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ECOLOGY AND ENVIRONMENT

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Contents

Ecology and Environment

PART–I: ECOLOGY & ENVIRONMENT

Chapter - 1

Chapter - 2

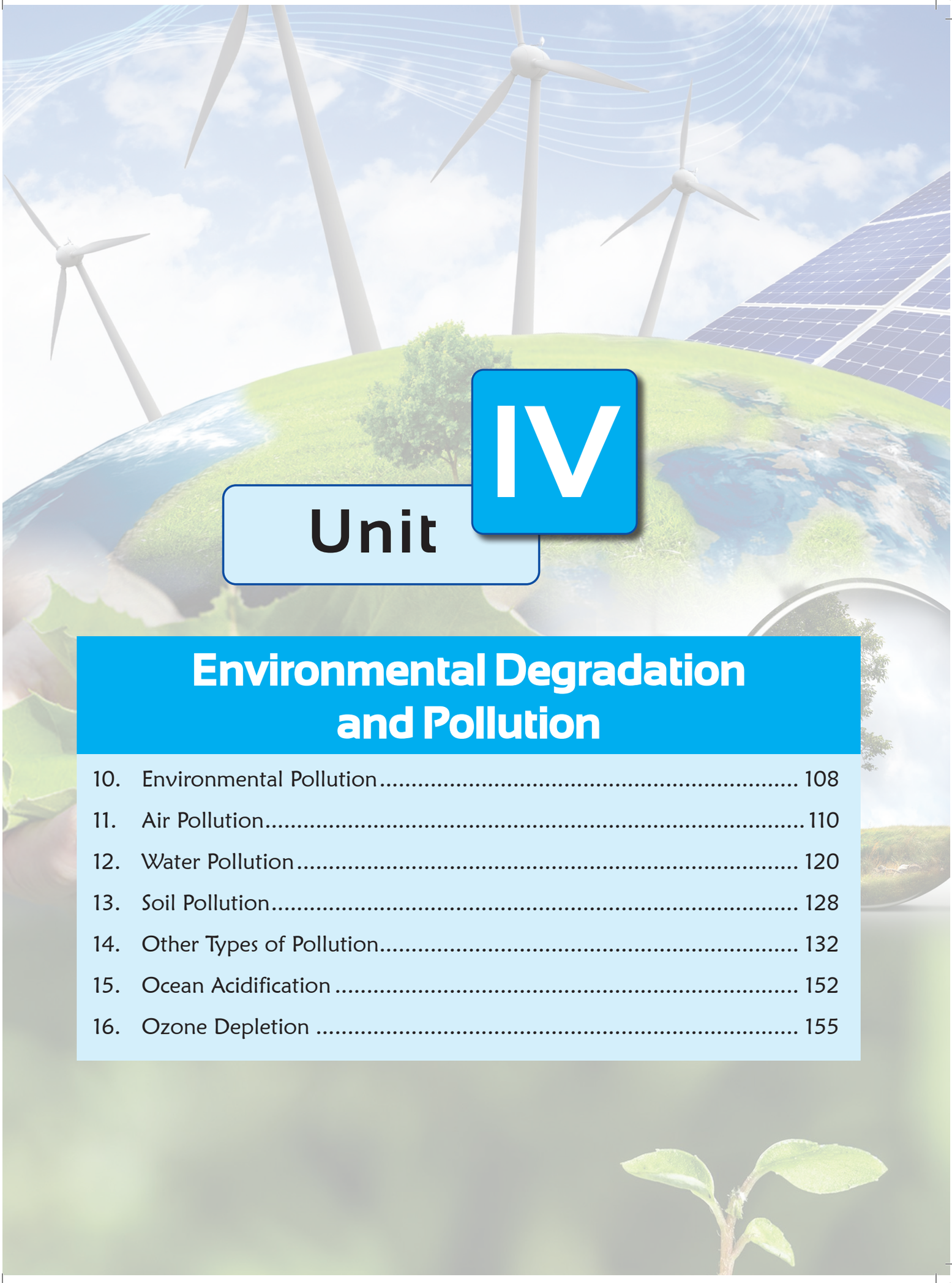
PART–II: BIODIVERSITY

Chapter - 3

PART–VII: MISCELLANEOUS

Chapter - 24

APPENDIX



Unit IV

Environmental Degradation and Pollution

10 CHAPTER ENVIRONMENTAL POLLUTION

10.1 Introduction

Environmental pollution is the contamination of the physical and biological components of the environment to such an extent that normal environmental processes are adversely affected.

Ever since the industrial revolution began, human beings has caused irreparable damage to the Earth. In the name of development, manufacturing, construction and transportation activities have not only depleted the natural resources but has also produced a large amount of waste leading to pollution.

10.2 Pollution and Pollutants

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

Pollutant is the substance which contaminates air, water and soil etc. Pollutants can be naturally occurring substances or energies but are considered contaminants when present in excess.

10.3 Types of Pollutants

Based on Nature of Disposal

From the ecosystem point of view, i.e., according to their natural disposal, pollutants are of two types:

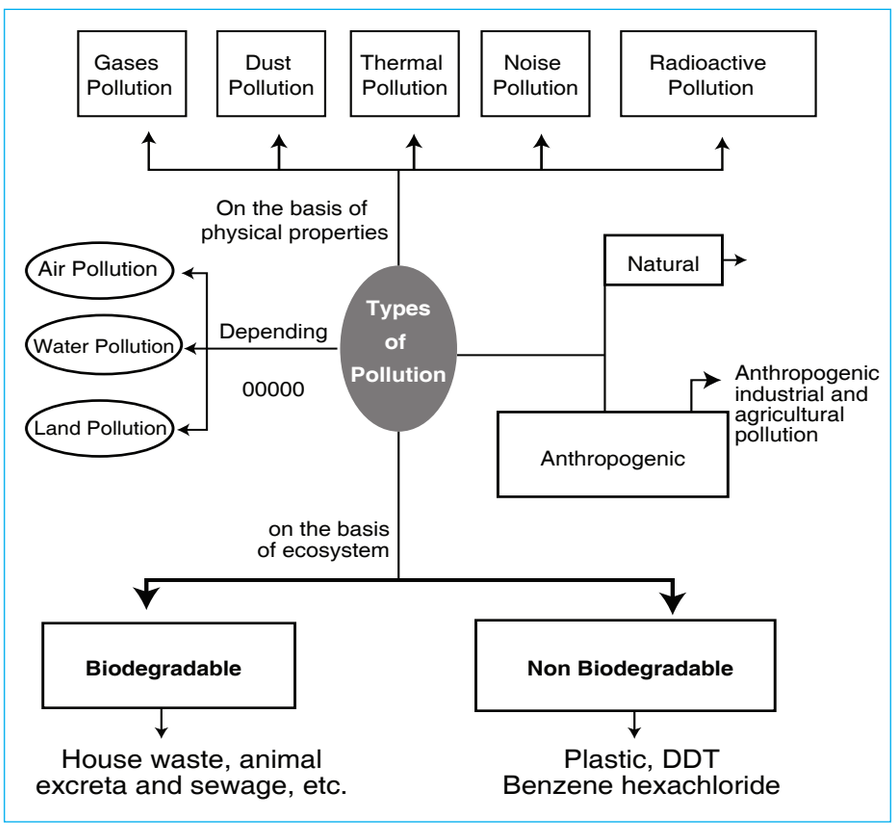
Non-Biodegradable Pollutants

Pollutants which cannot be broken down into simpler, harmless substances in nature, are called non-biodegradable pollutants. Through ***bioaccumulation and biomagnification***, pollutants may appear in the food chain. ***For example:*** DDT, plastics, polythene, insecticides, pesticides, mercury, lead, arsenic, aluminum cans, synthetic fibres, glass objects, iron products and silver foils etc.

Biodegradable Pollutants

Those pollutants which can be broken down into simpler, harmless, substances in nature in due course of time are called biodegradable pollutants.

For example: Domestic wastes, urine, faecal matter, sewage, agriculture residues, paper, wood, cloth, cattle dung, animal bones, leather, wool, vegetable stuff or plants etc.



Based on Form of Persistence

Depending upon the form in which they persist after being released into the environment, the pollutants are categorized into two types, namely primary and secondary pollutants:

Primary Pollutants

These are those which are emitted directly from the source and persist in the form in which they were added to the environment. Examples: ash, smoke, fumes, dust, nitric oxide, sulphur dioxide, hydrocarbons etc.

Secondary Pollutants

These are those which are formed from the primary pollutants by chemical interaction with some constituents present in the atmosphere. Examples are Sulphur trioxide, nitrogen dioxide, aldehydes, ketones, ozone etc.

Based on Nature of Pollutants

Depending upon their existence in nature, pollutants are of two types: namely quantitative and qualitative pollutants.

Quantitative Pollutants

These substances normally occurring in the environment but acquire the status of a pollutant when their concentration gets increased due to the un-mindful activities of man. For example: Carbon Dioxide (CO_2).

Qualitative Pollutants

These are those substances which do not normally occur in nature but are added by man, for example, insecticides.

10.4 Causes of Pollution

The causes of pollution is based on following factors:

Commercial or Industrial Waste

- Commercial waste consists of waste from premises used mainly for the general purposes of a business or trade or for the purpose of recreation, education, sport, or entertainment.*Example:* Leather and Textile Industries etc.

Rapid Urbanization

- Half of the global population already lives in cities, and by 2050 two-thirds of the world's people are expected to live in urban areas.
- Various pull factors (better living standard, infrastructure, opportunities etc.) and push factors (agriculture crisis, caste conflicts etc.) leads people to migrate people from rural to urban areas.

Forest Fires

- Wild fire, also called forest, bush or vegetation fire, can be described as any uncontrolled and non-prescribed combustion or burning of plants in a natural setting such as a forest, grassland, brush land or tundra, which consumes the natural fuels and spreads based on environmental conditions (e.g., wind, topography).
- Wildfire can be incited by human actions, such as land clearing, extreme drought or in rare cases by lightning.

Hazardous Waste

- Hazardous waste is a waste with properties that make it dangerous or capable of having a harmful effect on human health.
- Hazardous waste is generated from many sources, ranging from industrial manufacturing process wastes to batteries and may come in many forms, including liquids, solids gases, and sludge.

Improper Agricultural Practices and Deforestation

- Agriculture, the very industry that sustains us, also threatens our continued existence as a species. This sector produces at least 23 percent of global greenhouse gas emissions (second only to the energy sector) IPCC report.
- Deforestation refers to the decrease in forest areas across the world that are lost for other uses such as agricultural croplands, urbanization or mining activities.

■■■■

TRY THIS MAINS PREVIOUS YEAR QUESTION

1. Discuss in detail the photochemical smog emphasizing its formation, effects and mitigation. Explain the 1999 Gothenburg Protocol. (Write in 150 words) **(2022)**

CHAPTER 11

AIR POLLUTION

11.1 Introduction

Ambient air pollution poses grave, multi-faceted risks to India's prospects for achieving its development goals, it leads to a rapid increase in public health expenditure, diminished labour productivity, and reduced agricultural yields. Estimates peg the economic cost of air pollution to the Indian economy at more than US$150 billion a year.

Globally, air pollution is a silent killer. Air quality in India has deteriorated significantly over the past two decades; The air pollution levels in India are among the highest in the world, posing a heavy threat to the country's health and economy.

In 2024, all of India's 1.4 billion people (100% of the country's population) were exposed to particulate matter (PM2.5) in excess of the value specified by the World Health Organization (WHO) air quality guidelines, thereby making them vulnerable to serious health risks.

Air pollution affects individual health of citizens, increases mortality and morbidity rates, and contributes to climate change. The levels of morbidity and mortality have led to losses in welfare that in turn cost India's economy around 5.9 percent of GDP. A 2018 report by the Health Effects Institute projects a rise in annual deaths in India due to air pollution from 1.1 million in 2015 to 1.7 million in 2030.

