Capstone Project 1 Report

On

Air Quality Analysis and Management in Chandigarh: Understanding Seasonal Variations and Spatial Dynamics

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Contents

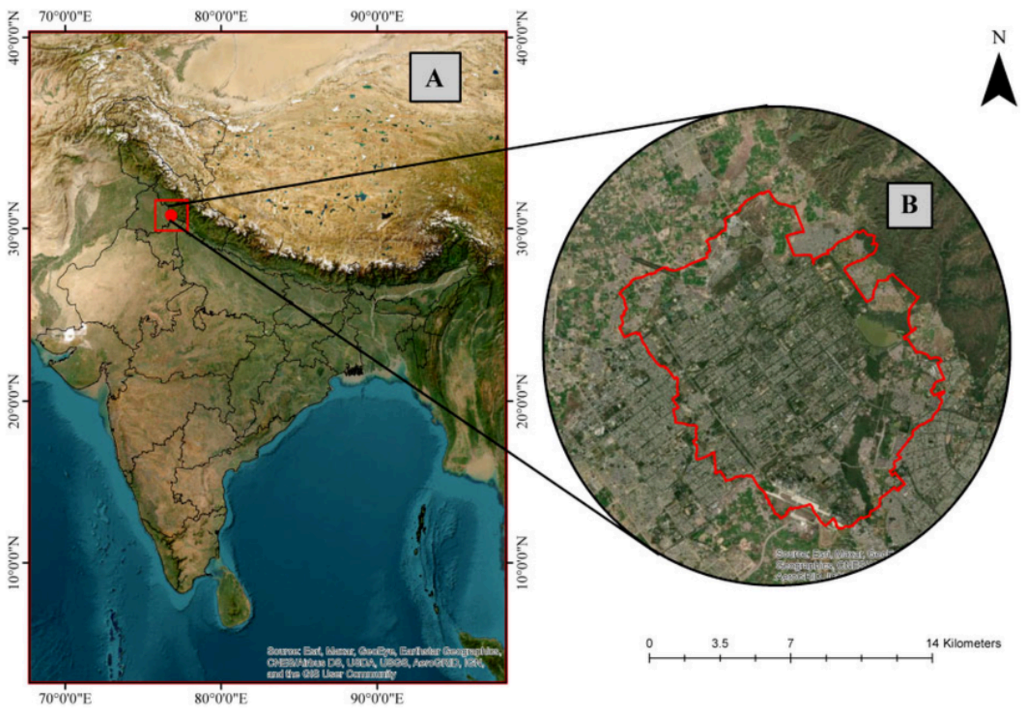
Abstract

This research project aims to analyze and assess the air quality in the city of Chandigarh, India, over a period of 28 months. The study utilizes raw air quality data obtained from the Central Pollution Control Board (CPCB) website, including hourly concentrations of pollutants such as PM2.5, PM10, NO2, SO2, and NH3. The data was processed to calculate daily and monthly average concentrations for each pollutant, following CPCB's norms and guidelines.

Spatial analysis of the data was conducted using ArcGIS to map AQI values across the city, identifying areas with high pollution levels and potential sources of pollution. Additionally, land use and land cover (LULC) maps were created using ERDAS Imagine software to analyze the impact of different land use patterns on air quality.p

The findings of this study provide valuable insights into the air quality trends and patterns in Chandigarh, highlighting areas of concern and potential health risks associated with poor air quality. The results can be used to inform policy interventions and urban planning strategies aimed at improving air quality and public health in the city.

1. Introduction



Study area map: (A) the Chandigarh city bordered by Panjab and Haryana states on the Indian map and (B) a satellite imagery of the study area.

Fig. 1.a Study Area Map of Chandigarh (researchgate.net)

Chandigarh, India, holds a unique position in terms of urban planning and environmental management. Designed by the renowned architect Le Corbusier in the 1950s, it serves as the capital of the states of Punjab and Haryana. The city is renowned for its well-planned layout, with designated sectors for residential, commercial, and institutional purposes, alongside ample green spaces and parks. However, like many urban areas, Chandigarh faces challenges related to air pollution and its impact on the environment.

