

Air Pollution-A Crisis Without Borders



“You can’t solve air pollution or transboundary pollution on a country-by-country basis. It requires global cooperation to deal with the problem at the source. The good news is that international efforts underway to combat climate change will greatly reduce air pollution and improve the health of children everywhere.”

— Janez Potocnik, Former Environment Commissioner, European Union

“When it comes to pollution, we are all connected. There is an invisible toxic thread that links workers being poisoned in low- and middle-income countries producing products and consumers exposed to poisons while consuming these products.”

Richard Fuller, President, Pure Earth

Context:

- A dense layer of smog enveloped Delhi, Noida, Ghaziabad, and other parts of the **National Capital Region (NCR)** on Wednesday (November 13) morning, causing a **significant drop in visibility**.
- According to **Swiss group IQAir's live ratings**, the **AQI in Delhi was 1133 (hazardous)**, with **PM2.5 as the main pollutant**.

1. What is Air Pollution?



- As per the definition by **WHO**, **Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent** that modifies the natural characteristics of the atmosphere.
- **Household combustion devices, motor vehicles, industrial facilities** and forest fires are common **sources of air pollution**.

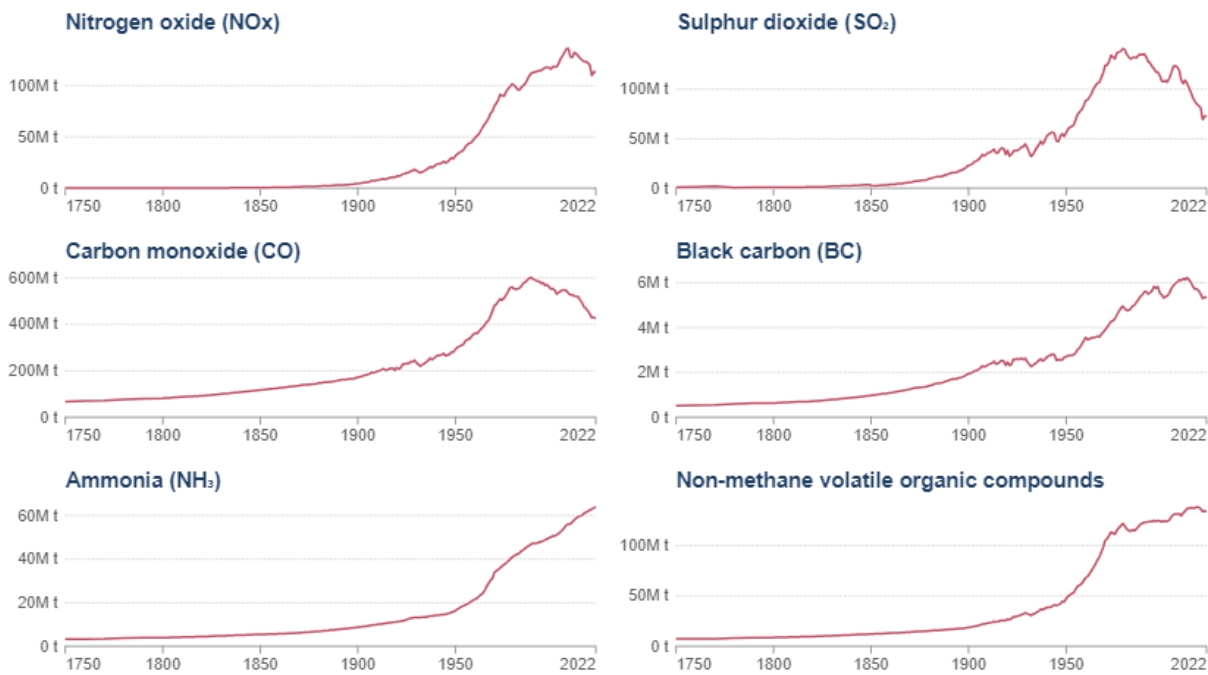
- **WHO data shows that almost all of the global population (99%) breathe air that exceeds WHO guideline limits and contains high levels of pollutants, with low- and middle-income countries suffering from the highest exposures.**
- **Air quality is closely linked to the earth’s climate and ecosystems globally.**

2. What is the status of air pollution globally?

Emissions of air pollutants, World, 1750 to 2022



Air pollutants are gases that can lead to negative impacts on human health and ecosystems. Most are produced from energy, industry, and agriculture.

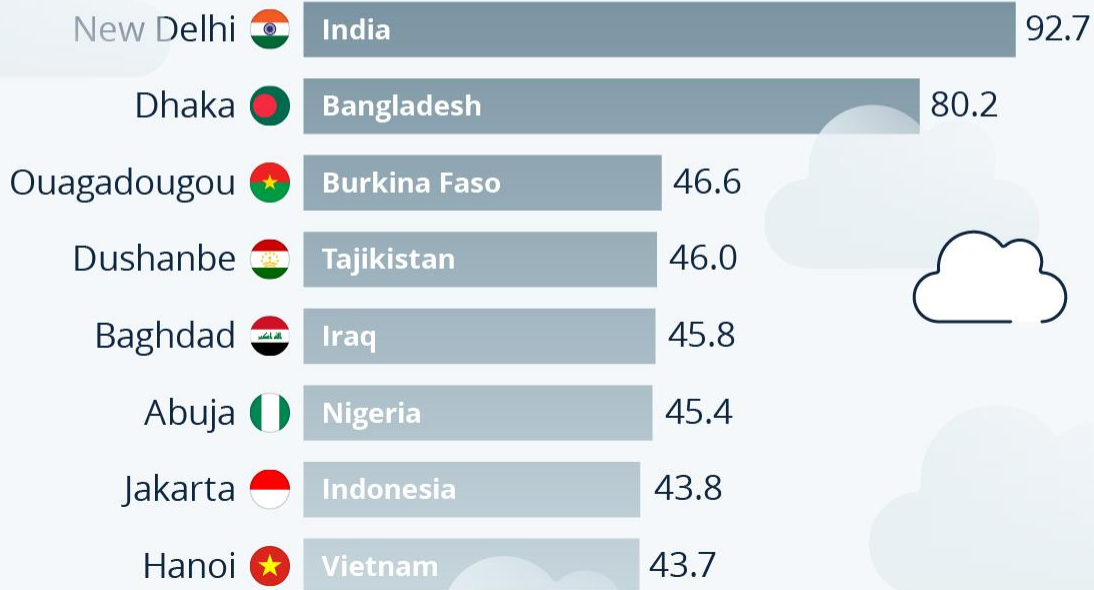


Data source: Community Emissions Data System (CEDs) 2024.

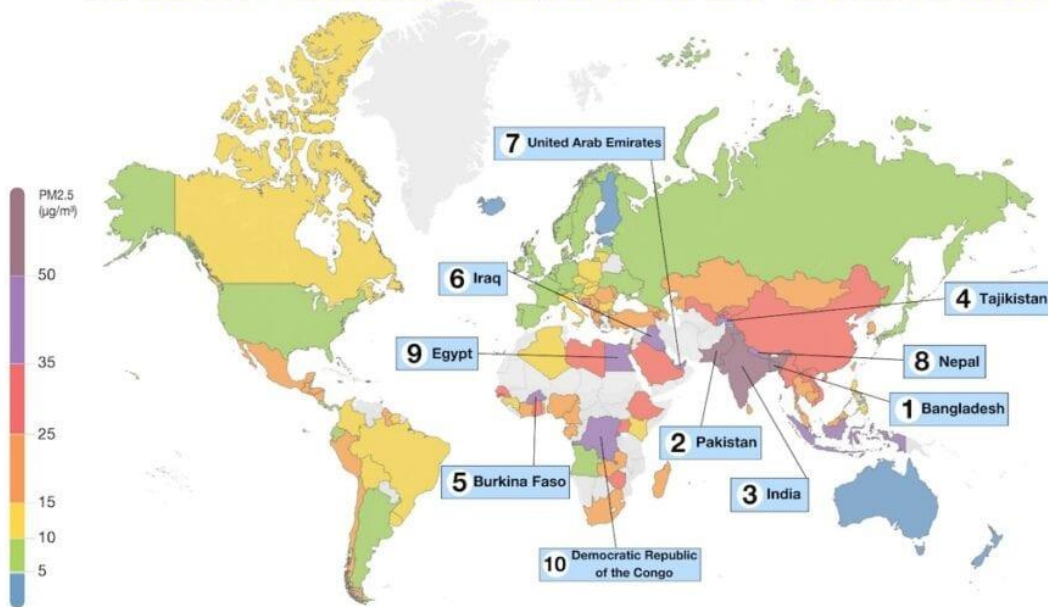
OurWorldInData.org/air-pollution | CC BY

The World's Most Polluted Capital Cities

National capitals with the highest average annual PM2.5 concentration in 2023 (in micrograms/m³ of air)



10 Most Polluted Countries in the World in 2023

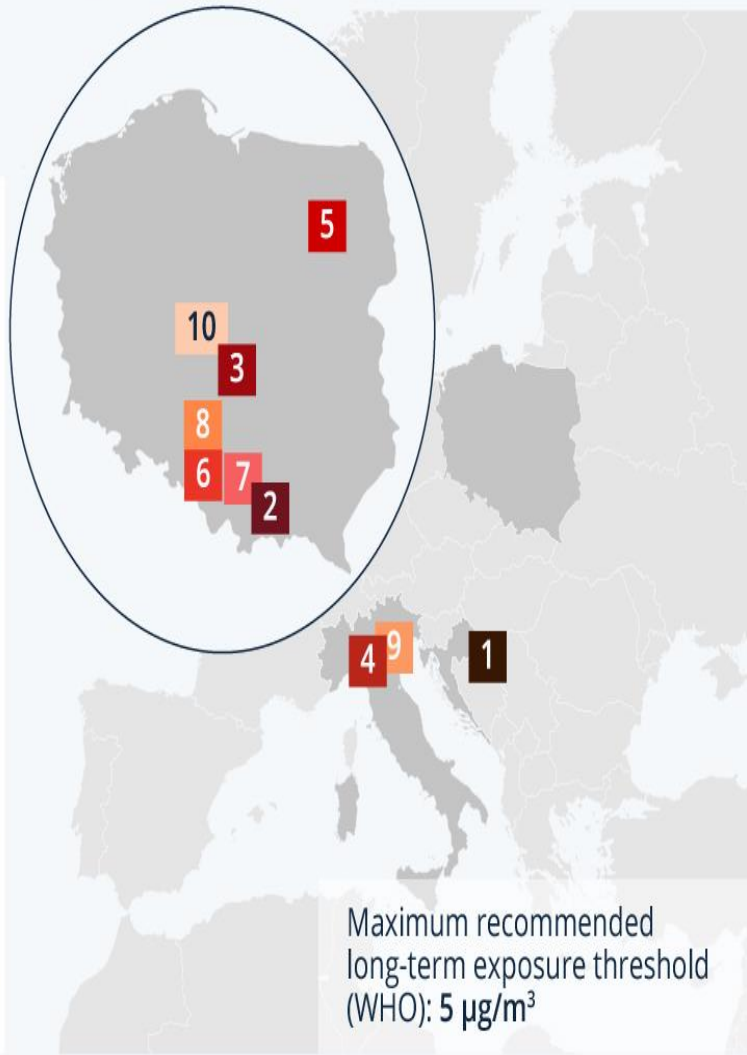


The 10 Most Polluted Cities in the EU

Average concentration of fine particles (PM2.5) in 2021 and 2022, in micrograms per cubic meter of air



1	 Slavonski Brod	28.0
2	 Nowy Sącz	27.9
3	 Piotrków Trybunalski	25.2
4	 Crémone	25.1
5	 Łomża	24.6
6	 Zory	24.3
7	 Cracovie	24.1
8	 Gliwice	21.9
9	 Padoue	21.5
10	 Zgierz	21.4





MOST POLLUTED CITIES FOR OCTOBER 2024

As of October 11, 2024

	Hanoi	175		Mumbai	91
	Shanghai	165		Seoul	91
	Lahore	162		Ho Chi Minh City	88
	Delhi	160		Guangzhou	88
	Hangzhou	158		Lima	87
	Karachi	155		Kampala	86
	Kuwait City	153		Dhaka	84
	Kinshasa	147		Santiago	84
	Baghdad	133		Incheon	83
	Wuhan	133		Tashkent	81
	Batam	128		Manama	79
	Kathmandu	122		Istanbul	76
	Dubai	119		Addis Ababa	75
	Medan	105		Tehran	74
	Cairo City	102		Doha	73
	Beijing	97		Hong Kong	73
	Chongqing	97		Shenzhen	71
	Ulaanbaatar	93		Yangon	69
	Jakarta	93		Chengdu	69
	Chiang Mai	93		Sao Paulo	69

151-200 Unhealthy	101-150 Unhealthy for sensitive groups	51-100 Moderate
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3. Why is air pollution considered a crisis without borders?

- As per the report *Pollution Knows No Borders* released by *Pure Earth* shows how toxic pollution travels from country to country, not only in the air and water, but also in the food and products we buy.

- **Air pollution knows no borders** because the **air we breathe moves freely across regions**, countries, and even continents due to atmospheric circulation.
- This movement of air is **driven by wind patterns, temperature gradients**, and other **natural forces**, which means **pollutants emitted in one location can travel vast distances** and affect air quality far away.
- The **incredible distances that pollution can spread** means that it is **not contained within the boundaries of any single nation**.

HOW INDUSTRIAL POLLUTION MIGRATES

FROM THE FARM TO THE GLOBAL TABLE

1 In low and middle-income countries, rapid industrial growth combined with poor environmental protection has resulted in a pollution crisis that is impacting us all.

2 Farmers in climate-stressed areas often have no choice but to use industrial wastewater contaminated with heavy metals to irrigate crops.


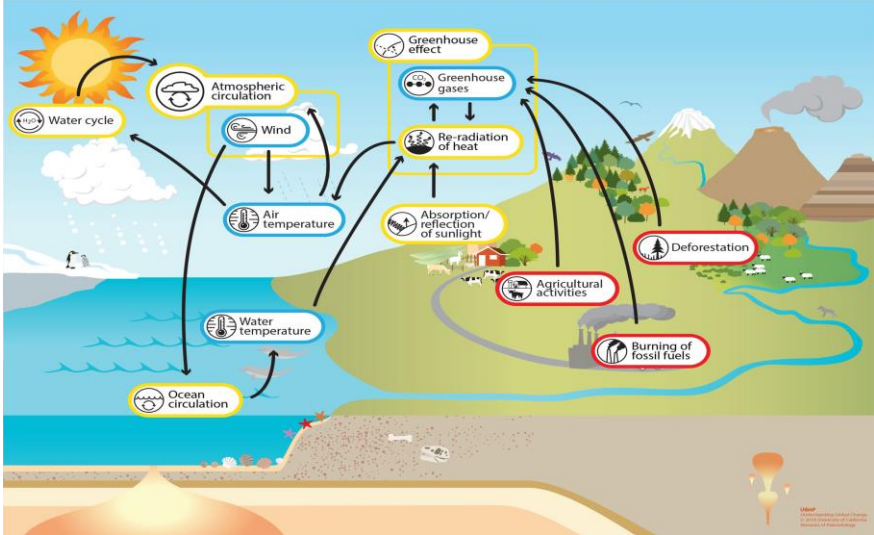
3 Crops are harvested and sold in nearby cities, some flowing into the global food processing system. Children are at greatest risk from exposure to toxic chemicals in irrigation water.

4 Only a small fraction of food imports can be tested. Products contaminated with heavy metals, banned pesticides or pathogens can make it through into food store shelves around the world.

5 After people become ill from consuming a tainted product, a recall may be issued and the product taken off the shelves.