History of Air Pollution

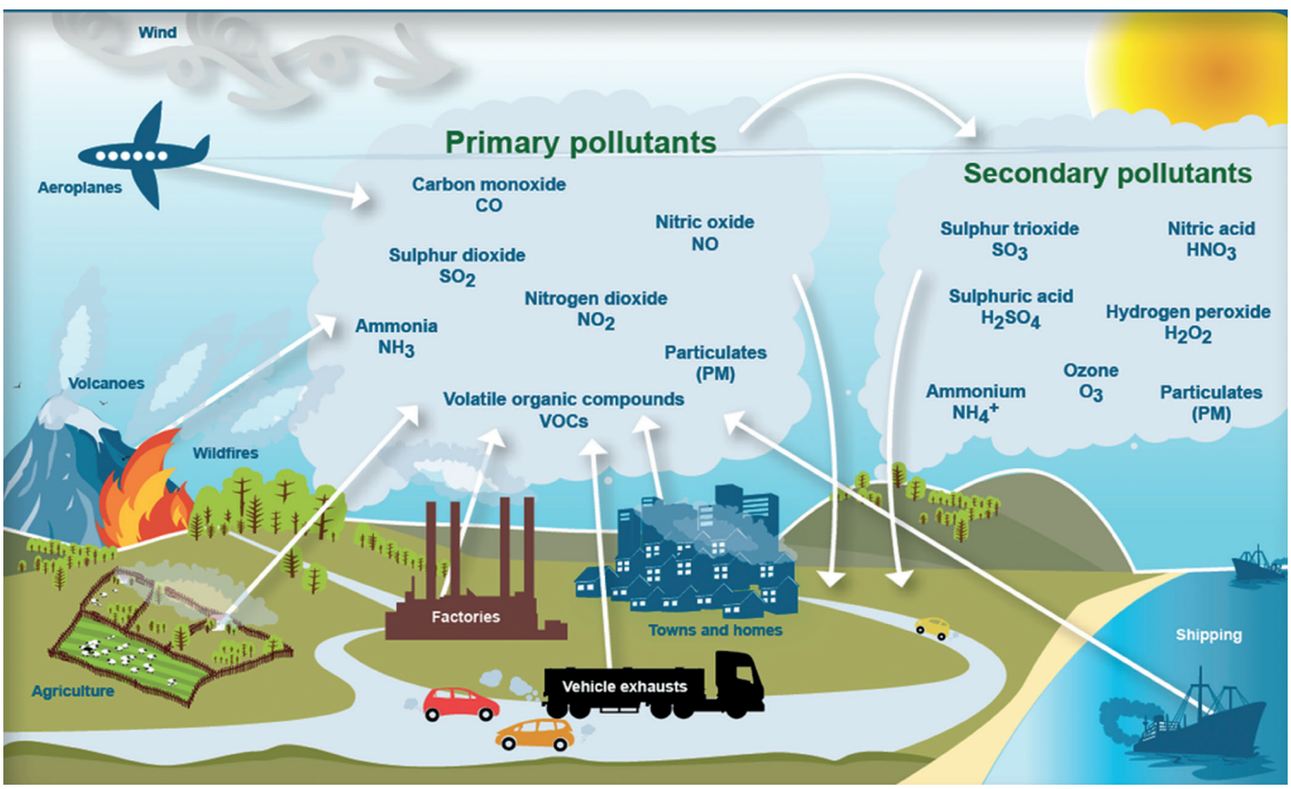
The origin of air pollution can be traced from the times when man started using firewood as a means of cooking and heating. With the discovery of coal and consequent industrialization, air pollution became more pronounced.

With the development of transportation, the use of petrol and diesel has increased. The severe air quality problems have arisen due to the formation of photochemical smog from the combustion residues of diesel and petrol engines. Pollution due to vehicles and industries remain a serious environmental issue in many developed and developing countries including India.

Types of Air Pollutants

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

- **Natural Pollutants:** These are created by natural activities such as *volcanic dust, sea salt particles, photo-chemically formed ozone, and products of forest fires, among others*. Nature has its own mechanisms of dealing with such pollution. Notably, the concentration of pollutants from the natural sources is often quite low and rarely causes any serious damage.



- **Primary Pollutants:** These pollutants enter the air as a result of a natural event or human activities. They can have effects both directly and as precursors of secondary air pollutants. There are five primary pollutants that together contribute about 90 percent of the global air pollution. These are carbon oxides (CO and CO_2), nitrogen oxides, sulphur oxides, volatile organic compounds (mostly hydrocarbons) and suspended particulate matter.
- **Secondary Pollutants:** A secondary pollutant is formed by reaction of one primary pollutant with another in the atmosphere. For example, Ground Level Ozone, Smog and Acid Rain, sulphuric acid, nitric acid, carbonic acid, etc.

Major Air Pollutants and Their Impact

Some of the major air pollutants, their sources and effects are given in the table below.

POLLUTANT	DESCRIPTION	SOURCES	IMPACT
Carbon Monoxide (CO)	• An odourless, colorless, tasteless and poisonous gas. • Produced by the incomplete burning of fossil fuels like gasoline, oil, natural gas. • Slightly lighter than air.	• Exhaust of Internal Combustion Engines, especially of vehicles with petrol engines. • Forest fires, Wood stoves, cigarette smoke, and burning of crop residues.	• CO interferes with the blood's ability to carry oxygen, slowing reflexes and causing drowsiness. In high concentrations, CO can cause death. • Heart patients are sensitive to CO and may experience chest pain. • Adverse effect on the foetus of a pregnant woman.
Sulphur Dioxide (SO_2)	• Produced by volcanoes and in various industrial processes.	• Combustion of fossil fuels. • Paper Industry. • Petroleum Refining. • Smelting of metals.	• Respiratory illness, visibility impairment, aggravates existing heart and lung disease. • Acid Rain • Aesthetic damage to properties.
Nitrogen Oxides (NOx)	• Nitrogen and oxygen combine during combustion to form nitrogen oxides. • Many nitrogen oxides are colorless and odorless gases.	• Burning of biomass and fossil fuels. • High temperature combustion (IC Engines, fossil fuel-fired power stations, industries).	• Irritates nose, throat and lungs. • Aggravate asthma or chronic bronchitis. Increases vulnerability to respiratory infections such as influenza or common colds. • Smog formation, Acid rain. • NOx easily dissolves in water and forms acids which can cause metal corrosion and deterioration in fabrics quality.
Lead	• Bright, silvery, soft, dense, ductile, highly malleable, bluish-white metal. • Poor electrical conductivity. • High resistance to corrosion.	• Waste incineration. • Metal Processing. • Paint Industry. • Automobile exhaust. • Food (as lead is absorbed by plants).	• Adverse effects on the central nervous system, cardiovascular system, kidneys and immune system. • Causes blood disorders like anaemia, increase in blood pressure. • Reduces the cognitive capacity of children. • Miscarriage, delay in puberty. • Reduction of fertility in males.
Volatile Organic Compounds (VOCs)	• VOCs are organic compounds that vaporize easily. • Gasoline, benzene, toluene and xylene are its examples. • Emitted as fumes.	• Solvents, cleaning supplies, paints, and glues. • Automobile exhaust.	• May cause chromosomal damage. • Affect the reproductive system, developing foetus and fertility in men. • May cause Cancer. • Contribute to smog formation.

