Air Pollution in Meerut City: An Environmental Chemistry Perspective-A Review

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Abstract:

Air pollution has become a serious problem in many fast-growing cities of India, including Meerut. Due to the increasing number of vehicles, industries, construction work, and burning of fossil fuels, the level of air pollution has risen significantly. Air pollution occurs when gases, dust particles, fumes (or smoke) or odour are introduced into the atmosphere in a way that makes it harmful to humans, animals and plant. Air pollution threatens the health of humans and other living beings in our planet. It creates smog and acid rain, causes cancer and respiratory diseases, reduces the ozone layer atmosphere and contributes to global warming.This project studies air pollution in Meerut from the point of view of environmental chemistry. It mainly focuses on common air pollutants such as particulate matter (PM, …. and PM €), sulphur dioxide (SO,), nitrogen oxides (NO"), and carbon monoxide (CO).The project explains the nature of these pollutants, their major sources, and how they react in the atmosphere to form secondary pollutants like photochemical smog and acid rain. Air Quality Index (AQI) data and information from secondary sources are used to understand the pollution level in Meerut. The effects of air pollution on human health, plants, and the environment are also discussed.

The study shows that air pollution levels in Meerut often go beyond safe limits, which can cause health problems and damage the environment. Therefore, the project suggests the need for effective pollution control measures and the use of eco-friendly and sustainable practices to reduce air pollution in the city.

Keywords

Air Pollution, Environmental Chemistry, Meerut, Particulate Matter (PM, …. , PM €), AQI, Vehicular Emissions, Industrial Pollution, Human Health

1. Introduction:

[1]Air pollution is one of the most serious environmental challenges faced by urban areas across the world. In India, rapid urbanization, industrial growth, and increasing vehicular population have significantly contributed to the deterioration of air quality. Meerut City, located in the western part of Uttar Pradesh, has been experiencing rising levels of air pollution due to various anthropogenic activities. From the perspective of environmental chemistry, air pollution involves the presence of harmful chemical substances in the atmosphere at concentrations that adversely affect human health, plants, animals, and the overall environment. In Meerut, major sources of air pollution include vehicular emissions, industrial activities, brick kilns, construction work, open burning of waste, and the use of fossil fuels. These sources release pollutants such as particulate matter (PM, …. and PM €), sulphur dioxide (SO,), nitrogen oxides (NO“), carbon monoxide (CO), and volatile organic compounds (VOCs) into the atmosphere. Atmospheric chemical reactions further transform these primary pollutants into secondary pollutants, leading to the formation of photochemical smog, acid rain, and ground-level ozone. These pollutants have severe impacts on air quality and pose significant risks to public health, causing respiratory disorders, eye irritation, allergies, and cardiovascular diseases. The increasing Air Quality Index (AQI) levels in Meerut highlight the urgent need for scientific assessment and effective pollution control strategies. This project aims to study the nature, sources, and chemical behavior of air pollutants in Meerut City, analyze their environmental and health impacts, and suggest suitable measures for air pollution control and sustainable development.Air pollution is one of the **biggest problems in cities** around the world. In India, cities are growing fast, industries are expanding, and there are more vehicles on the road, all of which are making the air dirtier. **Meerut**, a city in western Uttar Pradesh, is seeing **rising air pollution** because of human activities.

([2] “Air pollution is the contamination of the indoor or outdoor environment by any chemical,physical, or biological agent that modifies the natural characteristics of the atmosphere.” This module is a general introduction to ambient air pollution. It will consider the history of air pollution, its sources and health impacts as well as describe the classical air pollutants and their characteristics. The module will also discuss the main determinants of air pollution and health impacts, including climate change, and provide an overview on the WHO milestones on air quality and health, such as the global air quality guidelines.

