

Contemporary Issue (Smog Issue in India)

Overview of the Issue

Smog is a major global health crisis, with developing nations, especially India and South Asia, bearing a disproportionate burden. In India, the situation is particularly severe, with cities consistently ranking among the world's most polluted due to a combination of diverse emission sources and unfavourable weather patterns.

Timeline of Smog Events and Policy Interventions

- **1996:** A high of 46 foggy days were reported in Delhi's winter months, highlighting an emerging pattern.
- **1998:** The Supreme Court ordered a major transformation of Delhi's transport system to curb air pollution, leading to the introduction of unleaded petrol and later the conversion of buses and taxis to CNG.
- **2014:** The World Health Organization (WHO) announced New Delhi as the most polluted city in the world. The Indian government launched the National Air Quality Index (AQI) to inform the public about pollution levels.
- **November 2016 (The Great Smog of Delhi):** Air pollution levels reached 16 times above safe limits, with PM2.5 and PM10 levels hitting 999 (the maximum level for monitors). The Delhi government declared an emergency and temporarily shut down the Badarpur Thermal Power Station. The Graded Response Action Plan (GRAP) for Delhi-NCR was approved by the Supreme Court.
- **November 2017:** A public health emergency was declared by the Indian Medical Association in Delhi as the AQI breached 999. The Delhi government introduced the odd-even car rationing rule and the Supreme Court banned the sale of firecrackers in the region.

- **December 2017:** A Test cricket match between India and Sri Lanka in Delhi was disrupted due to severe smog, with several players experiencing breathing problems and vomiting.
- **October 2018:** The highly polluting Badarpur power plant was permanently shut down.
- **November 2019:** The Supreme Court described Delhi as "worse than narak (hell)" due to the high pollution levels. A study linked high pollution in fall/winter to post-harvest crop residue burning.
- **2020:** Air quality in Delhi significantly improved during the COVID-19 pandemic lockdowns due to reduced anthropogenic activity. The Commission for Air Quality Management (CAQM) in NCR and Adjoining Areas was established.
- **November 2021:** The Delhi government ordered the closure of all schools and government offices for a week, and banned the entry of trucks, in response to severe air quality.
- **Winter 2023:** Delhi and the NCR region faced high pollution levels, with authorities implementing GRAP measures and the Supreme Court advising the Punjab government to reconsider laws that encourage stubble burning.
- **November 2024:** Delhi recorded its worst air quality of the season, with the 24-hour AQI reaching 491 ("severe plus"), and on one day it reached a hazardous 1,081. This severe smog episode, part of the wider 2024 India–Pakistan smog event, was linked to agricultural burning, Diwali fireworks, and adverse weather.

Note Points to understand the Issue

➤ What is Smog?

Smog is a type of intense air pollution that reduces visibility, forming a hazy, often yellowish or brownish layer in the atmosphere, especially over urban and industrial areas. The term is a blend of the words "smoke" and "fog," coined in the early 20th century to describe the smoky fog that plagued London. Smog is a complex mixture of primary and secondary pollutants including ground-level ozone, nitrogen oxides, sulfur oxides, carbon monoxide, and fine particulate matter.

➤ Types of Smog:

- **Industrial smog:** Also known as "classical smog," this type is caused by the burning of coal and other fossil fuels, which releases large amounts of sulfur dioxide (**SO₂**) and particulate matter. It appears as a thick, gray haze and is often associated with cold, humid conditions.
- **Photochemical smog:** This is a more modern type that forms when sunlight reacts with nitrogen oxides (**NO_x**) and volatile organic compounds (**VOCs**) from vehicle exhaust and industrial emissions. It results in ground level ozone and other harmful pollutants, creating a brownish haze, and is most common in hot, sunny, and dry climates.

➤ Key Steps in Smog Formation?

- **Emissions of Pollutants:** Pollutants like nitrogen oxides (**NO_x**) and volatile organic compounds (**VOCs**) are released into the atmosphere from human activities like burning fossil fuels in vehicles and power plants.
- **Sunlight's role:** Sunlight (especially ultraviolet radiation) interacts with these primary pollutants, triggering a series of chemical reactions.
- **Photochemical reactions:** The energy from sunlight breaks down nitrogen dioxide (**NO₂**) into nitric oxide (**NO**) and a free oxygen atom (**O**). The oxygen atom then combines with molecular oxygen (**O₂**) to form ozone (**O₃**). **VOCs** also undergo photochemical oxidation, producing other reactive intermediates.

