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EASSYS ON ENVIROMENTAL ECONOMICS: RESERCH HIGHLIGHTS THE IMPACT OF NO2 & PM. 2.5 ON HUMAN HEALTH IN INDIA

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Abstract

Environmentalism increasingly appears to be confined to theoretical discourse. A recent study conducted by the Health Effects Institute (HEI) in conjunction with the State of Global Air (SoGA) 2022 has identified Delhi as the most polluted city globally, followed closely by DELHI, KOLKATA,MUMBAI and CHENNAI, both located in India. This report emphasizes the significant air pollution and its associated health ramifications in these urban areas, particularly concerning its effects on newborns worldwide. The HEI released this report in collaboration with the United States Environmental Protection Agency and other organizations. The primary focus of this analysis is on hazardous airborne pollutants, specifically fine particulate matter (PM2.5) and nitrogen dioxide (NO2), which pose considerable threats to human and animal health in the environment.

KEYWORDS: Atmospheric science, Aerosol, Environmentalism, Ramification, Degradation, Deforestation, Nitrogen oxide (NO2), Particulate Matter 2.5, Epidemiological Studies, Aerodynamic, Cardiopulmonary Diseases, COPD, Mitigate, Epitomize, Embrace, Encroache, Industrialization, Urbanization, AQI, Agricultural Productivity, Scarcity, Manifestation.

Introduction

Air pollution signifies a degradation of the atmosphere and its living constituents. Atmospheric science encompasses the study of Earth's atmosphere, its composition, and the dynamics of aerosols. Air pollution is a significant factor contributing to the rise in global temperatures, adversely affecting human daily activities as well as flora and fauna. The release of harmful particles from the combustion of fossil fuels, which occurs through transportation, forest fires, volcanic eruptions, and other sources, exacerbates this issue. Numerous epidemiological studies have examined the health impacts associated with the presence of nitrogen dioxide (NO2) and particulate matter (PM2.5) in the atmosphere. PM2.5 is defined as particulate matter with an aerodynamic diameter smaller than 2.5 micrometers. This category is further divided into two components: primary particles, which are directly emitted from either natural or anthropogenic sources, and secondary particles, which result from chemical reactions in the atmosphere. NO2 is primarily generated through industrial combustion processes, with significant emissions occurring in urban areas as a result of road transportation. A substantial number of epidemiological studies have reported on the presence of PM2.5 and its detrimental effects on cardiovascular and pulmonary health.

Methodology & Data Analysis

Secondary data is utilized to achieve the objectives of this study. The data has been sourced from various websites and was released by the Health Effects Institute, which assesses the impact of pollutants on human health in 7,239 cities from 2010 to 2019. Among these cities, over 1,500 are located in South Asia.

This data primarily focuses on the increasing levels of pollution, particularly concerning two harmful airborne particles: PM2.5 and NO2.

The main stages of the proposed methodology are as follows:

1.Creation of a multivariate dataset that includes ambient air quality measures and pollutant levels across various contexts, such as industrial and mining areas.

2.Development of a statistical tool based on the significance of the study area, employing mathematical modelling that integrates multivariable data with time series analysis.

Engagement in study locations:

HIGHLIGHTED THE MAIN COMPONENT OF POLLUTION

STATES	NO_2 **(Quarterly data from JANUARY-NOVEMBER 2025)**	$PM_{2.5}$ **(Quarterly data from JANUARY-NOVEMBER 2025)**	SO_X **(Quarterly data from JANUARY-NOVEMBER 2025)**	CO_2 **(Quarterly data from JANUARY-NOVEMBER 2025)**
DELHI	Min 41 – Max 74	Min111-Max334	Min 6-Max 20	Min 489-Max 841
KOLKATA	Min15-Max 34	Min 66-Max 207	Min 2-Max 6	Min 427-Max 810
MUMBAI	Min 12-Max 32	Min 35- Max 146	Min 6-Max 10	Min 328-Max 531
CHENNAI	Min 5-Max 11	Min 12-Max 92	Min 2-Max 4	Min 349-Max 655

WHO sets standards for air pollution are given below:

NO_2 =13.29ppb, According to WHO guidelines 24/24 hours in which exposure is above the recommended.$PM_{2.5} = 15\mu g/m^3$,$SO_2 = 15.27ppb$ and $CO_2 = 3490ppb$.

