone-depleting substances, including chlorofluorocarbons, hydrochlorofluorocarbons, and halons.

Crop and forest damage Air pollution can damage crops and trees in a variety of ways. Ground-level ozone can lead to reductions in agricultural crop and commercial forest yields, reduced growth and survivability of tree seedlings, and increased plant susceptibility to disease, pests and other environmental stresses (such as harsh weather). As described above, crop and forest damage can also result from acid rain and from increased UV radiation caused by ozone depletion.

Global climate change The Earth's atmosphere contains a delicate balance of naturally occurring gases that trap some of the sun's heat near the Earth's surface. This "greenhouse effect" keeps the

Earth's temperature stable. Unfortunately, evidence is mounting that humans have disturbed this natural balance by producing large amounts of some of these greenhouse gases, including carbon dioxide and methane. As a result, the Earth's atmosphere appears to be trapping more of the sun's heat, causing the Earth's average temperature to rise - a phenomenon known as global warming. Many scientists believe that global warming could have significant impacts on human health, agriculture, water resources, forests, wildlife, and coastal areas.

EFFECT OF AIR POLLUTION ON HUMAN HEALTH

Even healthy people can experience health impacts from polluted air including respiratory irritation or breathing difficulties during exercise or outdoor activities. Your actual risk of adverse effects depends on your current health status, the pollutant type and concentration, and the length of your exposure to the polluted air.

High air pollution levels can cause immediate health problems including:

- Aggravated cardiovascular and respiratory illness
- Added stress to heart and lungs, which must work harder to supply the body with oxygen
- Damaged cells in the respiratory system

Long-term exposure to polluted air can have permanent health effects such as:

- Accelerated aging of the lungs
- Loss of lung capacity and decreased lung function
- Development of diseases such as asthma, bronchitis, emphysema, and possibly cancer
- Shortened life span.

Those most susceptible to severe health problems from air pollution are:

- Individuals with heart disease, coronary artery disease or congestive heart failure
- Individuals with lung diseases such as asthma, emphysema or chronic obstructive pulmonary disease (COPD)
- Pregnant women
- Outdoor workers
- Older adults and the elderly
- Children under age 14
- Athletes who exercise vigorously outdoors

People in these groups may experience health impacts at lower air pollution exposure levels, or their health effects may be of greater intensity.

ECONOMIC EFFECTS OF AIR POLLUTION

- In 2015, WHO and OECD estimated that the economic cost of premature death and disability from air pollution in Europe is close to USD 1.6 trillion. Air pollution takes its toll on the economy in several ways
- it costs human lives
- it reduces people's ability to work
- it affects vital products like food
- it damages cultural and historical monuments
- it reduces the ability of ecosystems to perform functions societies need and it costs money in remediation or restoration.

OZONE LAYER DEPLETION

Ozone Layer Definition

"The ozone layer is a region in the earth's stratosphere that contains high concentrations of ozone and protects the earth from the harmful ultraviolet radiations of the sun."

