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3. An Analysis of Seasonal Variation of Different Ambient Air Quality Parameters and Indexing in an Industrial Cluster of Odisha

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ABSTRACT

Air pollution is a mixture of natural and man-made substances in the air we breathe. The presence of different pollutants and hazardous gaseous chemicals that cause dangerous health problems. Various ambient air quality parameters such as PM10, PM2.5, SO2 and NO2 were studied from September 2016 to May 2017, covering three seasons such as post-monsoon, winter and pre-monsoon at four locations. Standard methods as per CPCB were used to carry out the study.

The present research shows a brief idea of the atmospheric condition of the study area where maximum PM10 concentrations were recorded in the winter season at SS-1 i.e. 115.8 µg / m3, PM2.5 in the pre-monsoon at SS-1 i.e. 46.9 µg / m3, SO2 in the winter at SS-1 i.e. 5.1 µg / m3, NO2 in the winter at SS-1 i.e. 51.4 µg / m3. It was also revealed that, except for the PM10 parameters, all other parameters were well within the prescribed standards. The current study may give others a basic idea for further research in the field of air quality monitoring and the reduction of air pollution.

KEYWORDS

Ambient air quality, PM_{10}, $PM_{2.5}$, SO_2, NO_2.

Introduction:

It is reported that there is a significant increase in various atmospheric pollutants that have an impact on human health due to an increase in developmental activities (Atash, 2007; Cohen et al., 2017; Orioli et al., 2018). A progressive degradation of air quality has been observed in many developing countries over the last three decades (Agrawal et al., 2003). Maximum cases have shown that a population exposed to particulate matter (PM) with a diameter of less than 10 µm (PM10) causes several diseases (WHO 2016). Whereas PM2.5 is particularly responsible for various harmful effects on human health (Fang et al. 2017; Wang et al. 2018). There is also an impact on vegetation and plant species, which are indicators of the level of pollution (Dash and Dash, 2018).

According to the World Health Organization (WHO) report, in urban areas, people spend about 90 per cent of their time indoors, i.e. 70 per cent at work and 20 per cent at home (Turkstat, 2017; WHO, 2000). The level of indoor pollutants is 2 to 5 times higher than that of outdoor pollutants, as studied by the Environmental Protection Agency (EPA, 2016).

WHO has identified particulate matter (PM), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2) and ozone (O_3) as the pollutants with greatest public health importance. The United States National Ambient Air Quality Standard designates all of the above plus airborne lead as criteria pollutants.

A number of studies have been carried out in the assessment of ambient air quality and air quality indexing where it can be seen as a result of massive industrial development and transport activities that worsen atmospheric conditions (Dash and Dash, 2015; Dash and Dash, 2015; Nigam et al., 2016; Dash and Dash, 2017; Dash and Dash, 2018; Dash et al., 2018; Mishra et al., 2019).

Increased fuel combustion, which directly results in massive emissions of pollutants into the air, is due to continuous industrialization and rapid population growth (Sharma et al., 2014). With an annual average PM10 level of 134 µg / m3, India ranks tenth among the most polluted countries and more cities in India are among the world's most polluted areas (Dholakia et al 2014).

India formulated the Air Prevention and Pollution Control Act in 1981 and developed National Environmental Air Quality Standards (NAQS 2009) to regulate emissions of pollutants. To overcome the problems caused by air pollution, assessment at the regional level is very much needed, especially in countries such as India, where there are many health and environmental challenges facing us (Tobollik et al., 2015). The different models of air quality dispersion were designed to predict the impact of pollutants on the industrial clusters. (Dash et al., 2017; Dash et al., 2018; Dash and Dash 2018).

Therefore, in order to examine more information on the adverse effects of air pollutants, this study was conducted to analyze different environmental parameters and to draw up an air quality index based on various locations and seasons, such as pre-monsoon, winter and post-monsoon.

Material and Methodology:

Study Area:

Sundergarh is an important city in the state of Odisha, India recognized as an industrial map of Odisha. A number of different facilities industries have been established in and around the city, which is rich in mineral resources. Rajgangpur, the study area is located at 84.584251 latitude and 84.584251 longitude. Research work has been carried out around the cement plant, OCL India Limited, based on four locations within a radius of 2 km (Fig. 1). Table 1 shows the detailed descriptions of all ambient air quality monitoring stations and Table 2 shows the analysis procedure & details of monitoring equipments.