- **Accumulation:** In the presence of weather conditions like temperature inversions, pollutants can become trapped in the lower atmosphere, leading to their accumulation and the formation of a dense smog layer.
- **Result:** The combination of ground-level ozone and particulate matter from the reactions creates the visible hazy pollution we call smog.

➤ **Natural Fog vs. Smog:**

Feature	Natural Fog	Smog
Composition	Tiny water droplets in the air	A toxic mixture of smoke, particulate matter, and other pollutants, formed from a chemical reaction with fog
Formation	Condensation of water vapor as warm, moist air cools, often during winter or in a temperature inversion	A chemical reaction between pollutants like nitrogen oxides, volatile organic compounds, and sunlight
Colour	White or gray	Yellowish or brownish, though it can also have a gray or bluish tint depending on the pollutants
Health Impact	None. It's a natural phenomenon that can reduce visibility	Harmful to health, causing respiratory issues like asthma and coughing, and eye irritation
Odour	Odourless	May have a distinct, acrid odour
Example	A natural, white haze that settles in a valley during winter	The thick, yellowish haze seen in many large cities, like Delhi or Los Angeles, especially after a period of high pollution and stagnant weather

➤ What are PM 2.5 and PM 10?

Particulate matter is a complex mixture of solid and liquid droplets that are suspended in the air. The size of the particles is directly linked to their potential for causing health problems.

- **PM 10:** These are "coarse" particles with a diameter of 10 micrometers or less. This size is roughly one-seventh the width of a human hair. Sources include crushing or grinding operations and dust stirred up by vehicles on roads, in addition to natural sources like pollen and mold.
- **PM 2.5:** These are "fine" particles with a diameter of 2.5 micrometers or less. They can be emitted directly from sources like vehicle exhaust and fires, or they can form when gases emitted from power plants, industries, and vehicles undergo chemical reactions in the atmosphere. Due to their small size, PM 2.5 can penetrate deep into the lungs and even the bloodstream

Relation with Smog:

- **Formation of Smog:** Fine particles (PM 2.5) are key ingredients in the chemical reactions that form smog, often involving other pollutants like nitrogen oxides and volatile organic compounds reacting with sunlight.
- **Visibility:** Both PM 2.5 and PM 10 contribute to the hazy, brownish appearance of smog by scattering and absorbing sunlight.
- **Health Impacts:** Because these particles are a primary component of smog, the health effects associated with smog such as respiratory irritation, reduced lung function, asthma attacks, and increased risk of heart disease and premature death are largely attributed to exposure to PM 2.5 and PM 10.

➤ Major Historical Smog Events:

- **Donora Smog (1948):** In Donora, Pennsylvania, a town on the Monongahela River, a smog event in October lasted several days. Hydrogen fluoride and sulfur dioxide from local industrial plants were trapped by a temperature inversion. The smog caused respiratory distress for thousands of the town's 14,000 residents and led to the deaths of 20 people over the initial weekend, with more dying in the following weeks. This event spurred the first national air pollution conference in the United States.

- **The Great Smog of London (1952):** This event is considered the worst air pollution episode in history. A thick, yellow-black smog blanketed London for five days in December. Initial estimates counted 4,000 deaths, but later studies revealed the total number of fatalities was likely around 12,000 people, with tens of thousands more falling ill. The disaster directly led to the UK's Clean Air Act of 1956.

What are the main causes of smog in India?

The major causes of smog in India are a combination of anthropogenic emissions and unfavourable meteorological conditions that trap pollutants near the ground.

Meteorological and Geographical Factors

- **Temperature Inversions:** During winter, a layer of warmer air often traps cooler, pollutant-filled air close to the ground, preventing the dispersal of smog.
- **Low Wind Speeds and Stagnant Conditions:** Calm or low wind conditions prevent the horizontal movement of air pollutants, allowing them to accumulate and reach hazardous concentrations.
- **Geography:** Cities located in geographical basins or plains (like the Indo-Gangetic plain, which includes Delhi) are particularly vulnerable as surrounding landforms can act as barriers, trapping pollutants.
- **Sunlight:** In the presence of sunlight, primary pollutants like nitrogen oxides and volatile organic compounds undergo photochemical reactions to form secondary pollutants like ground-level ozone, a primary component of photochemical smog.

