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SEASONAL AND SPATIAL VARIATIONS IN AIR POLLUTION: INSIGHTS FROM AURANGABAD'S URBAN LANDSCAPE

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ABSTRACT

This study evaluates ambient air quality in Aurangabad, Maharashtra, focusing on ten diverse sites, including industrial, commercial, sensitive, and residential zones. The analysis highlights significant spatial and seasonal variations in pollutant concentrations, with industrial zones exhibiting the highest levels of SO_2, NO_2, PM_{10}, and $PM_{2.5}$ due to emissions from factories and traffic. Seasonal trends reveal elevated pollution during winter and notable relief during the monsoon, influenced by climatic conditions. The Air Quality Index (AQI) predominantly ranged from "Moderate" to "Poor," with industrial areas consistently performing worse. Sensitive zones, including schools and hospitals, displayed better air quality but faced occasional pollutant spikes. The findings underscore the necessity for emission control measures, sustainable public transportation, and clean energy promotion. Targeted interventions, particularly in industrial hotspots, are vital to mitigating air pollution and safeguarding public health. This research provides actionable insights for regional environmental planning and policy development to enhance air quality.

Key Words: *Ambient air quality, Seasonal trends, Air Quality Index (AQI), emission Sources.*

INTRODUCTION :

Three-fourths of the Earth's air is concentrated in the lowest layer of the atmosphere. It is a mixture of gases, primarily occurring naturally, but also includes a significant amount of human-made pollutants [1]. The air consists of various atmospheric gases, and their presence in the atmosphere is detailed in Table 1.[2].

Air pollution occurs when chemical, physical, or biological agents contaminate the indoor or outdoor environment, altering the atmosphere's natural characteristics. Common sources include household combustion devices, motor vehicles, industrial activities, and forest fires. Key pollutants of public health concern are particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide. Both indoor and outdoor air pollution significantly contribute to respiratory and cardiovascular diseases, posing major risks for public health and increasing morbidity and mortality rates worldwide [3]. Air pollution arises from various sources, with the combustion of fossil fuels being a primary contributor to the emission of classical pollutants such as Sulphure dioxide (SO_2), Nitrogen oxides (NO_x), Carbon monoxide (CO), Volatile organic compounds (VOCs), and Particulate matter (PM). Significant contributors include the burning of fuels for road transportation and electricity generation, which are particularly critical in driving pollution levels [4]. Sulphure dioxide is one of the most common pollutant gases in the atmosphere, often found in high concentrations in urban and industrial areas. When combined with other pollutants and moisture (e.g., humidity), it contributes to the formation of visible, highly resistant corrosion layers on metals and alloys, except for the most noble ones such as silver and gold. [7]Nitrogen dioxide is part of a group of highly reactive gases known as nitrogen oxides (NOx). These gases are primarily produced when fuel is burned at high temperatures, with major sources including motor vehicle exhaust, electric utilities, and industrial boilers. [8]Carbon monoxide: Carbon monoxide (CO), a significant contributor to air pollution, is linked to impaired neurodevelopmental outcomes. Experimental studies on perinatal exposure have demonstrated its disruptive effects on several critical processes in brain development. While the toxic effects of CO at symptomatic levels are well-documented, the public health implications of subclinical CO exposure remain largely overlooked. [9] Global VOC emissions have been steadily increasing, with non-volatile organic compounds (NVOCs) contributing the majority of the flux. However, most VOC emission inventories focus on either anthropogenic or natural sources, rarely combining both. To better capture current trends and assess their impact on air quality and public health, there is a need for comprehensive VOC emission inventories that include diverse sources, accurate estimates, and high spatial and temporal resolution.[10] Particulate matter (PM) is a complex mixture of components with diverse physical and chemical properties. The potential health impacts of these particles depend on their chemical composition and sources. Moreover, their size and physical characteristics are significant concerns for public health. [11].Household combustion devices, motor vehicles, industrial facilities, and forest fires are major sources of air pollution. Key pollutants that pose significant public health risks include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide. These pollutants contribute to various health issues, particularly respiratory and cardiovascular diseases.[5]Numerous epidemiological studies have associated PM_{10}, and particularly $PM_{2.5}$, with serious health issues. $PM_{2.5}$ is especially concerning due to its high toxin content and its ability to penetrate deeply into the lungs because of its aerodynamic properties.[14] The population size, level of economic growth, rural modernization, pollution index, and high-speed rail were positively correlated with air pollution, while the industrial structure, foreign direct investment, and urbanization level showed a negative correlation with air pollution. The effects of the pollution index, foreign direct investment, high-speed rail, and urbanization were statistically significant [6].Air quality in India, especially in urban areas, is a significant concern, with pollutants such as particulate matter (PM), sulphure dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and ozone (O_3) frequently exceeding the National Ambient Air Quality Standards (NAAQS). According to the World Health Organization (WHO), 37 Indian cities rank among the top 100 global cities with the highest PM_{10} pollution, with Delhi, Raipur, Gwalior, and Lucknow listed in the top 10.[16]