[3]The APHT toolkit for health workers is a comprehensive set of training materials covering air pollution and health topics while addressing global and regional challenges. It is designed for various audiences and health sector roles, equipping health workers with knowledge and tools to understand and mitigate air pollution risks. The toolkit helps them engage

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with patients, individuals, and communities while advocating for clean air interventions. Built around the train-the-trainer (TtT) concept, APHT enables trainees to become trainers and educate their peers and communities.''''Summary

[4]AIR POLLUTION CHART

Source (Causes)	Pollutants	Effects on Health	Prevention / Control
Vehicles	Carbon monoxide (CO)	Breathing problems	Use public transport
Factories	Sulphur dioxide (SO_2)	Lung diseases	Install filters
Burning garbage	Smoke, PM2.5	Eye & throat irritation	Proper waste disposal
Construction work	Dust particles	Asthma	Cover construction sites
Power plants	Nitrogen oxides (NO_2)	Heart problems	Use clean energy

[5]Air pollution is measured in several ways:

1. **Air Quality Index (AQI):** A numerical value indicating pollution levels.
2. **Particulate Matter (PM):** PM, …. and PM levels are measured.
3. **Nitrogen Dioxide (NO,):** NO, levels are monitored.
4. **Sulphur Dioxide (SO,):** SO, levels are tracked.
5. **Carbon Monoxide (CO):** CO levels are measured.
6. **Ozone (O*f*):** O*f* levels are monitored.
7. **Volatile Organic Compounds (VOCs):** VOCs levels are measured.

Various tools and techniques are used, like:

Air Quality Monitors: Devices measuring pollution levels.

Satellite Imaging: Satellites track pollution.

Ground-based Monitoring Stations: Stations measuring pollution levels.

2.[6]What is the U.S. Air Quality Index (AQI) ?

The U.S. AQI is EPA's index for reporting air quality.

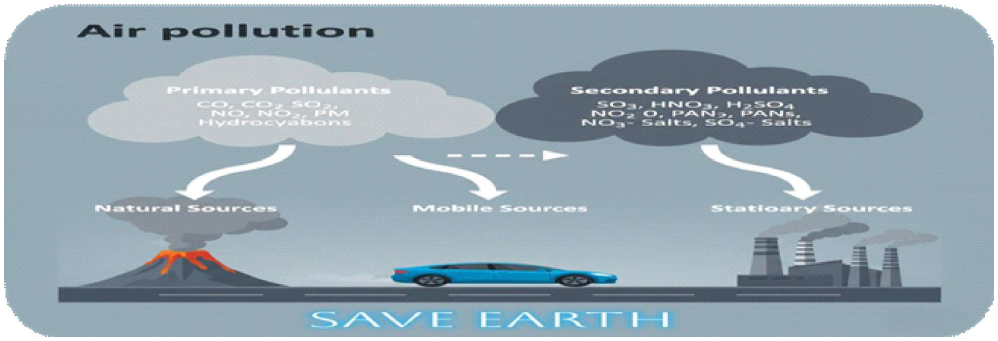
[6]How does the AQI work?

The U.S. Air Quality Index (AQI) is EPA's tool for communicating about outdoor air quality and health. The AQI includes six color-coded categories, each corresponding to a range of index values. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 or below represents good air quality, while an AQI value over 300 represents hazardous air quality.(AQI Basics | AirNow.gov)

For each pollutant an AQI value of 100 generally corresponds to an ambient air concentration that equals the level of the short-term national ambient air quality standard for protection of public health. AQI values at or below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is unhealthy: at first for certain

sensitive groups of people, then for everyone as AQI values get higher.

The AQI is divided into six categories. Each category corresponds to a different level of health concern. Each category also has a specific color. The color makes it easy for people to quickly determine whether air quality is reaching unhealthy levels in their communities.



AQI Basics for Ozone and Particle Pollution

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

2. (8)Types of Air Pollutants :

1. Primary Air Pollutants

Primary air pollutants are harmful substances that are released directly into the air from different sources. They do not change their form in the atmosphere and can cause

damage to human health, plants, animals, and the environment. Since their sources are known, these pollutants can be controlled by proper rules and pollution control methods.

Major Primary Air Pollutants

• **Carbon Monoxide (CO) :-** Carbon monoxide (CO) is a poisonous gas with no color or smell. It is mainly produced by vehicles due to incomplete burning of fuel. Breathing in carbon monoxide reduces the amount of oxygen in the blood and can cause headaches, tiredness, and serious heart and brain problems.

• **Sulphur Dioxide (SO,) :-** Sulphur dioxide is released when coal and oil are burned in factories and power plants. It irritates the lungs and throat and also leads to acid rain, which damages crops, buildings, and water bodies.

• **Nitrogen Oxides (NO") :-** Nitrogen oxides are gases formed during burning of fuel at high temperatures, especially in vehicles and industries. These gases are responsible for smog formation and ground-level ozone, which cause breathing problems and harm plants.

