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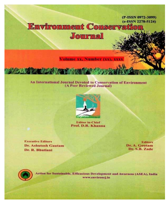

Ambient air quality monitoring of Chandrapur District, Central India

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ABSTRACT

Declining air quality is highly ignored and very common form of degradation of the environment in nations that are both developed and developing. There are several contaminants in the air that have been identified in various studies on air pollution. The crucial parameters of all air pollutants are gaseous and particle pollution. The present study was undertaken to estimate the quality of ambient air in Chandrapur district, Maharashtra state of India. In this paper, an effort has been made to study the standing and trend of Sulphur dioxide (SO_2), Oxides of Nitrogen (NOx), Carbon Monoxide (CO), Ozone (O_3), Ammonia (NH_3), Respirable Suspended Particulate Matter i.e.; PM_{10}, $PM_{2.5}$, toxic pollutants i.e.; lead, arsenic, nickel, benzo [a] pyarene and benzene and hydrocarbons. The results clearly show that, all parameters of ambient air quality monitoring values were some shown slightly below permissible limit. The ambient air quality monitoring data show that the Chandrapur district has substantial air pollution concerns in terms of SO_2, NO_x, PM, and other air pollutants. However, after comparing these values with NAAQS levels, the yearly averages of these air pollutants have been found to be below than the NAAQS levels. However, without effective mitigation measures, the concentrations of these pollutants will rise at quite alarming rate.

Introduction

The level of air pollution has increased rapidly in India during the most recent period (Ahamad *et al.,* 2022; Bhutiani *et al.,* 2021; Ruhela *et al.,* 2022a&b). New Delhi is one of the most polluted cities in the world and is located in northern India. In 2015, 1.09 million deaths related to ambient air pollution were reported in India. The death data were obtained from the Lancet Commission (Kumari and Jain, 2017; Ruhela *et al.,* 2022b). With an increasing population, development activities such as industrialization and urbanization are causing degradation and extreme changes in all characteristics of the environment, namely, the hydrosphere, lithosphere, atmosphere and biosphere, through pollution (Patel *et al.,* 2016). Owing to this characteristic, atmospheric air is a key life-supporting source. A single person respires approximately six liters of air per minute, which is why air quality has become a major concern. The definition of air pollution is defined under the Air (Prevention & Control of Pollution) Act 1981: "it is presence of any solid, liquid or gaseous material in the atmosphere in changeable concentrations as may be pose danger to human or other living creatures or plants or property or environment." The composition of air in the natural atmosphere is steady, but it is being changed due to the discharge of a large quantity of emissions by various industries, vehicles and other sources. This alteration has become a foremost risk to the survival of the species and their habitat. There are 23 major cities in India with a population of more than 1 million people, many of which have air pollution levels higher than those of the World Health Organization (Gupta *et al.,* 2002). Exposure to air pollution has been shown to impair lung development in children (CPCB, 2008), affect cognitive development (Clifford *et al.,* 2016) and

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increase mortality from respiratory infections (Cohen *et al.,* 2017). To stop this astonishing loss of life, we must determine the distinctiveness of lethal particles and gain insight into how this distinctiveness is associated with unfavorable health effects (Manik and Gudadhe, 2020). Rapid industrialization and improper urbanization are causing worsening of the environment and life superiority in budding countries (Gunasekaran *et al.,* 2012). The generated monitoring data can be compared with permissible air quality standards given by the National Ambient Air Quality Monitoring Standard (NAAQMS), and breaching these standards may exacerbate the severity of an area's existing air pollution problems.

In the present study, an effort was made to evaluate the concentrations and trends of particulate matter 10 (PM_{10}), particulate matter 2.5 ($PM_{2.5}$), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxide (NO_x), ozone (O_3), ammonia (NH_3), lead (Pb), nickel (Ni), arsenic (As), benzo a payrene (B(a)P) and volatile organic carbons (VOCs), such as methane and nonmethane, in a fast-growing city.

Materials and Methods

Study Area: Air quality evaluation was carried out at fifteen different locations in the Chandrapur district. The ambient air monitoring locations, geographical locations and monitoring heights are given in Table 1 and depicted in Figure 1. All the selected locations were away from any kind of obstacle.