The greatest health burden caused by Household Air Pollution (HAP) arises from respiratory illnesses such as asthma and pneumonia, reduced lung function, tuberculosis, eye diseases, pregnancy complications, cardiovascular diseases, and various forms of cancer. Children, women, and the elderly are particularly vulnerable, as they tend to spend more time indoors and are therefore more exposed.[12] The less developed states in northern and northeastern India experienced a higher burden of household air pollution compared to the more developed states. In contrast, states in northern India faced a significant burden from ambient particulate matter pollution, regardless of their level of development.[13]

Table 1: Atmospheric Gases

Atmospheric Gases		
Group	**Gases**	**Volume % of Dry Air**
Major Gases	Nitrogen	78.084
	Oxygen	20.9476
	Argon	0.934
	Co2	0.04
Minor Gases	Methane	0.002

	Neon	0.001818
	Helium	0.000524
	Krypton	0.000114
	Hydrogen	0.00005
	Xenon	0.0000087
	Ozone	0.00006
Variable Gasses	Water Vapour	Variable Amount
	Dust Particles	Variable Amount
	Aerosols	Variable Amount
Note: CO_2, Methane and Ozone gases are variables.		

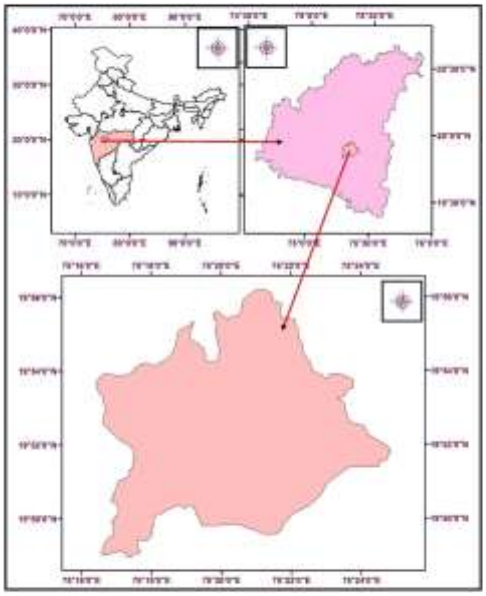
Study Area

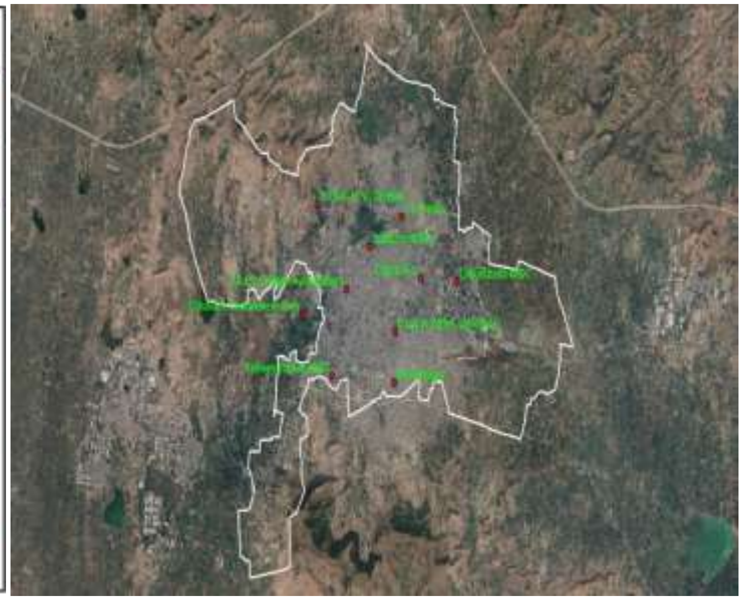
Aurangabad, now known as titled the "City of Gates" and has been declared the "Tourism Capital of Maharashtra." It is the 5th largest city in the state by population, following Mumbai, Pune, Nagpur, and Nashik. With a geographical area of approximately 138 km², the city is located at latitude of 19°53'59" N and longitude of 75°20'59" E.