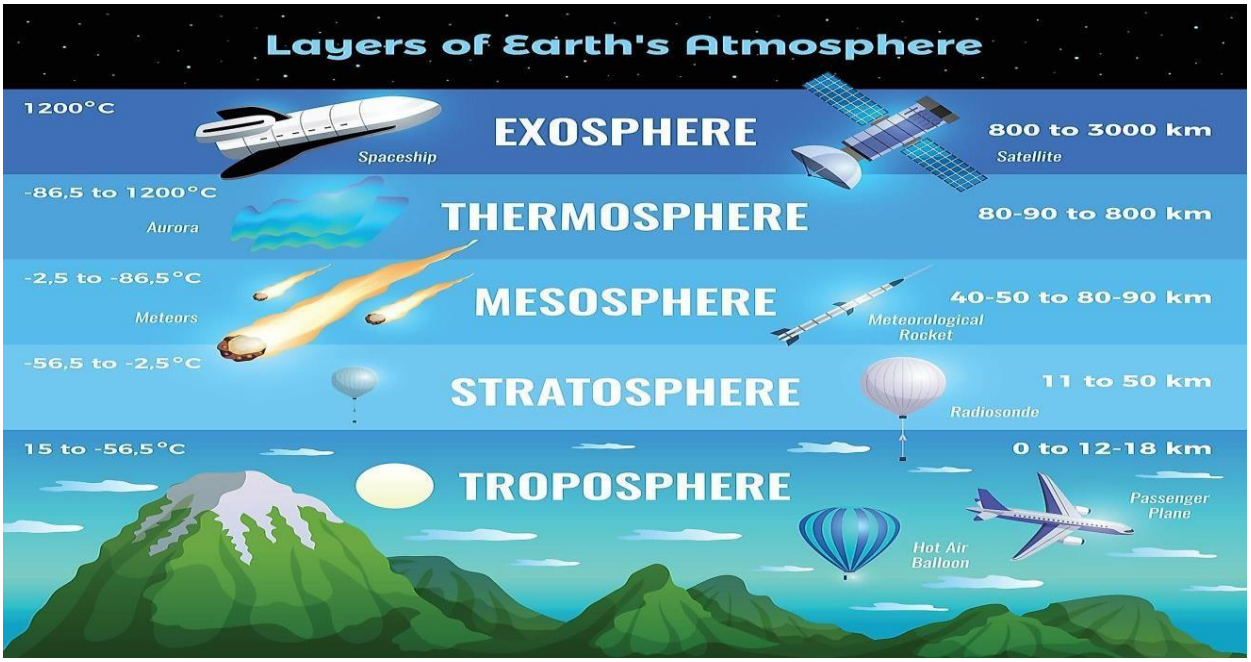
What is an Ozone Layer ?

- The ozone layer is mainly found in the lower portion of the earth's atmosphere.

It has the potential to absorb around 97-99% of the harmful ultraviolet radiations coming from the sun that can damage life on earth. If the ozone layer was absent, millions of people would develop skin diseases and may have weakened immune systems.

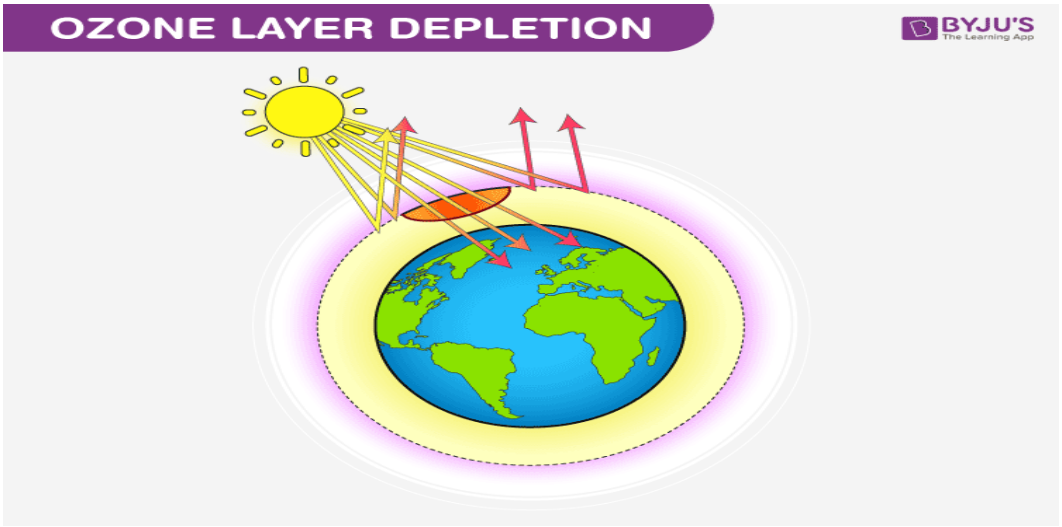
- However, scientists have discovered a hole in the ozone layer over Antarctica.