Table 1: Ambient air quality monitoring locations

Sampling Locations	Latitude and Longitude	Height (m) from ground level
Chandrapur	19^0 58’ 45.11’’ N and 078^0 59’ 55.09’’ E	7
Mul	20^0 03’ 46.71’’ N and 079^0 39’ 58.65’’ E	8
Gondpipari	19^0 43’ 08.98’’ N and 079^0 41’ 19.01’’ E	6
Warora	20^0 13’ 41.83’’ N and 079^0 56’ 50.49’’ E	5
Bhadrawati	20^0 05’ 15.99’’ N and 079^0 06’ 24.65’’ E	5
Chimur	20^0 29’ 29.92’’ N and 079^0 22’ 01.49’’ E	6
Bramhapuri	20^0 34’ 21.45’’ N and 079^0 49’ 37.08’’ E	9
Nagbhid	20^0 34’ 55.31’’ N and 079^0 40’ 55.86’’ E	8
Sindewahi	20^0 17’ 03.42’’ N and 079^0 39’ 17.79’’ E	6
Rajura	19^0 46’ 33.39’’ N and 079^0 21’ 34.57’’ E	6
Korpana	19^0 44’ 12.89" N and 078^0 59’ 34.00’’ E	6
Saoli	20^0 05’ 01.25’’ N and 079^0 47’ 11.49’’ E	5
Ballarpur	19^0 49’ 49.04’’ N and 079^0 20’ 55.71’’ E	7
Pombhurna	19^0 52’ 39.77’’ N and 079^0 37’ 52.00’’ E	5
Jiwati	19^0 38’ 13.11’’ N and 079^0 04’ 23.89’’ E	5

