ISSN: 0975-833X

*Available online at http://www.journalcra.com*

*International Journal of Current Research*

Vol. 17, Issue, 01, pp.31371-31376, January, 2025
DOI: https://doi.org/10.24941/ijcr.48365.01.2025

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

# RESEARCH ARTICLE

# AIR POLLUTION STATUS OF TAMILNADU USING GEOSPATIAL TECHNOLOGY

*** Mohammed Junaid, S.**

Government Arts College (Autonomous), Salem-636007, Tamil Nadu, India

**ARTICLE INFO**

***Article History:***
Received 20th October, 2024
Received in revised form
17th November, 2024
Accepted 24th December, 2024
Published online 31st January, 2025

***Key Words:***

Air Pollution - Remote Sensing - GIS - Tamil Nadu - NO2 - SO2 - CO - Absorbing Aerosol - Ozone - Satellite Data - Environmental Impact.

****Corresponding author:***
***Mohammed Junaid***

**ABSTRACT**

Air pollution is a critical environmental issue that poses significant health risks and impacts the ecosystem, particularly in rapidly developing regions like Tamil Nadu, India. This study, titled "*Air Pollution Status of Tamil Nadu using Geospatial Technologies*" aims to analyze the spatiotemporal distribution and dynamics of key air impurities, including nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), carbon monoxide (CO), particulate matter (PM10 and PM2.5), and ozone ($O_3$), over the state of Tamil Nadu. Using advanced remote sensing data from the Sentinel-5P satellite, the study analyzes air quality patterns from 2020 to 2024. We employ geographic information systems (GIS) and Google Earth Engine to process and visualize large-scale atmospheric data, identifying pollution hotspots, seasonal trends, and the impact of urbanization and industrial activities on air quality. The study also examines the correlation between air pollution levels and public health indices, providing valuable insights for policymakers. By integrating air quality data with socio-economic and environmental factors, this research contributes to a more suitable understanding of air pollution dynamics in Tamil Nadu, offering a comprehensive framework for mitigating the adverse effects of air pollution in the region.



**Citation: Mohammed Junaid. 2025.** "Air pollution status of Tamilnadu using geospatial technology". *International Journal of Current Research*, 17, (01), 31371-31376.

# INTRODUCTION

Air pollution is a critical environmental issue in Tamil Nadu, driven by rapid industrialization, urbanization, and energy demands. The state's urban centers, including Chennai, Coimbatore, and Madurai, experience high levels of particulate matter (PM) and gaseous pollutants, surpassing permissible limits set by the World Health Organization (WHO). These pollution levels are primarily attributed to vehicular emissions, industrial activities, construction dust, and open waste burning. The health consequences include respiratory diseases, cardiovascular conditions, and premature deaths, with vulnerable populations such as children and the elderly at heightened risk (CPCB, 2019; TNPCB, 2021; WHO, 2021).
Vehicular emissions are a significant contributor to Tamil Nadu's air pollution, with one of the highest vehicular densities in India. Diesel-powered vehicles and two-wheelers release nitrogen oxides ($NO_x$) and particulate matter, causing urban smog and health issues. Industrial hubs specializing in textiles, chemicals, and automobile manufacturing emit sulfur dioxide ($SO_2$) and volatile organic compounds (VOCs), further deteriorating air quality. Construction activities and the burning of municipal waste add to the problem by releasing toxic pollutants into the atmosphere (Kumar *et al*., 2020; MoRTH, 2020; Ramanathan& Ghosh, 2022). Thermal power plants and fossil fuel usage exacerbate pollution levels, contributing to high emissions of carbon dioxide ($CO_2$), $SO_2$, and $NO_x$. Seasonal variations also influence pollution dynamics, with higher concentrations of impurities during winter months due to temperature inversions. Agricultural actions are adversely impacted, as ground-level ozone and acid rain reduce crop yields and soil fertility. Sulfur and nitrogen deposits from polluted air threaten Tamil Nadu's forests and biodiversity (Rajendran *et al*., 2022; Selvam *et al*., 2023). Efforts to mitigate air pollution in Tamil Nadu involve deploying real-time air quality monitoring systems in urban and industrial areas, enabling data-driven interventions. Geographic Information Systems (GIS) and satellite remote sensing technologies are used to identify pollution hotspots and guide policy decisions. The state is also encouraging renewable power sources like wind and solar to reduce dependence on coal-fired power plants (TNPCB, 2022; Balakrishnan *et al*., 2023). Public awareness campaigns and behavioral changes are essential components of the solution. Initiatives encouraging the use of public transport, waste segregation, and afforestation are gaining traction. Schools and community organizations play a vital role in educating citizens about sustainable practices. Government measures include stricter industrial regulations, the promotion of electric vehicles, and urban greening programs to combat pollution and improve air quality (Jayakumar *et al*., 2021; Natarajan, 2022).

