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AMBIENT AIR QUALITY STATUS OF DEWAS INDUSTRIAL AREA OF MADHYA PRADESH, INDIA

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ABSTRACT

A study has been conducted to assess the ambient air quality status of Dewas industrial area of Madhya Pradesh, India. Total nine locations were selected in Dewas industrial area for ambient air quality monitoring. The eleven pollutants mainly Particulate matter less than 10 µ size (PM_{10}), Particulate matter less than 2.5 µ size ($PM_{2.5}$), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Ozone (O_3), Ammonia (NH_3), Benzene (C_6H_6), Benzo (a) Pyrene (BaP) – particulate phase, Lead (Pb), Arsenic (As) and Nickel (Ni) were monitored during different four quarters from April 2019 to March 2020. The study revealed that average concentration (24 hrs) of gaseous pollutants viz, NO_2, SO_2, C_6H_6 and average concentration (1 hr) of O_3, NH_3 in ambient air were well within standard limits at all selected locations, however average concentration (24 hrs) of particulate matter (PM_{10}, $PM_{2.5}$) and heavy metals (Pb & Ni) except As level were found exceeding the limit of National Ambient Air Quality Standards (NAAQS) 2009, India at few monitoring locations. Benzo (a) Pyrene (BaP) –particulate phase in ambient air was not detected during this study. Ambient Air Quality Index was found to be moderate (107.42-198.36) at six locations and satisfactory (71.60-95.94) at three locations in Dewas industrial area. Overall ambient Air Quality Index of Dewas industrial area was observed, satisfactory to moderate during the study w.r.t. Air Quality Index.

KEY WORDS: ***Industrial Area, Ambient Air, Air Pollutants, Air Quality Index***

1. INTRODUCTION

In India, ambient air is mainly due to pollutants from automobile exhaust and industrial activities. Though respiratory system usually bears the main brunt of air pollutants, many other disorders involving other organ systems even cancers are attributed to air pollution [1]. Major man-made activities include automobiles, power generation and industrial activities in particular oil refineries, which represent the main source of air pollution. Prolonged exposure to inhalant dust can cause serious disease. Industrial activities will be more hazardous in highly populated areas [2]. Such activities have great impact on the ecology and agriculture as well as health and safety effects. Dust is small enough (small volume ranges between 0.01 - 200 Microns), that can be carried away for long distance and cause soil degradation in case it contains heavy metals and air pollution. Small suspended solids particle (small volume ranges between 0.01 - 200 Microns), remain in air for a long period of time. Long term exposure to air pollutants causes respiratory and cardiovascular diseases [3]. The risk of respiratory illnesses such as allergies, asthma, chronic obstructive pulmonary disease and lung cancer increases with exposure to atmospheric air pollutants [4, 5]. Economic development, urbanization, energy consumption, transportation and rapid population growth have been identified as anthropogenic activities contributing to air pollution [6]. Air bone gases and particles were never envisaged as a threat to the ecological balance until the dramatic changes in their concentrations with the advent of industrial era. Anthropogenic emissions from various industrial, domestic and automobile sources have increased manifold and eventually have led to many global problems [7]. $PM_{2.5}$ causes cardiovascular disease and lung cancer. $PM_{2.5}$ also affects air visibility and contributes to global climate change [8-10]. The harm of PM_{10} cannot be ignored. It can affect visibility

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and temperature. Nitrogen dioxide in the atmosphere has a variety of toxicities and damages the bronchus and lungs after entering the human body, which can induce various types of respiratory inflammation [11,12]. Some types of industrial production are discharged into the atmosphere and undergo a chemical reaction to form sulfuric acid or nitric acid. After rainwater falls onto the ground, they cause acidification of groundwater and surface water, contaminate the soil, and affect crop yields [13, 14]. After entering the human body, ozone stimulates the respiratory tract, triggers bronchitis and emphysema, and affects the nervous system of humans. Research has shown that children and the elderly are particularly vulnerable to the health effects of air pollutants such as O_3, particulate matter and other airborne toxicants [15, 16]. The Air Quality Index (AQI) is a conceptual value that evaluates air quality, representing the air quality status and trends in a given area. It includes a measurement of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), fine particulate matter ($PM_{2.5}$), and coarse particulate matter (PM_{10}), which determine the air quality index on a given day. Therefore Air Quality Index of an industrial area i.e. Dewas is important for health concern in India.

