



TARGET PRELIMS 2024

BOOKLET-12; EB&CC-2

AIR POLLUTION

1. TABLE OF CONTENTS

1. <i>Table of Contents</i>	0
2. <i>Pollution and Pollutants</i>	2
3. <i>Air Pollution</i>	2
1) CO ₂	3
2) Suspended Particulate Matter (SPM).....	3
A) PM2.5.....	3
B) PM10.....	3
3) Carbon monoxide.....	4
4) Ozone	4
5) Nitrogen dioxide	5
6) SO ₂	6
7) Benzene	7
8) Ammonia	7
9) Smog.....	9
10) Aerosol Pollution.....	10
11) Fly Ash.....	11
12) Indoor Air Pollution	13
A) Radon (Rn ²²²)	14
13) Pet Coke (Petroleum Coke) and Associated Issues	14
14) Fuel Oil/ Heavy Oil/ Furnace Oil -> Issues Concerning Them	15
15) Agri-Subsidy and Air Pollution	15
16) WHO's Air Quality Guidelines	16
4. <i>Institutions, Initiatives, Schemes, Programs etc.</i>	16
1) Central Pollution Control Board (CPCB)	16

2)	Air (Prevention and Control of Pollution) Act, 1981	17
3)	Environment Pollution (Prevention and Control) Authority (EPCA) [1998 - 2020].....	17
4)	The Commission for Air Quality Management in National Capital Region and Adjoining Areas ..	17
5)	Graded Response Action Plan (GRAP).....	18
6)	National Clean air Program	21
7)	Bharat Stage Emission Standards (BS Norms)	22
8)	Petrol Vs Diesel Comparison.....	23
9)	Natural Gas	24
5.	<i>Recent Air Pollution Issues</i>	25
1)	Delhi's Air pollution Problem	25
2)	Ban on Coal and Other Unapproved Fuel in Delhi (Jan 2023)	26
3)	Stubble Burning – CClass discussion.....	27
A)	Pusa Decomposer	27
4)	Fire crackers.....	27
5)	NGT Bans Fire Crakers (Nov 2020)	28
6)	Petroleum and Explosive Safety Organization (PESO)	28
7)	Green Crackers.....	29
8)	Smelting Industry and Pollution	29
9)	Odour Pollution.....	30
6.	<i>Various Air QUality measuring Initiatives in India</i>	31
1)	National Air Quality Monitoring Programmes (NAMP)	31
2)	NAAQS (National Ambient Air Quality Standards) by CPCB.....	31
3)	Air QUality Index (AQI).....	31

2. POLLUTION AND POLLUTANTS

- Pollution refers to introduction of harmful materials (pollutants) into environment.
- Many things which are useful to people produce pollution.
 - » **Vehicles, Electricity production, Fertilizers, Pesticides, Plastic etc.**
- **There** are various types of pollution - Air Pollution, Water Pollution, Soil/Land pollution, plastic pollution, noise pollution, light pollution etc.
- There are various ways of classifying pollutants:
 - i. **Primary vs Secondary**
 - **Primary Pollutants:** It is an air pollutant emitted directly from the source.
 - Examples of primary pollutants: (Particulates, CO, NO₂, SO₂ etc.)
 - **Secondary Pollutant:** It is not directly emitted from the source as such, but forms when other pollutants (primary pollutants) react in the atmosphere.
 - Examples of secondary Pollutants: (Ozone, NO₂, Acid Rain, Haze (Organic Aerosol))
 - ii. **Quantitative Pollutants vs Qualitative Pollutants**
 - **Quantitative Pollutant:** These substances are naturally present in environment. They become problematic only when their quantity increase.
 - **Qualitative Pollutant:** These are not naturally present in environment and are introduced in environment by human activities. E.g., Fungicide, herbicide etc.
 - iii. **Persistent Pollutant vs Non-Persistent Pollutant**
 - **Persistent Pollutants** are those pollutants which remain consistent in the environment for a long period of time without any change in its original form. (For e.g., nuclear wastes, pesticides, plastics etc.)
 - **Non-Persistent Pollutants** are the opposite of persistent pollutants and breakdown in the simple form.
 - iv. **Biodegradable vs non-Biodegradable**
 - Biodegradable pollutants are the pollutants which can be decomposed by micro-organisms.
 - **Non-biodegradable pollutants** are those which are not decomposed by microbial action (e.g., plastics, glass, DDT, salts of heavy metals etc.)
 - v. **Natural vs Anthropogenic**

3. AIR POLLUTION

- 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: WHO.

- **Sources** of Air pollution:
 - Vehicular emissions, industrial fuel burning, energy production, forest fires, household combustion etc. are important sources of air pollution.
- **Pollutants** of major public health concern include PM, CO, Ozone, NO₂, SO₂, Smog, Hydrocarbon, CFCs etc.

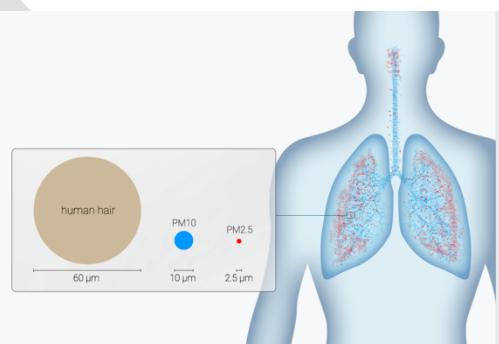
1) CO₂

It is a greenhouse gas which results into global warming.

2) SUSPENDED PARTICULATE MATTER (SPM)

A) PM2.5

- PM2.5 is defined as ambient airborne particulates (including dust, soot, dirt, smoke, and liquid droplets) that measure upto 2.5 microns in size. These particles include a range of chemical makeups and come from a range of source.
- **Main sources** include fossil fuel powered vehicles, power generation, Industries, Agriculture and biomass burning etc.
 - **Chemical reaction between gases** can also be a source of PM2.5 This include reactions between: SO₂, NO₂, Ammonia, Black carbon, Mineral dust, water, volatile organic carbon.
- Among criteria pollutants commonly measured in real time, fine particulate matter (PM2.5) is currently understood to be the most harmful to human health. Due to very small size, they can remain suspended in air for long periods and the microscopic size allows these particles to be absorbed deep into the bloodstream upon inhalation.
- **Exposure to PM2.5** have been linked to negative health effects like cardiovascular diseases, respiratory illness, premature mortality, low birth weight, and stroke.
- **PM2.5 can also cause negative environmental impact:** Damage to materials and buildings; Acid Deposition; increase ozone levels.



B) PM10

- **PM10** are suspended coarse particles, either solid or liquid, with a diameter of 10 micrometers or less. For comparison, a human hair is, on average, 50 to 70 micrometers in diameter. They are also sometimes referred to as floating dust or aerosols.
- **Difference between PM2.5 and PM10**
 - **Size:** PM2.5 is very fine, and PM 10 is larger and coarser.
 - **Less Harmful:** PM10 is less likely to cross from lungs to the bloodstream. Though they can penetrate deep into lungs.
- **Various sources:**
 - Smoke, Dust, and dirt from unsealed road, construction, landfill and agriculture

- Pollen
- Mold
- Smoke
- Industrial sources
- Fossil fuel burning
- Sea Salt

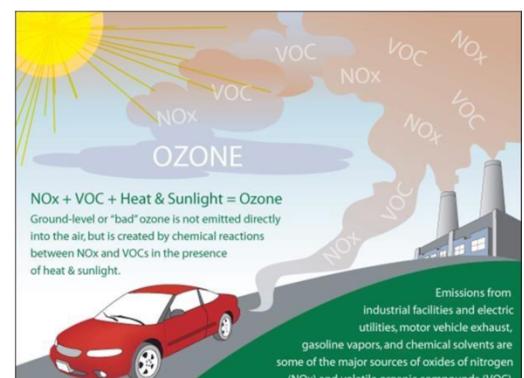
- **Health Impact:**
 - **Short term** - Difficulty breathing; coughing; eye, nose and throat irritation; Chest tightness and pain; Fatigue; General respiratory discomfort.
 - **Long term impact:** Heart failure, asthma, heart failure, cancer, adverse birth outcomes etc.
- **Environmental Impact:** Can corrode organic and inorganic material from vegetation to buildings. Painted surfaces, stone, fabrics, metal, and wood can become damaged and discolored.

3) CARBON MONOOXIDE

- CO is an odorless, colorless, and tasteless gas produced by the incomplete combustion of carbon in fossil fuels such as wood, propane, charcoal, oil, coal or other fuel.
- **Carbon monoxide Poisoning:** It occurs when carbon monoxide builds up in your bloodstream. When too much CO is in the air you're breathing, your body replaces the oxygen in your RBCs with carbon monoxide. This prevents oxygen from reaching your tissues and organs.
 - **Science behind this:**
 - Hemoglobin binds carbon monoxide (CO) 200 to 300 times more with oxygen, resulting in the formation of carboxyhemoglobin and preventing the binding of oxygen to hemoglobin due to competition of the same binding sites.
 - **Signs and symptoms** of CO Poisoning: Dull headache, weakness, dizziness, nausea or vomiting, shortness of breath, confusion, blurred vision, loss of consciousness etc.
 - It can particularly be dangerous for people who are sleeping or intoxicated. People may have a irreversible brain damage or even die before they realize the problem.

