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Ambient Air Quality of Guwahati City: A Spatio-Temporal Assessment

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KEYWORDS

Air Pollution, Ambient Air Quality, Suspended Particulate Matter, Respirable Suspended Particulate Matter, Vehicular Emission, Health Risk, Air Quality Index.

ABSTRACT:

Today, the air we breathe is being polluted by various natural and anthropogenic sources like accelerated industrialization, haphazard urbanization, rapid increase in human population and ever-burgeoning number of automobiles on the roads. Natural processes absorb these pollutants to a certain extent and air quality is restored, but when the limits are exceeded, pollutants accumulate in the environment and air quality deteriorates. Over the past few decades, human involvement has drastically modified Earth's chemistry and climate. The emissions from automobiles, prolific or partial burning of fossil fuels, industrial activities and intensification of agricultural practices have escalated the ambient concentration levels of harmful gases like Sulphur di-Oxide (SO_2), Nitrogen di-Oxide (NO_2) and Carbon Monoxide (CO) and of Ozone(O_3) and Suspended Particulate Matter (PM) to worrying levels.

Guwahati, the capital city of Assam and perhaps the most important city of north-easternIndia, has witnessed unprecedentedly high levels of air pollution over the last few years. Clean air should be an unlimited free natural resource and the basic need of all living beings. Against a daily requirement of 2 Kg of food and 3 Litre of water, an adult inhales and exhales about 8 Litre of air every single minute. But when this life-sustaining air gets polluted, it can have dire effects not only on humans but also on plants, animals and all other living organisms.

The present work aims to investigate seasonal variations in air pollution levels through the calculation and analysis of Air Quality Index (AQI) in Guwahati and assess the ambient air quality of the city together with highlighting the health impacts of major pollutants like $PM_{(10)}$, $PM_{(2.5)}$, SO_2, and NO_2 from 2011 to 2021.

Introduction:

Air pollution represents the biggest environmental risk to human health and is considered a major issue for the global community (Mannucci & Franchini, 2017; Rodriguez-Villamizar et al., 2015). Air pollution is defined as all destructive effects of any source which contributes to the pollution of the atmosphere and deterioration of the ecosystem. Air pollution is caused by both human interventions and natural phenomena. It is made up of many kinds of pollutants including materials in solid, liquid, and gaseous states (Ghorani-Azam et al., 2016). Sustainable development Goals (2015) includes three indicators related to air pollution. First Indicator (3.9.1) states that by 2030 mortality rate due to household and ambient air pollution should be reduced. Second indicator (11.6) explains that by 2030 the adverse per capita impact on air quality and other waste management should be reduced and Third indicator (8.4) implies that by 2020, the impact of chemicals on air, water, and soil should be minimized.

In 2014, 92% of the world's population was living in places where the WHO air quality guideline levels were not met (*Air Quality Database 2016*, n.d.). Furthermore, Ambient (outdoor air pollution) is a major cause of death and disease globally. An estimated 3 million premature deaths globally are linked to ambient air pollution, mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children (*Air Quality Database 2016*, n.d.).

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The prime air pollutants have been broadly classified as outdoor and indoor pollutants. Outdoor air pollution is a mixture of thousands of components; among them, Airborne Particulate Matter (PM) and the gaseous pollutants Ozone(O3), Nitrogen Dioxide (NO2), Volatile organic compounds (including Benzene), Carbon Monoxide (CO), and Sulphur Dioxide (SO2) are the most important from health perspective (Huang, 2014; Mannucci & Franchini, 2017). Outdoor air pollution can affect both the respiratory system (exacerbating asthma and chronic obstructive pulmonary disease) and the cardiovascular system (triggering arrhythmias, cardiac failure, and stroke) (Abelsohn & Stieb, 2011). The Global Burden of Diseases, Injuries, and Risk Factors Study 2015 (GBD 2015) identified air pollution as a leading cause of global disease burden, especially in low income and middle-income countries (Cohen et al., 2017). Air quality indexing is important for several reasons as it provides valuable information about the current state of the air we breathe. Here are some key reasons why air quality indexing is essential. AQI helps individuals, particularly vulnerable groups like children, the elderly, and those with respiratory or cardiovascular conditions, to assess the potential health risks associated with outdoor activities. It aids in making informed decisions, such as whether to limit outdoor exposure or wear protective masks during periods of high pollution. Air quality indexing fosters environmental consciousness by highlighting the impact of human activities on the atmosphere. This knowledge can motivate individuals and communities to take collective actions to reduce pollution and improve air quality. AQI data is essential for urban planning and infrastructure development. It helps guide decisions related to the location of schools, hospitals, parks, and residential areas, considering air quality factors to protect public health. The use of standardized air quality indexes allows for easy comparison of air quality data across different cities, regions, or countries. This comparative analysis can lead to the sharing of best practices and solutions to address airpollution.

