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Air Quality Deterioration in Urban Environments: A Review of Industrial and Vehicular Pollutant Source

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Abstract :

Urban air quality is a pressing concern with far-reaching consequences for public health, the environment, and overall well-being. This review offers an extensive examination of the origins and contributors to deteriorating air quality in urban settings, with a specific focus on pollutants stemming from industrial and vehicular sources. Industrial operations are substantial contributors to urban air pollution, emitting a wide array of harmful substances like particulate matter (PM), volatile organic compounds (VOCs), nitrogen oxides (NOx), sulfur dioxide (SO_2), and heavy metals. The paper delves into the various industrial processes responsible for these emissions and explores strategies to mitigate their adverse impacts. In addition to industry, vehicular emissions resulting from the burning of fossil fuels in automobiles play a pivotal role in the decline of urban air quality. This review examines the various pollutants produced by vehicles, including carbon monoxide (CO), hydrocarbons (HC), and greenhouse gases, while also assessing advancements in technology and policy measures aimed at curbing these emissions. In summary, this review emphasizes the pressing necessity for collaborative actions aimed at mitigating industrial and vehicular pollution within urban regions. These efforts are crucial for safeguarding the health and welfare of urban inhabitants and protecting the environment. Additionally, the study underscores the significance of ongoing research and innovation to create sustainable solutions for enhancing air quality in our constantly evolving urban environments.

***IndexTerms* - Air quality , Urban environments , Industrial pollution , Vehicular pollution ,Pollutant sources.**

I. INTRODUCTION

Urbanization is a global trend characterized by an increasing proportion of the world's population residing in urban areas. While this urban growth has brought about numerous advantages, it has also given rise to significant challenges, with one of the most critical being the decline in urban air quality. The adverse effects of poor air quality on human health, ecosystems, and the overall well-being of urban residents cannot be overstated. Therefore, it is imperative to comprehend and tackle the factors contributing to air quality deterioration in urban settings. The motivation behind this review arises from the necessity to comprehensively scrutinize the origins of urban air pollution, with a particular emphasis on industrial and vehicular pollutants. As urbanization continues its rapid pace, industrial activities and transportation systems expand, resulting in heightened emissions of detrimental pollutants. Consequently, there is a growing urgency to delve into the intricacies of urban air quality, assess its impacts on health and the environment, and evaluate the existing regulatory structures and standards designed to safeguard the public and natural surroundings [1].

1.1 Grasping Urban Air Quality

Urban air quality pertains to the composition and condition of the atmosphere within cities and metropolitan regions. It encompasses a wide array of pollutants, including particulate matter (PM), volatile organic compounds (VOCs), nitrogen oxides (NOx), sulfur dioxide (SO_2), carbon monoxide (CO), and various other contaminants. Understanding the dynamics of urban air quality entails an exploration of the sources of these pollutants, their dispersion and transformation within urban environments, and the factors influencing their concentrations [1].

1.2 Health and Environmental Ramifications

The deterioration of urban air quality has grave repercussions for public health and the environment. Exposure to pollutants in urban areas is linked to a spectrum of health issues, encompassing respiratory diseases, cardiovascular problems, and even premature mortality. Moreover, pollutants can inflict harm on ecosystems, compromise water quality, and harm vegetation, with adverse consequences for biodiversity and the ecological equilibrium [1].

1.3 Health Implications

Air quality deterioration in urban settings exerts profound and far-reaching health effects on residents and workers within these areas. Some of the key health implications encompass:

- **Respiratory Ailments:** Poor air quality heightens the risk of respiratory problems, including bronchitis, worsened asthma, chronic obstructive pulmonary disease (COPD), and reduced lung function. Particulate matter (PM2.5) and ground-level ozone (O_3) are especially deleterious to the respiratory system [2].
- **Cardiovascular Impact:** Urban air pollution is linked to cardiovascular diseases such as heart attacks, strokes, and hypertension. Prolonged exposure to pollutants like PM2.5 and nitrogen dioxide (NO_2) can contribute to the development of these conditions [2].
- **Cancer Risk:** Certain air pollutants, notably benzene, formaldehyde, and polycyclic aromatic hydrocarbons (PAHs), are established carcinogens. Extended exposure to these substances in urban areas may elevate the risk of cancer, particularly among individuals residing near industrial zones or busy roadways.
- **Neurological Effects:** Emerging research indicates that air pollution may negatively affect the central nervous system and cognitive function. It has been associated with cognitive decline in older adults and potentially detrimental developmental outcomes in children.
- **Mental Health:** Poor air quality can indirectly impact mental health. The stress of living in an environment with compromised air quality, coupled with concerns about health risks, can contribute to mental health issues such as anxiety and depression.
- **Premature Mortality:** Long-term exposure to urban air pollution is associated with premature mortality, signifying that individuals in highly polluted urban areas face a greater likelihood of premature death due to pollution-related health conditions [2].

1.4 Environmental Consequences

Urban air pollution does not solely affect human health; it also carries substantial environmental implications:

- **Ecosystem Harm:** Air pollutants can inflict harm on terrestrial and aquatic ecosystems. Acid rain, for instance, resulting from emissions of sulfur dioxide (SO_2) and nitrogen oxides (NOx), can damage forests, lakes, and rivers, impacting aquatic life and soil quality.
- **Biodiversity Loss:** Air pollution can directly harm wildlife by contaminating their habitats and food sources. It can also indirectly contribute to biodiversity loss by damaging plants, reducing the availability of clean water, and disrupting ecosystems [3].
- **Climate Change:** Certain urban air pollutants, such as carbon dioxide (CO_2), methane (CH_4), and black carbon (a component of PM2.5), are also greenhouse gases that contribute to global warming and climate change. This can have far-reaching environmental consequences, including more frequent extreme weather events.
- **Infrastructure Damage:** Air pollution can corrode and deteriorate buildings, bridges, and other infrastructure. It can also stain and erode surfaces, diminishing the aesthetic quality of urban areas.
- **Economic Costs:** The environmental impacts of urban air pollution can result in significant economic burdens, encompassing expenses related to healthcare, environmental restoration, and reduced productivity due to pollution-related health issues [3].

Understanding these intricate health and environmental consequences of deteriorating air quality in urban environments underscores the urgency of addressing this issue through effective pollution control measures, policy interventions, and sustainable urban planning to ensure the well-being of both urban populations and the ecosystems on which they depend.

1.4 Regulatory Structures and Standards

Recognizing the hazards posed by urban air pollution, governments and regulatory bodies worldwide have established air quality standards and regulations aimed at limiting pollutant emissions and safeguarding public health and the environment. These standards prescribe permissible concentration levels for specific pollutants and outline strategies for monitoring and mitigating air quality degradation. A comprehension of the existing regulatory structures and standards is pivotal for assessing the efficacy of pollution control measures and identifying areas requiring improvement [4].

These structures provide a systematic approach to monitoring, evaluating, and mitigating air quality issues. Here are key facets in more detail:

- **Air Quality Standards:** Regulatory structures typically incorporate air quality standards, which are legally binding thresholds or recommendations specifying the maximum allowable concentrations of particular pollutants in the atmosphere. These standards are established based on scientific research and health assessments, aiming to protect public health, the environment, and vulnerable ecosystems. Commonly regulated pollutants include particulate matter (PM2.5 and PM10), ground-level ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), lead, and volatile organic compounds (VOCs) [4].
- **Pollutant Monitoring:** Regulatory agencies establish networks of air quality monitoring stations within urban areas to continuously measure pollutant concentrations. These stations collect data on pollutant levels, weather conditions, and other pertinent parameters. Real-time monitoring assists in identifying pollution sources, assessing compliance with air quality standards, and issuing timely alerts to the public during periods of poor air quality.
- **Emission Standards:** In addition to ambient air quality standards, regulatory structures frequently incorporate emission standards for various pollution sources. These standards stipulate the maximum allowable emissions for industrial facilities, power plants, vehicles, and other sources of pollution. Emission standards aim to restrict the release of pollutants into the atmosphere, promoting the adoption of cleaner technologies and practices.
- **Air Quality Index (AQI):** Many regulatory agencies employ the Air Quality Index (AQI) as a user-friendly tool for conveying air quality information to the public. The AQI offers a numerical scale and color-coded system categorizing air quality from "Good" to "Hazardous," aiding individuals in comprehending the health risks associated with prevailing air quality conditions [4].
- **Compliance and Enforcement:** Regulatory structures institute mechanisms for ensuring adherence to air quality standards and emission limits. Violations can result in penalties, fines, and legal actions against non-compliant entities. Enforcement is pivotal for deterring polluters and preserving air quality improvements.
- **Public Engagement and Awareness:** Effective regulatory structures often encompass public engagement and educational campaigns. These initiatives inform residents and businesses about air quality issues, health risks, and the significance of reducing pollution. Public involvement can garner greater support for endeavors to enhance air quality.
- **Policy Instruments:** In addition to setting standards, regulatory structures may employ various policy instruments to diminish pollution, including emissions trading systems, vehicle emission controls, and incentives for embracing clean energy sources. These instruments can incentivize pollution reduction while stimulating economic growth and innovation.
- **Adaptive Management:** Regulatory structures should integrate principles of adaptive management, permitting periodic reviews and updates of air quality standards and policies based on evolving scientific insights and changing urban dynamics.
- **International Cooperation:** In some instances, transboundary air pollution necessitates international cooperation and agreements. Nations may collaborate to address shared air quality challenges and harmonize standards for preserving air quality across borders [4].

Regulatory structures and standards serve as pivotal tools for managing and mitigating urban air pollution, safeguarding the health of urban populations, conserving the environment, and promoting sustainable urban development. These structures continuously evolve to confront emerging air quality challenges and advancements in scientific understanding.

II. Industrial Pollution in Urban Areas

The term "industrial pollution in urban settings" refers to the contamination of the environment in cities and metropolitan areas resulting from industrial activities. These activities encompass a wide spectrum of processes, including manufacturing, energy production, chemical processing, and waste disposal. The proximity of these industries to densely populated urban regions raises concerns due to the potential adverse effects on public health and the environment [5].

2.1 Origins of Industrial Pollution

The sources of industrial pollution in urban settings are diverse and can be classified into several key categories:

- **Manufacturing Facilities:** Factories and manufacturing plants are major contributors to industrial pollution. They may release pollutants such as particulate matter, volatile organic compounds (VOCs), heavy metals, and chemical byproducts into the air and water.
- **Power Generation:** Urban areas often host power plants that burn fossil fuels (e.g., coal, natural gas) to generate electricity. These facilities emit greenhouse gases (e.g., carbon dioxide), sulfur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter.
- **Chemical Processing:** Industries engaged in chemical production and processing can discharge a wide range of hazardous chemicals and toxins into the environment, including solvents, acids, bases, and chemical byproducts.
- **Waste Management**: Inadequate disposal and management of industrial waste, including hazardous waste, can lead to soil and groundwater contamination. Leachate from landfills and runoff from waste storage areas can transport pollutants into the environment.

- **Transportation and Shipping:** Urban industrial areas often serve as transportation and shipping hubs. Diesel-powered vehicles and ships emit air pollutants such as nitrogen oxides, particulate matter, and sulfur compounds.
- **Construction and Demolition:** Construction and demolition activities generate dust, debris, and construction-related pollutants that can impact air and water quality in urban settings.
- **Mining and Extractive Industries:** Some urban regions may include mining and extractive industries that contribute to soil and water contamination through the release of heavy metals, sediment, and mining-related pollutants [5].