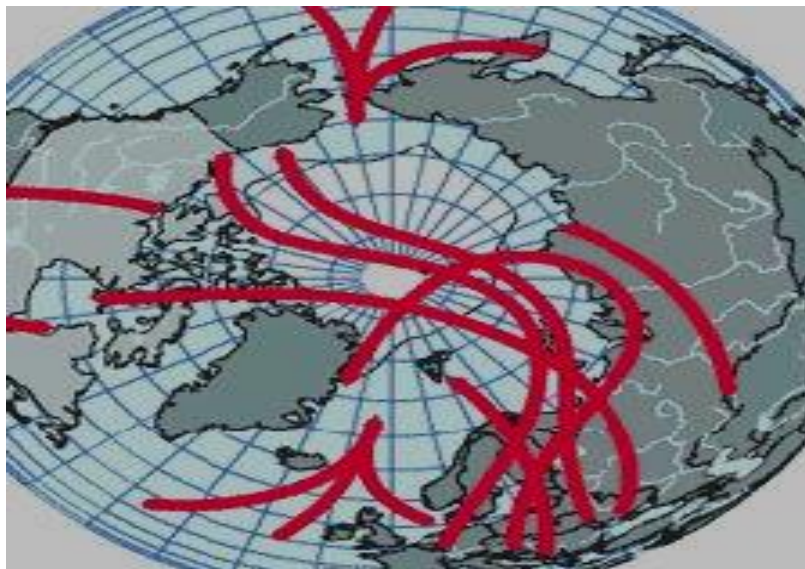
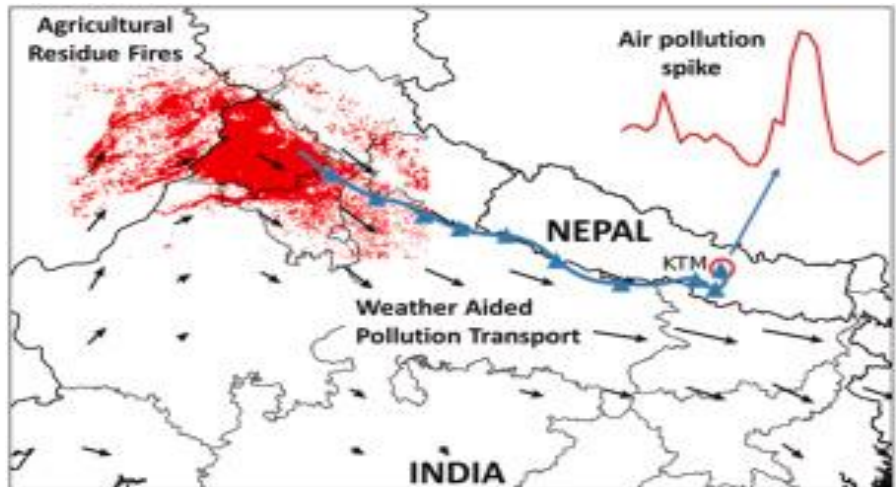
6 Children are being hurt on both ends of the production and consumption chain. Long-term damage to developing brains is especially pernicious.

The global food production system is complex and interdependent. Stopping imports is not feasible. Investing in stopping pollution at the source is the answer.

Determinants	Analysis
<p>Wind and Weather Patterns</p>	<ul style="list-style-type: none"> • Winds can carry pollutants, such as particulate matter, sulfur dioxide, nitrogen oxides, and carbon monoxide, hundreds to thousands of miles. • For instance, pollution from industrial regions in East Asia can cross the Pacific Ocean, impacting air quality in North America.  <p>The map illustrates the Pacific Ocean with wind patterns indicated by arrows. Red and orange shaded areas represent industrial regions in East Asia (China and Japan). Arrows show wind blowing from these regions across the Pacific Ocean towards North America, indicating the transport of pollutants.</p>
<p>Global Atmospheric Circulation</p>	<ul style="list-style-type: none"> • The strong winds created by atmospheric circulation are believed to have the ability to carry air pollution from one region of the planet to another. • In Asia, for example, clouds of industrial pollutants are picked up by eastward air currents in China and deposited across Japan and the Korean peninsula  <p>The diagram illustrates the Earth's climate system. It shows the sun, atmosphere, and ocean. Key components include: <ul style="list-style-type: none"> Greenhouse effect: Sunlight is absorbed by the Earth's surface and re-radiated as heat, which is trapped by greenhouse gases in the atmosphere. Atmospheric circulation: Wind patterns are shown moving air across the globe. Water cycle: Shows evaporation, condensation, and precipitation. Ocean circulation: Shows currents moving water in the ocean. Human activities: Agricultural activities, deforestation, and burning of fossil fuels are shown as sources of greenhouse gases. Absorption/reflection of sunlight: Shows how the Earth's surface and atmosphere interact with solar radiation. </p>

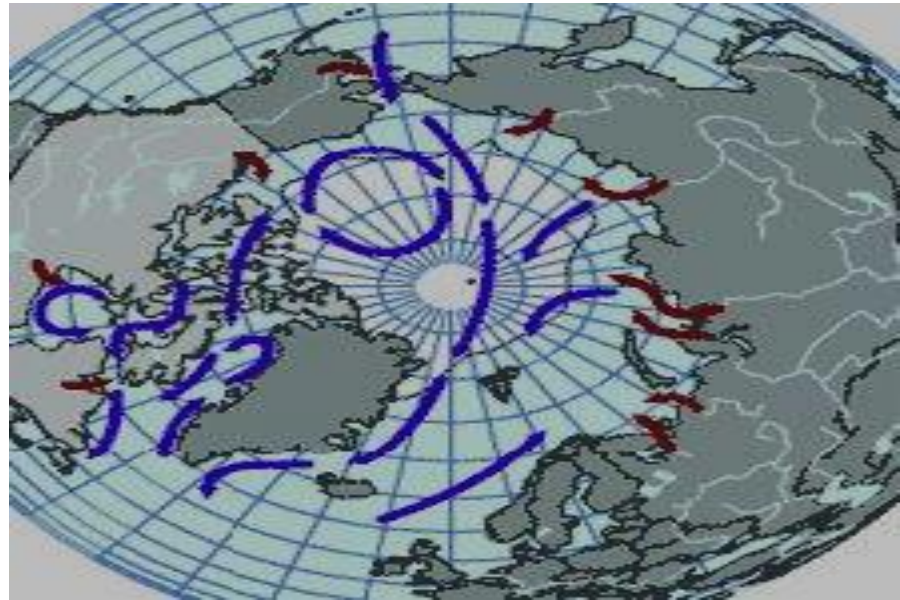
Transboundary Pollution

- **Trans boundary pollution is the pollution that originates in one country but is able to cause damage in another country’s environment, by crossing borders through pathways like water or air.**
- It can occur through **air, water, or soil contamination.**
- **Persistent Organic Pollutants (POPs) are able to travel great distances by attaching to dust particles that are blown north by the wind when there is no precipitation.**



Ocean Currents and Evaporation

- **Oceans can also play a role, as some pollutants settle into water, travel with currents, and eventually re-enter the atmosphere through evaporation, where they can continue to spread.**



4. How India and Pakistan are divided by borders but united by smog?



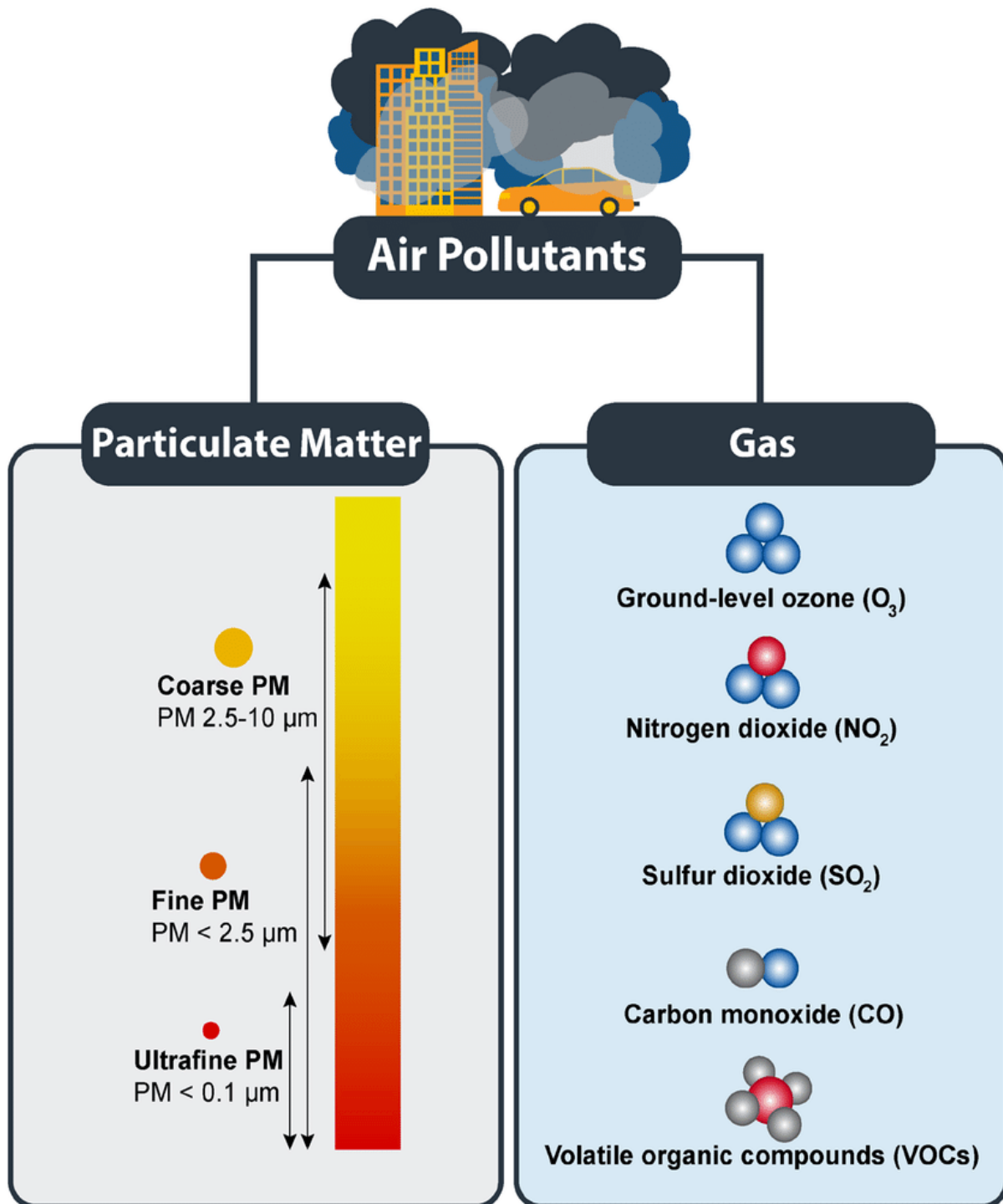
- A **thick toxic blanket of smog covering eastern Pakistan and entire northern India** is seen in a striking satellite image released by American space agency NASA.
- It shows location pins for **Lahore in Pakistan's Punjab and New Delhi**, with both cities under a **huge cloud of grey smog**.
- While Pakistan struggles with unprecedented levels of smog, **Delhi is not far behind in its battle against pollution**.
- Both countries share a troubling commonality, **the rapid deterioration of air quality in major urban centers**.
- IQAir's data showed that at **6 am on Tuesday (12, November) Lahore's AQI was 1045, followed by Delhi's at 329**.
- **Wind patterns play a crucial role in transporting pollution across the 500 to 1,000 kilometers (310-620 miles) separating the two Punjabs**.

- For smog to cross the border, wind speeds between 5 to 20 km/h (3-12 mph) are ideal, with westerly or north westerly directions acting as a kind of highway for airborne particles.
- When these conditions align, smog can travel from one side of the border to the other in anywhere from one to eight days, depending on wind speed:
 - At 5 km/h: Particles might take 4-8 days.
 - At 20 km/h: Smog could arrive in just 1-2 days.

5. Enlist the highlights of the World Air Quality Report 2023?

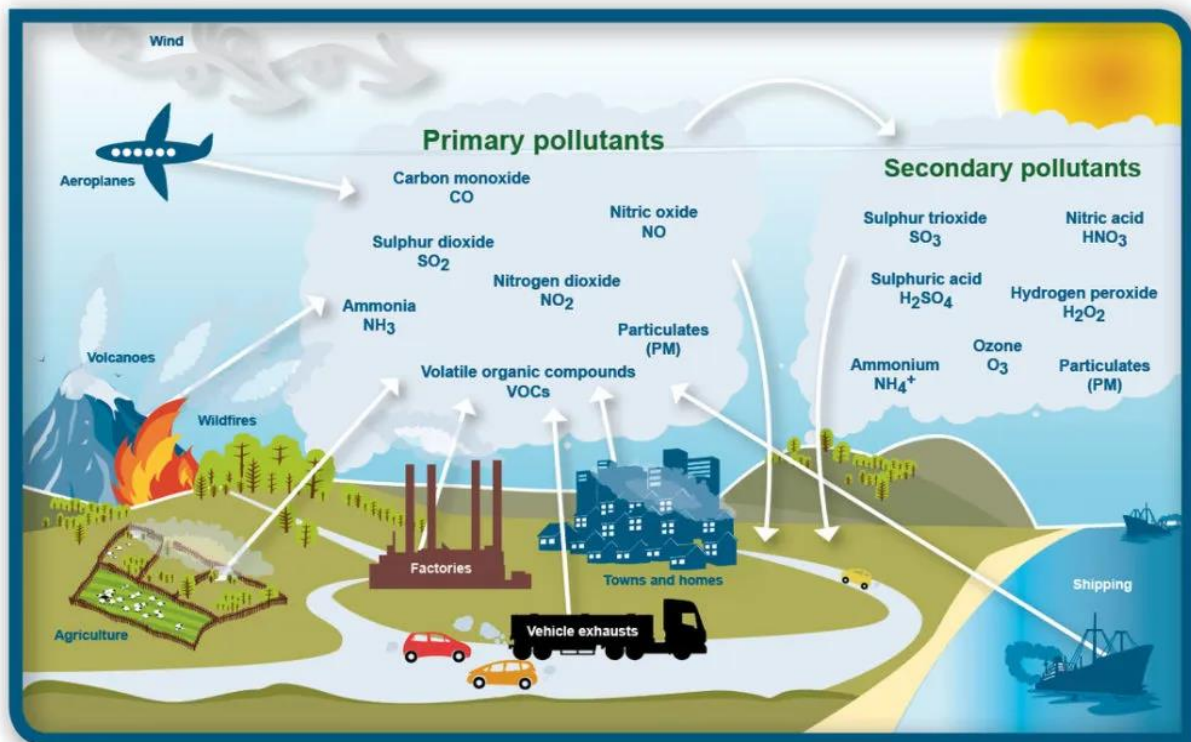
- According to the World Air Quality Report 2023 by Swiss organization IQAir, Delhi has the poorest air while Bihar's Begusarai is said to be the world's most polluted metropolitan area.
- As per the World Air Quality Report 2023, India had the third worst air quality out of 134 countries in 2023 with an average annual PM2.5 concentration of 54.4 micrograms per cubic meter after Bangladesh (79.9 micrograms per cubic meter) and Pakistan (73.7 micrograms per cubic meter).
- In 2022, India was ranked as the eighth most polluted country with an average PM2.5 concentration of 53.3 micrograms per cubic meter.
- Delhi's PM2.5 levels worsened from 89.1 micrograms per cubic meter in 2022 to 92.7 micrograms per cubic meter in 2023.
- As per the report, 96 percent of India's population faces PM2.5 levels that exceed the WHO annual guideline by more than seven times.
- As per the report, worldwide one in every nine deaths worldwide is caused by air pollution.

6. Enlist various types of air pollutants?



The air pollutants can be classified into the following two types:

Air pollutant	Description
<p>Primary air pollutants</p>	<ul style="list-style-type: none"> • These pollutants are emitted directly from a source, such as a vehicle, volcanic eruption, or wildfire. • Examples include carbon monoxide, nitrogen oxide, and sulfur oxide, particulate matter (PM).
<p>Secondary air pollutants</p>	<ul style="list-style-type: none"> • These pollutants are formed when primary pollutants react with other substances in the atmosphere. • Examples include ozone, secondary organic aerosol (haze), and acid rain. <ul style="list-style-type: none"> ▪ Ozone: Formed when hydrocarbons and nitrogen oxides combine in the presence of sunlight ▪ Nitrogen dioxide (NO₂): Formed when NO combines with oxygen in the air ▪ Acid rain: Formed when sulfur dioxide or nitrogen oxides react with water ▪ Secondary organic aerosol (haze): A secondary pollutant. • Secondary pollutants are harder to control than primary pollutants because they are formed through complex chemical reactions that are not well understood.



Classification of pollutant according to their existence in nature:

- **Quantitative Pollutants:** These occur in nature and become pollutants when their concentration reaches beyond a threshold level. E.g. carbon dioxide, nitrogen oxide.
- **Qualitative Pollutants:** These do not occur in nature and are human-made. E.g. fungicides, herbicides, DDT etc.