• **Particulate Matter (PM_{10} and $PM_{2.5}$....) :-** Particulate matter includes tiny dust and smoke particles present in the air. They come from construction work, vehicle exhaust, burning of fuels, and natural dust. Very fine particles like PM, ... can go deep into the lungs and even enter the blood, causing serious health problems.

• **Volatile Organic Compounds (VOCs) :-** VOCs are chemicals released from fuels, paints, solvents, and industrial processes. Many of them are harmful and help in forming smog and ozone in the air.

• **Lead (Pb):-** Lead is a dangerous metal released from some industries and battery factories. It builds up in the body over time and affects the brain and nervous system, especially in children.

2.[9] Secondary Pollutants and How They Are Formed:-

Secondary pollutants are not released directly into the air. They are formed **after primary pollutants mix and react in the atmosphere**. Sunlight, air, and moisture help these reactions happen. Many secondary pollutants are **more harmful** than the original pollutants.

• Common Secondary Pollutants

• **Ozone (O*f*):** Ozone at ground level is formed when gases from vehicles and industries (NO" and VOCs) react in sunlight.

• **Acid Rain:** Acid rain forms when sulphur dioxide and nitrogen oxides mix with water vapor in the air and fall back to the ground with rain.

• **Photochemical Smog**:**T**his is a thick, brownish haze seen in cities. It is formed when NO" and VOCs react in strong sunlight.

• **Peroxyacetyl Nitrate (PAN)**:PAN is formed when NO" and VOCs react. It

irritates the eyes and damages plants.

(10) How Major Secondary Pollutants Are Formed

• Sulphuric Acid: Formed when sulphur dioxide reacts with oxygen and moisture in the air.

• Ground-level Ozone: Formed when nitrogen oxides and VOCs react under sunlight.

• Nitric Acid: Formed when nitrogen oxides react with water in the atmosphere.

• Secondary Organic Aerosols: Formed when gases from fuels and chemicals change into tiny particles in the air.

• PANs: Formed during smog formation from vehicle and industrial gases.v

(11) Important Chemical Reactions (Simple Explanation)

Secondary Pollutant	Precursor (Primary) Pollutants	Formation Process
Ground-level Ozone (O_3)	NO_X + VOCs	Photochemical reaction triggered by sunlight.
Sulfuric Acid (H_2SO_4)	Sulfur Dioxide (SO_2)	SO_2 reacts with water vapor and oxidants.
Nitric Acid (HNO_3)	Nitrogen Oxides (NO_X)	NO_X reacts with moisture in the air.
Peroxyacetyl Nitrates (PANs)	NO_X + Hydrocarbons	Formed during photochemical smog production.
Secondary Organic Aerosols (SOA)	Volatile Organic Compounds (VOCs)	Condensation of oxidized organic gases into particles.

Formation of Acid Rain

• **Sulphur dioxide** reacts with oxygen and water to form sulphuric acid.

$2SO_2 + O_2 + 2H_2O \rightarrow 2H_2SO_4$

• **Nitrogen dioxide** reacts with oxygen and water to form nitric acid.

$$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$$

These acids mix with rainwater and fall on the earth as acid rain.

(12)Formation of Ozone

Ozone is not released directly into the air. It is formed when sunlight breaks nitrogen dioxide into simpler parts, which then combine with oxygen to make ozone.

1. $NO_2 + h\nu \rightarrow NO + O$ (where $h\nu$ represents solar radiation)
2. $O + O_2 + M \rightarrow O_3 + M_5$

Research Impact and Importance :-

• **Causes Haze and Smog:** Very fine particles in the air are the main reason cities look hazy or smoky. These particles block and scatter light, making it hard to see clearly,

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especially during winter and early mornings.

- **Harmful to Health and Plants:** Secondary pollutants like ozone and PANs are very harmful. They make it difficult to breathe and can cause coughing, chest pain, and lung problems. They also damage plants by harming their leaves and slowing down their growth.
- **Hard to Control:** Secondary pollution is difficult to control because it is not released directly. For example, ozone cannot be stopped by putting filters on vehicles or factories. To reduce it, we must control the gases that create it, especially pollution from vehicles and industries, at the same time**.**

3. Methodology

[13]Data Collection

- Air quality data was collected for **six months, from June to December 2025**, from different places in Meerut. This information was taken from the **AQI app and newspapers**.
- Air samples were collected using a **dust sampling machine**.