Objectives:

The main objectives of the present study are as follows::

1. To analyses the nature of the ambient air quality of the Guwahati city
2. Compare the ambient air quality of Guwahati with National Ambient Air Quality Standard (NAAQS)
3. Find out the gradual change of ambient air quality of Guwahati city
4. To compare the changes of AQI before and after CCVID-19 lockdown Period.
5. Seasonal Changes of ambient air quality in the area under study.
6. How the Air Quality of Guwahati impact on human health.

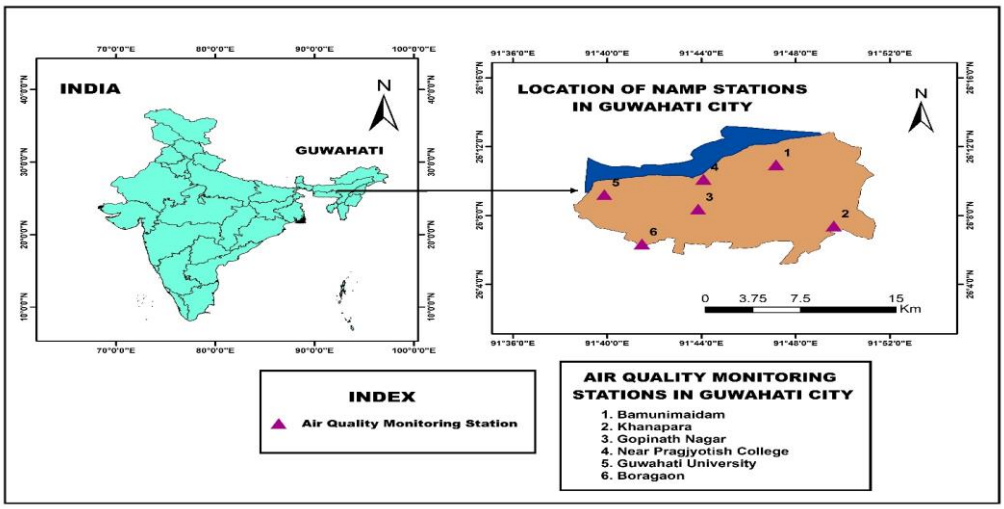

Figure 1: Location of the study area

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: **Methodology:**

The air quality index (AQI) is a measure of the ratio of the pollutant concentration to the status of ambient air in different places. The AQI is one of the important tools available for analyzing and representing air quality status uniformly (Dadhich *et al.,* 2017). The cumulative effect of concentration of individual pollutants in the ambient air is often expressed through a single value in the form of AQI. For calculation of AQI in Guwahati city, we considered only three pollutants namely, RSPM, SO2 (Sulphur Dioxide), NOx (Nitrogen Oxides).

- **The AQI index has been computed by using the following equation:**

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

- $\boldsymbol{I}$ = the air Quality Index
- **C=** the pollutant concentration
- $\boldsymbol{Clow}$= the concentration breakpoint that is ≤ $\boldsymbol{C}$
- $\boldsymbol{Chigh}$= the concentration breakpoint that is ≥ $\boldsymbol{C}$
- $\boldsymbol{Ilow}$= the index breakpoint corresponding to $\boldsymbol{Clow}$
- $\boldsymbol{IHigh}$= the index breakpoint corresponding to $\boldsymbol{C}$high