All four stations were established in such a way as to cover all four study areas such as Ranibandh (North, SS-1), OCL Market (South, SS-2), IT Colony (East, SS-3) and Liploi (West, SS-4). For research purposes, data were collected for one year, i.e. from September 2016 to May 2017 on a seasonal basis, i.e. post-monsoon (PoM), winter (W) and pre-monsoon (PrM).

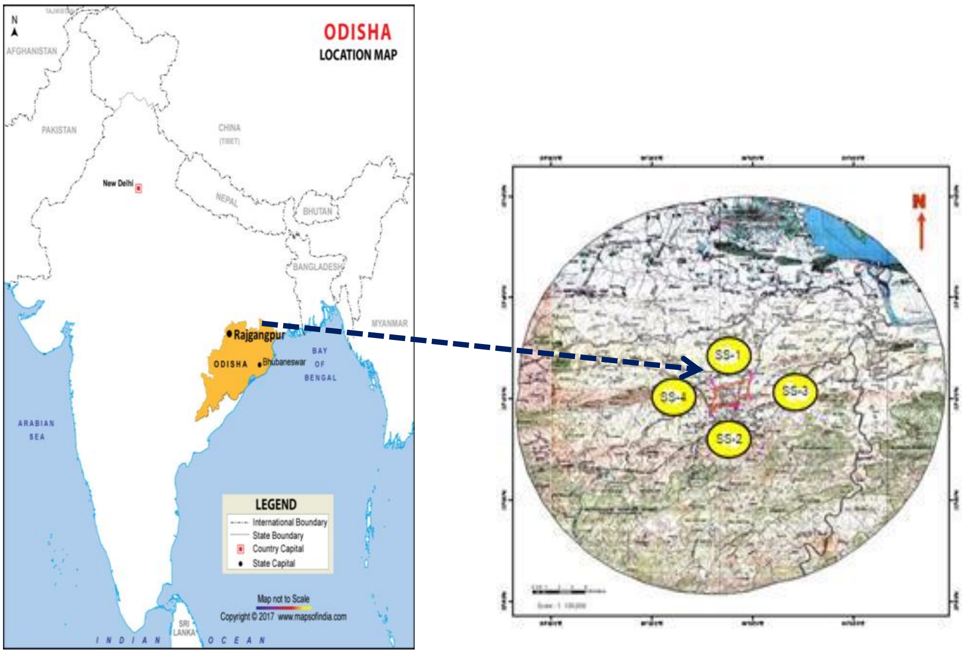

Fig. 1 Study Area with four sampling stations

Table 1: Detailed description of all monitoring stations.

Sr. No.	Sampling Station Code	Latitude	Longitude
1	Sampling Station – 1 (SS-1)	22° 12' 27.09" N	22° 12' 27.09" N
2	Sampling Station – 2 (SS-2)	22° 11' 47.5476" N	84° 35' 5.9136" E
3	Sampling Station – 3 (SS-3)	22° 12' 2.8116" N	22° 12' 2.8116" N
4	Sampling Station – 4 (SS-4)	22° 11' 52.8" N	84° 34' 29.7516" E

Sampling Methodology and Details of Equipment:

Parameters such as PM_{10}, $PM_{2.5}$, SO_x, NO_x has been analyzed as per the standard guidelines stipulated by Central Pollution Control Board (CPCB), Govt. of India. Details are mentioned in Table 2 as under:

Table 2: Details of Air Quality Monitoring Equipment's and Methods used for Analysis

Instrument Sr. No.	Model	Make / Supplier	Parameters	Methods as per CPCB
1537-DTG-2009	APM 460BL	ENVIROTECH	PM_{10}	Gravimetric method with RDS (Avg. Flow rate not less than 1.1 m3/min)
571-DTK-2010	APM 550	ENVIROTECH	$PM_{2.5}$	As above
1338-DTG-2009	APM 460BL	ENVIROTECH	SOx	Improved West and Gaeke method
1339-DTG-2009	APM 460BL	ENVIROTECH	NOx	Jacob & Hechheiser method
39-DTA-2009	WM-271	ENVIROTECH	MET. DATA	

Result and Discussion:

Maximum concentrations of PM10 observed during the winter season, i.e. 115.8 µg / m^3 followed by pre-monsoon and post-monsoon, i.e. 112.8 µg / m3 and 110.0 µg / m^3 , respectively, at station SS-1 (Fig . 2).