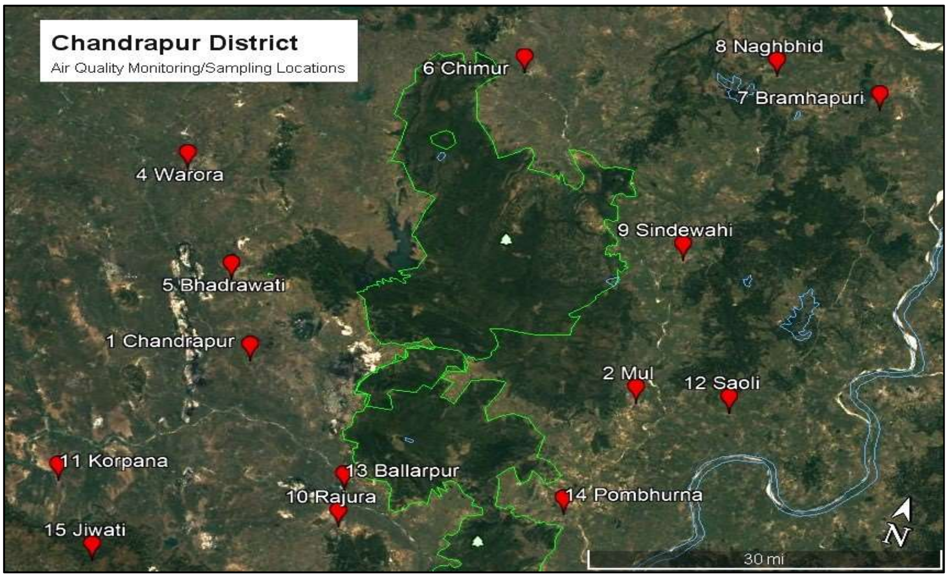

Figure 1: Map showing monitoring locations

Experimental Setup:
The different air parameters considered throughout the present study included $PM_{2.5}$, PM_{10}, CO, SO_2, NO_x, O_3, and NH_3; particulate-associated pollutants such as lead, nickel and arsenic; and B(a)P and VOCs. Similarly, the atmospheric temperature and relative humidity were also recorded. Samples of PM_{10} and $PM_{2.5}$ were collected gravimetrically from the aboveground building station by a respirable dust sampler (RDS) on 8x10 inch fiberglass filter papers at a flow rate of 1.5 m^3/min. After collection, the filter papers were transported to the laboratory for additional analysis, and the dust concentration was computed in $\mu g/m^3$.
The gaseous air pollutants were measured via wet chemical analysis. SO_2, NO_x and NH_3 were estimated as per the Improved West and Gaeke methods (IS 5182 Part 2 Method of Measurement of Air Pollution), Modified Jacob-Honchheiser (Na-Arsenite) (IS 5182 Part 6 Methods for Measurement of Air Pollution), and Indophenol Blue method (Method 401, Air Sampling and Analysis, 3rd Edition), respectively. Ozone was estimated by chemical methods (Method 411, Air Sampling and Analysis, 3 Edition) (Guidelines for the Measurement of Ambient Air Pollutants Volume I). Particulate-associated pollutants such as lead, nickel and arsenic were estimated by digestion with concentrated HNO_3 and analysis via AAS. Hydrocarbon and CO analyses were carried out on an HC-CO analyzer. B(a)P was synthesized by solvent extraction followed by GC analysis. All the methods for ambient air monitoring and analysis were followed according to the National Atomic Maculation Board (CPCB) manual NAAQM (Study on Ambient Air Quality, Respiratory Symptoms and Lung Function of Children in Delhi, 2008).

Statistical methods used:
Statistical analysis is an essential and vital tool in the field of research. The majority of knowledge breakthroughs have occurred as a result of experiments conducted using statistical methodologies (Manik and Gudadhe, 2020) (Yennawar, 1970).

Standard deviation:
The positive square root of the arithmetic mean of the squares of the deviations of the provided observation from the arithmetic mean was used to indicate the standard deviation. It is the most crucial statistic for making statistical forecasts for a variety of research results, and it is the most common measure of dispersion (Manik and Gudadhe, 2020) (Mungikar, 2003).

Results and Discussion
The results for particulate and gaseous pollutants are quantified in Table 2.

Particulate matter (PM): PM consists of many organic and inorganic compounds that vary in size and component characteristics (Cheng & Lin, 2010) (Manik and Gudadhe, 2020). In the present study, the average concentration of $PM_{10\ \mathrm{was}}$ recorded in the range of 42 $\mu g/m^3$-71 $\mu g/m^3$. The highest value was observed at the Chandrapur location due to high vehicular movement and street dust, which is expected to increase the quantity of suspended particulate matter in the atmosphere. In 2017, Patel *et al.* observed a comparable range of PM_{10} concentrations in their investigation conducted in Gujarat (Patel *et al.,* 2017). The average concentration of $PM_{2.5}$ ranged from 28 $\mu g/m^3$ to 36 $\mu g/m^3$. The highest value was observed at Rajura. The concentrations of PM_{10} and $PM_{2.5}$ at all sampling sites were less than the stipulated NAAQS standards (24 hourly PM_{10}-100 $\mu g/m^3$ and $PM_{2.5}$ = 60 $\mu g/m^3$).

Gaseous pollutants: Airborne gaseous pollutants can impair the environment and human health. Gaseous contaminants cause widespread air pollution.

SO_2: The average recorded concentration range of SO_2 was 18 µg/m3–37 $\mu g/m^3$. The lowest average value of SO_2 was found at Bhadrawati, and the highest average value was found at Ballarpur due to various anthropogenic activities, such as the burning of fossil fuels, industrial processes and biomass burning. SO_2 is typically the outcome of industrial activities, and the chief source of SO_2 is anticipated to be motor vehicles, mainly diesel-engined vehicles. The objective of mitigating and reducing SO_2 emissions is achieved by implementing laws that restrict the sulphur content in fuels. The SO_2 concentrations were less than the stipulated CPCB standards (24 hourly SO_2 = 80 $\mu g/m^3$).

NO_x: The average NOx concentration ranged from 30 $\mu g/m^3$- 43 $\mu g/m^3$. The lowest average value of NO_x was found at Rajura, and the highest average value was found at Ballarpur due to human activities, particularly those involving combustion processes. NOx is a collective term for nitrogen oxide gases, including nitric oxide (NO) and nitrogen dioxide (NO_2). Controlling and reducing NO_x emissions involve the use of new and sustainable technology, changes in fuel composition, and regulatory measures. Stricter emission standards and regulations aim to limit the release of nitrogen oxides from various sources. The NO_x concentrations were less than the stipulated standards of the CPCB (NO_x = 80 µg/m^3).