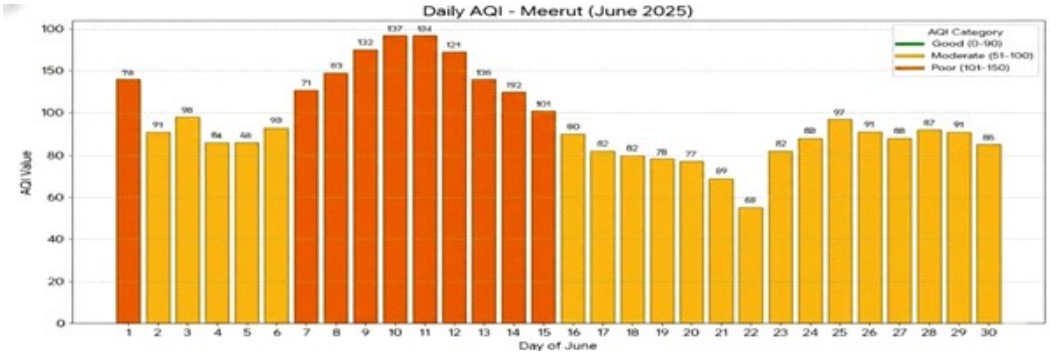
These samples were tested to find out the levels of **PM € , PM, …. , NO, , SO, , and CO** in the air.

Data Analysis

- The AQI data was used to understand how polluted the air in Meerut is.
- The pollution levels were compared with the **government's safe limits**.
- Simple calculations were used to find out the **main sources of air pollution** in the city.

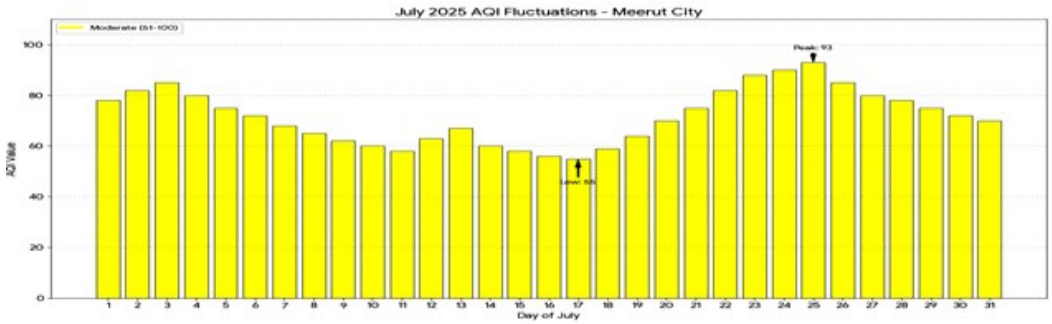
AQI Data of Meerut CITY

June 2025 AQI Data for Meerut City



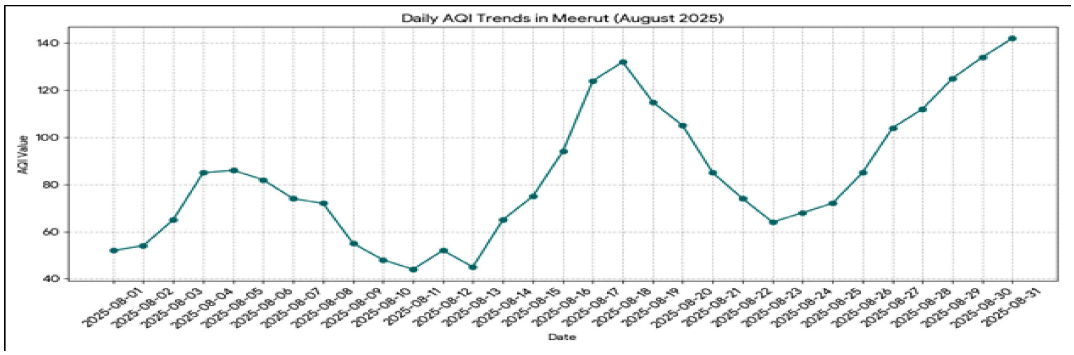
The data shows that the air quality in Meerut city was mostly moderate to unhealthy during June 2024. The highest AQI was recorded on 10 and 11 June with a value of 137, falling under the unhealthy category.