4) OZONE

- **Ozone (O_3)**
 - Ozone is a gas composed of three atoms of oxygen (O_3).
 - » **Key Properties:** It is a bluish gas. It is also a major oxidant.
 - It occurs in both earth's upper atmosphere and at ground level.
 - Ozone can be "good" or "bad" for health and the environment depending on where it's found in atmosphere.
- **What is Ground Level Ozone Pollution?**
 - Ozone pollution is a **secondary pollution** and is not emitted by source directly. It is created by chemical reactions between oxides of Nitrogen (NOx) and Volatile Organic Compounds that are



emitted from combustion sources like vehicles, industry, power plants etc. in **the presence of sunlight and heat.**

- It is most likely to reach unhealthy levels on hot sunny days in urban environment. It may also reach high level during colder winter months because of high pollution and sunlight.
- Since it can also be transported for long distances by wind, it may also impact rural areas.

- **Unprecedented Ozone Levels have made Delhi Air More Toxic: CSE analysis (June 2022)**
- **Why increasing in Delhi**
 - High level of pollution, with high sunshine and high ambient temperatures.
- **Negative Impact of Ozone Pollution**
 - **Health Impacts** -> Breathing problems, chest pain, cough, throat irritation; Further people with certain genetic conditions, and people who have lower intake of Vitamin C and Vitamin E are at greater risk of Ozone exposure.
 - **Environmental Impact** -> impact sensitive vegetation during growing season
- **Monitoring of Ozone**
 - **NAAQS (National Ambient Air Quality Standards)** by CPCB measures Ozone
 - AQI and SAFAR measurements also has listed ozone as a pollutant which is regularly measured.
- **Increase in Ozone levels even during lockdown: CSE Study (June 2020): Class Discussion**

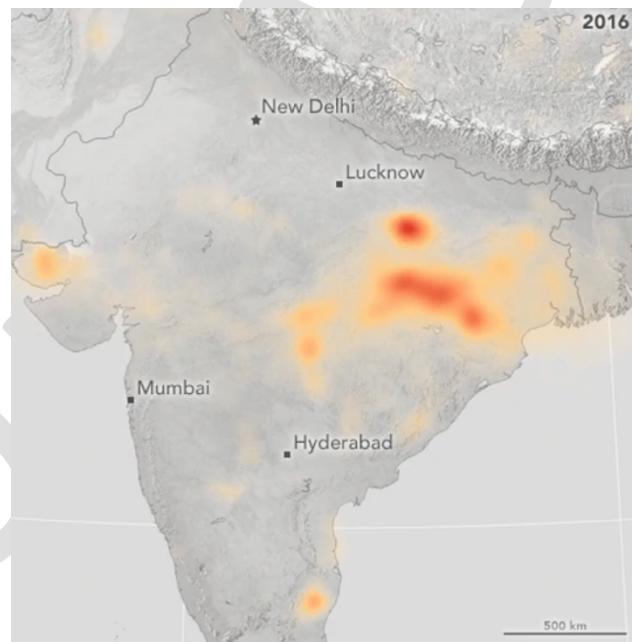
5) NITROGEN DIOXIDE

- **Details**
 - **Physical features:** It is a deep red-orange gas and when released into the air, it is seen as a reddish-brown haze. It has a pungent and acrid odour.
 - NO₂ is a major contributor in the formation of Smog and a precursor to many harmful secondary pollutants, including ozone and particulate matter. It is highly reactive with other chemicals and is strong oxidizing agent.
 - **Sources of NO₂**
 - **Natural Sources:**
 - Lightning Strikes
 - Volcanoes
 - Oceans
 - Biological decay
 - **Manmade sources:**
 - **Combustion** creates oxides of nitrogen, a major portion of which is nitrogen dioxide. When vehicles emit oxides of nitrogen, 90-95% of the emissions are nitric oxide (NO). However, nitric oxide quickly oxidizes in outdoor air when reacting to oxygen, ozone, and volatile organic carbons (VOCs) to form nitrogen dioxide.
 - **It is both a primary and secondary pollutant.**
 - As primary pollutant, NO₂ is emitted in limited amounts through vehicles.

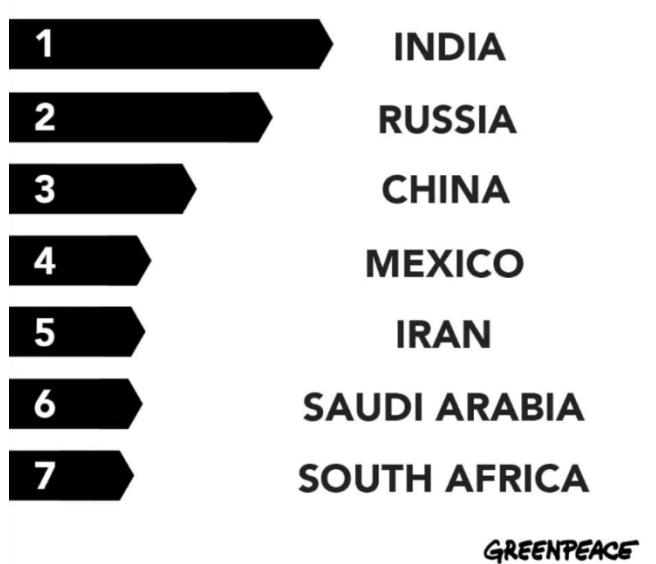
- It is also a secondary pollutant as it can be formed through oxidation. Nitrogen dioxide further oxidizes into **Nitric Acid (HNO₃)**, which can enter the environment through the ground as droplets or nitrate containing particles.

6) SO₂

- **Basics**
 - SO₂ is a colorless gas which has a nasty, sharp smell. It reacts with other substances to form harmful compounds, such as sulfuric acid, sulfurous acid, and sulfate particles.
- **Main Sources** - Burning of Fossil fuels and ships, locomotives using furnace oil/ heavy oil; Other small sources are - **industrial processes** like extracting metal from ore; nature sources such as volcanoes.
- **Why Sulphur dioxide pollution is problematic?**
 - **Health Issues:** Respiratory diseases; contribute to PM pollution.
 - **Environmental Issues ->**
 - **Harm trees and plants** -> Damaging foliage and decrease growth of trees and plants.
 - **ACID Rain** -> harms sensitive ecosystem
 - **Damage Cultural Heritage**
 - Deposition of sulfur particles may cause discoloration and damage of monuments, statues etc.
 - The fine particles may reduce visibility (Haze)
- **India has emerged as the largest SO₂ emitter in the world: NASA data.**
 - India has **highest number (more than 15%) of all anthropogenic SO₂ hotspots** in the world detected by the **Ozone Monitoring Instrument (OMI)** satellite. These include Singaruli, Nevyeli & Chennai, Talcher & Jharsuguda, Korba, Kutch etc.
- **Key reasons for High Sulphur pollution in India**
 - **Nearly all the SO₂ emission in India** comes from coal burning power plants which are the major source of energy for India.
 - The vast majority of power plants in India lack flue-gas desulfurization technology to reduce their air pollution.



Worst emitters of SO₂ pollution in the world



- **Note: Flue Gas Desulfurization (FGD)** is a set of technologies used to remove SO₂ from exhaust gas of fossil fuel based power plants.

7) BENZENE

- **Details**
 - Benzene (C₆H₆) is an aromatic, organic compound with a single six-member unsaturated carbon ring. It is clear, colorless, volatile, highly inflammable liquid with a characteristic order and a density of 874/m³.
 - Benzene in air mostly occurs in vapor phase, with residence times varying between 1 day to two weeks, depending on the environment, the climate and the concentration of other pollutants.
 - It is an **air pollutant** emitted from gasoline stations, motor vehicle exhausts and fuel evaporation, the burning of coal and oil, and various other sources. Urban areas generally have higher ambient air concentration of benzene than other areas.
 - **Indoor sources** of benzene pollution are material used in construction, remodeling, and decorating. Benzene is also present in particle board, furniture, plywood, fiberglass, flooring adhesives, paints, wood paneling, paint removers etc. Therefore, new buildings or recently decorated indoor environments have been associated with high concentration of benzene from materials and furnitures. Use of **fuel for space heating** like coal, wood, gas, Kerosene, LPG etc. also produce benzene.
 - **Negative Health Impacts of Benzene**
 - » Cancer, damage to immune system, neurological, reproductive or developmental issues.
 - In addition of being an air pollutant, it may also pollute water.
- **Joint Committee by NGT**
 - The joint committee consisted of officials from MoEF&CC, CPCB, SPCBs, NEERI etc. The committee was directed to assess the ambient air quality levels in the state, especially in major cities of Kerala.
 - **Key findings**
 - » Petrol refueling stations were a major source of benzene emissions, volatile organic compounds, and particulate matter 2.5 concentration.
 - **Key recommendations**
 - » Installation of vapor recovery systems at the fueling stations
 - » Retrofitting of diesel vehicles with particulate filters to improve air quality.
 - » Stringent action against industrial units that don't comply with emission norms.
 - » Retrofitting of emission control devices of generators and replacing diesel generators with gas-based ones.
 - » Promoting battery operated vehicles and banning old diesel vehicles in a phased manner, greening of open areas, and creation of green buffers along traffic corridors.

8) AMMONIA

- **About Ammonia**
 - Ammonia is a colorless gas with characteristics pungent odor.
 - **Natural sources** include decaying organic matter and animal waste.