Primary Human-Caused Contributors

- **Vehicular Emissions:** This is a major source of urban air pollution, especially in large cities like Delhi, Mumbai, and Kolkata. Vehicles emit pollutants such as nitrogen oxides (NO_x), carbon monoxide (CO), and fine particulate matter (PM_{2.5}), which are key ingredients in smog formation.

- **Industrial Emissions:** Factories, power plants (especially coal-fired ones), and various manufacturing units release a steady stream of pollutants, including sulfur dioxide (SO₂), nitrogen oxides, and particulate matter.
- **Agricultural Stubble Burning:** The practice of burning crop residues in states like Punjab and Haryana during the post-monsoon transition (October-November) significantly contributes to severe seasonal smog in North India. The smoke is carried by north-westerly winds and gets trapped in the Indo-Gangetic Plain.
- **Biomass and Solid Fuel Burning:** A large portion of rural, and some urban, households still use biomass, wood, and cow dung cakes for cooking and heating, which releases substantial amounts of smoke and particulate matter, creating a near-permanent haze over the country.
- **Construction and Road Dust:** India's rapid urban infrastructure development generates significant construction dust. Unpaved roads and ongoing construction activities stir up large amounts of dust and debris, a major source of PM10 and PM2.5 pollution.
- **Waste Burning:** The open burning of municipal solid waste and garbage in urban areas is a common practice that releases a variety of toxic gases and black carbon into the atmosphere.
- **Fireworks:** Widespread use of fireworks, especially during festivals like Diwali, leads to a massive surge in particulate matter and toxic gases over a short period, intensifying smog events.

What are the main geographical areas affected by smog in India?

Indo-Gangetic Plain (IGP)

This region is consistently the most affected, particularly during the winter months when geographical and meteorological conditions (like temperature inversion and low wind speeds) trap pollutants near the ground. The key states and cities include:

- **Delhi (National Capital Territory):** Often ranks as the world's most polluted capital city and experiences hazardous air quality levels, especially in winter.
- **Uttar Pradesh:** Numerous cities in this state, including Ghaziabad, Kanpur, Lucknow, Varanasi, Noida, Greater Noida, and Agra, face severe pollution issues.

- **Haryana:** Cities such as Gurugram, Faridabad, Hisar, and Panipat are heavily impacted.
- **Punjab:** Locations like Mullanpur, Jalandhar, Amritsar, and areas along major highways experience significant smog, partly due to seasonal stubble burning.
- **Bihar:** Cities like Patna, Gaya, and Muzaffarpur consistently show high levels of particulate matter.
- **West Bengal:** Kolkata and surrounding urban areas (like Sodpur, Titagarh, and Ingraj Bazar) also grapple with high pollution, particularly during winter.

Other Affected Areas

While the IGP is the primary hotspot, other regions also face significant, localized air pollution crises:

- **Central India:** Industrial and mining areas in states like Madhya Pradesh and Chhattisgarh (e.g., Bhopal, Raipur, Bhilai) experience poor air quality.
- **Western India:** Major urban centers such as Mumbai, Ahmedabad, and Pune experience rapid localized pollution build-up and high AQI levels.
- **Northeast India:** Industrial towns such as Byrnihat in Assam/Meghalaya have been identified as global pollution hotspots due to local industrial emissions.
- **Southern India:** Generally less polluted than the north, cities like Hyderabad, Chennai, and Bengaluru still see localized spikes in pollution due to urban growth, industrial activities, and vehicular traffic.

Why is smog particularly bad in northern India (like Delhi) during the winter months?

Smog is especially bad during the winter months in north India, including Delhi, due to a "perfect storm" of unfavorable weather conditions that trap pollutants combined with increased seasonal and year-round emissions.

Meteorological Factors (The "Trapping" Effect)

- **Temperature Inversion:** This is a key phenomenon where a layer of warm air in the upper atmosphere acts like a lid, trapping cooler, denser air (and all the

pollutants) near the surface. Normally, warm air near the ground rises and disperses pollutants, but in winter, this process is reversed.

- **Low Wind Speeds and Stagnant Air:** Winter months often feature calm or weak winds, meaning pollutants from vehicles, industries, and other sources are not dispersed horizontally or vertically. They accumulate and linger for extended periods, forming a thick, dense layer of smog.
- **Geographic "Bowl" Effect:** Delhi's location in the Indo-Gangetic Plain, with the Himalayas to the north, acts like a geographical bowl. This topography restricts air movement, further trapping pollutants within the region.
- **Lack of Natural Cleansing:** Compared to summer and monsoon seasons, winter has less rainfall and stronger winds, which naturally help to "wash out" and disperse pollutants. Dry, cold, and stable atmospheric conditions in winter suppress these natural cleaning mechanisms.
- **High Humidity and Fog:** High humidity during winter causes water vapor to condense around particulate matter, forming dense fog that combines with smoke to create hazardous smog, which reduces visibility and persists for days.