2. METHODOLOGY

2.1. Study Area

Dewas District in Ujjain Revenue Division, is situated on the Malwa plateau in the West-central part of Madhya Pradesh, India and lies between 20°17′ and 23°20′ North latitude and 75°54′ and 77°08′ East longitude. The district is bounded by Ujjain district in the north, Indore district in the west, West-Nimar district in the south-west, East Nimar district in the south, Hoshangabad district in the South East, Sehore district in the east and Shajapur district in the North-East.

2.2. Monitoring Locations

Dewas industrial area is consist of four industrial area i.e. Industrial Area 1, Industrial Area 2 & 3, Sia Industrial Area, Ujjain Road Industrial Area. Total nine locations in different industrial area in Dewas were selected for ambient air monitoring is depicted in table no 1 and figure no 1.

Table 1: Monitoring Locations

S.N	Code	Industrial Area	Monitoring Locations	Latitude & Longitude
1.	A1	Industrial Area 1	M/S White Star milk and milk products , Dewas	22.5754 & 76.2453
2.	A2	Industrial Area 1	M/S Tata International Ltd, Dewas	23.1064 & 77.52432
3.	A3	Industrial Area 1	M/S Raj Pioneer Laboratories (India), Dewas	23.07689 & 77.55652
4.	A4	Industrial Area 2 & 3	M/S Roca Bathroom Products Pvt Ltd (Parryware Industry) Dewas	23.11448 & 77.51583
5.	A5	Industrial Area 2 & 3	M/S VE Commercial Vehicle Ltd unit 2 (Eicher), Dewas	23.10886 & 77.51757
6.	A6	Industrial Area 2 & 3	M/S Navin Fluorine International Ltd, Dewas	23.09844 & 77.52922
7.	A7	Sia Industrial Area	M/S Krishna Food Products Ltd, Dewas	23.08073 & 77.53493
8.	A8	Ujjain Road Industrial Area	M/S Kriloskar Brother's Ltd, Dewas	23.07719 & 77.54176
9.	A9	Ujjain Road Industrial Area	M/S Bank Note Press , Dewas	23.07449 & 77.53204

