

# Recent Status of Ambient Air Quality of Bhopal City, Madhya Pradesh, India

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## ABSTRACT

To assess the Ambient Air Quality Index of Bhopal city of Madhya Pradesh, India, this study has been conducted during year 2017 to 2018. Total eighteen locations were selected in Bhopal city for ambient air quality monitoring of seven pollutants mainly Particulate Matter less than 10  $\mu$  size (PM<sub>10</sub>), Particulate Matter less than 2.5  $\mu$  size (PM<sub>2.5</sub>), nitrogen dioxide (NO<sub>2</sub>), Sulphur dioxide (SO<sub>2</sub>), Ozone (O<sub>3</sub>), Ammonia (NH<sub>3</sub>) and Lead (Pb). The study revealed that average concentration of gaseous pollutants i.e. NO<sub>x</sub>, SO<sub>2</sub>, O<sub>3</sub>, NH<sub>3</sub> in ambient air are well within standard limits at all selected locations however Particulate Matter (PM<sub>10</sub>, PM<sub>2.5</sub>) levels were found exceeding the National Ambient Air Quality Standards 2009 at all monitoring locations. Air Quality Index was poor (202.26-218.05) at two locations, Moderate (106.08-184.75) at fourteen locations and satisfactory (63.90-96.38) at two locations in Bhopal city. Overall ambient Air Quality Index of Bhopal city was observed to be moderate during this study span.

**Keywords:** Ambient Air Pollution, PM<sub>10</sub>, PM<sub>2.5</sub>, Gaseous Pollutants, Pb, Air Quality Index

## 1. INTRODUCTION

Ambient air pollution in urban cities is serious concern in world due to many reasons such as Urbanization, transportation, industrialization, power generation and anthropogenic activities. An "Air Quality Index" may be defined as a single number for reporting the air quality with respect to its effects on the human health (Bortnick et al., 2002). Air pollution is now widely known to have impacts over human health, agriculture, ecology, buildings, and climate. It affects the respiratory, cardiovascular, cardiopulmonary and reproductive systems and can also lead to cancer. Air Quality Index is a tool for effective communication of air quality status to people in terms, which are easy to understand. It transforms complex air quality data of various pollutants into a

single number (index value), nomenclature and color. There are six AQI categories, namely good, satisfactory, moderately polluted, poor, very poor and severe. Each of these categories is decided based on ambient concentration values of air pollutants and their likely health impacts which known as health breakpoints. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. Unhealthy AQI is 151-200. Very Unhealthy AQI is 201-300. Hazardous AQI greater than 300 which can be very poor (301-400) and severe (4001-500 & >500). All atmospheric substance that is not gases but may be suspended droplets, solid particle or mixture of the two is generally referred to as particulates. Oxides of nitrogen cause respiratory problem, asthma, lung irritation

and pneumonia. Higher concentration of oxides of sulphur causes bronchitis and also causes acid rain, sulfurous smog and reduced atmosphere visibility. Combination of particulate matter with sulphur oxides is more harmful than either of them separately (Balashanmugam et al., 2012). Ozone is produced in the upper atmosphere by solar reaction. Small concentration of this gas diffuses downward and become the major concern in air pollution. It causes irritation of eyes nose and throat, headache in human. In Indian context, the studies on AQIs have been carried out for the various cities i.e. Delhi (Prakash et al., 2010), Choudwar, Cuttack district (Bhuyan et al., 2010), Rohtak city (Shukla et al., 2010), Jaipur city (Kumar et al., 2011, Sharma and Sharma, 2016), Garhwal (New Tehri), Kumaon (Muktheshwar) (Meena. et al., 2012), Puducherry ( Balashanmugam et al., 2012), Hosur, Tamilnadu (Harikrishnan et al., 2012), Udaipur (Kapoor et al., (2013), Nashik (Khandbahale et al., 2013) and Bhopal (Chaurasia et al., 2013, Mishra et al., 2019 ). Earlier other prominent studies related to various aspects of air quality indexes were studied by Kassomenos et al. (1999), Malakos and Wong (1999), Swamee and Tyagi (1999), Trozzi et al. (1999), Khanna (2000), Cogliani (2001), Jiang et al. (2004), Longhurst (2005), Mayer and Kalberlah (2008), and Elshout et al. (2008). These studies on air pollution in large cities of India concluded that ambient air pollution concentrations are at such levels where serious health effects are possible. These all pollutants may pose harmful effect on human health, as exposure of these are associated with cardiovascular, respiratory disease, neurological impairments, increased risk of preterm birth, mortality and morbidity. Therefore Air Quality Index study of developing city such as Bhopal is important for health concern in India.