This has focused their concern on various environmental issues and steps to control them. The main reasons for the ozone hole are chlorofluorocarbons, carbon tetrachloride, methyl bromide and hydrochlorofluorocarbons.



Ozone Layer Depletion

"Ozone layer depletion is the gradual thinning of the earth's ozone layer in the upper atmosphere caused due to the release of chemical compounds containing gaseous bromine or chlorine from industries or other human activities."



Ozone layer depletion is the thinning of the ozone layer present in the upper atmosphere. This happens when the chlorine and bromine atoms in the atmosphere come in contact with ozone and destroy the ozone molecules. One chlorine can destroy 100,000 molecules of ozone. It is destroyed more quickly than it is created. Some compounds release chlorine and bromine on exposure to high ultraviolet light, which then contributes to ozone layer depletion. Such compounds are known as Ozone Depleting Substances (ODS).The ozone-depleting substances that contain chlorine include chlorofluorocarbon, carbon tetrachloride, hydrochlorofluorocarbons, and methyl

chloroform. Whereas, the ozone-depleting substances that contain bromine are halons, methyl bromide, and hydro bromo fluorocarbons. Chlorofluorocarbons are the most abundant ozone-depleting substance. It is only when the chlorine atom reacts with some other molecule, it does not react with ozone.

Montreal Protocol was proposed in 1987 to stop the use, production and import of ozone-depleting substances and minimize their concentration in the atmosphere to protect the ozone layer of the earth.

Causes of Ozone Layer Depletion

Ozone layer depletion is a major concern and is associated with a number of factors. The main causes responsible for the depletion of the ozone layer are listed below:

Chlorofluorocarbons

- Chlorofluorocarbons or CFCs are the main cause of ozone layer depletion. These are released by solvents, spray aerosols, refrigerators, air-conditioners, etc.
- The molecules of chlorofluorocarbons in the stratosphere are broken down by ultraviolet radiations and release chlorine atoms. These atoms react with ozone and destroy it.

Unregulated Rocket Launches

- Researches say that the unregulated launching of rockets results in much more depletion of the ozone layer than the CFCs do. If not controlled, this might result in a huge loss of the ozone layer by the year 2050.

Nitrogenous Compounds

- The nitrogenous compounds such as NO_2, NO, N_2O are highly responsible for the depletion of the ozone layer.

Natural Causes

- The ozone layer has been found to be depleted by certain natural processes such as Sun-spots and stratospheric winds. But it does not cause more than 1-2% of the ozone layer depletion.
- The volcanic eruptions are also responsible for the depletion of the ozone layer.

Ozone Depleting Substances (ODS)

“Ozone-depleting substances are the substances such as chlorofluorocarbons, halons, carbon tetrachloride, hydrofluorocarbons, etc. that are responsible for the depletion of the ozone layer.”

Ozone-Depleting Substances	Sources
Chlorofluorocarbons (CFCs)	Refrigerators, air-conditioners, solvents, dry-cleaning agents, etc.
Halons	Fire-extinguishers
Carbon tetrachloride	Fire extinguishers, solvents
Methyl chloroform	Adhesives, aerosols
Hydrofluorocarbons	fire extinguishers, air-conditioners, solvents

Effects Of Ozone Layer Depletion

- The depletion of the ozone layer has harmful effects on the environment. Let us see the major effects of ozone layer depletion on man and environment.

Effects on Human Health

- Humans will be directly exposed to the harmful ultraviolet radiation of the sun due to the depletion of the ozone layer. This might result in serious health issues among humans, such as skin diseases, cancer, sunburns, cataract, quick ageing and weak immune system.

Effects on Animals

- Direct exposure to ultraviolet radiations leads to skin and eye cancer in animals.

Effects on the Environment

- Strong ultraviolet rays may lead to minimal growth, flowering and photosynthesis in plants. The forests also have to bear the harmful effects of the ultraviolet rays.