NH_3: The average concentration of NH_3 was in the range of 37 µg/m^3 - 56 µg/m^3. The lowest average value of NH_3 was found in Ballarpur, and the highest average value was found in Chandapur because of the numerous natural processes and activities carried out by humans. Agricultural, industrial, and natural activities all produce ammonia, which is a substance that is made up of nitrogen and hydrogen. Ammonia is a typical byproduct of these processes. The NH_3 concentrations were less than the stipulated standards of CPCB (NH_3 = 100 µg/m^3).

Table 2: Status of ambient air quality {Units: µg/m3, Average24Hours}

Sampling Locations	Average ± Standard Deviation (minimum - maximum)						AQI
	PM_{10}	$PM_{2.5}$	SO_2	NOx	NH_3	O_3	
Chandrapur	71±7 (62-85)	31±7 (21-39)	19±2 (16-22)	35±1 (29-39)	56±6 (43-66)	66±13 (44-72)	71
Mul	52±6 (44-65)	30±5 (22-38)	25±2 (20-25)	42±1 (41-43)	50±5 (40-60)	33±5 (22-44)	53
Gondpipari	49±6 (45-65)	28±5 (21-35)	23±2 (21-25)	41±1 (40-42)	49±5 (42-62)	30±5 (20-41)	51
Warora	49±6 (45-65)	29±5 (23-34)	22±2 (22-24)	42±1 (40-43)	45±5 (41-50)	32±5 (22-45)	53
Bhadrawati	62±9 (49-75)	31±4 (25-39)	18±1 (16-19)	39±1 (38-40)	49±5 (44-61)	62±11 (42-78)	62
Chimur	55±12 (30-72)	32±6 (23-41)	29±2 (25-30)	37±1 (32-45)	49±9 (39-59)	51±12 (25-65)	55
Bramhapuri	45±7 (42-62)	30±8 (20-44)	24±1 (23-25)	33±5 (26-41)	49±6 (43-62)	48±9 (28-60)	50
Nagbhid	56±12 (35-72)	35±6 (22-41)	25±2 (24-31)	40±1 (39-41)	53±10 (40-72)	56±11 (31-65)	58
Sindewahi	48±7 (41-62)	31±7 (21-42)	24±1 (21-25)	33±5 (26-41)	49±6 (43-62)	45±9 (25-65)	61
Rajura	51±12 (31-69)	36±6 (24-42)	29±2 (25-30)	30±1 (29-31)	54±8 (39-74)	57±12 (28-65)	60
Korpana	49±7 (40-61)	30±8 (20-44)	25±2 (21-28)	33±5(26-41)	49±6 (43-62)	47±9 (26-61)	50
Saoli	42±7 (41-62)	31±6 (22-47)	22±2 (23-26)	33±5 (26-41)	49±6 (43-62)	48±9 (32-62)	52
Ballarpur	62 ± 13 (49-80)	35±7 (31-58)	37±9 (29-55)	43±8 (22-56)	37±1 (35-39)	51±10 (39-70)	62
Pombhurna	56±12 (30-72)	32±6 (23-41)	29±2 (25-30)	39±1 (37-40)	53±10 (39-74)	58±12 (29-65)	58
Jiwati	48±7 (44-60)	30±8 (20-44)	26±1 (21-29)	33±5 (26-41)	49±6 (43-62)	48±9 (24-51)	58
NAAQS (2009)	**100**	**60**	**80**	**80**	**100**	**100**	

O_3 and CO: Ozone (O_3) was found in the range of 30 µg/m^3-66 µg/m^{3,} and the range of CO was found to be between 0.42 mg/m^3 and 1.22 mg/m^3. The values of these pollutants were within the stipulated standards of the CPCB. These findings indicated that the levels of gaseous pollutants were somewhat elevated from a health perspective but nevertheless fell below the acceptable limits set by the NAAQM regulations.

