

International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452

NAAS Rating (2025): 4.49

Maths 2026; 11(5): 122-126

© 2026 Stats & Maths

<https://www.mathsjournal.com>

Received: 13-03-2026

Accepted: 15-04-2026

Dr. Keerthi Astagimath

Associate Professor, Karnatak
Science College, Dharwad,
Karnataka, India

Statistical analysis of ambient air pollution in selected areas of Bengaluru city

Keerthi Astagimath

DOI: <https://www.doi.org/10.22271/math.2026.v11.i5b.2324>

Abstract

Air pollutants such as PM_{10} and $PM_{2.5}$, pose severe health threats due to their ability to penetrate the respiratory system, while SO_2 and NO_2 contribute to secondary pollutant formation, smog, and respiratory irritation. CO affects oxygen transport in the bloodstream, leading to acute and chronic health issues.

Air pollution has become a critical environmental challenge facing industrial and urban regions in India. Bangalore, one of the country's major metropolitan cities, has experienced rapid industrial growth, urban expansion, and increased vehicular activity, all contributing to deterioration in ambient air quality. The study selects three air pollutant stations of Bangalore city namely City Railway Station, Majestic, H.S.R Layout, Near Central Silk board, NTTF, Peenya Industrial Area which are highly polluted as compared to other stations due to industrial activities and heavy traffic emissions significantly impact local air quality, particularly concentrations of particulate matter and gaseous pollutants.

The data for the study is collected from KARNATAKA STATE POLLUTION CONTROL BOARD Bengaluru for different pollutants like PM_{10} , $PM_{2.5}$, SO_2 , NO_2 and CO for the period for three months from 1st August 2025 to 31st October 2025. The whole data is categorised into three categories, low pollution, moderate pollution and high pollution using percentiles. The tools used for the study are Diagrammatic and Graphical representation, Descriptive and comparative statistics.

The analysis of the study shows level of air pollution shows on an average PM_{10} is highest in Silk board followed by this next highest is Majestic and the least value in Peenya area, the value of NO_2 is highest in Majestic area and other two pollutants are similar in all the three areas. On an overage all the pollutants are below the standard value. There is positive relation between the different pollutants in all regions except NO_2 and SO_2 of Majestic region.

Keywords: Air pollution, particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide

Introduction

Air pollution is one of the major concerns in environment effecting public health in the world. Increasing urbanization, growth in industry, increasing vehicles and heavy use in consumption of energy have decreased the ambient air quality in almost all countries. It is also a major issue in India especially in metro cities.

The accumulation of certain unwanted substances in air which effects man and the surrounding environment is called air pollution. Substances such as particulate matter ($PM_{2.5}$ to PM_{10}) which are considered to be most harmful due to their ability to harm the respiratory system. These are formed due to smoke, dust, fumes etc. Apart from these gaseous pollutants such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO) are also present which are formed due to burning of fuel such as through emissions from vehicles and emissions from industries. High concentrations of these pollutants can lead to diseases of respiratory system.

Most of these substances are naturally present in air in low concentrations and are considered to be harmless (Rao, 1996). But heavy concentrations of these pollutants harm the quality of environment. The Central Pollution Control Board (CPCB) (2009) ^[1] has prescribed some limits to these pollutants by the National Ambient Air Quality Standards (NAAQS). If the

Corresponding Author:

Dr. Keerthi Astagimath

Associate Professor, Karnatak
Science College, Dharwad,
Karnataka, India

concentrations exceed these limits then the air is harmful. Also, the World Health Organization (2024) ^[2] states that exposure to ambient air pollutants contributes to serious respiratory diseases, cardiovascular illness and death, premature mortality, cancers and asthma.

Indian metropolitan cities such as Delhi, Mumbai, Chennai, Hyderabad, Kolkata etc are facing major challenges with high increase in air pollution over the past few years. Among them, Bengaluru known as “Silicon Valley of India”, is witnessing a heavy growth in population, expansion in industry and a heavy increase in vehicles.

Few studies have been made on the ambient air pollution in India and also in some areas of Bengaluru. Sangeetha MD, *et al* 2024 ^[3] have evaluated the average concentrations of particulate matter (PM₁₀, PM_{2.5}), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), and carbon monoxide (CO) in four distinct areas of Bengaluru in a year. Dr. Praseeda E, *et al* ^[6] have assessed the Air Quality in Bangalore Before, During & after Covid-19 Lockdown. Ganesh Babu Kn, *et al* 2025 ^[4] have determined Ambient Air Quality in Peenya Industrial Area of the Bangalore City, India. Shobitha Sunil, *et al* have analysed Air Quality in Bengaluru city. However limited work has been done on the trend of these pollutants in different areas within Bengaluru and their deviation from the prescribed standards and also the interrelationship among the air pollutants.