Distribution of Ambient Air Quality

Below is a description of the (pre-Covid) air quality situation in Guwahati city and it is shown using a few diagrams. Here it is shown that covid in the previous period i.e. 2017-18 in Bamunimaidam area of Guwahati city, Sulphur Dioxide (SO2) gas concentration is 7.5% (Figure 2). On the other hand, the concentration of sulphur dioxide in Boragaon region is 7% at Guwahati University Centralized 7%, Gopinath Nagar and Khanapara concentrated 7 and 7.5% respectively. On the other hand, the amount of sulphur dioxide gas is lowest in Boragaon, Guwahati University and Gopinath Nagar area. Nitrogen dioxide (NO2) gas levels were highest in 2017-18 in the pre-Covid period (17.5 µg/m3) in Guwahati University area (Figure 3). Nitrogen dioxide in Bamunimaidam, Boragaon, Gopinath Nagar, Khanapara, Shantipur areas was 17 µg/m3. The after covid period has a low NO2 concentration with maximum and minimum value of 14.1 and 13.3 respectively. Maximum concentration was in Santipur and Guwahati University and Bamunimaidam experienced a low concentration.

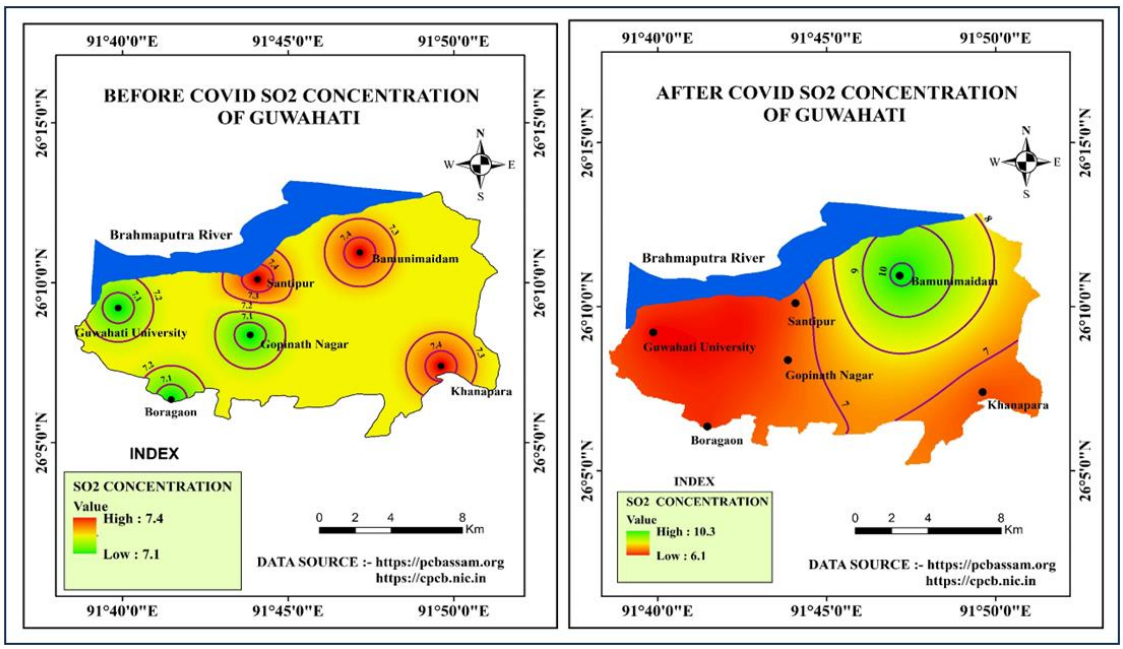

Figure 2: Sulphur Di-Oxide concentration of Guwahati in before-covid and after-covid periods

