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Full Length Research Article

An Assessment of Air Quality in Siliguri, West Bengal: Current Scenario and Challenges

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Abstract

Air pollution is a growing environmental concern in urban India, and Siliguri is no exception. Located in West Bengal, Siliguri is an important economic hub for northeastern India, strategically positioned near national borders. Rapid urbanization, traffic congestion, industrial activities, and changing land-use patterns have contributed to a concerning increase in air pollution in Siliguri. This article presents an assessment of air quality across Siliguri to understand the sources, variations, and potential mitigation strategies specific to different areas within the city. To evaluate the pollution status in Siliguri, one automatic monitoring station was strategically established at key sites across the city: Babu Para in Ward 33,Tinbatti More areaand another one is in the University of North Bengal campus, by the West Bengal Pollution Control Board (WBPCB). Data from the WBPCB sitesprovided a detailed picture of air quality trends. Additionally, regular primary field surveys were conducted at various locations to pinpoint main pollution sources and understand their effects on public health. The result shows that amount of PM 10 and PM 2.5 the air are excessively higher. The findings also show that pollution levels are heavily influenced by seasonal changes, meteorological conditions, and vehicle quality, highlighting the dynamic air quality in Siliguri and the need for targeted, adaptive management strategies.

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Keywords: Air Pollution, WBPCB, Meteorological events, Air Quality.

1. Introduction

Evaluating air quality is essential for pinpointing regions that require immediate pollution control interventions. Air pollution results from the release of hazardous substances into the atmosphere, significantly increasing the risk of health problems such as respiratory disorders, allergies, cardiovascular diseases, and cancer. Major contributors to air pollution include greenhouse gases like carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), methane (CH_4), chlorofluorocarbons (CFCs), and ammonia (NH_4), along with particulate matter. Additionally, minor sources such as aerosols, dust, burning leaves, perfumes, and smoking also contribute to air contamination. According to a 2014 report by the World Health Organization (WHO), air pollution is responsible for approximately seven million deaths worldwide each year, making it the most significant environmental health hazard (World Health Organization, 2014). In India, air pollution has escalated into a major public health concern. The 2018 World Air Quality Report by IQAir found that 22 out of the 30 most polluted cities globally were in India (IQAir, 2018). Additionally, a study using 2016 data from Greenpeace India and AirVisual revealed that at least 140 million people in the country are exposed to air pollution levels ten times higher than the WHO's recommended safe limit. This contributes to an estimated two million premature deaths annually (Greenpeace India & AirVisual, 2018).

Siliguri, a rapidly developing city in West Bengal, serves as a key transit point for northeastern India. In recent years, swift urbanization and economic expansion have resulted in significant environmental challenges, with air pollution emerging as a major concern. According to reports from the Central Pollution Control Board (2021) and the West Bengal Pollution Control Board (2022), Siliguri frequently experiences high concentrations of particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2), surpassing national air quality standards (Das & Choudhury, 2019). The rapid urbanization of the region has exacerbated these issues, with an increase in vehicular density and unregulated industrial emissions contributing to worsening air pollution (Sharma & Gupta 2018, Roy & Singha, 2020a). These pollutants pose severe health risks, particularly respiratory and cardiovascular diseases, affecting vulnerable populations such as children and the elderly. The city's growth has been accompanied by rising industrial activities, vehicle emissions, and construction dust, all of which contribute to declining air quality. Additionally, Siliguri’s geographical location at the foothills of the Eastern Himalayas influences pollution patterns, particularly during winter when temperature inversions trap pollutants close to the ground. The surge in urbanization has further intensified these issues, as increased vehicular traffic and unregulated industrial emissions worsen air pollution. Exposure to these pollutants has severe health consequences, particularly for vulnerable populations such as children and the elderly, leading to higher incidences of respiratory and cardiovascular illnesses. A temporary improvement in air quality was noted during the COVID-19 lockdown due to reduced transportation and industrial activities (Roy *et al*, 2020a). However, pollution levels have risen again post-lockdown, underscoring the need for long-term pollution control measures. Growing public awareness has led to increasing demands from citizens and environmental groups for stricter regulations and sustainable urban development policies. While the National Clean Air Program (NCAP) has introduced certain measures to address air pollution, their success depends on proper implementation and long-term planning to ensure lasting improvements in air quality.

2. Study area

Siliguri is a major urban center in the northern part of West Bengal, India. Geographically, it is located between 26°41’N to 26°46’N latitude and 88°24’E to 88°28’E longitude, at the foothills of the Eastern Himalayas, along the banks of the Mahananda River. Its strategic location makes it an important gateway connecting the northeastern states of India with the rest of the country. Siliguri is also located close to three international borders—Nepal to the west, Bhutan to the north, and Bangladesh to the south—enhancing its importance as a transit and trade hub. Major national highways, including NH-10 and NH-31, pass through the city, facilitating regional and cross-border connectivity. Administratively, Siliguri is governed by the Siliguri Municipal Corporation (SMC), which is divided into 47 wards (Figure 1). Each ward has its own population characteristics and infrastructural features. According to the Census of India 2011, the total population under SMC jurisdiction was 513,264, with 263,702 males and 249,562 females, resulting in a sex ratio of 946 females per 1000 males. Children aged 0–6 years accounted for about 43,915 individuals, representing roughly 8.5% of the population. While official data on the aged population is limited, estimates suggest that around 8–10% of residents are above 60 years of age. The city has a literacy rate of 82.5%, with male literacy at 86.8% and female literacy at 78% (Census, 2011). In recent years, Siliguri has witnessed rapid urban growth due to in-migration from nearby hill and rural areas, as well as from neighboring countries. The current estimated population in 2025 is 7,49,000 (Siliguri Municipal Corporation. (n.d.)**.** This growing urban pressure presents challenges related to infrastructure, transportation, housing, healthcare, and education, particularly in densely populated wards.