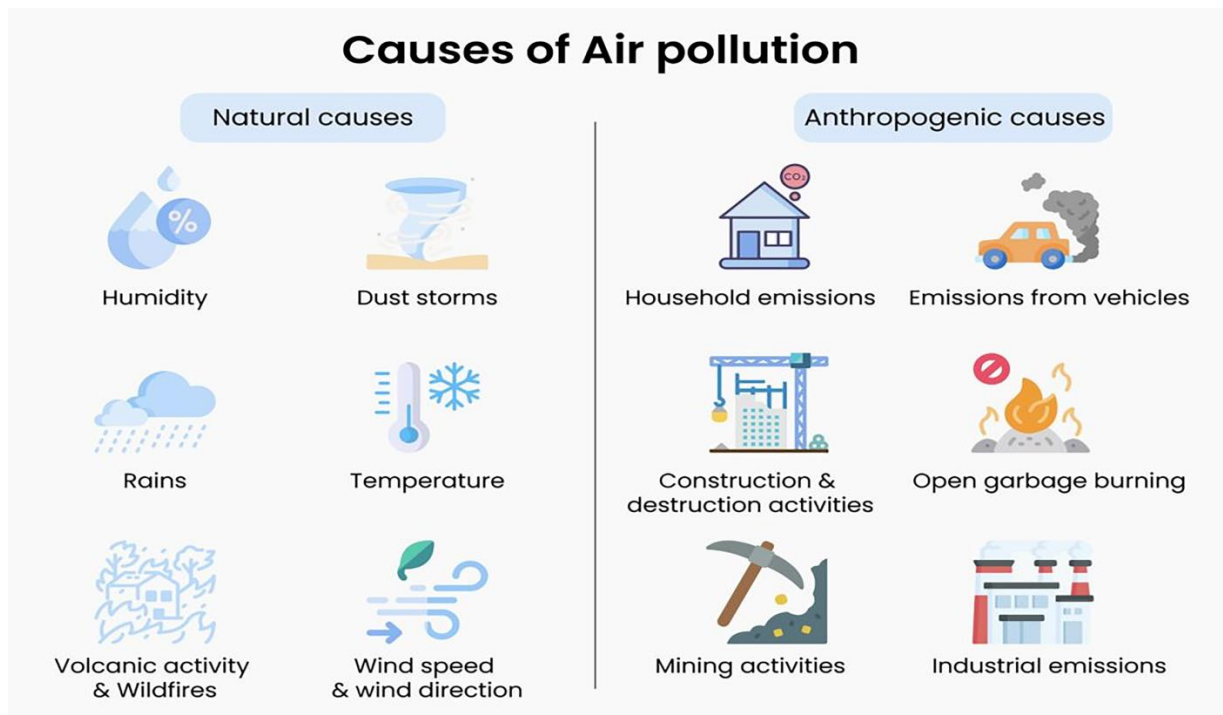
7. How Is Air Quality Measured?

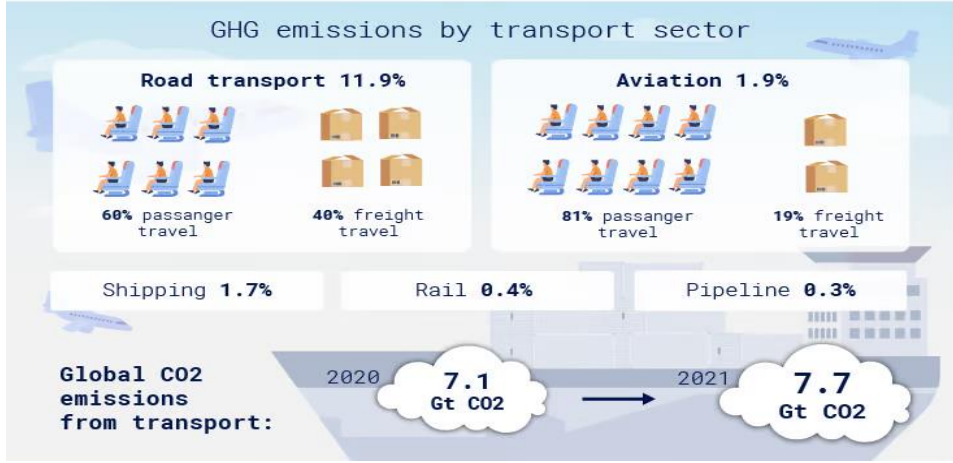
- Air quality is a **measure of how clean or polluted the air is.**
- Air quality is measured with the **Air Quality Index, or AQI.**
- The AQI works like a **thermometer that runs from 0 to 500 degrees.**
- The AQI has **six categories** that communicate the **level of health concern using specific colors.**
- **Instruments on the ground and satellites orbiting Earth** collect **information about what is in our air.**

- For example, satellites in NOAA’s GOES-R (short for Geostationary Operational Environmental Satellites-R) Series monitor the particle pollution in our atmosphere.

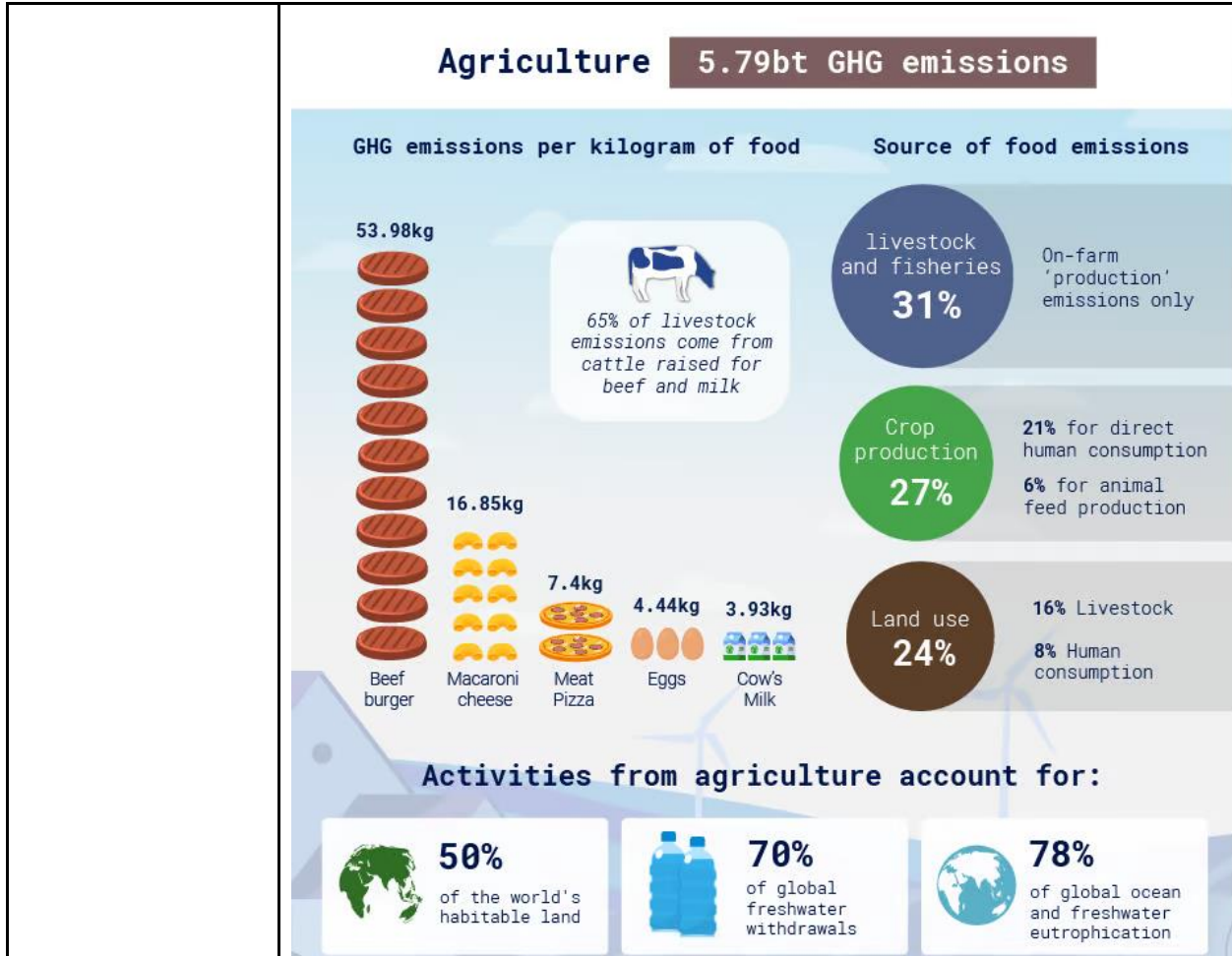
AQI Category, Pollutants and Health Breakpoints								
AQI Category (Range)	PM ₁₀ 24-hr	PM _{2.5} 24-hr	NO ₂ 24-hr	O ₃ 8-hr	CO 8-hr (mg/m ³)	SO ₂ 24-hr	NH ₃ 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 – 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+

8. What are the causes of Air pollution?

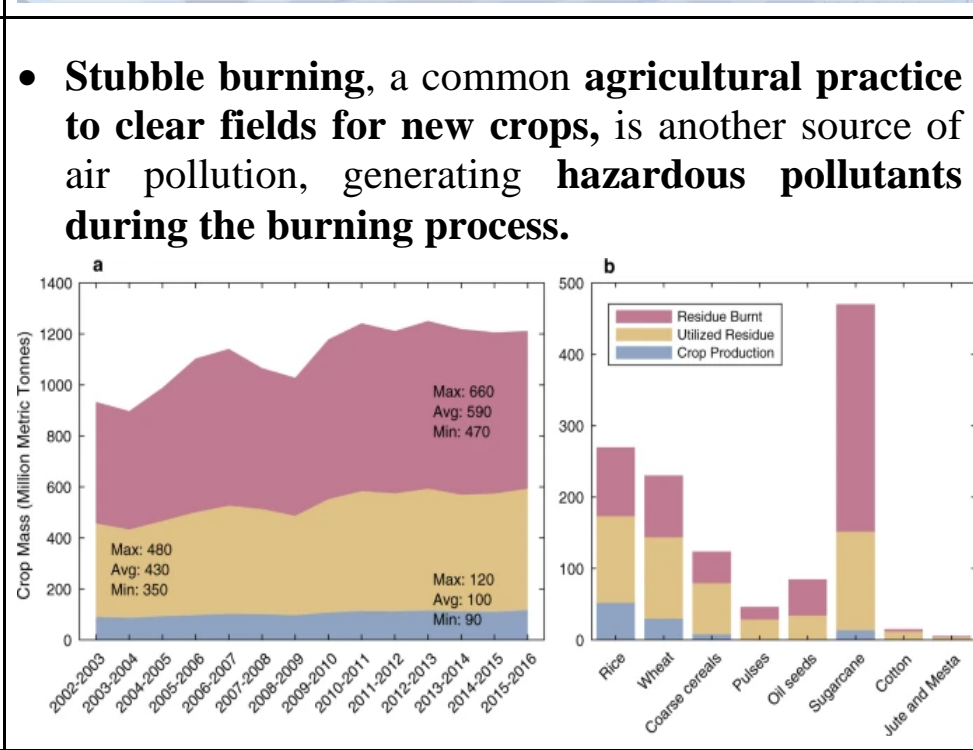







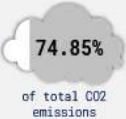
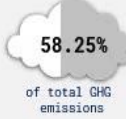
Causes of air pollution	Analysis												
Natural Factors	<ul style="list-style-type: none"> • Certain natural phenomena, such as volcanoes, forest fires, and dust storms, can contribute to air pollution. 												
Fossil fuels	<ul style="list-style-type: none"> • Petrol and diesel engines of cars, ships, trains and other vehicles emit pollutants such as carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), sulfur dioxide (SO₂), and volatile organic compounds (VOCs). • Friction from tires and brake wear also create primary – i.e. direct – particulate matter emissions. In addition, the nitrogen dioxide (NO₂) and VOCs released by road vehicles also undergo photochemical reactions to form ozone (O₃). • In Europe, more than 40% of NO_x and almost 40% of primary PM_{2.5} emissions are linked to road transport. • In the United States, 35.8% of CO and 32.8% of NO_x stem from road transport. <p style="text-align: center;">Transport 8.43bt GHG emissions</p>  <p style="text-align: center;">GHG emissions by transport sector</p> <table border="1" style="width: 100%; text-align: center;"> <tr> <td colspan="2">Road transport 11.9%</td> <td colspan="2">Aviation 1.9%</td> </tr> <tr> <td>60% passenger travel</td> <td>40% freight travel</td> <td>81% passenger travel</td> <td>19% freight travel</td> </tr> <tr> <td colspan="2">Shipping 1.7%</td> <td>Rail 0.4%</td> <td>Pipeline 0.3%</td> </tr> </table> <p>Global CO₂ emissions from transport: 2020: 7.1 Gt CO₂ → 2021: 7.7 Gt CO₂</p>	Road transport 11.9%		Aviation 1.9%		60% passenger travel	40% freight travel	81% passenger travel	19% freight travel	Shipping 1.7%		Rail 0.4%	Pipeline 0.3%
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	<p style="text-align: center;">Global Greenhouse Gas Emission from Fossil Fuels</p> <table border="1"> <thead> <tr> <th>Year</th> <th>Global Greenhouse Gas Emissions (GtCO2)</th> <th>Emissions from Fossil Fuels (GtCO2)</th> </tr> </thead> <tbody> <tr> <td>1990</td> <td>22</td> <td>17.9</td> </tr> <tr> <td>2000</td> <td>25</td> <td>19.6</td> </tr> <tr> <td>2010</td> <td>31</td> <td>24.5</td> </tr> <tr> <td>2020</td> <td>33</td> <td>26.5</td> </tr> </tbody> </table>	Year	Global Greenhouse Gas Emissions (GtCO2)	Emissions from Fossil Fuels (GtCO2)	1990	22	17.9	2000	25	19.6	2010	31	24.5	2020	33	26.5
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<p>Agriculture</p>	<ul style="list-style-type: none"> • Agricultural practices contribute to air pollution through the release of ammonia, a hazardous chemical byproduct. • The use of insecticides, pesticides, and fertilizers in farming introduces harmful chemicals into the air and water. • A wide range of nitrogen compounds (NO, NO₂, N₂), including ammonia (NH₃), can be attributed to fertilizer production, farm machinery, and livestock waste management in agriculture. • In Europe, agricultural activities cause approximately 90% of ammonia emissions and 80% of methane emissions. 															



Stubble burning







<p>Industrial waste</p>	<ul style="list-style-type: none"> • The combustion of fossil fuels such as coal and oil in industrial processes in power plants, refineries, and factories release a variety of pollutants, the majority of which are identical to those emitted by traffic and mobility. • Industrial activities release pollutants such as carbon monoxide, hydrocarbons, organic compounds, and various chemicals into the air, adversely affecting air quality. <p style="text-align: center;">Heavy industry and manufacturing 6.30bt GHG emissions</p> <p style="text-align: center;">Extraction and processing of materials, fuels and food make up for:</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>50% of total global greenhouse gas emissions.</p> </div> <div style="text-align: center;">  <p>over 90% of biodiversity loss and water stress.</p> </div> </div> <p style="text-align: center;">GHG emissions from manufacturing sectors (% of total emissions)</p> <div style="display: flex; justify-content: space-around; text-align: center;"> <div style="width: 30%;"> <p>Iron and steel</p>  <p>7.2%</p> </div> <div style="width: 30%;"> <p>Chemicals and petrochemicals</p>  <p>3.6%</p> </div> <div style="width: 30%;"> <p>Food and tobacco</p>  <p>1%</p> </div> </div> <p style="text-align: center;">The world's most industrialised countries in total produce</p> <div style="display: flex; justify-content: space-around; text-align: center;"> <div style="width: 45%;"> <p>25,576.7 million tonnes of CO2 emissions</p>  <p>74.85% of total CO2 emissions</p> </div> <div style="width: 45%;"> <p>18,37,026.82 thousand metric tons of GHG emissions</p>  <p>58.25% of total GHG emissions</p> </div> </div> <p style="text-align: center;">The average crude death rate in this region is 8.23 per 1000 population.</p>
<p>Indoor Pollution</p>	<p>Household cleaning products and painting supplies release hazardous chemicals into the air, contributing to indoor pollution.</p>

- Around **2.1 billion people** worldwide (around a third of the global population) **cook using open fires or inefficient stoves fuelled by kerosene, biomass** (wood, animal dung and crop waste) and coal, which generates harmful household air pollution.
- **Household air pollution** was responsible for an estimated **3.2 million deaths per year in 2020**, including over **237 000 deaths of children under the age of 5**.
- The **combined effects of ambient air pollution** and household air pollution are associated with **6.7 million premature deaths annually**.

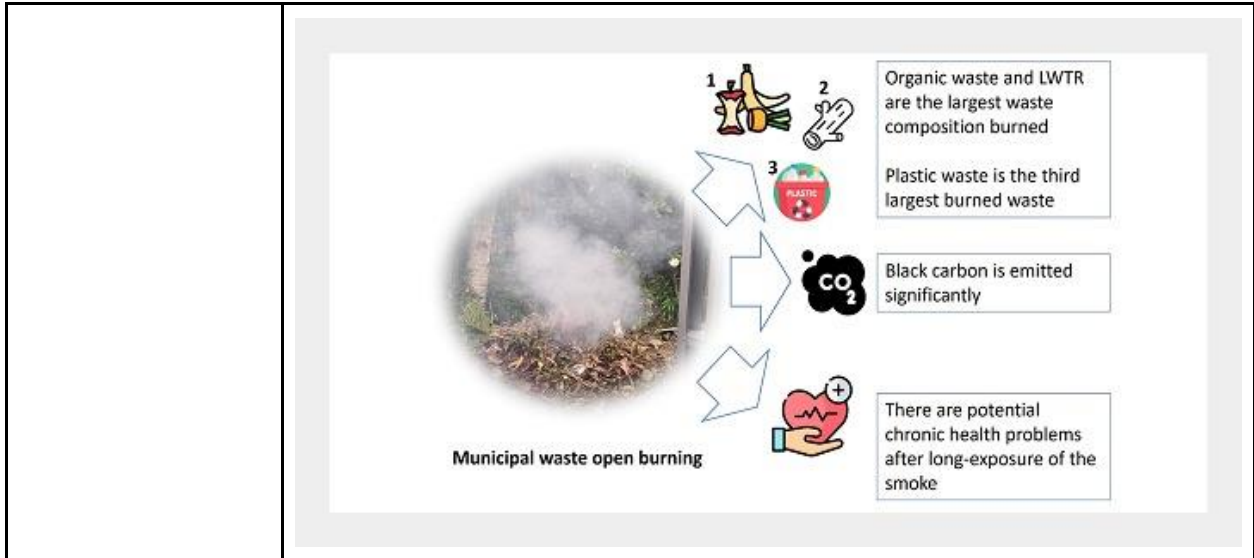


Livestock

- **Half of direct agriculture emissions** come from livestock.
- **Digestive processes in livestock release methane, a greenhouse gas**, as a by-product into the atmosphere.