Aurangabad is a prominent hub for IT and manufacturing, housing numerous colleges and universities. The region's climate is generally hot and dry, with annual mean temperatures ranging from 17°C to 33°C. Most rainfall occurs during the monsoon season (June to September), while relative humidity is typically low (35–50%) throughout the year, peaking at 85% during the monsoon.

According to the provisional 2011 Census of India, the city's population is 1,175,116. It also boasts a significant number of industrial units spanning small, medium, and large-scale enterprises. The study area within Aurangabad urban area including different sampling locations based on their longitudes, is depicted in Figure 1.

Sr. No.	Latitude	Longitude	Monitoring Locations	Locations Area
1	19°53'33N	75°20'28E	Collector Office	Commercial
2	19°52'9N	75°21'4.E	C.A.D.A. Office, Garkheda	Commercial
3	19°52'54N	75°19'27E	S.B.E.S. College, Aurangapura	Commercial
4	19°88'52N	75°38'26E	Chikalthana MIDC	Industrial
5	19°83'84N	75°38'90E	Railway Station MIDC	Industrial
6	19°90'42N	75°35'36E	Dr. B.A. M. U. Campus	Sensitive
7	19°87'65 N	75°29'17E	Chhavani, Contonment Area	Sensitive
8	19°90'16N	75°35'79E	Shivajinagar	Residential
9	19°88'39N	75°36'31E	CIDCO N-5,	Residential`
10	19°90'42°N	75°35'36°E	T.V. Center	Residential`





Sr. No.	Locations	Descriptions
1	Collector Office (Commercial Area, Heavy Traffic)	Located at the administrative hub, surrounded by government offices, residential colonies, and historical sites. Air pollution sources include vehicular emissions, refuse burning, diesel generators, and construction activities.
2	C.A.D.A. Office, Garkheda (Commercial Area, Heavy Traffic)	Key traffic intersection near government offices, hospitals, and schools. Major pollution sources include vehicular emissions, diesel generators, refuse burning, and construction activities.
3	S.B.E.S. College, Aurangapura (Commercial Area, Heavy Traffic)	A busy educational and market hub with heavy traffic. Pollution sources include vehicular emissions, refuse burning, diesel generators, and ongoing construction.
4	Chikalthana MIDC (Industrial Area, Medium Traffic)	An industrial area with warehouses, car showrooms, and hospitals. Air pollution arises from industrial emissions, construction, refuse burning, and poor road conditions.
5	Railway Station MIDC (Industrial Area, Heavy Traffic)	Located near railway yards, highways, and slum areas. Key pollution sources include industrial emissions, railway engines, heavy-duty vehicles, refuse burning, and wood/coal combustion.
6	Dr. B.A.M.U. Campus (Sensitive Area, Low Traffic)	A green and well-planned area with historical and tourist sites. It serves as a reference site with minimal air pollution and negligible traffic.
7	Chhawani, Cantonment Area (Sensitive Area, Medium Traffic)	Military area surrounded by schools and government offices. Vehicular emissions from nearby city entrances are the primary pollution source.

8	Shivajinagar (Residential Area, Heavy Traffic)	A dense residential area with a busy traffic intersection. Pollution sources include vehicular emissions, construction dust, refuse burning, and cement roadworks.
9	CIDCO N-5 (Residential Area, Medium Traffic)	A densely populated residential area near Rajiv Gandhi Stadium. Pollution sources include vehicular emissions, refuse burning, and construction activities.
10	T.V. Center (Residential Area, Heavy Traffic)	A crowded residential-commercial area near highways and hospitals. Major pollution sources are vehicular emissions, diesel generators, refuse burning, and coal usage by street vendors.

