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A STUDY ON STATE WISE AIR POLLUTION WITH REGARD TO PARTICULATE MATTER IN INDIA

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ABSTRACT

This study looks at air quality in various Indian states, focusing on the prevalence and composition of particulate matter (PM) as a key indicator of air pollution. The study takes a comprehensive approach to assessing state-by-state variations in PM concentrations, taking into account a variety of geographical, climatic, and demographic factors. The research aims to identify patterns, trends, and potential sources of PM in different regions by utilizing extensive air quality monitoring data, statistical analyses, and geographical information systems (GIS).The environment and public health are seriously threatened by air pollution, particularly when it comes to particulate matter (PM). PM is composed of minuscule particles suspended in the atmosphere, which are often generated by combustion, natural, and industrial processes. Prolonged exposure to high particulate matter has been linked to respiratory and cardiovascular disorders, as well as detrimental effects on the environment. Using data from the Air Quality Life Index (AQLI) for five years, from 2016 to 2021, and breaking down each state separately, this study examines the intricate rise of PM in India in great detail. Uttar Pradesh has the highest PM rate (2021) at 5.754. This implies that there has been a discernible increase in air pollution in this state. With the lowest is Arunachal Pradesh.

Keywords: Particulate Matter (PM), Air Pollution, Environmental Impact, Public Health, Atmosphere, AQLI

1. INTRODUCTION

Pollution is a multifaceted, ubiquitous problem that has gained global attention because to its serious risks to human health, the environment, and the stability of entire ecosystems. It includes a range of forms, mainly brought on by industrial operations and human activity, such as pollution of the air, water, soil, and noise levels. As we explore the complexities of this complex issue, it becomes clear that, in order to minimize the far-reaching effects of pollution, immediate global action, comprehensive policies, and sustainable behaviors are required. Pollution, in all its forms, is one of the biggest issues facing modern society. It describes when dangerous materials or forms of energy are released into the environment and have negative consequences. The planet's overall health, human health, and ecosystems have all been negatively impacted by pollution, which has reached unprecedented levels due to the exponential increase of the human population and industrialization. Comprehending the diverse categories of pollution, their origins, and possible remedies is vital in tackling this worldwide issue. One of the most prevalent forms of pollution is known as air pollution. This sort of pollution is caused when potentially hazardous substances such as particulate matter, carbon monoxide, sulfur dioxide, and nitrogen oxides are released into the atmosphere. The quality of the air is getting worse as a result of these pollutants, which are released into the atmosphere by sources like as automobiles, factories, and the combustion of fossil fuels. Extended exposure to these contaminants may result in respiratory ailments, cardiovascular issues, and premature mortality. Initiatives including switching to renewable energy sources, tightening emission standards, and encouraging public transportation have gained traction in the fight against air pollution.

One of the most important environmental and public health issues of the twenty-first century is air pollution. Air pollution levels have skyrocketed due to increased urbanization, industrialization, and population growth, endangering human health, ecosystems, and the climate. Throughout the past few decades, air pollution levels have dramatically increased in India, one of the economies with the fastest rate of growth in the world. This study intends to explore the complex dynamics of air pollution in India, with a particular emphasis on a state by-state examination to comprehend the disparities specifically the particulate matter in the pace of growth in the nation. According to AQLI India is the second most polluted nation in the world. As a result of fine particulate air pollution (PM2.5), the life expectancy of the typical Indian is 5.3 years lower than it would be if the WHO recommendation of 5 micrograms per cubic meter was adhered to. Some regions of India do substantially worse than average; for instance, the National Capital Territory of Delhi, which is the world's most polluted city, has air pollution that shortens life expectancy by 11.9 years. Other regions of India also perform significantly worse than average.

Due to the country's varied geography, climate, and population, air pollution in India follows a complicated pattern. The declining quality of the air is mostly caused by factors including household energy use, industrial activity, agricultural practices, and vehicle emissions. In order to reduce air pollution's detrimental impacts on the environment and public health, specific policies and actions must be developed. India has long struggled with air pollution, but in recent years, there has been a concerning increase that has sparked worries both domestically and internationally. Air pollution is a serious public health concern since it is thought to cause over a million premature deaths in India each year, according to the Global Burden of Disease research. While dangerously high air quality levels frequently make headlines in big cities like Delhi, Mumbai, and Kolkata, growing pollution is also a problem in rural areas and smaller towns.

