ENVIRONMENTAL SCIENCE

EV10003

Understanding Air Pollution

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Topics covered

- Air pollutants - Classification
- Air pollutants - Sources
- Air pollutants - Impacts
- Clean Air Act
- National Ambient Air Quality Index
- Air Quality Index
- Ground level ozone and Photochemical smog
- Long range transboundary air pollution
- Ozone depletion in Antarctic stratosphere and the Montreal Protocol
- Understanding and improving indoor air quality

Pollution

Pollution is the ***introduction of harmful materials*** into the environment. These harmful materials are called pollutants. Pollutants can be natural, such as volcanic ash. They can also be created by human activity, such as trash or runoff produced by factories. Pollutants damage the quality of air, water, and land.

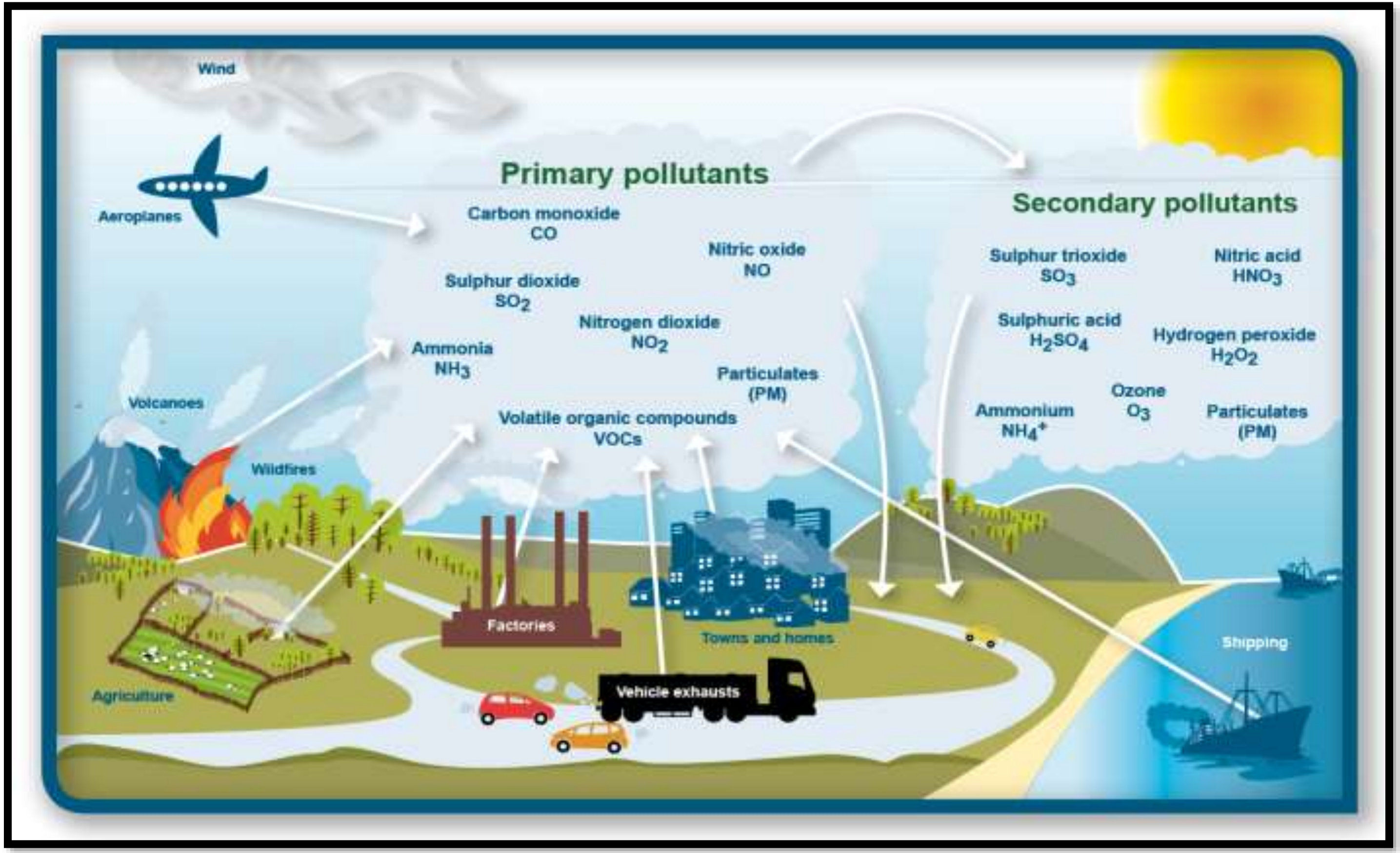
Source : https://www.nationalgeographic.org/encyclopedia/pollution/

Air pollution is the presence of substances in the atmosphere that are ***harmful to the health*** of humans and other living beings, or cause damage to the climate or to materials.

Air pollutant is a material in the air that can have ***adverse effects on humans*** and the ecosystem. These are the substance found in the ambient air that is not part of its natural composition or any substance whose concentration is higher than the concentration found in the air's natural composition.

- A pollutant can be ***solid particles, liquid droplets, or gases***.
- A pollutant can be of natural origin such as ***volcanic eruption or man-made*** such as burning fossil fuels.
- There are different types of air pollutants, such as ***gases (such as ammonia, carbon monoxide, sulfur dioxide, nitrous oxides, methane and chlorofluorocarbons), particulates (both organic and inorganic), and biological molecules.***

Classification of pollutants



Source : https://groundwater-modeling.teachable.com/p/air-pollution-causes-and-impacts

Classification of pollutants

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. E.g. Sulphur trioxide, ozone, ketones, sulphuric acid, nitric acid, carbonic acid etc.

Source: http://ecoursesonline.iasri.res.in/mod/page/view.php?id=25940

Classification of Air pollutants

According to state of matter**:** The pollutants are classified into:-

Gaseous air pollutants:

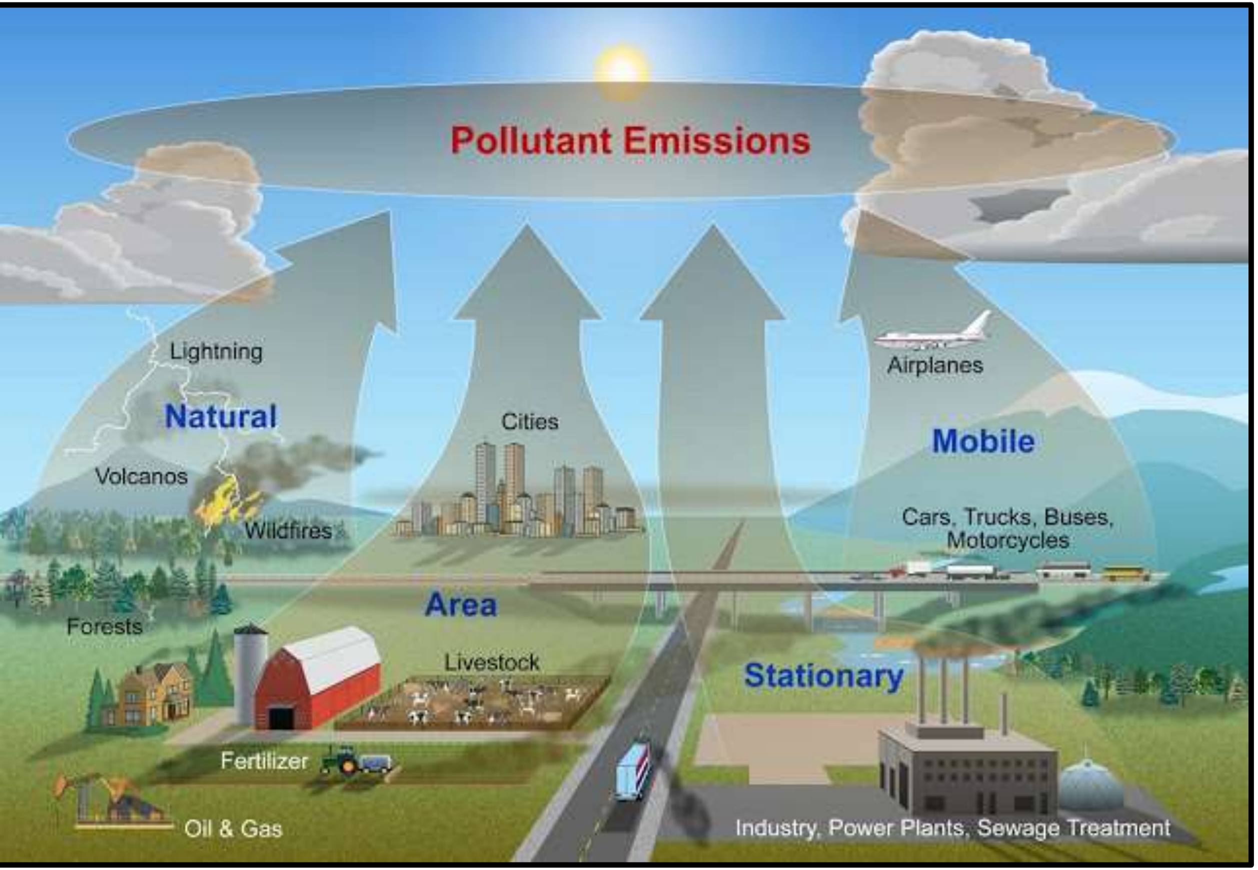
These pollutants exist in a gaseous state at normal temperature and pressure. They are carbon dioxide, nitrogen dioxide, sulphur oxides etc.

Particulate air pollutants:

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

Source: http://ecoursesonline.iasri.res.in/mod/page/view.php?id=25940

Source of Air Pollution



Anything which Emits Pollutants in the Atmosphere is known as Source of Air Pollution.

Classification of Sources of Air Pollution :-

1. Natural Source &
2. Anthropogenic Source

Source : https://greenanand.blogspot.com/2018/08/air-pollution-causes-sources-effects_7.html

Natural Sources :-

Forest fires, Volcanic eruptions, Dust Storms.

Anthropogenic Sources are Divided into 2 Types :-

1. Mobile Source :-

Sources of Pollution, ***which can move from one place to another***, are known as Mobile Source.

Mobile Source are Divided into 2 types :-

- **Road Sources** :-

Cars, Light Duty and Heavy Duty Trucks, Buses, Motorbike

- **Non-road Sources** :-

Aircraft, Motorboats (Diesel and Gasoline), Locomotives, Construction Equipment

Sources of Air Pollution

2. Stationary Source :-

Sources of Pollution ***which doesn't move***, is a Stationary Source of Pollution.

Stationary Source are Divided into 2 Types :-

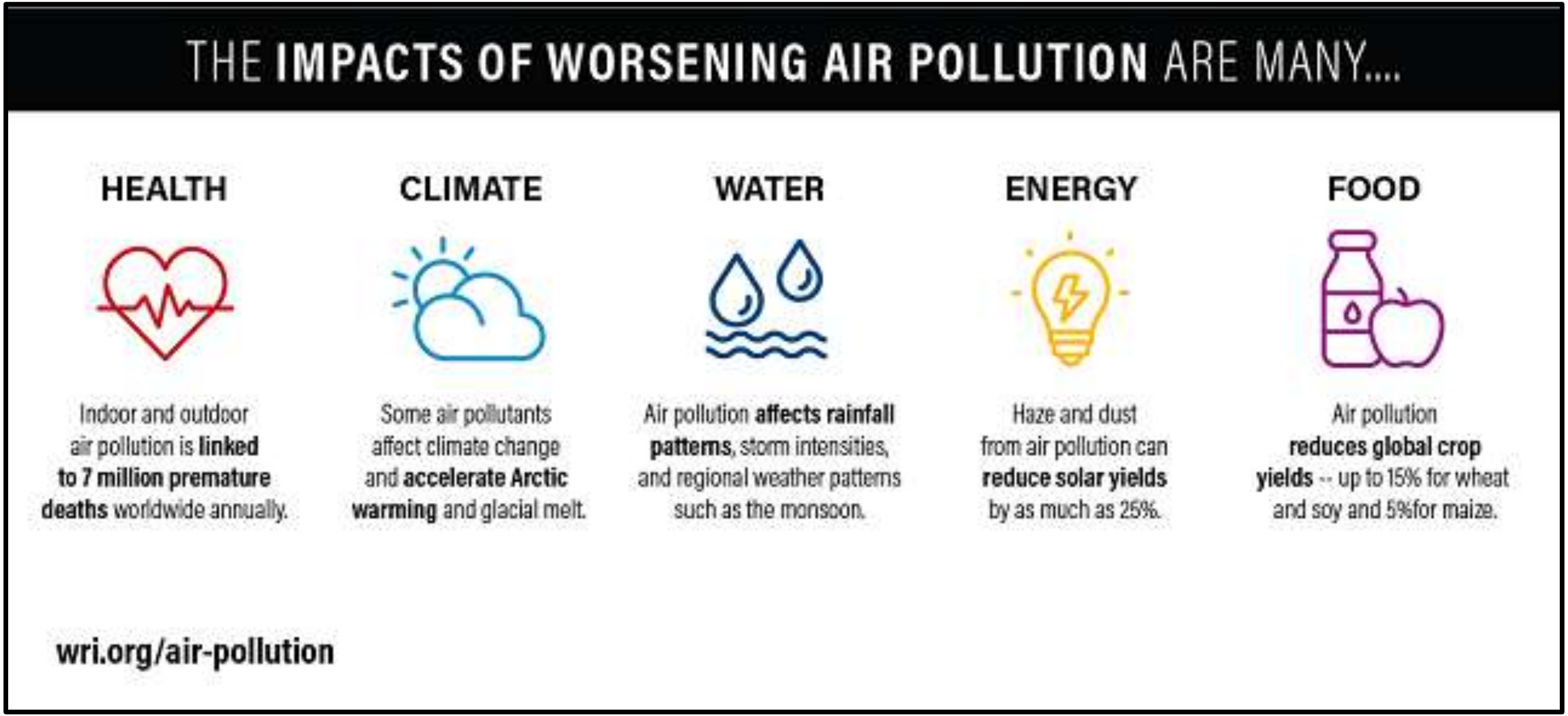
- **Point Source** :-When we can Trace the Source of Pollution to a Single Point, we call it Point Source of Pollution.