MATERIAL AND METHOD

Particulate Matter (PM_{10} & $PM_{2.5}$):

For particulate matter sampling, pre-weighed desiccated Whatman filter papers (8 × 10 in) with 0.00001 g sensitivity were used. To prevent contamination, conditioned filter papers were transported in sealed envelopes. PM_{10} & $PM_{2.5}$ was sampled for 24 hours using a High-Volume Sampler at a flow rate of 1.1 m^3/min. Initial readings (volume, timer, and manometer) were recorded before securely loading the filter. Particles with aerodynamic diameters below the inlet cut-point were captured on the filter. After sampling, the filter paper was carefully removed, sealed, and reweighed to determine PM_{10} and $PM_{2.5}$ concentrations.

Sulphur Dioxide (SO_2):

Using the "West and Geake" method, SO_2 was sampled at a flow rate between 1–2.2 m^3/min. Airborne SO_2 was absorbed in potassium tetrachloromercurate (TCM), forming a stable dichlorosulphitomercurate complex. This complex reacted with para-rosaniline and formaldehyde to produce pararosanilinemethylsulphonic acid, with absorbance measured at 560 nm.

Nitrogen Dioxide (NO_2):

The "Modified Jacob and Hochheiser" method was used to sample NO_2 at a flow rate of 1–2.2 m^3/min. Ambient NO_2 was absorbed in a sodium hydroxide and sodium arsenite solution, forming nitrite ions. These reacted with phosphoric acid, sulfanilamide, and N-(1-naphthyl)-ethylenediaminedihydrochloride (NEDA) to produce an azo-dye. Absorbance was measured at 540 nm.

Observation:

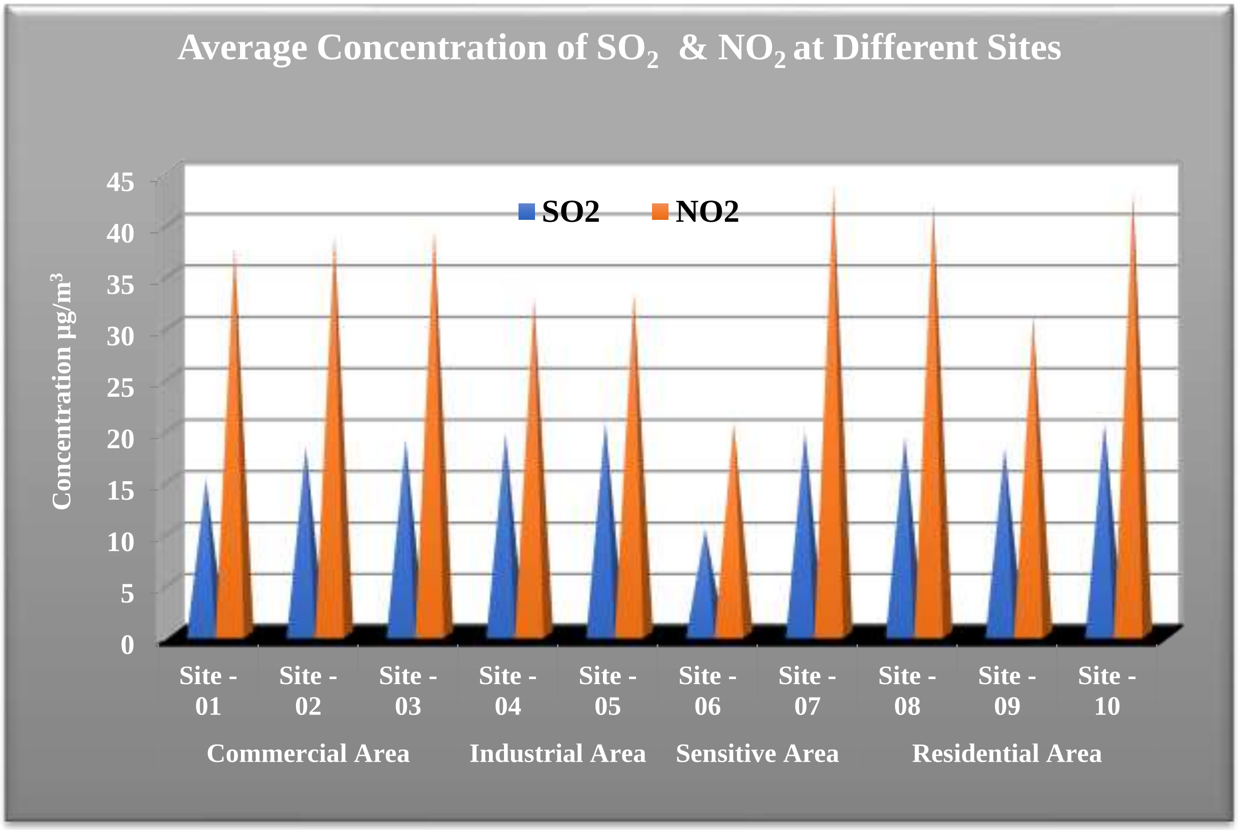
Ambient air quality monitoring at ten locations in Aurangabad, Maharashtra, covering diverse land-use categories such as commercial, industrial, sensitive, and residential areas. The monitored locations include the Collector Office, C.A.D.A. Office, S.B.E.S. College, Chikalthana MIDC, Railway Station MIDC, Dr. B.A.M.U. Campus, Chhavani Cantonment Area, Shivajinagar, CIDCO N-5, and T.V. Center. The study analyzed key air pollutants, including $PM_{2.5}$, PM_{10}, SO_2, and NO_2, to assess air quality status. Minimum and maximum pollutant concentrations were recorded at each site, revealing significant variations influenced by local activities and land-use patterns. The findings provide valuable insights for air quality management and environmental planning in the region.