Effects on Marine Life

- Planktons are greatly affected by the exposure to harmful ultraviolet rays. These are higher in the aquatic food chain. If the planktons are destroyed, the organisms present in the food chain are also affected.

SOLUTIONS TO OZONE LAYER DEPLETION

- The depletion of the ozone layer is a serious issue and various programmes have been launched by the government of various countries to prevent it. However, steps should be taken at the individual level as well to prevent the depletion of the ozone layer.

Following are some points that would help in preventing this problem at a global level:

Avoid Using ODS

- Reduce the use of ozone depleting substances. E.g. avoid the use of CFCs in refrigerators and air conditioners, replacing the halon based fire extinguishers, etc.

Minimize the Use of Vehicles

- The vehicles emit a large amount of greenhouse gases that lead to global warming as well as ozone depletion. Therefore, the use of vehicles should be minimized as much as possible.

Use Eco-friendly Cleaning Products

- Most of the cleaning products have chlorine and bromine releasing chemicals that find a way into the atmosphere and affect the ozone

Use of Nitrous Oxide should be Prohibited

The government should take actions and prohibit the use of harmful nitrous oxide that is adversely affecting the ozone layer. People should be made aware of the harmful effects of nitrous oxide and the products emitting the gas so that its use is minimized at the individual level as well.

PHOTO CHEMICAL CHANGES

- Photochemical smog is a type of air pollution due to the reaction of solar radiation with airborne pollutant mixtures of nitrogen oxides (NOx) and volatile organic compounds (hydrocarbons). Smog is a byproduct of modern industrialization. Due to industry and the number of motor vehicles, this is more of a problem in large cities that have a warm, sunny and dry climate.
- Oxidation: Photochemical smog is also referred to as oxidizing smog. Oxidation reactions have been defined several ways. In terms of oxygen transfer, oxidation is a gain of oxygen. Oxidation can also be defined as a loss of hydrogen. The most important use of oxidation is described in terms of electron transfer. Oxidation can be described as an increase in oxidation number or loss of electrons. Oxidation numbers represents a distribution of charge. In other words, oxidation numbers represent the charge of the atom if the compound was composed of ions.
- Reduction: Reduction can involve the gain of hydrogen or loss of oxygen. Reduction can refer to the gain of electrons, which results in a decrease in oxidation number.

Formation of Photochemical Smog

1: People begin driving in the morning, nitrogen is burned or oxidized

$$N2+O2 \rightarrow 2NO$$

Oxidation number of N_2 is 0. The nitrogen in NO has acquired an oxidation number of +2.

- Step 2: After a few hours, NO combines with O_2, in another oxidation reaction

$$2NO+O2 \rightarrow 2NO2$$

The nitrogen in NO has an oxidation number of +2. The nitrogen in NO_2 has an oxidation number of +4.

Step 3: Nitrogen dioxide absorbs light energy, resulting in a reduction reaction

$$NO2 \rightarrow NO + O$$

The nitrogen in NO_2 has an oxidation number of +4 and the nitrogen in NO is +2.

Step 4: In sunlight, atomic oxygen combines with oxygen gas to form ozone

$$O + O2 \rightarrow O3$$

Step 5: Reaction is temperature and sunlight dependent

CONTROLE OF AIR POLLUTION

- Air pollution control, the techniques employed to reduce or eliminate the emission into the atmosphere of substances that can harm the environment or human health.

For general awareness

- Conserve energy - at home, at work, everywhere.
- Look for the ENERGY STAR label when buying home or office equipment.
- Carpool, use public transportation, bike, or walk whenever possible.
- Follow gasoline refueling instructions for efficient vapor recovery, being careful not to spill fuel and always tightening your gas cap securely.
- Consider purchasing portable gasoline containers labeled “spill-proof,” where available.
- Keep car, boat, and other engines properly tuned.
- Be sure your tires are properly inflated.
- Use environmentally safe paints and cleaning products whenever possible.
- Much or compost leaves and yard waste.
- Consider using gas logs instead of wood.