POLLUTANT	DESCRIPTION	SOURCES	IMPACT
Ozone (O_3)	• A pale blue gas • Soluble in water and non-polar solvents. • Ozone is created by a chemical reaction between NOx and VOCs in the presence of sunlight.	• Formed by the reaction of sunlight with air, containing hydrocarbons and nitrogen oxides emitted by car engines and industrial operations. • Electronic equipment such as photocopier.	• Lung Function deficits. • Respiratory illness. • Premature death, asthma, bronchitis, heart attack and other cardiopulmonary problems. • Stunts overall growth of some plants. Damages leaves of trees and other plants. • Decreases the ability of plants to produce and store food and reduces crop yield.
Particulate Matter (PM 2.5 and PM 10)	• Solid or liquid matter that is suspended in the air. • To remain in the air, particles usually must be less than 0.1-mm wide and can be as small as 0.00005 mm.	• Road traffic emissions. • Industrial Combustion plants for power generation. • Construction activities. • Residential combustion. • Wind-blown dust such as road dust, fly ash, soot.	• Visibility reduction. • Cardiopulmonary problems. • Asthma, chronic bronchitis and pneumonia in elder people. • Aesthetic damage to properties.
Some Pollutants not included in NAAQS (National Ambient Air Quality Standards) list:			
Carbon Dioxide (CO_2)	• Colorless gas.	• Respiration by animals and plants. • Burning of Fossil fuels.	• Green House effect and climate change • Breathlessness, Headache, Chest congestion.
Chloro-fluoro-carbons (CFC)	• Non-toxic, non-flammable.	• Air conditioners, refrigerators. • Foam insulations • Aerosol propellants • Solvent cleaners.	• Depletion of stratospheric Ozone. It protects human from harmful UV radiation. • Enhanced UV rays cause skin cancer, cataracts, etc.
Noise		• Factories, Industries, Transportion. • Religious, cultural activities.	• Auditory problems. • Speech interference. • Annoyance. • Loss in Efficiency. • Physiological disorders.

Indoor Air Pollution

More than 3 billion people use solid fuels like wood, charcoal, cow dung and crop wastes to cook food on traditional stoves or open fire. Such inefficient practices produce high levels of indoor air pollution with release of a range of health damaging pollutants such as fine particles and carbon monoxide.

Smoke in and around the poorly ventilated dwellings can exceed threshold pollution levels and may lead to health hazards. Women and young children, having high exposure to such pollution, suffer from acute respiratory problems which include cough, lung infection, asthma, noisy respiration and wheezing.

Indoor air problems can be subtle and is not always recognizable. According to World Health Organization (WHO), 4.3 million people in a year die from the exposure to household air pollution.

Smog

It is a type of air pollution derived from vehicular emission and industrial fumes that react in the atmosphere with sunlight to form secondary pollutants. These secondary pollutants combine with the primary emissions to form photochemical smog. One of the primary components of photochemical smog is Ozone. Ozone in stratosphere protects the Blue Planet, but Ozone is a harmful pollutant in troposphere, detriment for human and environmental health.

Fly Ash

The ash produced mostly by thermal power plants as by-products of coal burning operations is termed as Fly ash.

It consists primarily of *oxides of silicon, aluminum iron and calcium*. Magnesium, potassium, sodium, titanium, and sulfur are also present to a lesser degree.

Fly ash pollutes air as well as water. It affects vegetation as a result of its direct deposition on leaf surfaces or indirectly through its deposition on soil.

Now a days, Fly ash is being used for making bricks and as a landfill material. Bricks made of fly ash have increased strength and durability making it more resilient. It is also less susceptible to chemical attacks.

The Ministry of Environment and Forests, recognizing the value of fly ash, has made it mandatory to use Fly ash in all construction projects, road embankment works and landfilling works within 100 km radius of coal or lignite based thermal power plants.

Control Measures for Pollution

Realizing the urgent need for arresting the trend, steps must be taken to reduce the growing menace. It can be controlled by two fundamental ways:

Preventive Measures

- Use of cleaner fuels such as Liquefied Natural Gas (LNG) in power plants which is cheaper in addition to being environmentally friendly.
- Use of hydrogen fuel and e-vehicles should be promoted.
- Environment friendly industrial processes should be encouraged so that emission of pollutants and hazardous waste is minimized.
- Increasing the height of chimneys, closing industries which are hazardous for environment, shifting of polluting industries away from cities, development and maintenance of green belt of adequate width can greatly reduce air pollution.
- Setting up of emission standards for automobiles has already seen an improvement in vehicular emissions. Further research and innovation in technology will reduce the pollution to a great extent.
- In bigger cities like Delhi and Mumbai, motor vehicles need to obtain Pollution under Control (PUC) Certificate at regular intervals. This ensures that levels of pollutants emitted from vehicle exhaust are always within the prescribed legal limits.
- Alternate fuels like CNG is being encouraged for use in public transport vehicles.

Effluent Control

Pollution can be minimized by installing devices which reduce release of pollutants. Some devices which can help in minimizing pollution as they restrict the release of pollutants in the atmosphere, are as under:

- **Filters:** Filters remove particulate matter from the gas stream. The medium of a filter may be made of fibrous materials like cloth, granular material like sand, a rigid material like screen, or any mat like felt pad.
- **Electrostatic Precipitators (ESP):** The flue gas dust is charged with ions and the ionized particulate matter is collected on an oppositely charged plate. The particles are removed from the collecting plate by occasional shaking or by rapping the surface. ESPs are used in boilers, furnaces, thermal power plants, cement factories, steel plants, etc.
- **Scrubber:** It is a system that is used to remove harmful materials from industrial exhaust gases before they are released into the environment. These are mainly of 2 types:
  - **Wet Scrubbing:** The removal of harmful components of exhausted flue gases by spraying a liquid substance through the gas.
  - **Dry Scrubbing:** The removal of harmful components of exhausted flue gases by introducing a solid substance to the gas - generally in powdered form.

  By removing acidic gases from the exhaust before it is released into the sky, scrubbers help prevent the formation of acid rain.

STEPS WE CAN TAKE TO HELP OUR ENVIRONMENT

In addition to all the measures mentioned above, we must put conscious efforts individually to reduce air pollution at home as well as on the move. Some of them have been mentioned below:

- Instead of outdoor burning of waste, composting of waste is advisable. The compost can be used in the farm.
- Use of air conditioners should be minimized.
- Planting of trees must be encouraged. Trees absorb carbon dioxide from the atmosphere and filter the pollution.
- Regular maintenance of vehicles should be ensured for better engine efficiency and reduced pollution levels.
- Walking and bicycling for works in the vicinity should be adopted.
- Use of public transport should be imbibed at an individual level. Moreover, we should encourage family members to use public conveyance as much as possible. It can save us money as well as reduce air pollution.

11.2 Air Pollution in India

The rate at which air pollution, especially urban, has been growing across India is a cause of concern. A vast majority of cities fail to meet health-based standard due to deteriorating air quality.

Almost all cities are reeling under severe particulate pollution while newer pollutants like nitrogen oxides and air toxics have begun to add to the public health challenge. Interestingly, even small and medium-sized cities are seeing a phenomenal rise in pollution.