Sr. No.	Months	Min- Max Average Concentration of SO_2 at all Monitoring Locations (Year 2022)									
		Commercial Area			Industrial Area		Sensitive Area		Residential Area		
		Collector Office	C.A.D.A. Office	S.B. E.S. College	Chikalthana MIDC	Railway Station MIDC	DR. B.A.M.U	Contonment Area Chhavani	Shivajinagar	CIDCO N-5	T. V. Center
	Months	Site - 1	Site - 2	Site - 3	Site - 4	Site - 5	Site - 6	Site -7	Site - 8	Site - 9	Site - 10
1	Jan	25.72	26.19	26.04	31.105	31.685	13.345	24.73	29.1	31.3	31.55
2	Feb	27.17	27.37	27.87	30.83	30.8	12.05	25.375	26.11	29.175	29.435
3	Mar	25.43	25.03	25.5	24.26	26.42	11.3	20.73	24.805	23.985	25.13
4	Apr	12.62	13.99	15.13	20.21	20.815	10.065	19.485	21.695	22.62	20.88
5	May	13.65	12.55	15.67	17.175	19.46	9.22	17.48	16.655	21.06	17.805
6	Jun	12.96	12.87	13.33	12.455	14.58	10.505	13.91	14.54	15.035	13.31
7	Jul	10.99	10.59	11.27	9.895	10.49	6.19	10.485	10.16	12.745	12.91
8	Aug	8.8	9.18	8.89	6.655	6.225	5.665	6.655	7.6	9.865	8.015
9	Sep	6.63	11.87	9.08	6.97	5.425	5.28	5.645	8.02	8.91	8.72
10	Oct	7.21	18.42	24.73	16.245	17.7	14.275	22.27	15.38	16.62	11.82
11	Nov	13.62	22.72	22	27.695	33.33	12.2	24.905	26.5	28.28	29.395
12	Dec	16.72	28.37	28.68	31.395	31.935	13.465	26.75	30.645	27.75	29.05