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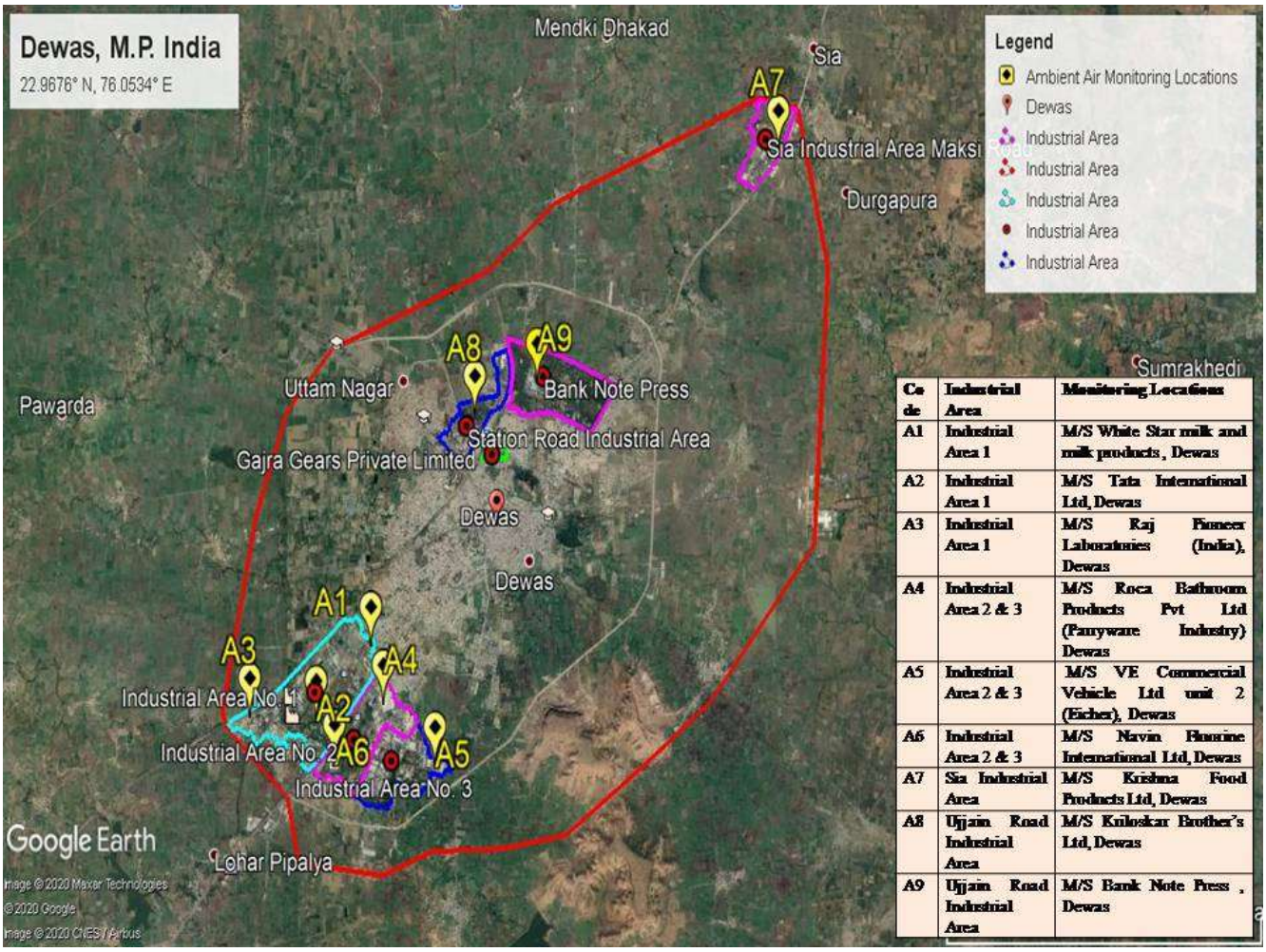

Code	Industrial Area	Monitoring Locations
A1	Industrial Area 1	M/S White Star milk and milk products, Dewas
A2	Industrial Area 1	M/S Tata International Ltd, Dewas
A3	Industrial Area 1	M/S Raj Pioneer Laboratories (India), Dewas
A4	Industrial Area 2 & 3	M/S Roca Bathroom Products Pvt Ltd (Pantyware Industry) Dewas
A5	Industrial Area 2 & 3	M/S VE Commercial Vehicle Ltd unit 2 (Eicher), Dewas
A6	Industrial Area 2 & 3	M/S Navin Fluorine International Ltd, Dewas
A7	Sia Industrial Area	M/S Krishna Food Products Ltd, Dewas
A8	Ujjain Road Industrial Area	M/S Kirloskar Brother's Ltd, Dewas
A9	Ujjain Road Industrial Area	M/S Bank Note Press, Dewas

Figure 1: Monitoring Locations in Dewas industrial area

2.3. Monitoring

Ambient air was drawn through a size-selective inlet of the dust sampler Envirotech APM-460 BL and APM 540 equipments. 24 hour air monitoring has been conducted in eight hrs basis in selected nine locations for parameters namely Particulate Matter less than 10 µ size (PM_{10}), Particulate Matter less than 2.5 µ size ($PM_{2.5}$), Sulphur dioxides (SO_2), Nitrogen dioxides (NO_2) were monitored on four hourly basis. Ozone (O_3) and ammonia (NH_3) 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 [17]. Particulate Matter (PM_{10} and $PM_{2.5}$) in ambient air were analyzed by gravimetric method. Nitrogen dioxide, sulphur dioxide in ambient air were analyzed by Jacob & Hochheiser method and West & Geake method respectively. Benzene (C_6H_6) in ambient air was collected in by polypropylene tadler beg and analysed by gas chromatography based continuous BTEX analyser. Ozone, ammonia, in ambient air was analyzed by chemical method and indophenols blue method. Benzo (a) Pyrene (BaP) – particulate phase was analyzed by solvent extraction followed by gas chromatography mass spectrometry (GCMS). Heavy metals such as arsenic, nickel and lead in ambient air were analyzed by atomic absorption spectroscopy respectively.