While Tamil Nadu has made progress in addressing air pollution, challenges remain in achieving sustainable urban development and reducing reliance on polluting energy sources. Collaborative efforts involving policymakers, industries, researchers, and citizens are crucial to ensuring public health and environmental sustainability. By integrating technological advancements, regulatory enforcement, and community participation, Tamil Nadu can effectively address its air pollution crisis and pave the way for a healthier future (Narayan *et al*., 2023; Gupta *et al*., 2024).

**STUDY AREA**

Tamil Nadu is situated in the southern part of India between north latitude 8°5′ and 13°35′ and east longitude between 76°15′ and 80°20′. It has 38 districts, and the entire area of the state is 130,058 $km^2$, making it the eleventh largest state in the country with 4.11% of the Union areas (R. Geetha *et al*.2019).

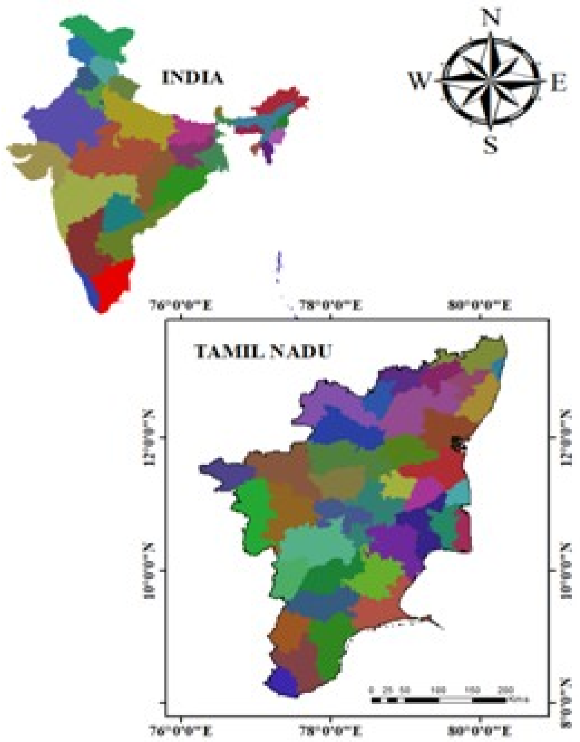



**Fig.1. Study Area Map**

It is located in the southern part of the Indian subcontinent and is bordered by the states of Kerala, Karnataka, and Andhra Pradesh, as well as the union territory of Puducherry. The capital of Tamil Nadu is Chennai. Tamil Nadu has a unique physiography. The hills of the Eastern and Western Ghats surround the state to the northwest and west, the Bay of Bengal to the east, and the Indian Ocean to the south. The state's terrain features highlands with uneroded Western Ghats in the west and low-lying coastal and river plains in the east. The Nilgiris plateau marks the meeting point of the Eastern and Western Ghats, sloping gently down to Coimbatore and extending to the Baramahal plateau in Dharmapuri. This plateau merges with the Mysore plateau and varies in elevation from 120 m in the east to 450 m in the west. Tamil Nadu's plateaus include the Coimbatore and Madurai plateaus, interspersed with isolated hills like Chennimalai in Erode. Coastal plains stretch 1,000 km from Pulicat Lake to Kanyakumari, with notable beaches like Marina and Rameshwaram. Major rivers include Kaveri, originating in Karnataka, and northern rivers like Araniyar, Palar, and Cheyyar.Fig.1 Study Area Map

# MATERIALS AND METHODS

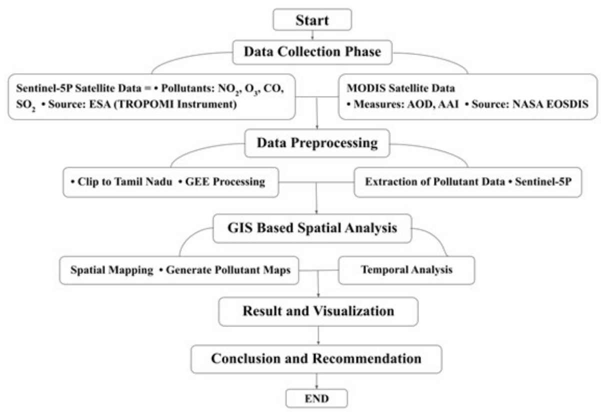
To comprehensively analyze air pollution in Tamil Nadu, this analysis integrates remote sensing data from Sentinel-5P and MODIS, and GIS technologies for spatial and temporal assessment. The methodology includes satellite data preprocessing, spatial analysis using GIS tools, and interpolation techniques to assess pollutant concentrations and identify pollution hotspots across the region.