July 2025 AQI Data for Meerut City



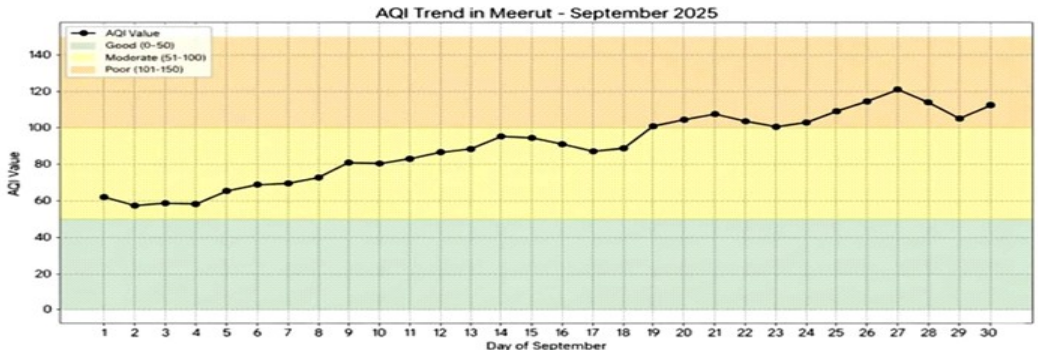
The data shows fluctuations in AQI throughout July. The highest AQI is 93 on the 25th, and the lowest is 55 on the 17th.

August 2025 AQI Data for Meer



The image shows an AQI calendar for August 2025 in Meerut, with daily values ranging from 60 to 92, predominantly in the Moderate air quality range.

September 2025 AQI Data for Meerut City



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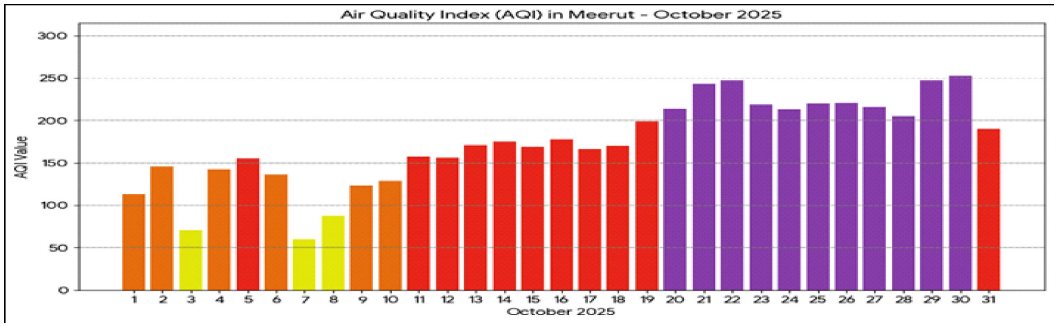
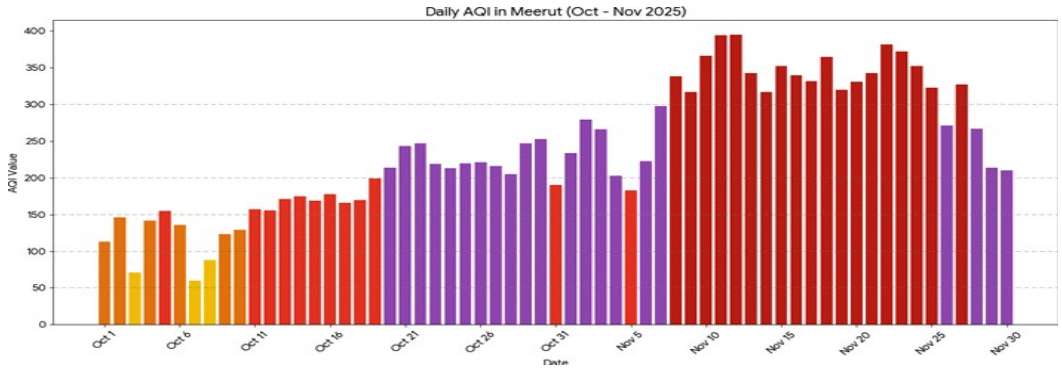
October 2025 AQI Data for Meerut City



The chart shows a clear upward trend in pollution levels as the month progresses, moving from "Poor" and "Moderate" levels at the start of October to "Severe" levels by the end of the month.