Central Pollution Control Board, India set guidelines for Indian national ambient air quality standards of 12 pollutants (CPCB, 2009). Out of which 7 pollutants NO_2, SO_2, $PM_{2.5}$, PM_{10}, O_3, Pb and NH_3 were used to analyze AQI in this study. The details of India-AQI are available elsewhere (CPCB, 2014), and only briefly summarized here. The concentration of each pollutant is converted to a number on a scale of 0–500. The sub AQI (AQIi) for each pollutant (i) is calculated using Eq. (1).

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$$AQI = I_{HL}-I_{LO} / B_{HO}-B_{LO} * (C_i - BR_{LO}) + I_{LO} \quad \text{Eq. (1)}$$

Where, Ci is the concentration of pollutant 'i'; BR_{HI} and BR_{LO} are breakpoint concentrations greater and smaller to Ci and I_{HI} and I_{LO} are corresponding AQI ranges.

The India-AQI is then taken as the maximum AQI_i of the constituent pollutants, denoted as dominating pollutant. The India-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 [18].

3. RESULTS & DISCUSSION

The observed concentration of eleven studied pollutants depicted in table 2.

Table 2: Various Ambient Air Pollutants in Dewas industrial area

S.N	Analytes	Unit	NAAQS	A1	A2	A3	A4	A5
1	PM10	µg/m³	100	86	181	167	111	84
2	PM2.5	µg/m³	60	39	59	79	52	69
3	Sulphur Dioxide	µg/m³	80	2.0	2.0	2.0	2.0	2.0
4	Nitrogen Dioxide	µg/m³	80	20.66	26.25	27.5	28.84	9.89
5	Ozone	µg/m³	100	21.80	4.66	6.0	1.30	7.36
6	Ammonia	µg/m³	180	3.82	2.92	6.5	7.49	1.04
7	Benzo (a) Pyrene (BaP) – particulate phase	ng/m³	01	ND	ND	ND	ND	ND
8	Benzene	µg/m³	05	0.41	0.3	0.3	0.28	0.37
9	Pb	µg/m³	1.0	1.054	1.64	0.218	0.417	0.05
10	As	ng/m³	6.0	0.196	0.043	2.77	0.024	0.056
11	Ni	ng/m³	20	53.12	37.3	125.8	75	56
Remark : ND – Not Detectable								

Continue..

S.N	Analytes	Unit	NAAQS	A6	A7	A8	A9
1	PM10	µg/m³	100	203	123	72	95
2	PM2.5	µg/m³	60	90	57	42	46
3	Sulphur Dioxide	µg/m³	80	2.0	2.0	2.0	2.0
4	Nitrogen Dioxide	µg/m³	80	18.62	16.85	8.46	23.38
5	Ozone	µg/m³	100	3.92	28.99	10.30	10.95
6	Ammonia	µg/m³	180	3.33	7.36	20.55	1.94
7	Benzo (a) Pyrene (BaP) – particulate phase	ng/m³	01	ND	ND	ND	ND
8	Benzene	µg/m³	05	0.34	0.3	0.29	0.24
9	Pb	µg/m³	1.0	0.138	0.082	0.141	0.121
10	As	ng/m³	6.0	0.249	0.045	0.532	0.678
11	Ni	ng/m³	20	45.68	22.83	60.67	11.48
Remark : ND – Not Detectable							

In present study, dust pollution ($PM_{2.5}$, PM_{10}) levels were exceeding the NAAQS limits at few selected locations in Dewas industrial area. In figure no 2, average concentration of PM_{10} was found between

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72-203 µg/m³ at all selected monitoring locations in during this study. Minimum average concentration of PM_{10} was found at A8 (72 µg/m³) and maximum average concentration at A6 (203 µg/m³). Average concentration of $PM_{2.5}$ was found between 39- 90 µg/m³ at all selected monitoring locations in during this study. Minimum average concentration of $PM_{2.5}$ was found at A1 (39 µg/m³) and maximum average concentration at A6 (90 µg/m³).