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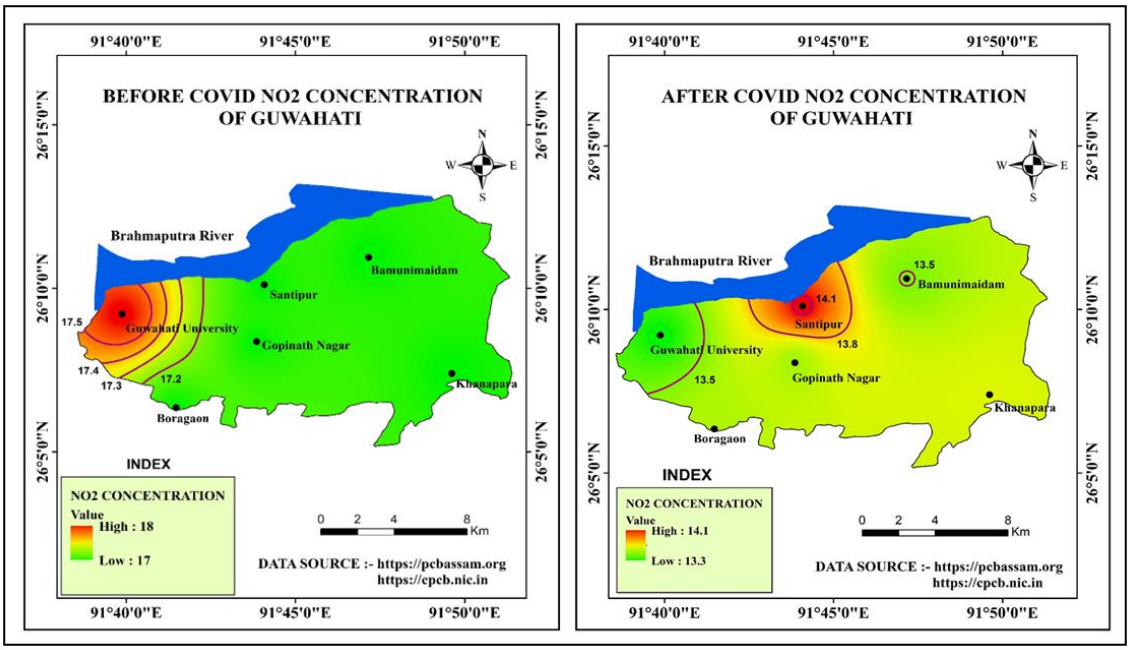

Figure 3: Nitrogen Di-Oxide concentration of Guwahati in before-covid and after-covid period

Particulate matter (PM) in 2017-18 was most concentrated in Gopinathnagar region (136µg/m3) (Figure 4). Particulate Matter (PM) concentration is 115.5 µg/m3 in Bamunimaidam area, Boragaon respectively 104 µg/m3 in the region, 90 µg/m3 in the Guwahati University region, 136 µg/m3 in the Gopinath Nagar region, 100 µg/m3 in Khanapara region, 107 µg/m3 in Shantipur region.Below is a description of the (post-Covid) air quality situation in Guwahati city in Manch. Here it shows that in post covid i.e. 2019-20 in Bamunimaidam area of Guwahati city.