Sources of Air pollution are:

1) Fossil fuel combustion, construction, industrial pollutants, and vehicle emissions are the main causes of pollution in urban areas.
2) Particulate matter is produced as a result of tires and road wear and tear, which increases air pollution, particularly in cities.

3) The post-harvest burning of crop remains in states with high agricultural activity contributes significantly to atmospheric pollution.
4) Emissions of methane (CH4) from cattle in particular are a contributing factor to air pollution. Furthermore, methods used to manage animal faces may cause ammonia (NH3) to be released into the atmosphere.
5) Air pollution occurs both indoors and outdoors in rural areas where households frequently utilize biomass fuels for cooking and heating, such as wood and crop leftovers.

Impact of air pollution on public health

1) Being exposed to air pollutants such as particulate matter and ozone can cause respiratory disorders such as asthma, chronic obstructive pulmonary disease (COPD), and respiratory infections. Air pollution can lead to oxidative stress and inflammation in the body, it has been associated with a higher risk of heart attacks, strokes, and other cardiovascular problems.
2) Prolonged exposure to particular air pollutants, such as benzene and airborne particulate matter, has been associated to an increased risk of developing lung cancer in addition to other types of cancer. Negative neurological effects, such as cognitive decline and an elevated risk of neurodegenerative disorders like Parkinson's and Alzheimer's, have been associated with air pollution.
3) Babies who are delivered by moms who are pregnant and are exposed to air pollution are more likely to be born preterm or with low birth weights. Being exposed to pollution can also have a negative effect on a child's development and health over the long term. Air pollution exposure over an extended period of time can impair immunity, making a person more vulnerable to infections and diseases.
4) Comprehending these origins is essential for formulating focused strategies and initiatives to tackle the distinct obstacles encountered by various Indian states. The well-being of the population and the sustainable growth of the nation are seriously threatened by the significant increase in air pollution levels that India has experienced in recent years. The nation's air pollution levels are rising due to a combination of factors including fast industrialization, urbanization, car emissions, and farming practices.

The purpose of this study is to provide what is aimed to be a comprehensive examination of the rising levels of air pollution in India on a state level, with the primary emphasis being placed on particle matter (PM2.5). This study aims to determine the primary causes of pollution, evaluate the effects on the public health. The goal of this research is to offer light on the distinct issues that each state faces by exploring the complex dynamics of its industrial operations, transportation systems, agricultural practices, and urbanization levels. The potential value of this research to inform politicians, environmental experts, and concerned individuals makes it significant. We may create customized solutions and gain a deeper knowledge of the complexities of the issue by thoroughly examining the state-by-state growth rates of air pollution in India. Also, this study will add to the corpus of information already available on-air quality management. The data collection and analysis methods used, the state-by-state analysis results. Our goals are to deepen understanding of the problem, encourage wise decision-making, and spark group initiatives to create a cleaner, healthier environment for everybody through this thorough investigation.

2. LITERATURE REVIEW

This review discusses the trends of air quality in major states of North India, highlighting the sources of pollution and the challenges faced in mitigating air pollution. This study focuses on the impact of agricultural activities, particularly crop residue burning, on air quality in North India, providing insights into the seasonal variations and spatial distribution of pollutants. Examining the relationship between urbanization, meteorological factors, and air pollution, this study uses Delhi as a case study to explore the dynamics of pollution in rapidly urbanizing regions. Focusing on the health implications of air pollution, this study estimates the disease burden attributable to ambient air pollution in India, shedding light on the significant public health challenges. A review of size-segregated particulate matter and its impact on health in India's air pollution by: Manoj Kumar N. & More than any other nation, India has had severe air quality problems recently, with accompanying mortality. PM (particulate matter) is recognized as a significant health risk factor. However, size segregated PM data are also essential to comprehending the sources, deposition in the human respiratory tract, generation, size distribution, and health impacts of PM. This study provides a spatial and temporal analysis of air quality in South Indian cities, with a focus on emissions and pollution from coal-fired thermal power plants. An empirical study that spanned the months of May 2019 through February 2020 looked at the seasonal effects of air pollution on both urban and rural areas. Because of our findings, we were able to make a number of significant discoveries, some of which are as follows: the levels of AQI, PM2.5, and PM10 were greater in states like Uttar Pradesh, Punjab, and Haryana that are predominately agricultural. This study investigates the sources of particulate matter (PM10 and PM2.5) in the ambient air of Hyderabad, South India, providing insights into industrial contributions and pollution apportionment. Focusing on health impacts, this study, part of the Global Burden of Disease Study 2017, assesses the effects of air pollution on deaths, disease burden, and life expectancy in various states of India, including those in South India. While specific literature on air pollution in Northeast India may be limited compared to other regions, there are studies that discuss air quality in the broader context of India, which includes observations and data from North East India. The seasonal effects of air pollution on cities and rural states were the focus of an empirical study that ran from May 2019 to February 2020 and covered the period from May 2019 to February 2020. Our findings led us to make a number of important observations, including: AQI, PM2.5, and PM10 levels were higher in states like Uttar Pradesh, Punjab, and Haryana that are primarily agricultural. The capital of India is the most polluted city overall and has had many difficulties, which could lead to dangerously high pollution levels in the future. The typical AQI readings vary throughout different parts of the cities, including Delhi, where the AQI index value might fluctuate by more than 500 in some places. In the conclusion, a number of color-coding-based graphical and tabular representations are used to show the most recent effects of air pollution. These include variations in the Air Quality Index (AQI) from May 2019 to February 2020, seasonal variations in the AQI, and the effects of PM2.5 and PM10 in a variety of agrarian states and Indian cities. Air quality issues in various cities across India, including Northeast India. It covers sources, trends, and challenges in mitigating air pollution. This study assesses particulate matter levels in both urban and rural areas of Northeast India, offering a regional perspective on air quality issues.