The present study aims to bridge this gap by conducting a comprehensive statistical analysis of key air pollutants PM₁₀, PM_{2.5}, SO₂, NO₂, and CO across selected locations in Bangalore city. The study tries to analyse the deviation from the standard limits, the trend analysis and correlation among the pollutants.

Objectives of the Study

1. To study the deviation of major air pollutant concentrations from National Ambient Air Quality Standards (NAAQS).
2. To examine the relationship between different air pollutants.
3. To analyze the temporal trends of air pollutant concentrations in selected areas of Bangalore city.

2. Materials and Methods (Methodology)

2.1 Study area and Data Collection

Our study selects the three air pollutant stations of Bangalore city namely which differ in their urban activity.

1. City Railway Station, Majestic- which is characterised by heavy vehicular activities, dense population and having a major transportation activity.
2. H.S.R Layout, Near Central Silkboard- which is a well planned locality and residential layout.
3. NTTF, Peenya Industrial Area-which is an industrial area surrounded by a number of manufacturing and engineering firms.

Air quality in these areas is prone to be affected by the concentrations of particulate matter and gaseous pollutants.

The analysis of air pollution levels around these heterogeneous areas may provide information regarding variability of these pollutants. It will also give an insight into the interrelations among the air pollutants and the sources of their emission.

The data for the study is collected from KARNATAKA STATE POLLUTION CONTROL BOARD Bengaluru for different pollutants like concentrations of particulate matter PM₁₀, PM_{2.5}, Sulfur dioxide SO₂, nitrogen dioxide NO₂ and carbon monoxide CO for the period for three months from 1st August 2025 to 31st October 2025.

2.2 Standards for Comparison

The observed pollutant concentrations were compared with the National Ambient Air Quality Standards (NAAQS) prescribed by the Central Pollution Control Board (CPCB) ^[1].

Units of measurement for each pollutant

- PM₁₀, PM_{2.5}, SO₂, NO₂ → µg/m³
- CO → mg/m³

An increased industrial activity, urbanization and an increased growth of vehicles in India have reduced the ambient air quality in almost all the urban and industrial regions. Also, there is scientific evidence which shows that exposure to air pollutants such as particulate matter, sulfur dioxide, nitrogen dioxide, and carbon monoxide adversely effects health. People face respiratory illness, cardiovascular illness, premature mortality and cancers. In order to protect public health and environment air quality standards have been set up. The National Ambient Air Quality Standards (NAAQS) which was set up by the Central Pollution Control Board (CPCB) in 2009 ^[1] were prescribed to safeguard human health and ensure clear environment. These permissible concentration limits for major air pollutants were set up based on international guidelines and national air quality monitoring data.

Following are the standard level of Air pollutants

Pollutant	Standard
PM ₁₀	100 µg/m ³ (24-hr)
PM _{2.5}	60 µg/m ³ (24-hr)
SO ₂	80 µg/m ³
NO ₂	80 µg/m ³
CO	2 mg/m ³ (8-hr)

2.3 Descriptive Statistics

Basic descriptive statistics such as mean, standard deviation, minimum, and maximum values and coefficient of variation were computed to understand the distribution and variability of air pollutant concentrations. Correlation Analysis was also done to study the relationship between air pollutants; Pearson's correlation coefficient was used. The analysis was done using SPSS.

3. Results and Discussion

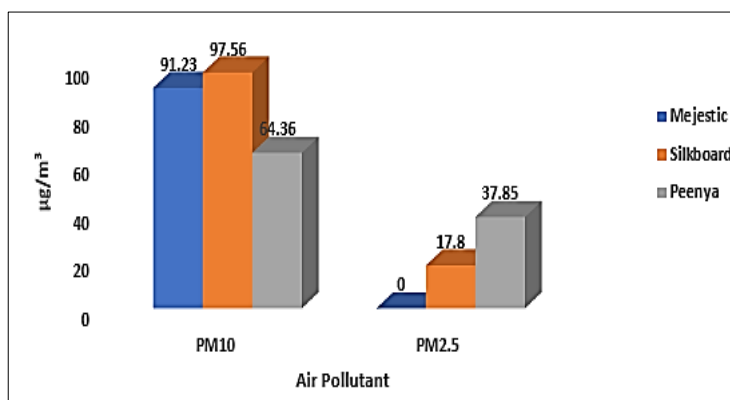
This section presents and discusses the results of the statistical analysis of air pollutant concentrations across the selected locations in Bangalore city, in line with the stated objectives of the study. The analysis focuses on deviation from prescribed standards, trend analysis, average distribution of air pollutants across the three stations from August 2025 to October 2025, interrelationships among pollutants.