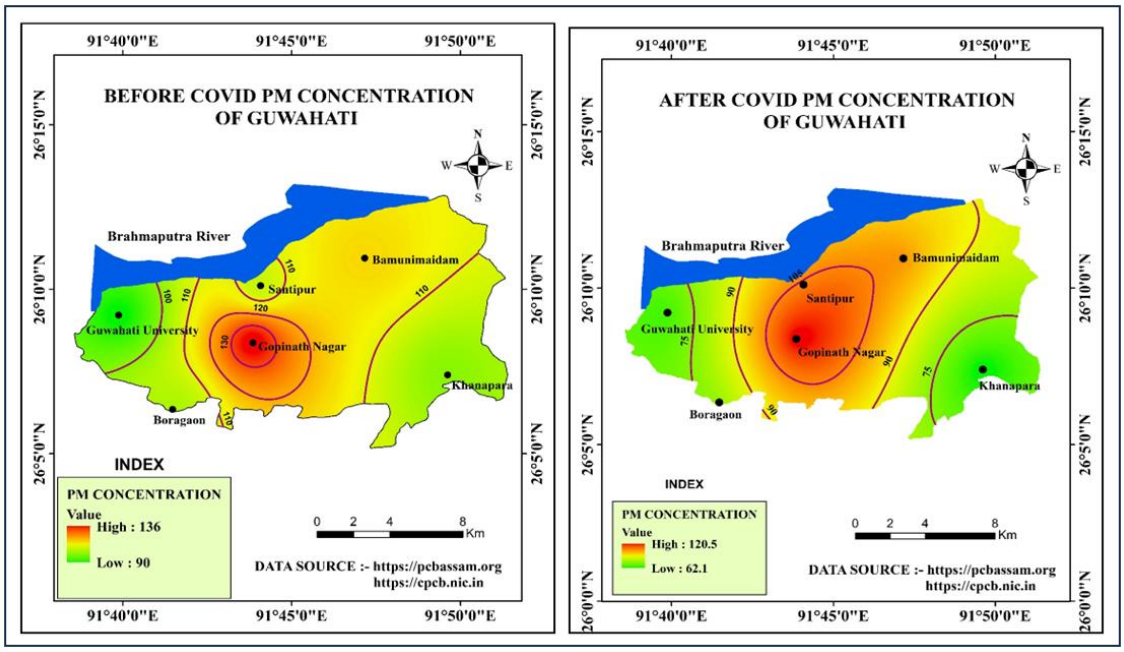

Figure 4: Particulate Matter concentration of Guwahati in before-covid and after-covid period

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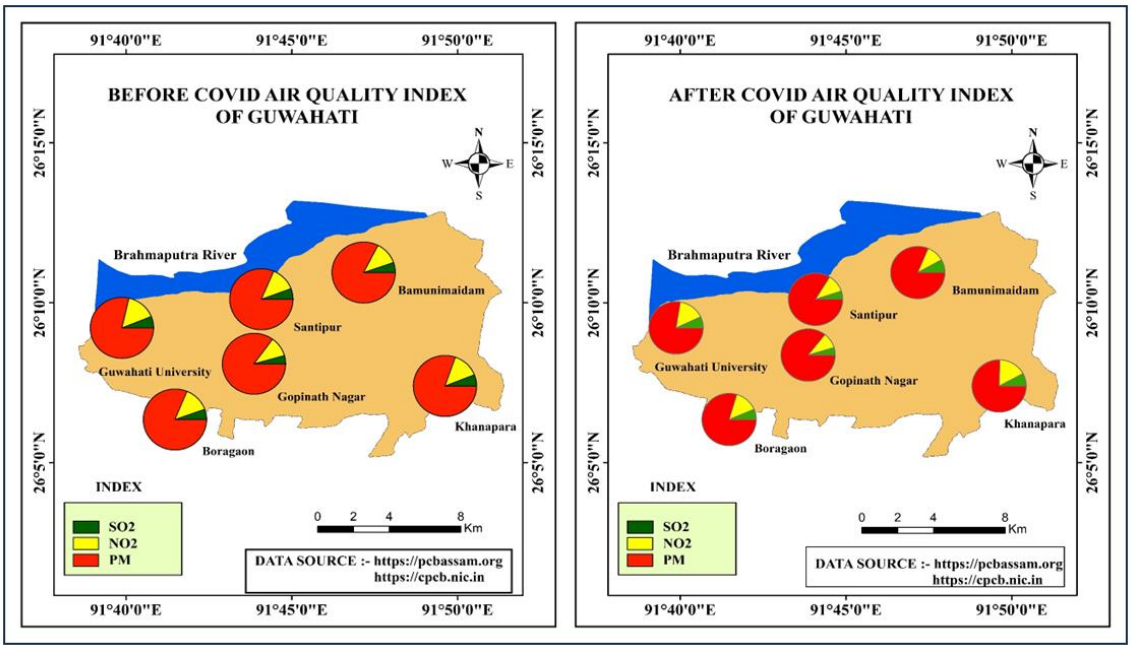

Figure 5: Distribution of AQI of Guwahati in before-covid and after-covid period

Concentration of Air Pollutants

In the after covid period, the Sulphur dioxide (SO2) gas concentration was 10.33875% in Bamunimaidam regiion. On the other hand, in Boragaon region, the concentration of sulphur dioxide is 6.22 % at Guwahati University. Centralized 6.020625%, Gopinath Nagar and Khanapara concentrated 6.58625% respectively and 6.48875 %. Sulphur Dioxide level in the Santipur region is 6.47%. The amount of sulphur dioxide gas is lowest in Boragaon, Guwahati University and Gopinath Nagar area. 2019-20 Nitrogen Dioxide (NO2) gas levels hit highest post-Covid period (14.125 µg/m3) in Santipur region.The amount of nitrogen dioxide is 13.49625 µg/m3, 13.588125 µg/m3, and 13.35125 µg/m3, respectively. In 2019-20, Particulate matter (PM) was most concentrated in Gopinath Nagar region(120.589375 µg/m3). Particulate Matter (PM) concentration in Bamunimaidam area is 103.358125 µg/m3, respectively 77.418125 µg/m3 in Boragaon region, 67.004375 µg/m3 in Guwahati University region 61.936875 µg/m3 in Khanapara region, 106.029375 µg/m3 in Shantipur region.