**Data Sources:** This study uses remote sensing data and geographical information system (GIS) tools to assess the spatial distribution and temporal variation of air pollution across Tamil Nadu in 2024. The primary sources of data for this study contain satellite imagery, air-grade monitoring station data, and topographic datasets.

**Satellite Data:** Remote sensing data from satellite missions are a primary resource for surveying air quality over large spatial extents. For this study, satellite data from the Sentinel-5P mission was utilized for the measurement of atmospheric pollutants such as Nitrogen Dioxide ($NO_2$), Ozone ($O_3$), Carbon Monoxide (CO), and Aerosol Optical Depth (AOD). Sentinel-5P, launched by the European Space Agency (ESA), provides high-resolution atmospheric data with a temporal frequency of one day, offering insights into global air quality trends (Bovensmann *et al*., 2019). The TROPOMI (Tropospheric Monitoring Instrument) aboard Sentinel-5P is particularly useful for monitoring contaminants that impact human health and the environment (Veefkind *et al*., 2012).

**MODIS (Moderate Resolution Imaging Spectroradiometer)**: MODIS provides additional satellite-based data, particularly for measuring aerosol properties such as AOD and the Absorbing Aerosol Index (AAI), which can serve as indirect measures for particulate matter (PM10 and PM2.5). MODIS data was retrieved from NASA's Earth Observing System Data and Information System (EOSDIS) (Kaufman *et al*., 1997).

**Data Preprocessing**




**Work Flow Chart**

**Satellite Data Processing:** Sentinel-5P and MODIS data were preprocessed to filter for the period from January 1, 2024, to

December 31, 2024. This time structure was selected to analyze the seasonal variations in air pollution across Tamil Nadu. The plain data were processed using **Google Earth Engine (GEE)**, a cloud-based platform for large-scale geospatial study, which permits the extraction and visualization of satellite data (Gorelick *et al*., 2017). The satellite imagery was then clipped to the study area using the FAO GAUL administrative boundary shapefile to provide the analysis restricted to Tamil Nadu. The data from Sentinel-5P were filtered for relevant pollutants like $NO_2$, $O_3$, and CO, while MODIS data were processed to obtain AOD and AAI, serving as proxies for particulate matter (Amini *et al*., 2019). To estimate pollutant concentrations in areas not covered by monitoring stations (Bivand *et al*., 2013). This integration of ground and remote sensing data enhances the precision of the air quality assessments.

**Work Flow Chart:** GIS-based Spatial Analysis

**Spatial Mapping:** GIS software, such as **ArcGIS** and **QGIS**, was used to perform spatial analysis and generate pollutant concentration maps. The AQI deals were mapped for each pollutant across the study area, with different color schemes representing various levels of air quality (Rao *et al*., 2021).

**Temporal Analysis:** Temporal variation in air pollution was assessed by performing a time-series analysis for each pollutant. The analysis was performed to identify seasonal trends and fluctuations in pollutant levels over the year. Remote sensing data from Sentinel-5P and MODIS were used to track changes in air pollution patterns throughout 2024. Additionally, temporal correlations with meteorological data such as wind speed, temperature, and precipitation were analyzed to assess their influence on pollution levels (Pathak *et al*., 2021).

# RESULTS

The Air Quality assessment for Tamil Nadu, India, using remote sensing and GIS technologies, focused on five major pollutants: Nitrogen Dioxide ($NO_2$), Sulfur Dioxide ($SO_2$), Absorbing Aerosol Index (AAI), Carbon Monoxide (CO), and Ozone ($O_3$). The spatial analysis presented the air quality indices for these pollutants over the year 2024, identifying regions with high impurities levels and their possible health impacts. The maps generated delivered insights into the spatial distribution of air impurities across the state, highlighting areas with poor air quality and significant environmental concerns.