3.1 Trend Analysis

The average distribution of all the pollutants across the three stations from August 2025 to October 2025 was studied and analysed. A multiple bar diagram was prepared using excel.

Table 1: The average distribution of particulate matter PM₁₀ and PM_{2.5} across the three stations from August 2025 to October 2025

Air Pollutant	City Railway Station, Majestic	H.S.R Layout, Near Central Silkboard	NTTF, Peenya Industrial Area
PM ₁₀	91.23	97.56	64.36
PM _{2.5}	-	17.8	37.85

**Fig 1:** The average distribution of particulate matter PM₁₀ and PM_{2.5} across the three stations from August 2025 to October 2025

PM₁₀ concentrations were highest at H.S.R Layout, Near Central Silkboard, followed by City Railway Station, Majestic, and lowest at NTTF, Peenya Industrial Area, and the concentration of PM_{2.5} is not available for City Railway Station, Majestic. It was higher at NTTF, Peenya Industrial Area than at H.S.R Layout, Near Central Silkboard. Since H.S.R Layout, Near Central Silkboard is residential area, the concentration of PM₁₀ may be highest due to more vehicular emission, road dust and due to construction and demolition.

In City Railway Station, Majestic which is a major transportation area the concentration is a little lesser than at H.S.R Layout, Near Central Silkboard and it may be due to heavy vehicle emissions.

In contrast, the concentration of PM₁₀ is relatively less in NTTF, Peenya Industrial Area which shows that relatively there is less industrial emission. This shows that there may be regulated industrial emissions and relatively less vehicular activity during the study period.

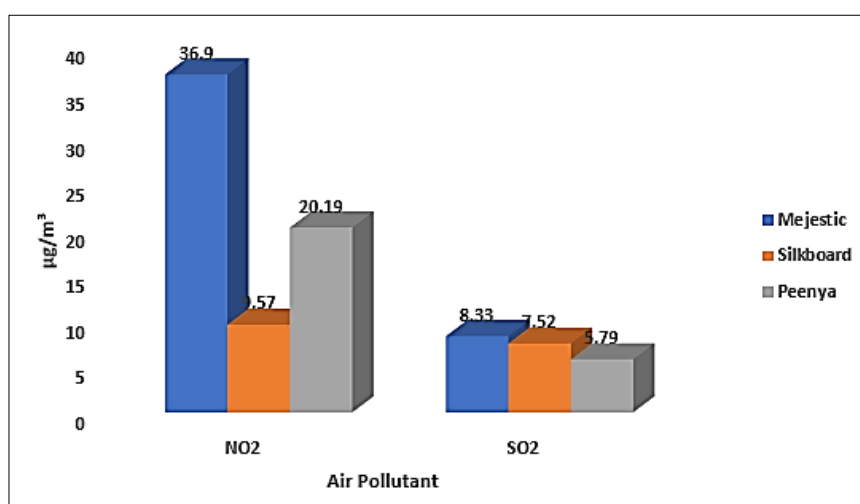
Also the concentration of PM_{2.5} is highest at NTTF, Peenya Industrial Area than at H.S.R Layout, Near Central Silkboard showing that the finer particulates are more due to industrial emissions.

When compared with the CPCB, the concentration of PM₁₀ at H.S.R Layout, Near Central Silkboard and City Railway Station, Majestic are close to the permissible limit while it is very low in NTTF, Peenya Industrial Area.

Also the concentration of PM_{2.5} at both the areas are within the permissible limits.

Table 2: The average distribution of NO₂ and SO₂ across the three stations from August 2025 to October 2025

Air Pollutant	City Railway Station, Majestic	H.S.R Layout, Near Central Silkboard	NTTF, Peenya Industrial Area
NO ₂	36.90	9.57	20.19
SO ₂	8.33	7.52	5.79

**Fig 2:** The average distribution of NO₂ and SO₂ across the three stations from August 2025 to October 2025

NO₂ concentration were highest at City Railway Station, Majestic, moderate at NTTF, Peenya Industrial Area and lowest at H.S.R Layout, Near Central Silkboard. This shows that the heavy concentration is due to vehicular emissions

since City Railway Station, Majestic is a major transportation area. Also, due to industrial emission it may be highest in NTTF, Peenya Industrial Area and at H.S.R Layout, Near Central Silkboard it is the lowest during our study period.

