

A Review on Air Pollution and Its Impacts on Human Health & Environment: An Integrated Approach Towards Sustainability

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Abstract - Air pollution is one of the most significant environmental challenges affecting human health and ecosystems worldwide. This study reviews air pollution levels, pollutant transport, monitoring methods, climate effects, and associated health outcomes across different regions. Major pollutants such as PM_{2.5}, PM₁₀, NO₂, SO₂, and O₃ are responsible for respiratory diseases, cardiovascular disorders, environmental degradation, and reduced quality of life. The study highlights the need for improved monitoring systems, stricter pollution control measures, cleaner technologies, and long-term research to protect human health and the environment.

Keywords - Air Pollution, PM_{2.5}, PM₁₀, Human Health, Environment, Air Quality Monitoring, Climate Change

I. INTRODUCTION

Air pollution is one of the most pressing environmental issues this century. The growing number of fossil fuel power plants, cars, factories, and agricultural industries contribute to the high level of pollutants in the atmosphere. Inhalation of fine particulate matter, carbon monoxide, nitrogen oxides, sulphur dioxide, and other harmful substances leads to lung disease, disabilities, and premature death. Apart from the impact on the health of individuals, air pollution also brings dramatic consequences to the environment, including biodiversity loss, climate change, acidification, and destruction of natural habitats.

There are several reasons why air pollution remains a serious environmental problem worldwide, particularly in developing economies. First, countries with high levels of urbanization and industrialization experience serious air quality issues due to the rise in greenhouse gas emissions and the lack of proper environmental policies. Second, climate change as a result of a warmer climate, altered weather patterns, and extreme temperatures affects the health of individuals and promotes the destruction of ecosystems and natural habitats. Moreover, air pollution is often regional since the distribution of harmful substances depends on the prevailing wind direction and speed. It means that specific geographical locations and populations are vulnerable to environmental contamination in a particular region.

A study of the impact of air pollution involves an assessment of the human health hazards posed by the emissions of various harmful substances. Modern research increasingly

recognizes the indirect and long-term effects of air pollution, including the impact on the economies of developed and developing countries. High rates of air pollution often lead to poor labour productivity and put high pressure on national health care systems. Socially vulnerable populations and communities are particularly vulnerable to the adverse consequences of environmental pollution. Understanding the impact of air pollution on individuals and the environment is critical to developing effective strategies for managing and controlling air quality.

This paper presents a review of twelve research studies on the effects of air pollution published in different reputable journals. Each work was examined in terms of the objectives, data, and conclusions drawn by the authors. While some articles provide an insight into the effects of air pollution on human health and the environment, others focus on issues of climate change, air quality assessment, air pollution in specific locations, and potential solutions for controlling and reducing emissions in the atmosphere. The review aims to systematize the information found in published papers, highlight gaps in air pollution studies, and provide recommendations for future research.

II. REVIEW OF LITERATURE

Evolution of the Effects of Global Air Pollution at Different Horizontal Resolutions.

The author explains that the impact of ambient air pollution on human health, particularly PM_{2.5}, O₃ critical global concern. Atmospheric Chemical Transport Models (CTM's) used for to predict air pollution concentrations and assess health risks. There is a serious comparison between performance of global low resolution CTM's with high resolution for estimating O₃ and PM_{2.5} concentrations. The nested grid simulations improve the representation of regional air pollution and better reproduce local observations, especially in areas with complex terrain and localized emission sources, they do not significantly improve global scale model performance. The differences in estimated global health and agricultural impacts between low and high-resolution models are small and fall within uncertainty associated with emission inventories and CTM's. High

resolution models are beneficial for regional studies and policy applications; accurate representation of local pollution is important. Low resolution CTM's provide sufficient accuracy for global scale assessments while requiring much lower computational resources.

Air Pollution and Climate Change Effect on the Caribbean

The chapter reviews the relationship between air pollution, climate change and public health in the Caribbean region. It highlights that air pollution, PM, ground level ozone(O₃) is growing environmental and health concern. Many Caribbean countries lack effective air quality standards and enforcement, increasing risk of respiratory illnesses, morbidity. Climate change is expected to impact by increasing pollutant concentrations. Major contributions to air pollution in Caribbean, including dependency on fossil fuels, industrialization, poor land use practices, waste management and natural events. Discusses how these pollution sources, together with climate change, increase the vulnerability of Caribbean populations.