Minimum concentrations of PM10 observed during the winter season, i.e. 62.7 µg / m^3 followed by post-monsoon and then pre-monsoon, i.e. 67.1 µg / m^3 and 72.0 µg / m^3, respectively, at station SS-3.

It is observed that the maximum concentrations exceed the statutory norms, while the minimum concentrations are within the norms (PM10 – 100 µg / m^3 standards).

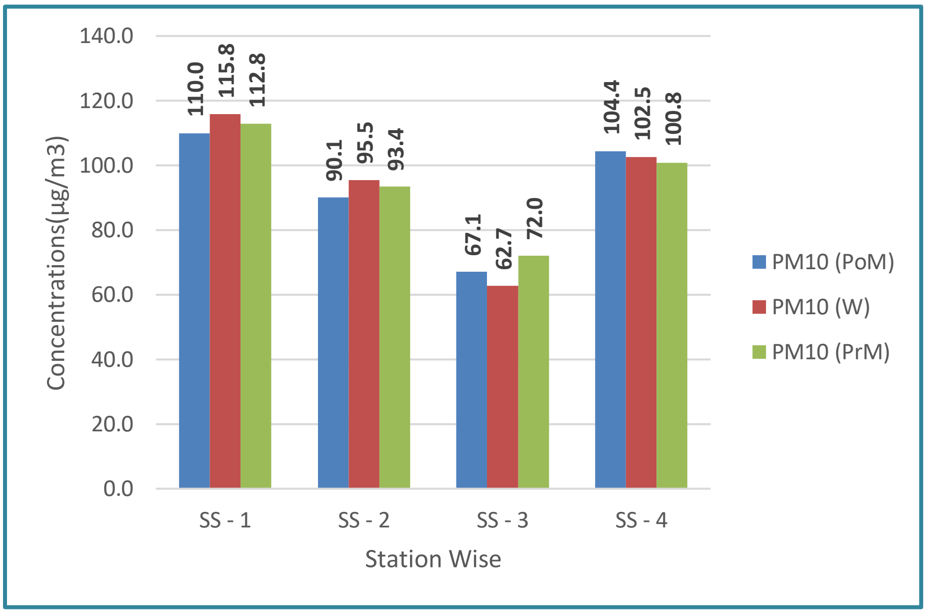

Fig. 2 Variation of PM_{10}, station & season wise.

Similarly, the maximum $PM_{2.5}$ concentrations observed in pre-monsoon i.e. 46.9 µg / m^3 followed by post-monsoon and then winter i.e. 41.4 µg / m^3 and 40.3 µg / m^3 at SS-1 (Fig. 3). Maximum concentrations are observed to be well within the statutory norms ($PM_{2.5}$ – 60 µg / m^3 standards).