- **Manmade sources** include fertilizer manufacturing, waste disposal sites, industrial processes etc.
- It doesn't last long in environment and thus doesn't bio-accumulate.

- Applications

- 80-90% of ammonia all over the world is used for **making fertilizer** (ammonium nitrate is an important nitrogen fertilizer)
- It is a precursor of various nitrogenous compounds. Virtually, all synthetic nitrogen compounds are derived from ammonia.
- It is also used in making household cleaners, plastics, dyes, pharmaceuticals etc.
- It is an anti-septic and is used in food preservation industry.
- Scientists are also experimenting with using ammonia as a storage of renewable energy. (Nitrogen gas and water use energy to convert into Ammonia). Later Ammonia can be used a fuel in the fuel cell.

- Ammonia Pollution

- Majority of airborne ammonia comes from fertilizers.
- Ammonia can also contribute to formation of PM_{2.5} (ammonia combines with VOC, NO_x, SO₂ etc. to form PM_{2.5})



- Health Impacts:

- At higher concentration ammonia is toxic, caustic, and hazardous. Exposures at high levels of ammonia can be irritating to a person's skin, eyes, throat, lungs, and cause coughing and burns.
- **Long term health concerns** associated with Ammonia exposure include – severe cardiovascular and respiratory effects, decreased lung function, asthma aggravation, premature death etc.

- Environmental Impacts -> Eutrophication, Soil Acidification; biodiversity loss -> promote species which prefer nutrient fueled growth to outcompete other species.

- Indo-Gangetic Plain Global Hotspot of atmospheric Ammonia: Study by IIT KGP (Dec 2020)

- The study titled “**Record high levels of atmospheric ammonia over India: Spatial and temporal analysis**” has been published in the international Elsevier journal “*Science of the Total Environment*”. In this study, the seasonal and inter-annual variability of atmospheric ammonia emitted by the agricultural sector was analyzed and the key highlights have raised certain concerns:
 - » The general trend in atmospheric ammonia over India is negative in most seasons. But, in USA, China and Europe, this trend is positive.
 - » For the period 2008-2016, the atmospheric ammonia during the month of June to Aug have grown rapidly at a rate of 0.08% annually.
 - » The Indo-Gangetic Plain is a global hotspot of atmospheric ammonia.
 - **Reason:** Intense agri activity and a lot of fertilizer use and production
 - » Atmospheric Ammonia has a positive correlation with Fertilizer use, hot weather (high temperature supports volatilization) and fires.

- » It has a negative correlation with total precipitation as wet deposits helps in the removal of ammonia.

- Water Pollution

- An ammonia concentration of upto 0.5 ppm (BIS) is maximum limit for drinking water. But, if the ammonia concentration is more than 1 ppm, it would negatively impact our health in long run. Similarly, ammonia concentration of more than 1 ppm in water bodies is dangerous for fish population.
- **High Ammonia Concentration in Yamuna River** is regularly disrupting water supply in Delhi.
 - For e.g., in July 2020, the ammonia concentration in Yamuna River reached 3 ppm. This led to reduction of water supply from Yamuna for Delhi, as Delhi Jal Board doesn't have technology to treat this high concentration of water.
- **Why ammonia pollution is so high?**
 - Industrial units of Sonipat and other drains joining the river along the way may be contributing to this.
- **Way Forward – Precision agriculture; Regulation of discharge; Reducing Nitrogen feed to animals; Improving water treatment technology; maintaining ecological flow of water.**

9) SMOG

- Smog

- Smog is a kind of air pollution, originally named for the mixture of smoke and fog in the air.
 - » **Classical smog** results from the large amount of coal burning in the area and is caused by mixture of Sulphur dioxide and smoke.
 - » Today, **most of the smog** that we see is **Photochemical Smog** (or ground level Ozone). It is produced when Nitrogen oxides in presence of **sunlight** react with **Volatile Organic Compounds (VOCs)** in the atmosphere.
 - **Nitrogen oxides** come from car exhaust, coal power plants, and factory emissions.
 - **VOCs** are released from petrol, paints, and many cleaning solvents.
 - When sunlight hits these chemicals, they form airborne particles and ground-level Ozone or Smog.

- Harmful impacts of SMOG

- **Health Impacts:** Ground level ozone, SO₂, NO₂, CO are especially harmful for senior citizens, children, and people with heart and lung conditions such as bronchitis and Asthma.
 - It may inflame breathing passage, impacting the functioning of lungs thus causing breathlessness, wheezing and coughing. It can also cause irritation to eyes and nose. It also dries out the protective membrane of the nose and throat and interfere with the body's



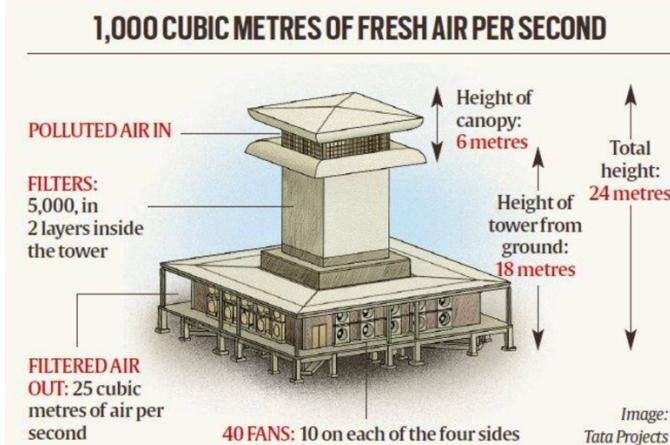
ability to fight infection, increasing susceptibility to illness.

- **By decreasing visibility**, it slows down traffic and increases the chance of accidents.
- Smog also negatively affects the **aesthetics** of the city by making sky brown and gray.

- **Supreme Court verdict:**

- **The Supreme Court** in Nov 2019 asked the CPCB and the Delhi government to come up with a road map on installing smog towers in the NCR to combat air pollution. In Jan 2020, the SC directed that the two towers should be installed by April as a pilot project.

- **Components of Delhi's first Smog tower by Government of Delhi:**



- The tower uses a '**down draft air cleaning system**' developed by University of Minnesota.
 - Polluted air is sucked in at a height of 24 meters, and filtered air is released at the bottom of the tower, at a height of about 10 meters from the ground.
 - When the fan at the bottom layer operates, the negative pressure created sucks in the air from the top. The 'macro layer' in the filter traps particles of 10 microns and larger, while the 'micro layer' filters smaller particles of around 0.3 microns.
 - This method is **different from the 'Updraft system'** - in which air is sucked in from the ground and is propelled upwards by heating and convection. Filter air is released at the top of the tower.
- **Expected Impacts**
 - Computational fluid dynamics modelling by IIT Bombay suggest that towers could have an impact on air quality of upto 1 KM.
- **Criticism**
 - Experts say that there isn't enough evidence to show that Smog towers work.

10) AEROSOL POLLUTION

- **What is aerosol?**

- » An aerosol is a **mixture of tiny particles suspended in a gas**, typically air. This particle can be solid, liquid, or a combination of both. These particles can range in size from a few nanometers to several tens of micrometers and can be produced naturally or by human activities.
 - » **Examples of natural aerosols** include dust, pollen, sea salt, and volcanic ash.

- » Examples of Human made aerosols include smoke, soot, exhaust fumes from vehicles, and particles generated by industrial processes like mining and manufacturing. They include PM2.5 and PM10.
- Impacts that aerosols can have:
 - » On Human Health: they may cause respiratory problems and exacerbating heart disease.
 - A study published in Science Advances showed that excess infant deaths in India were estimated to be three million - the highest among the eight regions evaluated in the study.
 - » On Environment: They can contribute to climate change by altering the balance of radiation in the atmosphere and affecting cloud formation.
- Aerosol Optical Depth (AOD):
 - » It is a measure of how much atmospheric aerosols, such as smoke, dust, and pollution, are scattering and absorbing sunlight.
 - It is typically measured using specialized instruments that detect the amount of light that is scattered or absorbed by aerosols in the atmosphere.
 - It is the quantitative estimate of the aerosol present in the atmosphere and it can be proxy measurement of PM2.5.
 - » The value of AOD range from 0 and 1. 0 indicating crystal-clear sky with maximum visibility whereas a value of 1 indicates very hazy conditions.
 - » AOD value less than 0.3 falls under green zone (safe), 0.3-0.4 is the blue zone (less vulnerable), 0.4-0.5 is orange zone (vulnerable) while over 0.5 is the red zone (highly vulnerable)
- Aerosol Pollution in West Bengal and Bihar (Nov 2022)
 - A study by Bose Institute in Kolkata as revealed that aerosol pollution in WB is anticipated to rise by 8% and continue to remain in the "highly vulnerable" red zone for aerosol pollution. This is the second highest forecasted aerosol pollution level in the country after Bihar.
 - India's regional weather patterns and topography makes the country highly vulnerable to aerosol pollution.
- Why?
 - West Bengal receives Indo-Gangetic Plain air pollution outflows and its local emissions have put WB in the highly vulnerable zone.

11) FLY ASH

- Introduction
 - Fly ash is a coal combustion byproduct produced in coal based thermal power plants. It refers to ash that is driven out of coal fired boilers together with the flue gases.
 - In modern coal fired power plants, fly ash is captured by electrostatic precipitators or other particle filtration equipment before the flue gas reaches the chimney.
 - The composition of fly ash varies considerably, but all fly ash includes substantial amount of Silicon di oxide (SiO₂), Aluminium oxide (Al₂O₃) and Calcium oxide(CaO), the main mineral compounds in coal-bearing rock strata.
 - **Note:** The ash that falls to the bottom of the boiler is called bottom ash.