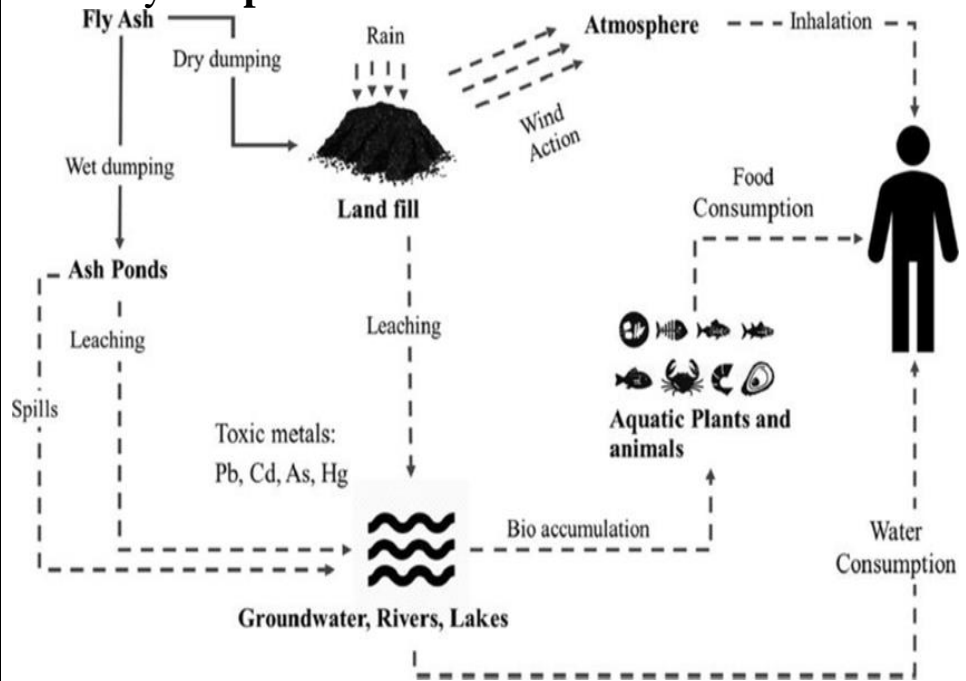
<p>Wildfires</p>	<ul style="list-style-type: none"> • Climate change is not just increasing wildfire but also spiking air pollution. • As many as 90% of the wildfires are caused by anthropogenic reasons, a small spark can turn acres of forest area into ashes. • The soot and dust particles, smoke (that contains several toxic chemicals) can stay suspended in the air for days. 																																				
<p>Open Burning of Garbage Waste</p>	<ul style="list-style-type: none"> • Open burning of garbage is very harmful to the environment. • Open air garbage burning releases toxins such as black carbon, soot, and carcinogens. <div data-bbox="479 934 1421 1606"> <p>Burning of garbage, wood, garden waste and plastic waste is one of the major sources of winter pollution in the capital</p>  <p>A study conducted by IIT-Delhi in 2021 found winter haze episodes in January were highly affected by biomass burning emissions</p>  <p>Delhi govt had carried out an anti-open burning campaign last year</p>  <p>Enforcement Biomass burning episodes during October-November 2022</p> <ul style="list-style-type: none"> No. of inspections of garbage sites conducted: 10,968 No. of open burning incidents addressed: 824 Amount of fines imposed: ₹79 lakh 21 Vulnerable areas/spots identified <p>PM2.5 source contribution (%)</p> <table border="1"> <thead> <tr> <th>Source</th> <th>Stubble burning (Oct 15-Nov 15, 2021)</th> <th>After stubble burning phase (Nov 15-Dec 15, 2021)</th> <th>Peak winter phase (Dec 15-Jan 15, 2022)</th> </tr> </thead> <tbody> <tr> <td>Dust</td> <td>16</td> <td>17</td> <td>16</td> </tr> <tr> <td>Transport</td> <td>12</td> <td>16</td> <td>15</td> </tr> <tr> <td>Open fires</td> <td>32</td> <td>8</td> <td>3</td> </tr> <tr> <td>Waste burning</td> <td>6</td> <td>9</td> <td>8</td> </tr> <tr> <td>Power plants and DG sets</td> <td>5</td> <td>10</td> <td>9</td> </tr> <tr> <td>Industries</td> <td>8</td> <td>11</td> <td>10</td> </tr> <tr> <td>Household heating, cooking</td> <td>10</td> <td>17</td> <td>32</td> </tr> <tr> <td>Others</td> <td>12</td> <td>12</td> <td>8</td> </tr> </tbody> </table>  </div>	Source	Stubble burning (Oct 15-Nov 15, 2021)	After stubble burning phase (Nov 15-Dec 15, 2021)	Peak winter phase (Dec 15-Jan 15, 2022)	Dust	16	17	16	Transport	12	16	15	Open fires	32	8	3	Waste burning	6	9	8	Power plants and DG sets	5	10	9	Industries	8	11	10	Household heating, cooking	10	17	32	Others	12	12	8
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- Open garbage burning **causes skin irritation, aggravates asthma and other respiratory diseases and illnesses**, increases the **risk of heart diseases**, and difficulties in **breathing, nausea and headaches**.

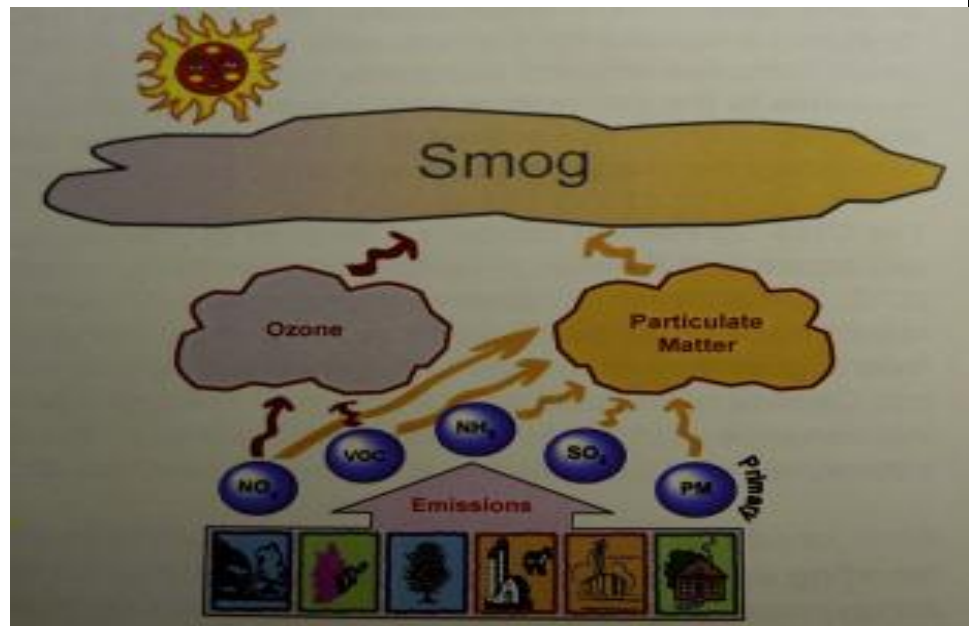


Fly ash

- The ash produced mostly by thermal power plants as by-products of coal burning operations is termed Fly ash.
- It consists primarily of oxides of silicon, aluminum, iron and calcium.
- Fly ash pollutes the air as well as water.

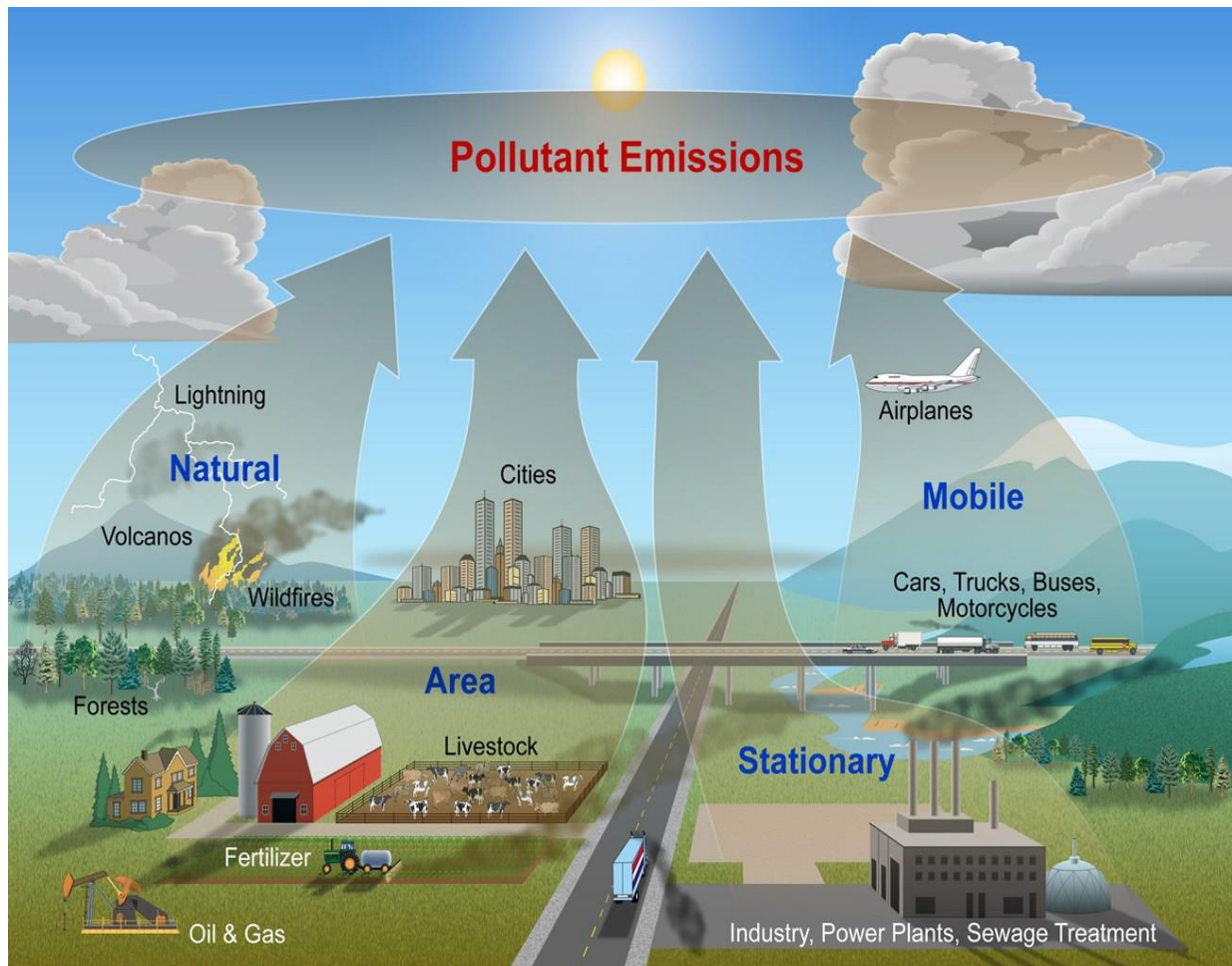
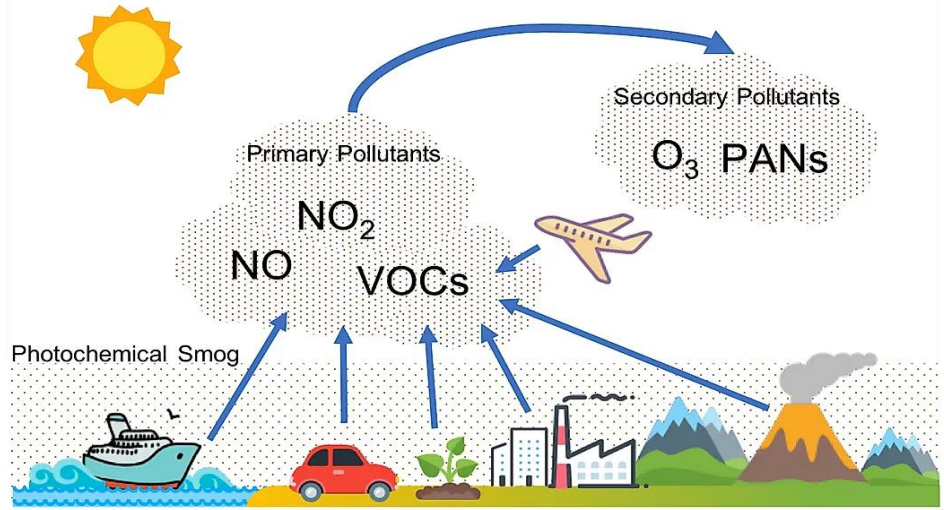


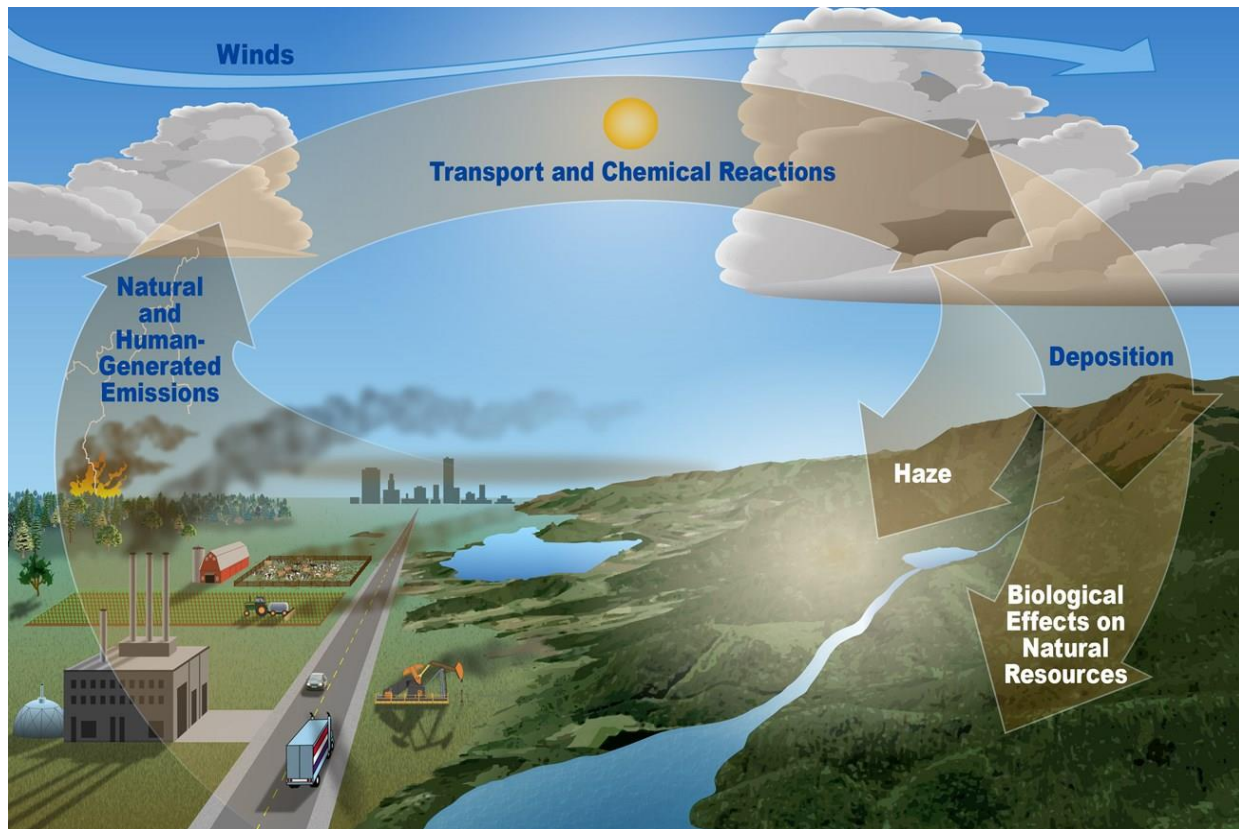
	<table border="1"> <caption>Global Fly Ash Generation (MT) - Utilization (%)</caption> <thead> <tr> <th>Country</th> <th>Annual Ash Generation (MT)</th> <th>Ash Utilization (%)</th> </tr> </thead> <tbody> <tr> <td>India</td> <td>112</td> <td>38</td> </tr> <tr> <td>China</td> <td>100</td> <td>45</td> </tr> <tr> <td>USA</td> <td>75</td> <td>65</td> </tr> <tr> <td>Germany</td> <td>40</td> <td>85</td> </tr> <tr> <td>UK</td> <td>15</td> <td>50</td> </tr> <tr> <td>Australia</td> <td>13.1</td> <td>85</td> </tr> <tr> <td>Canada</td> <td>6</td> <td>75</td> </tr> <tr> <td>France</td> <td>3</td> <td>85</td> </tr> <tr> <td>Denmark</td> <td>2</td> <td>100</td> </tr> <tr> <td>Italy</td> <td>2</td> <td>100</td> </tr> <tr> <td>Netherland</td> <td>2</td> <td>100</td> </tr> <tr> <td>Russia</td> <td>26.7</td> <td>18</td> </tr> </tbody> </table>	Country	Annual Ash Generation (MT)	Ash Utilization (%)	India	112	38	China	100	45	USA	75	65	Germany	40	85	UK	15	50	Australia	13.1	85	Canada	6	75	France	3	85	Denmark	2	100	Italy	2	100	Netherland	2	100	Russia	26.7	18
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<p>Construction and Demolition</p>	<ul style="list-style-type: none"> • Construction and demolition sites are a rich source of PM and other air pollutants including VOCs, etc. • People living near these sites experience various health concerns like difficulty in breathing, irritation in the eyes, nose, and throat, etc. • Several construction sites and raw materials such as bricks and concrete cause haze and foul air which is hazardous for people especially, children and elderly citizens. 																																							
<p>Smog</p>	<ul style="list-style-type: none"> • Smog is a type of air pollution derived from vehicular emissions and industrial fumes that react in the atmosphere with sunlight to form secondary pollutants. 																																							