Sr. No.	Months	Min- Max Average Concentration of NO_2 at all Monitoring Locations (Year 2022)									
		Commercial Area			Industrial Area		Sensitive Area		Residential Area		
		Collector Office	C.A.D.A. Office	S.B. E.S. College	Chikalthana MIDC	Railway Station MIDC	DR. B.A.M.U	Contonment Area Chhavani	Shivajinagar	CIDCO N-5	T. V. Center
		Site - 1	Site - 2	Site - 3	Site - 4	Site - 5	Site - 6	Site -7	Site - 8	Site - 9	Site - 10
1	Jan	59.18	61.1	62.57	38.785	46.7	27.865	46.775	54.47	61.15	61.77
2	Feb	61.12	61.42	61.93	37.575	43.27	27.38	47.755	52.595	58.7	61.895
3	Mar	59.1	57.11	57.73	35.645	40.865	25.735	48.57	48.53	54.065	54.75
4	Apr	28.65	29.8	30.85	35.245	34.33	21.97	25.78	44.135	52.725	49.19
5	May	29.59	28.29	29.34	29.845	31.91	20.895	22.57	38.2	41.105	35.46
6	Jun	26.18	28.24	27.51	25.615	27.77	16.33	21.545	33.05	38.72	29.635
7	Jul	27.1	25.15	25.57	19.8	19.68	15.24	17.12	29.73	33.15	27.325
8	Aug	26.29	26.01	25.32	15.7	13.75	11.775	17.63	26.09	31.64	23.68
9	Sep	25.97	27.4	26.36	11.295	13.215	10.15	16.08	23.7	27.395	22.35
10	Oct	27.65	37.02	39.78	44.08	30.36	16.565	23.585	39.29	31.695	41.785
11	Nov	29.43	38.04	37.91	47.925	47.495	25.22	32.85	55.5	37.61	54.4
12	Dec	52.36	47.26	49.26	52.235	50.785	29.645	51.5	57.87	47.53	60.105

Sr. No.	Months	Min- Max Average Concentration of $PM_{2.5}$ at all Monitoring Locations (Year 2022)									
		Commercial Area			Industrial Area		Sensitive Area		Residential Area		
		Collector Office	C.A.D.A. Office	S.B. E.S. College	Chikalthana MIDC	Railway Station MIDC	DR. B.A.M.U	Contonment Area Chhavani	Shivajinagar	CIDCO N-5	T. V. Center
		Site - 1	Site - 2	Site - 3	Site - 4	Site - 5	Site - 6	Site -7	Site - 8	Site - 9	Site - 10
1	Jan	53	58.455	59.94	76.18	76.115	22.08	49.915	70.94	70.395	63.08
2	Feb	62.085	59.2	64.67	75.15	74.245	24.445	48.72	73.955	69.04	62.505
3	Mar	60.925	64.59	55.74	73.17	76.725	22.89	47.04	70	62.34	63.74
4	Apr	55.665	61.26	51.575	72.71	72.61	25.02	46.68	64.55	57.02	53.12
5	May	61.26	64.795	71.05	74.645	72.475	23.05	44.17	62.56	54.755	54.165
6	Jun	51.175	48.81	60.84	62.63	52.405	19.545	38.145	59.535	37.23	50.15
7	Jul	33.385	41.105	47.47	50.6	40.915	16.695	34.23	35.13	37.595	40.05
8	Aug	28.075	20.8	40.82	34.305	36.47	14.825	26.59	37.06	31.62	34.26
9	Sep	23.175	15.66	36.96	32.11	28.655	14.87	26.515	33.765	28.86	34.56
10	Oct	20.48	21.175	67.18	82.58	74.58	20.305	40.855	64.17	57.505	63.575
11	Nov	49.72	58.395	59.35	71.54	75.33	22.51	46.595	63.665	62.87	64.08
12	Dec	55.375	58.7	66.895	73.385	75.035	19.67	50.7	69.095	64.29	71.12

Sr. No.	Months	Min- Max Average Concentration of PM_{10} at all Monitoring Locations (Year 2022)									
		Commercial Area			Industrial Area		Sensitive Area		Residential Area		
		Collector Office	C.A.D.A. Office	S.B. E.S. College	Chikalthana MIDC	Railway Station MIDC	DR. B.A.M.U	Contonment Area Chhavani	Shivajinagar	CIDCO N-5	T. V. Center
		Site - 1	Site - 2	Site - 3	Site - 4	Site - 5	Site - 6	Site -7	Site - 8	Site - 9	Site - 10
1	Jan	88.53	94.25	111.28	101.32	110.5	38.31	94.74	121.16	126	142.22
2	Feb	112.27	116.42	123.4	108.61	101.63	40.215	95.26	123.75	121.3	132.655
3	Mar	115.29	116.75	121.65	130.11	120.615	45.515	96.715	119.45	117.85	145
4	Apr	108.07	111.52	114.34	127.17	161	40.08	100.705	130	119.68	165.205
5	May	118.38	112.45	120.83	140.535	183.5	43.205	104.63	134.76	126.12	188.62
6	Jun	100.71	108.1	108.89	100.77	91.285	34.45	83.68	95.625	109.58	153.02
7	Jul	89.1	79.44	75.47	75.325	76.13	30.86	47.22	55.87	73.115	67.16
8	Aug	55.86	55.19	54.54	50.76	46.58	24.615	45.855	53.2	54.62	46.69
9	Sep	41.97	47.88	42.97	44.59	41.105	21.67	46.04	48.785	52.3	42.305
10	Oct	52.07	62.67	88.99	83.035	136.81	25.875	47.345	105.5	82.265	53.11
11	Nov	70.35	128.92	131.17	99.39	147.5	37.02	90.36	119	109	115.64
12	Dec	85.97	110.93	116.26	108.53	170.5	40.385	101.375	121	114	132.5