Particulate-associated toxic pollutants: Heavy metals are naturally present chemicals, but human actions introduce them in significant amounts into many environmental components. The presence and dispersion of small amounts of metals are determined by the characteristics of the substances released into the air. Elevated levels of heavy metals pose a significant threat to human health. Estimation of heavy metal concentrations in ambient air is essential for environmental academics because of the harmfulness of heavy metals to humans. Some heavy metals, such as Cr, As, Cd and Ni, have been listed as carcinogens. Additionally, these heavy metals in the atmosphere can accumulate in several plants and animals and may pass through the human food chain (Suvarapu and Baek, 2017). Pb, Ni and As are naturally found in nature and in manufactured products (Gudadhe *et al.,* 2012). The average concentrations of these toxic pollutants ranged from 0.05 µg/m^3-0.18 µg/m^3 and 5.9 ng/m^3-8.9 ng/m^3 for Pb and Ni, respectively, whereas As was not detectable at any of the other locations. All these pollutants were found within the NAAQS stipulated standards. The results are listed in Table 3.

Levels of hydrocarbons: Methane and nonmethane hydrocarbons (MHCs and NMHCs) are the key organic pollutants and ozone (O_3) pioneers in the atmosphere (Poisson *et al.,* 2000) and can considerably affect atmospheric photochemical interactions and human health (Atkinson, 2000). The

Table 3: Levels of particulate-associated toxic pollutants

Sampling Locations	Pb	As	Ni	BaP	CO	Benzene	N-CH4	CH4	HCs
	Particulate associated pollutants				Volatile Organic Pollutants				
Chandrapur	0.14	ND	8.9	0.06	0.42	1.13	0.44	1.33	1.45
Mul	0.08	ND	7.2	0.12	0.81	1.10	0.49	0.98	1.00
Gondpipari	0.09	ND	7.9	0.07	0.83	0.37	0.84	0.79	1.13
Warora	0.08	ND	8.5	0.06	0.75	1.00	0.15	0.30	0.69
Bhadrawati	0.09	ND	7.1	0.16	0.49	0.89	0.45	0.82	1.05
Chimur	0.06	ND	7.5	0.06	0.82	0.20	0.15	1.29	1.21
Bramhapuri	0.07	ND	7.4	0.11	0.65	0.84	0.58	0.88	1.25
Nagbhid	0.05	ND	7.0	0.09	0.89	0.55	0.25	1.05	0.87
Sindewahi	0.18	ND	7.1	0.08	1.22	0.22	0.79	0.79	0.99
Rajura	0.07	ND	6.8	0.09	0.98	0.87	0.55	0.65	1.43
Korpana	0.08	ND	6.2	0.10	0.87	1.05	0.39	1.13	1.31
Saoli	0.09	ND	5.9	0.07	0.79	0.89	0.95	0.77	0.68
Ballarpur	0.08	ND	6.2	0.09	0.88	0.59	0.93	1.01	1.72
Pombhurna	0.06	ND	7.0	0.13	0.93	0.87	0.47	0.85	1.59
Jiwati	0.10	ND	6.9	0.08	1.14	0.88	0.30	0.65	1.31
NAAQS (2009)	**1**	**6**	**20**	**1**	**04**	**05**	**03-10**		

Sources of hydrocarbons in urban air are usually led by anthropogenic discharge, including liquefied petroleum gas (LPG) leakage, solvent usage and vehicular releases (Barletta *et al.,* 2005; Tang *et al.,* 2007; Duan *et al.,* 2008). The average concentration of total hydrocarbons was in the range of 0.68 ppm – 1.72 ppm. The concentrations of BaP and benzene were also found to be in the range of 0.06 ng/m3–0.16 ng/m^3 and 0.20 µg/m3–1.13 µg/$m^{3,}$ respectively. The levels of HCs, BaP, and benzene were within the stipulated NAAQS standards. The results are quantified in Table 3.

Conclusion
All the ambient air quality monitoring parameters were less than the stipulated NAAQM standard. However, due to the increase in industrial activities, urbanization, and pollution due to vehicles, there is a boost in A high pollution level may pose a danger to the health of people residing in those particular areas. Due to the risk of health hazards, it is essential to control the increasing concentration of air pollutants. This is the time when good plantations and large trees and green belts were planted in cities or in open spaces in cities to preserve the health of common peoples and curtail atmospheric pollution.

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Conflict of interest
The authors declare that they have no conflicts of interest.

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