- There are mainly two types of smog namely **sulfurous smog and photochemical smog.**
- **Sulfurous smog:**
 - **Sulfurous smog**, also known as “**London smog**,” is caused by a **high concentration of sulfur oxides in the air**, which is caused by the use of sulfur-containing fossil fuels, particularly coal. **Dampness and a high concentration of suspended particulate matter** in the air aggravate this type of smog.
- **Photochemical smog:**
 - **Photochemical smog**, also known as “**Los Angeles smog**,” is most prevalent in **urban areas with a high concentration of automobiles.**
 - It is a **mixture of pollutants** that are formed when **nitrogen oxides and volatile organic compounds (VOCs)** react to **sunlight, creating a brown haze above cities.**

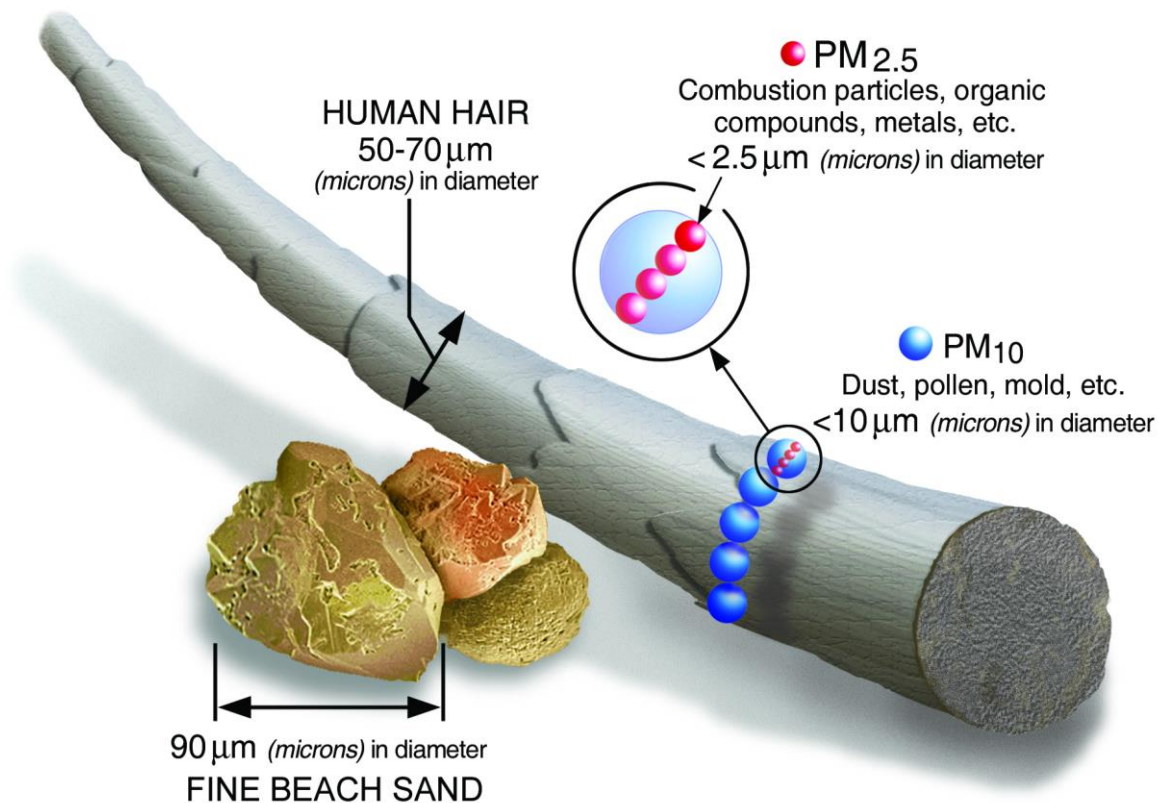
- It tends to occur more often in summer, because that is when there is enough sunlight.



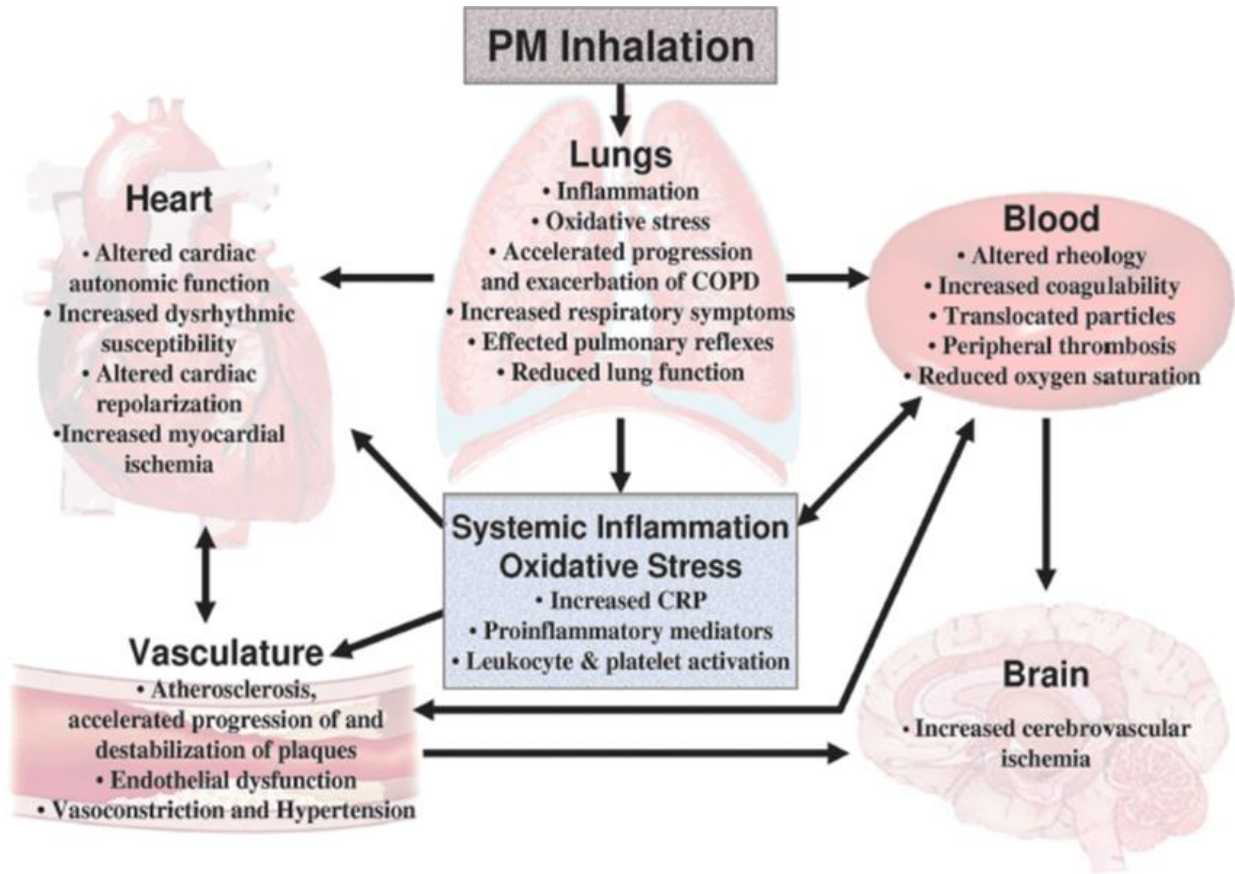


9. What is PM, and how does it get into the air?

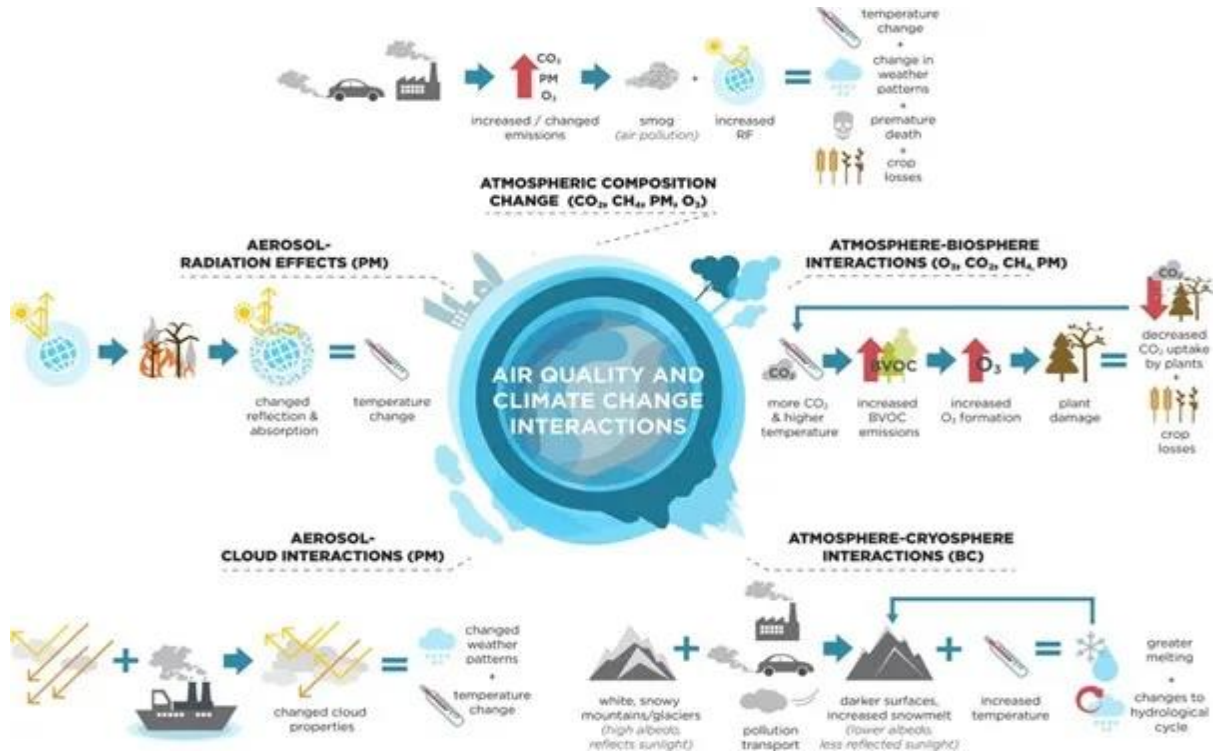
- **PM stands for particulate matter** (also called particle pollution) and it is a **mixture of solid particles and liquid droplets** found in the air.
- Some particles, such as **dust, dirt, soot, or smoke**, are **large or dark** enough to be seen with the **naked eye**.
- Others are so small they can **only be detected using an electron microscope**.
- **Particle pollution includes:**
 - **PM10:** inhalable particles, with diameters that are generally **10 micrometers and smaller**; and
 - **PM2.5:** fine inhalable particles, with diameters that are generally **2.5 micrometers and smaller**.

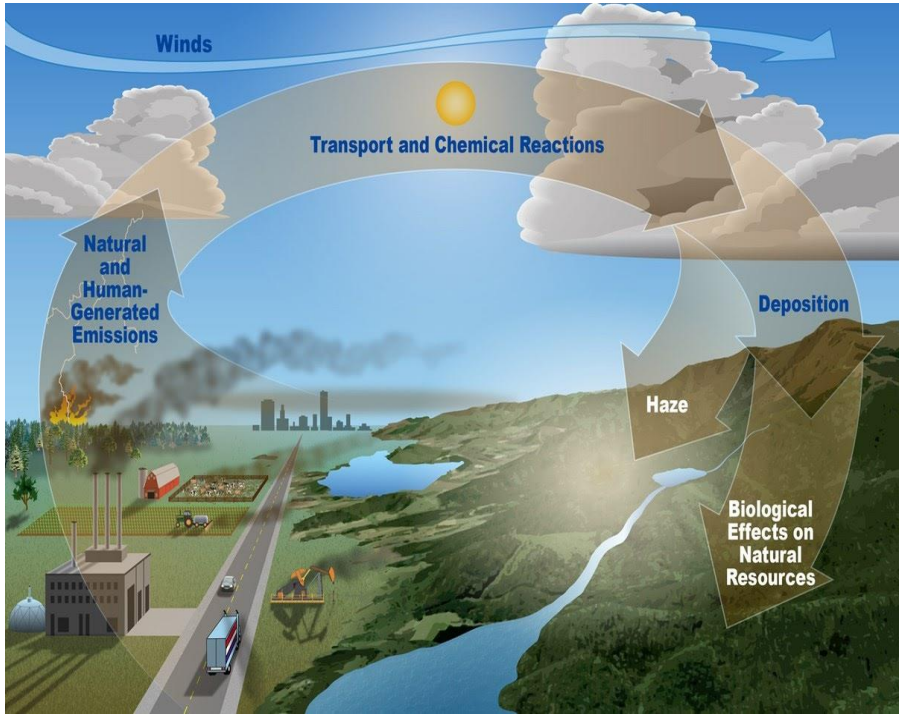


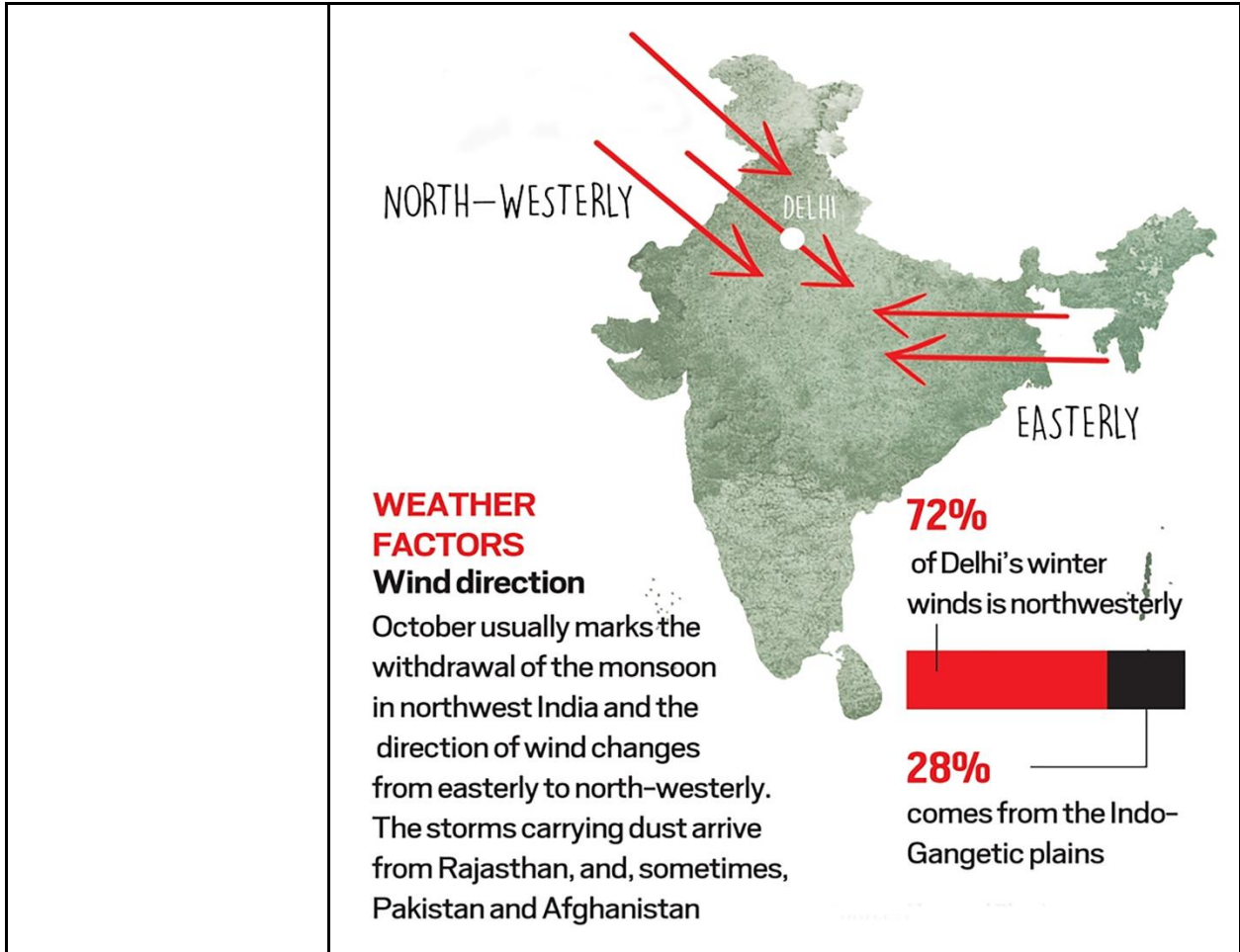
- Most particles form in the atmosphere as a **result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides**, which are pollutants emitted from power plants, industries and automobiles.
- Some are emitted **directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires.**
- Particulate matter contains microscopic solids or liquid droplets that are so small that they **can be inhaled and cause serious health problems.**



10. Mention how weather affects the air quality?



Determinants	Analysis
<p>Wind and temperature</p>	<ul style="list-style-type: none"> • Wind carries air contaminants away from their source, causing them to disperse. • In general, the higher the wind speed, the more contaminants are dispersed and the lower their concentration. • However, high wind can also generate dust which is a problem in dry windy rural areas. • As the ground heats during daytime the air becomes more turbulent, especially in the middle of the day. • Air turbulence causes polluted air to disperse as it moves away from its source. • In contrast, stable conditions often occur at night when the air is cooler. 



