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Study of Ambient Air Quality Trends and Analysis of Contributing Factors In Faridabad, India

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ABSTRACT
This research examines the changes in air quality that have occurred during a predetermined time period in Faridabad, which is an industrial city located in the state of Haryana in India. The purpose of this study is to determine the natural and man-made elements that are at play, as well as to identify the primary pollutants and observe how they fluctuate with the changing of the seasons. There has been a significant increase in the amount of air pollution in Faridabad as a result of the city's rapid urbanisation, increasing vehicle density, and industrial expansion. This has put both human health and the environment in potential risk. Utilizing secondary data gathered from the Central Pollution Control Board (CPCB) and the Haryana State Pollution Control Board (HSPCB), the study focusses on a number of significant air pollutants, including particulate matter (PM) and particulate matter (PM) in particular, as well as NO, SO, CO, and O. Statistical techniques such as seasonal decomposition, correlation matrices, and trend analysis were used in order to uncover patterns and establish connections between the sources of pollutants and the levels of pollutants. During the winter and post-monsoon seasons, the data demonstrate that particulate matter, namely PM1 and PM2, is consistently greater than the permissible limits. This is especially true for PM1 and PM2. The emissions from automobiles, dust from roads and building sites, and the burning of agricultural waste in adjacent regions are the primary contributors to this environmental problem. The impacts of temperature, relative humidity, wind speed, and other meteorological factors on the spread of pollution are also included in the study that is being conducted. According to the research, the urgently required integrated air quality management strategies include the implementation of more stringent pollution control requirements, the adoption of cleaner fuels, the promotion of public transit, and the construction of green infrastructure. These kinds of insights ought to be of use to the politicians, environmentalists, and urban planners of Faridabad in their efforts to lessen the city's air pollution and ensure that it expands in a sustainable manner.
Keywords: Ambient Air Quality, Faridabad, Particulate Matter ($PM_{2.5}$, PM_{10}), Air Pollution. Seasonal Variation.

1. INTRODUCTION

Over the course of the last several decades, Faridabad, which is considered to be one of the most important industrial cities in India's National Capital Region (NCR), has had a rapid urbanisation and industrial boom. Although it has been beneficial to the economy, this growth has resulted in significant environmental issues, the most notable of which is a rise in the number of pollutants in the air. As a result of the increased number of companies, automobiles, and construction sites in the region, the issue of air pollution has grown increasingly widespread. According to a number of studies conducted by the Central Pollution Control Board (CPCB), Faridabad is considered one of the most polluted cities in India during the winter months, which is the time of year when air pollution is at its highest pollution levels. The quality of the air in urban areas is influenced by the interaction between human activity and meteorological conditions. Ground-level ozone (O2), nitrogen dioxide (NO2), sulphur dioxide (SO2), particulate matter (PM2.5 and PM10), carbon monoxide (CO), and nitrogen dioxide (NO2) are the primary pollutants that need to be considered seriously. Those who are young, those who are elderly, and those who have respiratory problems that do not yet exist are the ones who are most at risk from these toxins. In the city of Faridabad, the National Ambient Air Quality Standards (NAAQS) have been routinely surpassed, with PM2.5 and PM10 levels that have been consistently high the whole time. For the purpose of comprehending the dynamics and long-term effects of this, it is necessary to conduct a comprehensive analysis of the changes in air quality.

A number of weather conditions, such as wind speed, temperature, and relative humidity, as well as variations in the seasons, all play a part in the distribution and concentration of pollutants. The winter months are characterised by higher levels of pollutants due to the presence of temperature inversion and feeble winds, both of which trap contaminants close to the ground. As a consequence of precipitation washing away particles that are airborne, the quality of the air has a tendency to improve during the monsoon seasons. Therefore, in order to effectively manage the air pollution in Faridabad, it is essential to do research on the seasonal impacts that these factors have on the quality of the air in the surrounding environment. As a result of its proximity to Delhi and the rest of the National Capital Region (NCR), Faridabad is also susceptible to the effects of transboundary pollution. The burning of stubble in Punjab and Haryana, two states that are immediately next to one another, takes place throughout the months of October and November, which is one of the reasons why PM2.5 levels tend to increase during the fall season. When the pollution from adjacent sources, such as industrial pollutants, automobile exhausts, and road dust, is added to the existing pollution, the quantity of pollution gets exponentially worse. It is required to undertake thorough geographical and chronological investigations of these connected events in order to identify the primary causes and give particular remedies. This is necessary in order to provide specific solutions. Over the course of the past few years, numerous governmental and non-governmental organisations have implemented a variety of monitoring and control mechanisms. Some examples of these mechanisms include the Graded Response Action Plan (GRAP), more stringent vehicle emission standards (BS-VI), and the promotion of cleaner fuels and technology. Nevertheless, in order to evaluate the effectiveness of these therapies, trend analysis and empirical data are required. The use of long-term data analysis is beneficial in determining whether or not these approaches are effective and whether or not more action is required.