- **Key characteristics of fly ash**
 - **Harmful for human health:** Fly ash contains toxic constituents like lead, cadmium, chromium, arsenic which can be very dangerous for human health. They contribute heavily to particulate matters in air and cause lung problems.
 - **Bad for environment**
 - Toxic content results in both soil pollution and water pollution (toxic leaching)
 - **Affects large land area.**
 - If fly ash is not captured at the power plant itself, it spreads easily through air and affects large land area.
 - **It is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water.** Hence it can be used in construction process.

- **Reducing Fly Ash pollution**
 - Washing the coal at its place of origin is an important step which ultimately reduces the amount of ash being produced.
 - Increasing R&D, for enhancing the efficiency of power plants, would also help in reducing the ash content.
 - Capturing fly ash before it is released in air by Chimney using various types of precipitators.

- **Where can the captured fly Ash be used?**
 - Cement industry uses Fly Ash in the manufacturing of Portland Pozzolana Cement.
 - Recently, scientists at IIT-Hyderabad have found ways to turn fly ash into products like paints, textile coatings etc.
 - It can also be used fly ash bricks/blocks/ and tiles manufacturing, road embankments construction etc.
 - Fly ash may also be utilized in agriculture as soil conditioners.
 - It is also used as a substitute of soil/sand for reclamation of low lying areas.
 - In mining it can be used for backfilling of mines.

- **Steps taken to promote the use of Fly Ash?**
 - i. **Various notification for fly ash utilization** since 1999
 - The **2016 notification** calls for every agency engaged in construction activity within a radius of 300 km of coal-based thermal power plant to use ash based products for construction.
 - It also mandates the use of ash-based bricks or products in all government schemes and programs.
 - ii. **Maharashtra** is the first state to have a Fly Ash Utilization Policy. It is also looking to export fly ash to countries like Singapore and Dubai where it is in demand.
 - iii. **GST rates** on fly ash and its products have been reduced to **5%**.
 - iv. Launching of **ASHTtrack Mobile App** for better management of fly ash produced by thermal power plant in Feb 2018.
 - It will act as an interface between fly ash producers (thermal power plants) and potential ash users such as road contractors, cement plants etc and thus will help in increasing the utilization of fly ash being produced at coal based thermal power plants.
 - v. **Various awareness campaigns**

- Through workshops and other programs.
- **Draft Fly Ash Notification (2021)** - it is the proposed 5th amendment to the 1999 fly ash notification.
 - It introduces a concept of 3-5 years compliance cycle to achieve a target of 100 percent fly ash utilization by the end of cycle.
 - It also gives an extension of 10 years to power plants to progressively utilize their legacy ash.

12) INDOOR AIR POLLUTION

- Indoor Air Pollution or Household Pollution is the air pollution whose source lies within the household. Various recent studies have found that indoor PM2.5 level in most Indian households is much higher than the outdoor PM2.5 concentration of the respective geographic area.
 
- **Causes:**
 - Use of **the traditional biomass** (Cow dung cake, firewood, coal etc.) for cooking is the leading cause of air pollution.
 - Burning fuels such as dung, wood, coal in inefficient open hearth produce a variety of health-damaging pollutants, including particulate matter, methane, CO, polycyclic aromatic hydrocarbon and VOCs.
 - These pollutants may **further accumulate** in the indoor environment if the indoor air is not well ventilated.
 - **Tobacco** consumption
 - **Building Materials** (Deteriorating asbestos containing insulation, paints, varnishes, wood flooring, etc.)
 - Products for household cleaning and maintenance, personal care, or hobbies.
 - Broken CFLs, Tubelights etc.
 - **Increased penetration of closed ventilation** due to Air-conditioners etc. makes situation worst.
 - **Outdoor sources** such as Radon, Pesticides, outdoor air pollution.
- **Health Impacts**
 - Household air pollution is responsible for 3.2 million deaths per year in 2020.
 - Household air pollution leads to non-communicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer.
 - The most common effect of IAP is called **sick building syndrome**, in which people experience uncomfortable or acute health effects such as irritation of nose, eyes and throats, skin ailments, allergies and so on.
- **Key steps being taken by government.**
 - **RAISE initiative**.
 - **Unnat Chulha Abhiyan** – By Ministry of New and Renewable Energy for providing a clean cooking energy solution with a view to reduce consumption of fuel wood with higher efficiency and low emissions.
 - **PM Ujjwala Yojna**

A) RADON (Rn^{222})

- It is an odorless, invisible, radioactive gas, naturally released from rocks, soil, and water.
 - It is a noble gas and thus doesn't react chemically with other substances.
- It is formed by decay of uranium and thorium in the earth's crust.
- It can seep into buildings and accumulate to dangerous levels, especially in areas with poor ventilation.
- **Harmful Impacts:**
 - Carcinogen: It can cause lung cancer.
 - In USA, radon is the leading cause of lung cancer after smoking.
- **The risk of developing lung cancer** from radon exposure depends on the level of radon in air, the duration of exposure, and whether or not the person is smoker.
 - **Note:** For smokers the risk is higher as smoking can damage the lungs and make them more susceptible to the harmful effects of radon.
- **Detection of Radon:**
 - Since, radon is colorless, odorless gas, the only way to know if the building has higher levels of radon is to test for it.
 - The test is relatively easy and inexpensive, and it can be done by homeowners and professionals.
- **Some Steps that can be taken are:**
 - Sealing cracks in the foundation
 - Installing a ventilation system
 - Relocating to different house

13) PET COKE (PETROLEUM COKE) AND ASSOCIATED ISSUES

- **Introduction: What is Pet Coke**
 - » It is a type of coke derived from oil refining process. It is the final carbon-rich solid material from the bottom of the barrel after refining of heavy oils.
 - **Coking Process:** In petroleum coker units, residual oils from other distillation processes used in petroleum refining are treated at high temperature and pressure leaving petcock after driving off gases and volatiles, and separating off remaining light and heavy oils.
 - » **Properties**
 - Petcoke is 90% carbon and emits 5-10% more carbon dioxide (CO₂) than coal on a per-unit-energy basis when it is burned.
 - As they have higher energy content, they emit between 30-80% more CO₂ than coal per unit weight.
 - It also contains higher sulfur content which makes it burning more polluting.
 - It is cheaper and burns hotter than coal.
 - » **Used less in western countries.**
 - Its higher sulfur content makes it a less attractive fuel in US and thus power hungry India becomes an easy export destination.
 - » **Impact of use of petcock in India**
 - **India is the largest user** of the Pet coke.
 - It is making a bad situation worse in India due to its higher CO₂ and Sulfur emissions.

- **Ban on Pet Coke Import as fuel (Aug 2018)**
 - DGFT has banned import of Pet-Coke as fuel.
 - Import is allowed for only Cement, Lime Kiln, Calcium carbide and gasification industries, when used as feedstock or in the manufacturing process of actual condition.

14) FUEL OIL/ HEAVY OIL/ FURNACE OIL -> ISSUES CONCERNING THEM

- **Introduction**
 - » Fuel oil/ Heavy Oil/ Furnace Oil is the heavier fraction obtained from petroleum distillation.
 - **Note: Fractional Distillation**
 - Crude oil is separated into fractions by fractional distillation. The fractions at the top have lower boiling points than the fractions at the bottom.
 - » All the fractions are processed further in refining units.
 - » **Bunker Fuel** is the fuel used aboard vessels (heavy ships). Generally the heaviest variety of oil i.e. fuel oil is used there. It is also known as marine fuel oil.
- **Some features of heavy fuel oil:**
 - » Heavy fuel combustion products remain high in NO_x, So_x, Particulate matter and CO₂.
 - » It has high viscosity when compared to Diesel, Kerosene and Petrol. To be used as fuel it's viscosity should be less and therefore it needs to be kept at higher temperature. It is also mixed with lighter fuel (e.g. diesel) to reduce its viscosity.
- **In case of oil spills heavy oil is more aggravating in nature because:**
 - i. Marine fuel is hazardous and very toxic to marine life.
 - The incombustible material that remains after the combustion mainly consists of the metals vanadium, silicon, aluminium, nickel, sodium, and iron that are present in the original heavy fuel oil supply
 - Marine organisms are very susceptible to these heavy metals.
 - ii. It evaporates at a slower pace when compared to other fuel (petrol, Kerosene, diesel etc) and thus remain in water for longer period impacting marine diversity more.
- Despite the above limitations the use continues because of the cheap price and large availability (as it keeps getting produced in oil refineries)

15) AGRI-SUBSIDY AND AIR POLLUTION

- High MSP for Rice -> Rice grown in Haryana, Punjab etc. -> Stubble burning.

- Power subsidy -> more use of water -> paddy cultivation -> stubble burning
- Fertilizer subsidy -> Overuse -> Indo-Gangetic plains emerging as atmospheric ammonia hotspots

16) WHO'S AIR QUALITY GUIDELINES

- In Sep 2021, WHO revised the air quality guidelines. This was the first major update to the standards in 15 years.
- **Why was there a need of update?**
 - New studies have found that even smaller quantity of pollutants were harmful for human beings.
- Therefore, WHO has strengthened nearly all pollutant standards in comparison to the quality guidelines established in 2005 (published in 2006)
 - **Expected Impact:** If the target levels are implemented and achieved by governments, it would lead to saving of lakhs of lives.
- **The new guidelines recommend air quality levels for 6 pollutants**, where evidence has advanced the most on health effects from exposure.