1. Using public transports

Using public transport is a sure short way of contributing to less air pollution as it provides with less gas and energy, even carpools contribute to it. In addition to less release of fuels and gas, using a public transport can also help in saving money.

2. Turn off the lights when not in use

The energy that the lights take also contribute to air pollution, thus less consumption of electricity can save energy. Use energy saving fluorescent lights to help the environment.

3. Recycle and Reuse

The concept of recycle and reuse is not just conserve resources and use them judicially but also is helpful for air pollution as it helps in reducing pollution emissions. The recycled products also take less power to make other products.

4. No to plastic bags

The use of plastic products could be very harmful to the environment as they take a very long time to decompose, due to their material made up of oil. The use of paper bags instead is a better alternative as they decompose easily and are recyclable.

5. Reduction of forest fires and smoking

The collecting of garbage and getting it on fire in dry seasons or dry leaves catching fires is a huge factor for causing air pollution, moreover smoking also causes air pollution and causes the air quality to worsen along with obviously damaging one's health.

6. Use of fans instead of Air Conditioner

The usage of AC's takes a lot of energy and emits a lot of heat which is bad for the environment. AC's also take a lot of power and energy to work as compared to fans.

7. Use filters for chimneys

The gas that is emitted from fireplaces in homes and factories are extremely dangerous for air pollution and harms the air quality severely. The use of filters should be used at least if the consumption couldn't be lessened, this will help to reduce the effect of harmful gases absorbing in the air.

8. Avoid usage of crackers

The use of crackers during festivals and weddings is sadly one of the biggest contributors to air pollution, leading to a layer of smog which is extremely harmful for health. So, practice of no crackers should be implemented.

9. Avoid using of products with chemicals

Products that use the chemicals in their usage or smell strongly, like paints or perfumes should be used less or outside the house. There can also be an alternative to use products with low chemical content and organic properties.

10. Implement Afforestation

Last but not the least, plant and grow as many trees as possible. The practice of planting trees provides a lot of benefits to the environment and helps with the release of oxygen.

CONTROL OF AIR POLLUTION USING DEVICES

Air pollution control equipment, or emission control systems, remove and eliminate pollutants classified as volatile organic compounds (VOCs) or hazardous air pollutants (HAPs) that cause environmental and biological damage. Pollutants such as sulfuric fumes, gases, and atmospheric vapors cause a wide variety of problems including smog, acid rain, and global warming. Manufacturers that are concerned for the health of the planet have developed air pollution control equipment designed to reduce or eliminate the problem.

- Oxidizers
- Thermal oxidizers
- Air filtration systems
- Air scrubbers
- Electrostatic precipitator

- Mist collectors
- Odor control systems

OXIDIZERS

- Oxidizers are chemicals that release oxygen when they react with other substances. They have a variety of uses and different types produce different results. Oxidizers break up pollutants and reform them into safe, non-toxic carbon. There are two types of oxidizers – thermal and catalytic.
- These complex machines are often very large and are therefore more applicable in industries that yield high emissions such as paper and pulp, agriculture, printing, food processing, polymer and resin manufacturing, pharmaceuticals, painting and more. Not all oxidizers are so cumbersome, however, as they are also implemented in automotive exhaust systems. The volume and solvent load of process air stream should be carefully considered when selecting an oxidizer as is the typical temperature range of a system. All of these factors have a significant impact on the destruction efficiency of an oxidizer which is generally between 90% and 99%.