As a result, the objective of this study is to examine the patterns that have emerged in the ambient air quality of Faridabad over the course of the last several years and to determine, via the use of graphs and statistics, what has been occurring with it. This study will make use of secondary data that has been gathered by a variety of environmental monitoring agencies, including pollution control boards and meteorological departments, among others. This project intends to educate stakeholders, policymakers, and the general public on the primary sources of pollution and how it varies over time in order to create a city environment in Faridabad that is both healthier and more ecologically friendly via the implementation of this project.

2. OBJECTIVE

1. To Identify seasonal and yearly variations in ambient air quality metrics ($PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and O_3) in Faridabad throughout recent years.
2. To examine how automotive emissions, industrial operations, construction projects, and weather variables impact regional air pollution.

3. METHODOLOGY

Monitoring of the ambient air pressure was carried out throughout the summer of 2022, namely from March to June. During every eight-hour period, samples of PM10, PM2.5, SOx, and NO2 were taken. APM-460 respirable dust samplers (RDS) with the potential for gaseous sampling were used in order to ascertain the levels of PM10, PM2.5, NO2, and SOx that were present in the surrounding air. These instruments were manufactured by Envirotech in New Delhi. The sample input was positioned anywhere from one to three meters above ground level, depending on the amount of space that was available for the RDS that was accessible. A cyclone and a glass fibre filter (GFF) sheet measuring 20 by 25 centimetres were used to extract air from the atmosphere via a flow rate that ranged from 1.0 to 1.2 meters per minute for about eight hours. This allowed for the determination of the average flow rate. As part of this study, an attempt was made to ascertain the average concentration of particulate matter (PM10), particulate matter (PM2.5), sulphur oxides (SOx), and nitrogen dioxide (NO2) in the emerging metropolitan regions of Haryana (CPCB: 2003). The processes mentioned in the CPCB report are used in conjunction with Microsoft Excel in order to calculate the Air Quality Index (AQI). On the basis of the Exceedance factor, the levels of pollution are classified as either critical, high, moderate, or low. In order to determine the exceedance factor, the following formula should be utilised:

$$\text{Exceedance Factor} = \frac{\text{The annual average concentration of critical pollutant}}{\text{The annual standard for a particular pollutant}}$$

Table 1: Showing station code and station name

Station Code	Station Name
S1	Manesar
S2	Faridabad
S3	Panipat
S4	Bawal
S5	Hisar
S6	Sonipat

4. RESULTS

Six different stations were selected for the goal of monitoring and evaluating data on the quality of the air in the surrounding environment throughout the summer season, which lasted from March to June of 2022. After eight hours, samples were taken from each of the parameters. At S5, the PM 2.5 concentration was measured to be 53.42 µg/m3, whereas at S2, it reached a maximum of 71.39 µg/m3. This information is shown in Table 3, Figure 2. S5 had a concentration of 53.42 µg/m3, which was the lowest possible value. Every single one of the average PM2.5 values, with the exception of S3, was higher than the standard limit (Table-2). According to table-4 and figure-3, the PM10 concentration varied between 151.33 and 189.41 µg/m3, with the highest concentration being 189.41 µg/m3 at S6 and the lowest concentration being 151.33 µg/m3 at S3. In every single site, the average concentration of PM10 was higher than the level that is considered to be acceptable (Table-2).

The SOx concentration varied between 35.72 and 46.25µg/m3 (as shown in Table-5 and Figure4), with the highest concentration being 46.25µg/m3 at S3 and the lowest concentration being 35.72µg/m3 at S1. An average SOx concentration that was determined to be within the standard limit was discovered to be present at each and every site (Table-2). When comparing the NO2 level of S6 and S5, S6 had the greatest at 75.98µg/m3, whereas S5 had the lowest at 70.55µg/m3. The content of nitrogen dioxide (NO2) was found to vary from 70.55 to 75.98µg/m3, as shown by table 6 and figure 5. It was determined that the average PM10 values at each of the sites was within the permissible limit (Table-2).