Inversion layers

- **Air usually cools with increasing height in the atmosphere.**
- **However, sometimes an upper air layer is warmer than a lower one.**
- **This is called an inversion.**

Normal Conditions

Warm Air

Cooler Air

Cold Air

Temperature Inversion

Cold Air

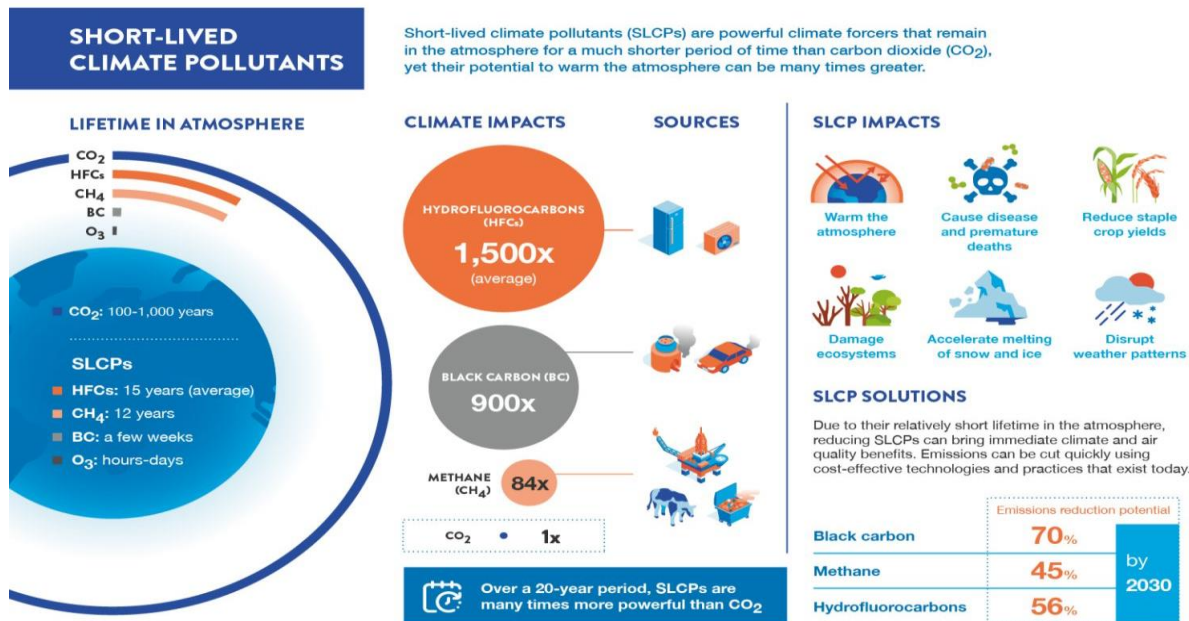
Warm Air – Inversion Layer

Cooler Air

Smog

11. What are short-lived climate pollutants and how do they impact climate and health?

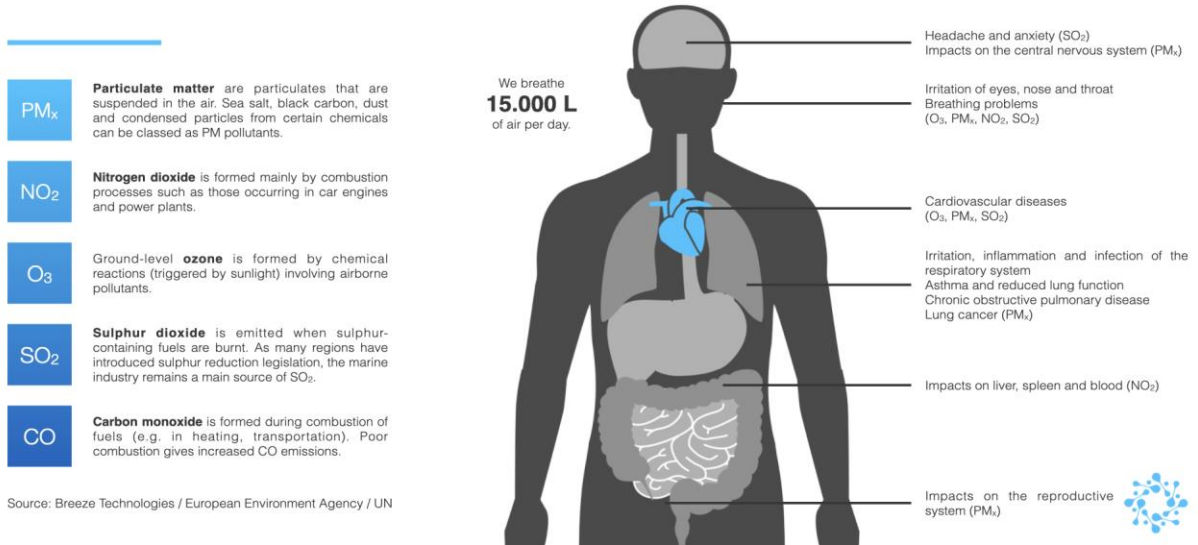
- **Air pollutants, such as methane and black carbon, are powerful short-lived climate pollutants (SLCPs) that contribute to climate change and ill health.**
- Although SLCPs **persist** in the **atmosphere for short lifetimes**, their **global warming potential** is often much greater than carbon dioxide (CO₂).
- **Black carbon**, a component of fine particulate matter, is **one of the largest contributors to global warming after CO₂**.
- **Black carbon warms the earth's atmosphere by absorbing sunlight**, thereby accelerating the melting of snow and ice.
- **Methane has a warming impact 86 times stronger than CO₂ per unit of mass over a 20 year period.**
- **Methane (CH₄) is estimated to have a GWP of 27-30 over 100 years.**
- **Ozone and black carbon affect weather processes and decrease agricultural yields**, thus threatening food security.



12. What is the impact of air pollution on health?

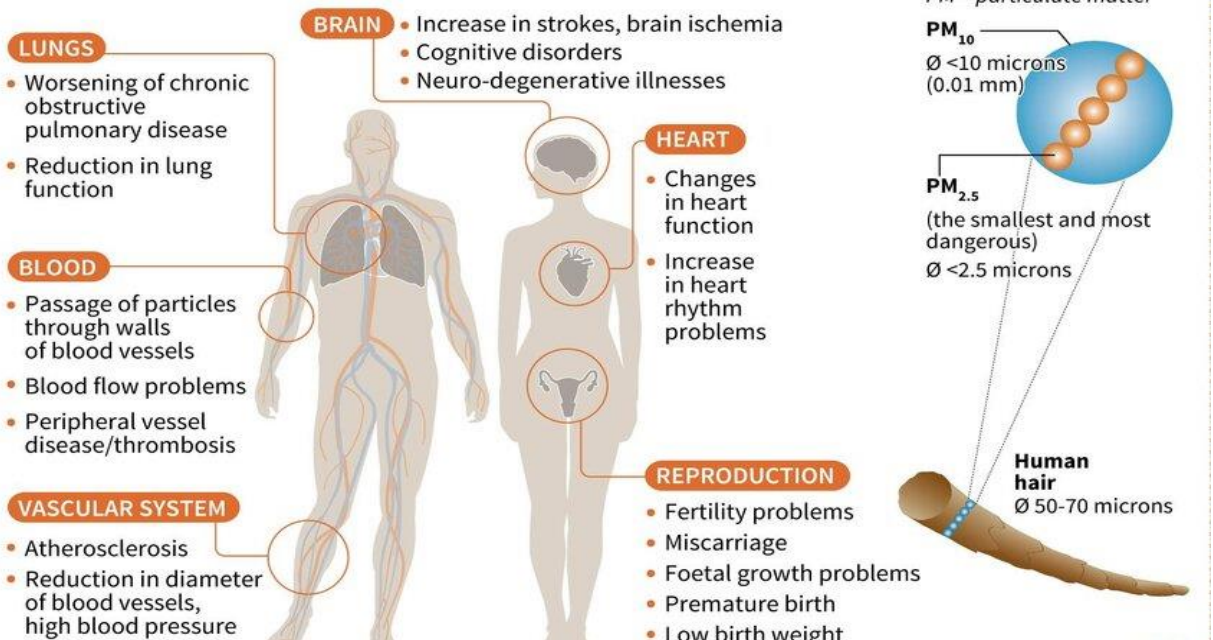
- **Air pollution poses serious health risks, including respiratory diseases such as asthma and chronic bronchitis, cardiovascular conditions, and premature mortality.**

Main air pollutants and their health impacts

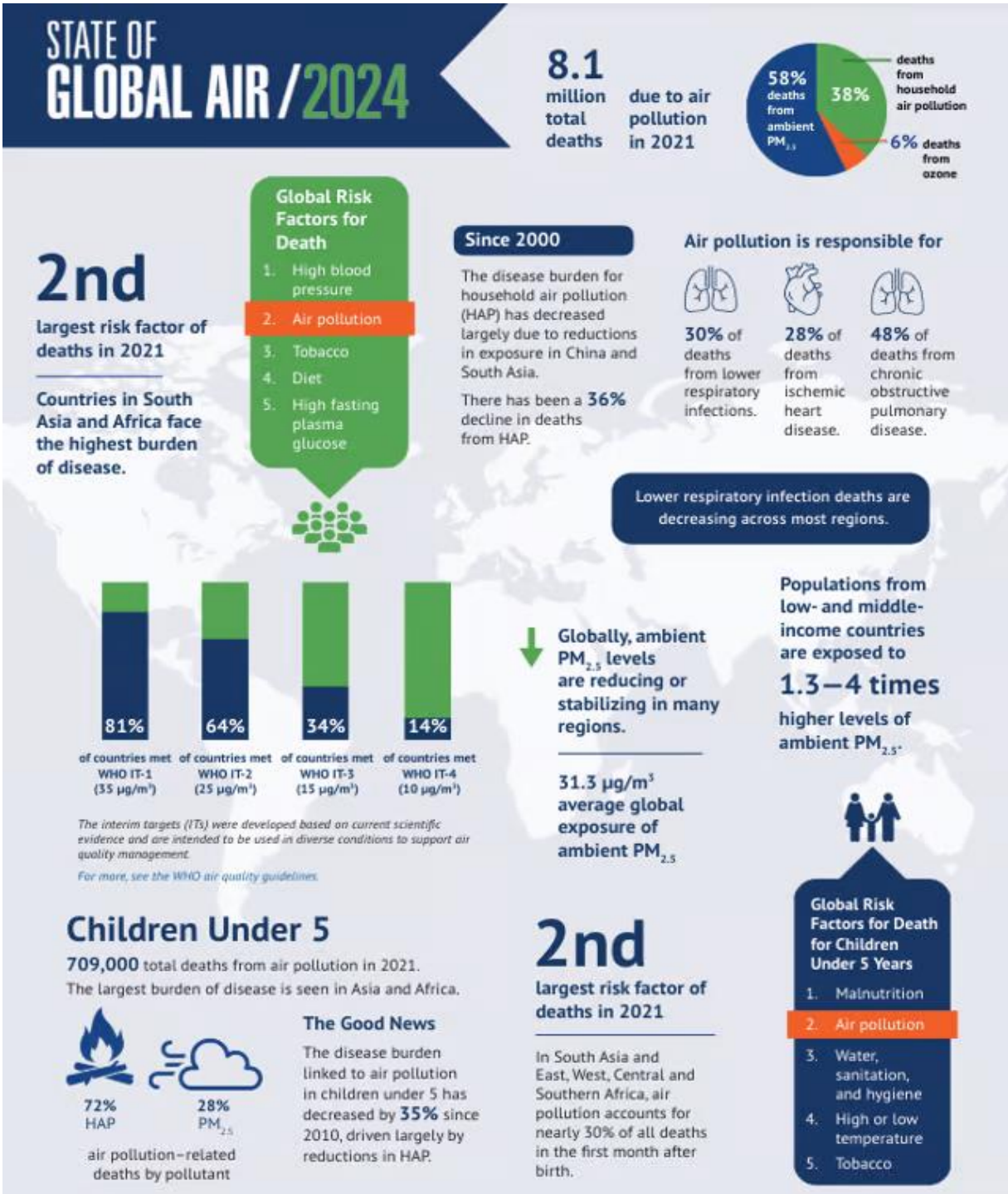


Health impact of air pollution

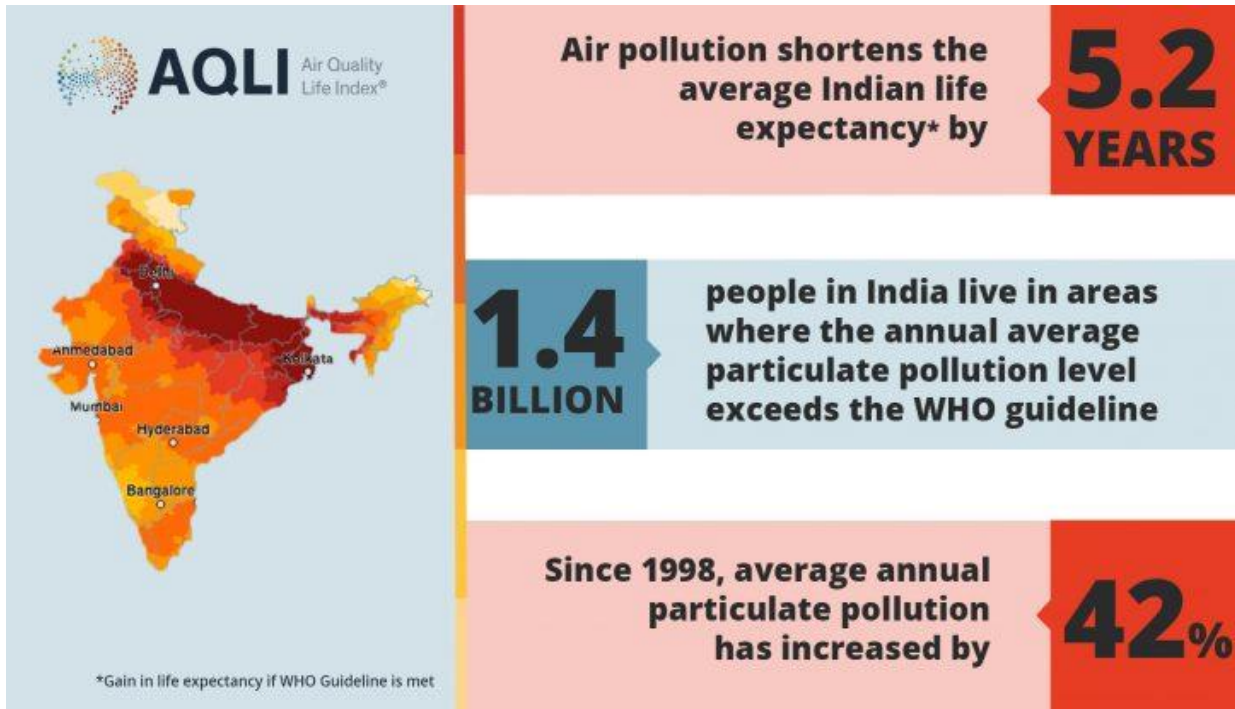
How fine particles affect the body



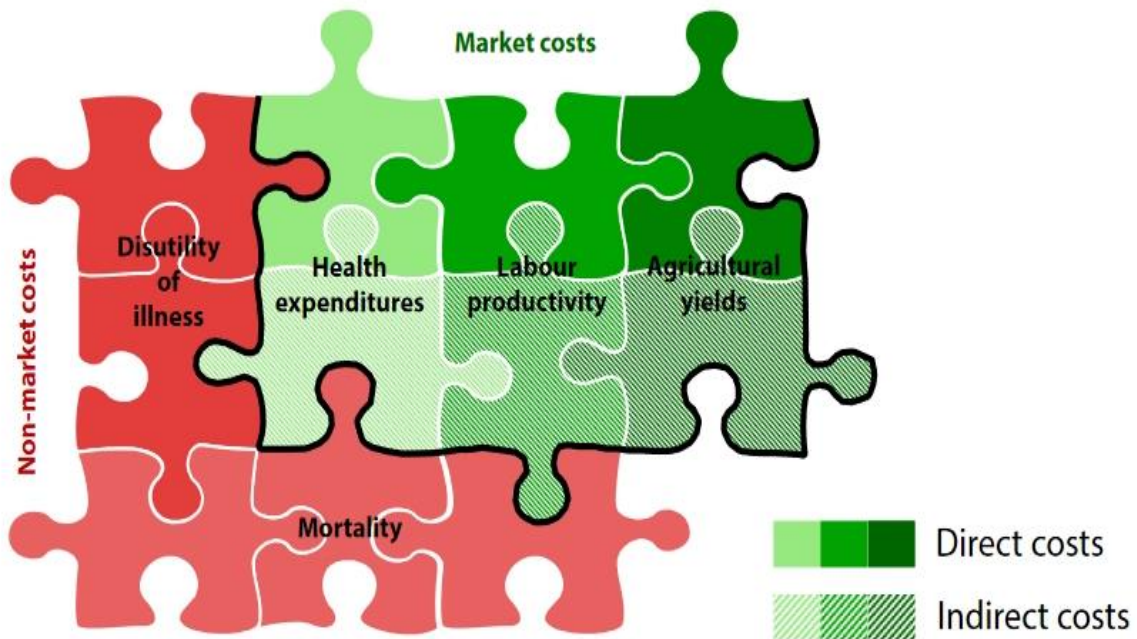
- In 2021, air pollution was a major global killer, contributing to **8.1 million deaths worldwide**.
- The report, published by the **US-based Health Effects Institute (HEI) in partnership with UNICEF**, also highlighted the devastating impact on young children.