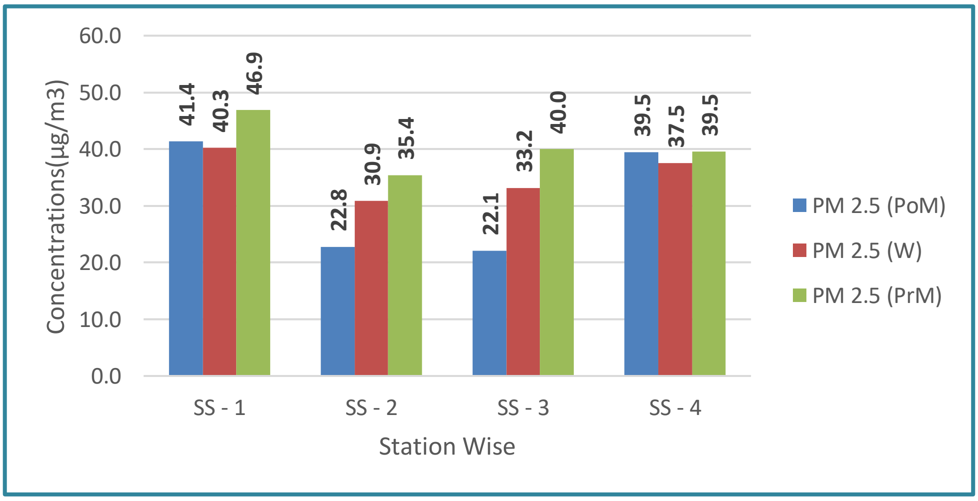

Fig. 3 Variation of $PM_{2.5}$, station & season wise.

The observed concentrations of SO_2 at all four seasonal stations are well within statutory standards (SO_2 standards – 80 µg / m^3). The study has shown that there is no such impact of SO_2 in the atmosphere of the study area.

However, the maximum concentrations of NO_2 observed in winter are 51.4 µg / m^3 followed by post-monsoon and then pre-monsoon, i.e. 40.7 µg / m3. and 34.2 µg/m^3 respectively, at station SS-1 (Fig. 4).

Minimum concentrations of NO_2 observed in pre-monsoon i.e. 15.5 µg / m^3 followed by post-monsoon and then winter i.e. 21.7 µg / m^3 and 27.60 µg / m^3 at station SS-2. All monitored values are well within statutory standards (Norms NO_2 – 80 µg / m^3).

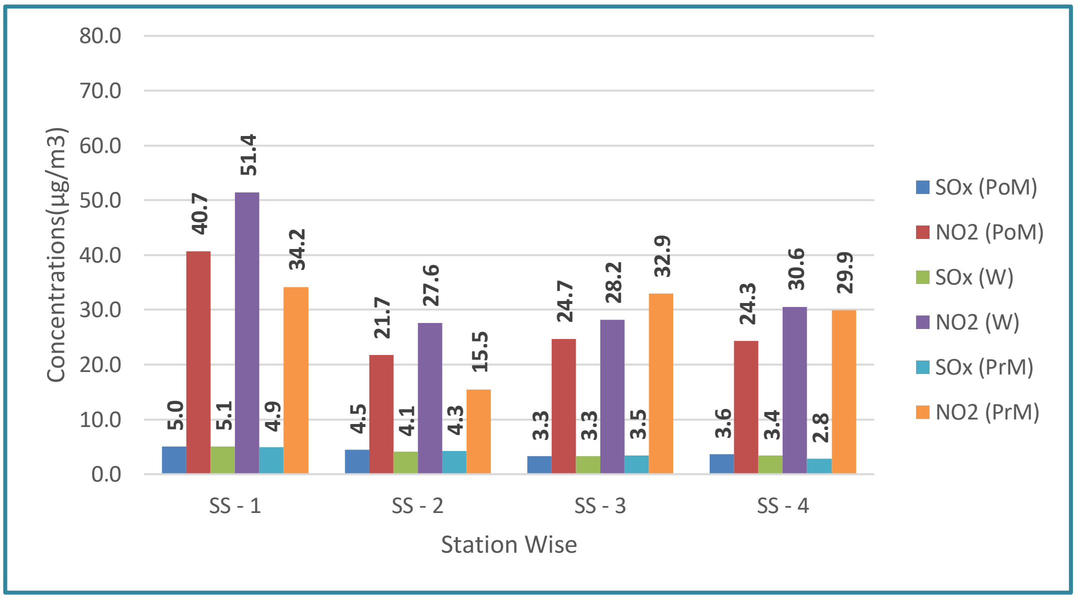

Fig. 4 Variation of SO_2 & NO_2, station & season wise.