Table 1: Average Ambient Air Quality Monitoring Data in before-covid period

Year	Station	Head Office, Bamunimaidam	Boragaon, IASST, Kamrup	Guwahati University, Kamrup	ITI Building, Gopinath Nagar	Khanapara, Central Dairy, Kamrup	Near Pragjyotish College, Santipur
Average AMBIENT AIR QUALITY MONITORING DATA FOR THE YEAR	SO2 Annual average	7	7	7	7	7	7
	SO2 Annual average	8	7	7	7	8	8

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2017- 2018 before Covid 19	Average SO2 (2017-18)	7.5	7	7	7	7.5	7.5
	Nitrogen Dio-xide (NO2) in µg/m3	16	17	17	16	16	16
	Nitrogen Dio-xide (NO2) in µg/m3	18	17	18	18	18	18
	Average NO2 (2017-18)	17	17	17.5	17	17	17
	Particulate Matter (≤10 µg/m3) in µg/m3	115	109	86	149	99	113
	Particulate Matter (≤10 µg/m3) in µg/m3	116	99	94	123	101	101
	Average PM (2017-18)	115.5	104	90	136	100	107

Table 2: Average Ambient Air Quality Monitoring Data in after-covid period

Year	Station	Head Office, Bamunimaidam	Boragaon, IASST, Kamrup	Guwahati University, Kamrup	ITI Building, Gopinath Nagar	Khanapara, Central Dairy, Kamrup	Near Pragjyotish College, Santipur
Average AMBIENT AIR QUALITY MONITORING DATA FOR THE YEAR	SO2 Annual average	12	7	7	7	7	7
	SO2 Annual average	8.7	5.4	5.0	6.2	6.0	5.9
	Average SO2 (2019-20)	10.33875	6.22	6.020625	6.58625	6.48875	6.47

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2019- 2020 after Covid 19	Nitrogen Dio-xide (NO2) in µg/m3	15	16	16	15	15	16
	Nitrogen Dio-xide (NO2) in µg/m3	12.0	11.2	10.7	12.1	12.4	12.3
	Average NO2 (2019-20)	13.49625	13.58813	13.35125	13.56688	13.675	14.125
	Particulate Matter (≤10 µg/m3) in µg/m3	122	79	74	142	48	115
	Particulate Matter (≤10 µg/m3) in µg/m3	84.7	75.8	60.0	99.2	75.9	97.1
	Average PM (2019-20)	103.3581	77.41813	67.00438	120.5894	61.93688	106.0294

Monthly trend of AQI

If we take a look at the monthly trend of AOI of Guwahati, the value of AQI has significantly increased over the period from the year 2011 to 2019. After 2019, there is a clear drop in the AQI value in the year of 2020. The reason of this drop may be due to covid. In the covid period, there was a complete lockdown all over the country. This may cause the air of Guwahati to get a better quality. The ambient air quality from the month of April to October seems to be higher than the rest of the months during the whole study period.