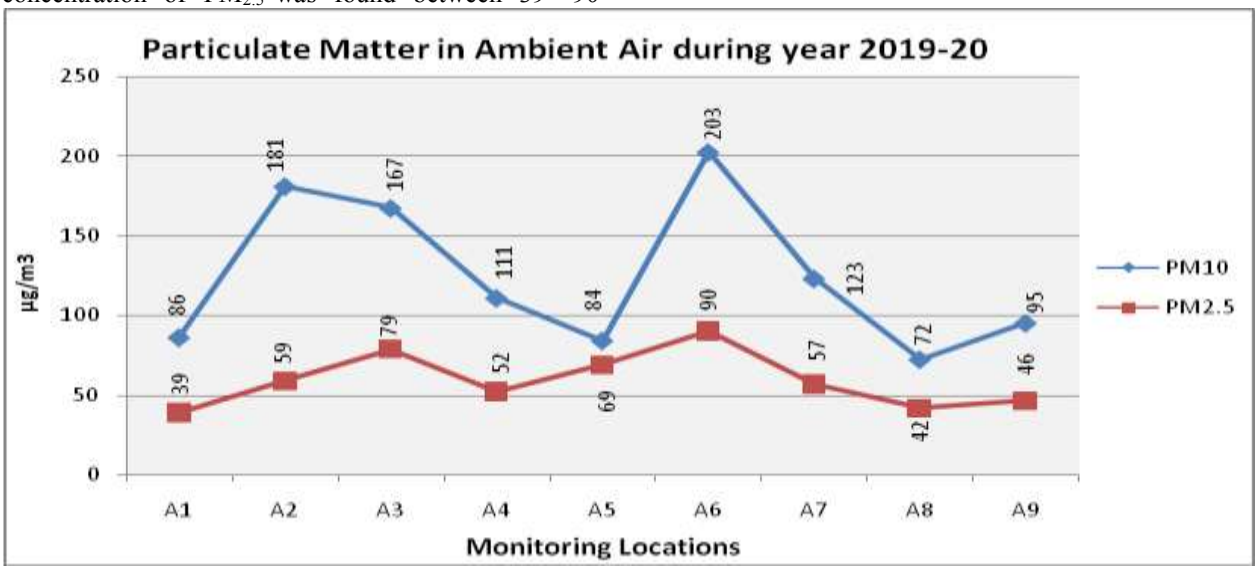

Fig 2: Particulate matter in ambient air of Dewas industrial area

Figure 3, revealed that average concentration of gaseous pollutants i.e. NO_2, SO_2, O_3, NH_3 and C_6H_6 in ambient air are well within standard limits at all selected locations. Benzo (a) Pyrene (BaP) –particulate phase in ambient air was not detected during this study.