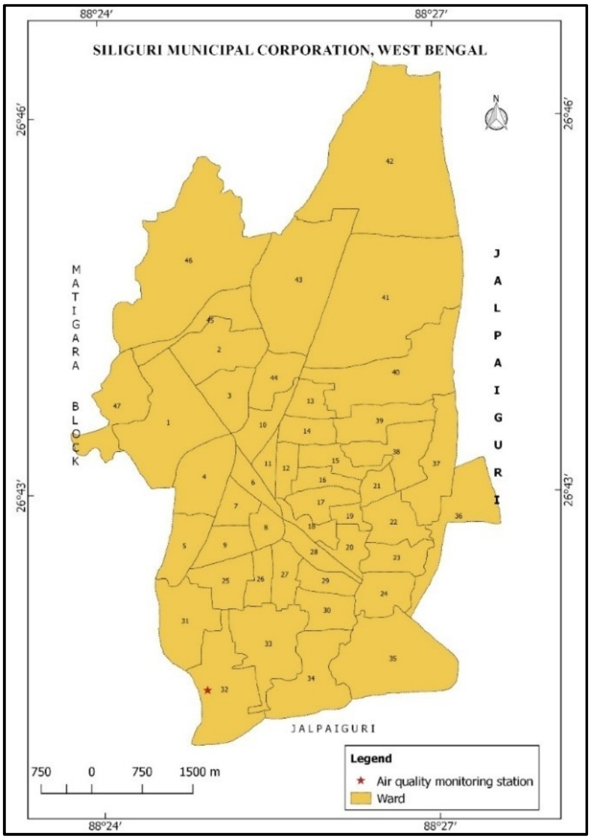

Figure 1: Ward distribution map of the study area

3. Objective

This article aims to analyse the air pollution trends in Siliguri from the year 2014 to 2024, explore its sources and health impacts, and discuss potential mitigation strategies for achieving sustainable urban development while ensuring better air quality for its residents.

4. Methodology

This study analysed the air quality in Siliguri, West Bengal, using real-time data obtained from an automatic monitoring station located in Babu Para, Ward 33, near the Tinbatti More area (Plate 1). The monitoring station continuously recorded multiple air quality parameters, providing a comprehensive assessment of pollution levels (Plate 2). The key parameters measured included Particulate Matter (PM10 & PM2.5), which are fine particles responsible for respiratory issues; Sulphur Dioxide (SO2), mainly emitted from industrial activities and vehicular emissions; Nitrogen Dioxide (NO2), a pollutant generated from combustion processes; Carbon Monoxide (CO), primarily emitted from vehicular sources; Ozone (O3), a secondary pollutant formed through photochemical reactions; and Ammonia (NH3), released from industrial and agricultural activities.The data was collected over a 11-year period, from 2014 to 2024. Each month, eight data points were collected, and an average value was calculated to assess variations in pollutant concentrations over time.A comparative analysis was performed by comparing the observed pollutant levels with the National Ambient Air Quality Standards (NAAQS) prescribed by the Central Pollution Control Board (Table 1). Additionally, statistical analysis was carried out, involving descriptive statistics such as mean, standard deviation, and range for each parameter. Correlation analysis was also conducted to identify relationships between different pollutants. To enhance interpretation, data trends were visualized using graphs and charts.The results were analyzed to assess the severity of air pollution in Siliguri. The study identified peak pollution period, possible sources of pollution, and seasonal variations. Furthermore, the findings were compared with previous studies and reports to evaluate long-term trends over time.Based on the analysis, conclusions were drawn regarding the air quality conditions in Siliguri.

5. Discussion

Siliguri, like many rapidly urbanizing cities in India, is experiencing increasing air pollution due to a sharp rise in pollutant levels. To better understand this issue, AQI data from the official website of the West Bengal Pollution Control Board for the period 2014 to 2024 was analyzed, and the trends were visualized using a graph.

Table 1: Air Quality Index (AQI) Classification and Associated Health Risks

AQI	Remark	Symbolic colour	Possible Health Impacts
0-50	Good		Minimal Impact

51-100	Satisfactory		Minor breathing discomfort to sensitive people
101-200	Moderate		Breathing discomfort to the people with lung, heart disease, children and older adults
201-300	Poor		Breathing discomfort to people on prolonged exposure
301-400	Very Poor		Respiratory illness to the people on prolonged exposure
>400	Severe		Respiratory effects even on healthy people