Average Concentration of SO_2 & NO_2 at Different Sites
SO2
NO2
Concentration µg/m³
45
40
35
30
25
20
15
10
5
0
Site - 01
Site - 02
Site - 03
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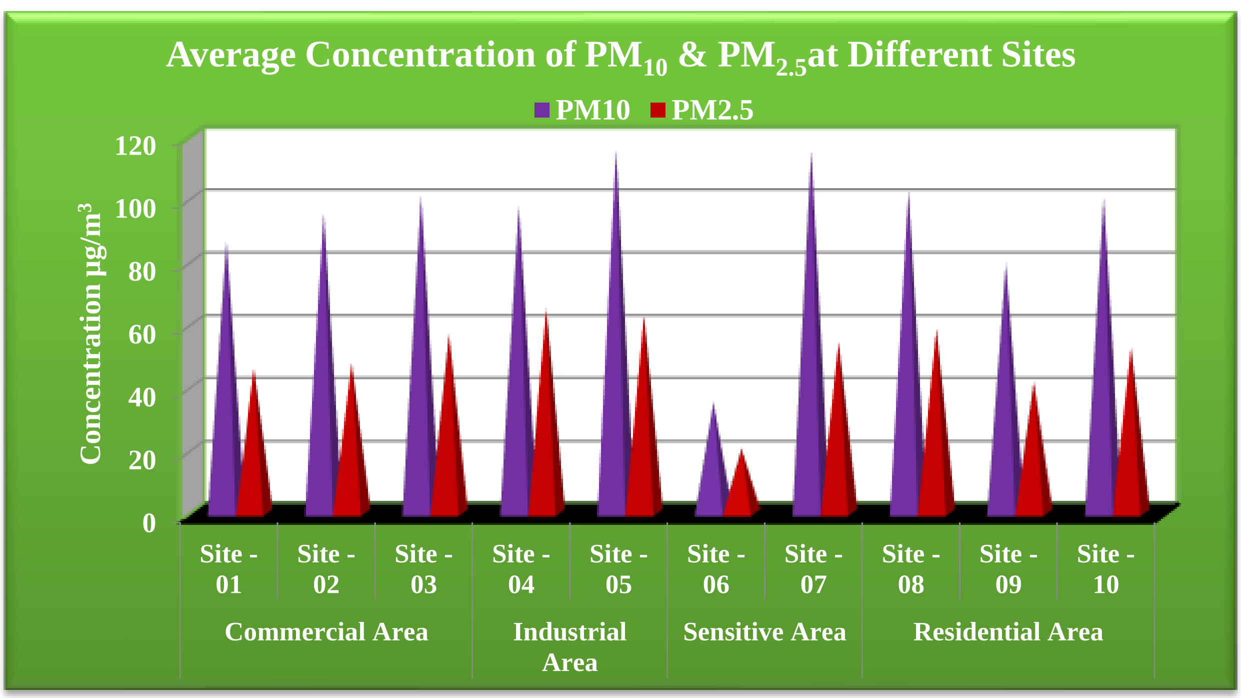
Industrial Area
Sensitive Area
Residential Area


Average Concentration of PM_{10} & $PM_{2.5}$ at Different Sites
PM10
PM2.5
Concentration µg/m³
120
100
80
60
40
20
0
Site - 01
Site - 02
Site - 03
Site - 04
Site - 05
Site - 06
Site - 07
Site - 08
Site - 09
Site - 10
Commercial Area
Industrial Area
Sensitive Area
Residential Area

RESULT & DISCUSSION:

The air quality in the monitored cities exhibited notable fluctuations in pollutant levels throughout the year. Concentrations of SO_2 were generally within permissible limits, with values ranging from a minimum of 6.22 µg/m³ in August to a maximum of 33.33 µg/m³ in November. This indicates moderate sulfur dioxide pollution, which is seasonally influenced, with peak levels during winter months due to increased industrial and vehicular emissions. Nitrogen dioxide (NO_2) levels showed a declining trend during the monsoon season, reaching as low as 10.15 µg/m³ in September, while peaking in December at 61.89 µg/m³. The industrial areas consistently recorded higher NO_2 levels compared to residential and sensitive zones, highlighting the localized impact of industrial activities.