The Ip values were calculated in accordance with the Central pollution Control Board, Government of India guidelines issued in 2014in India as under-

The sub-index (Ip) for a given pollutant concentration (Cp), as based on 'linear segmented principle' is calculated as:

Ip = [{(IHI - ILO)/ (BHI-BLO)} * (Cp-BLO)] + ILO

BHI= Breakpoint concentration greater or equal to given conc. from Table 3

BLO= Breakpoint concentration smaller or equal to given conc. from table 3

IHI = AQI value corresponding to BHI

ILO= AQI value corresponding to BLO

Table 3 Breakpoint concentration value for calculation of AQI

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 –1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

**One hourly monitoring (for mathematical calculation only)*

Finally;

AQI = Max (Ip) (where; p= 1, 2, n; denotes n pollutants)

All values of season-based ambient air quality and pollutant concentrations (Ip) monitored for four stations are shown in Table 4.

Maximum, minimum, mean and standard deviations of the monitored values have been formulated for better understanding and analysis.

Table 4: Monitored values of different parameters with I_p Values (season wise).

Post Monsoon (PoM)

Sl. No.	Monitoring Stations	PM10	PM10 (Ip Value)	PM 2.5	PM2.5 (Ip Vaue)	SO2	SO2 (Ip Value)	NO2	NO2 (Ip Value)	AQI Value
1	SS - 1	110.0	107.0	41.4	68.6	5.0	6.3	40.7	50.7	107.0
2	SS - 2	90.1	93.8	22.8	38.0	4.5	5.6	21.7	27.2	93.8
3	SS - 3	67.1	78.5	22.1	36.9	3.3	4.1	24.7	30.9	78.5
4	SS - 4	104.4	103.3	39.5	65.3	3.6	4.5	24.3	30.4	103.3
Maximum		**110.0**	**107.0**	**41.4**	**68.6**	**5.0**	**6.3**	**40.7**	**50.7**	**107.0**
Minimum		**67.1**	**78.5**	**22.1**	**36.9**	**3.3**	**4.1**	**21.7**	**27.2**	**78.5**
Mean		**92.9**	**95.6**	**31.4**	**52.2**	**4.1**	**5.1**	**27.9**	**34.8**	**95.6**
Stand. Dev.		**19.1**	**12.7**	**10.4**	**17.1**	**0.8**	**1.0**	**8.7**	**10.7**	**12.7**
Stand Error		**9.57**	**6.36**	**5.21**	**8.55**	**0.41**	**0.51**	**4.34**	**5.36**	**6.36**

Winter(W)

Sl. No.	Monitoring Stations	PM10	PM10 (Ip Value)	PM 2.5	PM2.5 (Ip Vaue)	SO2	SO2 (Ip Value)	NO2	NO2 (Ip Value)	AQI Value
1	SS - 1	115.8	110.8	40.3	66.7	5.1	6.3	51.4	64.1	110.8
2	SS - 2	95.5	97.4	30.9	50.8	4.1	5.1	27.6	34.5	97.4
3	SS - 3	62.7	75.6	33.2	54.6	3.3	4.1	28.2	35.2	75.6
4	SS - 4	102.5	102.0	37.5	62.0	3.4	4.2	30.6	38.2	102.0
Maximum		**115.8**	**110.8**	**40.3**	**66.7**	**5.1**	**6.3**	**51.4**	**64.1**	**110.8**
Minimum		**62.7**	**75.6**	**30.9**	**50.8**	**3.3**	**4.1**	**27.6**	**34.5**	**75.6**
Mean		**94.1**	**96.4**	**35.5**	**58.5**	**4.0**	**4.9**	**34.4**	**43.0**	**96.4**
Stand. Dev.		**22.6**	**15.0**	**4.2**	**7.2**	**0.8**	**1.0**	**11.4**	**14.1**	**15.0**
Stand Error		**11.28**	**7.50**	**2.12**	**3.58**	**0.42**	**0.52**	**5.69**	**7.07**	**7.50**

Pre Monsoon (PrM)