Table 2: National Ambient Air Quality Standard (2009)

S.NO.	Name of Pollutant	Time weighted average	Concentration in ambient air	
			Industrial, residential, Rural & other Area	Ecologically sensitive area (notified by central government
1	SOx (µg/m3)	Annual	50	20
		24 hours	80	80
2	NO2 (µg/m3)	Annual	40	30
		24 hours	80	80
3	PM10 (µg/m3)	Annual	60	60
		24 hours	100	100
4	PM2.5(µg/m3)	Annual	40	40
		24 hours	60	60

Source: CPCB, 2009

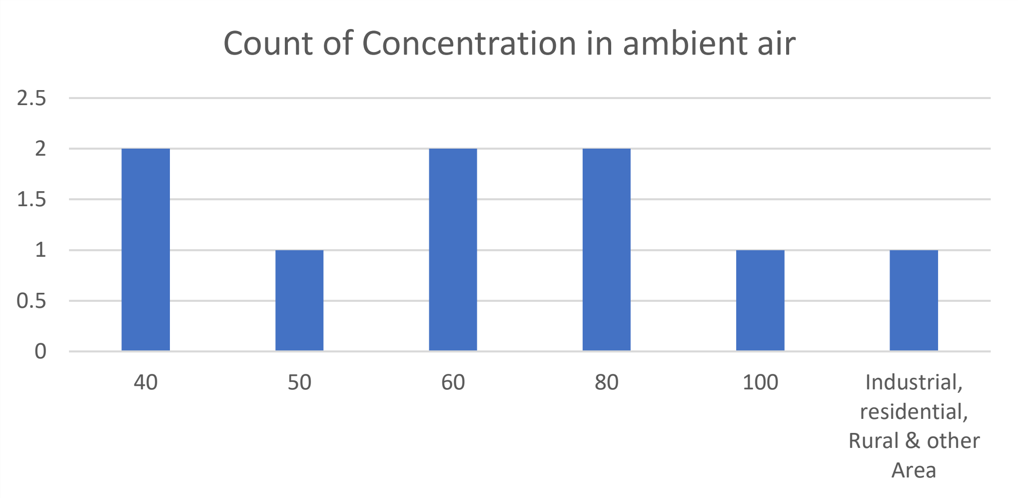


Table 3: Monthly Average Concentration of PM2.5

Month	S1	S2	S3	S4	S5	S6
March	46.59	68.77	44.8	61.96	58.06	66.96
April	54.11	70.82	52.68	69.88	59.08	67.01
May	67.29	72.51	56.89	74.9	60.91	70.34
June	72.86	73.45	59.32	77.62	62.58	71.08
Mean	60.21	71.39	53.42	71.09	60.16	68.85
±SD	12.01	2.06	6.37	6.88	2.00	2.17
Max	72.86	73.45	59.32	77.62	62.58	71.08
Min	46.59	68.77	44.8	61.96	58.06	66.96

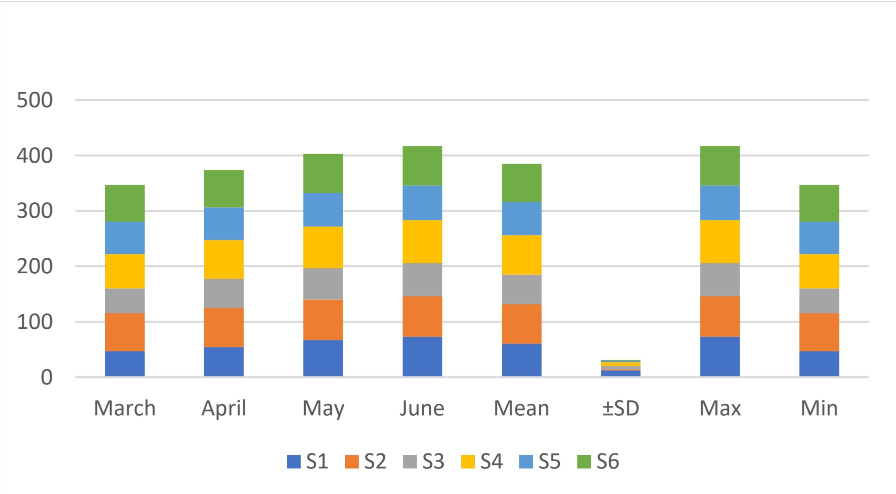


Table 4: Monthly Average Concentration of PM10

Month	S1	S2	S3	S4	S5	S6
March	110.41	153.18	123.27	149.65	142.61	174.31
April	149.95	155.93	158.99	153.98	153.98	189.67
May	188.49	159.87	155.63	163.38	163.38	194.89
June	195.05	164.88	167.43	171.63	169.75	198.78
Mean	160.98	158.47	151.33	159.66	157.43	189.41
±SD	39.14	5.08	19.35	9.82	11.81	10.74
Max	195.05	164.88	167.43	171.63	169.75	198.78
Min	110.41	153.18	123.27	149.65	142.61	174.31