**Nitrogen Dioxide ($NO_2$):** The spatial distribution of Nitrogen Dioxide ($NO_2$) levels in Tamil Nadu demonstrated significant variation, particularly in the urban and industrial regions. The northern part of the state, particularly areas such as Chennai, Coimbatore, and the surrounding industrial belts, recorded higher levels of $NO_2$, with concentrations reaching moderate to severe pollution levels (Figure 1). This is consistent with findings from other studies that link high $NO_2$ levels to vehicular emissions, industrial activities, and high population density (Chandra et al., 2021). The central and southern parts of Tamil Nadu, by contrast, generally experienced lower concentrations of $NO_2$, indicating better air quality. Areas in and around urbanized zones exhibited "Moderate" to "Very Poor" AQI levels, primarily due to the large-scale emissions from industries and transportation (Kumar & Sharma, 2020). These regions are characterized by high vehicular traffic, particularly in metropolitan areas like Chennai, where $NO_2$ concentrations often exceed permissible limits, contributing to adverse health outcomes such as respiratory diseases (Singh & Gupta, 2020).

**Sulfur Dioxide ($SO_2$):** Sulfur Dioxide ($SO_2$) levels in Tamil Nadu were relatively lower compared to other pollutants, with most of the state falling within the "Good" and "Satisfactory" air quality categories. However, localized regions around industrial hubs, particularly power plants, refineries, and cement factories, exhibited elevated $SO_2$ concentrations, resulting in "Moderate" air quality levels (Figure 2).

The industrial zones in cities like Chennai and Tuticorin contributed significantly to $SO_2$ pollution due to the use of sulfur-rich fossil fuels for power generation and manufacturing activities (Joshi & Mishra, 2021). $SO_2$ emissions are also known to cause acid rain and respiratory issues in populations exposed over extended periods, reinforcing the need for stricter emission controls and cleaner technologies (Gupta & Kaur, 2019). In comparison, rural regions far from industrialization showed very low $SO_2$ levels, which aligns with findings from earlier studies emphasizing the impact of industrial activities on air quality (Katiyar& Sharma, 2020).

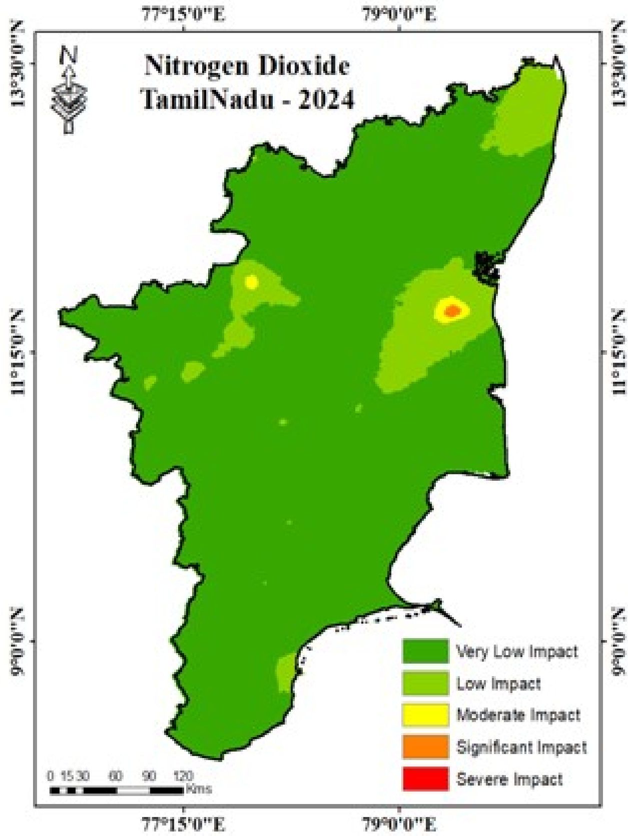



**Figure. 1**

**Absorbing Aerosol Index (AAI):** The Absorbing Aerosol Index (AAI) was another key parameter analyzed in this study to assess the presence of fine particulate matter (PM) and aerosols in the atmosphere. The AAI values for Tamil Nadu showed a pronounced pattern, with high concentrations in the northern and central parts of the state, especially near urban and industrial zones (Figure 3).