Seasonal and Local Emission Sources

- **Agricultural Stubble Burning:** In October and November, farmers in neighboring states like Punjab and Haryana burn crop residue to clear fields for the next season. The smoke and fine particulate matter (PM2.5) are carried by prevailing northwesterly winds into the Delhi region, significantly contributing to the pollution load.
- **Increased Domestic Heating and Biomass Burning:** Colder temperatures lead to increased use of biomass (wood, crop residues, cow dung) and charcoal for heating and cooking in households, adding fine particulate matter and other gaseous pollutants to the air.
- **Festivals:** Winter coincides with festivals like Diwali, where firecrackers release large amounts of harmful particulate matter and toxic chemicals. While short-lived, these emissions occur during periods of poor dispersion and act as tipping points for severe smog episodes.
- **Year-Round Emissions:** Emissions from vehicles, industrial activities, and construction dust persist year-round but become much more potent in winter due to the atmospheric conditions that prevent their dispersal.

How is the level of "smog" measured?

"Smog" levels are measured and reported using various Air Quality Index (AQI) scales, such as those used by the National Air Quality Index (NAQI) in India or the U.S. Environmental Protection Agency (EPA). The AQI is a numerical and color-coded scale that runs from 0 to 500, with higher values indicating greater levels of pollution and health concern.

Air Quality Index (AQI) Scale

The AQI translates complex air pollutant concentrations (e.g., PM_{2.5}, PM₁₀, ozone, carbon monoxide) into a simple number and a corresponding colour. The categories and their associated health concerns for the Indian scales are:

AQI Range	Air Pollution Level	Colour	Health Implications
0 to 50	Good / Satisfactory	Green	Little to no risk. Air quality is satisfactory.
51 to 100	Moderate	Yellow	Acceptable air quality; some risk for unusually sensitive individuals.
101 to 150	Unhealthy for Sensitive Groups	Orange	Members of sensitive groups may experience health effects; the general public is not likely to be affected.
151 to 200	Unhealthy	Red	Everyone may begin to experience health effects; sensitive groups may experience more serious effects.
201 to 300	Very Unhealthy / Poor	Purple	Health warnings of emergency conditions; the entire population is more likely to be affected.
301+	Hazardous / Severe	Maroon	Health alerts: everyone may experience serious health effects, potentially life-threatening.

Other Relevant Scales

- **Ringelmann Scale:** This is an older scale for measuring the apparent darkness or opacity of smoke, primarily from industrial sources or fires. It uses a chart with varying shades of gray, from 0 (transparent) to 5 (completely black), to visually assess smoke density.
- **Smog Readability Formula:** This is a completely different type of scale used in linguistics to determine the readability of a text (a "Simple Measure of Gobbledygook") based on the number of multi-syllable words. It is unrelated to air pollution.

What are the main international organizations working to combat smog?

Intergovernmental and UN-affiliated organizations

- **World Health Organization (WHO):** Sets global air quality guidelines and provides data on the health impacts of air pollution.
- **United Nations Environment Programme (UNEP):** Works on a range of environmental issues, including air quality, often in conjunction with other UN agencies.
- **Climate and Clean Air Coalition (CCAC):** A partnership of governments, organizations, and businesses focused on reducing short-lived climate pollutants that also impact air quality.
- **World Bank Group:** Has programs like the Pollution Management and Environmental Health Program to help developing countries reduce pollution and improve air quality through funding and knowledge sharing.

Non-governmental and civil society organizations

- **International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA):** A federation of over 40 national organizations that works to prevent air pollution globally.
- **Global Alliance on Health and Pollution (GAHP):** Coordinated by Pure Earth, this is a network of over 65 organizations working to reduce the health impacts of pollution from air, water, and soil.
- **Clean Air Fund:** Supports work to end air pollution, with a focus on solutions for clean air.

What are the main organizations working to combat smog in India?