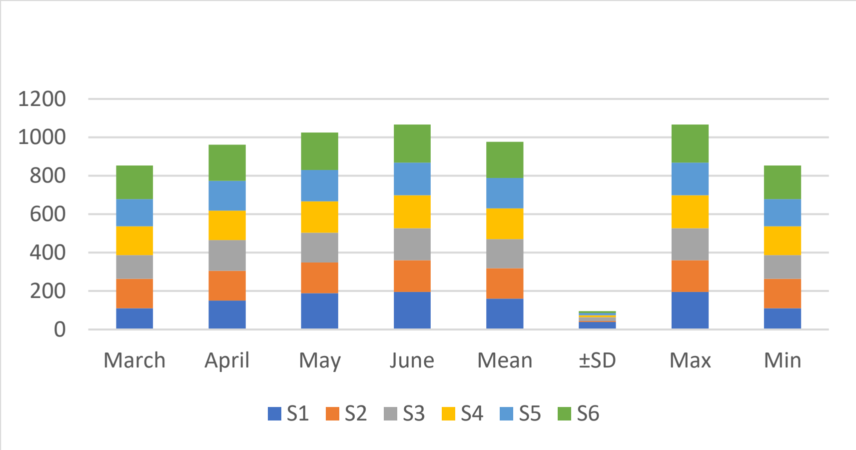


Table 5: Monthly Average Concentration of SOx

Month	S1	S2	S3	S4	S5	S6
March	26.25	39.67	36.98	38.51	31.83	38.9
April	32.78	41.32	48.98	41.94	35.48	33.51
May	40.01	43.44	49.18	44.96	41.13	42.96
June	43.85	44.79	49.86	45.84	43.03	44.74
Mean	35.72	42.31	46.25	42.81	37.87	40.03
±SD	7.81	2.26	6.19	3.32	5.15	4.99
Max	43.85	44.79	49.86	45.84	43.03	44.74
Min	26.25	39.67	36.98	38.51	31.83	38.9

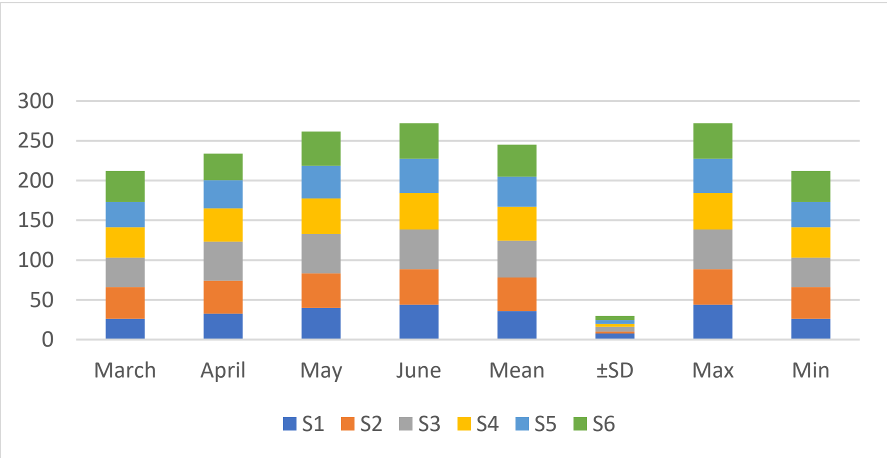
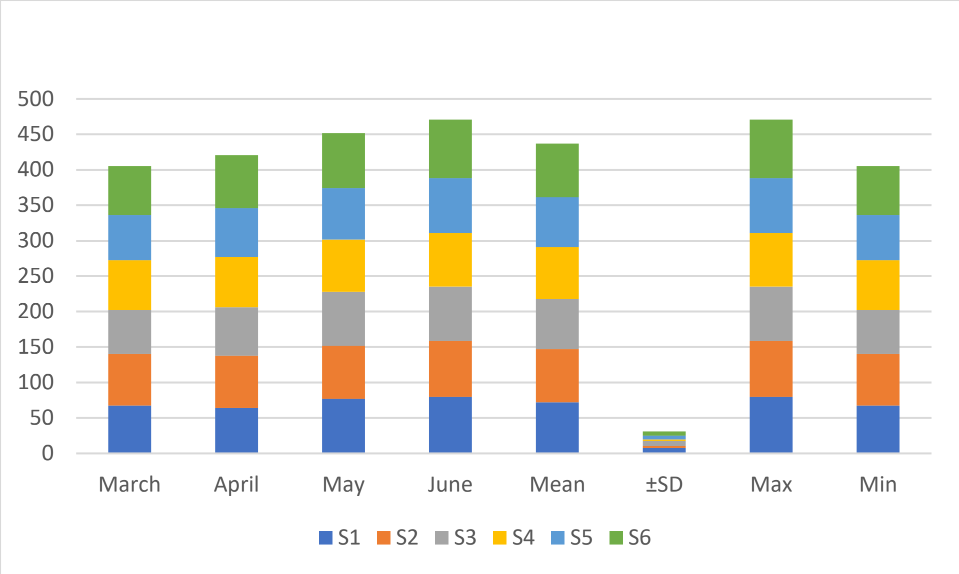