Sl. No.	Monitoring Stations	PM10	PM10 (Ip Value)	PM 2.5	PM2.5 (Ip Vaue)	SO2	SO2 (Ip Value)	NO2	NO2 (Ip Value)	AQI Value
1	SS - 1	112.8	108.8	46.9	77.8	4.9	6.2	34.2	42.7	108.8
2	SS - 2	93.4	96.0	35.4	58.5	4.3	5.3	15.5	19.4	96.0
3	SS - 3	72.0	81.8	40.0	66.2	3.5	4.3	32.9	41.2	81.8
4	SS - 4	100.8	100.9	39.5	65.4	2.8	3.5	29.9	37.4	100.9
Maximum		**112.8**	**108.8**	**46.9**	**77.8**	**4.9**	**6.2**	**34.2**	**42.7**	**108.8**
Minimum		**72.0**	**81.8**	**35.4**	**58.5**	**2.8**	**3.5**	**15.5**	**19.4**	**81.8**
Mean		**94.8**	**96.9**	**40.5**	**67.0**	**3.9**	**4.8**	**28.1**	**35.2**	**96.9**
Stand. Dev.		**17.1**	**11.4**	**4.7**	**8.0**	**0.9**	**1.2**	**8.6**	**10.8**	**11.4**
Stand Error		**8.56**	**5.69**	**2.37**	**4.00**	**0.47**	**0.58**	**4.30**	**5.38**	**5.69**

Note – All above monitored values are in ***$\mu g/m^3$***.

AQI values provide a brief description of the air quality conditions. The observed values have shown that the maximum AQI values are found in SS-1 & SS-2 and are important.

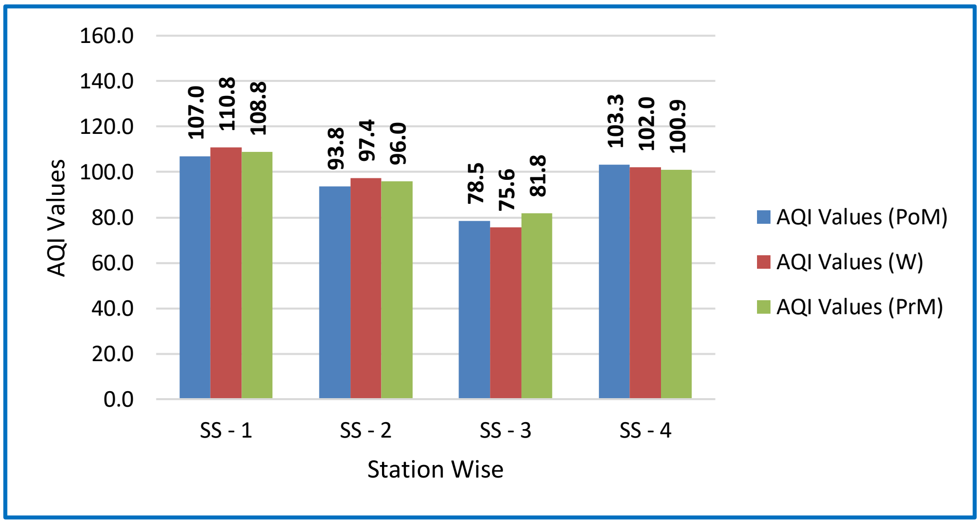

Fig. 5 Variation of AQI Values, station & season wise

Observation has been indicated during all three seasons that it falls under the category "moderately polluted." In SS-1, the maximum AQI values in the winter season, i.e. 110.8, and in the same way in SS-4, the maximum AQI values in the postmonsoon, i.e. 103.3. Whereas SS-2 & SS-3 is in the "satisfactory" category. The variation of the AQI values is shown in Fig.5.

Conclusion:

The study shows that the concentrations of air pollutants in the study area were maximum during the winter season, followed by post-monsoon and pre-monsoon. Among all four parameters, PM10 concentrations were detected during the winter season at stations SS-1 & SS-4, where PM10 values exceeded the statutory standards, but other monitored parameters were well within the standards. In addition, the AQI values gave a broad idea of the air conditions in the season-based study area. SS-1 and SS-4, both stations fall under the category of "moderately polluted" while SS-1 and SS-2 fall under the category of "satisfactory." Many research work has shown that there is a progressive degradation of air quality in India and other developing countries. This is happening due to urbanization and industrialisation. The study found that the ambient air quality is very high during the winter season due to the confluence of natural phenomena, which exacerbates air pollution. More rigorous action to be planned and implemented to ensure a pollution-free environment.

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