## 2. METHODOLOGY

### 2.1. Study Area

Bhopal city is the capital of Madhya Pradesh which is very well connected to all

the corners of the country situated in the central part of India which lies between N-latitude 23°07' & 23°20' and E- longitude 77°19' & 77°31'. Bhopal is also known as the “Lake City” for its various natural as well as artificial lakes and is one of the greenest cities in India. Bhopal is one of the developing city of home to various markets, parks, schools, hospitals and malls etc. Total eighteen locations were selected for this study during 2017-18. Details of all monitoring locations are depicted in table 1 and shown in figure 1.

**Table 1: Selected Ambient Air Monitoring Locations in Bhopal City**

S.N.	Code	Monitoring locations
1	A1	Bairagharh
2	A2	Chhola Road
3	A3	Sultania Road
4	A4	Karod
5	A5	BHEL Area
6	A6	Govindpura
7	A7	Anand Nagar
8	A8	Arera Colony
9	A9	Saket Nagar
10	A10	Katara Hills
11	A11	Vidhya Nagar
12	A12	Babdiya Kalan
13	A13	Misrod
14	A14	Gehun Kheda Kolar
15	A15	WALMI Kolar
16	A16	Kotra
17	A17	T T Nagar
18	A18	VanVihar Colony

### 2.2. Monitoring and Analysis

Ambient air was drawn through a size-selective inlet of the ambient air sampler Envirotech APM-460 BL and APM 540 equipments. 24 hour air monitoring has been conducted in eight hrs basis in selected eighteen locations for parameters namely particulate matter less than 10 μ size (PM<sub>10</sub>), particulate matter less than 2.5 μ size (PM<sub>2.5</sub>), sulphur dioxides (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>) were monitored on four hourly. Ozone (O<sub>3</sub>) and ammonia (NH<sub>3</sub>) were monitored on one hourly basis for during the entire monitoring duration. The collected samples were analyzed for various parameters using standard methods prescribed by Central Pollution Control Board, India (Guidelines, CPCB, 2011). Particulate Matter (PM<sub>10</sub> and PM<sub>2.5</sub>) in ambient air were analyzed by gravimetric method. Nitrogen dioxide, sulphur dioxide

in ambient air was analyzed by Jacob & Hochheiser method and West & Geake method respectively. Ozone, ammonia, heavy metal lead in ambient air was

analyzed by chemical method, indophenols blue method and atomic absorption spectroscopy respectively.