Source: National Ambient Air Quality Standard, CPCB 2009

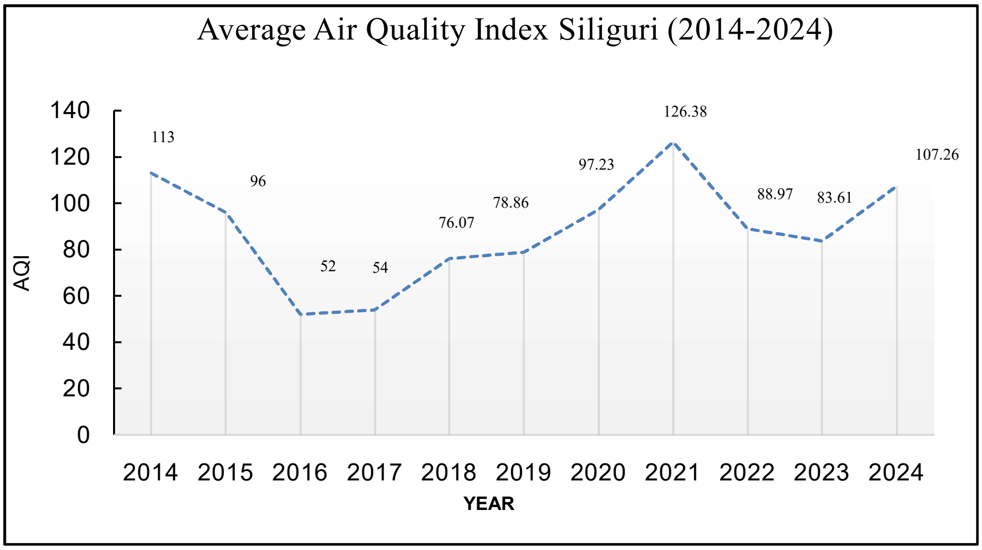

Figure 2. Variation of average AQI in Siliguri from the year 2014 to 2024

The data shows that the average AQI in 2014 exceeded 100, indicating unhealthy conditions for sensitive groups. Between 2014 and 2017, AQI levels improved, dropping below 100, making air quality generally acceptable (Figure 2). Between 2015 and 2017, Siliguri experienced relatively low levels of urban congestion and minimal construction activity. During this period, initiatives to enhance green cover and the absence of major deforestation programme, industrial or infrastructural expansion, contributed positively to the city's air quality. The rapid pace of urban development, including the construction and widening of highways such as the Asian Highway, the building of multiple flyovers, large buildings across Siliguri, and the swift expansion of the urban periphery, began accelerating only after 2017. This post-2017 phase marked the beginning of increased environmental pressure on the region, contributing to the gradual deterioration of air quality in the following years.

However, from 2018 onwards, AQI values began rising, with the 2021 average reaching 126.38, the highest in the last ten years, enough to cause respiratory discomfort and worsen conditions like asthma and heart disease (Figure 3). A closer look at recent years reveals that, after a decline in AQI values post-2021, levels have again increased beyond 100 by 2024.During the COVID-19 lockdown, numerous cities worldwide witnessed an improvement in air quality due to decreased human activities. However, in certain cases, including Siliguri, the Air Quality Index (AQI) rose during the later phases of the lockdown. This increase could be attributed to biomass burning in rural and peri-urban areas, including regions near air quality monitoring stations. Many households in these areas continued to rely on burning wood, leaves, and crop residue for cooking and heating, even as industrial activities remained limited.

The data, summarized in Table 2, shows that AQI levels peak during January, February, and March, especially in recent years like 2021 when concentrations exceeded 200. Winter conditions contribute to this seasonal increase, as cool air near the ground traps pollutants and leads to poor air quality.Winter inversions, low wind speeds, vehicle emissions, and biomass burning are primary causes for high AQI levels. Areas like Darjeeling More and Sevoke Road are especially affected, with higher concentrations of particulate matter, SO_2, NO_2, and CO_2. These hotspots are also heat islands, with temperatures 4 to 5 degrees higher than surrounding areas, primarily due to traffic and construction activities.

Table2: Seasonal Variations of Average AQI (2014-2024)

Month & Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Jan	M	VP	M	S	S	S	M	VP	M	M	M
Feb	M	VP	M	S	S	S	M	P	M	M	M
Mar	M	M	M	S	S	NA	S	P	M	S	M
April	S	S	S	S	S	S	NA	M	S	S	S
May	S	S	S	S	S	S	NA	S	S	S	G
June	S	S	S	S	S	S	S	G	G	G	G
July	G	S	G	S	S	S	S	G	G	G	G
Aug	G	G	S	S	S	S	S	G	G	S	G
Sep	S	G	S	S	S	NA	S	G	S	G	G
Oct	M	S	S	S	S	S	S	S	S	S	S

G=Good, S=Satisfactory, M=Moderate, P=Poor, VP=Very Poor, NA= No Data available, Compiled by the researchers Source: http://emis.wbpcb.gov.in

The Monthly Variation of Pollutant Concentration in Siliguri (2014) highlights significant seasonal fluctuations in air pollution levels, particularly in PM10, NO_2, and SO_2 concentrations. PM10 levels peak in April (173.44 µg/m³) and May (144.98 µg/m³), likely due to increased dust, vehicular emissions, and construction activities during the dry summer months, before dropping significantly during the monsoon in July (68.58 µg/m³) as rainfall naturally cleanses the air. A gradual rise is observed again from September to December, peaking in November (108.7 µg/m³) due to dry conditions, vehicular emissions, and winter temperature inversion trapping pollutants.

NO_2 levels follow a similar pattern, with the highest concentration in May (35.27 µg/m³) and the lowest in October (12.76 µg/m³), indicating seasonal variations influenced by vehicular pollution and industrial emissions. SO_2 levels remain relatively low throughout the year, with minor fluctuations, peaking in May (7.45 µg/m³) and August (7.1 µg/m³), possibly due to increased coal and biomass burning. The data clearly shows that air pollution is highest during summer and winter months, while monsoon provides temporary relief. To improve air quality, authorities must focus on controlling dust emissions, promoting cleaner fuels, enhancing public transport, and increasing green cover to mitigate seasonal spikes in pollution.

A comparison of the Monthly Variation of Pollutant Concentration in Siliguri between 2014 and 2024 reveals significant changes in air pollution patterns over the decade. PM10 levels have increased during winter months (January, February, November, and December) in 2024 compared to 2014, indicating worsening air quality, possibly due to rising vehicular emissions, construction activities, and temperature inversion (Figure 6, 7). In 2014, PM10 levels peaked in April (173.44 µg/m³) and May (144.98 µg/m³), whereas in 2024, the highest PM10 concentrations were recorded in March (164.33 µg/m³) and December (152 µg/m³), showing a shift in peak pollution months.NO_2 concentrations have also increased in certain months, particularly in March (48.33 µg/m³ in 2024 vs. 29.73 µg/m³ in 2014) and May (15.33 µg/m³ in 2024 vs. 35.27 µg/m³ in 2014). This suggests a rise in vehicular emissions and industrial activities contributing to nitrogen dioxide pollution. Meanwhile, SO_2 levels have remained relatively stable over the years, with only minor fluctuations.