3. OBJECTIVES

- To measure the annual and compound annual growth rates of particulate matter in air pollution in India from time period 2016-2021.
- To compare the growth rate of particulate matter in air in various states of India.
- To understand the minimum and maximum number of air pollution with regard to particulate matter in various states of India from time period 2016-2021.

4. METHODOLOGY, RESEARCH FINDINGS AND DATA SOURCE

4.1. METHODOLOGY

The data for the Air Quality Life Index is collected by the secondary method.

4.2. RESEARCH FINDINGS

The following techniques, which are listed below, have been used to comprehend the relationship between variables:

1) Rate of growth Year on Year (YOY)
2) Annual Compound Growth Rate
3) Characteristic Statistics (Mean, Variance Coefficient, Minimum and Maximum Values)

Year Over Year Growth Rate: In business, economics, and finance, the Year Over Year (YOY) growth rate—also known as the annual growth rate or yearly growth rate—is used to compare a metric or variable's performance over a 12-month period, typically from one year to the next. It is often expressed as a percentage and is calculated by comparing the metric's value at the end of the current year with that of the year before. The YOY growth rate can be calculated using the formula below:

YOY Growth= (Current Year Value - Previous Year Value) / Previous Year Value) * 100

The average yearly growth rate of an investment or a statistic over a given time period— typically more than a year—is found using the compound annual growth rate, or CAGR. Because it takes into account the compounding effect, which assumes that the investment or statistic is increasing or decreasing on a compounded basis, compared to simple yearly growth rate, it more properly represents growth. In simple terms, the compound annual growth rate, or CAGR, accounts for the possibility of uneven growth during the research period. The following formula can be used to determine the CAGR:

CAGR = (end value / starting value) ^ (1 / The Total Number of Years) – 1

The term "mean" describes a central tendency metric that is utilized to determine the mean or typical value within a particular dataset. The type of mean that is utilized most frequently is known as the arithmetic mean. To determine it, divide the result by the total number of values in the dataset. This gives you the average.

Formula: Arithmetic mean.

Mean = (Total number of values / Sum of all values)

It can be expressed mathematically as follows:

$$\text{Mean} = \Sigma x / N$$

- Σx is the total of all values in the dataset is represented by.
- The total number of values contained in the dataset is denoted by "N.".

A statistical tool called the coefficient of variation (CV) can be used to express the relative variability or risk of a set of data points in relation to the data's mean, or average. In the fields of finance, economics, and statistics, it is customary to compare the risk or volatility of different investments or data series. This is particularly true when different units or scales of measurement are used in the data sets. The coefficient of variation can be obtained using the formula below:

CV= (Mean / Standard Deviation) * 100

However,

- The variability or spread among the data points is quantified by the standard deviation.
- Greater variability is indicated by a bigger standard deviation.
- The average of the data points is called the mean.

4.3. DATA SOURCE

The research was conducted using time-series data from the years 2016 to 2021 for each of India's states (with the exception of the Union Territories) that were obtained from the Air Quality Life Index (AQLI) website.