In recent years, air pollution in Chandigarh has become a pressing issue, primarily due to rapid urbanization, industrial growth, vehicular emissions, and agricultural activities in the surrounding areas. To tackle the situation a thorough study of the air quality is required. Data of various pollutants and their concentration in the ambient air are to be collected primarily. This data can be collected on site or from monitoring stations. Once we get the data we can convert it into AQI for that site. The collected data over a period of a couple of months can help us understand the diurnal as well as the seasonal variations in the trends. Spatial Mapping describing the regional variation of the data can be done with the help of softwares like ArcGIS. Such spatial analysis can help us find the potential sources of pollutants and feasible solutions as well. Various conclusions and inferences can be drawn from the observations from the maps and thus further actions can be taken to bring the ambient air quality under control.

1.1 Project Objectives

- **Collect Secondary Data:** Collection of secondary data including the concentration of various pollutants from CAAQM stations for the years 2022, 2023 and 2024.
- **Estimation of Air Quality Index:** The collected data of concentration is to be converted into AQI.
- **Analyze Air Quality Trends:** Examine historical air quality data to understand long-term trends, including seasonal variations and changes over the past 28 months.
- **Spatial Mapping:** Map AQI values across Chandigarh to identify areas with consistently poor air quality and potential sources of pollution.
- **Correlate AQI with LULC:** Investigate how land use and land cover patterns in Chandigarh relate to air quality, particularly focusing on the impact of urbanization, green spaces, and industrial areas.
- **Health Impact Assessment:** Evaluate the potential health effects of air pollution in Chandigarh based on the calculated AQI values, highlighting areas of concern for public health.
- **Policy Recommendations:** Provide recommendations for policy interventions and urban planning strategies to mitigate air pollution in Chandigarh based on the analysis findings

2. Literature Review

2.1 Air Quality Monitoring and Management:

The National Ambient Air Quality Series NAAQMS/36/2012-13 likely contains crucial data and findings regarding air quality monitoring in India during the fiscal year 2012-13. However, to provide a comprehensive literature review, it should be integrated with other studies and reports. The National Ambient Air Quality Monitoring Program in India plays a vital role in assessing air quality, with standards set by the Central Pollution Control Board (CPCB) and the World Health Organization (WHO) guiding monitoring efforts. Trends in air quality, including improvements or deteriorations in key pollutants, are closely monitored to assess their impact on public health. Technological advances, such as satellite-based monitoring and low-cost sensor networks, are revolutionizing air quality monitoring, complementing traditional methods. These monitoring efforts are crucial for informing policy decisions and regulatory frameworks governing air quality in India, ensuring a healthier environment for all.

Table 2.a Concentration of Various Pollutants in Ambient Air and Methods of Measurement (NAAQMS/36/2012-13)

Pollutants	Time-weighted Average	Concentration in Ambient Air		Methods of measurement
		Industrial, Residential, Rural, and other Areas	Ecologically Sensitive Area (Notified by Central Government)	
Sulphur Dioxide (SO_2), µg/m3	Annual * 24 Hours **	50 80	20 50	-Improved West and Gaeke Method -Ultraviolet Fluorescence
Nitrogen Dioxide (NO_2), µg/m3	Annual * 24 Hours **	40 80	30 80	-Jacob & Hochheiser modified (NaOH-$NaAsO_2$) Method -Gas Phase Chemiluminescence
Particulate Matter (Size less than 2.5µm) or PM2.5, µg/m3	Annual * 24 Hours **	40 60	40 60	-Gravimetric -TEOM -Beta attenuation
Particulate Matter (Size less than 10µm) or PM10,	Annual * 24 Hours **	60 100	60 100	-Gravimetric -TEOM -Beta attenuation

µg/m3				
Lead (Pb) µg/m3	Annual * 24 Hours **	0.50 1.0	0.50 1.0	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper -ED-XRF using Teflon filter
Ammonia (NH3), µg/m3	Annual * 24 Hours **	100 400	100 400	-Chemiluminescence -Indophenol method
Carbon Monoxide(CO), mg/m3	8 Hours ** 1 Hour **	02 04	02 04	-Non-dispersive Infrared (NDIR) Spectroscopy

2.2 Seasonal Variation of Air Quality:

Air quality in urban areas is influenced by various factors, including seasonal variations in meteorological conditions and pollutant emissions. Several studies have investigated the seasonal variation of air quality in cities worldwide, highlighting the impact of different seasons on pollutant concentrations and associated health risks.