Examples :- Power plants, Oil refineries, Industrial facilities, and Factories.

- ***Area Source*** :-When source of pollution cannot be traced back to a single source is known as area source of pollution.

Examples :- Cities, Agricultural areas, Wood burning fireplaces, etc.

Impacts of Air Pollution



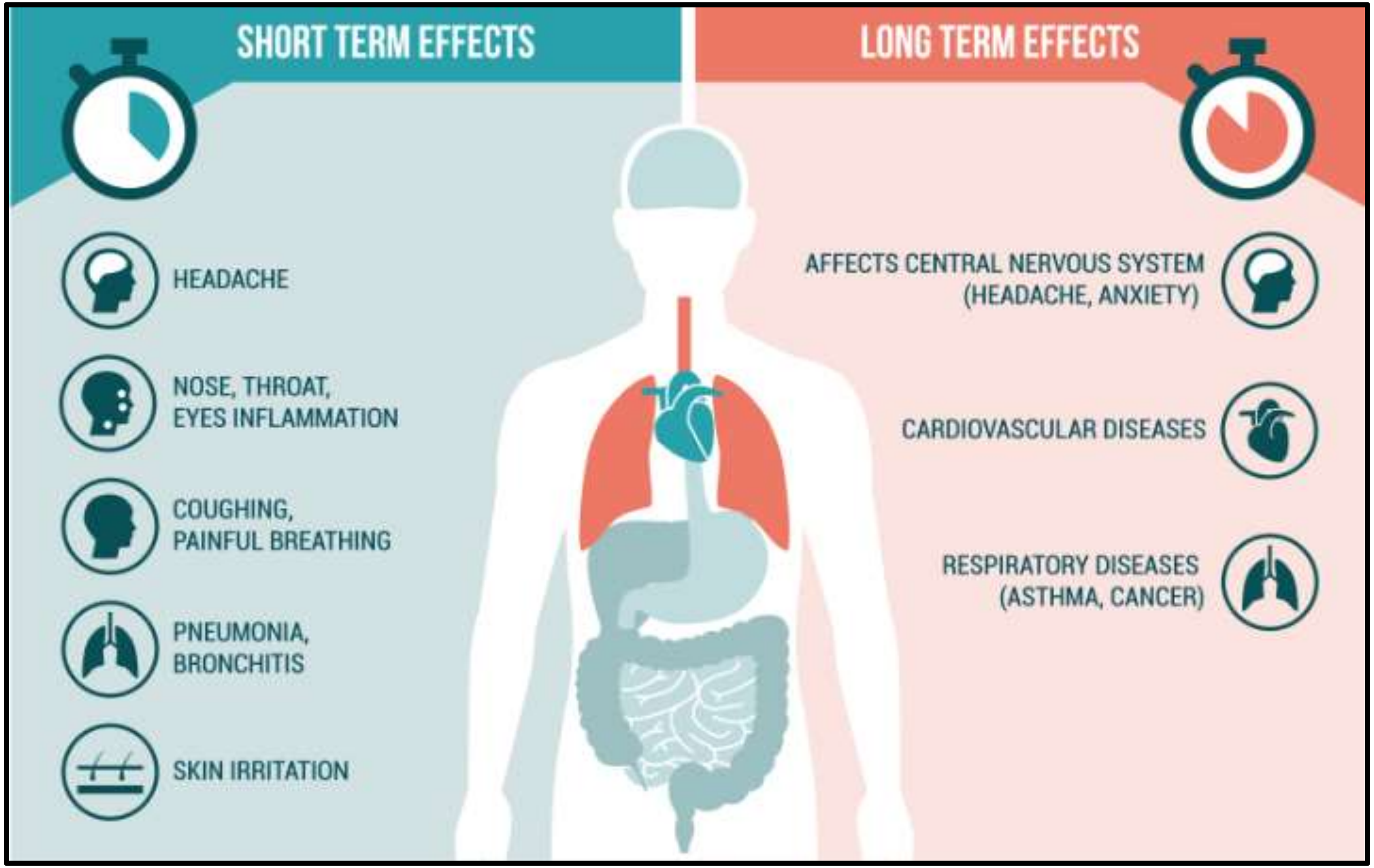
Source: https://thecityfix.com/blog/5-recognized-impacts-air-pollution-jessica-seddon-seth-contreras-beth-elliott/

Effects of Air pollution

- Adverse effect on human health
- Reduces the Yield of Crops Standing in Agricultural Field.
- Corrodes Metals and Deforms Monuments made up of marbles like Taj Mahal.
- Produces Atmospheric Haze in Atmosphere, which leads to difficulty in seeing clearly to long distances in air.
- Makes Soil Acidic and Less Fertile.
- Causes Eutrophication in Lakes and Ponds.
- Causes Global Warming and Global Climate Change.
- Forms Ozone Hole

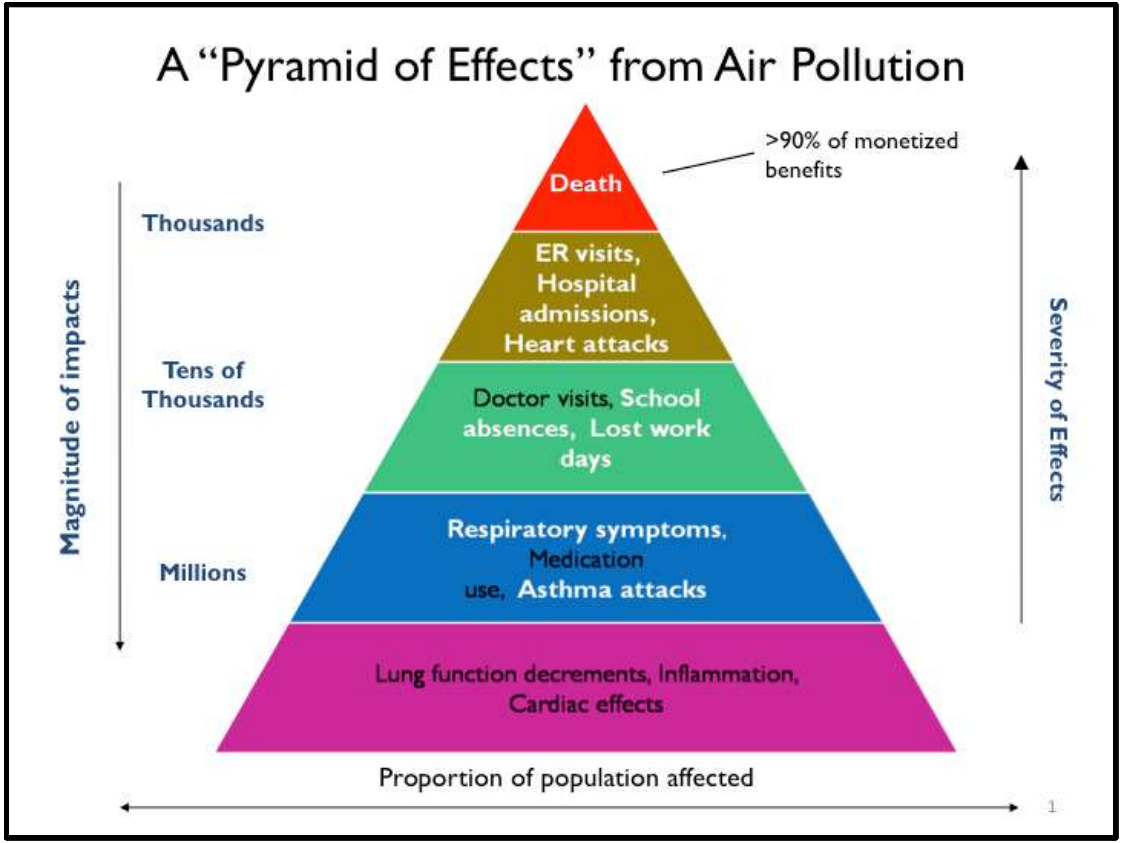
Source : https://greenanand.blogspot.com/2018/08/air-pollution-causes-sources-effects_7.html

Effects on human health



Source : https://www.lalpathlabs.com/blog/health-effects-of-air-pollution/

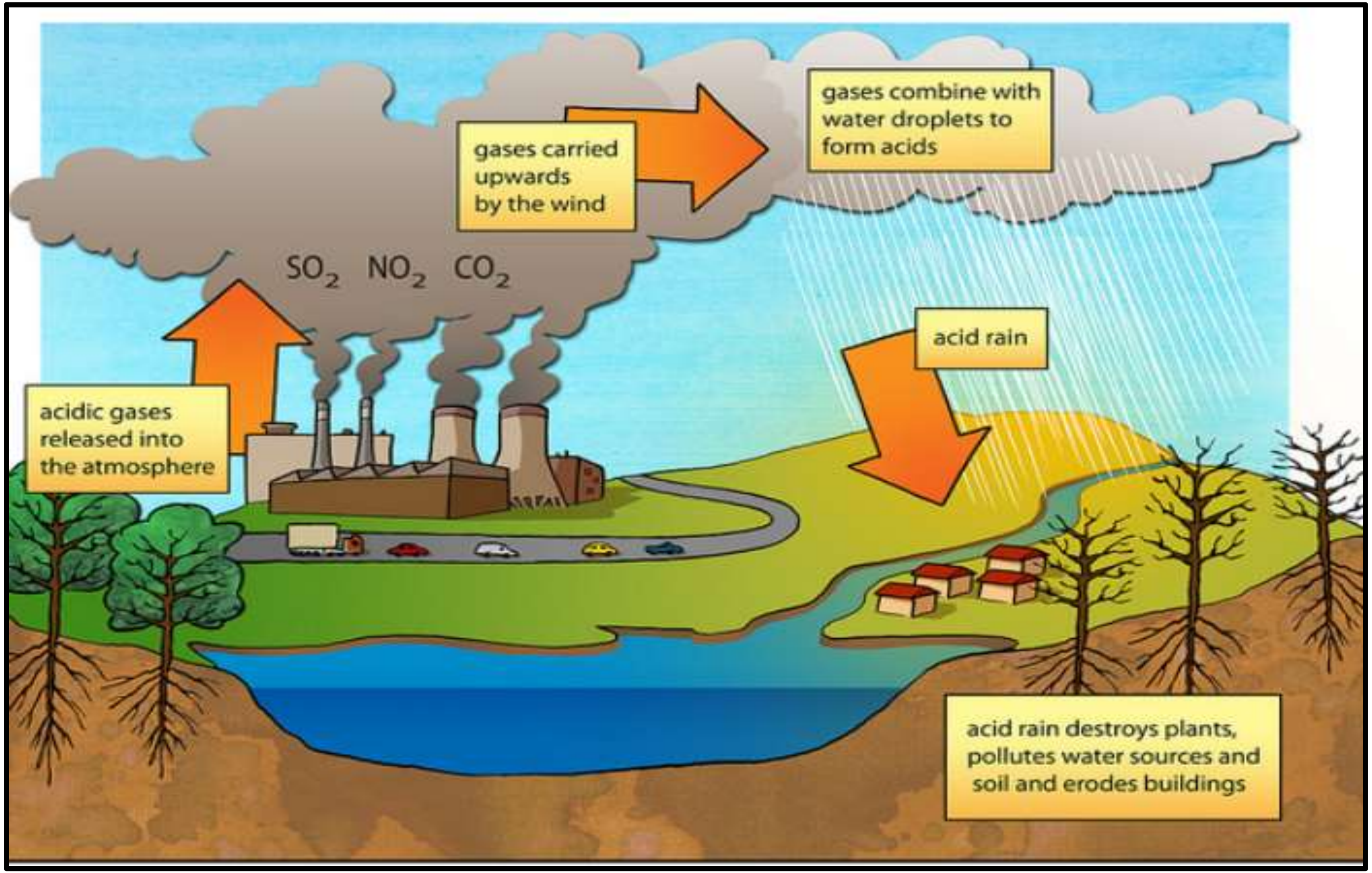
Effects on Human Health



- Air pollution leads to death of millions of people worldwide.