November 2025 AQI Data for Meerut City



November 2025: Pollution levels escalated significantly, with many days reaching the **"Hazardous"** category (AQI >300).

December 2025 AQI Data for Meerut City

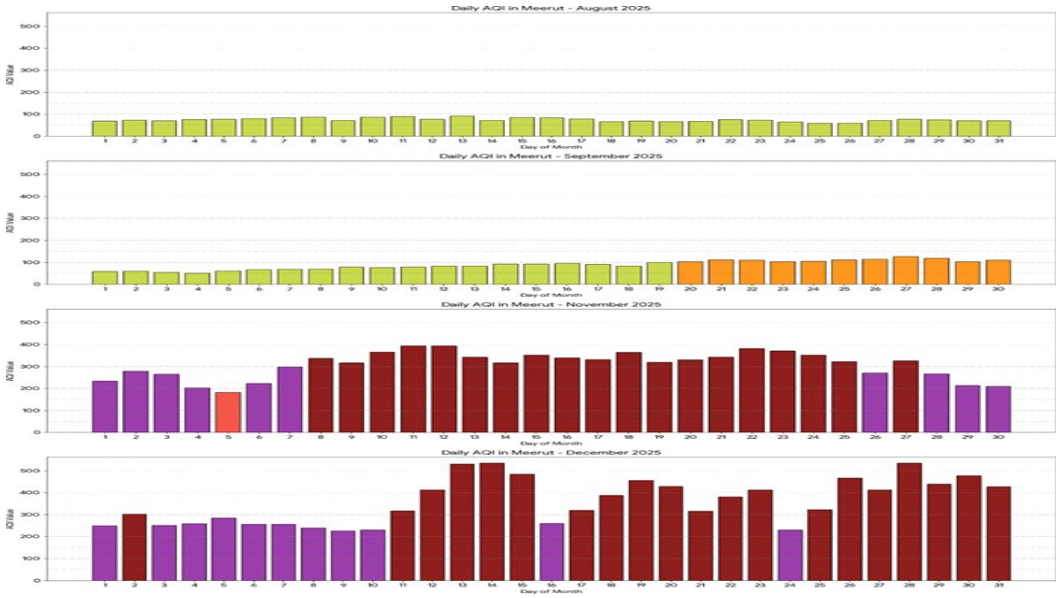
I have compiled and visualized the Air Quality Index (AQI) data from the calendars for **August, September, November, and December 2025** for Meerut.

AQI Trends & Comparison

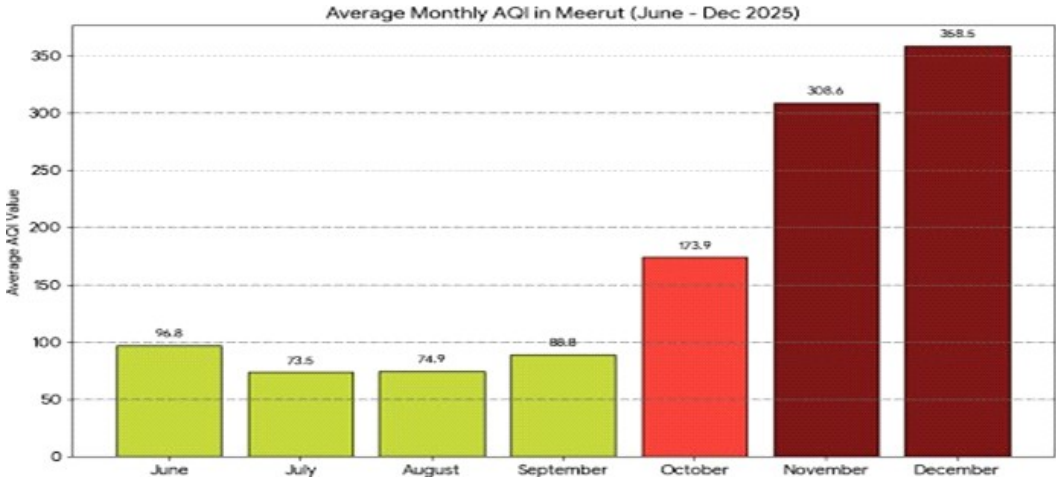
The charts show a clear and alarming deterioration of air quality as the year progressed:

- **August & September (Moderate):** Air quality was relatively stable, mostly within the **Moderate** (Yellow) category. The average AQI for August was **75**, and for September was **89**.
- **November (Hazardous):** There was a massive surge in pollution. Most days fell into the **Severe** (Purple) or

- **Hazardous** (Maroon) categories. The average AQI jumped to **310**.
- **December (Critical Crisis):** Air quality reached its worst levels. Many days recorded AQI values above **400** and even **500**, signifying an extreme health emergency. The average for December was **357**.