One such study by I. Indraj, et al. (2024) examined the seasonal variation of air quality in Gurugram, Haryana, using data from the Central Pollution Control Board. The study found that PM2.5 concentrations were highest in winter, attributed to increased emissions from heating and reduced dispersion due to stable atmospheric conditions. In contrast, ozone (O3) concentrations were highest in summer, driven by photochemical reactions involving precursor pollutants.

These findings highlight the complex relationship between meteorological conditions, pollutant emissions, and air quality in urban environments. Understanding seasonal variations in air quality is crucial for developing effective air quality management strategies and mitigating the health impacts of air pollution in cities.

2.3 Sources of air pollutants:

Air pollution is caused by countless sources that include both natural phenomena and human activities. Anthropogenic sources include industrial emissions, vehicle emissions, and energy production, which emit pollutants such as nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and particulate matter (PM). Industrial processes, from manufacturing to power generation, contribute significantly to air pollution by releasing pollutants directly into the atmosphere. Also, traffic emissions from fossil fuel vehicles produce significant amounts of NO_x, VOCs and particulates.Agricultural practices such as raising and burning crops, which release ammonia (NH_3) and particulate matter. Natural sources, although less controllable, include volcanic eruptions, wildfires and dust storms, which can release large amounts of pollutants into the air.

3. Methodology

3.1 Data Collection:

- **Source of Data:** The data for this project was obtained from the Central Pollution Control Board (CPCB) website, which is the primary agency responsible for monitoring and managing air quality in India.
- **CAAQM Stations:** There are 3 stations within the territory of Chandigarh city viz.
    1. Panjab University South Campus, Opp.: Centre for Public Health Institute, Sector 25 Chandigarh.
       (Lat: 30.751462, Lon: 76.762879)
    2. Govt. Model SR. SEC. School, Sector- 22-A, Chandigarh.
       (Lat: 30.735567, Lon: 76.775714)
    3. Forest Department Nursery, Sector-53, Chandigarh.
       (Lat: 30.719859, Lon:76.738637)

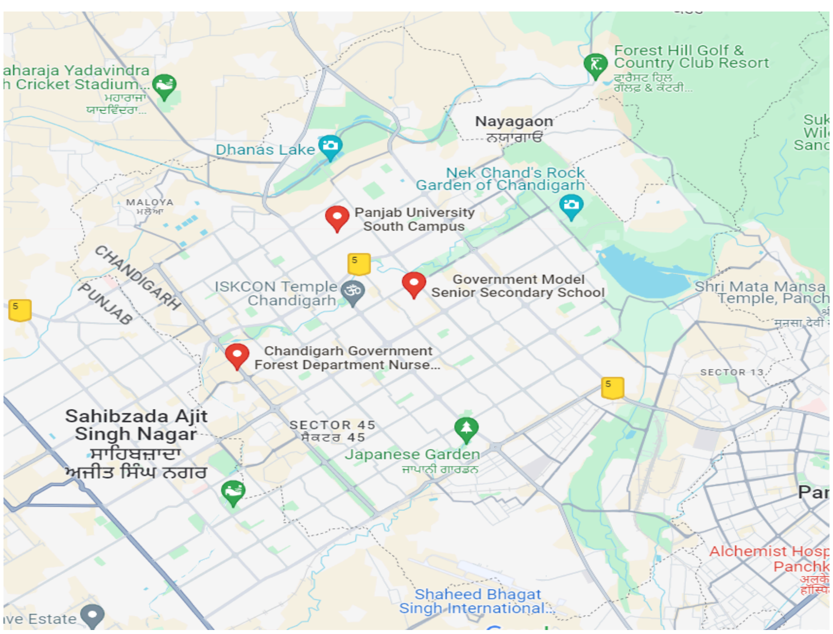


Fig 3.a. Locations of CAAQM Stations in Chandigarh

- **Raw Data Format:** The raw data obtained from the CPCB website includes hourly concentrations of pollutants such as PM2.5, PM10, NO2, SO2, and NH3 for each monitoring station in Chandigarh. Each pollutant's concentration is recorded in micrograms per cubic meter (μg/m³).