2.2 Categories of Industrial Pollutants

Industrial pollutants encompass a broad array of substances, and their specific composition can vary depending on the industry and processes involved. Common categories of industrial pollutants include:

- **Particulate Matter (PM):** These are tiny solid or liquid particles suspended in the air, including dust, smoke, soot, and aerosols. PM is associated with respiratory problems and reduced air quality.
- **Volatile Organic Compounds (VOCs):** These are organic chemicals that easily vaporize into the air. VOCs contribute to the formation of ground-level ozone (smog) and can have adverse health effects.
- **Heavy Metals:** Metallic elements like lead, mercury, cadmium, and arsenic that can be toxic to humans and ecosystems. They often enter the environment through industrial processes.
- **Sulfur Dioxide (SO_2) and Nitrogen Oxides (NOx):** Gases primarily emitted from power plants and combustion processes. They can contribute to acid rain, respiratory issues, and smog formation.
- **Hazardous Chemicals:** Various chemicals used in industrial processes that can be hazardous to human health and the environment. Examples include solvents, pesticides, and industrial byproducts [5].

2.4 Strategies for Pollution Control and Best Practices

Mitigating industrial pollution in urban areas involves the implementation of strategies and best practices to minimize the environmental and health impacts of industrial activities. Key approaches include:

- **Emission Control Technologies:** The installation of pollution control equipment, such as scrubbers and filters, to capture and reduce emissions of pollutants from industrial sources.
- **Waste Reduction and Management:** Implementing practices to reduce the generation of industrial waste and promoting recycling and responsible disposal [6].
- **Clean Technologies:** Encouraging the adoption of cleaner and more sustainable technologies and processes that reduce emissions and resource consumption.
- **Regulatory Frameworks:** Enforcing and enhancing environmental regulations and standards to limit emissions and mandate adherence to best practices by industries.
- **Public Awareness and Engagement:** Educating the public about the risks of industrial pollution, promoting responsible consumer choices, and encouraging community involvement in pollution prevention efforts.
- **Zoning and Planning:** Thoughtful urban planning and zoning to separate industrial zones from residential areas to reduce community exposure to industrial emissions.
- **Environmental Impact Assessments:** Conducting thorough assessments before permitting new industrial facilities to ensure compliance with environmental standards and the implementation of mitigation measures.

Effective mitigation of industrial pollution in urban areas necessitates a combination of regulatory measures, technological advancements, public participation, and sustainable industrial practices. These efforts are essential to protect both the urban environment and the health and well-being of urban residents [6].

III. VEHICULAR POLLUTION IN URBAN ENVIRONMENTS

Vehicular pollution in urban areas refers to the contamination of the air and environment caused by emissions from various forms of transportation within cities and metropolitan regions. This type of pollution primarily arises from the combustion of fossil fuels in vehicles, leading to the release of a range of harmful pollutants into the atmosphere.

3.1 Emission Types and Pollutants

Emissions from vehicles encompass a diverse set of pollutants generated by motorized transportation modes such as cars, trucks, buses, motorcycles, and other urban transport systems. Notable vehicular pollutants include:

- **Carbon Monoxide (CO):** A colorless, odorless gas formed when carbon-containing fuels undergo incomplete combustion. It hinders the body's ability to transport oxygen and can have adverse health effects.
- **Hydrocarbons (HC):** Organic compounds composed of hydrogen and carbon atoms that can react in the atmosphere to form ground-level ozone (O3) and other harmful compounds. HC contributes to smog and respiratory issues.
- **Nitrogen Oxides (NOx):** Gases produced when nitrogen in the air reacts with oxygen at high temperatures in engines. NOx serves as a precursor to ground-level ozone and particulate matter and is associated with respiratory problems.

- **Particulate Matter (PM):** Tiny solid particles and liquid droplets released from vehicle exhaust. PM includes PM2.5 (fine particles) and PM10 (coarse particles), which can penetrate deep into the respiratory system and cause health problems.
- **Sulfur Dioxide (SO_2):** A gas formed when sulfur-containing fuels, like diesel, are burned. SO_2 can irritate the respiratory system and contribute to acid rain.
- **Greenhouse Gases (GHGs):** Emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) from vehicles contribute to global warming and climate change [6].
- **Volatile Organic Compounds (VOCs):** Organic chemicals that vaporize into the air and contribute to the formation of ground-level ozone and secondary organic aerosols, both of which impact air quality and human health.