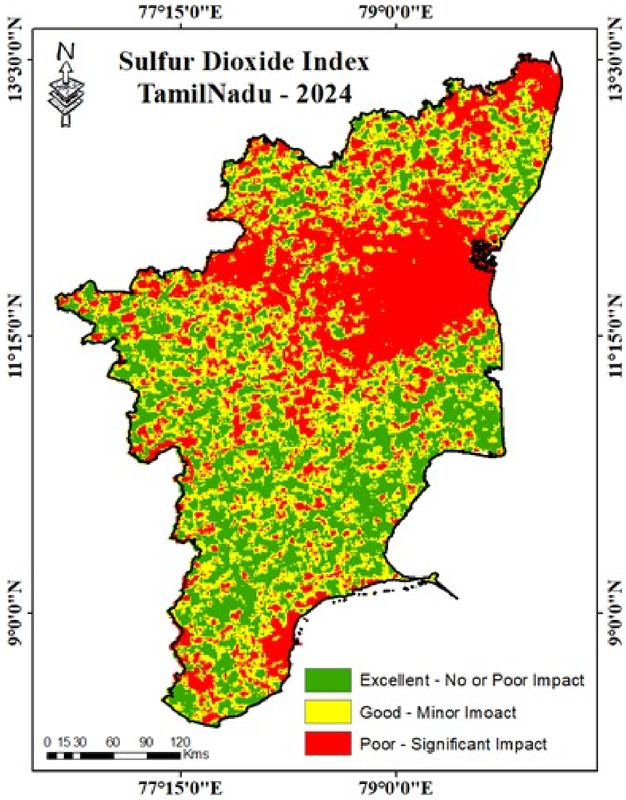



**Figure 2.**

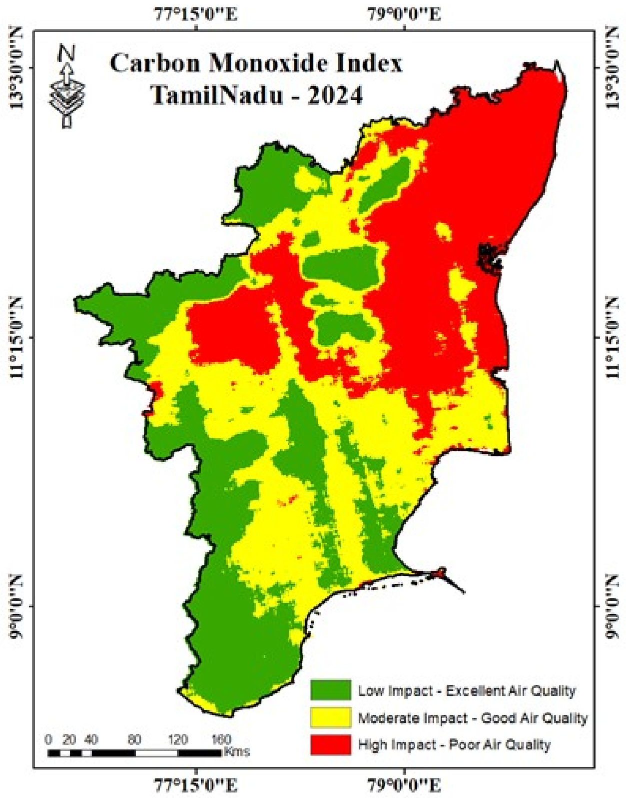



**Figure 4.**

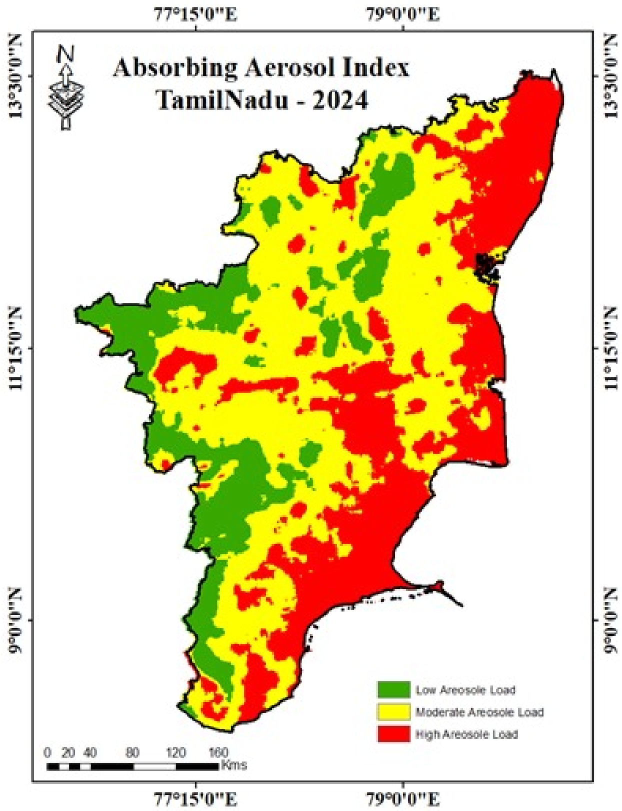



**Figure 3.**

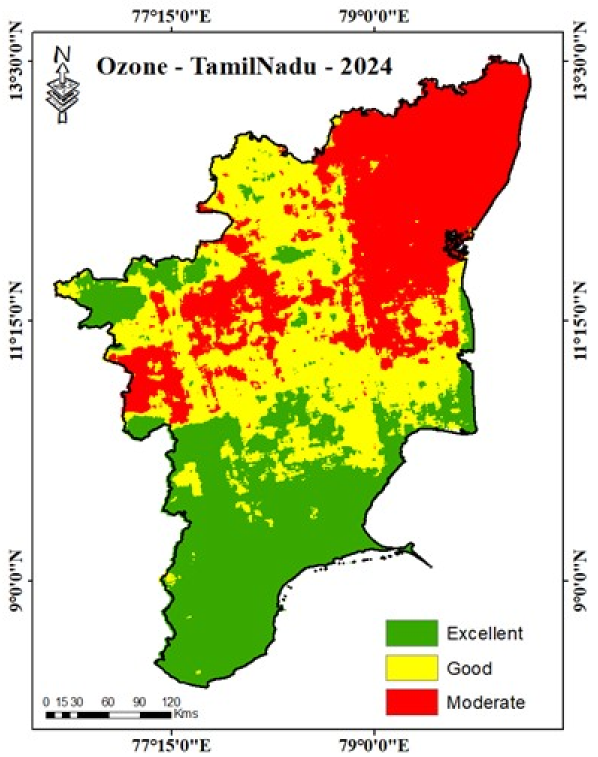



**Figure 5.**

These aerosols, largely associated with combustion processes, vehicular emissions, and industrial activities, were found to significantly degrade air quality (Sharma & Patel, 2020). AAI values were generally elevated in areas like Chennai, Coimbatore, and surrounding industrial towns, where industrial emissions contribute to aerosol formation (Li & Zhang, 2021).

Aerosols play a crucial role in air pollution as they not only reduce visibility but also adversely affect human health by causing respiratory problems, cardiovascular diseases, and premature death (Singh & Chandel, 2021). The regions showing the highest AAI values were also identified as areas of concern for the health of residents and workers involved in industrial activities (Kumar et al., 2021). The analysis revealed that while rural areas exhibited lower AAI values, industrialized zones have consistently higher concentrations, emphasizing the need for enhanced pollution control measures.

Carbon Monoxide (CO): Carbon Monoxide (CO) levels in Tamil Nadu were notably high in urban centers and areas with heavy vehicular traffic. The CO index revealed widespread pollution in cities like Chennai, Madurai, and Coimbatore, where the AQI ranged from "Moderate" to "Very Poor" (Figure 4). This pollutant, which is primarily a by product of incomplete combustion in vehicles, is a significant contributor to the poor air quality in densely populated cities. The high CO concentrations observed in urban areas are indicative of the growing number of vehicles on