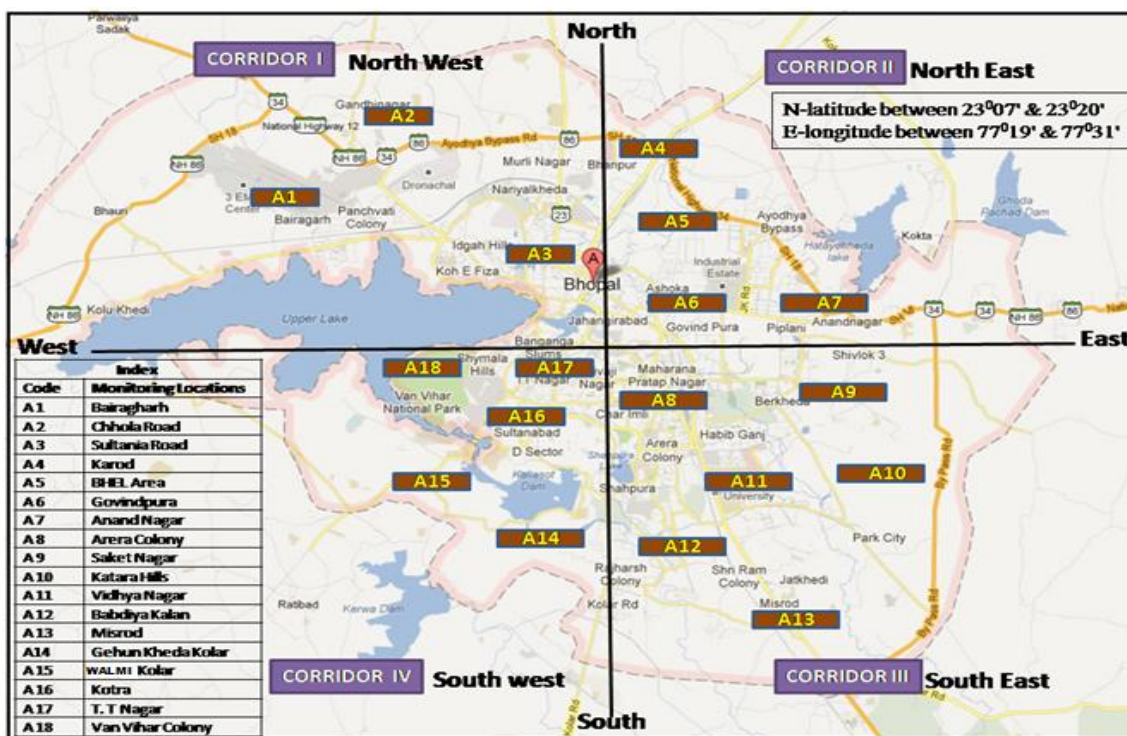


Figure 1: Selected monitoring locations in Bhopal City

12 pollutants are listed in National Ambient Air Quality Standards (2009), Out of which 7 pollutants NO<sub>2</sub>, SO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, O<sub>3</sub>, Pb and NH<sub>3</sub> were studied during this study. The concentration of each pollutant is converted to a number on a scale of 0–500. Sub index for each pollutant concentration is calculated by given equation 1:

$$I_p = \left[ \left\{ \frac{(I_{HI} - I_{LO})}{(B_{HI} - B_{LO})} \right\} \times (C_p - B_{LO}) \right] + I_{LO}$$

Eq 1

Where

$I_p$  = Sub Index for a given pollutant concentration,  $B_{HI}$  = Break point concentration greater or equal to given concentration (CP),  $B_{LO}$  = Break point concentration smaller or equal to given concentration (CP),  $I_{HI}$  = AQI value corresponding to  $B_{HI}$ ,  $I_{LO}$  = AQI value corresponding to  $B_{LO}$ ; subtract one from  $I_{LO}$ , if  $I_{LO}$  is greater than 50,  $C_p$  = Pollutant concentration,  $AQI = \text{Max}(I_p)$  (where  $p = 1, 2, \dots, n$ ; whereas 'n' denotes no. of pollutants)

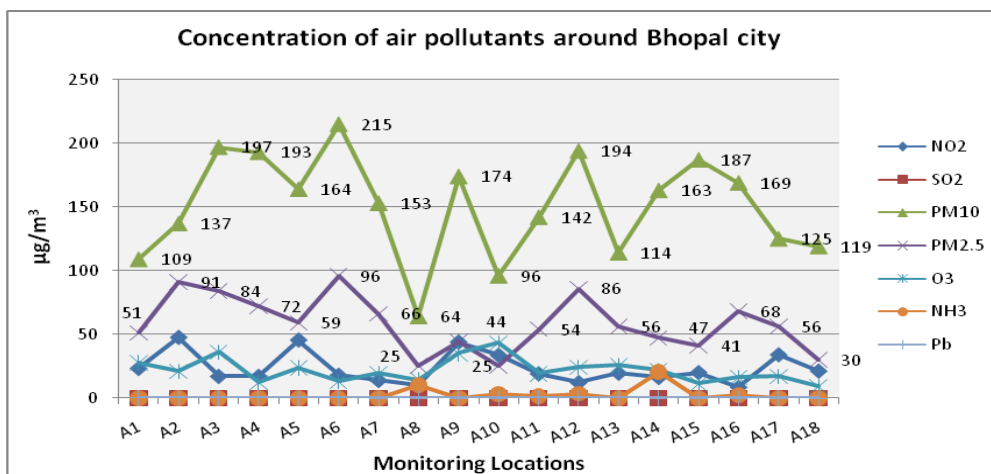
The overall AQI, can be estimated only if the concentrations of minimum three pollutants are available, with at least one of them being either PM<sub>2.5</sub> or PM<sub>10</sub>. The India-AQI is then taken as the maximum AQI<sub>i</sub> of the constituent pollutants, denoted as dominating pollutant. The AQI is divided into five categories: good, satisfactory, moderate, poor, very poor and severe depending on whether the AQI falls between 0–50, 51–100, 101–200, 201–300, 301–400 or 401–500, respectively (Sahu and Kota, 2017).