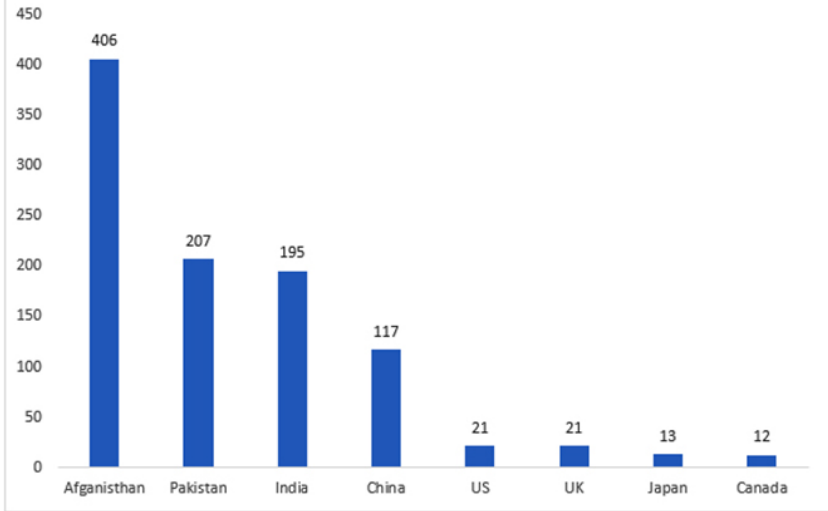


- According to a study published in The Lancet Planetary Health journal, 1.7 million deaths were attributable to air pollution in 2019, which is around 18% of all deaths in India.

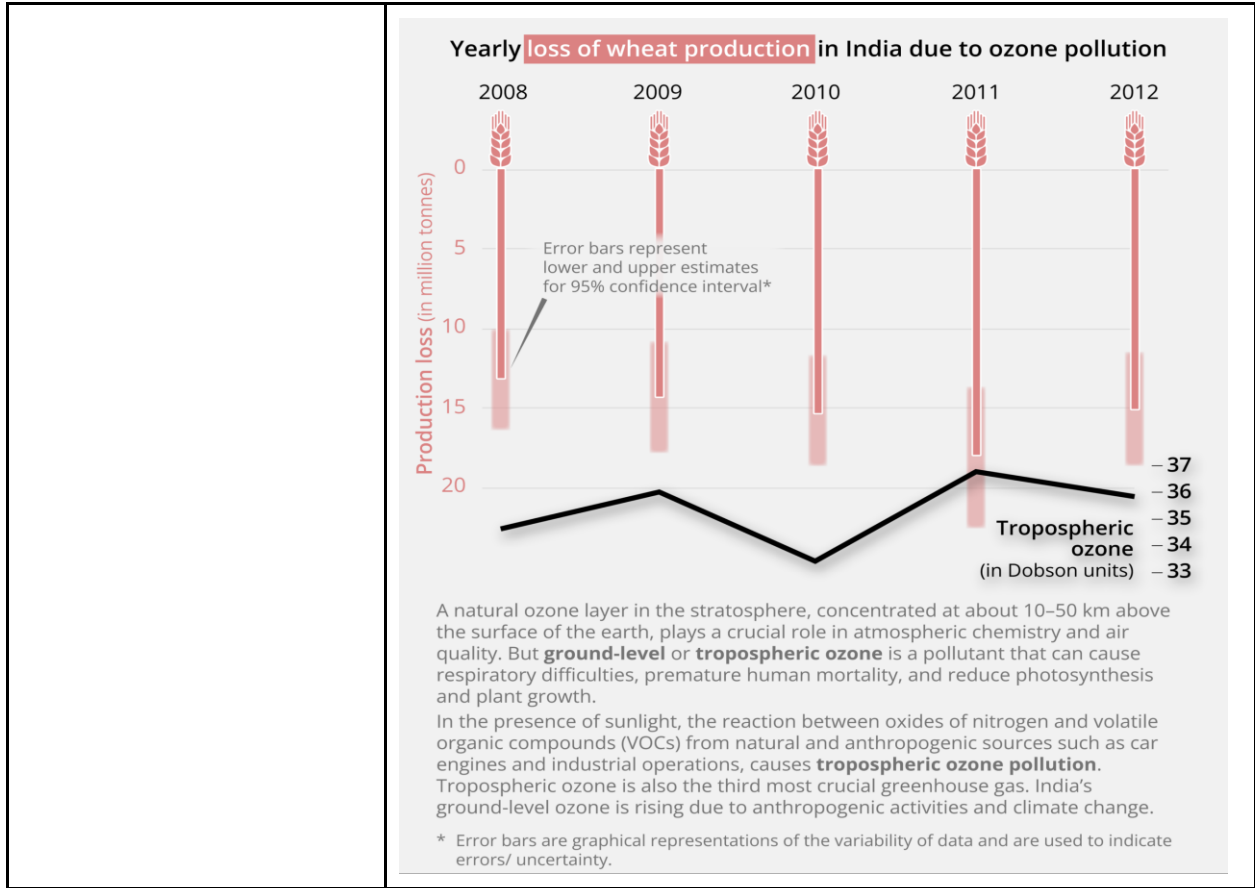


13. What are the Economic impacts of air pollution?



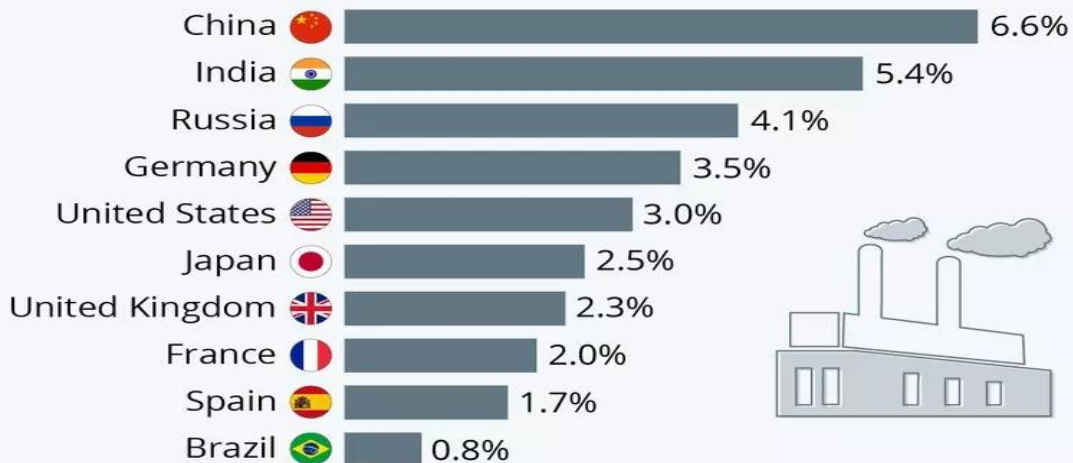
Impact	Analysis																		
<p>Healthcare costs</p>	<ul style="list-style-type: none"> • The World Bank estimates that the health damage caused by air pollution costs \$8.1 trillion a year, equivalent to 6.1% of global GDP. <div data-bbox="586 512 1409 1104" style="text-align: center;"> <p>Country wise Mortality Rate per 1,00,000 due to Air Pollution (2016)</p>  <table border="1" data-bbox="586 596 1409 1104"> <thead> <tr> <th>Country</th> <th>Mortality Rate per 1,00,000</th> </tr> </thead> <tbody> <tr> <td>Afganisthan</td> <td>406</td> </tr> <tr> <td>Pakistan</td> <td>207</td> </tr> <tr> <td>India</td> <td>195</td> </tr> <tr> <td>China</td> <td>117</td> </tr> <tr> <td>US</td> <td>21</td> </tr> <tr> <td>UK</td> <td>21</td> </tr> <tr> <td>Japan</td> <td>13</td> </tr> <tr> <td>Canada</td> <td>12</td> </tr> </tbody> </table> </div>	Country	Mortality Rate per 1,00,000	Afganisthan	406	Pakistan	207	India	195	China	117	US	21	UK	21	Japan	13	Canada	12
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<p>Affects productivity</p>	<ul style="list-style-type: none"> • Air pollution hampers workforce productivity and economic activity and around 1.2 billion work days are lost globally every year, which could reach 3.8 billion days by 2060. • In India, reduced productivity, work absences and premature deaths caused by air pollution cost the economy an estimated \$95 billion or 3% of the country's GDP in 2019. • Despite the EU's recent progress, air pollution still causes €600 billion in losses each year, or 4% of its annual GDP. 																		

	<p style="text-align: center;">Economic impact of Air pollution deaths in 2021</p> <p>The infographic consists of two charts. The top chart is a pie chart with a 3D effect, showing a large orange slice representing 93.9% labeled 'Remaining Global GDP' and a smaller dark red slice representing 6.1% labeled 'Cost of Air pollution deaths'. The bottom chart is a 3D wedge chart, also with a 6.1% label, pointing to a text box that states: '8.1 millions deaths contributed to air pollution costing \$8.1 trillion annually'. The background features a faint world map.</p>
<p>Agriculture</p>	<ul style="list-style-type: none"> • High air pollution affects the global crop yields. As many greenhouse gasses emission contributes to acid rains and smog it affects crop production. • Ground-level ozone and Nitrogen dioxide significantly affect crop yields. • A study indicates that 5% to 12% yield losses globally due to these pollutants and it resulted in around \$20 billion per year loss in the economy



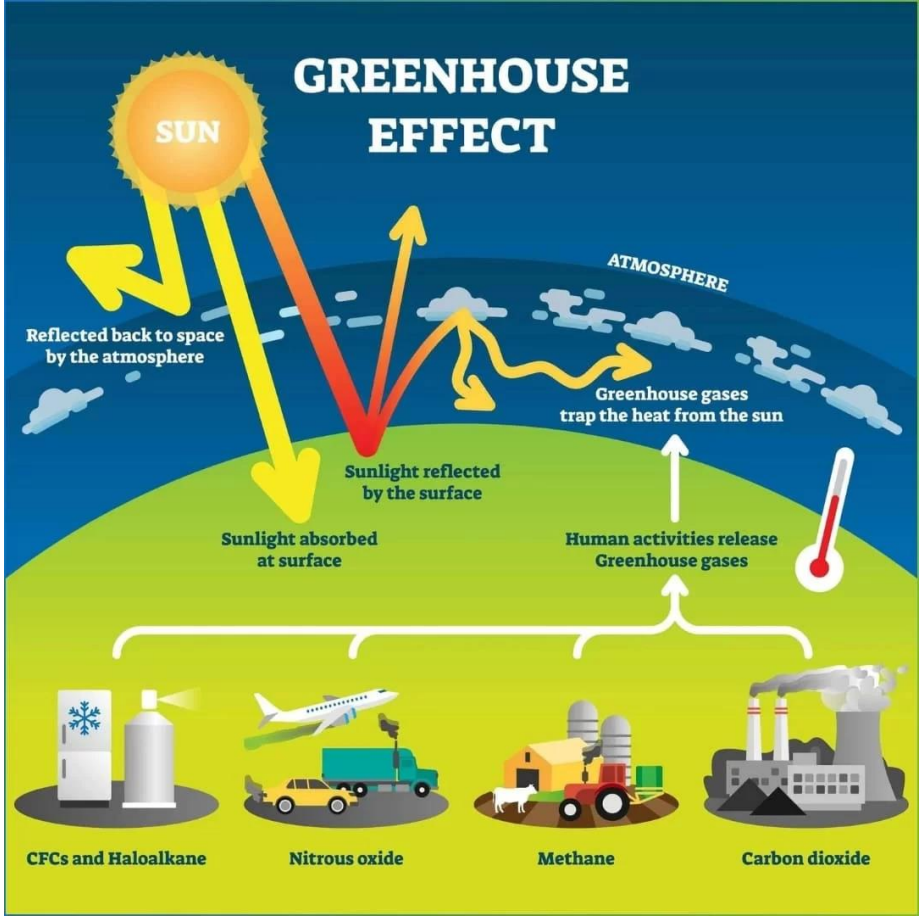
The Economic Burden Of Air Pollution

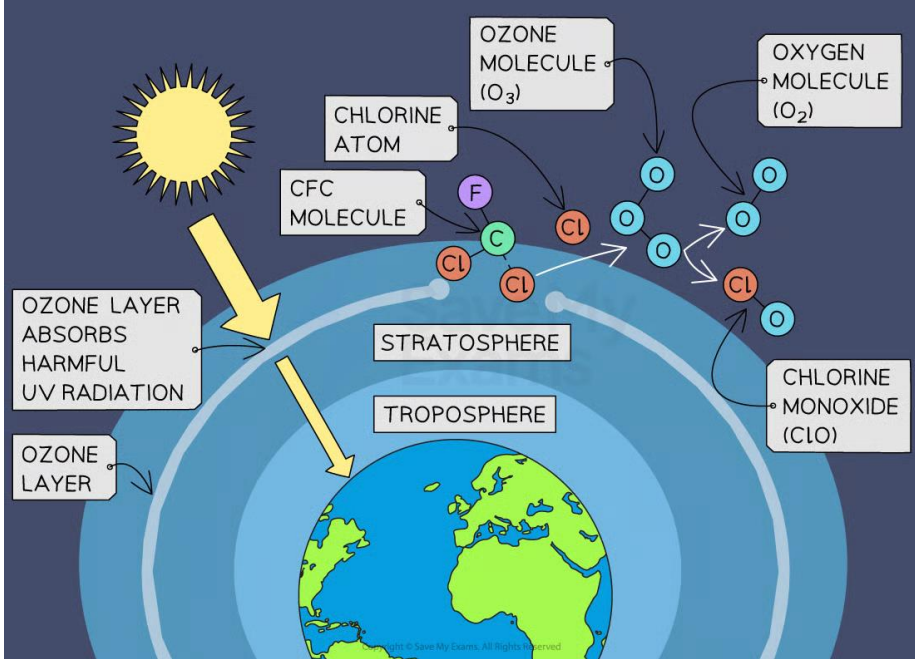
Economic costs of air pollution from fossil fuels as a share of GDP in 2018



14. Mention how air pollution contributes to climate change?

- **Air pollutants** not only severely **impact public health**, but also the **earth’s climate and ecosystems globally**.
- **Air pollution** contributes to climate change in several ways, including:


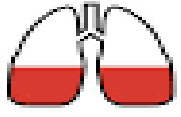





Impact	Analysis
<p>Greenhouse gasses</p>	<ul style="list-style-type: none"> • Air pollutants like methane and black carbon are short-lived climate pollutants (SLCPs) that trap heat in the atmosphere, causing global warming. • Methane is 84 times more potent than carbon dioxide, another greenhouse gas.  <p>The diagram, titled "GREENHOUSE EFFECT", shows the Sun emitting rays. Some rays are reflected back to space by the atmosphere. Some are absorbed by the surface, which then reflects some back. Greenhouse gases in the atmosphere trap the heat from the sun. A thermometer indicates rising temperatures. At the bottom, four sources of greenhouse gases are listed: CFCs and Haloalkane (represented by a refrigerator and a gas canister), Nitrous oxide (represented by a truck and a car), Methane (represented by a farm with a tractor and cow), and Carbon dioxide (represented by a factory with smokestacks).</p>

<p>Ozone depletion</p>	<ul style="list-style-type: none"> • Ozone depletion is the thinning of the ozone layer in Earth's atmosphere, which allows more harmful ultraviolet (UV) radiation to reach the planet. • The main reasons for the ozone hole are chlorofluorocarbons, carbon tetrachloride, methyl bromide and hydrochlorofluorocarbons.  <p>The diagram illustrates the catalytic cycle of ozone depletion. It shows the Sun's UV radiation hitting the Earth's atmosphere. In the stratosphere, a CFC molecule (containing Carbon, Fluorine, and Chlorine) is broken down by UV radiation into a Chlorine Atom and a CFC radical. The Chlorine Atom then reacts with an Ozone Molecule (O₃) to form Chlorine Monoxide (ClO) and an Oxygen Molecule (O₂). The Chlorine Monoxide then reacts with another Ozone Molecule to regenerate the Chlorine Atom and produce another Oxygen Molecule. This cycle repeats, destroying many ozone molecules for each chlorine atom. Labels include: Sun, Ozone Layer, Ozone Layer Absorbs Harmful UV Radiation, Stratosphere, Troposphere, CFC Molecule, Chlorine Atom, Ozone Molecule (O₃), Oxygen Molecule (O₂), Chlorine Monoxide (ClO), and Earth.</p>
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
15. Enlist global initiatives to combat air pollution?