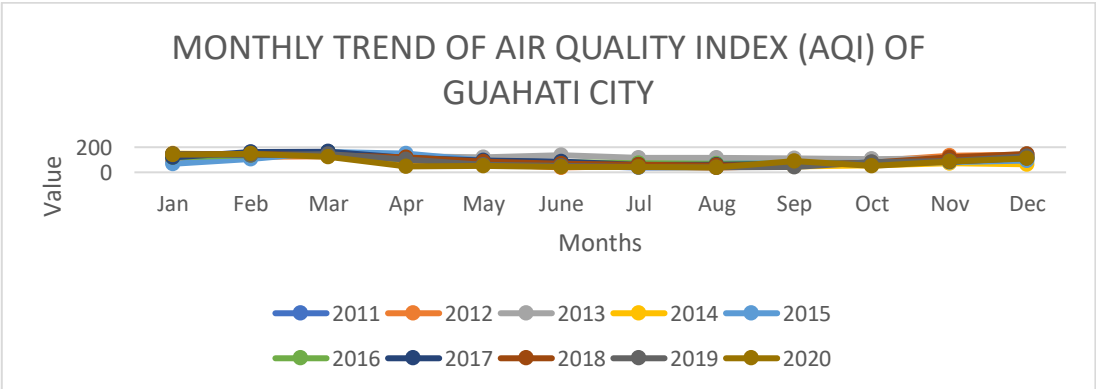

Figure 6: Monthly trend of AQI of Guwahati City

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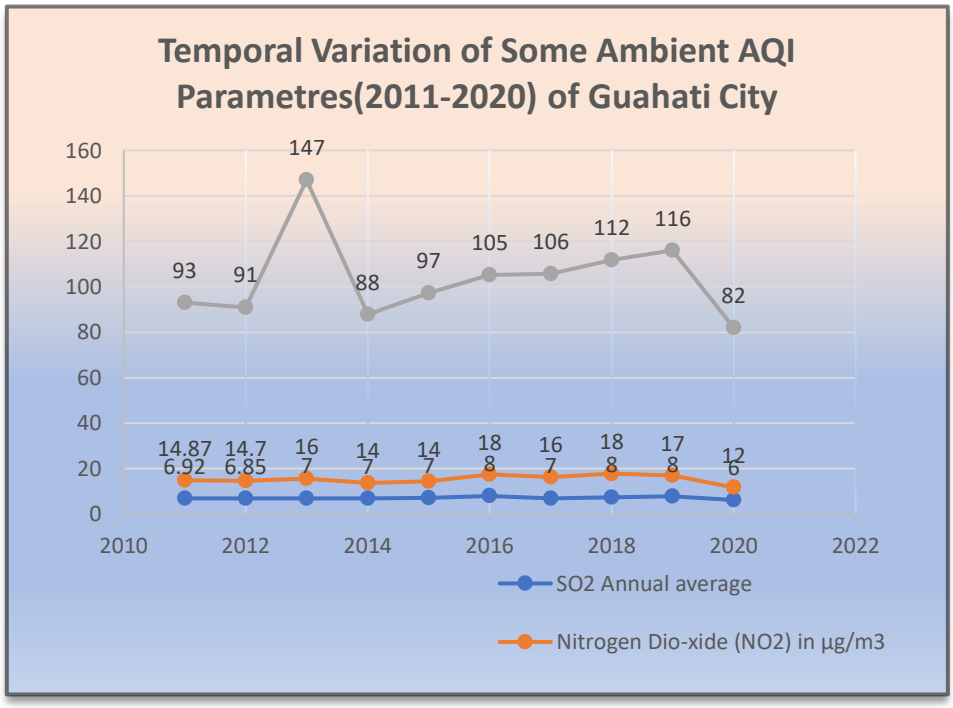

Figure 7: Temporal Variation of Some Ambient AQI Parameters (2011-2020) of Guwahati City

Temporal variation of Ambient Air Quality Index Parameters

The Figure 7 depicts the temporal variation of some ambient air quality index parameters, which includes the average yearly PM concentration, the average yearly NO2 concentration, and the average yearly SO2 concentration during the time period of 2011 to 2020 of the Guwahati city. The PM value was under 100 till 2015 except in the year of 2013, in which surprisingly peaked up to 147, making it the highest PM value during the study period. The PM value was running above 100 with a nearly 3%-4% increment every year till 2019. In the year of 2020, it took a dip and came back to 82. The similar trends prevail in average yearly NO2 concentration and average yearly SO2 concentration where both increased to nearly 20% or above during 2011 to 2019, and then suddenly took a dip in the year of 2020 due to covid and lockdown.

Common Causes of Air Pollution in Guwahati

Guwahati, the largest city in the north-eastern state of Assam, India, faced several causes of air pollution. It's important to note that these causes might still be relevant today, but there might have been developments or changes after my last update. Here are some common causes of air pollution in Guwahati:

1. Vehicular Emissions: Like many urban areas, the high density of vehicles on the roads of Guwahati contributes significantly to air pollution. Emissions from cars, trucks, buses, and two-wheelers release harmful pollutants such as carbon monoxide (CO), nitrogen oxides (NOx), particulate matter (PM), and volatile organic compounds (VOCs) into the atmosphere.