A notable improvement is observed during the monsoon season, where PM10 levels in July (63 µg/m³ in 2024 vs. 68.58 µg/m³ in 2014) and August (30.67 µg/m³ in 2024 vs. 121.67 µg/m³ in 2014) have decreased significantly. This suggests better pollution control measures, possibly due to stricter regulations or improved environmental policies.However, the worsening winter pollution in 2024, particularly in January (144 µg/m³), February (150 µg/m³), and December (152 µg/m³), compared to 2014 levels, highlights the growing impact of emissions, urbanization, and meteorological conditions. To counteract these trends, authorities must strengthen air quality monitoring, enforce stricter emission regulations, promote sustainable transportation, and expand green cover to mitigate worsening pollution, especially during peak months.

6. Causes of Air Pollution in Siliguri

The primary contributors to air pollution in Siliguri are diverse, stemming from both human activities and natural factors. The city's rapid growth has outpaced its infrastructure development, leading to a range of pollution sources.

7. Rapid Urbanization and Traffic Congestion

The rapid population growth in Siliguri has led to a sharp increase in fossil fuel-powered vehicles, significantly contributing to air pollution (Table 3). The city's compact roadways, illegal parking, and frequent congestion worsen pollution levels, particularly in key areas such as Hill Cart Road, Darjeeling More, Sevoke Road, Burdhaman Road, and Venus More.Traffic congestion remains a major contributor to air pollution in Siliguri. The lack of new roads and flyovers exacerbates congestion, while illegal parking further obstructs traffic flow. Areas such as Hill Cart Road, Sevoke Road, Bidhan Road, Hashmi Chowk, Airview More, Siliguri Junction, and Darjeeling More experience severe congestion daily, causing delays for commuters and passengers. As a result, vehicular emissions from idling and slow-moving traffic contribute significantly to air pollution.

Plate 1: Automatic Air quality monitoring station at Tista Barrage Office, Near Tinbatti More area, Siliguri

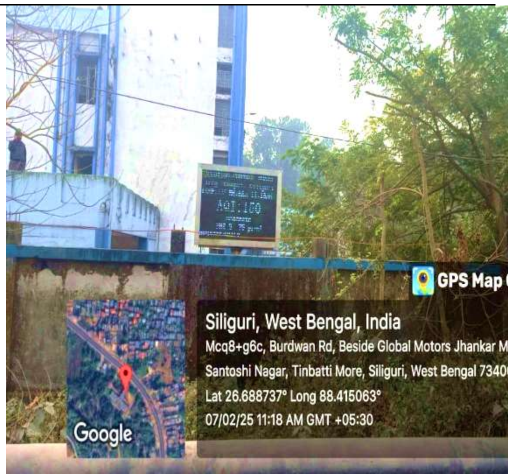

Photo 2: Display board of Air Quality Index,Siliguri

Figure 3: Average AQI of Siliguri from 2014 to 2024 (*Source:* http://emis.wbpcb.gov.in, *Data compiled by the researchers)*

Table 3: Decade-wise Per cent of urban population growth in Siliguri

Census Year	Population	Population Growth	Decadal Growth (%)
1951	11,500	-	-
1961	32,480	20,980	182.40%
1971	67,754	35,274	108.60%
1981	1,46,733	78,979	116.60%
1991	3,01,002	1,54,269	105.20%
2001	4,71,194	1,70,192	56.50%

2011	7,05,579	2,34,385	49.80%

Source: Census of India, 1951, 1961, 1971, 1981, 1991, 2001, 2011

7.1. A case study of Darjeeling more

The entry point into the main city—particularly areas such as Darjeeling More and Checkpost—is highly congested, with Darjeeling More serving as a critical junction for both local and regional traffic. This area acts as the primary gateway toward the hills, making it a vital yet overburdened transit zone. Located just beyond Darjeeling More is a mega shopping mall, which adds to the area's traffic density. Additionally, this junction connects directly to the Bagdogra Airport road, further increasing vehicular flow. A prominent commercial establishment, the City Centre mall, is also located in this vicinity, contributing to the area's growing importance as a retail and leisure hub. Moreover, the right flank of Darjeeling More is rapidly transforming into the city's educational corridor, with a concentration of both government and private educational institutions. This includes schools, medical colleges, and law institutes, attracting a significant student and commuter population.

Despite the width of the main road, the actual entry point at Darjeeling More is relatively narrow, creating a bottleneck. This bottleneck is further complicated by the presence of a railway underpass and a small river crossing known as the Panchanoi River Bridge. These structural constraints limit the smooth flow of traffic, causing frequent and severe traffic congestion, especially during peak hours.

With the rapid increase in the number of private educational institutions, the volume of school buses—particularly the yellow buses—has surged significantly. During the morning arrival and afternoon dispersal times, these buses dominate the city's roads, exacerbating the already congested traffic conditions. For daily commuters, especially those who must cross this area regularly, the situation has become increasingly frustrating and time-consuming.