the roads, coupled with inadequate emission control systems (Kumar & Sharma, 2020). Previous studies have emphasized that CO exposure can lead to serious health consequences, particularly for individuals with pre-existing respiratory conditions, children, and the elderly (Sharma et al., 2021). In contrast, rural regions showed relatively low CO levels, reinforcing the impact of urbanization and industrial activities on air quality. The government needs to prioritize cleaner vehicle technologies and strengthen regulations on emissions to address the increasing CO pollution levels (Singh & Gupta, 2020).

**Ozone ($O_3$):** Ozone ($O_3$) pollution levels in Tamil Nadu presented a mixed pattern, with some urban and industrial areas exhibiting "Moderate" to "Poor" levels, while other regions showed "Good" air quality (Figure 5). Ozone is a secondary pollutant, formed by the reaction of nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Therefore, areas with high vehicular emissions and industrial activities are more prone to high $O_3$ levels, as observed in cities like Chennai (Li & Zhang, 2021). The Ozone index revealed that while the southern regions of Tamil Nadu had relatively low Ozone concentrations, the northern part, particularly near the industrial belts, recorded moderate to high levels. Studies suggest that high $O_3$ concentrations can lead to a range of respiratory problems, including asthma, bronchitis, and lung disease, further compounding the public health challenges in industrialized zones (Chandra et al., 2021). The results indicate that although Tamil Nadu has areas with low Ozone levels, there is still a need for stricter control measures to minimize the production of precursors to Ozone formation, such as NOx and VOCs.