Limitations

Air quality data is vital for assessing public health impacts caused by poor air quality. The challenge is to get measurements of daily local air. However, Geographic or spatial gaps exist in the air quality monitoring network, especially in rural areas.

The gaps in temporal and spatial coverage restrains the complete assessment of air pollution exposure that is needed to assess health outcomes. The air quality monitor may not be located where a person lives or works. Also, the air quality monitor may not have sampled the air at the time a person experienced a health issue (e.g., an asthma attack).

As every instruments or steps has cost considerations, the measure we choose at any given time depends on what our concerns may be. Moreover, since we do not know which compounds have the greatest health effects, it can be difficult to know which measure is most important. Consequently, our considerations may be based on our premises like short-term versus long-term effects or do we need to find single pollutant versus multi-pollutant measures.

Measures Taken for Air Pollution

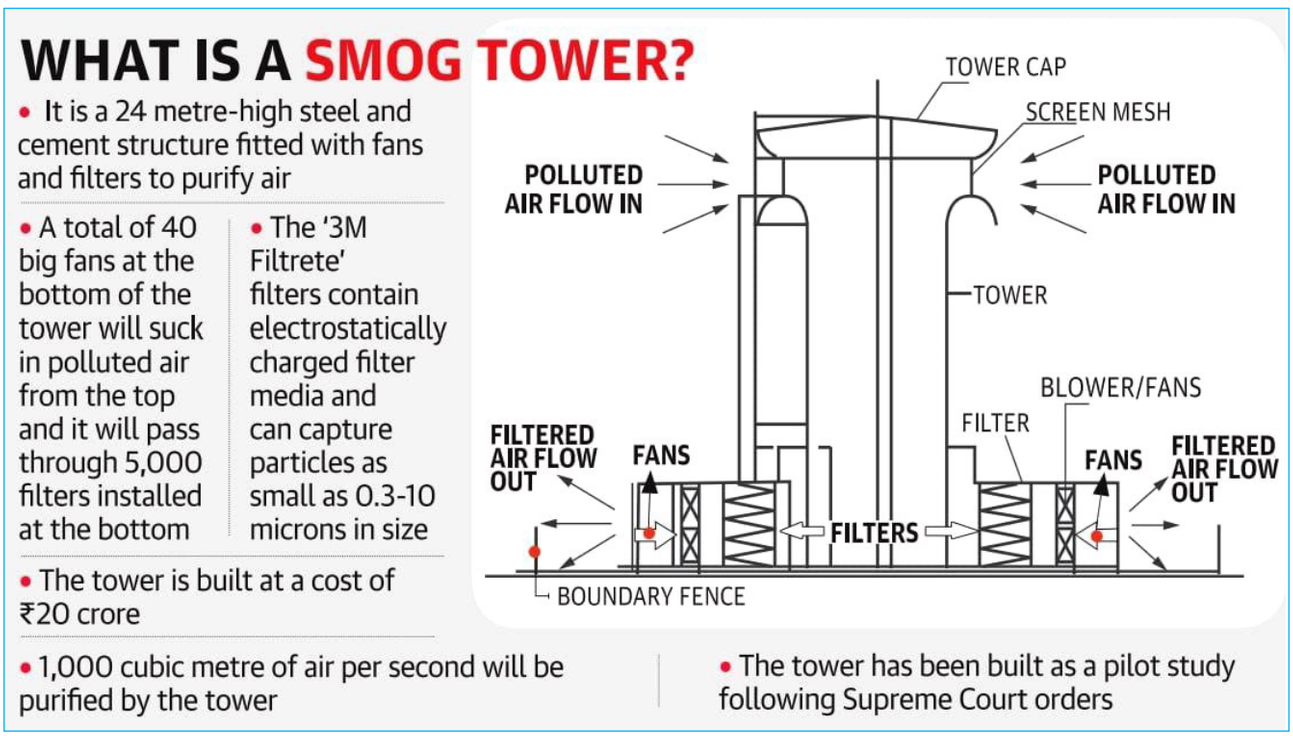
The country brought *The Air (Prevention And Control of Pollution) Act, 1981,* after which the government took the agency to monitor the national air quality and curb pollution. *The Central Pollution Control Board (CPCB)* was entrusted with the functions and powers to monitor air quality under this act.

Additionally, the Supreme Court of India declared the *"right to a decent environment, including pollution-free water and air"* as a fundamental right under Article 21 (right to life) in the *MC Mehta vs. Union of India, 1988 Case.*

Following the case, apex court itself started monitoring Delhi's air quality and gave directions to the central government to establish the *Environment Pollution (Prevention and Control) Authority(EPCA).*

To minimize the impact of environmental pollution particularly air pollution, the Government has taken the following actions:

- The Government has notified National Ambient Air Quality Standards 2009, envisaging 12 pollutants to indicate the levels of air quality.
- Setting up of a monitoring network for assessment of ambient air quality in different cities.
- Introduction of cleaner or alternate fuel like CNG, LPG and Bio-Diesel (B_{20}).
- Strengthening of public transport network including Metro and Bus Rapid Transit System (BRTS).
- Setting up of common pollution control facilities for industrial pollution control.
- Rolled out of Bharat Stage VI norms has been enforced all over the country since 2020.
- Stringent industrial standards have been formulated and notified for public/stakeholder's comments.
- Environment clearances has been made compulsory for developmental projects. Also, public hearing has been made an important component of Environmental Impact Assessment process.
- Environmental audits have been made compulsory for all polluting industries.
- Introduction of Green Crackers, Smog Towers etc.



Air pollution is known to be one of the aggravating factors for many respiratory ailments and cardiovascular diseases. We need to be proactive and ensure that it remains below the prescribed limit for a healthy living. Some of the steps that could help us in moving forward towards a clean environment are as under:

- **Emphasis on Clean Energy Resources:** Government of India has been incentivizing the use of Clean energy technologies like solar, wind and geothermal to curb air pollution.
- **Use of Energy Efficient Devices:** E.g. LED consumes less electricity as against traditional bulbs. They have a longer life and helps in reducing pollution by consuming less energy.
- **Use of Public Mode of Transportation:** Concept of car-pooling is on the rise as awareness towards air pollution is increasing.
- **Conserving Energy:** Behavioral change will foster energy efficiency in home and Industrial establishment.
- **Emission Norms:** Better traffic management and timely implementation of the emission norms will go a long way in curbing air pollution.
- **Green Corridors:** Development of green belts across the highways and transportation lines will reduce harmful effects of pollution.

Other Developments

Measurement of Air Pollution

Central Pollution Control Board along with State Pollution Control Boards has been operating National Air Monitoring Program (NAMP) covering 240 cities of the country. In addition, continuous monitoring systems that provide data on near real-time basis are also installed in a few cities.