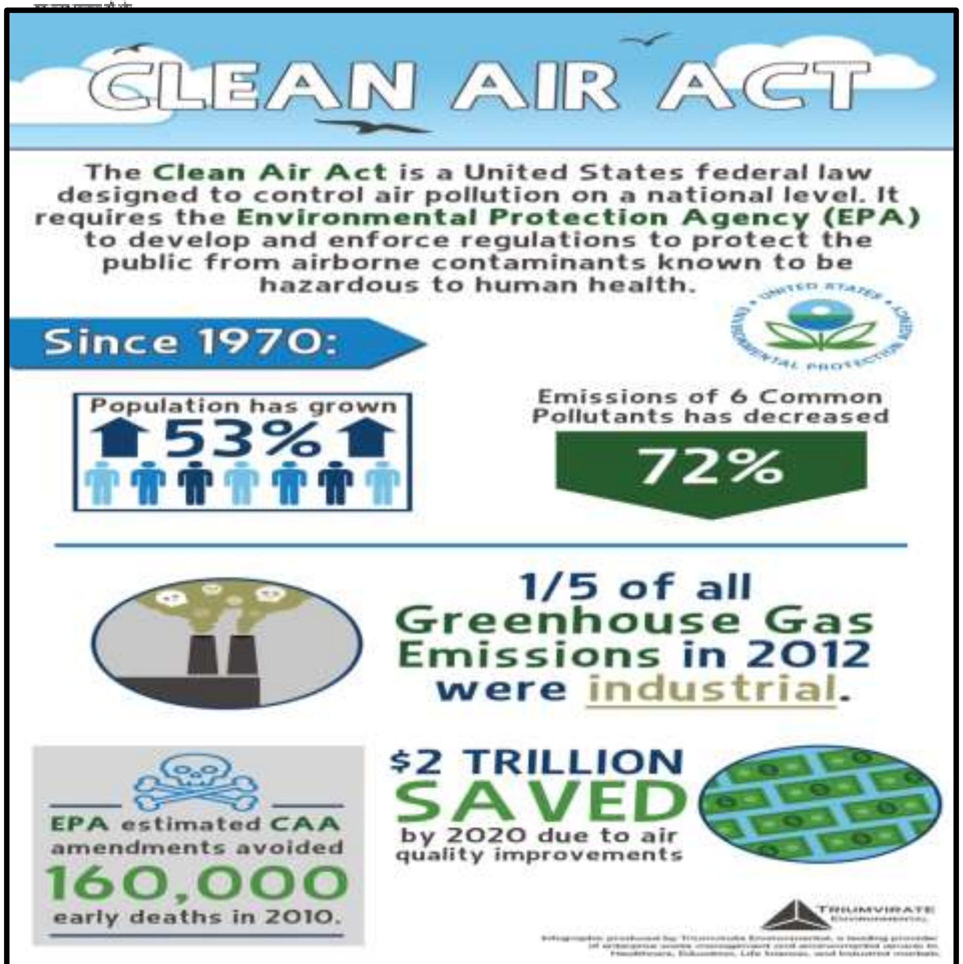
Source : https://greenanand.blogspot.com/2018/08/air-pollution-causes-sources-effects_7.html

Effects of Air pollution



Source : https://smoglhr.wordpress.com/2016/11/04/smog-and-air-pollution-causes-acid-rain/

Clean Air Act



The Clean Air Act (CAA) is the comprehensive federal law that regulates air emissions from stationary and mobile sources. Among other things, this law authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants.

Source : https://www.triumvirate.com/resources/clean-air-act-resources & https://www.epa.gov/laws-regulations/summary-clean-air-act

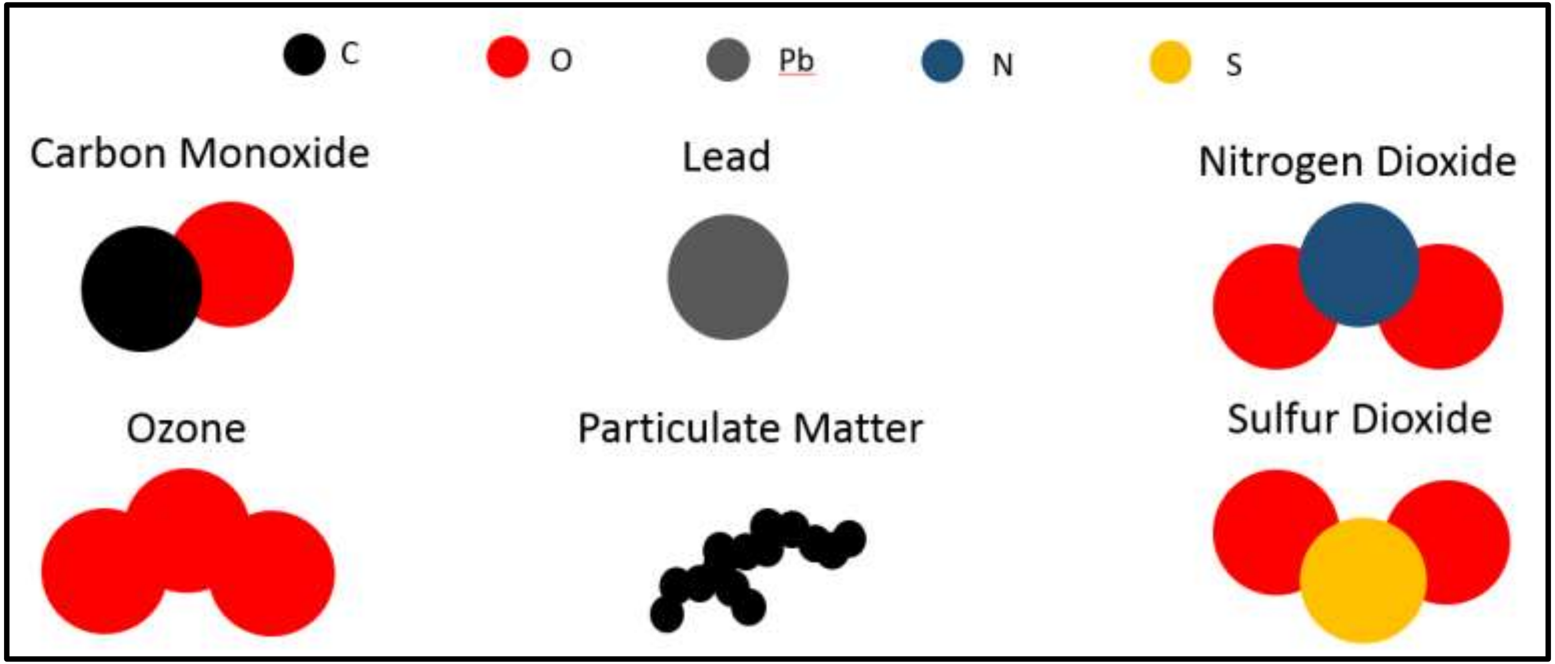
NAAQS

National Ambient Air Quality Standards (NAAQS) are limits on atmospheric concentration of six pollutants that cause smog, acid rain, and other health hazards.

- The ***six criteria air pollutants*** (CAP), or criteria pollutants, for which limits are set in the NAAQS are
  - Ozone (O_3)
  - Atmospheric particulate matter
  - Lead
  - Carbon monoxide (CO)
  - Sulfur oxides (SO_x)
  - Nitrogen oxides (NO_x)

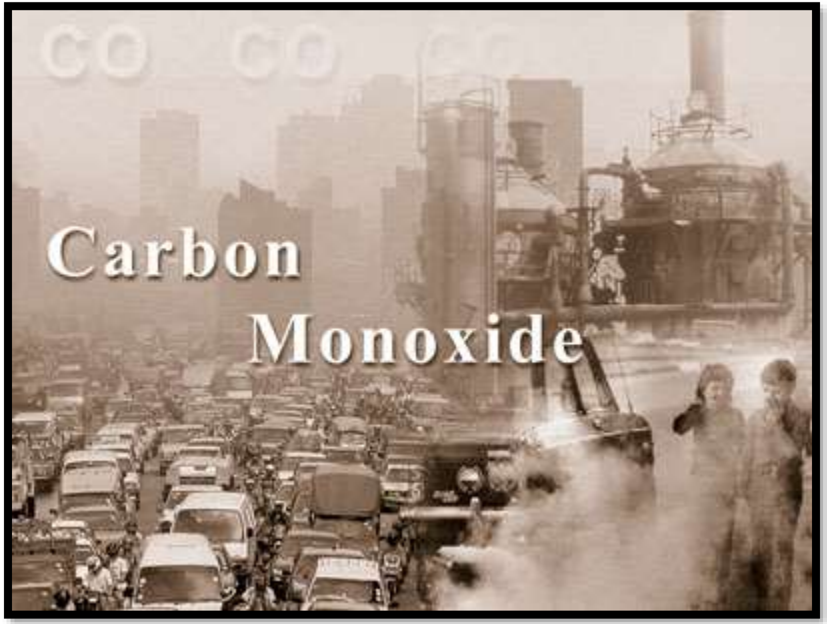
- These are typically emitted from many sources in industry, mining, transportation, electricity generation and agriculture. In many cases they are the products of the combustion of fossil fuels or industrial processes

Criteria Pollutants



Criteria pollutants are regulated pollutants and the permissible level or concentration of each pollutant are based on human health and environmental criteria.

Source : https://pollution.ucr.edu/criteria-pollutants-and-health-effects



Description: ***Colorless, odorless gas***; forms during incomplete combustion of carbon containing fuels.

Major human sources: Cigarette smoking, incomplete burning of ***fossil fuels***. About 77% (95% in cities) comes from ***motor vehicle exhaust***.

Health effects: Reacts with hemoglobin in red blood cells and ***reduced the ability of blood to bring oxygen*** to body cells and tissues. This impairs perception and thinking; slows reflexes; causes headaches, drowsiness, dizziness, and nausea; can trigger heart attacks and angina; damages the development of fetuses and young children; and aggravates chronic bronchitis, emphysema, and anemia. At high levels, it causes collapse, coma, irreversible brain cell damage, and death.

Nitrogen dioxide

Description: ***Reddish brown irritating gas***; can be converted to nitric acid, a major component of acid deposition.

Major human sources: ***Fossil fuel*** burning in motor vehicles (49%), and ***power plants*** and industries (46%).

Health effects: Lung irritation and damage; aggravates ***asthma and chronic bronchitis***; increases susceptibility to respiratory infections such as the flu and common colds (especially in young children and older adults).

Environmental effects: Reduces visibility; acid deposition of HNO_3 can damage trees, soils, and aquatic life in lakes.

Property damage: HNO_3 can corrode metals and eat away stone on buildings; statues, and monuments; NO_2 can damage fabrics.

Sulfur dioxide

Description: ***Colorless,*** irritating; forms mostly from the ***combustion of sulfur containing fossil fuels*** such as coal and oil; in the atmosphere can be converted to sulfuric acid a major component of acid deposition.

Major human sources: ***Coal burning*** in power plants (88%) and industrial processes (10%).

Health effects: ***Breathing problems*** for healthy people; restriction of airways in people with asthma; chronic exposure can cause a permanent condition similar to bronchitis.

Environmental effects: Reduces visibility; acid deposition of H_2SO_4 can damage trees, soils, and aquatic life in lakes.

Property damage: SO_2 and H_2SO_4 can ***corrode metals*** and ***eat away stone*** on buildings; statues, and monuments; SO_2 can damage paint, paper and leather.

Particulate matter

Description: Variety of ***particles and droplets (aerosols)*** small and light enough to remain suspended in the atmosphere for short periods (large particles) to long periods (small particles); cause smoke, dust and haze.

Major human sources: Burning ***coal in power and industrial plants*** (40%), ***burning diesel and other fuels*** in vehicles (17%), agriculture (plowing, burning off fields), unpaved roads, construction.

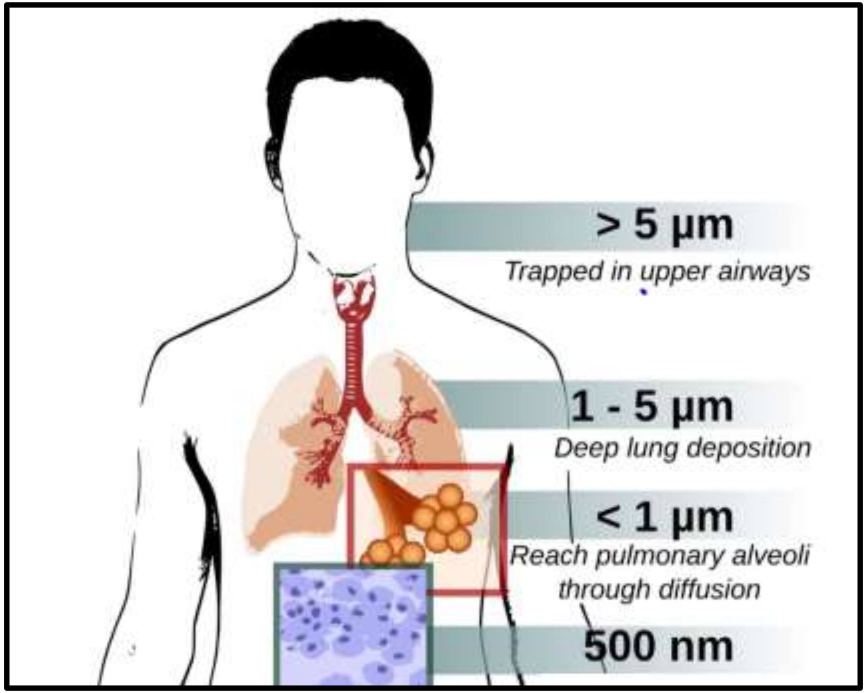
Health effects: Nose and ***throat irritation, lung damage, and bronchitis***; aggravates bronchitis and asthma; shortens life; ***toxic particulates*** (such as lead, cadmium and dioxins) can cause mutations, reproductive problems, cancer.

Environmental effects: ***Reduces visibility***; acid deposition of H_2SO_4 droplets can damage trees, soils, and aquatic life in water bodies.