5. ANALYSIS OF RESULTS AND DISCUSSION

Table 1

Table 1 Year Over Year Growth Rate of Pm in Air in Different States of India

State/year	Andhra Pradesh	Arunachal Pradesh	Assam	Bihar	Chhattisgarh	Goa	Gujarat	Haryana	Himachal Pradesh
2016									
2017	7.550	-0.860	4.716	8.282	-2.922	1.914	10.376	-2.505	-17.745
2018	-3.038	5.798	11.027	4.029	-0.241	8.312	-7.931	1.856	0.415
2019	-5.606	-1.518	-8.137	5.645	4.396	21.665	14.649	7.357	-6.220
2020	3.537	-7.264	1.873	0.935	8.112	15.162	-0.544	-7.175	4.733
2021	7.020	12.007	6.758	1.647	3.002	6.951	0.997	10.929	6.827

Source Authors Calculation

State/year	J & K	Jharkhand	Karnataka	Kerala	Madhya Pradesh	Maharashtra	Manipur	Meghalaya	Mizoram
2016									
2017	30.044	-6.718	8.821	-5.447	1.962	3.426	-3.684	2.949	-12.361

2018	-9.058	-3.359	-1.54	11.856	-3.192	-2.071	15.157	15.648	14.397
2019	2.076	9.633	-12.494	31.592	11.908	-0.134	-13.071	-10.611	-7.418
2020	-1.533	5.633	9.650	9.404	-1.576	5.858	5.244	1.416	2.365
2021	12.099	2.359	5.473	7.258	2.888	5.939	6.388	6.299	13.008

Source Authors Calculation

State/year	Nagaland	Odisha	Punjab	Rajasthan	Sikkim	Tamil Nadu	Telangana	Tripura	Uttar Pradesh	Uttara khand	West bengal
2016											
2017	1.228	-1.463	14.129	-2.987	4.493	0.774	3.649	12.040	-6.541	14.337	-4.867
2018	8.084	0.880	2.073	-1.226	3.544	0.629	-1.201	24.118	-1.240	4.206	8.015
2019	-4.133	1.384	-0.685	14.884	-8.102	10.771	-1.216	17.833	8.097	-7.473	10.385
2020	-0.075	5.706	2.030	-5.127	8.719	-0.702	1.634	4.702	-4.565	2.337	12.714
2021	8.252	5.339	6.788	3.311	-6.465	9.210	10.193	4.264	5.754	10.920	-2.330

Source Authors Calculation

Table 2

Table 2 CAGR of Different States in India from 2016-2021

State	CAGR
Andhra Pradesh	0.206
Arunachal Pradesh	0.069
Assam	0.333
Bihar	0.014
Chhattisgarh	0.403
Goa	0.257
Gujarat	0.369
Haryana	0.215
Himachal Pradesh	0.429
Jammu & Kashmir	0.421
Jharkhand	0.317
Karnataka	0.214
Kerala	0.106
Madhya Pradesh	0.359
Maharashtra	0.319
Manipur	0.258
Meghalaya	0.34
Mizoram	0.299
Nagaland	0.248
Odisha	0.327
Punjab	0.116
Rajasthan	0.322
Sikkim	0.042
Tamil Nadu	-0.415
Telangana	0.302
Tripura	0.340
Uttar Pradesh	0.138
Uttarakhand	0.006
West Bengal	0.212

Source Authors Calculation

An analysis of the YOY growth rate of particulate matter in air for each state in India revealed a number of trends and patterns. Uttar Pradesh is the state with the highest rate of pm, with 5.754 in 2021. This indicates a noticeable rise in the air pollution in this state. Next in the list is Haryana with, 10.929 in 2021. Followed by Bihar with, 0.935 in 2020. Arunachal Pradesh has the lowest rate of pm, with 14.73 in 2020. And then comes Kerala with, 15.51 in 2019.

According to Table 2, Chhattisgarh ranked third with a CAGR of 0.403, followed by Jammu & Kashmir in second place with a CAGR of 0.421. With a CAGR of 0.429, Himachal Pradesh has the highest. These states in India have the highest positive CAGR values when compared to the rest, indicating a significantly higher rate of increase in particulate matter in the air. The states with the lowest CAGR values are Tamil Nadu and Uttarakhand, at -0.412 and 0.006, respectively, and Bihar, at 0.014. These results show that both of these states are experiencing a decrease in the rates at which particulate matter is growing. This implies that the rate of increase of particulate matter in these states has decreased. When we compare the CAGR figures for India's different regions, we get the results as mentioned.