7.2. A case study of Sevoke& Hill Cart Road

Another major contributor to urban traffic congestion and related air pollution in Siliguri is the stretch comprising Sevoke Road and Hill Cart Road—two of the most vital arterial roads in the city. These roads not only act as lifelines for Siliguri's internal mobility but also serve as major connectors to neighboring regions including the hills of Darjeeling, Sikkim, and Kalimpong. However, both roads are characterized by extreme vehicular congestion, posing severe challenges for traffic flow, urban planning, and environmental health. Field observations and traffic studies indicate that one of the primary causes of traffic congestion on Sevoke Road is the heterogeneous mix of vehicleswith vastly different speed capabilities. The presence of slow-moving vehicles such as electric rickshaws (locally known as "totos") alongside high-speed vehicles such as private cars, trucks, and buses in the same undivided carriageway disrupts the overall traffic rhythm. The absence of dedicated lanes or segregated traffic systems forces all categories of vehicles—regardless of size or speed—into a single lane, resulting in frequent bottlenecks and erratic vehicular movement.

The situation is exacerbated during peak hours, when thousands of commuters—including daily office-goers, traders, school buses, and goods carriers—converge on Sevoke Road. As Siliguri continues to develop as the principal commercial hub of North Bengal, the road supports an increasing volume of intra-city and inter-regional commerce. The high density of commercial establishments and wholesale markets located along this corridor adds to the daily influx of goods vehicles and customers, placing an enormous strain on the existing infrastructure. The environmental toll of this congestion is deeply concerning. Sevoke Road, in particular, lacks significant roadside vegetation, making it more vulnerable to heat accumulation and offering no buffer to absorb vehicular emissions. During the summer months, the combination of urban heat island effectsidling traffic emissions results in acute discomfort for commuters—especially those using two-wheelers or walking on foot. Continuous idling and stop-start traffic conditions, typical of congested urban roads, contribute disproportionately to the concentration of air pollutants such as $PM_{2.5}$, PM_{10}, nitrogen oxides (NO_x). These pollutants have been scientifically linked to respiratory diseases, cardiovascular conditions, and degraded urban air quality. The high exposure levels, especially for pedestrians, two-wheeler riders, and street vendors, heighten the public health risks in this area.

8. Overpopulation

Overpopulation and excessive resource consumption exert significant pressure on the environment. A growing population generates more waste, and inadequate waste management often results in open burning and landfill emissions, releasing harmful pollutants into the atmosphere. For instance, the dumping ground near the Eastern Bypass consistently records a high Air Quality Index during waste-burning periods (Plate 3).

Plate3:Dumping Ground of Siliguri, Eastern Bypass

9. Industrial Activities

Industrial zones in and around Siliguri contribute significantly to air pollution. Factories and small manufacturing units often operate with inadequate emission control measures, releasing pollutants such as volatile organic compounds (VOCs) and greenhouse gases, including carbon dioxide ($CO2$) and methane ($CH4$).Many industries, including tea processing and timber production, emit pollutants like particulate matter, sulphur dioxide, and nitrogen oxides during their operations. Industries that rely on coal, diesel or other fossil fuels for energy contribute to greenhouse gas emissions and other harmful pollutants.

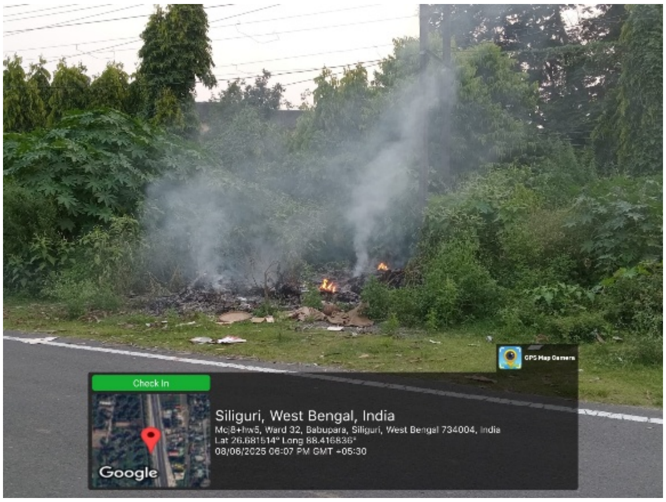

Plate 4: Open Burning of Waste near Tinbatti More area

10. Open Burning of Waste in Siliguri

In Siliguri, improper waste management, including the open burning of garbage, is a major contributor to air pollution (Plate 4). The burning of organic and plastic waste releases a hazardous mix of toxic chemicals, such as dioxins and furans, further degrading air quality. Areas near dumping grounds, particularly along the Eastern Bypass, often experience a spike in air pollution levels during waste-burning periods, worsening respiratory health risks for residents.

11. Construction Dust and Its Impact on Air Quality

The rapid urbanization of the city has led to extensive construction activities, significantly contributing to air pollution. Construction sites generate large amounts of dust and debris, increasing particulate matter in the air, which can worsen respiratory conditions and degrade overall air quality. Additionally, ongoing road construction projects and inadequate road dust management further contribute to particle pollution.Several major road construction projects are currently underway in