Author states that the burden of air pollution will continue to increase under future climate change unless effective mitigation measures are implemented at the community, national and global levels. They recommend Strengthening air quality monitoring, environmental surveillance and long-term epidemiological studies to better understand the health effects of pollutants

A Review of Air Pollution's Effects on the Environment and Human Health.

The paper provides a comprehensive review of the effects of air pollution on human health and the environment. The air pollution is a major global environment and public health issue caused by rapid industrialization, transportation and fossil fuel combustion. Major pollutants including CO, Pb, VOC's, PM_{2.5}, PM₁₀, NO_x, SO_x and explains their adverse impacts on human health and ecosystem.

The air pollution significantly contributes to respiratory diseases, cardiovascular, disorders, neurological problems, cancer and premature mortality, while also causing environmental regulations, sustainable development practices, improved emission control technologies, increased public awareness.

Examining Scientific Studies on the Environment and Air Quality PICTS's Health Risks and Effects.

The study presents systematic review of scientific research on air quality and environmental health risks in Pacific Island Countries, Territories and States (PICTS). The authors highlight that air quality has a significant impact on human health and the revised 2021 World Health Organization (WHO) Air Quality Guidelines require stricter control of air pollutants. It evaluates the current state of air quality in PICTS. Most of studies focused on pollutants PM_{2.5}, PM₁₀, SO₂ and CO. Research emphasized environmental risks, while studies on health, social, economic and technological impacts were limited.

The scientific evidence on air quality in PICTS is still insufficient and geographically limited. They recommend establishing continuous and coordinated regional air quality monitoring programs, expanding research to all Pacific Island Countries and Conducting long term studies to generate reliable and comparable data. Such efforts are essential for developing effective environmental policies, protecting public health and improving the sustainability of Pacific Island Communities.

Using Google Street View of Cars for High Resolution of Air Pollution Mapping; Making Use of Big Data.

The study introduces a high-resolution mobile air pollution monitoring approach using Google Street View vehicles equipped with advanced air quality sensors to measure nitric oxide (NO), nitrogen dioxide (NO₂) and black carbon (BC) at the street level. The paper highlights that conventional fixed site air quality monitoring stations have limited spatial coverage and are of Oakland, California, the study developed detailed pollution maps with a spatial resolution of 30m, revealing localized pollution hotspots and improving the understanding of human exposure to urban air pollution.

The mobile monitoring approach provides 4-5 orders of magnitude higher spatial resolution than traditional monitoring methods and successfully identifies persistent pollution hotspots caused by traffic, industrial activities and other local emission sources. The study demonstrates that repeated mobile measurements can accurately characterize long term urban air pollution patterns while requiring fewer monitoring days than expected. The authors suggest that this scalable and cost effective can complement existing air quality monitoring networks, improve exposure assessment, support environmental policies and enhance public health research. They also recommend expanding this approach to other cities worldwide to address gaps in urban air quality monitoring and management.

The Effects of Stratospheric Infiltration and Indian Summer on Air Pollution Across the Tibetan Plateau.

The author describes that air pollutants can be transported to the pristine regions such as the Tibetan Plateau, by monsoon and stratospheric intrusion. The Tibetan Plateau region has limited local anthropogenic emissions, while this region is influenced strongly by transport of heavy emissions mainly from South Asia. They conducted a comprehensive study on various air pollutants (PM_{2.5}, gaseous Hg, Surface Ozone O₃). Monthly mean PM_{2.5} concentrations at Nam Co peaked in April before monsoon season and decreased during the whole monsoon season (June-September). The Indian summer monsoon acted as a facilitator for transporting gaseous pollutants but a suppressor for particulate pollutants (PM_{2.5}) during the monsoon season. Different from both PM_{2.5} and total gaseous mercury variabilities, surface ozone concentrations at Nam Co are primarily attributed to stratospheric intrusion of ozone and peaked in May. The effects of the Indian summer monsoon and stratospheric

intrusion on air pollutants in the inland Tibetan Plateau are requiring further studies.