Again the SO₂ concentration was highest at City Railway Station, Majestic showing that the area has highly vehicular emission.

But here SO₂ concentration is more in H.S.R Layout, Near Central Silkboard compared to NTTF, Peenya Industrial Area. This suggests that there is heavy vehicle emission at H.S.R

Layout, Near Central Silkboard compared to the industrial emission at NTTF, Peenya Industrial Area during our study period.

When compared with the CPCB, the concentration of NO₂ and SO₂ at all the three stations were within the permissible limits.

Table 3: The average distribution of CO across the three stations from August 2025 to October 2025

Air Pollutant	City Railway Station, Majestic	H.S.R Layout, Near Central Silkboard	NTTF, Peenya Industrial Area
CO	1.12	0.56	0.69

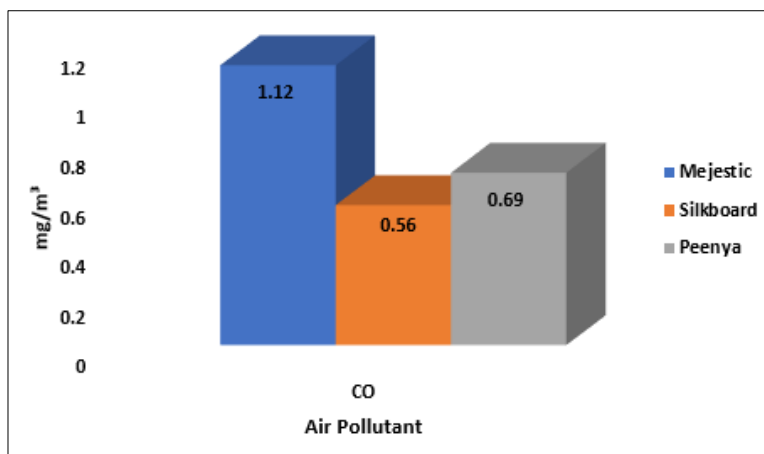


Fig 3: The average distribution of CO across the three stations from August 2025 to October 2025.

The CO concentration was highest at City Railway Station, Majestic followed by NTTF, Peenya Industrial Area and least concentration is at H.S.R Layout, Near Central Silkboard. This is may be due to heavy transportation and vehicular smoke in City Railway Station, Majestic.

3.2 Correlation Analysis

To study the relationship between air pollutants, Pearson's correlation coefficient was used. The analysis was done using SPSS.

Table 4: Correlation between the air pollutants at City Railway Station, Majestic

	PM10	SO2	NO2	CO
PM10	1	.227	.025	.387
SO2	.227	1	-.790	.480
NO2	.025	-.790	1	-.138
CO	.387	.480	-.138	1

The correlation analysis at City Railway Station, Majestic different levels of association between the air pollutants which shows differences in their atmospheric behaviour which may be due to different emission sources.

There is a weak correlation between PM₁₀ and CO ($r = 0.387$) showing that they may share some common sources of emissions such as vehicular emissions and road dust. But PM₁₀ shows a weak positive correlation with SO₂ ($r = 0.227$) and a very low correlation with NO₂ ($r = 0.025$) which shows that the particulate matter is not much related with the gaseous pollutants.

We observe a strong negative correlation between SO₂ and NO₂ ($r = -0.790$) showing that these pollutants may originate from different sources. The source of SO₂ is due to fuel combustion in vehicles and NO₂ is due to vehicular emissions. Also SO₂ shows a moderate positive correlation with CO ($r = 0.480$) indicating that combustion in vehicles are the sources for SO₂ and CO.

NO₂ shows a weak negative correlation with CO ($r = -0.138$) indicating that these pollutants may not vary together.

Correlation analysis at City Railway Station, Majestic shows that the source of these pollutants are due to traffic-related sources.

Table 5: Correlation between the air pollutants at HSR Layout, Near Central Silkboard

	PM10	PM2.5	SO2	NO2	CO
PM10	1	.603	.287	.333	.378
PM2.5	.603	1	.304	.276	.043
SO2	.287	.304	1	.410	.469
NO2	.333	.276	.410	1	.284
CO	.378	.043	.469	.284	1

The correlation analysis at HSR Layout, near Central Silkboard, shows positive associations among particulate and gaseous pollutants.