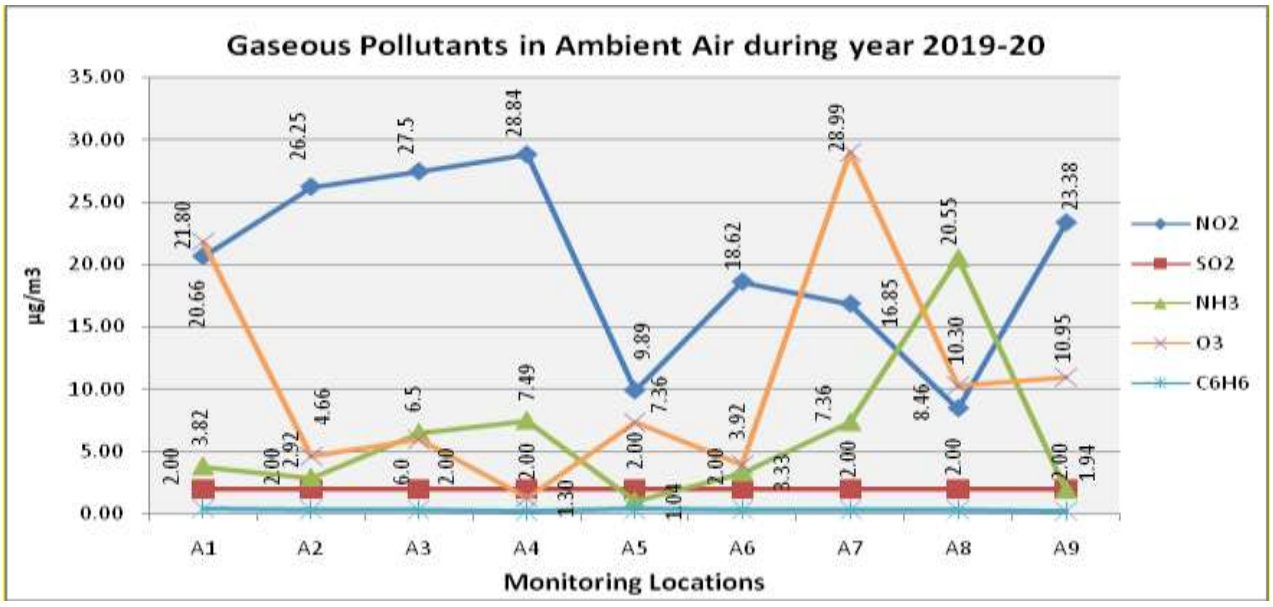

Fig 3: Gaseous pollutants in ambient air of Dewas industrial area

In figure 4, Concentration of heavy metals such as Pb, As and Ni levels in ambient air were found exceeding the National Ambient Air Quality Standards 2009 at few monitoring locations during this study.

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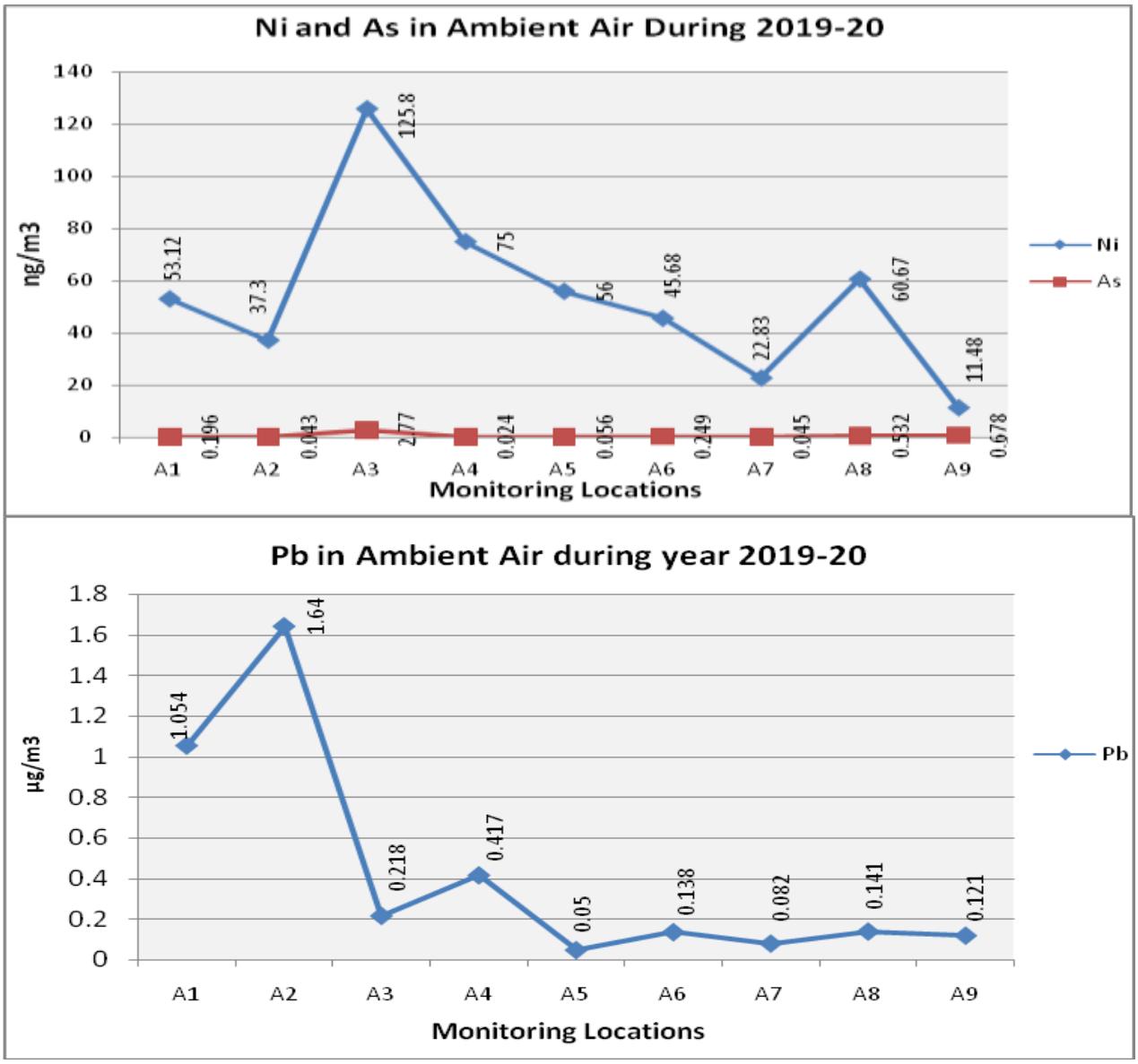