3.2 Technological Advances in Reducing Vehicle Emissions

Advancements in vehicle technology have played a pivotal role in reducing vehicular emissions and mitigating their impact on urban air quality. Notable technological strides include:

- **Catalytic Converters:** These devices, integrated into vehicle exhaust systems, facilitate the reduction of emissions of CO, NOx, and VOCs by catalyzing chemical reactions that convert harmful pollutants into less harmful compounds.
- **Enhanced Engine Efficiency:** Innovations in engine design and fuel injection systems have boosted fuel efficiency, thereby decreasing the overall emissions produced per mile traveled.
- **Hybrid and Electric Vehicles:** The adoption of hybrid and electric vehicles has increased, leading to reduced or zero tailpipe emissions. Electric vehicles (EVs) produce no tailpipe emissions and are considered an environmentally cleaner option.
- **Emission Standards:** Governments worldwide have enforced stricter emissions standards for vehicles, imposing limits on the quantity of pollutants that vehicles can release. These standards incentivize automakers to develop cleaner, more fuel-efficient vehicles.
- **Alternative Fuels:** The adoption of alternative fuels, such as natural gas, biofuels, and hydrogen, can lower emissions and reduce dependence on fossil fuels [6].

3.3 Policy Measures to Control Vehicular Pollution

To address the challenges posed by vehicular pollution in urban areas, policymakers have implemented various interventions, including:

- **Emission Standards:** Governments set and enforce vehicle emissions standards to restrict the amount of pollutants that vehicles can emit. These standards encourage the use of cleaner technologies and the development of low-emission vehicles.
- **Vehicle Inspection and Maintenance (I/M) Programs:** I/M programs necessitate periodic vehicle inspections to ensure that vehicles meet emissions standards. Non-compliant vehicles may be required to undergo repairs or face penalties.
- **Fuel Quality Standards:** Regulations that mandate cleaner fuel formulations can reduce vehicle emissions. Low-sulfur diesel fuel, for instance, reduces SO_2 emissions from diesel vehicles.
- **Public Transportation and Infrastructure:** Investment in public transportation systems, such as buses and subways, encourages people to use cleaner modes of transportation and reduces the number of private vehicles on the road.
- **Incentives for Clean Vehicles:** Financial incentives, tax credits, and rebates are often offered to promote the purchase and use of electric and low-emission vehicles.
- **Congestion Pricing:** Charging fees for vehicles entering congested urban areas during peak hours can reduce traffic congestion and emissions.
- **Urban Planning:** Thoughtful urban planning that promotes mixed land use, pedestrian-friendly design, and bike lanes can reduce the need for car travel and mitigate vehicular pollution.

Efforts to control vehicular pollution in urban environments aim to enhance air quality, reduce health risks, and address broader environmental challenges associated with transportation emissions. These interventions frequently require a blend of technological innovation, regulatory measures, public awareness campaigns, and sustainable urban planning initiatives.

IV. SYNERGISTIC EFFECTS OF INDUSTRIAL AND VEHICULAR POLLUTION

Synergistic effects, within the context of industrial and vehicular pollution, refer to a phenomenon where the combined impact of pollutants from both sources is greater than the sum of their individual effects. In other words, when industrial pollution and vehicular pollution coexist in urban environments, the pollutants interact in ways that can result in heightened and amplified environmental and health consequences.

Here's how this synergy typically manifests:

- Chemical Interactions: Pollutants originating from industrial processes and vehicle emissions can engage in chemical reactions with each other or with other substances in the environment. These reactions can lead to the creation of secondary pollutants that may be more harmful or persistent than the original pollutants. For example, the combination of nitrogen oxides (NOx) from vehicles and volatile organic compounds (VOCs) from industrial sources can contribute to the formation of ground-level ozone (O3), a potent respiratory irritant [6].