Property damage: Corrodes metal; soils and ***discolors buildings, clothes, fabrics and paints.***

The degree of damage of PM depends on the size of PM, number of particles inhaled, and the general health of the person who inhaled.

Particulate matter



- Larger particles may be trapped in the nose or eliminated through coughing and sneezing.
- Fine particles can penetrate deep into the lungs, and ultrafine particles may even enter the blood stream.
- These particles can carry toxic chemicals which are linked to cancer.

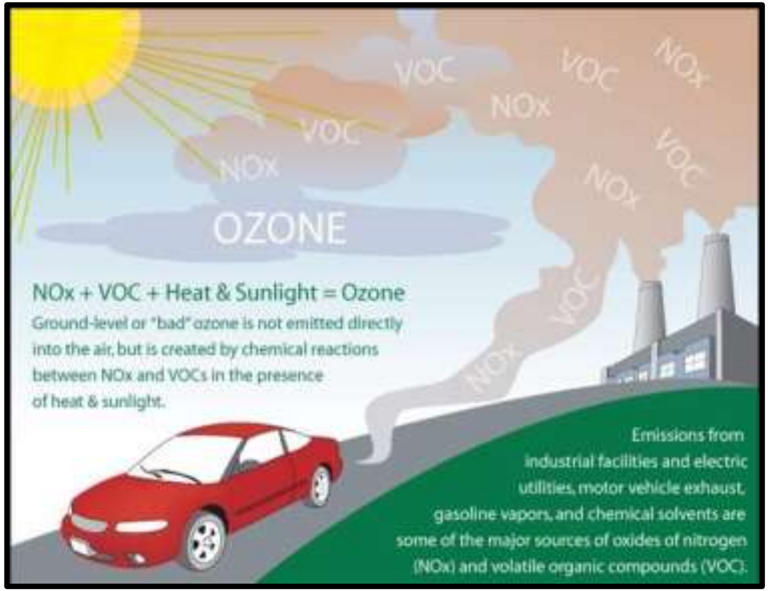
Lead

Description: Solid toxic metal and its compounds, emitted into the atmosphere to particulate matter.

Major human sources: ***Paint (old houses), smelters (metal refineries), lead manufacture, storage batteries***, leaded gasoline (being phased out in developed countries).

Health effects: Accumulates in the body; ***brain and other nervous system damage and mental retardation*** (especially in children); digestive and other health problems; some lead containing chemicals can cause cancer.

Environmental effects: Can harm wildlife.



Description: Highly reactive, irritating gas with an unpleasant odor that forms in the troposphere as a major component of photochemical smog.

Major human sources: Chemical reaction with volatile organic compounds (***VOCs,*** emitted mostly by cars and industries) and ***nitrogen oxides to form photochemical smog***.

Health effects: ***Breathing problems***; coughing; eye, nose, and throat irritation; aggravates chronic diseases such as asthma, bronchitis, emphysema, and heart disease; ***reduces resistance to colds and pneumonia***; may speed up lung tissue aging.

Environmental effects: Ozone can cause more ***damage to plants*** than any other pollutants; ***smog can reduce visibility***.

Property damage: Damages rubber, fabrics, and paints.

NAAQS

Pollutant	Time Weighted Average	Concentration of Ambient Air industrial Area	Residential Rural and Other Area	Sensitive Area	Method of Measurement
Respirable particulate matter (RPM)	Annual 24 h	120 $\mu g/m^3$ 150 $\mu g/m^3$	60 $\mu g/m^3$ 100 $\mu g/m^3$	50 $\mu g/m^3$ 75 $\mu g/m^3$	Respirable particulate matter sampler
Lead (Pb)	Annual 24 h	1.0 $\mu g/m^3$ 1.5 $\mu g/m^3$	0.75 $\mu g/m^3$ 1.0 $\mu g/m^3$	0.50 $\mu g/m^3$ 0.75 $\mu g/m^3$	AAS method after sampling using EPM 2000 or equivalent filter paper
Carbon Monoxide (CO)	8 h 1 h	5.0 $\mu g/m^3$ 10.0 $\mu g/m^3$	2.0 $\mu g/m^3$ 4.0 $\mu g/m^3$	1.0 μ g/m3 2.0 μ g/m3	Non-dispersive infrared spectroscopy

NAAQS

Pollutant	Time Weighted Average	Concentration of Ambient Air industrial Area	Residential Rural and Other Area	Sensitive Area	Method of Measurement
Sulphur dioxide (SO_2)	Annual 24 h	80 $\mu g/m^3$ 120 $\mu g/m^3$	60 $\mu g/m^3$ 80 $\mu g/m^3$	15 $\mu g/m^3$ 30 $\mu g/m^3$	Improved west and Gacke method Ultraviolet fluorescence
Oxides of nitrogen (NO_2)	Annual 24 h	80 $\mu g/m^3$ 120 $\mu g/m^3$	60 $\mu g/m^3$ 80 $\mu g/m^3$	15 $\mu g/m^3$ 30 $\mu g/m^3$	Jacab Hochheister modified(Na-Arsertine method) Gas phase chemilumine scene
Suspended particulate matter (SPM)	Annual 24 h	360 $\mu g/m^3$ 600 $\mu g/m^3$	140 $\mu g/m^3$ 200 $\mu g/m^3$	70 $\mu g/m^3$ 100 $\mu g/m^3$	High volume sampling (average floe rate not less than 1.1 m^3/minute

Air Quality Index

The ***Air Quality Index*** is a tool for 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.***

Indian AQI defines six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe.

Each of these categories is decided ***based on ambient concentration values of air pollutants*** and their likely health impacts (known as health breakpoints)

Air Quality Index

AQI Category	AQI	Concentration range*							
		PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	NH_3	Pb
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+

* CO in mg/m^3 and other pollutants in $\mu g/m^3$; 2h-hourly average values for PM_{10}, $PM_{2.5}$, NO_2, SO_2, NH_3, and Pb, and 8-hourly values for CO and O_3.

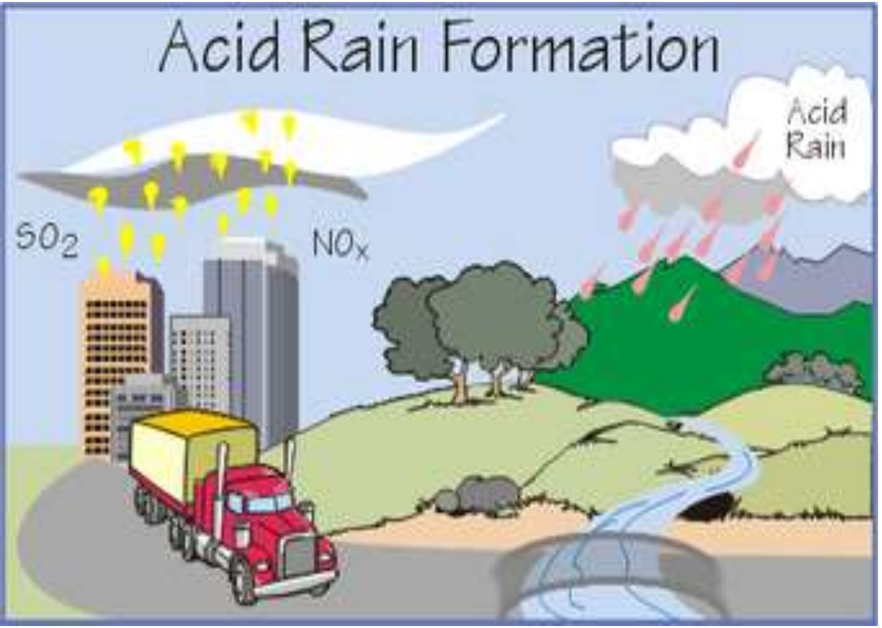
Source : https://www.airveda.com/blog/AQI-calculation-update

Air Quality Index

AQI Basics for Ozone and Particle Pollution			
Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Source : https://www.airnow.gov/aqi/aqi-basics/

Acid rain due to Air pollution



- Acid rain is produced by a ***chemical reaction*** created when ***sulfur dioxide and nitrogen oxides*** are released into the air.
- When ***mixed with water, oxygen, and other chemicals*** from rising high into the atmosphere - Acid rain is formed.
- Sulfur dioxide and nitrogen oxides can be carried far by the wind and dissolved easily in water.
- As a result of being carried the compounds become ***rain, sleet, snow, and fog***.
- The main reason these compounds are created is by humans. Electrical utility plants send out the majority of sulfur dioxide and much of the nitrogen oxides when fossil fuels (coal) are burned to produce electricity.

Source : http://humanimpacthobbs.weebly.com/acid-rain.html

Effects of Acid rain

The shiny white marble facade of the Taj Mahal, one of the seven wonders of the modern world, is turning yellow due to acid rain.

Acid rain causes extensive damage to monuments and stone sculptures of marble, limestone, slate etc. The damage caused to rocks and marble by acid rain is called as marble-leprosy or stone-leprosy.

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$$

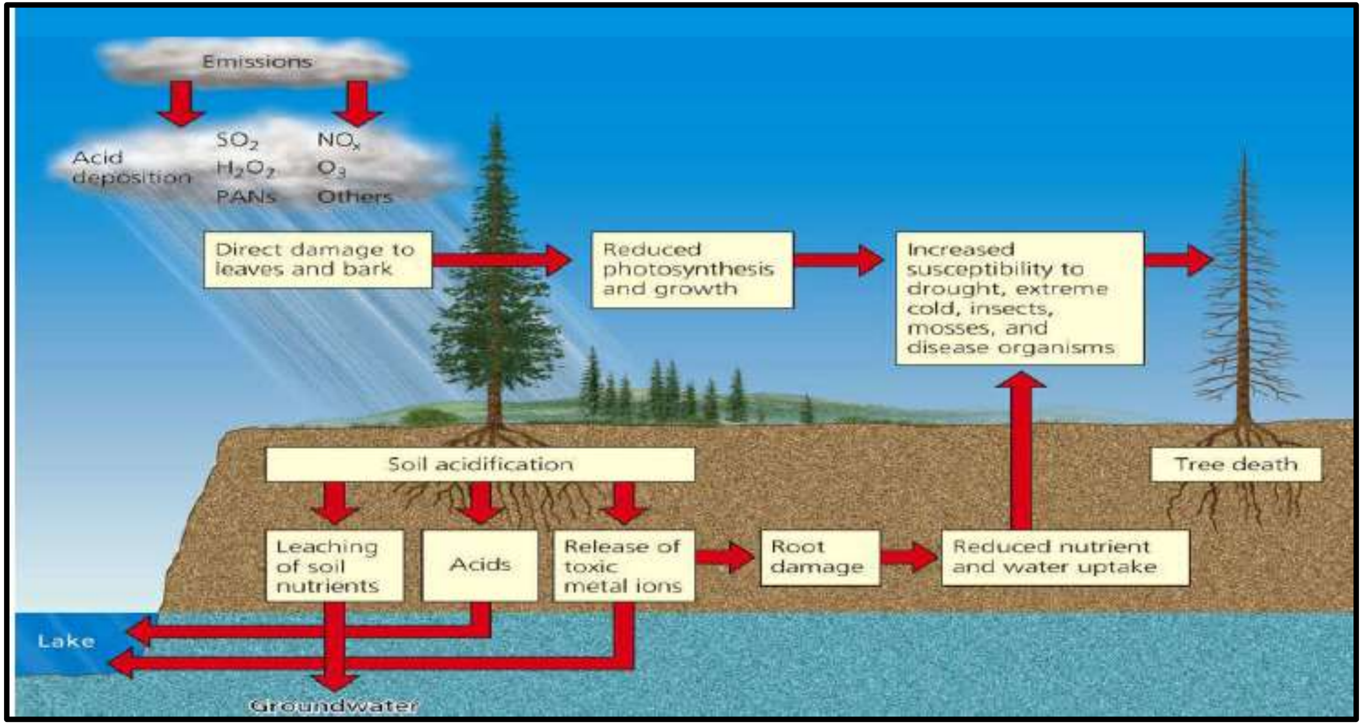
Acid rain corrodes houses, buildings, bridges, fences and railing that require huge cost for maintenance every year.

$$Cu + H_2SO_4 \rightarrow CuSO_4 + H_2$$

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

Source : https://www.skymetweather.com/content/weather-faqs/what-is-acid-rain-and-its-adverse-effects/

Effects of Acid rain



Acid rain does not kill trees directly. Instead, it ***weaken trees by damaging their leaves***, limiting the nutrients available to them, or exposing them to toxic substances slowly released from the soil. Quite often, injury or death of trees is a result of these effects of acid rain in combination with one or more additional threats.