Recommended 2021 AQG levels compared to 2005 air quality guidelines

Pollutant	Averaging Time	2005 AQGs	2021 AQGs
PM _{2.5} , µg/m ³	Annual	10	5
	24-hour ^a	25	15
PM ₁₀ , µg/m ³	Annual	20	15
	24-hour ^a	50	45
O ₃ , µg/m ³	Peak season ^b	-	60
	8-hour ^a	100	100
NO ₂ , µg/m ³	Annual	40	10
	24-hour ^a	-	25
SO ₂ , µg/m ³	24-hour ^a	20	40
CO, mg/m ³	24-hour ^a	-	4

- **Expected impact of the new guidelines:**
 - » Spur greater global reactions in pollution emissions.
 - » Contribute to fight against climate.
- **Note:** These guidelines are not legally binding on any country. But, countries and legislative bodies regularly refer to WHO guidelines when setting airborne pollutant control legal policy.
- **Implications for India**
 - » As per the new WHO guidelines, almost the entire India, specially the Urban areas would now be considered polluted for entire year.

4. INSTITUTIONS, INITIATIVES, SCHEMES, PROGRAMS ETC.

1) CENTRAL POLLUTION CONTROL BOARD (CPCB)

India's Central Pollution Control Board sets national ambient air quality standards and is responsible for both testing air quality and assisting governments in planning to meet such standards.

1974

2) AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

Provides for the prevention, control and abatement of air pollution through boards established under this Act like Central Pollution Control Board.

1981

3) ENVIRONMENT POLLUTION (PREVENTION AND CONTROL) AUTHORITY (EPCA) [1998 - 2020]

- **About EPCA**
 - » EPCA was a **Supreme Court mandated body** tasked with taking various measures to tackle air pollution in National Capital Region (NCR).
 - » MoEF&CC notified this body in 1998 under the EPA, 1986.
 - » **Mandate**
 - Protect and improve the **quality of environment** and prevent and control **environmental pollution** in the **NCR**.
 - It is also mandated to implement the **Graded Response Action Plan (GRAP)** in NCR as per the pollution level.
 - » The Authority can take complaints **suo motu** or on the basis of a **filed complaint**.
- **Key contributions of EPCA** in 22 years of its existence
 - » Notification of Graded Response Action Plan
 - » Early adoption of BS-VI fuels standards
 - » Suggestions for Construction of the regional rapid transport system
- **Note:** The 22-year-old Environment Pollution (Prevention and Control) has been dissolved. (Oct 2020)

4) THE COMMISSION FOR AIR QUALITY MANAGEMENT IN NATIONAL CAPITAL REGION AND ADJOINING AREAS

- **Need**
 - A major reason behind high pollution levels in NCR has been the inability of CPCB, EPCA etc. to impose rules on the ground.
- The new permanent Commission envisages a multi-sectoral, participatory, multi-state dynamic body with a statutory status.
- **Details**

- The commission has been set up to monitor and check air pollution levels in the NCR and adjoining region.
 - » It **supersedes all existing bodies**. The commission shall have exclusive jurisdiction in respect of matters covered by the law.
 - » **Powers of CPCB/SPCB continue:** The CPCB and its state branches have the power to implement provisions of the Environment Protection Act for air, water and land pollution.
 - However, in case of **dispute** or clash of jurisdictions, the Commission's writ will prevail specific to matters concerning air pollution.
 - **The commission** will look at:
 - » Coordination between states
 - » Planning and execution of policy and interventions
 - » Operations of industry
 - » Inspections
 - » Research into the cause of pollution etc.
 - The powers to **levy fines - ranging up to Rs 1 crore or five years of prison** also lies with the commission.
 - The commission will be empowered to constitute special investigative groups for stricter implementation of air pollution norms on the ground.
 - **Structure**
 - » There will be at least six permanent members and it will be headed by a former or incumbent secretary to the GoI, or chief secretary to a state government.
 - » Overall, there would be **18 members** which would include five ex-officio members representing the five states; technical members from CPCB and ISRO; three representatives from NGOs with experience in combating air pollution; one representative from NITI Aayog.
 - **NGT:** Only the NGT, and not civil courts, is authorized to hear cases where the commission is involved.
 - **Area covered:** Delhi, Punjab, Rajasthan, Haryana and Uttar Pradesh
- **How is it different from EPCA?**
- **EPCA** was a Supreme Court mandated body, whereas the commission will be a **statutory body**.
 - **Area coverage:** EPCA - NCR, Commission -> NCR and adjoining areas.
 - » The pollution in Delhi is also caused by adjoining areas and therefore it has been given powers accordingly.
 - **State representation** was absent in EPCA but is present in the commission.
 - » The new 18-member commission brings together the Centre, states, and other stakeholders on one collaborative platform.
 - **Improved coordination:** the body has the mandate/powers to coordinate among states, which was absent in case of EPCA.

5) GRADED RESPONSE ACTION PLAN (GRAP)

- **GRAP** is the Delhi's **five-step escalating plan** to counter air pollution.
 - It was formulated in 2016 by Environmental Pollution Control Authority (EPCA) and approved by SC in the same year.
- **MoEF&CC had notified GRAP** for Delhi and NCR in 2017 and it draws its authority from this notification.
 - It institutionalized measures to be taken when air quality deteriorates.
 - The plan is **incremental in nature**. The **nature scope and rigor of measures** to be taken is linked to levels of pollution viz. Severe+ or Emergency, Severe, Very Poor, Moderate to Poor and Moderate.
 - **Note:** GRAP works only as an emergency measure and doesn't include actions by various state governments to be taken throughout the year to tackle industrial, vehicular and combustion emission.
 - Various directives of GRAP kick in based on the recommendations of a committee of experts;
- **Note:**
 - Since the formation of "the Commission for Air Quality Management in National Capital Region and Adjoining Areas", it is the designated agency for the implementation of the plan.
- **Significance**
 - GRAP has been successful in doing two things that had not been done before:
 - Creating a step-by-step for the entire Delhi-NCR region.
 - Getting on board several agencies: All pollution control boards, industrial area authorities, municipal corporations etc.
 - Fixed accountability and deadlines. For each action to be taken under a particular air quality category, executing agencies are clearly marked. In a city like Delhi which has multiplicity of authority, this has had a crucial difference.
 - EPCA along with GRAP has contributed in **three major policy decisions**:
 - Closure of thermal power plant at Badarpur, bringing BS-VI fuel to Delhi before the deadline set initially, and the ban on Pet Coke as a fuel in Delhi-NCR.
- **Limitations of GRAP**
 - **Focus on Delhi** - other states have managed to delay several measures, citing lack of resources;
- **How was GRAP implementation different in 2022:**
 - On 5th Aug 2022, the CAQM issued statutory direction, for the implementation of revised schedule of the GRAP.
 - **Key Changes in the revised action plan:**
 - a. Restriction on polluting activities will be dependent on Air Quality Index (AQI) rather than PM2.5 and PM10 concentration.
 - b. Measures could be taken up to three days in advance based on forecasts, the revised plan states.
 - **Earlier**, measures were implemented only after the PM2.5 and PM10 concentrations (micrograms per cubic meter) reached a certain threshold.
 - The **GRAP** for Delhi-NCR is divided into four stages. As per the plan, actions under stages 2-4 are invoked at least three days in advance of the AQI reaching the projected levels.

Stage	Key steps in each stage:
-------	--------------------------

Stage-1: "Poor" AQI: 201-300	<p><u>Ban on construction and demolition activities at specific sites.</u></p> <p>Agencies must ensure that all solid waste is lifted from dedicated dump sites, and none is dumped on the open land.</p> <p>Heavy fines are to be imposed for <u>openly burning municipal solid waste and biomass</u>.</p> <p>Roads will be <u>mechanically cleaned</u> and water will be <u>sprinkled from time to time</u>.</p> <p>Authorities will ensure that <u>thermal power plants comply with emission norms</u> and that <u>industries use approved fuel</u>.</p> <p>The <u>ban on firecrackers</u> should be followed as per the directions of respective courts</p> <p>Social Media is to be used to <u>update people about pollution levels and control room contact details so that violations can be reported to the authorities</u>.</p>
Stage-2: Very Poor AQI: 301-400	<p>Daily Mechanized sweeping of roads; Water sprinkling with dust suppressants at least on alternate days;</p> <p><u>Use of Coal and firewood in eateries would be banned.</u></p> <p><u>Use of Diesel Generators</u> might be allowed only in <u>certain cases</u>. Parking fees may be raised to discourage private transport.</p> <p><u>Resident Welfare Associations</u> would be required to provide <u>electric heaters</u> to security staff during winter to prevent the burning of solid waste or biomass.</p>
Stage-3: Severe AQI: 401-450	<p>The frequency of cleaning roads intensifies in this stage. Water would be <u>sprinkled daily before traffic hours</u>.</p> <p>Strict ban on <u>all construction activities except ongoing work on roadways, railways, metro, hospital etc.</u> Authorities will levy <u>different rates on public transport services to encourage off-peak travels</u>.</p> <p>The <u>state government</u> will be empowered to impose restrictions on BS-III petrol and BS-IV diesel light motor vehicles (4-wheelers)</p>
Stage-4: Severe Plus AQI > 450	<p>Entry of <u>all trucks</u> except those carrying essential commodities, or providing essential services is to be stopped into Delhi. This will be <u>followed by a ban on plying of diesel-operated medium goods and heavy goods vehicles in Delhi</u>, except those carrying essential items.</p> <p>All construction and demolition activities would have to be <u>stopped</u>.</p>

The respective government could meanwhile, take a call on allowing public, municipal and private offices to work at 50% strength.