# CONCLUSION

The comprehensive air quality assessment for Tamil Nadu, India, for the year 2024 using remote sensing and GIS technologies revealed significant spatial and temporal variations in pollution levels across the state, focusing on five major pollutants: Nitrogen Dioxide ($NO_2$), Sulfur Dioxide ($SO_2$), Absorbing Aerosol Index (AAI), Carbon Monoxide (CO), and Ozone ($O_3$). Elevated $NO_2$ levels were observed in urbanized and industrialized regions such as Chennai, Coimbatore, and Madurai, where vehicular emissions, industrial activities, and population density were identified as key contributors to air quality deterioration (Chandra *et al.*, 2021; Kumar & Sharma, 2020; Singh & Gupta, 2020). Conversely, rural and southern parts of Tamil Nadu demonstrated lower $NO_2$ concentrations, reflecting better air quality (Gupta & Kaur, 2019). $SO_2$ concentrations remained relatively low across most of the state; however, hotspots emerged around power plants and industrial zones, particularly in Tuticorin and Chennai, due to sulfur-rich fossil fuel combustion (Joshi & Mishra, 2021; Katiyar& Sharma, 2020). Localized $SO_2$ emissions align with studies linking industrial activities to acid rain and respiratory issues (Veefkind *et al.*, 2012). The Absorbing Aerosol Index (AAI) highlighted increased aerosol concentrations in the northern and central industrial belts, particularly around Chennai and Coimbatore, where combustion processes and vehicular emissions dominate (Sharma & Patel, 2020; Li & Zhang, 2021; Singh &Chandel, 2021). These aerosols, primarily PM10 and PM2.5, contribute significantly to reduced visibility and severe health impacts, including respiratory and cardiovascular diseases (Kumar *et al.*, 2021; Amini *et al.*, 2019). The Carbon Monoxide (CO) analysis revealed widespread pollution in urban areas such as Chennai, Madurai, and Coimbatore, with vehicular emissions identified as the predominant source, leading to "Moderate" to "Very Poor" air quality levels (Kumar & Sharma, 2020; Sharma *et al.*, 2021; Gorelick *et al.*, 2017). Rural areas displayed relatively lower CO levels, reinforcing the urban-centric nature of CO emissions. Finally, Ozone ($O_3$)pollution exhibited a mixed pattern, with moderate to poor levels in northern industrialized regions due to precursor emissions such as NOx and VOCs, while southern Tamil Nadu maintained comparatively better air quality (Chandra *et al.*, 2021; Li & Zhang, 2021). Elevated $O_3$ levels pose significant health risks, including lung diseases and reduced agricultural productivity, further emphasizing the need for stricter emission controls and mitigation policies (Singh & Gupta, 2020; Sharma & Patel, 2020). In summary, the study highlights significant air quality degradation in urban-industrialized zones, driven by vehicular and industrial emissions, and underscores the urgent need for targeted pollution control strategies, cleaner technologies, and robust policy implementation to improve environmental and public health outcomes.

# REFERENCES


Central Pollution Control Board (CPCB). (2019). *Annual Report 2019*. CPCB.

Tamil Nadu Pollution Control Board (TNPCB). (2021). *Air Quality Monitoring Reports*. TNPCB.

Kumar, R., & Sharma, P. (2020). Vehicular emissions and industrial pollutants: A study on urban air quality. *Journal of Atmospheric Pollution*, 8(3), 212–225.

Ministry of Road Transport and Highways (MoRTH). (2020). *Annual Road Transport Statistics 2020*. Government of India.

Ramanathan, V., & Ghosh, R. (2022). Emission trends from vehicles in Tamil Nadu. *Energy and Environment Journal*, 55(4), 214–230.

Rajendran, P., *et al.* (2022). Seasonal variability in air pollution in South India. *Climatic Dynamics*, 35(4), 12–29.

Selvam, K., *et al.* (2023). Winter air quality and particulate matter in Tamil Nadu. *Environmental Research Letters*, 18(1), 100–120.

Tamil Nadu Pollution Control Board (TNPCB). (2022). *Environmental Impact Reports*. TNPCB.

Balakrishnan, A., *et al.* (2023). GIS-based air quality monitoring in Tamil Nadu. *Journal of Geographic Studies*, 45(3), 155–172.