### 3. RESULTS & DISCUSSION

The cumulative effect of concentration of individual pollutants in ambient air is often expressed through a single value in the form of Air Quality Index (AQI). Air pollution index was calculated for all the parameters at all monitoring location of Bhopal city. The observed concentration of seven air pollutants is depicted in table 2 and figure 2

**Table 2: Concentration of air pollutants of Bhopal city**

S.N	Sampling Locations	NO <sub>2</sub> (µg/m <sup>3</sup> )	SO <sub>2</sub> (µg/m <sup>3</sup> )	PM <sub>10</sub> (µg/m <sup>3</sup> )	PM <sub>2.5</sub> (µg/m <sup>3</sup> )	O <sub>3</sub> (µg/m <sup>3</sup> )	NH <sub>3</sub> (µg/m <sup>3</sup> )	Pb (µg/m <sup>3</sup> )
1	A1	23.2	0	109	51	27.6	0	0.001
2	A2	47.6	0	137	91	21.0	0	0.001
3	A3	16.9	0	197	84	36.0	0	0.001
4	A4	16.9	0	193	72	12.0	0	0.001
5	A5	45.5	0	164	59	23.5	0	0.001
6	A6	17.8	0	215	96	12.9	0	0.002
7	A7	13.7	0	153	66	19.0	0	0
8	A8	9.8	0	64	25	14.1	10.5	0
9	A9	43.9	0	174	44	34.8	0	0
10	A10	33.6	0	96	25	43.1	3.3	0
11	A11	18.9	0	142	54	19.0	1.55	0.001
12	A12	12	0	194	86	24.0	3.54	0.001
13	A13	19.4	0	114	56	25.4	0.25	0.001
14	A14	16	0	163	47	21.3	20.6	0
15	A15	19.9	0	187	41	11.0	0	0
16	A16	8.3	0	169	68	16.0	2.35	0
17	A17	33.9	0	125	56	17.0	0	0
18	A18	21.1	0	119	30	9.0	0	0



**Figure 2: Concentration of air pollutants of Bhopal city**

AQ sub-index also evaluated for seven pollutants (PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub>, NH<sub>3</sub>, and Pb) are depicted in table 3.