Initiatives	Analysis
<p>Global Methane Pledge</p>	<ul style="list-style-type: none"> • The Global Methane Pledge (GMP) is a voluntary framework supporting nations to take action to collectively reduce methane emissions by 30% from 2020 levels by 2030. • This could eliminate over 0.2°C of warming by 2050.

	<ul style="list-style-type: none"> • The GMP was announced at COP 26 in November 2021 by the European Union and the United States. • As of September 2024, over 155 countries have joined the GMP. • India has opted not to sign the Global Methane Pledge. <div data-bbox="472 604 1416 1180"> <p>Methane Push More than 100 countries have signed up to the Global Methane Pledge</p> <p>■ Signatory</p>  </div>
<p>International Clean Air Day</p>	<ul style="list-style-type: none"> • Since 2020, each 7th of September has been recognised as International Day of Clean Air for Blue Skies (Clean Air Day). • This event recognises the importance of reducing air pollution – the single greatest environmental health risk globally, and one of the main avoidable causes of death and disease globally.

	 <p style="text-align: center;">Invest in #CleanAirNow: The Urgent Call of the 2024</p> <p style="text-align: center;">International Day of Clean Air for Blue Skies</p> <p style="text-align: center;">7 September 2024</p>
<p>BreatheLife campaign</p>	<ul style="list-style-type: none"> • Brea the Life is a joint campaign of the Clean Air and Climate Coalition, World Health Organisation, United Nations Environment Programme, and World Bank to mobilize cities and individuals to protect our health and our planet from the effects of air pollution. <p style="text-align: center;">THE INVISIBLE KILLER Air pollution may not always be visible, but it can be deadly.</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>29% OF DEATHS FROM LUNG CANCER</p> </div> <div style="text-align: center;">  <p>24% OF DEATHS FROM STROKE</p> </div> <div style="text-align: center;">  <p>25% OF DEATHS FROM HEART DISEASE</p> </div> </div> <div style="background-color: #0056b3; color: white; padding: 10px; margin-top: 10px;"> <p>BREATHELIFE. Clean Air. Healthy Future.   </p> </div>

16. Enlist initiatives taken by India to combat air pollution?

Initiatives	Analysis
<p>The Winter Action Plan 2024</p>	<ul style="list-style-type: none"> • Delhi government launched a 21-point winter action plan to combat air pollution, featuring real-time drone surveys and a special task force. <div data-bbox="560 655 1414 1367" style="border: 1px solid black; padding: 10px;"> <p style="text-align: center;">PEOPLE'S PARTICIPATION TO BE KEY</p>  <ol style="list-style-type: none"> 1 Monitoring sources of pollution at 13 hotspots using drones  2 A six-member special task force constituted to monitor pollution and take action 3 Enforcement of dust norms 4 Giving Harit Ratna Award to individuals, agencies, NGOs in private & govt sectors to combat air pollution 5 Operation of mobile anti-smog guns  6 Public participation campaign 7 Controlling pollution caused by vehicles 8 Controlling stubble burning  9 Setting up Green War Room and using Green Delhi app 10 Controlling Industrial pollution 11 Increasing green cover through tree plantation drives  12 Conducting real-time source apportionment study 13 Setting up e-waste eco park 14 Banning firecrackers 15 Strict implementation of GRAP 16 Controlling open waste burning 17 Encouraging work from home and staggering office timings during peak pollution period 18 Encouraging voluntary private vehicle restriction 19 Preparing odd-even scheme, if needed 20 Using artificial rain  21 Dialogue with Centre and neighbouring states </div>
<p>National Clean Air Programme (NCAP)</p>	<ul style="list-style-type: none"> • The National Clean Air Programme (NCAP) was launched in 2019 as a long-term, time-bound, national-level strategy to tackle the country's air pollution problem comprehensively. • NCAP aims to achieve a 20-30% reduction in Particulate Matter concentrations by 2024, keeping 2017 as the base year for comparing concentrations.

BY 2024, POLLUTION CUT BY 30%

NATIONAL CLEAN AIR PROGRAMME (NCAP)

Cities to be covered: 102

GOAL: To meet annual average ambient air quality standards

MID-TERM (5 YEARS) TARGET: Reducing air pollution by 20-30% by 2024, taking 2017 as base year

HOW: Through city-specific air pollution abatement action plan

BUILD CAPACITY BY SETTING UP:

- 1 National emission inventory
- 2 Air Information Centre for data analysis
- 3 Source apportionment studies
- 4 Guidelines for indoor air pollution
- 5 Rural monitoring stations

INTERNATIONAL SUPPORT AGENCIES: World Bank, German development agency (GIZ), AFD (French funding agency), Swiss Development Corporation, Bloomberg Philanthropies

New Commission for Air Quality Management

- The Commission for Air Quality Management (CAQM) was established as a statutory body by the government in August 2021 as an overarching body to carry out air quality management in Delhi NCR.

NEW BOSS TO FIGHT BAD AIR



BEFORE CENTRAL BODY, WHO?

EPCA

- > Supreme Court-backed Environment Pollution (Prevention and Control) Authority on the job since 1998
- > Mandated to protect and improve quality of environment
- > Assisted SC in matters related to noise pollution, hazardous waste, etc, too
- > Drew power from the Environment (Protection) Act, 1986, and implemented various mitigation measures through CPCB

OTHERS

- > Several committees and task forces - both at Centre and NCR states - dealt with air pollution
- > Union environment ministry worked as a coordination body
- > High-level task force, led by principal secretary to PM, reviewed action taken

EPCA and all such committees now stand dissolved with the ordinance

The issue will now be handled by a powerful statutory authority - Commission For Air Quality Management in NCR and Adjoining Areas

COMMISSION TO ADDRESS THREE BROAD ISSUES

- Monitoring of air pollution
- Enforcement of laws after such monitoring
- Research and innovation

COMMISSION TO HAVE CHAIRPERSON PLUS 17 MEMBERS

Key Functions | Take mitigation measures through central/state agencies

Entertain complaints for protecting and improving air quality	Regulate or prohibit activities that may cause or increase air pollution	Lay down parameters for air quality and for emissions or discharge of pollutants	Restrict industrial operation that may cause air pollution
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CPCB AND SPCBS WILL CONTINUE TO DEAL WITH AIR POLLUTION. HOWEVER, THE COMMISSION'S ORDERS PREVAIL IN CASE OF CONFLICT

PENALTY PROVISIONS

- > Non-compliance punishable with a jail term up to 5 years or fine up to Rs 1 crore, or both
- > Appeal can be made only before NGT

DIRECT CLOSURE OF POLLUTING INDUSTRIES

STOP OR REGULATE SUPPLY OF WATER OR ELECTRICITY TO ERRING INDUSTRIES

<p>BS-VI Norms</p>	<ul style="list-style-type: none"> ● BSVI, or Bharat Stage Emission Standard 6, is a set of regulations that control the amount of pollutants emitted by vehicles in India. ● The government of India introduced BSVI in April 2020 to replace BS4 and reduce pollution levels. ● BS6-compliant engines use modern technology like Lean NOx traps (LNTs), selective catalytic reduction (SCR) units, and diesel particulate filters (DPFs) to meet the emission targets. <div data-bbox="568 814 1404 1302" style="border: 1px solid black; padding: 5px;"> <p>Mechanics of BS-VI</p> <ul style="list-style-type: none"> ▶ Bharat Stage VI (BS-VI) norms will take effect in India from 1 April 2020 ▶ BS-VI is the most advanced emission standard for automobiles and is equivalent to Euro-VI norms ▶ In order to reduce vehicular pollution, the government decided to leapfrog from BS-IV to BS-VI ▶ The new norms make on-board diagnostics (OBD) mandatory for all vehicles  <ul style="list-style-type: none"> ▶ The OBD unit can identify likely areas of malfunction by means of default codes stored on a computer ▶ For two-wheelers, manufacturers will introduce a fuel injection system—a first in India </div>
<p>Graded Response Action Plan</p>	<ul style="list-style-type: none"> ● The Graded Response Action Plan (GRAP) is a set of measures that are implemented to reduce air pollution in the National Capital Region (NCR) of India. ● The plan is based on the National Air Quality Index (AQI) and is activated when the air quality reaches a certain level.

Fight against pollution
A look into the city's Graded Response Action Plan to fight air pollution

STAGE 1 MODERATE-TO-POOR QUALITY AIR (PM2.5 above 61µg/m3 or PM10 above 101µg/m3)
 • Mechanized sweeping, washing roads with water
 • Enforcing ban on firecrackers, increased scrutiny of vehicles for pollution standards

STAGE 2 VERY POOR AIR (PM2.5 above 121 µg/m3 or PM10 above 351 µg/m3)
 • Ban on diesel generators
 • Parking fee to surge by 3-4 times
 • Stop use of coal/firewood in eateries
 • Urge people with respiratory or cardiac problems to stay inside

STAGE 3 SEVERELY POLLUTED AIR (PM2.5 above 250µg/m3 or PM10 above 430µg/m3)
 • Increase frequency of road cleaning and washing
 • Shut down of brick kilns
 • Restrictions on operation of coal-based power plants in NCR

STAGE 4 EMERGENCY (also known as severe, PM2.5 above 300 µg/m3 or PM10 above 500µg/m3)
 • Ban entry of trucks (except for essential items)
 • Halt construction work
 • Begin odd-even road scheme for private vehicles

BEGINNING FROM OCT 15
Some of these measures will already kick in from October 15. These are:

1 BAN ON DIESEL GENERATORS | **2 WASHING OF ROADS** | **3 NIGHT PATROLS AT HOT SPOTS**

National Electric Mobility Mission Plan (NEMMP)

- Under **NEMMP 2020**, the Government has launched **Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India)** scheme to promote manufacturing of **electric and hybrid vehicle technology**.

The Mission

National Electric Mobility Mission Plan launched in 2013

Aims to put 6-7 million e-vehicles on roads by 2020

Govt committed to achieve 30% e-mobility by 2030

Automotive Mission Plan 2026 estimates creation of additional 65 million jobs in auto sector

(R&D) initiatives

- **Wind Augmentation and Air Purifying Unit (WAYU):**

- A device developed by the **Department of Science and Technology (DST) and CSIR-NEERI** that can reduce air pollution in **industrial complexes, residential areas, and schools.**
- This device uses wind generators to **dilute pollutants and filters to remove them.**



- **Air Pollution Control Division (APCD):**

- A division of **CSIR-NEERI** that conducts **research on air quality management**, including monitoring, prediction, and simulation.
- The **APCD** also uses **emission inventories** and dispersion modeling to identify impacts.

17. What could be the possible way ahead?

Way ahead	Analysis
<p>Psychological Nudging</p>	<ul style="list-style-type: none"> • New research by the University of Kent has found that using low-cost psychological interventions can reduce vehicle engine idling and in turn improve air quality, especially when there is increased traffic volume at railway level crossings. • Convincing individuals to shift from personal vehicles to public transport or carpooling necessitates a major shift in behavior
<p>Enforcement of Regulations</p>	<ul style="list-style-type: none"> • Implementing and enforcing regulations against forest fires, smoking in public spaces, and the use of firecrackers during festivals require a robust legal framework and effective law enforcement.
<p>Community Engagement</p>	<ul style="list-style-type: none"> • Engaging local champions and communities in clean air initiatives requires sustained efforts in awareness building and community participation. Building a sense of responsibility and ownership among residents can be a game changer in combating air pollution.

<p>Integrated Urban Planning:</p>	<ul style="list-style-type: none"> • Develop and implement comprehensive urban planning that integrates sustainable transportation, waste management, and green spaces. • Prioritize mixed-use developments to reduce commuting distances and promote walkability.
<p>Government Policies and Incentives:</p>	<ul style="list-style-type: none"> • Formulate and enforce policies that promote clean transportation, energy efficiency, and waste reduction. • Provide financial incentives for businesses and individuals adopting eco-friendly practices and technologies.

18. What is the relevance of the topic for UPSC CSE?

- **For Prelims:** Air pollution, Solid Waste Management, National Green Tribunal, National Clean Air Programme, System of Air Quality and Weather Forecasting and Research (SAFAR) Portal, New Commission for Air Quality Management, Graded Response Action Plan

- **For Mains:** Major Driving Factors of Air Pollution, Reasons for Persistent Air Pollution in India Despite Significant Initiatives

Some previous years prelims questions.

Q1 According to the Environmental Protection Agency (EPA), which one of the following is the largest source of sulfur dioxide emissions? (2024)

- (a) Locomotives using fossil fuels
- (b) Ships using fossil fuels
- (c) Extraction of metals from ores
- (d) Power plants using fossil fuels

Ans: (d)

Q2. In the context of WHO Air Quality Guidelines, consider the following statements: (2022)

1. The 24-hour mean of PM_{2.5} should not exceed 15 µg/m³ and annual mean of PM_{2.5} should not exceed 5 µg/m³.
2. In a year, the highest levels of ozone pollution occur during the periods of inclement weather.
3. PM₁₀ can penetrate the lung barrier and enter the bloodstream.
4. Excessive ozone in the air can trigger asthma.

Which of the statements given above are correct?

- (a) 1, 3 and 4
- (b) 1 and 4 only
- (c) 2, 3 and 4
- (d) 1 and 2 only

Ans: (b)

Q3. In the cities of our country, which among the following atmospheric gasses are normally considered in calculating the value of the Air Quality Index? (2016)

1. Carbon dioxide
2. Carbon monoxide
3. Nitrogen dioxide
4. Sulfur dioxide
5. Methane

Select the correct answer using the code given below:

- (a) 1, 2 and 3 only
- (b) 2, 3 and 4 only
- (c) 1, 4 and 5 only
- (d) 1, 2, 3, 4 and 5

Ans: (b)

Some previous years mains questions.

Q1. Describe the key points of the revised Global Air Quality Guidelines (AQGs) recently released by the World Health Organisation (WHO). How are these different from its last update in 2005? What changes in India's National Clean Air Programme are required to achieve revised standards? (2021)

Some questions from this year and previous years interview transcripts.

Board Lieutenant General Raj Shukla sir:

- Why is there air pollution in delhi?

Board Sheel Vardhan Sir:

- What is NGT? its role, why and when it was set up ?
- So do you think NGT has really made an impact?

- Why do we take actions when air is polluted and not put limitations on when it is clean to maintain the good AQI?

Board Suman Sharma mam:

- How Delhi air is polluted by parali from Punjab?
- If you are DM in Punjab, how will you solve it?

Board Suman Sharma mam:

- What are we doing for air and water pollution?

Board BB Swain sir:

- How to tackle stubble burning?
- Tell an issue of stubble burning apart from pollution.

Board Sheel Vardhan Singh sir:

- Tell me why groundwater is getting polluted? and solutions.
- As we know there is stubble burning in states surrounding NCR, what are its solutions?
- How will you pursue farmers in this case at an individual level?

Some questions for QUIZ.

Q1. Consider the following pollutants:

1. Nitrogen dioxide
2. Sulphur dioxide
3. Ammonia
4. PM 10
5. Ground-level ozone
6. Lead

How many of the above pollutants are considered in the calculation of AQI?

- (a) Only three
- (b) Only four
- (c) Only five
- (d) All six

Ans: (d)

Some questions for POLL.

Q1. Are you satisfied with the steps taken to combat Air pollution in the Delhi region?

- (a) YES
- (b) NO
- (c) Can't say.

Q2. Are developed countries spending enough to combat pollution?

- (a) YES
- (b) NO
- (c) Can't say.