Traditionally, air quality status has been reported through voluminous data. Thus, it was important that information on air quality is put up in public domain in simple linguistic terms that is easily understood by a common person. Air Quality Index (AQI) is one such tool for effective dissemination of air quality information to people.

About AQI

- The AQI, as *'One Number-One Colour-One Description'* for the common man to judge the air quality within his vicinity.
- The formulation of the index was a continuation of the initiatives under Swachh Bharat Mission.
- The index constituted part of the Government's mission to introduce the culture of cleanliness. Institutional and infrastructural measures were being undertaken in order to ensure that the mandate of cleanliness was fulfilled across the country.
- As a part of the process the clean air would be a part of peoples' campaign to take up the issue in a mission mode.

Under the new measurement process an effort had been made to include a comprehensive set of parameters. While the earlier measuring index was limited to three indicators, the current measurement index had been made quite comprehensive by the addition of five additional parameters. The recent initiatives undertaken by the Ministry aimed at balancing environment and conservation and development.

There are ***six AQI categories***, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe.

The AQI will consider eight pollutants (PM10, PM2.5, NO_2, SO_2, CO, O_3, NH_3, and Pb) for which short-term (up to 24-hourly averaging period) National Ambient Air Quality Standards are prescribed.

Based on the measured ambient concentrations, corresponding standards and likely health impact, a sub-index is calculated for each of these pollutants.

AQI	ASSOCIATED HEALTH IMPACTS
Good (0-50)	Minimal Impact
Satisfactory (51-100)	May cause minor breathing discomfort to sensitive people.
Moderately polluted (101-200)	May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults.
Poor (201-300)	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease
Very Poor (301-400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
Severe (401-500)	May cause respiratory impact even on healthy people, and serious health impacts on people with lung/heart disease. The health impacts may be experienced even during light physical activity.

Commission for Air Quality Management (CAQM)

Air Quality Management in National Capital Region and Adjoining Areas Act, 2021 was passed on 12th August 2021 to ***set up a Commission*** which provides for better co-ordination, research, identification, and resolution of problems related to air quality in the National Capital Region (NCR) and adjoining areas.

Adjoining areas have been defined as areas in the states of Haryana, Punjab, Rajasthan, and Uttar Pradesh adjoining the NCR where any source of pollution may cause adverse impact on air quality in the NCR.

Earlier several bodies and agencies have carried out monitoring of air quality in the capital city of Delhi. These included the CPCB, EPCA, state governments of the region (Delhi, Uttar Pradesh, Rajasthan, and Haryana), etc. Above all, the Union Ministry of Environment, Forest and Climate Change and the Supreme court also kept an eye.

The act seeks to create a body that overarches and consolidates all these agencies. This will enhance the air quality monitoring by bringing all the stakeholders on one platform and enhancing the efficiency of the monitoring process. Ultimately the process will become more efficient and comprehensive while reaching the results in a time-bound manner.

National Clean Air Programme (NCAP)

National Clean Air Programme (NCAP) is a national level strategy for reduction in air pollution levels at both regional and urban scales. NCAP was launched in ***2019*** as a long-term, time-bound, national level strategy to tackle the air pollution problem across the country in a comprehensive manner with targets to ***achieve 20% to 30% reductio***n in Particulate Matter concentrations by 2024 keeping 2017 as the base year for the comparison of concentration.

Recently center has set a ***new target*** of a ***40% reduction*** in PM concentration in cities coverd under NCAP by 2026. Under NCAP, ***123 non-attainment cities*** have been identified across the country based on the Air Quality data from 2014-2018.

The broad objectives of NCAP are:

- To augment and evolve effective and proficient ambient air quality monitoring network across the country for ensuring comprehensive and reliable database
- To have efficient data dissemination and public outreach mechanism for timely measures for prevention and mitigation of air pollution and for inclusive public participation in both planning and implementation of the programmes and policies of government on air pollution
- To have a feasible management plan for prevention, control and abatement of air pollution.

The approach which will be followed by NCAP includes Collaborative, Multi-scale and Cross-Sectoral Coordination between relevant Central Ministries, State Government and local bodies and Focus on no Regret Measures, Participatory and Disciplined approach.

Under NCAP, 132 cities are being targeted for improving air quality. Of these 132 cities, 123 cities (NACs) are identified under NCAP based on non-conforming to national ambient air quality standards (NAAQS) consecutively for five years. 131 cities (NACs and MPCs) are being monitored under the NCAP for improving air quality.

A recent analysis by the environmental think tank, Centre for Science and Environment has revealed that there is no change in trends in particulate matter pollution (PM2.5) between the group of cities under the National Clean Air Programme (NCAP) and those outside its ambit.

A non-attainment city is defined as a city whose air quality did not meet the national ambient air quality standards of 2011 to 2015.

The recent analysis by Centre for Research on Energy and Clean Air (CREA) has revealed that NCAP has failed to achieve its target as of now:

- Out of 130 cities, 28 still do not have continuous ambient air quality monitoring stations (CAAQMS). Among the 102 cities that do have monitoring stations, only 97 cities reported 80% or more PM10 data coverage.
- Of these 97 NCAP cities, 29 recorded an increase in PM10 concentrations. Only 41 cities out of the 97 achieved the initial NCAP target of a 20-30% reduction in PM10 levels.
- Also, 61 of the 68 cities that reported a reduction still had PM10 concentrations exceeding the National Ambient Air Quality Standards (NAAQS).
- State level analysis showed that all 8 monitored cities in Punjab exceeded PM 2.5 NAAQS. Also, the exceedance was high in Haryana (22 cities exceed NAAQS out of 24 monitored cities), Bihar (20 out of 23), Odisha (14 out of 16), Rajasthan (26 out of 36), Maharashtra (18 out of 31), Uttar Pradesh (13 out of 20), Madhya Pradesh (8 out of 14), West Bengal (5 out of 7), and Assam (4 out of 6).
- Rajasthan, Maharashtra, Bihar, Haryana, Odisha, Punjab, West Bengal, Gujarat and Uttarakhand states had all the monitored cities exceeding PM10 NAAQS.

Comprehensive Action Plan (CAP)

The Comprehensive Action Plan (CAP) is a long term plan to address the issue of air pollution (especially in Delhi-NCR). It aims to meet ambient air quality standards in the National Capital Territory of Delhi and National Capital Region, including states of Haryana, Rajasthan and Uttar Pradesh.