Preventing acid deposition

Solutions

Acid Deposition

Prevention

Reduce coal use

Burn low-sulfur coal

Increase natural gas use

Increase use of renewable energy resources

Remove SO_2 particulates and NO_X from smokestack gases

Remove NO_X from motor vehicular exhaust

Tax emissions of SO_2

Reduce air pollution by improving energy efficiency

Cleanup

Add lime to neutralize acidified lakes

Add phosphate fertilizer to neutralize acidified lakes

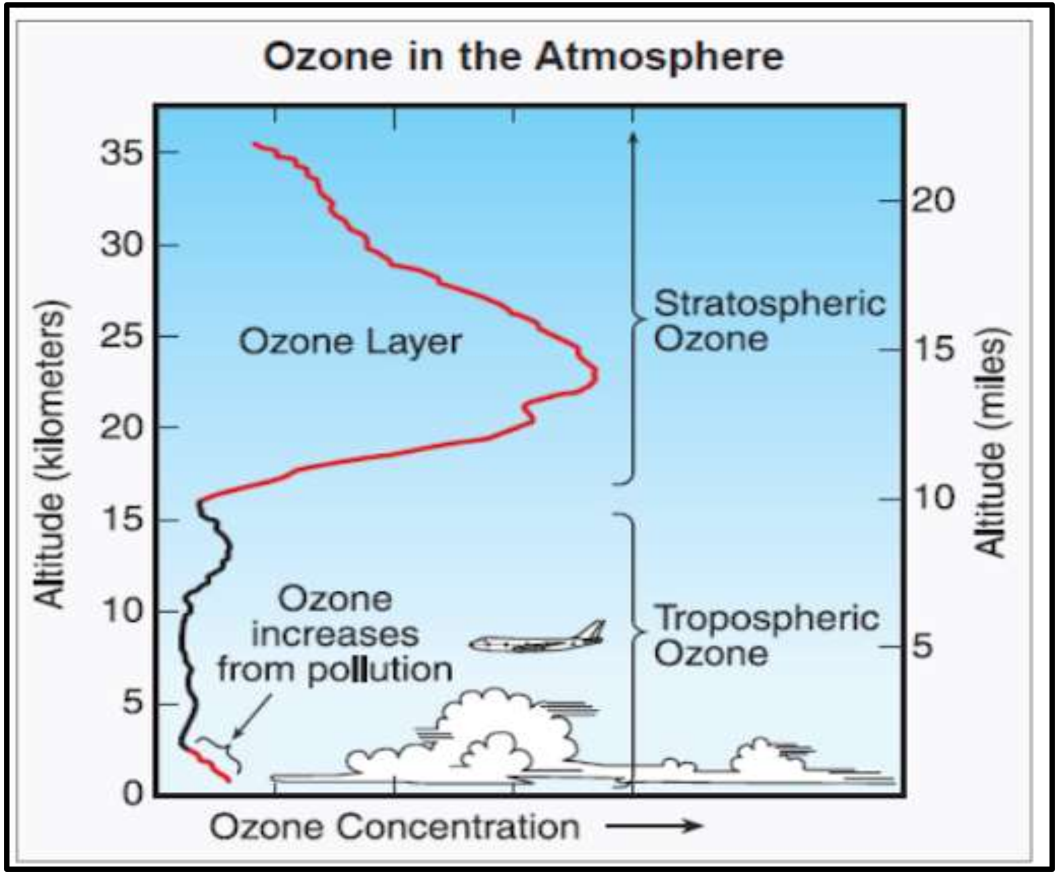
Ground level Ozone

- Tropospheric, or ***ground level ozone,*** is not emitted directly into the air, but is created by ***chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC).*** This happens when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources chemically react in the presence of sunlight.

- Ozone is most likely to reach ***unhealthy levels on hot sunny days*** in urban environments, but can still reach high levels during colder months. Ozone can also be transported long distances by wind, so even rural areas can experience high ozone levels.

Source : https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics

Ozone in atmosphere



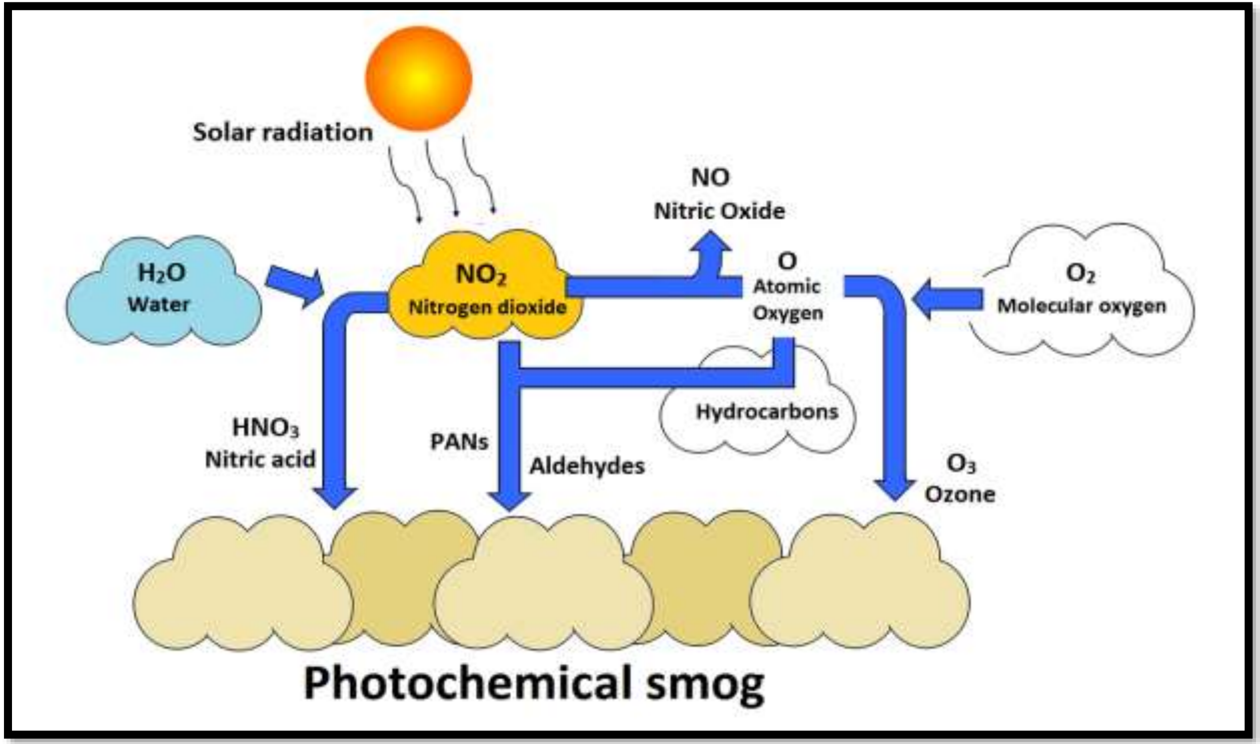
Source : http://www.atmo.arizona.edu/students/courselinks/fall16/atmo336s2/lectures/sec3/ozone.html

Effects on Plants

Ground level ozone causes more damage to plants than all other air pollutants combined.

- ***Ozone enters leaves through stomata*** during normal gas exchange. As a strong oxidant, ozone causes several types of ***symptoms including chlorosis and necrosis***.
- High concentrations of ozone cause plants to close their stomata, ***slowing down photosynthesis***.
- Prolonged ozone exposure ***reduces health and productivity of crops***.
- High ozone concentrations can also ***affect soil fertility.*** Plants that are exposed to high ozone concentrations metabolize less carbon dioxide, so less carbon is available in the soil, and ***fewer soil microbes grow and thrive.***

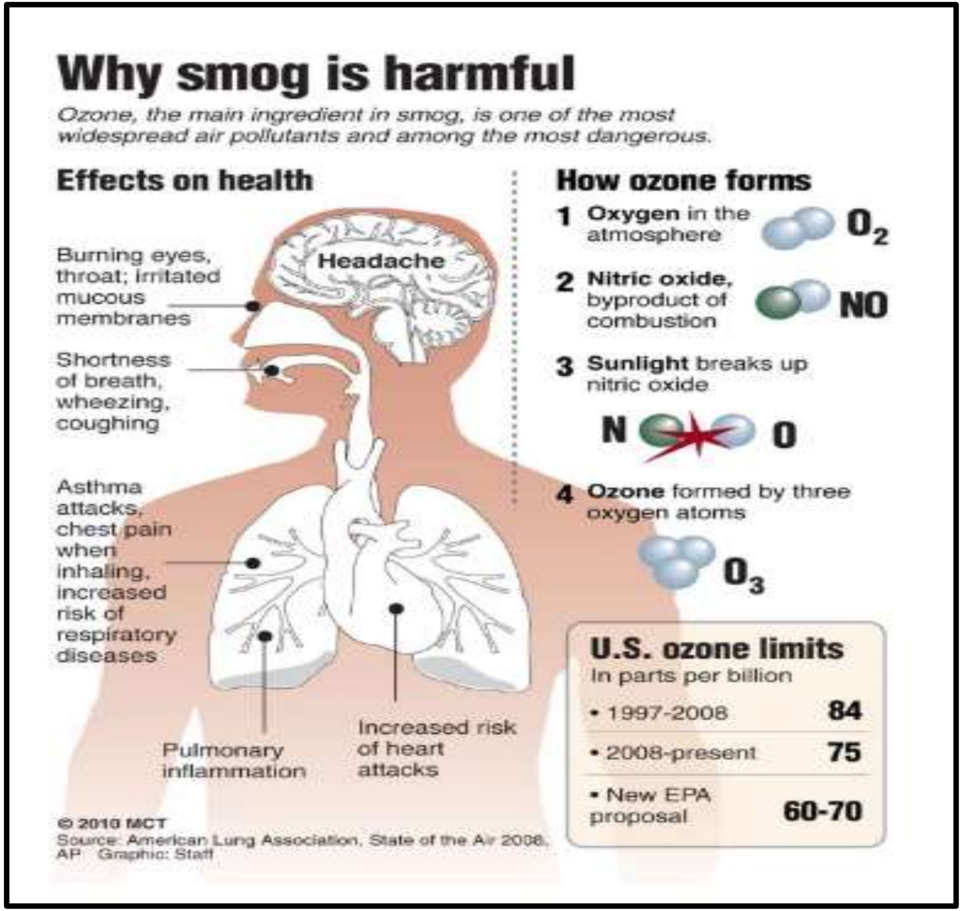
Photochemical smog



Photochemical smog is a type of smog produced when ***ultraviolet light from the sun reacts with nitrogen oxides in the atmosphere***. It is visible as a brown haze, and is most prominent during the ***morning and afternoon***, especially in densely populated, warm cities

Source : https://energyeducation.ca/encyclopedia/Photochemical_smog

Effects on human



Source : https://howweseetheenvironment.wordpress.com/2015/02/28/its-hard-not-to-care-when-there-is-so-much-smog-in-the-air/

CLRTAP

The Convention on Long-Range Transboundary Air Pollution, often abbreviated as Air Convention or CLRTAP, is ***intended to protect the human environment against air pollution and to gradually reduce and prevent air pollution, including long-range transboundary air pollution.***
It is implemented by the European Monitoring and Evaluation Programme (EMEP), directed by the United Nations Economic Commission for Europe (UNECE). The convention opened for signature on November 13, 1979 entered into force on March 16, 1983.

Source : https://en.wikipedia.org/wiki/Convention_on_Long-Range_Transboundary_Air_Pollution

- Under the ***Geneva Convention on Long-Range Transboundary Air Pollution***, the parties (i.e. the countries which ratified it) commit themselves to working together to limit, ***to gradually prevent and to reduce their discharges of air pollutants*** in order to combat the resulting transboundary pollution.

- The Council decision concludes the convention on behalf of the EU. All Member States are parties to the convention as well.

Source : http://publications.europa.eu/resource/cellar/5ab9bbd2-018b-43c1-99d3-3ac8f3b1c00b.0004.03/DOC_1

Protocols under the convection

8 separate protocols have been developed under this convention.

1. *The 1984 protocol* on long-term financing of the cooperative programme for monitoring and evaluation of the long-range transmission of air pollution in Europe (EMEP Protocol): an instrument for the international cost-sharing of a monitoring programme which forms the backbone for the review and assessment of European air pollution in the light of agreements on emission reduction.

2. *The 1985 protocol on the reduction of sulphur emissions* or their transboundary fluxes (Helsinki Protocol) by at least 30% compared with 1980 levels.

3. *The 1988 protocol concerning the control of emissions of nitrogen oxides (NOx)* or their transboundary fluxes (Sofia Protocol): a first step requires the freezing of emissions of NOx or their transboundary fluxes at 1987 levels; a second step requires the application of an effects-based approach to further reduce emissions of nitrogen compounds, including ammonia (NH3), and of volatile organic compounds (VOCs), in view of their contribution to photochemical pollution, acidification and eutrophication and of their effects on human health, the environment and materials, by addressing all significant emission sources.

4. *The 1991 protocol on the control of emissions of VOCs* or their transboundary fluxes: these compounds are responsible for the formation of ground-level ozone and parties have to opt for 1 of 3 emission-reduction targets, to be reached by 1999:

- 30% reduction in VOCs, using a year between 1984 and 1990 as a basis;
- 30% reduction in emissions of VOCs within the tropospheric ozone management area specified in Annex I to the protocol and ensuring that total national emissions do not exceed 1988 levels; or
- where emissions in 1988 did not exceed certain specified levels, parties may opt for a stabilization at that level of emission.

Protocols

5. *The 1994 protocol on further reduction of sulphur emissions (Oslo Protocol)*: this protocol builds on the 1985 Helsinki Protocol and sets emission ceilings until 2010 and beyond. Parties are required to take the most effective measures for the reduction of sulphur emissions, including:

- increasing energy efficiency;
- using renewable energy;
- reducing the sulphur content of fuels; and
- applying best available control technologies (BATs). The protocol also encourages the application of economic instruments for the adoption of cost-effective approaches to the reduction of sulphur emissions.

Protocols

6. *The 1998 protocol on heavy metals (Aarhus Protocol):* it targets 3 metals cadmium, lead and mercury.