Table 6 Monthly Average Concentration of NO2

Month	S1	S2	S3	S4	S5	S6
March	67.38	72.66	61.83	70.38	64.01	69.11
April	63.83	73.83	68.28	71.41	68.34	74.88
May	76.93	75.05	75.91	73.62	72.66	77.61
June	79.86	78.66	76.82	75.81	77.18	82.3
Mean	72.00	75.05	70.71	72.81	70.55	75.98
±SD	7.62	2.60	7.05	2.42	5.66	5.51
Max	79.86	78.66	76.82	75.81	77.18	82.3
Min	67.38	72.66	61.83	70.38	64.01	69.11



DISCUSSION

A pattern of persistently high levels of pollutants such as PM2.5, PM10, NO2 and SO2 is indicated by the evaluation of ambient air quality data in Faridabad, particularly during the winter months. This trend is notably noticeable during the season of winter. The concentrations of particulate matter are found to significantly increase when wind speeds are low, when temperatures invert, and when there is an increase in the burning of biomass, which is impacted by seasonal fluctuation. Furthermore, the findings indicate that industrial zones continuously have a worse air quality compared to residential or commercial districts, and that urbanisation and car emissions play a substantial influence in the seasonal increase in air pollution. The rapid rise of Faridabad's industrial sector, notably in the areas of metallurgy, manufacturing, and construction, is one of the primary factors that has contributed to this phenomenon. A significant quantity of particulate matter and gaseous pollutants are released into the atmosphere as a result of these activities. Because pollution from across international boundaries has a significant influence on the air quality in Faridabad, the fact that Faridabad is located in such close proximity to Delhi, which is another city that is infamous for its high levels of pollution, makes the situation much more dire. Additionally, the usage of diesel generators during power outages and the absence of efficient public transportation are also factors that contribute to the amplification of emissions from fossil fuels. The ever-increasing number of vehicles has become a significant contributor to air pollution due to the practice of driving outdated automobiles and the lack of maintenance that is performed on them. Inadequate urban planning, the disappearance of green buffers, and the encroachment on natural water bodies and green zones all contribute to a further reduction in the city's capacity to absorb pollutants in a natural manner. In order to lessen the amount of pollution in the air and protect the health of the general people in Faridabad, our findings show the vital need for investments in environmentally friendly infrastructure, stricter legislation regarding emission limits, and integrated urban planning.

CONCLUSION

It was found that the levels of SOx and NO2 were within the allowed limits set by the NAAQS; nevertheless, the findings of this study indicate that the levels of particle pollutants, namely PM2.5 and PM10, are typically greater than the limits at each of the stations. It was established that the average air quality index (AQI) ranged from 134.25 to 159.75. According to the Air Quality Index (AQI), the air quality at each and every station is considered to be moderate. It was discovered that the PM2.5 exceedance factor was at a high level of pollution at S1, S2, S4, S5, and S6, while it was at a moderate level at S3. This was the case during the S3 level. In addition, the critical pollution level is shown by the exceedance factor of PM10 for each and every station. In the majority of sites, the levels of SOx and NO2 that exceeded the acceptable threshold were in the moderate range.

Statements and Declarations

Ethical Approval

"The submitted work is original and not have been published elsewhere in any form or language (partially or in full), unless the new work concerns an expansion of previous work."

Consent to Participate

"Informed consent was obtained from all individual participants included in the study."

Consent to Publish

"The authors affirm that human research participants provided informed consent for publication of the research study to the journal."

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Competing Interests

"The authors have no relevant financial or non-financial interests to disclose."

Availability of data and materials

"The authors confirm that the data supporting the findings of this study are available within the article."

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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