1	CENTRAL POLLUTION CONTROL BOARD						
2	CONTINUOUS AMBIENT AIR QUALITY						
3	Date: Tuesday, Feb 06 2024						
4	Time: 12:17:07 PM						
13	Sector-25, Chandigarh - CPCC						
14	Prescribed Standards		0-60	0-100	0-80	0-400	0-80
15	Exceeding Standards		NA	NA	NA	NA	NA
16	Remarks						
17	From Date	To Date	PM2.5	PM10	NO2	NH3	SO2
18	01-01-2020 00:00	01-01-2020 01:00	104.29	217.26	None	None	7.28
19	01-01-2020 01:00	01-01-2020 02:00	103.59	223.97	8.34	8.27	7.68
20	01-01-2020 02:00	01-01-2020 03:00	95.34	205.86	9.82	11.95	7.41
21	01-01-2020 03:00	01-01-2020 04:00	82.45	181.98	8.08	11.12	6.84
22	01-01-2020 04:00	01-01-2020 05:00	72.19	141.78	9.11	14.73	5.71
23	01-01-2020 05:00	01-01-2020 06:00	59.85	117.24	8.73	15.67	5.56
24	01-01-2020 06:00	01-01-2020 07:00	48.87	99.96	8.69	16.1	5.46
25	01-01-2020 07:00	01-01-2020 08:00	49.07	102.19	9.33	15.92	5.18
26	01-01-2020 08:00	01-01-2020 09:00	46.13	106.64	10.21	15.74	5.96
27	01-01-2020 09:00	01-01-2020 10:00	45.46	113.07	12.62	18.06	8.31
28	01-01-2020 10:00	01-01-2020 11:00	46.41	124.9	54.08	29.09	7.93

Fig 3.b Hourly data for Sector 25 station.

- **Time Period:** The data covers a period of 28 months (year 2022, year 2023, and first 4 months of year 2024), providing a comprehensive dataset for analyzing air quality trends over time.

3.2 Data Preprocessing:

- **Conversion to Daily Data:** The raw hourly data was preprocessed to convert it into daily AQIs. This involves aggregating the hourly data for each pollutant and converting it into a sub-index for each pollutant. The maximum of all the sub-indices is considered to be the AQI.

$$I_p = \frac{I_{HI} - I_{LO}}{BP_{HI} - BP_{LO}}(C_P - BP_{LO}) + I_{LO}$$

I_p = The index for pollutant p
C_P = The rounded 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
I_{HI} = The AQI value corresponding to BP_{HI}
I_{Lo} = The AQI value corresponding to BP_{LO}

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Sector-22 Chandigarh - CPCC													
2	Prescribed Standards		0-60		0-100		0-80		0-400		0-80			
3	From Date	To Date	PM2.5	Sub Index	PM10	Sub Index	NO2	Sub Index	NH3	Sub Index	SO2	Sub Index	AQI	Daily AQI
4	01-01-2022 00:00	01-01-2022 01:00	200.75	362	277.00	227	105.75	126	34.9	9	3.70	5	362	
5	01-01-2022 01:00	01-01-2022 02:00	186.50	351	264.25	214	99.27	119	30.07	8	3.33	4	351	
6	01-01-2022 02:00	01-01-2022 03:00	165.25	335	222.75	182	84.55	105	32.95	8	3.50	4	335	
7	01-01-2022 03:00	01-01-2022 04:00	147.00	321	198.25	166	85.20	105	31.23	8	3.80	5	321	
8	01-01-2022 04:00	01-01-2022 05:00	134.00	311	194.50	163	74.50	93	26.25	7	3.83	5	311	
9	01-01-2022 05:00	01-01-2022 06:00	126.50	305	167.50	145	65.05	81	27.33	7	3.05	4	305	
10	01-01-2022 06:00	01-01-2022 07:00	114.00	280	140.25	127	64.90	81	22.85	6	2.80	4	280	
11	01-01-2022 07:00	01-01-2022 08:00	120.50	300	171.50	148	74.45	93	23.62	6	3.40	4	300	
12	01-01-2022 08:00	01-01-2022 09:00	117.50	292	212.50	175	87.20	107	27.77	7	4.33	5	292	
13	01-01-2022 09:00	01-01-2022 10:00	130.25	308	256.25	206	78.62	98	28.95	7	24.65	31	308	
14	01-01-2022 10:00	01-01-2022 11:00	130.00	308	187.25	158	86.03	106	29.62	7	31.93	40	308	
15	01-01-2022 11:00	01-01-2022 12:00	143.50	318	199.75	167	89.00	109	29.35	7	29.57	37	318	307
16	01-01-2022 12:00	01-01-2022 13:00	145.25	319	213.25	176	78.08	98	26.62	7	21.40	27	319	
17	01-01-2022 13:00	01-01-2022 14:00	126.75	305	197.25	165	58.95	74	24.73	6	12.52	16	305	
18	01-01-2022 14:00	01-01-2022 15:00	110.25	268	157.25	138	48.72	61	23.98	6	7.38	9	268	
19	01-01-2022 15:00	01-01-2022 16:00	95.00	217	138.75	126	47.28	59	24.47	6	4.80	6	217	
20	01-01-2022 16:00	01-01-2022 17:00	91.00	203	138.50	126	53.75	67	26.68	7	4.58	6	203	
21	01-01-2022 17:00	01-01-2022 18:00	83.50	178	130.50	120	79.75	100	27.38	7	5.50	7	178	
22	01-01-2022 18:00	01-01-2022 19:00	108.75	263	174.25	150	152.50	173	38.25	10	6.05	8	263	
23	01-01-2022 19:00	01-01-2022 20:00	156.50	328	249.25	200	171.98	192	42.25	11	8.62	11	328	
24	01-01-2022 20:00	01-01-2022 21:00	183.50	349	277.25	227	173.95	194	40.65	10	7.65	10	349	
25	01-01-2022 21:00	01-01-2022 22:00	214.50	373	314.75	265	177.58	198	45.83	11	10.25	13	373	
26	01-01-2022 22:00	01-01-2022 23:00	258.50	407	393.00	354	138.88	159	35.98	9	6.30	8	407	
27	01-01-2022 23:00	02-01-2022 00:00	211.75	371	296.50	247	105.95	126	31.35	8	4.33	5	371	