7. *The 1998 protocol on persistent organic pollutants*, whose ultimate objective is to eliminate any discharges, emissions and losses of such pollutants.

8. *The 1999 protocol to abate acidification, eutrophication and ground-level ozone (Gothenburg Protocol):* it sets national emission ceilings for 2010 up to 2020 for 4 pollutants: sulphur dioxide (SO2), NOx, VOCs and NH3.

Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer is the landmark multilateral environmental agreement that ***regulates the production and consumption of nearly 100 man-made chemicals referred to as ozone depleting substances (ODS).*** When released to the atmosphere, those chemicals ***damage the stratospheric ozone layer***, Earth's protective shield that protects humans and the environment from harmful levels of ultraviolet radiation from the sun. Adopted on 15 September 1987, the Protocol is to date the only UN treaty ever that has been ***ratified every country on Earth - all 198 UN Member States***.

Source : https://www.unenvironment.org/ozonaction/who-we-are/about-montreal-protocol

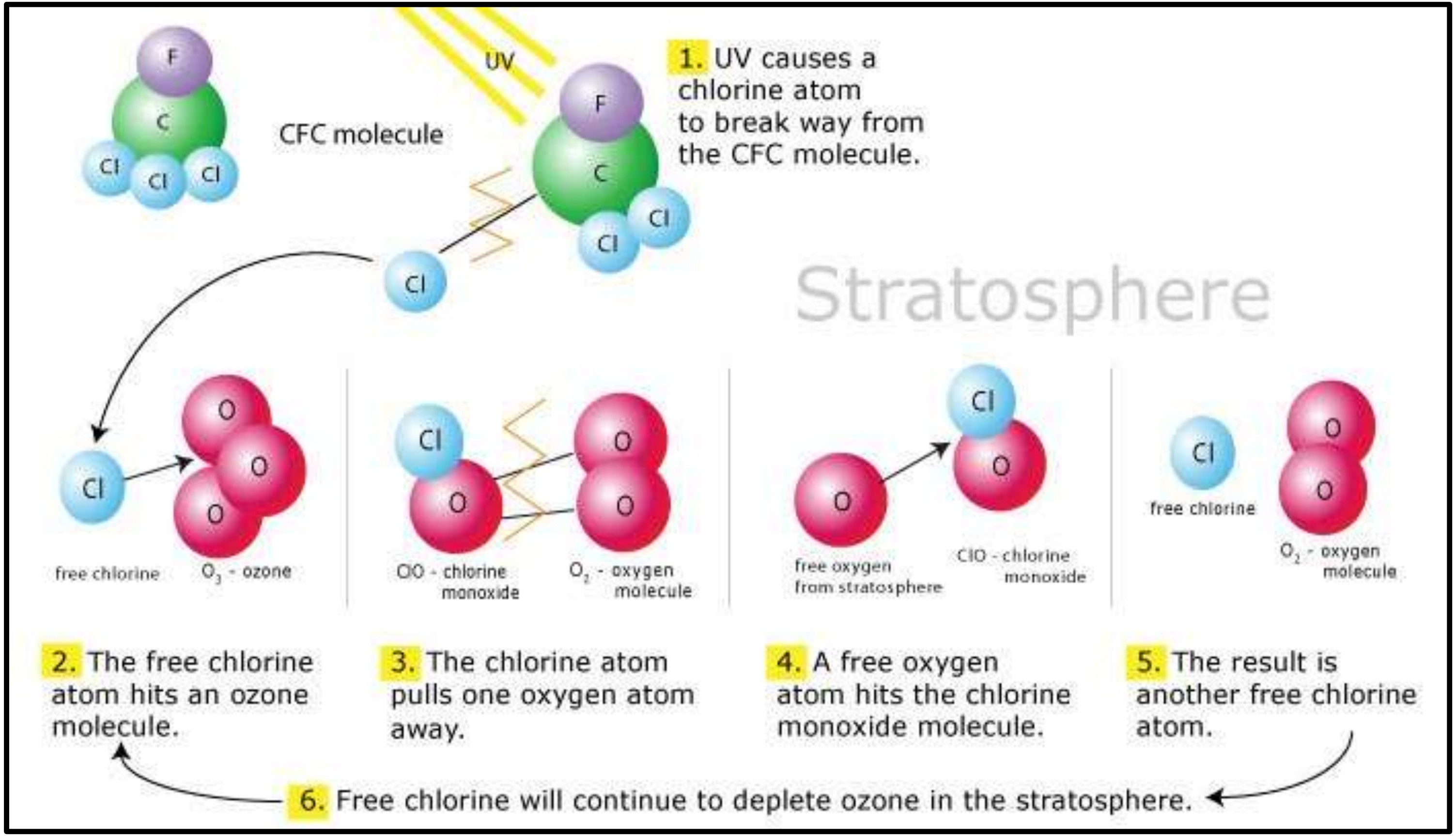
Ozone depletion

- **Ozone depletion**, gradual thinning of Earth's ozone layer in the upper atmosphere ***caused by the release of chemical compounds containing gaseous chlorine or bromine from industry and other human activities***. The thinning is most pronounced in the polar regions, especially over Antarctica.

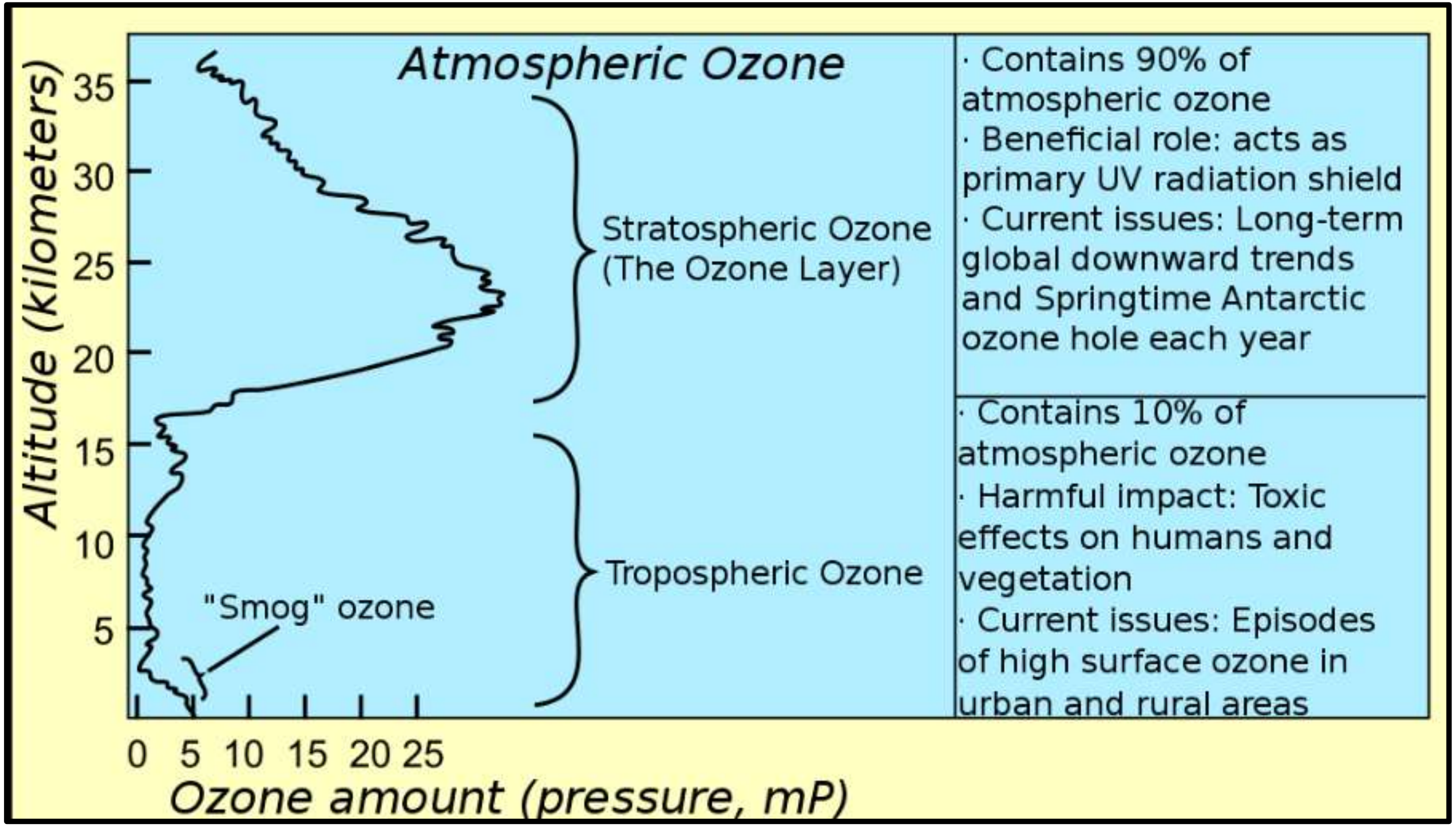
- Ozone depletion is a major environmental problem because ***it increases the amount of ultraviolet (UV) radiation*** that reaches Earth's surface, ***which increases the rate of skin cancer, eye cataracts, and genetic and immune system damage***.

Ozone depletion

- The *Montreal Protocol, ratified in 1987*, was the first of several comprehensive international agreements enacted to ***halt the production and use of ozone-depleting chemicals.*** As a result of continued international cooperation on this issue, the ozone layer is expected to recover over time.



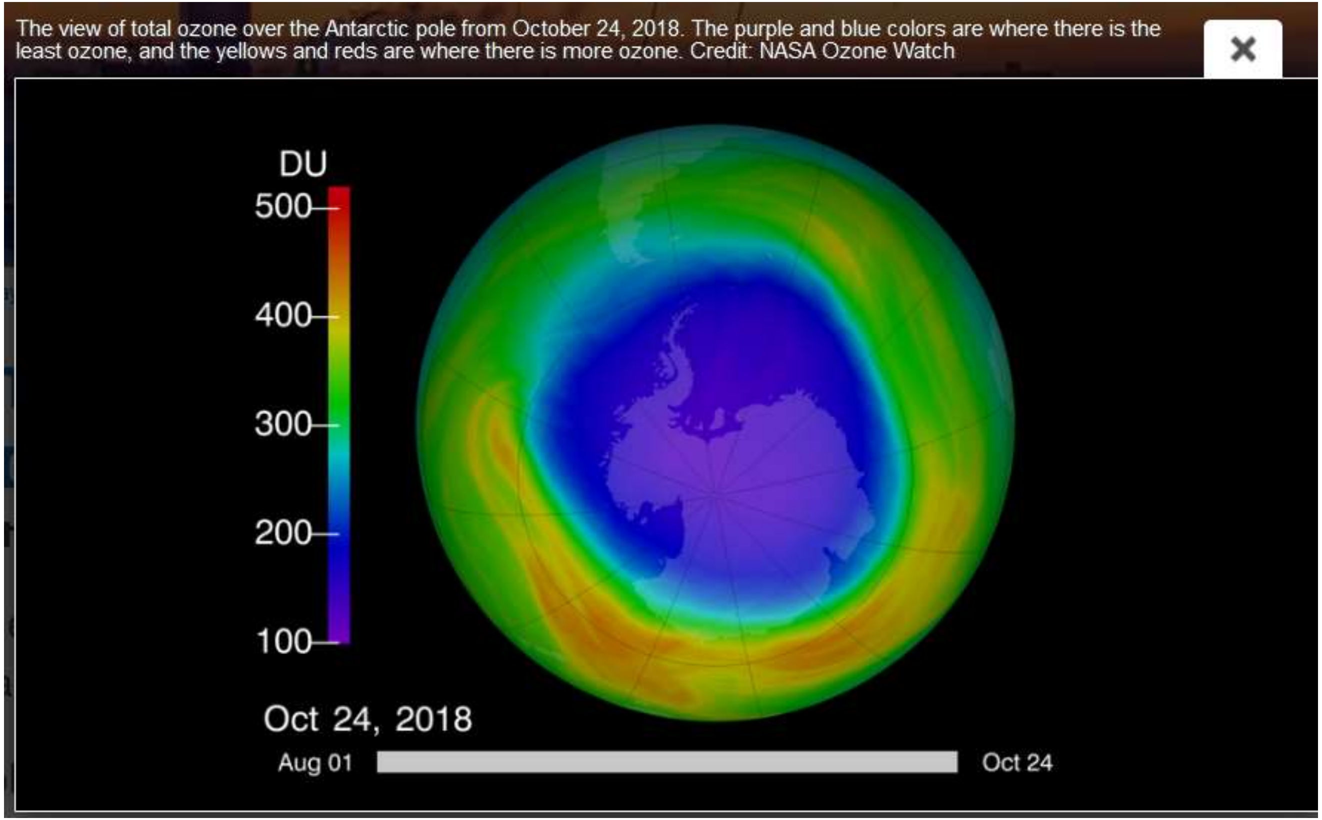
Source : https://theozonehole.com/ozonedestruction.htm