Table 3

Table 3 Descriptive Statistics of PM in Air in Different States of India (2016-2021)

States	Mean	Coefficient of Variation	Minimum No. of Pm recorded/Year	Maximum No. of Pm recorded/Year
Andhra Pradesh	29.786	0.043	28. 36	31.62
Arunachal Pradesh	15.61	0.046	14.73	16.74
Assam	32.335	0.067	29.29	34.92
Bihar	84.371	0.040	78.6	87.62
Chhattisgarh	57.453	0.068	53.93	63.29
Goa	26.273	0.083	22.94	29.06
Gujarat	34.465	0.084	30.49	37.1
Haryana	82.42	0.056	78.22	90.12
Himachal Pradesh	29.623	0.078	27.17	33.84
Jammu & Kashmir	34.658	0.143	31.13	44.15
Jharkhand	58.758	0.070	53.28	63.99
Karnataka	27.235	0.058	24.81	29.05
Kerala	18.076	0.092	15.51	20.41
Madhya Pradesh	48.805	0.062	45.42	52.27
Maharashtra	38.37	0.052	36.64	41.92
Manipur	31.326	0.069	28.77	33.91
Meghalaya	32.926	0.078	29.61	36.17
Mizoram	34.703	0.082	30.74	39.36
Nagaland	26.511	0.053	24.93	28.72
Odisha	43.598	0.054	41.67	47.76
Punjab	66.671	0.054	63.27	72.21
Rajasthan	51.255	0.069	47.29	55.56
Sikkim	40.201	0.039	38.47	42.32
Tamil Nadu	27.476	0.049	25.63	28.59

Telangana	34.676	0.05	33.27	38.16
Tripura	63.648	0.093	54.9	72.35
Uttar Pradesh	90.073	0.04	85.46	94.36
Uttarakhand	40.45	0.067	37.6	44.26
West Bengal	62.203	0.054	57.87	66.3

Source Authors Calculation

The above table shows that Uttar Pradesh has the highest average of pm growth in India, which is 90.07333333, while Arunachal Pradesh has the lowest pm growth which is 15.61. According to the findings from the coefficient of variation, Jammu & Kashmir has the highest variability in pm growth rates at 0.143342709, while Sikkim has the lowest variability at 0.039478857. Over time, areas with lower coefficients of variation exhibit more stable PM growth rates, while regions with higher coefficients of variation show more fluctuations in PM growth rates. Additionally, it is noted that Haryana, with 90.12 pm growth in 2021, trails Uttar Pradesh, which records 94.36 pm growth. In 2020, Bihar recorded the highest PM growth rate of 87.62.

6. CONCLUSION AND RECOMMENDATIONS

The statistical analysis shows several relevant trends and patterns connected to PM growth rates in different Indian states and regions, in addition to the Year-over-Year (YOY) growth rates of particulate matter in air. The highest executing states are Himachal Pradesh and Jammu & Kashmir, with CAGRs of 0.429 and 0.421, respectively. With the greatest pm growth rate in 2021, Haryana appeared to be experiencing a significant increase. Assam, Meghalaya, and Chhattisgarh all have noteworthy CAGR values of 0.340, 0.333, and 0.403, respectively. States with lower CAGR values—0.006, 0.014, and 0.042, respectively—include Uttarakhand, Bihar, and Sikkim. States such as Tamil Nadu, Madhya Pradesh, Kerala, Jammu & Kashmir, and Maharashtra show concerning trends with respect to PM growth rates.. Effective air quality management in these regions requires an understanding of the contributing factors. Positive trends are evident in certain states, such as Karnataka, Odisha, Punjab, Telangana, and West Bengal, where PM growth rates are stable and lower. Finding the strategies that work in these areas can act as a template for other states. In a few states, the growth rates for 2021 appear to be higher. There could be a multitude of reasons for this, including the pandemic's aftermath, changes in the economy, or specific local occurrences that affect the quality of the air. The findings highlight the importance of state-level policy for managing air quality and the need for customization. To address the unique challenges in each region, cooperation between governmental entities, environmental agencies, businesses, and the general public is imperative. For thorough planning, long-term trends in air quality should be taken into account. Adoption of renewable energy sources, sustainable practices, and strict pollution control measures can all help to improve air quality over time. To sum up, the study of PM growth rates across various Indian states points out the intricate and ever-changing landscape of air quality concerns. Personalized, area-specific approaches, coupled with ongoing surveillance and cooperative endeavors, are indispensable for efficient control of air quality and public health.

CONFLICT OF INTERESTS

None.

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