Result : Based on the comprehensive records from June to December 2025, the air quality in Meerut underwent a significant transition from "Moderate" during the monsoon months to "Hazardous" during the winter



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Seasonal AQI Analysis (June–December 2025)

The data illustrates a clear upward trend in pollution levels as the year progressed:

- **Monsoon Stability (June – August):** Air quality was at its best during this period, remaining largely in the **Moderate** category. The average AQI for August was the lowest of the recorded period at **75.4**.
- **Post-Monsoon Transition (September – October):** September saw a slight rise (Avg: **89.2**), which accelerated in October (Avg: **174.4**) as air quality shifted into the **Unhealthy** category.
- **Winter Crisis (November – December):** Conditions became critical during these months.
- **November:** The average AQI jumped to **310.2**, firmly in the **Hazardous** range.**December:** Recorded the worst overall air quality with an average of **357.2** and peak values reaching as high as **535**.

Summary :- Meerut is tackling air pollution with a **multi-pronged approach**: cleaning roads, managing traffic, controlling factories, handling waste better, monitoring air quality, enforcing rules, and involving the public. Still, winter pollution remains a big challenge that needs extra care.

Detailed Statistical Summary :

Month	Average AQI	Minimum AQI	Maximum AQI	Health Category
June	99.4	55	137	Moderate 9
July	74.0	55	93	Moderate 10
August	75.4	60	92	Moderate 11
September	89.2	51	126	Moderate 12
October	174.4	60	253	Unhealthy 13
November	310.2	183	395	Hazardous 14
December	357.2	227	535	Hazardous

Conclusion :-This project on air pollution in Meerut City, done by Prince Kumar, shows that the air in the city is often unsafe to breathe and harms both people and the environment.

- **Air is Getting Worse:** Pollution was moderate during the monsoon (June–August) but became very high in winter (November–December).

- **Most Polluted Time:** December 2025 had the worst air, with average AQI of 357 and peaks up to 535.
- **Main Causes:** The main reasons for bad air are **vehicles, factories, construction, brick kilns, and burning of waste**.
- **Effects on Health and Nature:** Pollutants like PM, …. , PM € , SO, , and NO“ can cause breathing problems, heart diseases, and damage plants and the environment.
- **Need for Action:** The city needs urgent pollution control, including **cleaner practices** and reducing the gases that create harmful secondary pollution like **NO“ and VOCs**.

[14]How Meerut Manages Air Pollution

Meerut often struggles with **bad air quality** and is called a **“non-attainment city”**, which means it regularly fails to meet safe air standards. To tackle this, the **Meerut Municipal Corporation (MMC)** and the **Uttar Pradesh Pollution Control Board (UPPCB)** follow a plan under the **National Clean Air Programme (NCAP)**. The main goal is to reduce harmful dust and smoke in the air, especially **PM10 and PM2.5 particles**.

1. Cleaning Up the Roads and Dust, Dust from roads and construction is one of the biggest problems. To manage this:

- **Street Sweeping:** Machines clean main roads every day.
- **Spraying Water:** Water sprinklers and anti-smog guns reduce dust near construction sites.
- **Paving Roads:** Road edges are paved to stop dust from blowing around.

2. Cleaner Transport, Traffic and vehicles also make the air dirty. The city is working on:

- **Electric Vehicles:** Encouraging e-buses and building charging stations.
- **Better Traffic Flow:** Fixing busy intersections so cars don’t idle too long.
- **Walking & Cycling:** Making it easier for people to walk or ride bikes.

3. Controlling Factories, Industries and diesel generators are big polluters. Measures include:

- **Switching to Cleaner Fuels:** Factories and generators use natural gas or cleaner fuel.
- **Monitoring Smoke:** Sensors track pollution in real-time so factories can’t break rules.

4. Managing Waste, Burning trash adds a lot of smoke. The city:

- **Bans Open Burning:** Strict rules and fines stop people from burning garbage or crop waste.