Fig 3.c Conversion of Hourly raw data to Hourly AQI and then Averaging them to Daily AQI

- **Conversion to Monthly Data:** The daily data was further aggregated to calculate the monthly average AQI. This step provides a broader overview of air quality trends over longer time periods and is useful for identifying seasonal variations and long-term trends.

Month	Monthly AQI
Jan-22	209
Feb-22	133
Mar-22	137
Apr-22	141
May-22	130
Jun-22	126
Jul-22	52
Aug-22	51
Sep-22	66
Oct-22	111
Nov-22	171
Dec-22	208

Fig 3.d Daily AQI is Averaged out to get the monthly AQI

- **Conversion Using CPCB's Norms:** The conversion of daily and monthly data was done using the norms and guidelines provided by the Central Pollution Control Board (CPCB). These norms define the methods for calculating average concentrations and converting them to standardized units, ensuring consistency and accuracy in the data analysis process.

Calculation of AQI

Date			Station	NSIT	
DD-MM-YYYY			City	Delhi	
			State	Delhi	
Pollutants		concentration in µg/m3 (except for CO)	Sub-Index	check	Air Quality Index
PM10	24-hr avg	121.00	114	1	
PM2.5	24-hr avg	97.33	224	1	
SO2	24-hr avg	0.00	0	0	
NO2	24-hr avg	8.00	10	1	AQI = 224
*CO (mg/m3)	max 8-hr	0.00	0	0	
O3	max 8-hr	57.00	57	1	
NH3	24-hr avg	34.00	9	1	

* Concentrations of minimum three pollutants are required; one of them should be PM10 or PM2.5

* The check displays "1" when a non-zero value is entered

Good (0–50)	Minimal Impact	Poor (201–300)	Breathing discomfort to people on prolonged exposure
Satisfactory (51–100)	Minor breathing discomfort to sensitive people	Very Poor (301–400)	Respiratory illness to the people on prolonged exposure
Moderate (101–200)	Breathing discomfort to the people with lung, heart disease, children and older adults	Severe (>401)	Respiratory effects even on healthy people

Fig 3.e AQI Calculator provided by CPCB

3.3 LULC Mapping using ERDAS Imagine:

- Preprocess the satellite imagery to improve quality and remove distortions, including radiometric and atmospheric corrections.
- Perform supervised or unsupervised classification using ERDAS Imagine to categorize land use and land cover into classes such as urban areas, vegetation, water bodies, and bare land.
- Validate the classified image using ground truth data collected from the field or existing land cover maps.

3.4 Importing Data into ARCGIS:

- Import the classified LULC map into ARCGIS for further analysis.
- Ensure that the spatial reference of the LULC map matches the AQI data for proper overlay analysis.