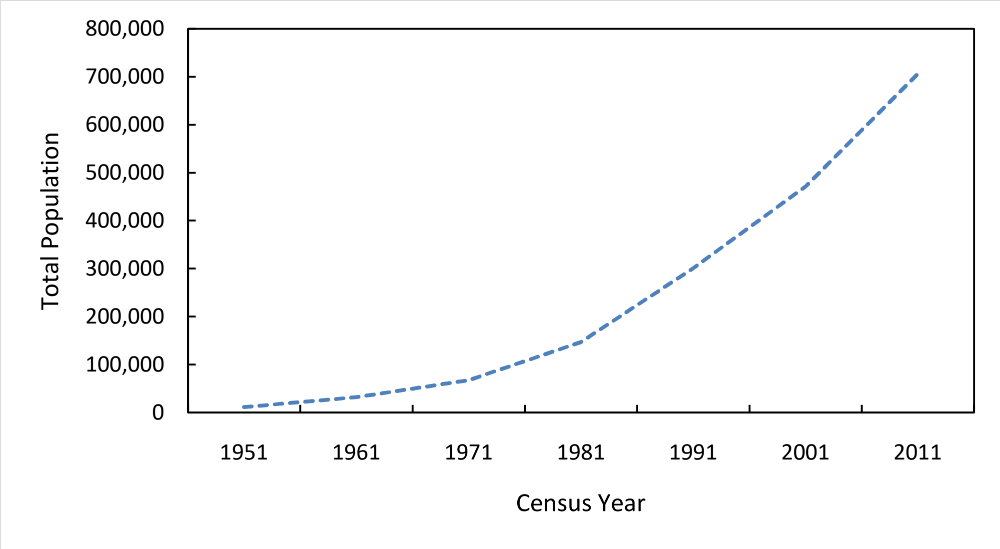

Figure 4: Population of Siliguri from 1951 to 2011

Source: Census of India, 1951, 1961, 1971, 1981, 1991, 2001, 2011

Siliguri, including: Darjeeling More to Matigara, Checkpost to Salugara, Bardwan Road, Asian Highway- 2, Payel More to Ektiasal Hut, NH-31 expansion, involving the four- to six-lane widening from Shiv Mandir to Sevoke Army Cantonment etc. Construction activities contribute to air pollution in various ways, including improper waste management, such as burning wood scraps and plastics, which releases toxic fumes and harmful pollutants. Additionally, dust emissions from construction sites further deteriorate air quality. Both infrastructure and commercial building projects play a role in exacerbating the city's air pollution crisis.

12. Diesel-powered vehicles

The large number of diesel-powered vehicles in the city is a major cause of air pollution. Diesel-powered vehicles emit oxides of nitrogen and particulars, which are major pollutants. Being a main hub of North East centre, Siliguri become a most populated city so, now days with increasing population in Siliguri the number of vehicles also increases. It effects badly in the air condition of the city.The increasing number of vehicle registrations in the Siliguri Municipal Corporation (SMC) area from 2000 to 2024 has had a significant impact on air quality, reflecting the consequences of urbanization and transportation expansion. Over the past two decades, Siliguri has witnessed rapid population growth, resulting in a notable surge in the number of registered vehicles. Information from the Regional Transport Office (RTO) Siliguri reveals a sharp rise in both private and commercial vehicles, leading to increased emissions of pollutants such as PM2.5, PM10, NO_2, and CO, which significantly affect air quality. Reports from the West Bengal Pollution Control Board (WBPCB) indicate that air quality in Siliguri has deteriorated over time, particularly during winter, when the Air Quality Index (AQI) often falls into the "Unhealthy" category. The reliance on fossil fuel-powered vehicles, combined with traffic congestion and limited public transportation options, has further contributed to worsening pollution levels. Addressing this issue requires initiatives such as promoting electric vehicles (EVs), enhancing public transport, enforcing stricter emission norms, and increasing green cover in the SMC area. Analyzing the correlation between annual vehicle registration trends and air quality data can provide valuable insights for policymakers to design effective pollution control measures.

13. Prolonged Absence of Rainfall

Siliguri's location at the foothills of the Himalayas contributes to the retention of air pollutants, particularly in winter (Roy & Singha 2021). During this season, temperature inversion occurs, where a layer of warm air traps pollutants near the surface, preventing their dispersion and worsening air quality. Various meteorological factors, including rainfall, temperature, wind speed, and air turbulence, influence pollutant concentration levels. Winters in Siliguri are marked by dry weather, low humidity, and minimal precipitation, which hinder the natural dispersion of pollutants.

Table 4: Rainfall Data of the Siliguri Region (in mm) from 2020 to 2024

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Rainfall
2020	-	-	-	-	-	644.6	1382.4	635.1	1127.2	141.8	0	-	3931.1
2021	-	-	-	-	-	589	590.2	1277.6	428.5	437.3	0	-	3322.6
2022	-	-	-	-	-	1322.6	742.8	689	765.6	86.2	0	-	3606.2
2023	-		-	-	-	578.4	758.4	701.4	307	95.4	0	-	2440.6
2024	-	-	-	-	-	1016	860	357	476	245.5	3	-	2957.5

Source: WRIS, https://www.nwic.gov.in/india-wris

The absence of rainfall allows particulate matter, vehicular emissions, industrial pollutants, and dust particles to remain in the air for extended periods, leading to their accumulation (Table 4). The increase in traffic emissions, construction activities, and biomass burning during this time further deteriorates air quality.The prolonged lack of rainfall from November to February leads to consistently high AQI levels, often reaching the "Unhealthy" category. Continuous exposure to such pollution poses serious health risks, particularly for individuals with respiratory diseases, asthma, and cardiovascular conditions. Addressing these concerns requires implementing measures such as expanding green cover, promoting eco-friendly transportation, controlling dust emissions, and strengthening air quality monitoring systems to improve environmental and public health conditions.