The particulate matter concentrations in the cities exhibited significant variations based on the area type and season. PM_{10} levels peaked in May with values as high as 188.62 µg/m³, far exceeding the recommended air quality standards, particularly in industrial zones. Conversely, the monsoon season showed the lowest levels, with PM_{10} dropping to 46.58 µg/m³ in August, attributed to precipitation effectively reducing airborne particulate matter. Similarly, $PM_{2.5}$ concentrations were elevated in winter months, reaching 75.03 µg/m³ in December, whereas the monsoon brought substantial relief, with values as low as 14.82 µg/m³ in August. This seasonal pattern underscores the significant influence of weather conditions on particulate matter pollution.

The Air Quality Index (AQI) classification varied across cities and locations, predominantly falling into the "Moderate" and "Poor" categories during high-pollution months. Industrial areas consistently exhibited the poorest air quality due to the aggregation of emissions from factories and traffic. Sensitive zones, including schools and hospitals, experienced better air quality but still registered occasional spikes in pollutants, emphasizing the need for stringent compliance measures. Residential areas displayed a mixed profile, with significant improvements during the monsoon. Overall, the findings highlight the necessity for targeted mitigation strategies such as reducing industrial emissions, enhancing public transportation, and promoting clean energy to improve air quality sustainably across all monitored locations.

The air quality analysis of the commercial, industrial, sensitive, and residential areas reveals significant spatial variations in pollutant levels. Sulphure dioxide (SO_2) concentrations ranged from 10.29 µg/m³ in sensitive areas (Site-06) to a maximum of 20.74 µg/m³ in industrial zones (Site-05), with industrial areas consistently exhibiting higher SO_2 levels. Nitrogen dioxide (NO_2) concentrations were notably elevated in industrial regions, with a peak value of 43.52 µg/m³ at Site-07, while residential and sensitive areas reported lower levels, such as 20.73 µg/m³ at Site-06. Particulate matter (PM_{10}) levels were alarmingly high in industrial zones, reaching 115.59 µg/m³ at Site-05, whereas sensitive areas recorded the lowest concentrations at 35.18 µg/m³ (Site-06). Similarly, fine particulate matter ($PM_{2.5}$) concentrations followed a comparable trend, with maximum levels of 64.96 µg/m³ observed in commercial areas (Site-04) and the lowest value of 20.49 µg/m³ in sensitive zones (Site-06). This analysis underscores the heightened pollution in industrial and commercial zones, likely driven by emissions from factories and vehicular traffic, while sensitive and residential areas demonstrated relatively better air quality. The findings highlight the urgent need for targeted interventions to control emissions in industrial and commercial zones, alongside policy-driven initiatives for sustainable air quality management.

CONCLUSION:

The analysis of air quality across various zones highlights significant spatial and seasonal variations in pollutant concentrations. Industrial areas consistently exhibit the highest levels of SO_2, NO_2, PM_{10}, and $PM_{2.5}$, underscoring the detrimental impact of industrial activities and vehicular emissions on air quality. Commercial zones also demonstrate elevated pollution levels, while sensitive and residential areas show comparatively better air quality, albeit with occasional spikes. Seasonal patterns reveal peak pollution during winter months and substantial relief during the monsoon, emphasizing the influence of climatic conditions. The Air Quality Index (AQI) classifications predominantly fall within "Moderate" to "Poor" categories, particularly in industrial zones, indicating the need for stringent emission control measures. The findings underscore the urgency of implementing targeted interventions such as reducing industrial emissions, improving public transportation, and promoting clean energy solutions. These efforts are essential for mitigating pollution and ensuring sustainable air quality management in all zones, with particular attention to industrial hotspots and sensitive areas.

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