In conclusion, The Indian Summer Monsoon acts as a facilitator for transporting gaseous pollutants such as TGM while suppressing particulate pollutants (PM_{2.5}) through rainfall and wet deposition. In contrast, surface ozone concentrations are mainly controlled by stratospheric intrusion rather than monsoon activity, resulting in distinct seasonal patterns for each pollutant. The study highlights that the sources and transport mechanisms of air pollutants over the Tibetan Plateau are highly complex and recommends further chemistry-transport modelling and long-term monitoring to improve understanding of pollutant behavior, reduce uncertainties in impact assessments, and support effective environmental protection policies.

Breathing in danger: Recognizing the various ways that Air Pollution Affects Health.

The paper presents a review of the relationship between air pollution, human health, and environmental sustainability. The air pollution remains one of the most critical global environmental challenges, contributing to respiratory, cardiovascular, neurological, and other chronic diseases while also imposing significant economic and environmental burdens. The paper highlights recent advancements in air pollution monitoring technologies, big data analytics, artificial intelligence, satellite remote sensing, and machine learning, which have improved the understanding, prediction, and management of air pollution. It discusses emerging pollutants such as microplastics and nanoparticles, along with their potential health risks and the need for further research.

Addressing air pollution requires a multidisciplinary and globally coordinated approach involving scientific research, technological innovation, effective environmental policies, public awareness, and international collaboration. They recommend strengthening air quality monitoring systems, promoting clean energy and sustainable urban planning, developing advanced pollution control technologies, and expanding research on emerging pollutants and their long-term health effects. The study emphasizes that continued investment in research, education, and policy interventions is essential to reduce air pollution, protect public health, and achieve sustainable environmental development.

Air Pollutions Effects on Environment and Individuals.

The Author states that, air pollution problem has become a major concern globally High concentration of air pollutants are putting millions of people's health at risk. Ind Air pollution may cause several health problems. It impacts economic productivity, reduces agricultural, productivity, damages property and causes ecological changes that increase the risk of environmental disaster. To minimize environmental pollution, some preventive measures need to be taken. Principle of 3R's: To save the environment, use the principle of 3 R's; Reuse, Reduce and Recycle.

It is the responsibility of every individual to save our planet from these environmental contamination agents. If preventive measures are not taken then our future generation will have to face major repercussions. The government is also

taking steps to create public awareness. Every individual should be involved in helping to reduce and control pollution.

Air Pollutions Effects on Human Health: An Environmental Impact Analysis using SO₂ and PM_{2.5}.

This study investigated the concentrations of PM_{2.5} and SO₂ around the Vellore dump yard in Coimbatore to assess their impact on air quality and public health. Air quality was monitored for one month using high precision instruments. The results showed that the mean concentrations of PM_{2.5} and SO₂ were above the permissible limits of World Health Organization (WHO) and Central Pollution Control Board (CPCB) which posed serious health hazards for the nearby population. Higher concentrations of pollutants were observed in the down-wind directions of the dump yard especially in dry weather conditions and waste burning activities. Low wind speeds and high temperatures also contributed to the accumulation of pollutants, increasing human exposure, the study found.

The authors concluded that poor waste management, combined with unfavourable meteorological conditions, significantly degrade local air quality. They suggested increasing air quality monitoring, enforcing environmental regulations, improving waste management practices, adopting advanced pollution control technologies and increasing community awareness. The study highlights that integrated air quality management and long-term monitoring are critical to reduce pollution levels and protect public health in urban areas. The given direct implications of these findings, it is imperative that comprehensive and enforceable air quality management strategies are immediately implemented. Key recommendations based on the study include:

- 1. Enhance Monitoring**
- 2. Regulatory Enforcement**
- 3. Technological Solutions**
- 4. Community Engagement and Education**

An Analysis of the available data on how Air Pollution Affects the Environment and Living Beings.

The author states that, the impact of air pollution on human health, living organisms, and the environment. The author highlights that air pollution has become one of the most serious global environmental challenges due to rapid urbanization, industrialization, fossil fuel combustion, and increasing vehicular emissions. The review identifies major air pollutants, including particulate matter (PM), Sulphur dioxide (SO₂), nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), lead, and mercury, and discusses their harmful effects on human health. The study explains that exposure to these pollutants is associated with respiratory diseases, asthma, chronic obstructive pulmonary disease (COPD), cardiovascular disorders, cancer, neurological damage, kidney failure, and premature mortality

Air pollution is a major threat to both human health and the environment, causing severe health problems, environmental degradation, and economic losses. The study recommends the adoption of clean technologies, renewable

energy sources, stricter industrial and vehicular emission regulations, improved urban planning with increased green spaces, and enhanced public awareness to reduce pollution levels. It further stresses that coordinated efforts by governments, industries, researchers, and the public are essential for improving air quality and protecting public health. The review concludes that comprehensive environmental policies and sustainable pollution control measures are necessary to achieve cleaner air and a healthier environment for future generations

The Effect of Air Pollution on Respiratory Conditions: An Urban Case Study.