The guiding principles of the plan are:

- Meet clean air standards in a time-bound manner
- Take action on all sources of pollution to meet clean air targets
- Reduce integrated exposure to protect public health
- Public health risk from air pollution is grave and growing
- Address quantum vs toxicity
- Adopt a regional approach for a common air-shed
- Enforce emergency action to control and minimize exposure on a daily basis
- Addressing both consistent and seasonal sources of pollution
- Address secondary particulates that are formed in the air by gasses

The aim is not to create new institutions but to make the current institutional arrangements mandated by the Hon'ble Supreme Court for implementation of the Graded Response Action Plan and by the Hon'ble National Green Tribunal for air pollution control in the region responsible for implementation of the action plan.

The following institutional arrangement is proposed for implementation of the Comprehensive Action Plan. The institutions are as follows:

- Central-level Committee under the Secretary, Ministry of Environment, Forests and Climate Change to oversee implementation at the NCR level

- State-level committees under the Chief Secretary to oversee implementation at the state level
- CPCB-Task Force to monitor air quality and to inform Central, state committees and the EPCA about the need for implementation of measures under the Graded Response Action Plan
- Directions under the Graded Response Action Plan; monitoring of key milestones in comprehensive action plan and preparation of special reports on key to guide action by EPCA. Regular compliance reports to the Hon'ble Supreme Court.

Graded Response Action Plan (GRAP)

The air pollution level of winter in Delhi has been a major concern for the past four-five years.The city is shrouded in smoke from burning stubble in the nearby rural regions of the states of Haryana and Punjab, as well as fumes from automobiles and industries. Lower temperatures and slower-moving winds also trap airborne pollution.

GRAP is a methodical strategy to stop Delhi-air NCR's quality from getting worse. It was developed in 2017 in collaboration with the Delhi government and the Environmental Pollution Prevention and Control Authority (EPCA).

It is an emergency response mechanism and is only enforced when air pollution reaches a certain threshold and the plan is incremental and adaptable, which means the preventive measures will be updated and escalated according to changes in the AQI.

GRAP measures are categorised by stages viz. Moderate to poor, Very poor, Severe and Severe-plus or emergency.

The GRAP requires action and coordination among 13 different agencies from Delhi, Uttar Pradesh, Haryana, and Rajasthan, including the respective state governments, state pollution control boards, traffic police, Central Public Works Department, and Petroleum and Explosives Safety Organisations (PESOs) from each state.

11.3 Acid Rain

Any precipitation in the form of rain, fog, mist or snow which is acidified is termed as Acid Rain. Air pollution from burning of fossil fuels increases the concentration of *oxides of Sulphur and Nitrogen* in the air. When these oxides in the air react with the moisture in the air then it leads to acid rain.

For its occurrence, the concentration of pollutants is necessary. This is common in the industrial areas. For example, in India acid rain was firstly reported in 1974 in Mumbai region which has high concentration of industries.

Acid rain is a problem all over the world, when acid gases are released, they go up in the sky, and then they are carried by strong winds. For example, Acid rain in Scandinavian countries is caused by air pollution in Britain and other countries of Europe. In the USA, winds blow the air pollution to certain areas in Canada

Rain is naturally acidic, but acid gases make it even more acidic. Acid rain has pH value less than 7 on the pH scale.

Types of Acid Deposition

The types of acid deposition in the air depends upon the moisture content in the atmosphere. Based on the moisture content acid deposition can be classified as:

- **Wet Deposition:** Acidic deposition is in the regions where atmospheric conditions are wet. These acidic elements in the air come down to the ground in the form of precipitations like rain, fog, mist or snow. Wet form of deposition like acid rain is common in regions of high moisture. This type of acid deposition is common in east margins of Tropical regions, west margins of the Temperate region and Polar Regions of the earth where there is high concentration of pollution sources.
- **Dry Deposition:** Acidic deposition in the regions where atmospheric conditions are dry, these acidic elements in the air come down to the ground along with wind by getting mixed with aerosols. For example, the dust particles, smoke, pollen grains, salt particles etc. act as the locus for acid deposition in dry areas.

These acidic elements get settled down on the ground along with aerosols. They are then washed out by the rain during rainy season. This type of acid deposition is common in west margins of Tropical areas, east margins of Temperate areas where there is concentration of pollution sources.

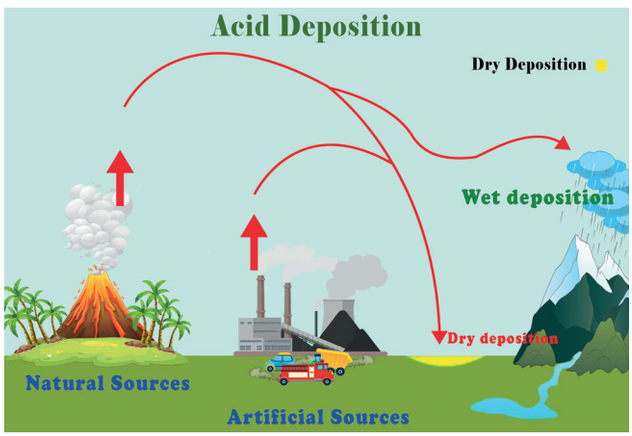
Sources of Acid Rain

Acid rain is the result of polluting gases like Sulphur dioxide, Nitrogen oxides, Formic acid, Carbon dioxide, Carbon monoxide, Methane, Chlorine as well as from Phosphoric acid and hydrochloric acid.

COMPOUNDS	NATURAL SOURCES	ANTHROPOGENIC SOURCES
Sulphur Dioxide	Volcanoes, Oceans, Decomposition of organic matter	Fossil fuel burning, Industrial processes, Thermal power plants based on coal.
Nitrogen Oxides	Volcanoes, Lightening, Decomposition of organic matter, Forest fires	Fossil fuel burning, Power plants based on coal, Biomass burning
Formic Acid	Forest fires	Biomass burning
Carbon Dioxide	Respiration, Decomposition	Fossil fuel burning, Industrial processes
Carbon Monoxide	Isoprene emissions by plants	Biomass burning, Industrial sources

Chemistry of Acid Rain

- As a result of both natural and anthropogenic activities, concentration of sulphur and nitrogen increases in the air. These are present in the form of oxides.
- In drier regions some of this is deposited in the form of dry deposits.
- Formation of Nitrogen dioxide and Sulphur dioxide in the atmosphere. Both sulphur dioxide and nitrogen dioxide are acidic oxides and react with water to form acids. Sulphur dioxide reacts with water to form sulphurous acid.
- Substances in the upper atmosphere then catalyse the reaction between sulphurous acid and oxygen to form sulphuric acid. Similarly, nitrogen dioxide reacts with water to form a mixture of nitric acid and nitrous acid.
- Both sulphuric acid and nitric acid are soluble in water and are the major acids present in acid rain. They come down as Acid Rain.