3.5 Spatial Analysis of AQI Variations:

- Use the Spatial Analyst extension in ARCGIS to interpolate the AQI data for each month to create continuous surfaces representing AQI levels across Chandigarh.
- Select an appropriate interpolation method (e.g., Kriging, Inverse Distance Weighting) based on the spatial distribution of the monitoring stations and the nature of the AQI data.
- Generate monthly AQI maps for Chandigarh showing the spatial distribution of air quality for each month.

3.6 Overlay Analysis:

- Overlay the LULC map with the monthly AQI maps to analyze the relationship between land use/land cover types and air quality variations.
- Identify areas with specific land use/land cover types that coincide with higher or lower AQI levels, providing insights into the impact of urbanization and land use changes on air quality.

3.7 Visualization and Reporting:

- Create visualizations, such as maps and charts, to present the spatial variations of AQI and their relationship with land use/land cover.
- Prepare a detailed report summarizing the methodology, key findings, and implications for air quality management and urban planning in Chandigarh.

4. Results Observations and Discussion

4.1 Seasonal Variations:

The analysis of monthly Air Quality Index (AQI) data for the past 28 months from three monitoring stations in Chandigarh (Sector 53, Sector 25, Sector 22) reveals a consistent trend: higher AQI levels during winter months (november, december, january and february) compared to summers (march, april, may and june) and monsoon (july, august and september) months. This seasonal variation is graphically depicted in the attached line chart, clearly illustrating the fluctuation in AQI levels throughout the year. The observed pattern can be attributed to several factors. During winter, the region experiences temperature inversions, where a layer of warm air traps cooler air near the ground. This phenomenon can lead to the accumulation of pollutants, especially particulate matter, resulting in poorer air quality. Additionally, increased emissions from heating systems, vehicular traffic, and industrial activities during the colder months contribute to higher pollutant concentrations. In contrast, the monsoon season often brings relief, as rainfall helps to disperse pollutants and cleanse the air. Understanding these seasonal variations is essential for developing targeted air quality management strategies to mitigate the adverse effects of pollution on public health and the environment.

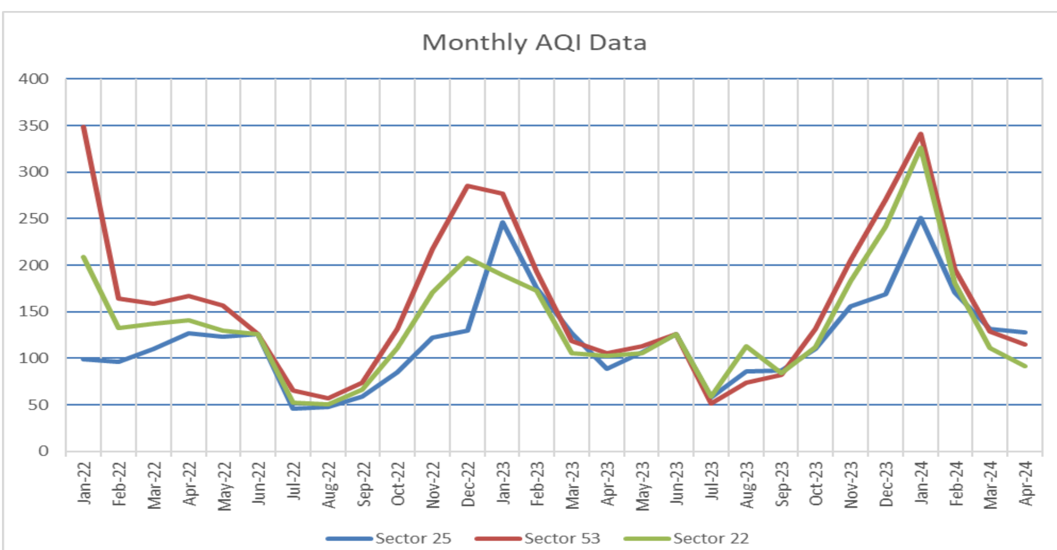
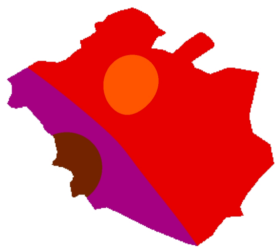
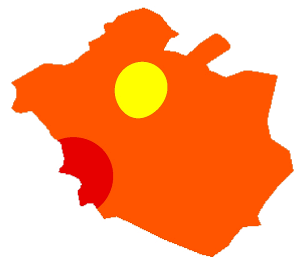