THERMAL OXIDIZERS

- Thermal oxidizers use combustion that produces high temperatures to break down hazardous gases releasing clean air. The two types of thermal oxidizers are regenerative and recuperative. Recuperative thermal oxidizers pass hot exhaust through a heat exchanger to heat the gas while regenerative thermal oxidizers pass hot exhaust through a heat exchanger bed made of ceramic. Regenerative thermal oxidizers destroy VOC ‘s, are the most common air pollution control equipment, and operate at very high temperatures. Recuperative thermal oxidizers run cooler than the regenerative version and have primary heat recovery. Catalytic oxidizers use a catalyst to increase the chemical reaction with VOC and HAP emissions. The catalyst allows the reaction to occur faster and at a lower temperature. The type of catalyst varies from a precious metal to simple base metals.

AIR SCRUBBERS

- It is a term used to describe a form of air cleaner that removes pollutants by washing the air that passes through it using either a chemical or water. It is referred to as a wet scrubber. On the other hand, dry scrubbers attract and collect pollutants through the application of a dry slurry or reagent forced into the exhaust stream. Chemicals in the slurry capture large particulates that cannot pass through a filter. Remaining particulates are caught when the gas stream is forced through a set of filters. Wet or dry air scrubbers are used by industry to remove gas emissions.

- While scrubbers can be used to remove particulates and chemicals, many are geared specifically towards one or the other as optimal operating conditions differ and chemical solutions and absorption techniques are often tailored to specific contaminants. Improperly configured or poorly maintained air scrubbers can leave harmful VOCs and HOCs in the atmosphere. For this reason, the EPA and other organizations encourage and even require the use of air scrubbers or other such equipment

ELECTROSTATIC PRECIPITATOR,

It is a Hohlfeld‘s idea, is a dry scrubber that uses static electricity to remove soot and ash from factory smokestacks. They filter smoke, mist, large liquids, or solid particulate contaminants in a mist collection process. Electrostatic precipitators are extremely effective and remove 99% of particulate matter.

To make sure an electrostatic precipitator works as well as it can with the highest level of efficiency that it can, an operator must make sure that it is assembled and installed properly and that it sees routine maintenance. For example, when installing, one must make sure that the ESP‘s potential maintenance areas, like motors, dampers, discharge devices, fans, insulators, hoppers, T- R sets and rappers, are readily accessible. Test and inspection areas, such as stack testing ports and continuous emission monitors, should be likewise accessible. Also, operators need to keep in mind any natural elements the ESP may encounter; if it will be exposed to snow or rain, for example, closer monitoring will likely be required.

MIST COLLECTORS, or moisture eliminator filters, remove moisture and vapors from gas streams. They use a very fine mesh filter to separate liquid from gases and collect them for processing. They are excellent for submicron particles but cannot be used for gases that contain large particles that may clog the filter.

Mist collection systems can be used for abrasives, coolant, smoke, oil, water and many other materials if properly engineered. Metal finishing and forming industries as well as chemical processing, brine desalination, marine, food processing, paper and pulp, agriculture and many other industries take advantage of mist collectors in daily operations. They are especially popular in applications where vapor quality is of utmost importance or where space and weight savings are integral. Installed in line, mist collectors have minimal impact on the gas flow of an operating system, another point of interest for many users.

ODOUR CONTROLE SYSTEM

- Odor control systems mask unpleasant odors with a pleasant scent or absorb them with powders, sprays, or filters. Absorption of unpleasant odors is a more permanent solution than covering them with a scent or smell, which is achieved with a porous material such as activated carbon from charcoal. The type of odor control system depends on the kind of odor and the system being used. There are four versions of odor control – chemical absorption, biological oxidation, chemical scrubbing, and a combination of the three. Each of these methods are more productive than a pleasant scent.
- In workplaces that have unpleasant odors caused by welding, plastic processing, high speed machining with coolants, tempering and quenching, mist collectors remove odors from gas streams. In order to manage smoke and exhaust odors, thermal oxidizers use chemicals that incinerate pollution in the air. Biofilters are small and fit inside pipes or tubes and remove sewer gas odors before the contents come in contact with humans. Atomization, vaporization, encapsulation or infusion are all popular delivery systems for odor control which may be marketed for specific odors or designed to breakdown a broad spectrum of odors.