If required, the Centre can allow work from home for central government employees.

Additional emergency measures like closing schools and other educational institutes, non-emergency commercial activities and plying of vehicles on an odd-even basis may also be enforced.

- **Revised GRAP to deal with adverse air quality scenario (Nov 2022)**

- In a move to mitigate dust arising out of C&D activities sites and intensify actions to further ameliorate the overall air quality of the NCR, the CAQM has mandated all C&D projects in NCR to deploy adequate number of anti-smog guns, in proportion of the total area of construction for the project.
 - Different number of guns have been recommended based on different size of the project. (1-> 5,000 - 10000 sqm; 2 for 10001-15,000 sqm; 3 for 15,001 - 20,000 sqm; 4 for 20,000 sqm)

- **Role of Citizens:**

- GRAP also includes a graded advisory for public:
 - **Under Stage-1**, the measures include properly tuning the engines of their vehicles, ensuring accurate air pressure in tyres, and updating PUC (pollution under control certificates). Turn off engines at red lights; don't dispose of waste or garbage in open space. Report air pollution activities through apps 311, Green Delhi, SAMEER"
 - **For Stages-2, 3 and 4**, the commission advises the public to opt for public transport, or work from home if required.
 - **Under stage-4**: the elderly and those with respiratory, cardiovascular, cerebrovascular or other chronic diseases are advised to avoid outdoor activities and stay indoors once stage-4 is implemented.

6) NATIONAL CLEAN AIR PROGRAM

- It is a pollution control initiative that was launched by the **Ministry of Environment** in Jan 2019 with the intention to cut the concentration of coarse particulate matter(**PM10**) and fine particles or **PM2.5** by at least **20%** (20-30%)in the **next five years** (i.e. by 2024), with **2017 as the base year** for comparison.
- It is a long term time bound national level strategy to tackle air pollution across Indian in a comprehensive manner.
- **Which are the cities covered?**
 - **132 Non-attainment Cities** identified on the basis of Ambient Air Quality Data for the period 2011-2015 and WHO report 2014/18.
- **Objectives**
 - Ensure implementation of **prevention, control and abatement** measures for air pollution
 - Improve the **monitoring network**.

- Enhance **public awareness** regarding air pollution and capacity building measures.
- **Who all are participating?**
 - Apart from **experts from industry** and academia, **various ministries** like Ministry of Road Transport and Highways, Ministry of Petroleum and Natural Gas, Ministry of New and Renewable Energy, Ministry of Heavy Industries, Ministry of Housing and Urban Affairs, Ministry of Agriculture, Ministry of Health, NITI Aayog, and **CBCB** are participating.
- **Key Steps being Taken**
 - Pollution Reduction measures**
 - Plantation drives, promotion of better technology, sectoral interventions like electric vehicle promotion, promoting renewable energy, waste management etc.
 - City specific Plan - A separate emergency action plan will be created for each of the 132 cities. It will include measures for strengthening the monitoring network, reducing vehicular/industrial emissions, increasing public awareness etc.
 - Enhancing R&D and Data collection**
 - Studies related to air pollution and its impact will be taken on
 - Monitoring infrastructure will be expanded and will start covering rural areas as well.
 - A National Emission inventory will be established to provide proper inputs for future policy making.
 - Strengthening various pollution related institutions**
 - A National Apex Committee under MoEF&CC, a steering committee under Secretary (environment) and a monitoring committee (under joint secretary) will be established.
 - There will be project monitoring committees at the state-level with scientists and trained personnel.
 - In Addition sectoral working groups, National level project monitoring units, State level project monitoring units, city level review committee under Municipal Commissioner and DM level committee in the districts are to be constituted under NCAP for effective implementation and success of the program.
 - Increased focus on awareness generation and people's participation.**

7) BHARAT STAGE EMISSION STANDARDS (BS NORMS)

- **Intro:**
 - » **Bharat stage emission standards** (first introduced in 2000) have been instituted by the GoI to regulate the output of certain air pollutant (NO_x, CO, HC, PM, SO_x) by vehicles and other equipment using internal combustion engine. As stage goes up, the control on emissions become stricter.
 - » The standards and timeline for implementation are set up by the Central Pollution Control Board under the Ministry of Environment, Forest and Climate Change.
- **Dates of Application**
 - » **BS-4:** BS-IV norms are applicable throughout the country from 1st April 2017.
 - » **BS-V:** GoI has **decided to skip** the standards and directly move to BS-VI standards by 2020.

- » **BS-VI:** Introduced in Delhi from 1st of April 2018, it is applicable **throughout the country from April 2020** for all vehicles.

- **Differences in BS-IV and BS-VI standards**

- » The main difference between BS-IV and BS-VI norms is the **amount of Sulphur** in the fuel.
 - Reduction in Sulphur will make it possible to equip vehicles with better catalytic converters that capture pollutants.
- » Similarly, **NO_x emission** from diesel is expected to come down by 70% and by 25% in petrol vehicles. Further, the **restrictions on PM** has been increased in both diesel and petrol vehicles.
- » There are also lower limit for **HC and NO_x** in diesel engine.

	g/km	g/km	g/km	g/km	g/km	Sulphur
Petrol Emission Norms	CO	HC	NO_x	HC + NO_x	PM	
BS-III	2.3	0.2	0.15	---	--	
BS-IV	1.00	0.1	0.08	---	--	50 ppm
BS-VI	1.00	0.1	0.06	---	0.005	10 ppm (10 mg/kg)
Diesel Emission Norms	CO	HC	NO_x	HC + NO_x	PM	
BS-III	0.64	--	0.50	0.56	0.05	
BS-IV	0.50		0.25	0.30	0.025	50 ppm
BS-VI	0.50	--	0.06	0.17	0.005	10 ppm

- **Other Key Changes being brought:**

- **Diesel Particulate Filter (DPF) and Selective Catalytic Reduction (SCR)** are being introduced with the roll-out of Bharat Stage VI norms, which were not a part of Bharat Stage IV.
- **Real Driving Emissions (RDE)** will be introduced in India for the first time with the implementation of Bharat Stage VI emission norms. It will measure a vehicle's emission in real-time conditions against laboratory conditions.
- **Onboard diagnostics** has been made mandatory for all vehicles.
- BS VI would require usage of **Fuel Injection Technology** for two wheelers. This will the first such norm in India. This will filter out some PMs, some NO_x etc.

8) PETROL VS DIESEL COMPARISON

- **Conversion to CNG**

- » Converting petrol car to CNG only costs around 30,000 rupees, whereas in case of diesel car it costs around 1,50,000 rupees, as it requires fundamental changes in the engine of the car and is an expensive time-consuming process.

- **Is Diesel worse than petrol?**

- » **More SPMs:** A diesel car emits 22 times more Suspended Particulate Matters (SPM) - the tiny particles which easily penetrate your lungs, hearts and even brains.

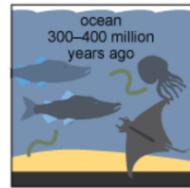
- » **More Nitrogen di oxide:** Diesel emits four times more nitrogen di oxide.
- » **Less CO₂ and better fuel economy:** However, a diesel car emits 15% less CO₂ than petrol and since it is more efficient fuel (it burns more than petrol), it also gives a higher fuel economy.

9) NATURAL GAS

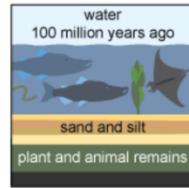
- Natural gas is a fossil fuel containing different organic compounds. It primarily consists of **methane**. Some other compounds in it includes ethane, propane etc. It is a colorless, tasteless and odorless gas.
- **How is natural gas formed?**
 - It is a fossil fuel which is formed due to extreme pressure and heat for millions of years on remains of plants and animals buried under the surface of the earth.

Petroleum and natural gas formation

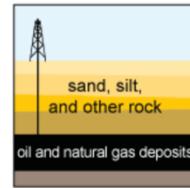
Tiny marine plants and animals died and were buried on the ocean floor. Over time, the marine plants and animals were covered by layers of silt and sand.



Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned the remains into oil and natural gas.



Today, we drill down through layers of sand, silt, and rock to reach the rock formations that contain oil and natural gas deposits.



- **Advantages of Natural Gas**
 - **Environmentally more clean than other fossil fuels:** It releases very less byproducts into the atmosphere as pollutants.
 - **Economical** - it is cheaper than other fossil fuels.
 - **Safer to use:** Unlike LPG cylinders which has the risk of leakage and accident, natural gas is lighter than air. In case of leakage, it dissipates quickly into air avoiding fire.
 - **Abundance**
 - **Easy to deliver - Piped transportation** make it easy to transport.
- **Limitations**
 - **Non-Renewable Fossil Fuel** - Emits CO₂ - Global Warming, Climate change.
 - **Easily inflammable**
- **Natural Gas comes in four basic forms:**
 - **Liquified Natural Gas** (liquified at -160 degree celsius). This facilitate transportation in large volumes in cryogenic tankers across seas/ land.
 - **Regasified LNG (RLNG)**: LNG re-gasified at import terminals before transporting it to consumers through pipelines.
 - **Compressed Natural Gas (CNG)**: Compressed to a pressure of 200-250 kg/ cm³ - used for fuel transportation.
 - **Piped Natural Gas**: Natural gas distributed through a pipeline network that has safety valves to maintain the pressure, assure safe, uninterrupted supply to the domestic sector for cooking and heating/ cooling applications.