Fig 4.a Monthly Variation of AQI for the year 2022, 2023 and 2024

4.2 Spatial Mapping of AQI Variation:



Jan 22



Feb 22

Mar 22

Apr 22

May 22

Jun 22

Jul 22

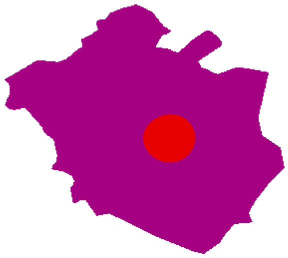
Aug 22

Sep 22

Oct 22

Nov 22

Dec 22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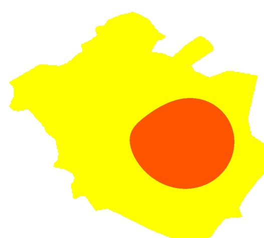
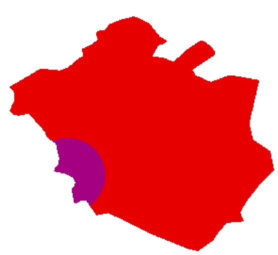
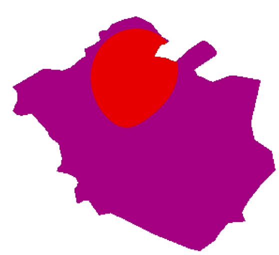

Aug 23

Sep 23


Oct 23


Nov 23


Dec 23

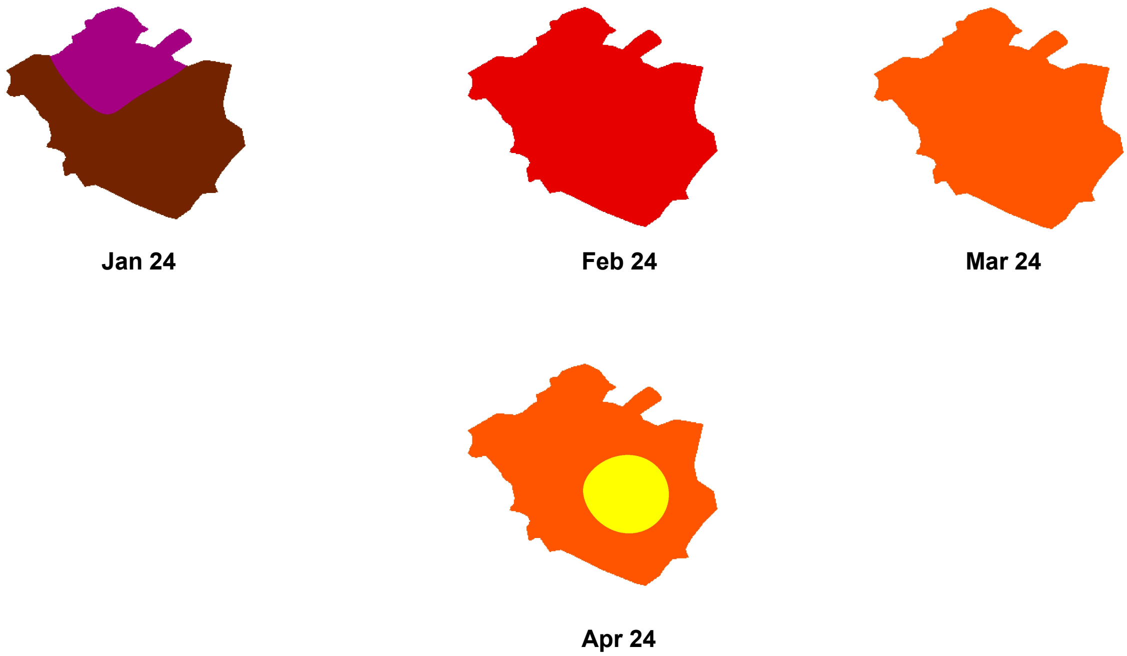


Fig 4.b Spatial Variation Maps showing change in AQI for the years 2022, 2023 and 2024

Daily AQI Color	Levels of Concern	Values of Index
Green	**Good**	**0 to 50**
Yellow	**Moderate**	**51 to 100**
Orange	**Unhealthy for Sensitive Groups**	**101 to 150**
Red	**Unhealthy**	**151 to 200**
Purple	**Very Unhealthy**	**201 to 300**
Maroon	**Hazardous**	**301 and higher**

Fig 4.c Table showing the daily AQI Color, Level of Concern and Values of Index
(Air Quality Index Basics, airnow.gov)

The spatial maps depicting the distribution of AQI in Chandigarh over the last 28 months reveal a clear pattern of seasonal variation. Consistent with the general trend observed in many urban areas, the winter months exhibit higher AQI levels, indicating poorer air quality, while the monsoon months typically show lower AQI levels, indicating better air quality. This pattern can be attributed to several factors.