**Table 3: Sub Index and Air Quality Index of air pollutants in Bhopal city**

S.N.	Monitoring Locations	NO <sub>2</sub>	SO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>	O <sub>3</sub>	NH <sub>3</sub>	Pb	AQI	Category
1	A1	29.00	0.00	106.08	84.44	27.60	0.00	0.10	106.08	MODERATE
2	A2	59.25	0.00	124.58	202.26	21.00	0.00	0.10	202.26	POOR
3	A3	21.13	0.00	164.36	179.43	36.00	0.00	0.10	179.43	MODERATE
4	A4	21.13	0.00	161.72	138.51	12.00	0.00	0.10	161.72	MODERATE
5	A5	56.63	0.00	142.91	98.29	23.54	0.00	0.10	142.91	MODERATE
6	A6	22.25	0.00	176.24	218.05	12.90	0.00	0.20	218.05	POOR
7	A7	17.13	0.00	135.59	117.06	19.00	0.00	0.00	135.59	MODERATE
8	A8	12.25	0.00	63.90	41.50	14.05	2.63	0.00	63.90	SATISFACTORY
9	A9	54.63	0.00	149.18	72.97	34.82	0.00	0.00	149.18	MODERATE
10	A10	42.00	0.00	96.38	41.14	43.15	0.83	0.00	96.38	SATISFACTORY
11	A11	23.63	0.00	127.86	89.85	19.00	0.39	0.10	127.86	MODERATE
12	A12	15.00	0.00	162.15	184.75	24.00	0.89	0.10	184.75	MODERATE
13	A13	24.25	0.00	109.49	93.23	25.42	0.06	0.10	109.49	MODERATE
14	A14	20.00	0.00	141.59	78.02	21.30	5.15	0.00	141.59	MODERATE
15	A15	24.88	0.00	157.76	67.14	11.00	0.00	0.00	157.76	MODERATE
16	A16	10.38	0.00	145.88	124.87	16.00	0.59	0.00	145.88	MODERATE
17	A17	42.38	0.00	116.79	93.23	17.00	0.00	0.00	116.79	MODERATE
18	A18	26.38	0.00	112.88	49.32	9.00	0.00	0.00	112.88	MODERATE

PM<sub>2.5</sub> was found in poor category (200-300) at two monitoring locations (A2 and A6) which indicate unhealthy air quality for health concern and other was in satisfactory to poor



category. Similarly PM<sub>10</sub> was found in moderate category (100-200) at all locations except locations A8 and A10. Air pollution index of SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, NH<sub>4</sub> and Pb was found in satisfactory category (0-100) indicating clean air quality which is not harmful in terms of health concern. Range and distribution of Air Quality at all selected monitoring locations of Bhopal city is depicted in table 4.

**Table 4: Range and distribution of air quality of Bhopal city**

Index	Category	No of Locations	Name of Locations
401-500	SEVERE	None	None
301-400	VERY-POOR	None	None
201-300	POOR	2	A2,A6
101-200	MODERATE	14	A1,A3,A4,A5,A7,A9,A11,A12, A13,A14, A15,A16,A17,A18
51-100	SATISFACTORY	2	A8,A10
0-50	GOOD	None	None

The Air Quality Index were found poor (200-300) at two monitoring location i.e. A2 (202.26) and A6 (218.05). The Air Quality Index were found moderate (100-200) at fourteen monitoring location i.e. A1 (106.08), A3 (179.43), A4 (161.72), A5 (142.91), A7 (135.59), A9 (149.18), A11 (127.86), A12 (184.75), A13 (109.49), A14 (141.59), A15 (157.76), A16 (145.88), A17 (116.79) and A18 (112.88). The Air Quality Index were found satisfactory (50-100) at two monitoring location i.e. A8 (63.90), A10 (96.38). The overall relative AQI with background study of sources of pollution at selected monitoring locations in Bhopal city during study period depicted in Table 5.