Governmental Organizations & Initiatives

- **Ministry of Environment, Forest and Climate Change (MoEF&CC):** This is the primary ministry responsible for planning, promoting, coordinating, and overseeing the implementation of environmental and forestry programs, including the National Clean Air Programme (NCAP).
- **Central Pollution Control Board (CPCB):** A statutory organization under the MoEF&CC, the CPCB is responsible for the prevention and control of air pollution. Its functions include air quality monitoring (through the National Ambient Air Quality Monitoring (NAMP) program), setting national standards, providing technical assistance to state boards, and operating a central control room for live air quality data.
- **Commission for Air Quality Management (CAQM):** Specifically established for the National Capital Region (NCR) and adjoining areas, this high-level body is responsible for coordinating efforts and enforcing measures to tackle severe air pollution in the region.
- **State Pollution Control Boards (SPCBs) and Pollution Control Committees (PCCs):** These state-level bodies work in coordination with the CPCB to implement pollution control legislation and monitor air quality within their respective states and Union Territories.
- **National Clean Air Programme (NCAP):** A flagship government initiative launched in 2019 that aims to reduce particulate matter (PM10 and PM2.5) concentrations in 131 non-attainment cities across India by up to 40% by 2025-26. It involves the preparation and implementation of city-specific action plans.
- **System of Air Quality and Weather Forecasting and Research (SAFAR):** This portal provides real-time air quality data and forecasts for major metropolitan areas, aiding in public awareness and policy decisions.

Non-Governmental Organizations (NGOs) and Research Institutions

- **The Energy and Resources Institute (TERI):** A prominent research institute involved in various clean air projects, including the "Clean Air Projects in India (CAP India)" which focuses on data analysis, capacity building, and awareness.
- **Centre for Science and Environment (CSE):** A well-known public interest research and advocacy organization that actively researches and campaigns on air pollution issues, providing expert input on policy and solutions.

- **Indian Institutes of Technology (IITs) and the National Environmental Engineering Research Institute (NEERI):** These premier academic and research institutions collaborate with government bodies like the CPCB on research projects, technical interventions, and developing solutions for air pollution control.

What health problems can smog cause in India?

Smog in India causes a wide range of severe short and long-term health issues, primarily affecting the respiratory and cardiovascular systems, and also leading to problems with the eyes, brain, and mental health. Fine particulate matter (PM2.5) is the most dangerous pollutant, as it can penetrate deep into the lungs and enter the bloodstream.

Respiratory Issues

Smog is a major cause and aggravator of respiratory diseases. Symptoms range from immediate irritation to chronic, life-threatening conditions.

- **Short-term effects:** Include coughing, a scratchy or sore throat, chest discomfort, wheezing, breathlessness, and upper and lower respiratory tract infections (like pneumonia).
- **Long-term effects:** Lead to chronic obstructive pulmonary disease (COPD), bronchitis, reduced lung function, and lung cancer.

Cardiovascular Issues

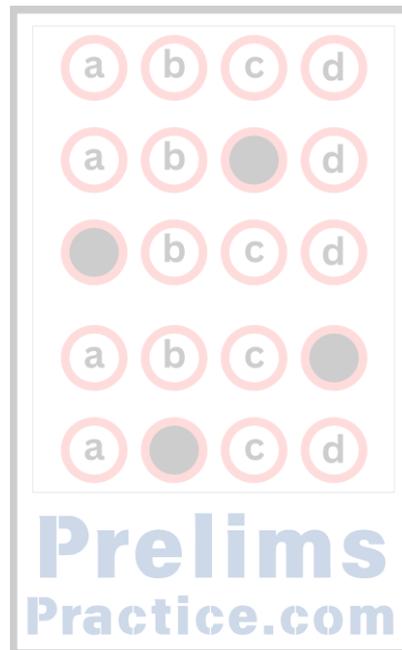
Air pollution places a substantial burden on the cardiovascular system and is a leading cause of related deaths in India.

- **Conditions:** PM2.5 can cause inflammation and damage to blood vessel linings, increasing the risk of hypertension (high blood pressure), atherosclerosis (plaque buildup in arteries), heart attacks, and strokes.

Other Health Impacts

- **Eyes:** Direct exposure to pollutants causes irritation, redness, dryness, burning sensations, and allergic conjunctivitis. Long-term exposure may also increase the risk of cataracts and vision decline.

- **Neurological and Mental Health:** Smog is linked to cognitive decline, memory loss, and faster aging of the brain in older adults. It can also worsen mental health conditions like depression and anxiety.
- **Diabetes:** Studies indicate a link between air pollution exposure and an increased risk of developing Type 2 diabetes and gestational diabetes.
- **Vulnerable Populations:** Children, the elderly, pregnant women, and individuals with pre-existing conditions are at a significantly higher risk of severe illness or premature death from smog exposure.