- Enhanced Dispersion: Urban areas often feature overlaps between industrial zones and transportation routes, resulting in elevated concentrations of pollutants in these areas. The proximity of industrial facilities to major roadways can lead to the concentrated release of pollutants, which can then disperse into surrounding neighborhoods, exacerbating air quality issues.
- Cumulative Exposure: Individuals residing or working in regions with both industrial and vehicular pollution sources may experience cumulative exposure to a broader range of pollutants over time. This sustained and simultaneous exposure to multiple pollutants can heighten health risks, particularly for vulnerable populations.
- Ecosystem Impacts: Synergistic effects extend beyond human health and can impact ecosystems as well. For instance, polluted runoff from industrial areas and roadways can contaminate water bodies, affecting aquatic life and soil quality [6].

4.1 Challenges in Evaluating Synergistic Effects

Evaluating the synergistic effects of industrial and vehicular pollution presents several challenges:

- Complex Interactions: Identifying and quantifying the interactions between various pollutants and their synergistic effects can be intricate. Pollution mixtures can vary in terms of composition, concentration, and duration, making it challenging to accurately predict their combined impact.
- Data Availability: Gathering comprehensive data on pollutant emissions from various sources and their interactions can be a significant challenge. Accurate monitoring and modeling of pollution interactions require access to extensive data, which may not always be readily available.
- Health Assessment: Assessing the health effects of synergistic pollution is complicated due to the difficulty in isolating and attributing specific health outcomes to combined exposures. Epidemiological studies often encounter methodological challenges in accounting for multiple pollutant exposures.
- Regulatory and Policy Implications: Establishing regulatory standards and policies that consider synergistic effects is challenging. It demands a nuanced understanding of pollution interactions and may involve the establishment of more stringent standards or the adoption of multipollutant approaches.
- Vulnerable Populations: Certain groups, such as children, the elderly, and individuals with preexisting health conditions, may be more susceptible to the synergistic effects of pollution. Identifying and safeguarding these vulnerable populations represent a significant challenge.

Addressing the challenges associated with assessing and mitigating the synergistic effects of industrial and vehicular pollution requires interdisciplinary approaches involving environmental scientists, epidemiologists, policymakers, and public health experts. Research into the intricate interactions between pollutants and the development of strategies to reduce combined exposures are essential for protecting both human health and the environment in urban areas [6].

4.2 Studies Related to Air Pollution Assessment in Urban Envrionments

Gualtieri et al. (2020) stated that the Lockdown measures during the COVID-19 pandemic significantly reduced urban road traffic emissions in Italy, leading to improved air quality. Nitrogen dioxide (NO_2) levels decreased by 24.9% in Milan to 59.1% in Naples, while ozone (O_3) concentrations remained stable or increased due to reduced NO emissions. Particulate matter (PM) showed mixed results, with PM10 decreasing by up to 31.5% and PM2.5 decreasing by 13-17%, but some increases observed. Increased household heating and agricultural activities may explain PM increases. This study highlights the complex nature of atmospheric pollution and the need for comprehensive decarbonization efforts [7].

Shehzad et al. (2020) highlighted that COVID-19 lockdowns in India led to a significant reduction in air pollution, particularly in highly populated cities like Mumbai and Delhi, with Nitrogen Dioxide (NO_2) levels dropping by 40-50%. This study suggests that the pandemic, while disruptive, had the unintended benefit of mitigating air pollution in India, benefiting both the environment and public health [8].

Menon & Sharma (2021) highlighted that India faces significant challenges related to air pollution and heat stress in urban areas. This review emphasizes the importance of addressing both issues in an integrated manner. Nature-Based Solutions (NbS) are proposed as a cost-effective approach to mitigate air pollution and urban heat, offering co-benefits like reduced energy costs and biodiversity conservation [9].

Anwar et al. (2021) examines air pollution sources, impacts, and health effects in South Asian countries, including India, China, and Pakistan. It highlights that major cities in these countries exceed permissible air quality limits, leading to severe health problems. The study emphasizes the need for targeted policies that consider various parameters, including economic status, industrial interests, and lifestyle, to effectively address air pollution [10].

Mangaraj et al. (2022) focuses on Bengaluru, an Indian megacity, and develops a high-resolution emission inventory for eight major pollutants. It identifies the transport sector as the dominant source of pollutants but also highlights emerging sources like windblown road dust and solid waste burning. This dataset is crucial for air quality studies and pollution control strategies [11].