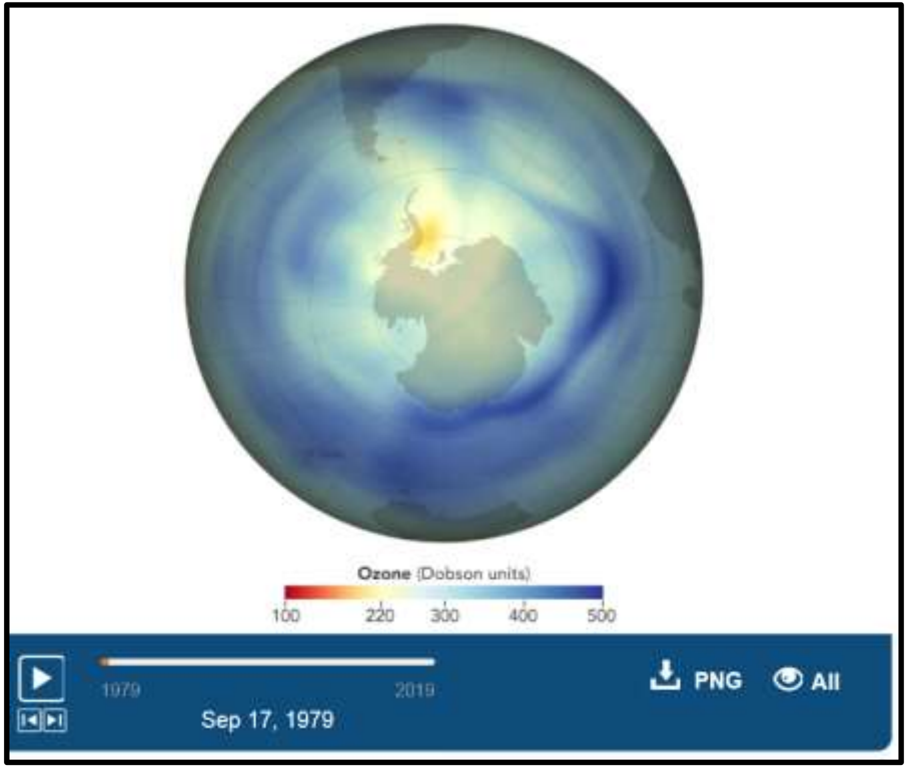
Source : https://en.wikipedia.org/wiki/Ozone_depletion#/media/File:Atmospheric_ozone.svg

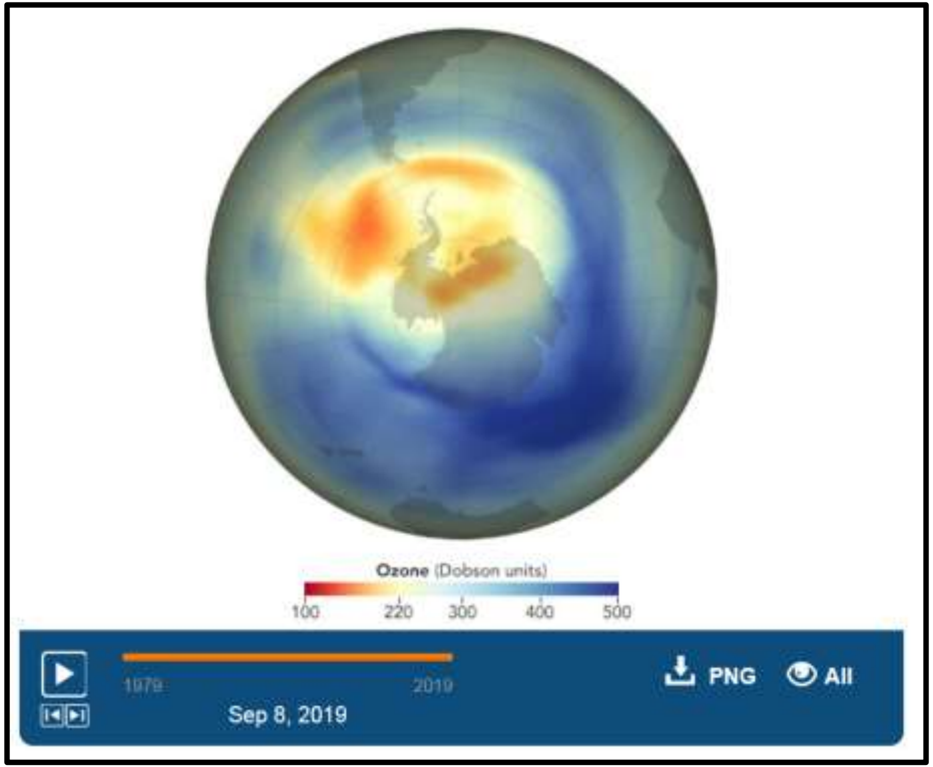
Appearance of Ozone hole over Antarctica

- In the Southern Hemisphere, the South Pole is part of a very large land mass (Antarctica) that is completely surrounded by ocean.
- This meteorological conditions allow the formation in winter of a very cold region in the stratosphere over the Antarctic continent, isolated by a band of strong winds circulating around the edge of that region.
- The very ***low stratospheric temperatures lead to the formation of clouds*** (polar stratospheric clouds) ***that are responsible for chemical changes that promote production of chemically active chlorine and bromine***.
- This chlorine and bromine activation then leads to rapid ozone loss when sunlight returns to Antarctica in ***September and October*** of each year, which then ***results in the Antarctic ozone hole.***



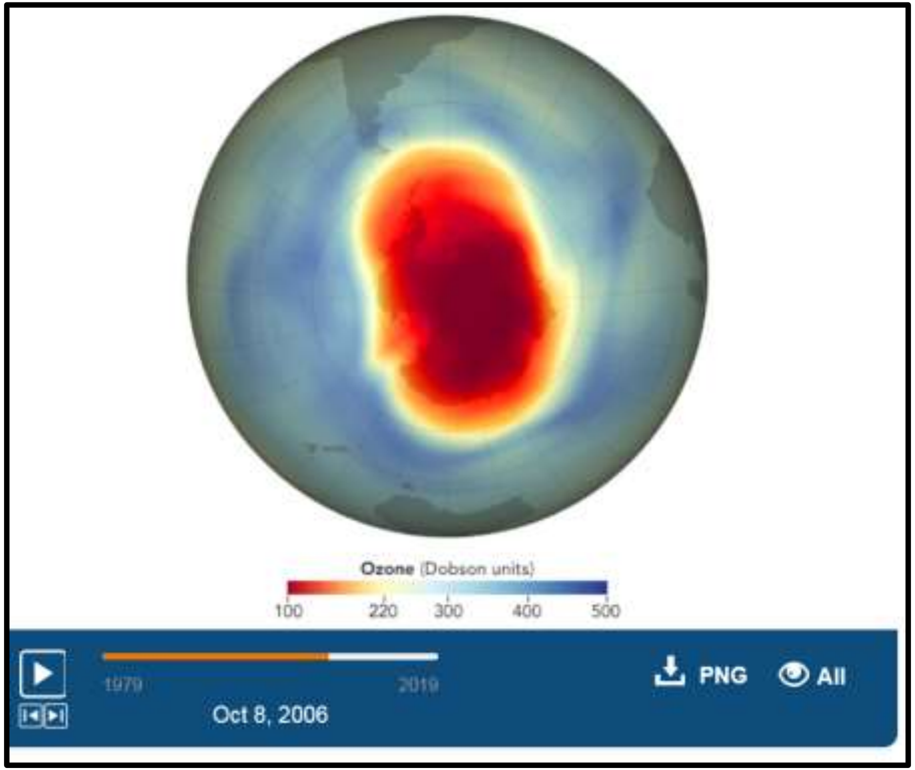
Source : https://research.noaa.gov/article/ArtMID/587/ArticleID/2395/Ozone-hole-modest-despite-optimum-conditions-for-ozone-depletion





Prior to 1979, scientists had not observed atmospheric ozone concentrations below 220 Dobson Units

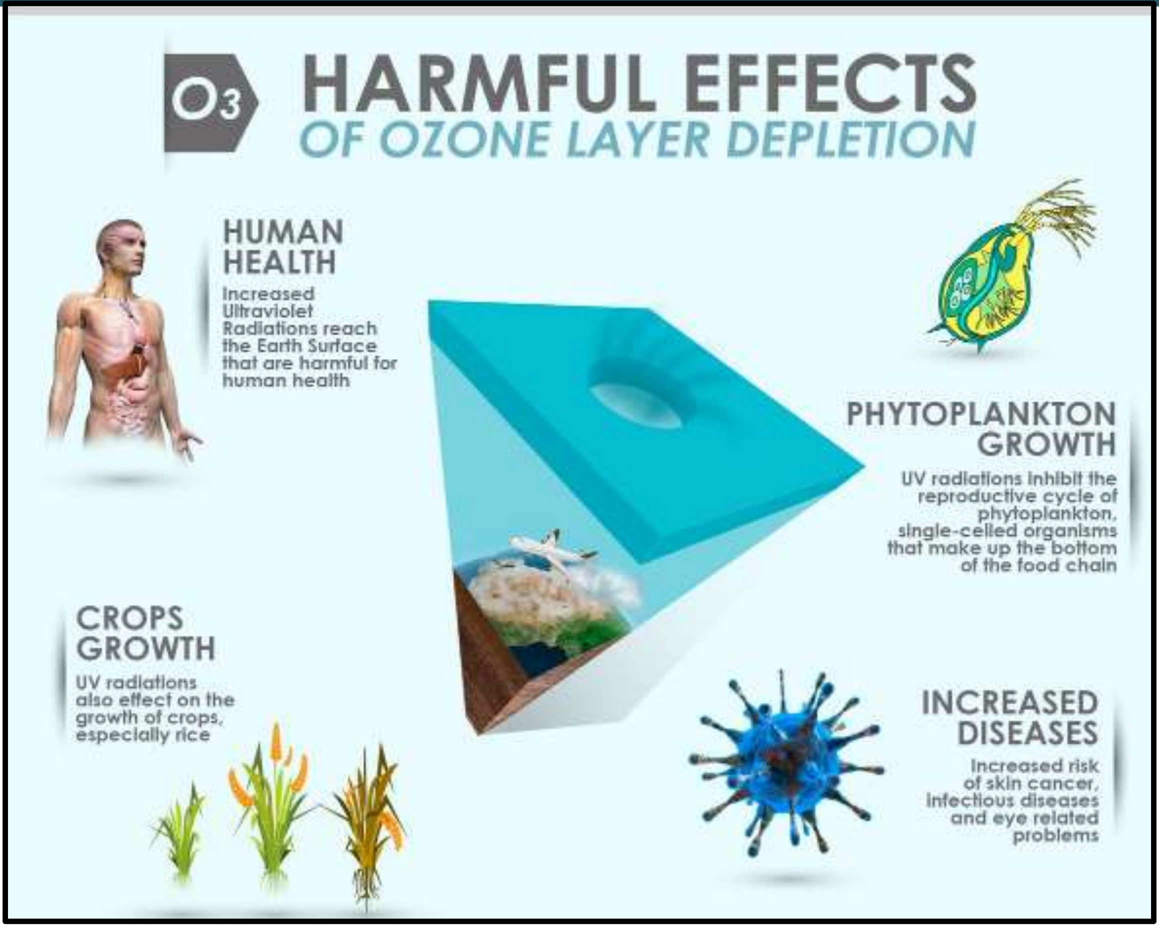
Source : https://earthobservatory.nasa.gov/world-of-change/Ozone



Satellites observed the largest ozone hole over Antarctica in September, 2006. The center of this image shows a large area where the concentration of ozone decreased by 50% or more.

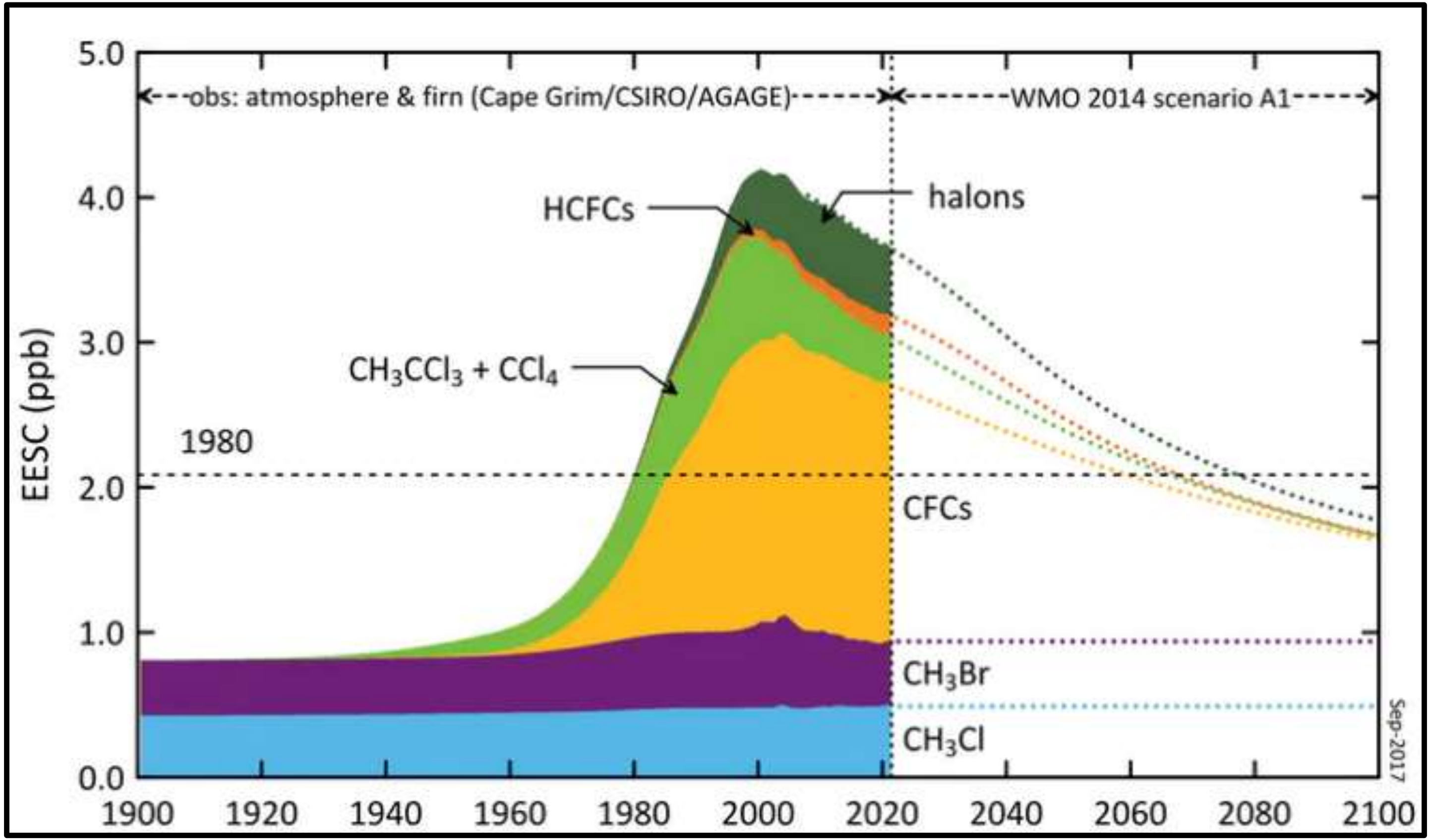
Source : https://earthobservatory.nasa.gov/world-of-change/Ozone