Air quality is the condition of the air we breathe, defined by the number of pollutants such as dust, smoke, chemicals, and harmful gases present indoors or outdoors. Poor air quality can lead to respiratory and heart problems. The Air Quality Index (AQI) was created to measure these pollution levels and indicate potential health risks.

$$\text{AQI} \quad = \quad l_p = \frac{l_{Hi} - l_{Lo}}{BP_{Hi} - BP_{Lo}}\left(C_p - BP_{Lo}\right) + l_{Lo}$$

Where,

□□ = The index value for pollutant p.

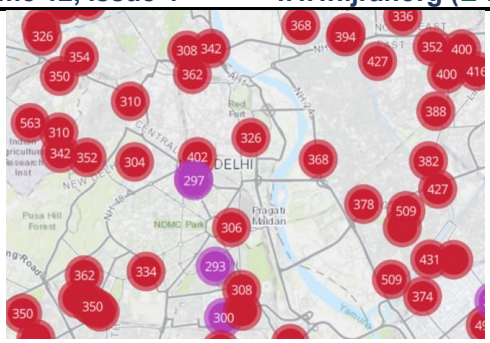
□□ = **The truncated concentration of pollutant p.**

BP_{Hi}=**The breakpoint that is greater than or equal to** C_p**.**

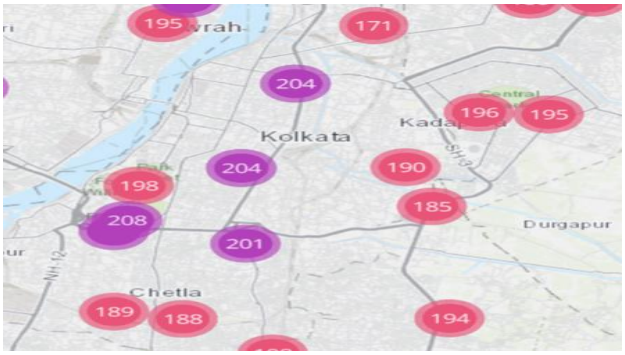
BP_{Lo} = **The breakpoint that is less than or equal to** C_p**.**

l_{Hi} = **The AQI value corresponding to** BP_{Hi}**.**

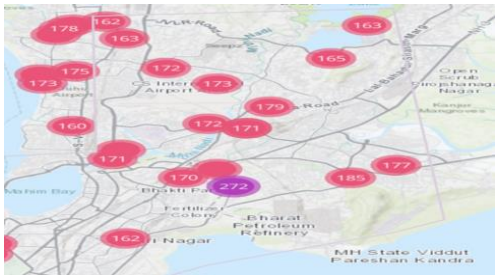
l_{Lo} = **The AQI value corresponding to** BP_{Lo}**.**