**Table 5: Air quality index with pollution sources at monitored locations of Bhopal city**

S.N.	Code	AQI	Category	Pollution Sources
1	A1	106.08	MODERATE	Indore High way, Small scale factories, Vehicle, Transport, Public, Anthropogenic activity, Residential and Commercial area
2	A2	202.26	POOR	Small scale factories, Vehicle, Transport, Public, Anthropogenic activity, Residential and Commercial area
3	A3	179.43	MODERATE	Wooden and door shops ,Small scale factories, High vehicle zone, Heavy Transport, Public, Anthropogenic activity, Residential and Commercial area
4	A4	161.72	MODERATE	Bypass road, Near union carbide area, Heavy traffic, Transport, Public, Anthropogenic activity
5	A5	142.91	MODERATE	Bypass road, Heavy traffic, MSW trenching ground, Transport, Public, Anthropogenic activity, Residential and Commercial area
6	A6	218.05	POOR	Industrial area, Large and Small scale factories, Vehicle, Transport, Public, Anthropogenic activity, Residential and Commercial area
7	A7	135.59	MODERATE	Bypass road, Heavy traffic, Transport, Public, Anthropogenic Activity, Residential and Commercial area
8	A8	63.90	SATISFACTORY	Near slam area, Vehicle, Transport, Public, Anthropogenic activity, Residential and Commercial area
9	A9	149.18	MODERATE	Near NH12 , Vehicle, Transport, Public, Anthropogenic activity, Residential and Commercial area
10	A10	96.38	SATISFACTORY	Less vehicle, Less transport, Less anthropogenic activity, Residential area and Silent area
11	A11	127.86	MODERATE	NH-12, Vehicle, Public, Anthropogenic activity, Residential area and Commercial area
12	A12	184.75	MODERATE	Near NH12,Vehicle, Transport, Public, Anthropogenic activity, Residential and Commercial area
13	A13	109.49	MODERATE	NH12,Vehicle, Transport, public, Anthropogenic activity, Residential and Commercial area
14	A14	141.59	MODERATE	Near slam area, Vehicle, Transport, Public, Anthropogenic activity, Residential area
15	A15	157.76	MODERATE	Less Vehicle, Less transport, Less anthropogenic activity, and Silent area
16	A16	145.88	MODERATE	Vehicle, Transport, Public, Anthropogenic activity, Residential area
17	A17	116.79	MODERATE	Vehicle, Transport, Public, Anthropogenic activity, Residential and Commercial area
18	A18	112.88	MODERATE	Less Vehicle, Less public, Less anthropogenic activity, Residential and Silent area

The significant comparison of Air Quality Index of eighteen monitoring locations in Bhopal city during year 2017-18 is shown in Figure 3.

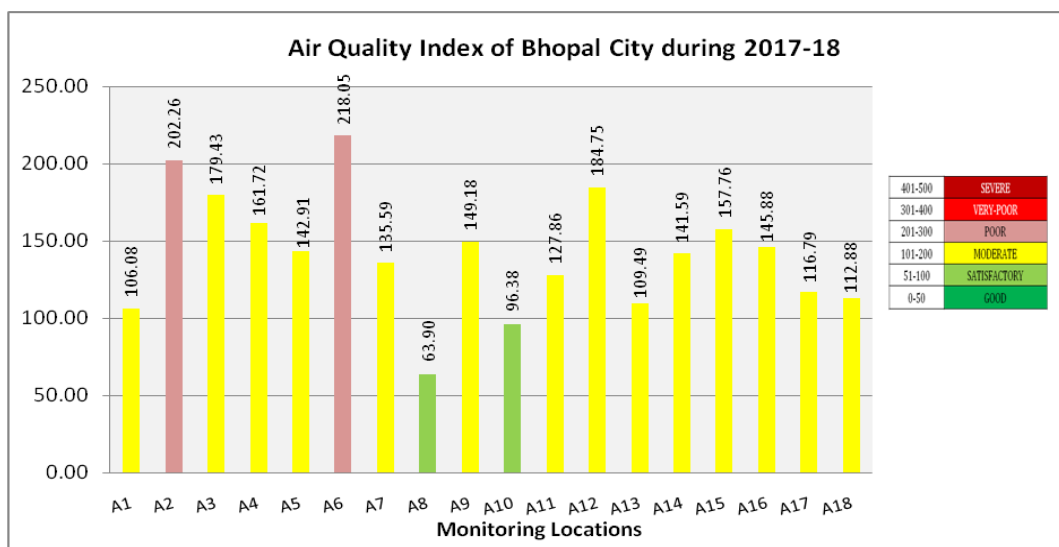


Figure 3: Air Quality Index of Bhopal City during year 2017-18

#### 4. CONCLUSION

It revealed that overall ambient air quality index of Bhopal city was observed as moderate during study span. Air Quality Index was poor (202.26-218.05) at two locations, Moderate (106.08-184.75) at fourteen locations and satisfactory (63.90-96.38) at two locations in Bhopal city. Moderate air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution. Although general public is not likely to be affected at this AQI range, people with lung disease, older adults and children are at a greater risk from exposure to ozone, whereas persons with heart and lung disease, older adults and children are at greater risk from the presence of particles in the air. It may indicate of increased risk of cardio respiratory symptoms in general population in Bhopal city of Madhya Pradesh, India.

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