5. RECENT AIR POLLUTION ISSUES

1) DELHI'S AIR POLLUTION PROBLEM

- Introduction

- » Delhi's air quality dips drastically every year with the arrival of harvest season during October-November. Though, government generally blames the stubble burning in the neighboring states as the key cause, but the air pollution in Delhi is a complex phenomenon that is dependent on a variety of factors.

- Key Factors include:

i. Input Pollutants

- Dust is the biggest cause of pollution during winters. Dry cold weather leads to dust being easily available in the entire region.
- Vehicular Pollution is the second biggest cause of pollution in winters.
 - According to a study by IIT Kanpur, around 20% of PM2.5 in winters comes from vehicular pollution.
- Stubble burning
 - At the time of Rabi harvesting around 25% of PM content in Delhi is due to stubble burning.
- Industries, thermal power plants, burning of waste during winters
- Diwali Pollution

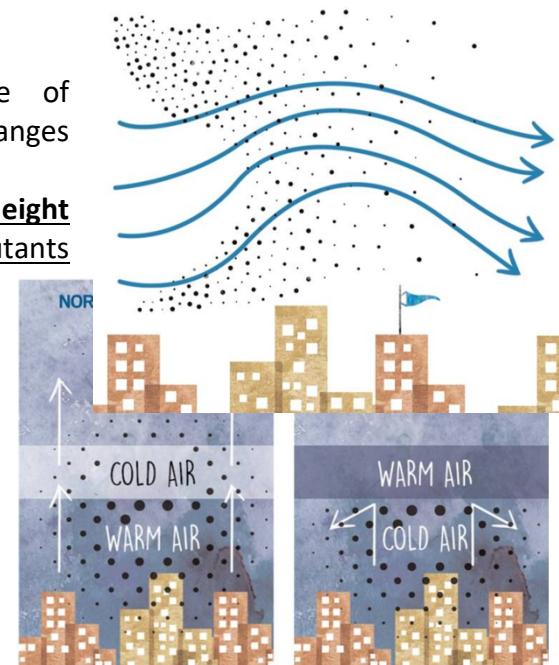
ii. Meteorological Factors

- **Wind Direction:** With the departure of Monsoon, the wind direction in Delhi changes from easterlies to westerlies.
- **Dip In Temperature brings the inversion height to lower levels.** The concentration of pollutants in the air increases when this happens.
 - Note: Inversion Height is the layer beyond which pollutants cannot disperse into the upper layer of the atmosphere.

- iii. **Low Wind speed in winters:** High wind speeds are effective in dispersing pollutants, but with arrival of winters, the average wind speed decreases.

iii. Other factors

- When compared to other metropolitan (i.e. Kolkata, Mumbai and Chennai) - Delhi is surrounded by high density region on all the sides. The other three cities are located near the coast, thus leaving the breathing space for the cities.



- **Steps taken in Delhi in the past to fight Air Pollution:**
 - In 1996, the Supreme Court took a note of the extremely poor air quality of Delhi and ordered the closure and relocation of over 1,300 highly polluting industries from Delhi's residential areas beyond the NCR in a phased manner. Multiple brick kilns were also directed to be relocated outside the city limit.
 - In 1998, the Supreme Court ordered the MoEF&CC to establish an authority for Delhi, which led to the creation of **Environment Pollution Control Authority (EPCA)** in 1998.
 - Supreme Court subsequently ordered conversion of the whole fleet of DTC buses, taxis and autos to CNG.
 - During this time centre also took several steps:
 - It revamped its Air Quality Monitoring Program and established a network of monitoring stations, under the National Air Quality Program.
 - In 2009, National Ambient Air Quality Standards were revised to include the 12 categories of pollutants including PM 2.5 - a noxious pollutant which can penetrate deep into the lungs and even enter the blood stream.
- **Steps taken in recent years to deal with pollution in Delhi**
 - **The Commission for Air Quality Management in National Capital Region and Adjoining Areas**
 - Formed in Oct 2020 through an ordinance to strengthen the air pollution control system in NCR and adjoining region
 - Replaces the EPCA
 - **Ban on Coal and other unapproved fuels from 1st Jan 2023**
 - Introduction of **BS-VI norms for Vehicles**
 - **Graded Response Action Plan (GRAP)**
 - **Push for Electric Vehicles - Delhi's Electric Vehicle Policy, 2019** subsidizes buying of electric vehicle and encourage people to move to electrical
 - **Various steps for controlling stubble burning**
 - **Prohibition on polluting crackers and promotion of green crackers**
 - **Odd-Even rule for vehicles** as emergency measures
 - **Construction of Eastern and Western Peripheral Expressways**
 - To provided fast alternative routes to vehicles not destined for Delhi.

2) BAN ON COAL AND OTHER UNAPPROVED FUEL IN DELHI (JAN 2023)

- CAQM has imposed a ban on coal and other unapproved fuels from 1st of Jan 2023. Industries using them would be closed and heavy fines would be imposed on them.
 - **Exceptions:**
 - Use of low sulphur coal in thermal power plants in Delhi NCR is allowed. It can be used wherever the primary purpose is power generation.
 - Firewood and biomass briquettes can be used for religious purposes and cremation.
 - Wood or bamboo charcoal can be used for tandoors and grills of hotels, restaurants, banquet halls (with emission control systems), and open eateries and Dhaba.
 - Use of wood charcoal for cloth ironing is allowed.
- The ban was notified by CAQM in June 2022

3) STUBBLE BURNING – CLASS DISCUSSION

A) PUSA DECOMPOSER

- a technology developed by IARI to manage paddy stubble in fields. It can rapidly degrade paddy straws in the field and convert them into compost, which then doesn't pose any issues for sowing of wheat crops, as per IARI scientists.
 - » It contains seven strains of fungi, which is to be mixed with water, 150 gms of jaggery and 50 gms of besan, to prepare a 25-litre solution that can be sprayed on 1 hectare of field.
 - » **Results:** Farmers of north Delhi found in 2020 that PUSA decomposer took about 20-22 days for stubble to decompose. This has helped in increasing soil fertility (less fertilizer use) and reduced the need of extensive ploughing to mix stubble with soil.

4) FIRE CRACKERS

- **Introduction**
 - » Firecrackers are among the most poisonous air pollutants. The **chemical footprint left by them have a devastating impact on human health and especially affects children**.
 - » CPCB in a study in Delhi in 2016 found that the levels of Aluminium, Barium, Potassium, Sulphur, Iron and Strontium rose sharply in Diwali night, from low to extremely high.
- **Science behind Firecrackers**
 - » Firecrackers use fuel and oxidizers to produce a combustion reaction, and the resulting explosion spreads the material in a superheated form. The metal salts in the explosive mix get 'excited' and emit light. Metals in the mix, which have varying arrangement of electrons in shells outside their nucleus, produce different wavelength of light in this reaction, generating spectacular colors.
 - For e.g. **Barium compounds** produce green light, Strontium and lithium salts produce red colors.
- **But firecrackers are big health hazards.**
 - » Chemicals such as barium nitrate and cadmium compounds cause respiratory irritation and gastrointestinal problems.
 - » Aluminium sulphide is known to cause Alzheimer's.
 - » Lithium and copper compounds cause hormonal imbalance and so on.
- In order to tackle the air and noise pollution during the festival season, the Supreme Court in a judgment (**Arjun Gopal & others Vs Union of India & others**), in Oct 2018 have mandated a series of steps to reduce the pollution from firecrackers. The key highlights of the Supreme Court Judgment includes:
 - i. **Improving the quality of crackers to reduce Air pollution**
 - a. Use of reduced emission firecrackers (**improved crackers**) only.
 - Avoiding use of ash as filler material -> Reduce particulate matter by 15-20%.
 - Use of charcoal meeting the PESO specifications.
 - b. Use of Reduced emission firecrackers (**green crackers**)
 - To reduce emission of PM, NO_x, and SO₂ due to in-situ water generation as dust suppressant.

- c. **Firecrackers only with permitted chemicals** to be allowed -> PESO shall test and check for the presence of banned chemicals like lithium/arsenic/antimony/lead & mercury.
 - d. **Banning of Barium salts in Firecrackers**
 - Barium emits poisonous gas causing respiratory problems and may have health complications due to long-term exposure.
 - **Why Barium so common in firecrackers:** emits green light, low cost, readily available.
 - e. **Enough facilities should be created to ensure use of quality raw material** in gun/flash powder as per the Petroleum and Explosives Safety Organization (PESO) specifications. This will address the issue of high content of unburnt/partially combusted material.
 - f. **PESO to ensure firecrackers satisfy decibel levels**
- ii. **Time Limit**
 - a. Firecrackers are only allowed from **8-10 pm** in Diwali and **11.55 pm - 12.30 pm** in Christmas and New year.
 - iii. **Blanket ban on online sale**
 - iv. **Ban on series cracker ('laris').**
 - v. **Stations house officer** will be held liable for contempt of court in case of violation of any judgment.