There is a moderately strong positive correlation between PM₁₀ and PM_{2.5} ($r = 0.603$) which shows that the source of coarse and fine particulate matter is due to vehicular emissions and road dust resuspension. Also, PM₁₀ showed moderate positive correlations with NO₂ ($r = 0.333$) and CO ($r = 0.378$) showing that the common source is the vehicular emission. There is a low positive correlation between PM₁₀ and SO₂ ($r = 0.287$).

PM_{2.5} shows moderate positive correlations with SO₂ ($r = 0.304$) and NO₂ ($r = 0.276$) which indicates that the fine particulates are due to combustion processes. Also a very weak correlation between PM_{2.5} and CO ($r = 0.043$) indicate that concentrations may not always vary with each other which may be due to emission timing.

Among gaseous pollutants, SO₂ showed moderate positive correlations with NO₂ ($r = 0.410$) and CO ($r = 0.469$) showing common sources such as vehicle combustion and a low positive association between NO₂ and CO ($r = 0.284$).

Table 6: Correlation between the air pollutants at NTTF, Peenya Industrial area

	PM10	PM2.5	SO2	NO2	CO
PM10	1	.131	.294	.448	.391
PM2.5	.131	1	.174	.076	.354
SO2	.294	.174	1	.368	.419
NO2	.448	.076	.368	1	.766
CO	.391	.354	.419	.766	1

The correlation analysis for the NTTF, Peenya Industrial Area indicates moderate to strong associations among several pollutants showing the influence of industrial activities, fuel combustion processes, and vehicular emissions. PM₁₀ exhibited a moderate positive correlation with NO₂ ($r = 0.448$) and CO ($r = 0.391$) indicating that they have a common source of emission such as combustion-related emissions. There is a weak correlation between PM₁₀ and PM_{2.5} ($r = 0.131$) indicating that these pollutants may originate from different sources. PM_{2.5} showed weak positive correlations with SO₂ ($r = 0.174$) and NO₂ ($r = 0.076$), but a moderate association with CO ($r = 0.354$). SO₂ exhibited moderate positive correlations with NO₂ ($r = 0.368$) and CO ($r = 0.419$). A strong positive correlation between NO₂ and CO ($r = 0.766$) was observed.

4. Conclusion

The present study indicates that there is a heterogeneity in pollutant concentrations, showing differences in land use patterns and weak correlation among the pollutants. It provides a brief analysis of ambient air quality across the three selected areas of Bangalore city, namely City Railway Station, Majestic (transport hub), HSR Layout, near Central Silkboard (traffic-residential zone), and NTTF, Peenya Industrial Area for the data obtained from the Karnataka State Pollution Control Board (KSPCB).

The analysis focused on key air pollutants PM₁₀, PM_{2.5}, SO₂, NO₂, and CO with emphasis on deviation from standards, trend analysis and interrelationships among pollutants. Such studies which are on larger scale and multicentric, policy measures such as control over traffic emission, monitoring of industrial emission, trend monitoring and improvement in the public health may be recommended.

References

1. Central Pollution Control Board (CPCB). National Ambient Air Quality Standards. New Delhi: Ministry of Environment and Forests, Government of India; 2009.
2. World Health Organization (WHO). WHO global air quality guidelines: particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Geneva: WHO Press; 2021.
3. Sangeetha MD, *et al.* Evaluation of particulate matter and air pollutants level in the ambient air of Bengaluru city. Indian J Community Health. 2024;36(3):452-458.
4. Ganesh Babu KN, Vasanthi Muthunayanan, Selvi KG. Determination of ambient air quality in Peenya Industrial Area of the Bangalore City, India. Int J Environ Sci. 2025;11(23s):5781-5788.
5. Guttikunda SK, Nishadh KA, Gota S, Singh P, Chanda A, Jawahar P, *et al.* Air quality, emissions, and source contributions analysis for the Greater Bengaluru region of India. Atmos Pollut Res.
6. Praseeda E, Ravi DR, Das A, Aiswarya CS, Evan Raj Subba, Kanojiya P. Assessment of air quality in

Bangalore before, during and after COVID-19 lockdown. Int J Eng Res Technol.

7. Ganesh Babu KN, Vasanthi Muthunayanan. Air quality monitoring in Bangalore - a case study. J Chem Health Risks.
8. S DV. Assessing the long-run impact of vehicular movement on air quality: an ARDL approach. Stud Appl Econ. 2023;41(1).