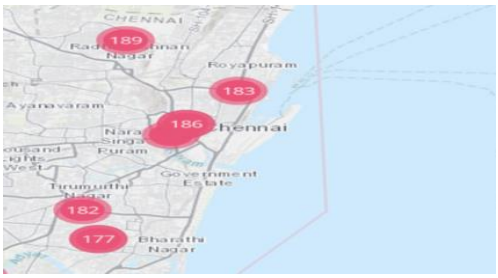
1.HEI,2025 DELHI INDIA



2.HEI,2025 KOLKATA INDIA

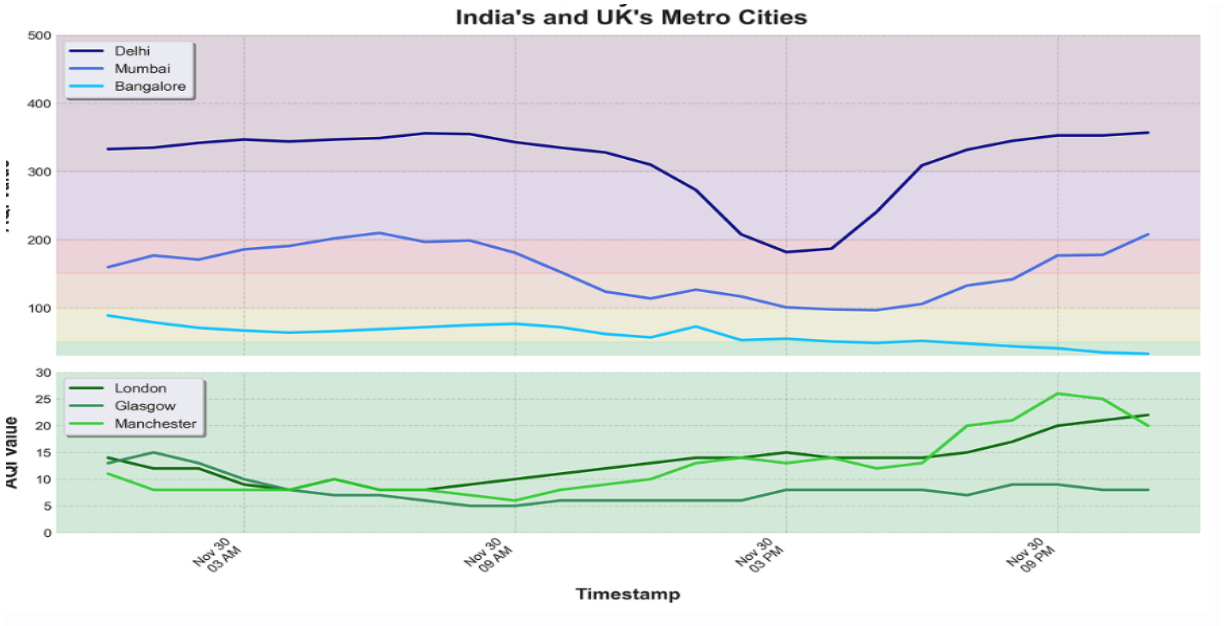


3.HEI,2025 MUMBAI INDIA



4.HEI,2025 CHENNAI INDIA

Comparison of Air Quality in India vs UK's metro cities



HEI,2025 where Indian metro stays in Moderate to Severe AQI category which means "NO GOOD" condition but always spikes day by day due to large number of populations in one small place. Simultaneously UK's metro cities stay in 5 and 30 AQI which is "GOOD" in AQI category.

Here HEI,2025 data use for analysis

India — Air is unhealthy much of the day; mornings and late evenings are worst.
UK — Air is generally clean most of the day with low health risk.

Data Processing & Analysis of Control

1. 24/7 Average (PM2.5)

Annual average exposure levels for PM2.5 are monitored continuously across various stations nationwide. It is essential to identify stations with the highest levels of pollution and implement prohibitory measures in those specific areas. Additionally, analyzing the average pollution levels in these regions can contribute to mitigating the problem.

2.One-Hour Observation (NO2)

A separate observing station for nitrogen dioxide (NO2) is required to conduct measurements over a one-hour interval. Following seven days of data collection, it will be feasible to calculate the average emissions from the stations that produce the highest levels of harmful particles.

3. Statistical Analysis of the Data

In this analysis, statistical methods, including the mean, standard deviation, and correlation, will be employed to derive insights from the data.

4. Modelling

The modeling of the data will rely on accurate data collection and the soundness of the statistical outcomes derived from the analysis.

Literature Review from Environmental Perspective about Air pollution

The Survey of Literature indicates that the modernization of society has significantly transformed human life; however, it has also resulted in numerous challenges. Ecosystem degradation, characterized by the presence of sulfur oxides (SOx) and nitrogen oxides (NOx) in the atmosphere, contributes to acid rain, which adversely affects trees, soil quality, and aquatic ecosystems. The combustion of fossil fuels and the incineration of industrial waste release greenhouse gases such as carbon dioxide (CO2), methane, NOx, and particulate matter (PM2.5). Air pollution undermines the delicate balance of ecosystems, leading to alterations in species behavior and natural processes.