Impact of Acid Rain

Acid rain has significant impact on both aquatic as well as terrestrial flora and fauna and also on buildings and monuments. Certain amount of acidity in rain may be buffered by the ecosystems without any serious dislocation. But excess of acidity in rainwater can change ecosystems considerably.

On Soil

- *Leaching* i.e. it is a process in which acid rain deposition adds hydrogen ions in the soil. This leads to displacement of important nutrients like calcium, magnesium, potassium. Leaching pushes the nutrients deeper in the soil, thus makes it difficult for plant roots to get nutrients. This makes soil infertile.
- It affects respiration by the soil organisms.
- As the nutrients become scarce in the soil, it also impacts rate of decomposition.
- If the soil is alkaline; when acid rain falls on it the acid becomes neutral and so the plants are not hugely affected, but if the soil is slightly acidic, it can be disastrous.

On Vegetation

- Acid rain reduces photosynthesis rate in plants. This affects their growth rate.
- The abnormal growth rate has various impacts like discolouration, decline in biomass, early ageing, death of tree.
- Moreover, absorption of acidic ions from the soil affects metabolism in plants.

On Microorganisms

Microorganisms have very limited range of pH in which they can survive. Any change in this pH affects their number in any environment. As most of the microorganisms like bacteria and protozoa, except fungi, thrive in the environment with near neutral pH, acid rain has severe impact on the population of microorganisms.

Acid rain changes the area from bacteria-dominated to fungi-dominated. This leads to increase in fungal diseases and reduces the rate of decomposition of organic material in the soil.

On Aquatic Life

The pH value is important determinant of metabolic process in aquatic region. The eggs or sperms of fish, frogs and other aquatic organisms are very sensitive to pH change. Acid rain kills their gametes affecting the life cycles and productivity.

This in turn have impact on food chain in the aquatic environment. This causes ecological imbalance. Further, acid rain kills planktons which are primary producers in the aquatic food chain. This makes water bodies lifeless as fishes die because of lack of availability of food. This has impact of livelihood of fishermen.

On Terrestrial Life

Acid rain affects the photosynthesis rate in plants. As plants are primary source of food in terrestrial ecosystem, this affects the food chain. Thus there is a threat to the population of terrestrial animals because of acid rain, but this is an indirect threat.

On Humans

Acid rain looks, feels, and tastes just like clean rain. The harm to people from acid rain is not direct. Acid rain does not have an acidic enough pH to burn human skin.

The air pollution that causes acid rain is more damaging to human health. Sulphur dioxide and nitrogen oxides, the major sources of acid rain, can irritate or even damage our lungs, reduce visibility and can cause irritation to the skin, eyes and respiratory tract.

Moreover, sulphur dioxide particles in the air can encourage chronic lung problems, like asthma and bronchitis. Additionally, the nitrogen oxides that create acid rain promote the formation of ground-level ozone which is harmful.

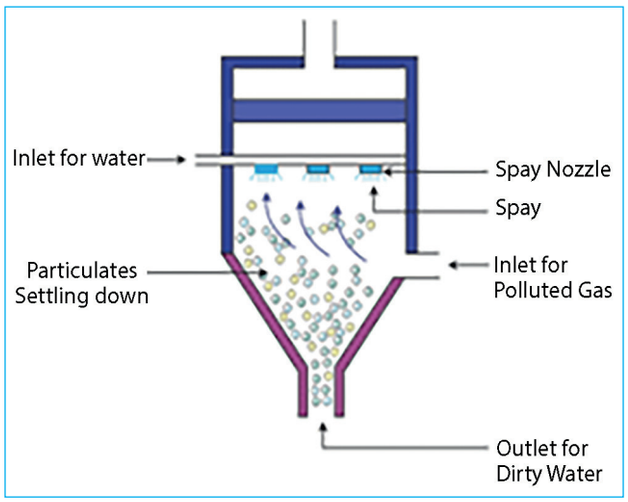
Further, acid rain has impact on water resources and on food chains of which humans are part. Thus acid rains can cause food poisoning.

On Buildings and Monuments

Many old, historic, ancient buildings and works of art/ textile etc. are adversely affected by acid rain. Limestone and marble are destroyed by acid rain. Smoke and soot cover such objects. They slowly dissolve/flake away the surfaces because of acid fumes in the air. Many buildings/ monuments such as Taj Mahal in Agra have suffered from acid rain.

Control Measures for Acid Rain

Any measure that controls the emission of pollutants like sulphur and nitrogen oxides will help in reducing acid rain. Following are some of the control measures:



- **Cleaner Fuels:** Use of low sulphur fuel, natural gas or washed coal in thermal power plants.
- **Scrubbers:** In power plants attaching devices known as 'scrubbers' in the chimneys. These scrubbers reduce the amount of sulphur produced in the smoke by 90 – 95%.
- **Catalytic Converters:** Fitting catalytic converters into the exhaust pipes of vehicles also reduces the amount of sulphur dioxide produced by the vehicles.
- **Shift to Renewable Energy:** Alternate energy sources like tidal, wind, hydropower etc can reduce the emission of harmful gases.

Other Measures

- Addition of neutralizing agents like lime to increase the pH value of the water.
- Shift towards better emission standards.
- Industries must regularly inspect and clean all their emission equipment and chimneys and pipes.
- All these acid rain solutions will be pointless unless people are informed and educated about the ill-effects and harms of acid rain. A widespread and nationwide effort must be made to make people aware. Only after that is done will all the acid rain solutions actually make a difference.

Acid rain can become the environmental hazard/disaster in the industrialized world and hence strong measure must be taken to prevent it.

Conclusion

Air quality management is an ongoing process. It needs to be integrated into the capabilities of the government, as well as incorporated into the behavior of businesses and individuals. This requires sufficient funding and a sustained focus on building capacity.

The air pollution crisis will require innovative, collaborative solutions from public, private, and civil society stakeholders. Institutions, governments, philanthropies, and members of the academic have been fighting the battle for clean air for decades; it is time to tap into the power of a multi-stakeholder framework to hurdle this challenge.

In 2020, based on the recommendations of the 15th Finance Commission, the Government of India has set aside about $1.7 billion to fight air pollution over the next five years for the 42 Indian cities that have million-plus populations – provided they reduce their air pollution levels by 15 percent every year. This is the world's first performance-based fiscal transfer funding program for air quality management in cities.

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TRY SOME MAINS PREVIOUS YEAR QUESTIONS

1. Describe the key points of the revived 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 these revised standards? (Write in 150 words) **(2021)**

2. What are the key features of the National Clean Air Programme (NCAP) initiated by the Government of India? (Write in 250 words) **(2020)**