The author examined the association between air pollution and respiratory diseases in Delhi, India from 2019 to 2024 using data from CPCB and DPCC and hospital records from major hospitals. The results showed that PM_{2.5} and PM₁₀ concentrations were constantly above WHO safety limits, with the highest pollution levels in 2023 and 2024. Hospital admissions for respiratory diseases increased by 31% during the study period, and a correlation between PM_{2.5} exposure and respiratory illnesses was observed. Pollution and hospitalization rates were highest during the winter. The study found that PM_{2.5} and NO₂ are the major causes of asthma, COPD and bronchitis and stressed the need for more stringent emission controls, better air quality management and public health interventions to reduce respiratory health hazards in urban areas.

The study says that air pollution in Delhi increased a lot between 2019 and 2024 causing an increase in respiratory diseases. PM_{2.5}, PM₁₀, NO₂, and SO₂ levels were highest in 2023–2024 due to vehicular emissions, industrial activities, and stubble burning during winter. PM_{2.5} was the most dangerous pollutant, associated with asthma, COPD and bronchitis, particularly in children and the elderly. The authors advocate for stricter emission standards, improved industrial and motor vehicle regulations, more green infrastructure, zones without emissions, and more awareness. They stress that coordinated action by policymakers and public health officials is necessary to improve air quality and reduce respiratory health risks.

Chinese Population Health, Climate Change and Ambient Air Pollution.

The authors highlight that rapid industrialization, urbanization and heavy reliance on fossil fuels have made China one of the world's largest emitters of air pollutants and greenhouse gases. Therefore, China is plagued by severe air pollution and major public health issues. The review also states that air pollution and climate change also lead to respiratory and cardiovascular disease and extreme weather events, poor air quality and shifts in infectious disease. Although the risk of death per unit of pollution is lower than in developed countries, China's high pollution and large population create a greater overall health burden. The study stresses the importance of reducing fossil fuel consumption and integrating air pollution control with climate change policies for sustainable development.

In conclusion, that the ambient air pollution and climate change are major environmental challenges for public health in China. Exposure to pollutants such as PM_{2.5}, PM₁₀, SO₂, NO₂, and O₃ can lead to increased respiratory and cardio. Although the health risk per unit of pollution is lower than in developed countries, China's high levels of pollution and large population mean it has a much higher overall health burden. The study stresses the need for long-term health research, improved air quality monitoring, and better identification of vulnerable populations. The authors suggest reducing fossil fuel use, promoting clean energy, improving air quality management, and integrating pollution control policies with climate change mitigation policies to protect public health and sustain development.

III. CONCLUSION

Air pollution is still one of the world's most serious environmental and public health challenges. This review reviewed twelve studies that explored the sources, distribution, monitoring, environmental impacts and health effects of air pollution in various geographical locations. The literature consistently demonstrates that pollutants such as particulate matter (PM_{2.5} and PM₁₀), nitrogen oxides (NO_x), Sulphur Dioxide (SO₂), Ozone (O₃), Carbon Monoxide (CO), volatile organic compounds (VOCs), and other hazardous emissions have significant adverse effects on both human health and the natural environment. The reviewed studies indicate that prolonged exposure to air pollutants increases the risk of respiratory diseases, cardiovascular disorders, Chronic Obstructive Pulmonary Disease (COPD), asthma, lung cancer, neurological disorders, and premature mortality. The health effects are especially severe in children, the elderly, and those with pre-existing medical conditions. Apart from its effect on human health, air pollution also contributes to climate change, acid rain, biodiversity loss, loss of agricultural productivity, deterioration of ecosystems and damage to buildings and cultural heritage. Overall, this review confirms that air pollution is not only an environmental issue, but also a major public health, economic and social concern. "Through effective implementation of scientific research, technological innovations, evidence-based environmental policies and active public participation, it will be essential to reduce pollution levels, protect ecosystems, improve human health and the natural health.

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