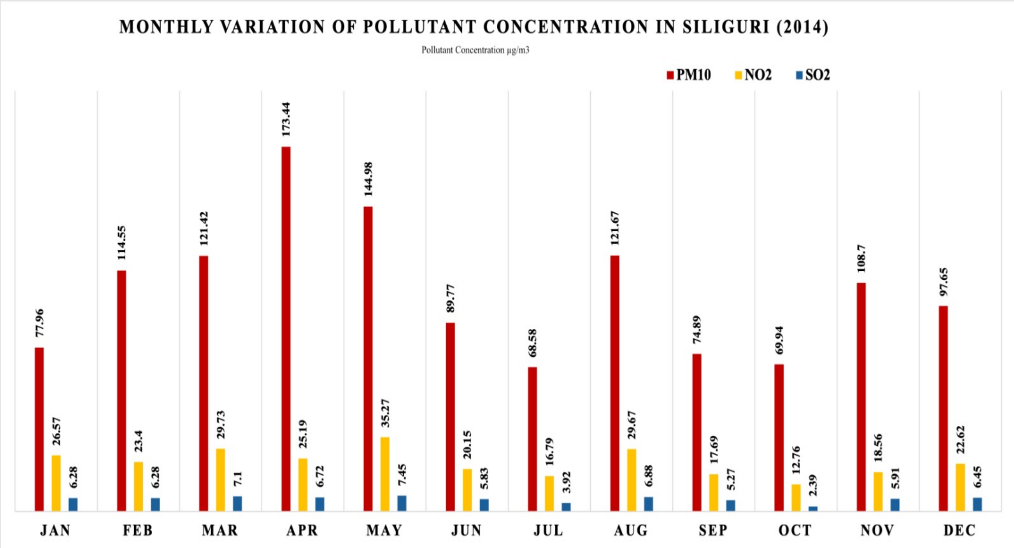

Figure 5: Monthly variation of pollutant concentration in Siliguri, 2014

Source: http://emis.wbpcb.gov.in*, Data compiled by the researchers*

14. Impacts of Air Pollution

The effects of air pollution in Siliguri are far-reaching, impacting human health, the environment, and the local economy. Some of the major consequences include:

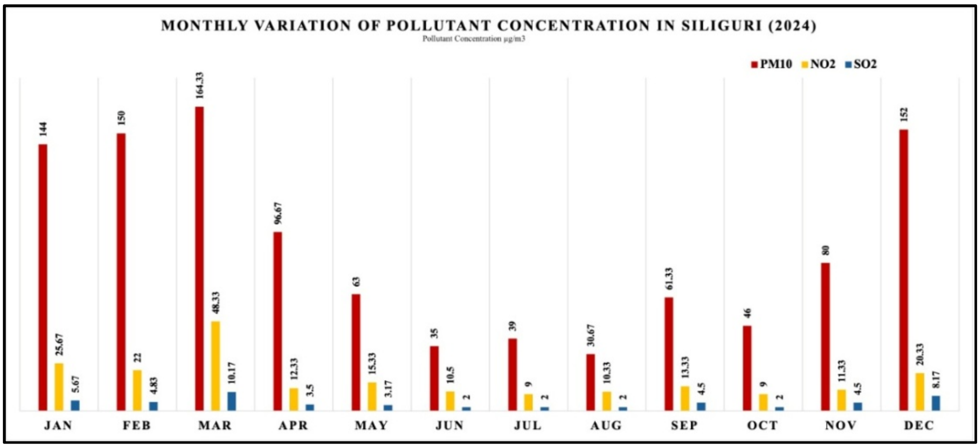

Figure 6: Monthly variation of pollutant concentration in Siliguri, 2024

Source: http://emis.wbpcb.gov.in*, Data compiled by the researchers*

14.1. Health Impacts

Air pollution has a direct effect on the health of Siliguri's residents. Prolonged exposure to pollutants such as particulate matter (PM2.5 and PM10) and toxic gases increases the risk of respiratory diseases, including asthma, bronchitis, and lung infections (Ghosh & Banerjee, 2020). Children, the elderly, and individuals with pre-existing health conditions are particularly vulnerable. Studies have also linked air pollution to cardiovascular diseases and premature mortality.

14.2. Environmental Degradation

Pollutants in the air can have detrimental effectson the local environment. Acid rain, caused by sulfur dioxide and nitrogen oxides, can damage crops, soil, and water bodies. Additionally, the deposition of fine particulate matter can negatively affect vegetation and wildlife in the surrounding areas.

14.3. Economic Costs

The economic implications of air pollution are significant. Healthcare costs rise as more people suffer from pollution-related illnesses. Additionally, pollution can deter tourists, a vital part of Siliguri's economy, especially since the city is a gateway to popular destinations like Darjeeling and the northeastern states.

14.4. Decreased Quality of Life

Poor air quality can reduce the overall quality of life for residents. Constant exposure to pollution limits outdoor activities, creates discomfort, and can lead to a general sense of unease among the population.

15. Solutions to Mitigate Air Pollution

Addressing the air pollution crisis in Siliguri requires a comprehensive and collaborative effort, involving both immediate interventions and long-term strategies. The Siliguri Municipal Corporation, along with state and central government bodies, needs to adopt robust policies and actions to mitigate pollution.

15.1. Infrastructure Expansion and Upgradation

To ease congestion near Darjeeling More, targeted infrastructure improvements are essential. First, widening the narrow entry point to match the width of connecting roads would eliminate the current bottleneck and improve traffic flow. Second, constructing a flyover or bypass would allow vehicles—especially those headed to Bagdogra Airport or the hills—to avoid surface-level congestion, reducing delays. Lastly, upgrading and widening the Panchanoi River Bridge would ensure smoother vehicular movement and reduce pressure on the nearby railway underpass. These measures are crucial for improving traffic efficiency and supporting Siliguri's growing urban needs.

15.2. Traffic Segregation and Lane Discipline

To effectively address both traffic congestion and its associated environmental impacts along the Sevoke Road and Hill Cart Road corridors, a comprehensive and well-planned approach is necessary. One key strategy involves introducing traffic segregation and enforcing lane discipline by creating separate lanes for slow-moving and fast-moving vehicles. Where possible, these lanes should be divided with physical barriers to prevent lane interference. Such a system would streamline traffic flow, reduce the risk of accidents, and minimize the delays caused by speed mismatches—ultimately contributing to reduced vehicle emissions and improved air quality.