Effects of ozone layer depletion



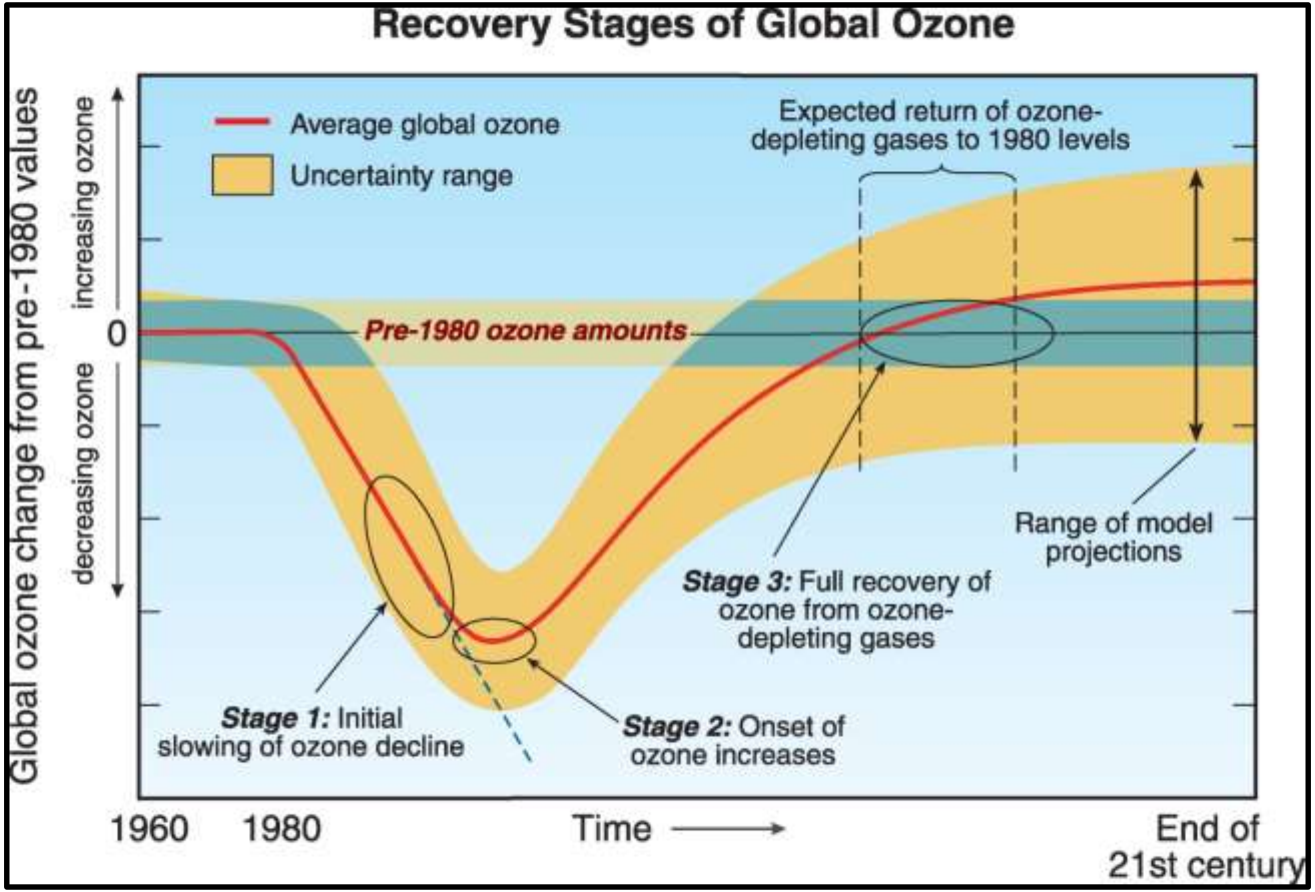
Sources : https://tambonthongchai.com/2020/09/30/ozone-depletion-part-2/

Reversing ozone depletion



Source : https://theconversation.com/after-30-years-of-the-montreal-protocol-the-ozone-layer-is-gradually-healing-84051

Recovery



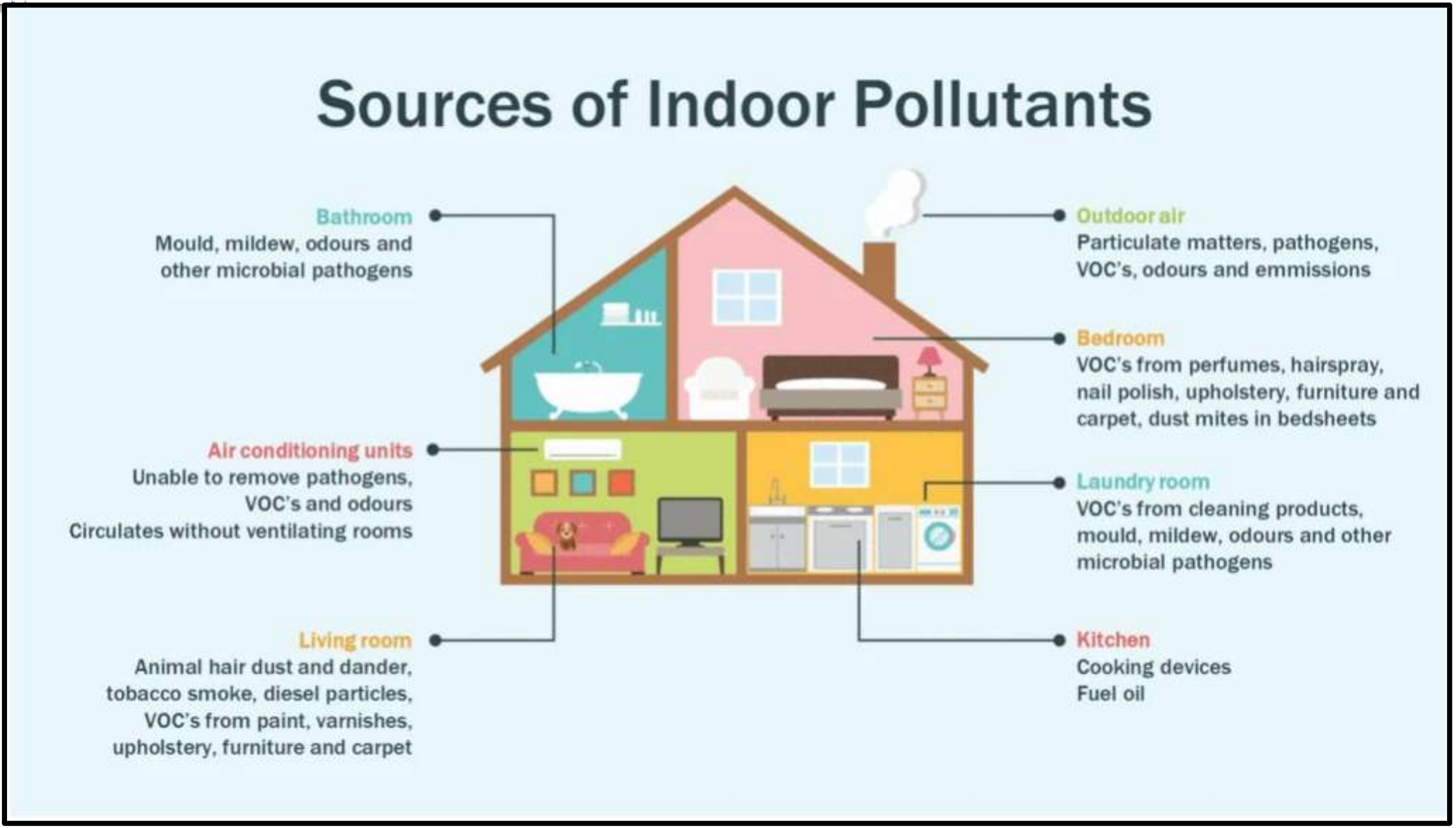
Source : https://csl.noaa.gov/assessments/ozone/2006/twentyquestions.html

Indoor Air Quality

- Indoor Air Quality (IAQ) refers to the ***air quality within and around buildings and structures,*** especially as it relates to the health and comfort of building occupants.
- Understanding and controlling common pollutants indoors can help reduce your ***risk of indoor health concerns.***

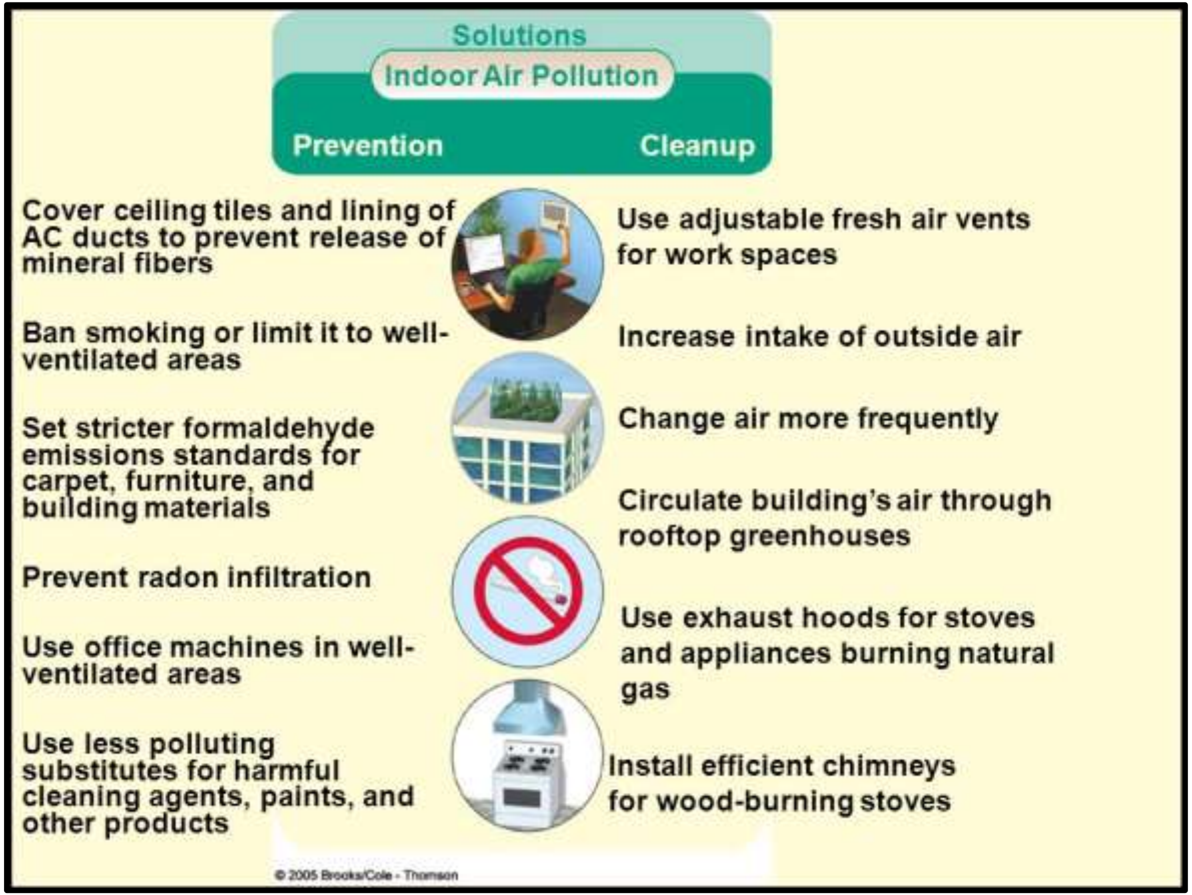
Indoor Air Quality

https://indoorbreathing.com/what-are-the-most-common-indoor-air-quality-complaints/



Source : https://www.andatechdistribution.com.au/blogs/news/indoor-air-quality-infographic

Solutions for Indoor Air Pollution



Source : http://noair-rors.weebly.com/indoor-air-pollution.html

THANK YOU