- **Turns Waste into Compost:** Wet waste is converted into compost instead of going to landfills.

5. Keeping an Eye on Air Quality, The city uses special a**ir quality monitoring stations:**

- **Real-Time Sensors:** Three main stations measure pollution constantly.
- **Manual Testing:** Two other stations check the chemicals in the air.
- **PRANA Portal:** An online dashboard collects and shows all the data.

6. Rules and Enforcement, Several authorities make sure the city follows the laws:

- **CAQM:** Gives emergency instructions, especially in winter when air gets worse.
- **UPPCB:** Checks factories and allows them to operate only if they follow rules.
- **NGT:** Makes sure environmental laws are followed and can punish non-compliance.

7. Getting Citizens Involved, People are encouraged to help improve the air:

- **City Rankings:** Meerut is rated on its pollution-control efforts.
- **Youth Programs:** Young people take part in tree planting and awareness campaigns.
- **Public Displays:** Boards in public places show live air quality updates.

8. Winter Challenges, Even with all these efforts, winter is tough:

- The **AQI often reaches hazardous levels (350–400)**.
- Main causes: **Cold air traps pollution** and **stubble burning in nearby areas**.
- Emergency actions: Construction bans and extra dust-control measures are enforced.

References :-

1. Ruhela,M. Bhutiani,R.Kumar,R., & Ahamad,F.(2024). Air quality evaluation A comparative analysis. Environment Consservation Journal, 25(4),11551162.
2. World Health Organization. (2021). WHO Global Air Quality Guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization. 10665/345329.
3. Adarsh, T., Haneena Sulthana, K. P., & Sandhya Aravind, C. A. (2025). Air Pollution and Public Health Research in India: Mapping Themes, Trends and Knowledge Gaps. Asian Journal of Environment & Ecology, 24(12), 143-169.
4. Dominici,F., et al.(2012). Air pollution :Impact and prevention. PCM, National Library of medicine.report 2012.
5. World Health Organization. (2021). Air quality and health. WHO.United States Environmental Protection Agency. (2022).
6. An AQI value of 100 corresponds to the National Ambient Air Quality Standards set for short-term exposure to protect public health" (U.S. EPA, 2023).
7. U.S. EPA (Global Standard): U.S. Environmental Protection Agency (EPA). (2018).

Technical Assistance Document for the Reporting of Daily Air Quality – the Air Quality Index (AQI). Office of Air Quality Planning and Standards..

8. Ruhela, M., Bhutiani, R., Kumar, R., & Ahamad, F. (2024). Air quality evaluation of Meerut city, Uttar Pradesh, India: A comparative analysis. Environment Conservation Journal, 25(4), 1155–1162.
9. Dutta, A., & Jinsart, W. (2021). Gaseous and particulate matter emissions from road transport: The case of Kolkata, India. Environmental and Climate Technologies, 25(1), 717–735.
10. Rajwar, M. C., Naja, M., Rawat, P., Venkataramani, S., & Tiwari, R. K. (2024). Health impacts, ozone and secondary organic aerosol formation potential of aromatic hydrocarbons (C6-C8) in the Central Himalayas and the Indo-Gangetic Plain. Environmental Science and Pollution Research, 32(3), 1525– 1540.
11. Ruhela, M., Bhutiani, R., Kumar, R., & Ahamad, F.(2024). Air quality evaluation of Meerut city, Uttar Pradesh, India: A comparative analysis. Environment Conservation Journal, 25(4), 1155–1162. Finlayson-Pitts, B. J., & Pitts Jr, J. N. (2025).
12. Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric chemistry and physics: From air pollution to climate change (3rd ed.). Wiley,Emberson, L. D., Ashmore, M. R., & Murray, F. (2003).Finlayson-Pitts, B. J., & Pitts, J. N. (2000).
13. United States Environmental Protection Agency. (2023). Air Quality Index (AQI): A guide to air quality and your health. U.S. EPA.,Central Pollution Control Board. (2013),Seinfeld, J. H., & Pandis, S.N. (2016).
14. Ministry of Environment, Forest and Climate Change. (2019). National Clean Air Programme (NCAP). Government of India.Central Pollution Control Board. (2022).Uttar Pradesh Pollution Control Board. (2023)Central Pollution Control Board. (2017).National Green Tribunal. (2020),Commission for Air Quality Management. (2022).