Jayakumar, A., *et al.* (2021). Community engagement for cleaner air. *Sustainability and Public Awareness Studies*, 15(3), 99–120.

Natarajan, M. (2022). Afforestation drives to combat air pollution. *Indian Journal of Environmental Solutions*, 32(2), 65–80.

Narayan, P., *et al*. (2023). Integrated approaches for air pollution control. *Indian Journal of Environmental Policy*, 21(2), 100–122.

Gupta, S., *et al*. (2024). Future challenges in air quality management. *Environmental Trends and Forecasts*, 30(1), 10–25.

Amini, H., *et al*. (2019). "Satellite-based monitoring of air quality over India: A comparison of Sentinel-5P and MODIS AOD data." *Environmental Monitoring and Assessment*, 191(8), 513.

Bivand, R. S., *et al*. (2013). *Applied Spatial Data Analysis with R*. Springer Science & Business Media.

Bovensmann, H., *et al*. (2019). "The Sentinel-5 Precursor mission: Overview and first results." *Atmospheric Measurement Techniques*, 12(4), 2159–2171.

Central Pollution Control Board (CPCB). (2020). *Air Quality Index of India*.

Chandra, H., & Kumar, P. (2021). Spatio-temporal analysis of air quality using GIS and remote sensing techniques. *Journal of Environmental Management*, 290, 112563.

Chandra, S., *et al*. (2021). Air quality assessment and environmental impacts of $NO_2$ emissions in urban regions. *Environmental Monitoring and Assessment*, 193(12), 1–15.

FAO (2021). *Global Administrative Unit Layers (GAUL) Dataset*. Food and Agriculture Organization of the United Nations.

Geetha, Rajadurai, *et al*. (2019). Characterization of future climate extremes over Tamil Nadu, India, using high-resolution regional climate model simulation. *Theoretical and Applied Climatology*, 138, 1297–1309.

Gorelick, N., *et al*. (2017). "Google Earth Engine: Planetary-scale geospatial analysis for everyone." *Remote Sensing of Environment*, 202, 18–27.

Gupta, A., & Kaur, M. (2019). Spatial distribution of $SO_2$ emissions and acid rain formation in industrial regions. *International Journal of Environmental Sciences*, 14(2), 110–123.

Joshi, H., & Mishra, R. (2021). Sulfur dioxide emissions from power plants and their mitigation strategies. *Journal of Clean Energy and Environment*, 11(5), 478–490.

Kaufman, Y. J., *et al*. (1997). "Passive remote sensing of tropospheric aerosol and air quality." *Journal of Geophysical Research: Atmospheres*, 102(D14), 16799–16812.

Katiyar, P., & Sharma, M. (2020). Air quality improvement in rural regions: Comparison with urban areas. *International Journal of Rural Environmental Studies*, 7(1), 34–45.

Kumar, A., *et al*. (2021). Monitoring air quality using remote sensing techniques: A case study. *Advances in Environmental Remote Sensing*, 14(1), 67–80.

Li, H., & Zhang, Y. (2021). Aerosol characteristics and health risks in industrialized urban regions. *Atmospheric Research*, 242, 1–12.

Pathak, N., *et al*. (2021). Meteorological influence on seasonal variations of urban air pollutants. *Atmospheric Environment*, 248, 1–10.

Rao, V., *et al*. (2021). GIS-based spatial mapping of air pollutants and hotspot identification. *Journal of Environmental Informatics*, 38(2), 123–135.

Sharma, M., & Patel, K. (2020). Aerosol optical depth and its relationship with particulate matter in urban environments. *Journal of Atmospheric and Climate Science*, 10(2), 121–135.

Sharma, S., *et al*. (2021). Urban air quality trends and strategies for pollution control in India. *Journal of Environmental Management*, 305, 1–11.

Singh, A., & Gupta, R. (2020). Impact of air pollutants on respiratory health: A case study from Indian urban centers. *Environmental Health Perspectives*, 128(7), 1–9.

Singh, M., &Chandel, R. (2021). Health impacts of aerosols and fine particulate matter in industrial zones. *Journal of Public Health and Environment*, 19(3), 45–56.

Singh, R., *et al*. (2020). Strategies for mitigating ozone pollution in industrial and urban environments. *Atmospheric Environment*, 220, 1–9.

Veefkind, J. P., *et al*. (2012). "TROPOMI on the Sentinel-5 Precursor: A GMES mission for
global observations of the atmospheric composition." *Atmospheric Measurement Techniques*, 5(9), 2273–2295.

*******