Furthermore, air pollution contributes to the contamination of water sources, including rivers and groundwater, and negatively impacts soil quality. The damage to plants caused by the depletion of the ozone layer permits harmful radiation to affect young plant tissues, which poses significant challenges to agricultural productivity and biodiversity. Additionally, the presence of PM2.5 in the air not only reduces visibility but also poses serious cardiopulmonary health risks and negatively affects overall well-being. The World Health Organization on his paper 2005 updated the air quality ambient every year based on pollution increase and population increase. According to Hingane, Hemlata in the article “Effects on air pollution on human and plant health”2022.’The impact of air pollution & well-being “by Google Scholer in 2023 gives us some brief idea regarding our daily life spend. World clean air congress 2019 in Science Direct found main key factors which effects directly in the human health and increase the cases of respiratory problem in near future UN Environmental Programmed also releases the articles on recent Banana Crisis due to environmental degradation and Coco Crisis etc. Are the example of environmental pollution.

Air Pollution in India & Human Health

"The earth, the air, the land, and the water are not an inheritance from our forefathers but on loan from our children. So we have to handover to them at least as it was handed over to us". ---------- Mahatma Gandhi

The study was conducted in Asansol, a metropolitan city in West Bengal. According to the Census of India (2011), Asansol has a population of 1.67 million, making it the second largest city in the state. This figure corresponds to the population within the jurisdiction of the Asansol Municipal Corporation (AMC). The Air Quality Index (AQI) of Asansol is currently categorized as poor, with a live AQI of 103, particulate matter (PM) levels at 112 µg/m³, and PM2.5 levels at 36 µg/m³. Asansol has gained a reputation as an unplanned and heavily polluted city in India. A comparative study of air quality data from four regions in India reveals a higher concentration of harmful particles in the air. The areas examined include the Chinnakuri mining site, Narankuri mining sites, Mahabir Colliery, and Khottadih Colliery. The current AQI in Chinnakuri is classified as very poor, with an AQI of 166, PM2.5 at 82.16 µg/m³, and nitrogen dioxide (NO2) at 45.6 µg/m³. Data provided by the Central Pollution Control Board (CPCB) and the West Bengal Pollution Control Board (WBPCB) highlights the significant health impacts associated with air pollution in the region.

Asthma

The Asthma Action Plan serves as a critical framework for identifying triggers and determining when medication and medical attention are necessary. Asthma is a chronic respiratory condition that affects the lungs, leading to airway obstruction and muscular constriction, which in turn causes breathing difficulties.

COPD (Chronic Obstructive Pulmonary Diseases)

Emphysema and chronic bronchitis are conditions that lead to airway obstruction. Although these disorders are not curable, they can be effectively managed.

Lung Cancer

The presence of particulate matter in the air has been demonstrated to contribute to an increase in lung cancer incidence among humans.

Cardiovascular Disease

Heart disease and stroke represent significant health concerns in these regions. They weaken the cardiovascular health of individuals and elevate the risk of heart attacks and strokes.
Additionally, mining activities have both direct and indirect effects on children, contributing to increased morbidity and illness. Such conditions exacerbate the disruption of educational opportunities for children and heighten the risks associated with child labor. Many children engaged in labor are also struggling with malnutrition and food insecurity.

Analysis of Environmental Effect in Rural and Urban India

Urban areas face several prevalent challenges, including air pollution, water pollution, noise pollution, and waste accumulation. Additionally, land degradation is a significant consequence of rapid urbanization and industrialization. In rural areas, deforestation poses considerable threats, as it is often driven by the establishment of industries. This deforestation is a major contributor to soil erosion and climate change. Furthermore, the increasing productivity of industries typically encroaches upon agricultural land, thereby disrupting agricultural productivity. The excessive use of pesticides not only depletes essential soil minerals but also adversely affects beneficial organisms within the soil ecosystem.

Faith on Environment According to Indian History

In Indian society, there exists a strong religious commitment to environmental preservation rooted in Hinduism. Historical texts such as the Vedas, Puranas, and Arthashastra advocate for the careful use of nature's resources, highlighting the concept of scarcity—where unlimited desires confront limited resources. Throughout ancient times, numerous spiritual and philosophical traditions regarded nature as a divine entity or a manifestation of the divine. During the Vedic period, various texts emphasized the importance of protecting forests, wildlife, and rivers, framing this responsibility as a fundamental duty (Dharma) to safeguard the environment.