2. Industrial Activities: The presence of industries in and around Guwahati can lead to the release of various pollutants into the air. Industrial processes and emissions from factories can contribute to air pollution with pollutants like sulfur dioxide (SO2), nitrogen oxides (NOx), and particulate matter.

3. Construction and Road Dust: Rapid urbanization and ongoing construction activities in the city can generate substantial amounts of dust. This dust, along with road dust, becomes airborne and contributes to the particulate matter concentration in the air.

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4. Biomass Burning: The burning of agricultural residues, firewood, and other biomass for cooking and heating purposes is prevalent in many areas surrounding Guwahati. This practice releases particulate matter, carbon dioxide (CO2), and other harmful pollutants into the atmosphere.
5. Waste Burning: Open burning of waste, including plastic and other non-biodegradable materials, is a common practice in some areas, leading to the release of toxic substances and pollutants into the air.
6. Weather Conditions: Guwahati's geographical location and climatic conditions can contribute to air pollution. In certain weather conditions, such as temperature inversions and stagnant air masses, pollutants can get trapped near the surface, leading to increased pollution levels.
7. Deforestation: The loss of green cover due to deforestation and urban expansion can reduce the city's natural ability to absorb pollutants and improve air quality.
8. Use of Solid Fuels for Cooking: In some households, especially in rural and peri-urban areas, solid fuels like firewood and coal are still used for cooking, which releases pollutants indoors and, in some cases, can contribute to outdoor air pollution as well.

Addressing air pollution in Guwahati requires a combination of measures, including better urban planning, promoting public transportation, implementing cleaner industrial practices, waste management strategies, and promoting the use of cleaner fuels for cooking and heating. It's essential for authorities and communities to work together to tackle this critical environmental issue for the well-being of residents and the overall health of the city.

Possible Solutions

Improving the air quality of Guwahati requires a coordinated effort from the government, industries, communities, and individuals. Here are some measures that can be taken to address air pollution and improve air quality in the city:

1. **Promote Public Transportation:** Encourage the use of public transportation like buses and trains to reduce the number of vehicles on the roads and, consequently, vehicular emissions.
2. **Adopt Clean Energy Sources:** Encourage industries and households to shift to cleaner energy sources such as natural gas and renewable energy (solar, wind, etc.) to reduce emissions from burning fossil fuels.
3. **Strengthen Industrial Regulations:** Implement and enforce strict emission standards for industries to control the release of pollutants into the air.
4. **Control Vehicular Emissions:** Enforce regular emission checks for vehicles, promote the use of electric and hybrid vehicles, and encourage carpooling and ridesharing.
5. **Improve Urban Planning:** Focus on sustainable urban development and city planning to reduce congestion, minimize the need for long-distance travel, and promote green spaces.
6. **Manage Construction Activities:** Enforce regulations on construction sites to minimize dust generation. Implement measures such as water spraying and covering construction materials to control dust.
7. **Ban Open Waste Burning:** Strictly prohibit the open burning of waste and promote proper waste disposal and recycling practices.
8. **Plant Trees and Create Green Spaces:** Increase green cover in the city by planting trees and creating parks and green spaces. Trees help absorb pollutants and improve air quality.
9. **Raise Awareness:** Educate the public about the causes and consequences of air pollution and the steps they can take to reduce their personal contributions.
10. **Monitor Air Quality:** Establish and maintain a comprehensive air quality monitoring system to track pollution levels and identify pollution hotspots.
11. **Promote Cleaner Cooking Practices:** Encourage the use of clean cooking technologies and fuels, such as LPG or induction cooktops, to reduce indoor air pollution.

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12. **Strictly Implement Anti-Idling Laws:** Enforce laws that prohibit idling of vehicles, especially near schools, hospitals, and busy intersections.
13. **Incentivize Green Initiatives:** Provide incentives and subsidies to industries and individuals who adopt cleaner and greener practices.
14. **Collaborate with Neighboring Areas:** Coordinate with neighboring cities and regions to address regional sources of pollution and work collectively on air quality improvement.
15. **Policy and Governance:** Strengthen environmental regulations and governance to ensure effective implementation of air quality improvement measures.

These steps require active participation and cooperation from all stakeholders, including government authorities, industries, local communities, and individual citizens. It's essential to have a long-term vision and commitment to creating a cleaner and healthier environment for the people of Guwahati.

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