During winter, the city experiences temperature inversions, where a layer of warm air traps cooler air near the ground. This phenomenon hampers the dispersion of pollutants, leading to their accumulation and resulting in higher AQI levels. Additionally, increased emissions from heating systems, vehicular traffic, and industrial activities during the colder months contribute to higher concentrations of pollutants, particularly particulate matter (PM2.5 and PM10), which are major contributors to poor air quality.

In contrast, the monsoon season brings relief, as rainfall helps to cleanse the atmosphere by removing pollutants and dust particles. The increased humidity and cloud cover also aid in the dispersion of pollutants, leading to lower AQI levels.

5. Future Work

Possible future work and solutions to problems observed in the air quality analysis of Chandigarh could include

5.1 Source Apportionment Studies:

Conducting source apportionment studies to identify the specific sources contributing to high pollutant levels in Chandigarh. This could involve emissions inventory analysis, source receptor modeling, and targeted monitoring campaigns.

5.2 Air Quality Forecasting:

Developing an air quality forecasting system for Chandigarh to provide real-time information on air quality conditions and help residents and policymakers take timely actions to mitigate pollution.

5.3 Air Purifiers:
Exploring the feasibility of installing big air purifiers in open spaces and regions with high air pollution levels to help improve air quality. These air purifiers could be designed to remove pollutants from the air and improve overall air quality in the area.

5.4 Green Infrastructure Development:
Implementing green infrastructure projects, such as increasing green cover, establishing urban forests, and promoting rooftop gardens, to improve air quality and reduce the urban heat island effect.

5.5 Transportation Planning:
Implementing sustainable transportation strategies, such as promoting public transportation, cycling, and walking, and encouraging the use of electric vehicles to reduce emissions from vehicles.

5.6 Industrial Emission Control:
Strengthening regulations and enforcement mechanisms to control emissions from industries, including promoting cleaner production technologies and implementing emission trading schemes.

6. Conclusions
In conclusion, this project has provided valuable insights into the air quality dynamics of Chandigarh over the past 28 months. The analysis of monthly AQI data from three monitoring stations has revealed distinct seasonal variations, with higher AQI levels observed during winter months and lower levels during monsoon months. These findings underscore the impact of seasonal meteorological conditions, emissions from various sources, and land use patterns on air quality in the city.

The spatial maps depicting the distribution of AQI have further highlighted the spatial variability of air quality within Chandigarh, emphasizing the need for localized air quality monitoring and management strategies. The observed higher AQI levels during winter months can be attributed to temperature inversions, increased emissions, and poor dispersion of pollutants. On the other hand, the lower AQI levels during monsoon months can be attributed to the cleansing effect of rainfall and increased dispersion of pollutants.

Overall, this project contributes to the body of knowledge on air quality management and urban planning in Chandigarh. The findings can inform policymakers, urban planners, and public health officials in developing effective strategies to improve air quality and mitigate the adverse health effects of air pollution in the city. Future research could focus on exploring the effectiveness of specific interventions, such as emission control measures and green infrastructure development, in reducing air pollution levels and improving air quality in Chandigarh

7. Reference

- AQI Calculator, CPCB https://cpcb.nic.in/upload/national-air-quality-index/AQI-Calculator.xls
- Central Control Room for Air Quality Management - All India https://airquality.cpcb.gov.in/ccr/#/caaqm-dashboard-all/caaqm-landing/caaqm-data-repository
- National Ambient Air Quality Series NAAQMS/36/2012-13 https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMjhfMTQ1ODExMDU4NV9OZXdJdGVtXzE5N19OQUFRTVNfVm9sdW1lLUlJLnBkZg==
- Assessment of the seasonal trends of air pollution: A case study of Gurugram city, Haryana, India, at el. Indraj Indraj*, Vishal Warpa