Following the 1970s, significant environmental movements emerged in India. One prominent example is the Bishnoi Movement in the Rajasthan region. Spearheaded by figures such as Amrita Devi, Jamaji, and 363 local individuals who sacrificed their lives in the 15th century to protect trees, this movement epitomizes a commitment to forest preservation. Its central tenet revolves around the ad hoc embrace of trees for their protection, marking it as a pioneering force in India's environmental and wildlife conservation efforts.

Chipko Movement (Uttarakhand, 1973): The Chipko Movement, pioneered by Sundarlal
Bahuguna, is recognized as a significant non-violent social and ecological initiative. It involved local villagers, predominantly women, who protested against governmental authorities' decisions regarding commercial logging in the Garhwal Valley of the Himalayas. The term "Chipko" translates to "to hug," symbolizing the villagers' determination to protect their forests. Central to the movement is the role of women as guardians of these trees, who view this action as vital for their livelihoods. This movement embodies principles of eco-feminism.

Appiko Movement (Karnataka, 1983): The Appiko Movement, initiated by Panduranga Hegde in the Uttara Kannada district of Karnataka within the Western Ghats, focuses on environmental conservation. The movement's primary slogan, "UBSU, BELESU & BALASU," translates to "SAVE, GROW & USE RATIONALLY." Local communities actively engage in efforts to preserve trees for future generations and for their own sustenance. The term "Appiko" means "HUG" in Kannada, reflecting the community's commitment to safeguarding their natural resources.

Modernization Effect on Environment

Modernization refers to the process of transforming society from traditional structures through a 'pre-modern' phase to a 'modern' or developed state. Theories of modernization have been instrumental in understanding the financial growth of societies. This process of economic development is closely linked with industrialization and urbanization, which often leads to significant environmental degradation and an increase in harmful pollutants in the ecosystem.

According to Etzoni (1996), "Historically, modernization is the process of change toward those types of socio-economic and political systems that emerged in Western Europe and North America from the seventeenth to the twentieth centuries, which subsequently spread to the continents of South America, Asia, and Africa." A prominent framework in this discourse is W.W. Rostow's Five Stages of Economic Growth, which includes: Stage 1 - Traditional Society, Stage 2 - Preconditions for Take-off, Stage 3 - Take-off Stage, Stage 4 - Drive to Maturity, and Stage 5 - The Age of High Mass Consumption.

The burgeoning human population and the resulting ecological crisis exert significant pressure on our ecosystems and jeopardize the sustainability of future generations. The rapid increase in population has intensified demand for energy and resource consumption. As a consequence, 52% of global freshwater reserves are now at risk. This growth also places immense strain on food security. It is projected that pollution will lead to the premature deaths of approximately 6.6 million people per year by the year 2050. The reliance on fossil fuels and the release of greenhouse gases are generating harmful pollutants, such as nitrogen dioxide (NO2) and particulate matter (PM2.5), as reported by ONGC. These factors are anticipated to elevate global temperatures by an estimated 3 to 5 degrees Celsius by 2075. Furthermore, biodiversity is declining at alarming rates, with land species experiencing a decrease of 10%, insect populations declining by 75%, and 33% of species facing endangerment. Deforestation represents another critical issue in contemporary society, driven by increasing population pressures and industrialization.

Objective Of the Study

1. Our primary objective is to classify nitrogen dioxide (NO2) and particulate matter (PM2.5) present in the atmosphere. It is essential to understand how these airborne particles adversely affect human health on a daily basis.

2. According to epidemiological studies, there is a concerning increase in the prevalence of respiratory issues.

3. To promote a healthy lifestyle, it is imperative to purify the ambient air by minimizing artificially induced chemical reactions in manufactured goods and by adopting electric vehicles, which contribute to lower particulate emissions.

4. Sustainable development necessitates the adherence to Sustainable Development Goals (SDGs) 11, 12, and 13.

Conclusion

The final aspect of this discussion pertains to the subjective matter of air pollution. This project presents a comprehensive examination of the topic titled "Research Highlights: The Impact of NO2 and PM2.5 on Human Health in India," providing detailed insights into the subject. Additionally, this project emphasizes key concepts related to the topic.

The ideas explored in this project were derived from an extensive review of pertinent literature, including both printed sources and online materials. I hope that this project will prove to be both informative and valuable.

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