5) NGT BANS FIRE CRAKERS (NOV 2020)

- In Nov 2020, NGT has prohibited the sale and use of firecrackers during Deepavali in the NCR and in urban centres that recorded poor or worse air quality in Nov 2019.
- Sale of green crackers are allowed in cities and towns where air quality is moderate or below. But bursting of firecrackers are restricted to two hours during Diwali, Chatth, Christmas, and New Year.
- **Significance:**
 - A response to deteriorating air quality in various parts of the country. Primacy to precautionary principle in sustainable development over employment and revenue losses.
- **In July 2021, the SC upheld the NGT judgement.**

6) PETROLEUM AND EXPLOSIVE SAFETY ORGANIZATION (PESO)

- PESO is an statutory authority entrusted with the responsibility under the Explosives Act, 1884; Petroleum Act, 1934; Inflammable Substances Act, 1952, Environment (Protection Act), 1986 and rules made under those acts.
- It is a subordinate office under Department of Industrial Policy & Promotion.
- It is the nodal organization to look after the safety requirements in manufacture, storage, transport and use of explosives and petroleum.
- The organization is headed by Chief Controller of Explosives with its headquarter at Nagpur (MHA).
- **Other Recent Developments**
 - » In May 2018, Union Cabinet approved formation of Group 'A' service of the technical cadre of PESO in the name of Indian Petroleum & Explosives Safety Services (IPESS).
 - » The measure will enhance the capacity and efficiency of the organization and it will also enhance the career progression of its Group 'A' Officer.

- **Barium Nitrate** is used to produce green light and can produce more colors in combination with other chemicals.
 - » It is used in all light emitting fireworks.
 - » **Health Hazards:** Barium salts, as per the SC, can lead to health complications.
 - » **A replacement** of the salt is yet to be explored

7) GREEN CRACKERS

- **What are Green Crackers?**
 - » **Green Crackers** are firecrackers produced using less harmful raw materials and additives to reduce emissions.
 - CSIR-NEERI has defined Green crackers as those which will reduce emission by 30% and can limit sound to 125 decibels (at a distance of 5 meters).
 - Since the Supreme Court had banned barium nitrate, the green chemicals contain Potassium nitrate and zeolite in green crackers instead.
 - They newly developed crackers also include Safe Water Releaser, Safe Minimal Aluminum Cracker and Safe Thermite Crackers.
 - The additives in Safe Water Releaser give out water, air and dust suppressants.
 - The Safe Minimal Aluminium minimizes the use of aluminium, potassium nitrate and sulfur.
 - The Safe Thermite Cracker is based on a combination of metals, including aluminium, and metal oxides like iron oxides to produce heat.
 - » The **packaging** of these crackers contains a **QR code** and a **green logo** that states that they have been certified by CSIR and NEERI.
- **Supreme Court** in Nov 2019 has said that it wants every consignment of the material used in manufacturing green fire crackers to be tested for quality control.
 - » Quality control mechanism should be set up in each manufacturing unit of green fire crackers within 15 days and such units be monitored by officials from the Petroleum and Explosive Safety Organization (PESO).
- **Are Green Crackers completely Green?**
 - » **No**
 - » They produce 30% less PM2.5 and 50% less SO₂ emissions. But they still produce PM2.5 and SO₂.

8) SMELTING INDUSTRY AND POLLUTION

- Smelting is a metallurgical process that involves heating raw ore or metal in order to extract or refine a desired metal.
 - » The process involves use of high temperatures and chemicals to break down the ore, allowing the desired metal to be separated from the other materials in the ore or metal.
 - » Generally, the raw material is usually heated to a high temperature in a furnace, along with a reducing agent such as coke or charcoal, which helps to reduce the metal oxide in the ore or metal to a pure metal.

- Smelting is used in the extraction of metals like iron, copper, lead and zinc as well as in the production of alloys such as steel.
- **Smelting is also a major source of Pollution:**
 - » It releases large amounts of pollutants such as sulfur dioxide and heavy metals into the air, water, and soil. The industry also causes noise pollution.

9) ODOUR POLLUTION

- **Introduction**
 - World Health Organization recognizes Odour (unpleasant smell) as a pollution and says it affects the quality of life and social well-being of individuals. The unpleasantness is created by presence of compounds such as Ammonia, Hydrogen Sulphide, butyric acid, ethyl and methyl mercaptan and dimethyl sulphide.
 - **Impact**
 - Effect of odour varies from person to person but at sufficiently high concentrations, odour compounds may have direct effect on human health.
 - It may lead to vomiting, headaches, nausea, stress, anxiety, frustration, restriction in outdoor activities, children unable to sleep and discomfort for elderly and others.
- **Main Sources of Odour Pollution**
 - MSW dumpyards, oil refineries, fish markets, slaughter houses, distilleries, pharmaceuticals, biomedical and hazardous waste disposal sites and pesticide plants.
- **Steps Taken**
 - i. **Central Pollution Control Board (CPCB) issues detailed guidelines for proper Monitoring and Management of Odour at Urban Municipal Solid Waste Landfills (Sep 2017)**
 - The guidelines were based on the 'scientific pilot study' of East Delhi's Ghazipur landfill site.
 - **Buffer zones: Green Belt around land fill** sites and suggested selection of appropriate plant species for vegetation cover to assist in reducing odour.
 - **Trapping LFG gases:** MSW landfill sites should be designed to tap landfill gases (LFG) efficiently to mitigate fugitive odorous emissions.
 - **Legislative norms on baseline data:** The guidelines also suggested for initiating legislative norms for creating baseline data on odour.
 - Need for **gradual shift for installation of Continuous Odour Measurement Systems** (Sensor based) similar to Continuous Air Quality Monitoring Stations (CAAQMS).
 - This is needed as manual measurement is time consuming
 - **Various Considerations before choosing landfill sites**
 - Present population and projected growth for the next 20 years
 - Whether the selected site is free from the impact of other odorous sources and the topography of the site (slope, proximity to water sources like river and natural springs)
 - Selection should be integrated with the urban development plan of the city so that even expansions of the city in next two or three decades are not encompassing the selected MSW site

6. VARIOUS AIR QUALITY MEASURING INITIATIVES IN INDIA

1) NATIONAL AIR QUALITY MONITORING PROGRAMMES (NAMP)

- CPCB is executing a nation-wide program of ambient air quality monitoring known as National Air Quality Monitoring Program (NAMP).
- Objective of NAMP is:
 - i. To Determine status and trends of ambient air quality
 - ii. To Ascertain whether the prescribed air quality standards are violated
 - iii. To obtain the knowledge and understanding necessary for developing preventive and corrective measures
 - iv. To understand the natural cleansing process undergoing in the environment through pollution, dilution, dispersion, wind-based movement, dry deposition, etc.
- Pollutants covered:
 - i. Under NAMP, four air pollutants viz., Sulphur dioxide (SO₂), Oxides of Nitrogen (NO₂), Respirable Suspended Particulate Matter (RSPM/ PM10), and Fine Particulate Matter (PM 2.5) have been identified for regular monitoring at all the locations.
 - ii. The monitoring of meteorological parameters such as wind and wind direction, relative humidity (RH) and temperature were also integrated with the monitoring of air quality.

2) NAAQS (NATIONAL AMBIENT AIR QUALITY STANDARDS) BY CPCB

- Ambient Air Quality refers to the condition or quality of air surrounding us in the outdoors.
- NAAQS are the standards for ambient air quality set up by CPCB and are applicable nationwide.
 - The CPCB has been conferred this power by the Air (Prevention and Control of Pollution) Act, 1981.
- The current standards were set up in 2009 and were an improvement over previous standard. It covers **12 pollutants**:
 - CO, SO₂, NO_x, PM10, PM2.5, Ozone, NH₃, lead, Arsenic, Benzene, Benzopyrene, Nickel.

3) AIR QUALITY INDEX (AQI)

- Air Quality Index is a number used by government agencies to communicate to the public how polluted the air quality is or how polluted it is forecasted to become.
- In India, National Air Quality Index, was launched in Sep 2014 as part of Swachh Bharat Abhiyan by MoEF&CC.
- The CPCB, the nodal agency for air pollution data in India, has developed a color coded air-quality index to mark hazardous levels for the public benefit.
- There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and severe.
- It considers 8 pollutants (PM₁₀, PM_{2.5}, NO₂, SO₂, CO, O₃, NH₃, and Pb.)
- Initially it was launched in 10 cities and today it covers 24 cities in 10 states.

Color	AQI	Remark
Green	Good 0-50	Minimal Impact
Yellow	Satisfactory 51-100	May cause minor breathing discomfort in sensitive people.
Orange	Moderate 101-200	May make breathing difficult for people with lung diseases and cause discomfort in children, older adults and heart patients.
Red	Poor 201-300	May make breathing difficult after prolonged exposure, and cause discomfort to people with heart diseases.
Dark Red	Very Poor 301-400	May cause respiratory illnesses in people on prolonged exposure. Effect may be more pronounced in those with lung and heart diseases.
Black	Severe 400	May cause respiratory problems even in healthy people, and seriously impact those with lung/heart diseases. Even increased breathing during light physical activity can impact health.

- **Need of AQI**

- Traditionally air pollution data has been reported in very voluminous way. It was important that information of air quality is put up in public domain in simple linguistic term that is easily understood by common person.