1. Consider the following statements regarding the role of the WTO in the context of the India-US tariff issue:

- I. The WTO provides a platform for settling trade disputes between member countries.
- II. A bilateral trade agreement between India and the US must comply with WTO rules, such as the MFN principle and requirements for Free Trade Agreements (FTAs).
- III. India can retaliate with its own tariffs on US goods, provided it does so under the framework of WTO norms and not arbitrarily.

How many of the above statements are correct?

- a) Only one
- b) Only two
- c) All three
- d) None



Answer: c

Explanation: Statement I is correct: The WTO provides a platform for settling trade disputes between member countries: The World Trade Organization's Dispute Settlement Body is a key function that helps member countries resolve trade disagreements through a formal process, ensuring that trade rules are followed. **Statement II is correct:** A bilateral trade agreement between India and the US must comply with WTO rules, such as the MFN principle and requirements for Free Trade Agreements (FTAs): All trade agreements between WTO members must adhere to the foundational rules of the organization, including the Most-Favored-Nation (MFN) principle and the requirements for creating Free Trade Agreements (FTAs). **Statement III is correct:** India can retaliate with its own tariffs on US goods, provided it does so under the framework of WTO norms and not arbitrarily: If a country is not complying with WTO rules, the WTO allows for authorized retaliation. This can include imposing tariffs, but this must be done within the rules framework established by the WTO, not on a unilateral or arbitrary basis.

Practice Questions

With reference to the smog, consider the following statements:

- I. Geographical location (landlocked basin)
- II. Temperature inversion
- III. Stubble burning in neighboring states
- IV. High concentration of sulfur-fueled industries

How many of the above factors primarily contribute to the severe air pollution and smog episodes in North Indian cities like Delhi during winter?

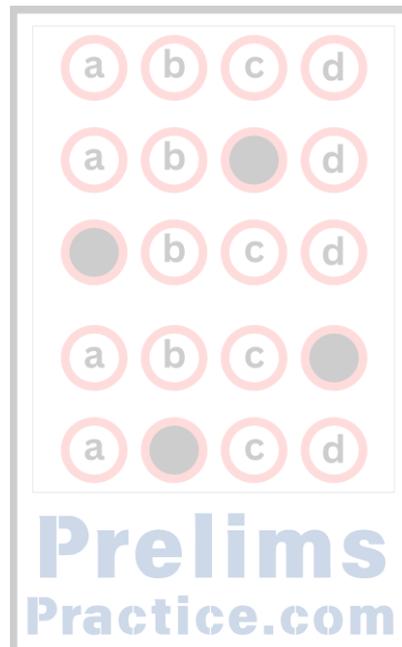
- a) Only one
- b) Only two
- c) All three
- d) None

Answer: c

Explanation: Factor I is correct: Delhi's landlocked geography, situated in the Indo-Gangetic plain, hinders the dispersion of pollutants, especially when winds are stagnant. **Factor II is correct:** During winter, a layer of warm air traps colder air near the ground (temperature inversion), preventing pollutants from rising and dispersing. **Factor III is correct:** Seasonal agricultural practices, specifically stubble burning in Punjab and Haryana, produce significant particulate matter and smoke that travel to Delhi due to wind patterns. **Factor IV is partially correct but less significant than other factors:** While industries exist, the combination of factors I, II, and III creates the severe winter crisis. The most pronounced industrial pollution type in Delhi is often linked to mixed sources including coal, leading to both sulphurous and photochemical smog components, but the unique winter crisis is tied to the first three points predominantly. Factors I, II, and III are the primary drivers of the acute winter smog episodes.

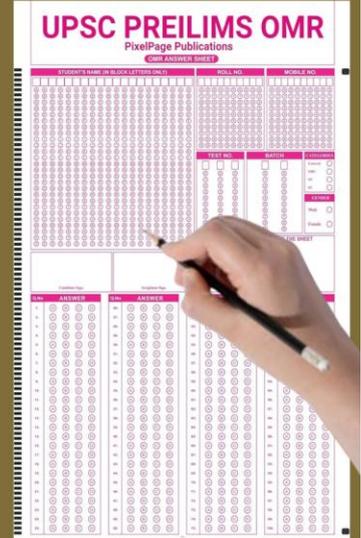
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