15.3. Development of green buffer zones

This strategy focuses on urban greening by planting trees and shrubs along roadsides and medians. Trees act as natural air filters, absorbing pollutants like CO_2, NO_x, SO_2, and particulate matter, improving air quality in busy areas. They also provide shade, reducing heat and offering comfort to pedestrians, cyclists, and two-wheeler riders, especially during Siliguri's hot summers. Additionally, green belts help lower noise, reduce vehicle glare, and enhance the city's appearance, benefiting residents' well-being. Using native, low-maintenance plants with proper irrigation and pedestrian paths, these green corridors can transform congested roads into healthier, more sustainable, and resilient urban spaces.

15.4. Infrastructure rationalization

It is crucial for easing congestion on the major roads of Siliguri. This involves redesigning intersections for smoother traffic flow and better signal coordination, reducing delays and emissions. Additionally, limiting and consolidating feeder roads can minimize merging conflicts and erratic lane changes. Fewer access points will streamline traffic, reduce idling, and help lower air pollution, making the corridor safer and more efficient.

15.5. Promoting Sustainable Urban Mobility

Improving public transport and encouraging electric vehicle (EV) use are key to reducing congestion and air pollution. Introducing electric shuttle services between schools, malls, and residential areas can cut down on private vehicle use. An integrated transport system with fixed routes for buses, auto-rickshaws, and e-rickshaws can enhance traffic flow and reduce random stops. Supporting this with EV incentives, such as subsidies and more charging stations, will further promote cleaner, more efficient urban travel in Siliguri.

15.6. Strengthening Industrial Regulations

Stricter enforcement of emission standards for industries operating within and around Siliguri is essential. The installation of air pollution control devices, such as scrubbers and filters, should be mandated to reduce industrial emissions. Regular monitoring and inspections can ensure compliance.

15.7. Controlling Dust from Construction Sites

Measures to control dust from construction activities include the use of water sprinklers, proper covering of construction materials, and implementing green building practices. These steps can minimize the spread of dust and particulate matter in the air.

15.8. Enhancing Waste Management

A more effective waste management system, including proper waste segregation, recycling, and composting, can help eliminate the need for open burning. The establishment of centralized waste treatment facilities and public awareness campaigns on proper waste disposal practices are crucial.

15.9. Public Awareness and Participation

Raising awareness about the dangers of air pollution and promoting public participation in pollution control efforts is essential. Educational campaigns can motivate citizens to adopt eco-friendly transportation, conserve energy, and support green initiatives to reduce their carbon footprint. Daily air quality monitoring reports should be published in local newspapers and broadcast on local news channels to inform the public about pollution hazards. Additionally, encouraging the use of masks and air purifiers can help minimize exposure and reduce health risks associated with poor air quality.

15.10. Planting Green Cover

Trees serve as natural air purifiers by absorbing pollutants and releasing oxygen. The Municipal Corporation can enhance air quality by initiating afforestation programs and promoting tree planting in urban spaces, parks, and along roadsides. Vacant land owned by the city, railways, and government can be utilized for this purpose after consultation with relevant departments. Additionally, open spaces in schools, colleges, and government offices can also be used to expand green cover and contribute to pollution reduction.

15.11. Regular Water Sprinkling on Roads

During winter, air pollution worsens due to dry weather and dust accumulation. A practical solution is the regular sprinkling of water on major roads to settle dust particles and prevent them from becoming airborne. Frequent road-watering in high-traffic and construction areas can significantly reduce pollution, especially when rainfall is scarce. Implementing a systematic sprinkling schedule can improve air quality and benefit residents, particularly those with respiratory issues. Using treated wastewater for this purpose can also support water conservation while effectively controlling dust pollution. The Siliguri Municipal Corporation can take the initiative as an immediate measure to mitigate the effects of air pollution.

15.12. Real-Time Air Quality Monitoring

The installation of air quality monitoring systems throughout the city will provide real-time data on pollution levels. This information can help authorities respond quickly to pollution spikes and provide valuable data for long-term policy planning.

16. Conclusion

Air pollution in Siliguri has become a growing concern, particularly during winter when meteorological conditions trap pollutants close to the surface. Factors such as rapid urbanization, increased vehicular emissions, industrial activities, and construction dust contribute significantly to deteriorating air quality. The absence of rainfall during winter further exacerbates pollution levels, leading to severe health risks, especially for individuals with respiratory and cardiovascular conditions.To mitigate these challenges, a combination of immediate and long-term strategies must be implemented. Measures such as regular road sprinkling to control dust, afforestation programs, and sustainable urban planning can help improve air quality. Raising public awareness through educational campaigns and ensuring the daily publication of air quality reports can encourage community participation in pollution control efforts. Additionally, promoting eco-friendly transportation, enforcing stricter emission regulations, and expanding green cover in vacant public spaces are crucial steps toward sustainable environmental management.Addressing air pollution in Siliguri requires a collaborative effort from the Siliguri Municipal Corporation, government agencies, environmental organizations, and residents. By implementing proactive and sustainable solutions, the city can work towards cleaner air, ensuring a healthier and safer environment for its residents.

17. Limitation

Despite its findings, the study has certain limitations. It primarily relies on data from a single monitoring station, which may not accurately reflect spatial variations in air quality across different parts of the city. Furthermore, key meteorological factors such as temperature, humidity, and wind speed—which play a crucial role in the dispersion and concentration of air pollutants—were not examined in detail. Although the study covers a broad time frame, it may still fall short in fully capturing the long-term complexities and fluctuations of air pollution trends in the region.

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