Chelani & Gautam (2022) The study assesses the impact of reduced emissions during the COVID-19 lockdown on PM2.5 and NO_2 concentrations in six Indian urban cities. It finds that confinement led to lower concentrations of these pollutants. The study also highlights the persistence of temporal characteristics in air pollutant concentration time series, even after emission reductions, suggesting the need for continued efforts to improve urban air quality [12].

Table 1. Comparison of Approaches

Author	Concept	Key Findings
Gualtieri et al. (2020)	COVID-19 Lockdown Impact on Air Quality in Italy	• Lockdown measures in Italy significantly reduced urban road traffic emissions. Nitrogen dioxide (NO_2) levels decreased in urban areas, with the highest reduction in Naples (-59.1%). • Ozone (O_3) concentrations remained stable or increased due to reduced NO emissions. • Particulate matter (PM) levels showed mixed results, with PM10 decreasing (up to 31.5%) and PM2.5 decreasing (13-17%), but some increases were observed. • Increased household heating and agricultural activities may explain PM increases. • Highlights the complex nature of atmospheric pollution and the need for comprehensive decarbonization efforts.
Shehzad et al. (2020)	COVID-19 Lockdown Impact on Air Pollution in India	• COVID-19 lockdowns in India led to a significant reduction in air pollution, particularly in highly populated cities like Mumbai and Delhi. - Nitrogen Dioxide (NO_2) levels dropped by 40-50%. • Suggests that the pandemic, while disruptive, had the unintended benefit of mitigating air pollution in India, benefiting both the environment and public health.
Menon & Sharma (2021)	Air Pollution and Heat Stress in Indian Urban Areas	• India faces challenges related to air pollution and heat stress in urban areas. • Emphasizes the importance of addressing both issues in an integrated manner. • Proposes Nature-Based Solutions (NbS) as a cost-effective approach to mitigate air pollution and urban heat, offering co-benefits like reduced energy costs and biodiversity conservation.
Anwar et al. (2021)	Air Pollution in South Asian Countries	• Examines air pollution sources, impacts, and health effects in South Asian countries, including India, China, and Pakistan. • Highlights that major cities in these countries exceed permissible air quality limits, leading to severe health problems. • Emphasizes the need for targeted policies that consider various parameters, including economic status, industrial interests, and lifestyle, to effectively address air pollution.

Author	Concept	Key Findings
Mangaraj et al. (2022)	Emission Inventory for Bengaluru, India	• Focuses on Bengaluru, an Indian megacity, and develops a high-resolution emission inventory for eight major pollutants. • Identifies the transport sector as the dominant source of pollutants but also highlights emerging sources like windblown road dust and solid waste burning. • This dataset is crucial for air quality studies and pollution control strategies.
Chelani & Gautam (2022)	Impact of COVID-19 Lockdown on Air Quality in Indian Urban Cities	• Assesses the impact of reduced emissions during the COVID-19 lockdown on PM2.5 and NO_2 concentrations in six Indian urban cities. • Finds that confinement led to lower concentrations of these pollutants. • Highlights the persistence of temporal characteristics in air pollutant concentration time series, even after emission reductions, suggesting the need for continued efforts to improve urban air quality.

V. Conclusion

In summary, the analysis of industrial and vehicular pollution in urban areas underscores the need for immediate and comprehensive action. Urban environments grapple with a complex interplay of pollution sources, resulting in intricate mixtures of pollutants that carry severe health and environmental ramifications. These health effects encompass respiratory, cardiovascular, and neurological disorders, with vulnerable demographics facing heightened risks. Simultaneously, ecosystems suffer harm, and climate change is further exacerbated. To confront this pressing challenge, stringent regulatory frameworks, the promotion of clean technologies, robust public awareness campaigns, interdisciplinary cooperation, and safeguarding vulnerable communities are of utmost importance. Continuous research and innovation are critical for devising sustainable solutions. By implementing these measures, we can work towards cleaner, healthier, and more sustainable urban spaces, ensuring the well-being of present and future generations while preserving our environment.

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