Fig 4: Metals concentration in ambient air of Dewas industrial area

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 seven parameters at all monitoring location in Dewas industrial area. AQ sub-index and health breakpoints are evolved for seven pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, O_3, NH_3, and Pb) for which short-term (upto 24-hours) National Ambient Air Quality Standards are prescribed by Central Pollution Control Board of India. Sub Index and Air Quality Index of seven air pollutant studied are depicted in table 3.

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Table 3: Sub Index and Air Quality Index of air pollutant in Dewas industrial area

S.N	Sampling Locations	NOx (µg/m³)	SO_2 (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	O_3 (µg/m³)	NH_3 (µg/m³)	Pb (µg/m³)	AQI
1	A1	25.83	2.50	85.88	64.62	21.80	0.95	95.94	95.94
2	A2	32.82	2.50	153.90	98.04	4.66	0.73	160.40	160.40
3	A3	34.35	2.50	144.81	161.85	6.01	1.63	21.80	161.85
4	A4	36.05	2.50	107.42	86.53	1.30	1.87	41.70	107.42
5	A5	12.37	2.50	83.87	128.26	7.36	0.26	5.00	128.26
6	A6	23.28	2.50	168.10	198.36	3.92	0.83	13.80	198.36
7	A7	10.58	2.50	71.60	69.17	10.30	5.14	14.10	71.60
8	A8	21.06	2.50	115.56	94.42	28.99	1.84	8.20	115.56
9	A9	29.22	2.50	94.98	77.14	10.95	0.49	12.10	94.98

Air Quality Index was moderate (107.42-198.36) at six locations and satisfactory (71.60-95.94) at three locations in Dewas industrial area. Overall ambient Air Quality Index of Dewas industrial area was observed, satisfactory to moderate during this study. Range and distribution of Air Quality Index at in Dewas industrial area is depicted in table 4.

Table 4: Range and distribution of air quality index of Dewas industrial area

Index	Category	2019-2020	
		No of Locations	Name of Locations
401-500	SEVERE	0	-
301-400	VERY-POOR	0	-
201-300	POOR	0	-
101-200	MODERATE	6	A2,A3, A4, A5, A6, A8
51-100	SATISFACTORY	3	A1, A7, A9
0-50	GOOD	0	-

The significant correlation of Air Quality Index of nine monitoring locations in Dewas industrial area during year 2019 to 2020 is shown in figure no 5 .

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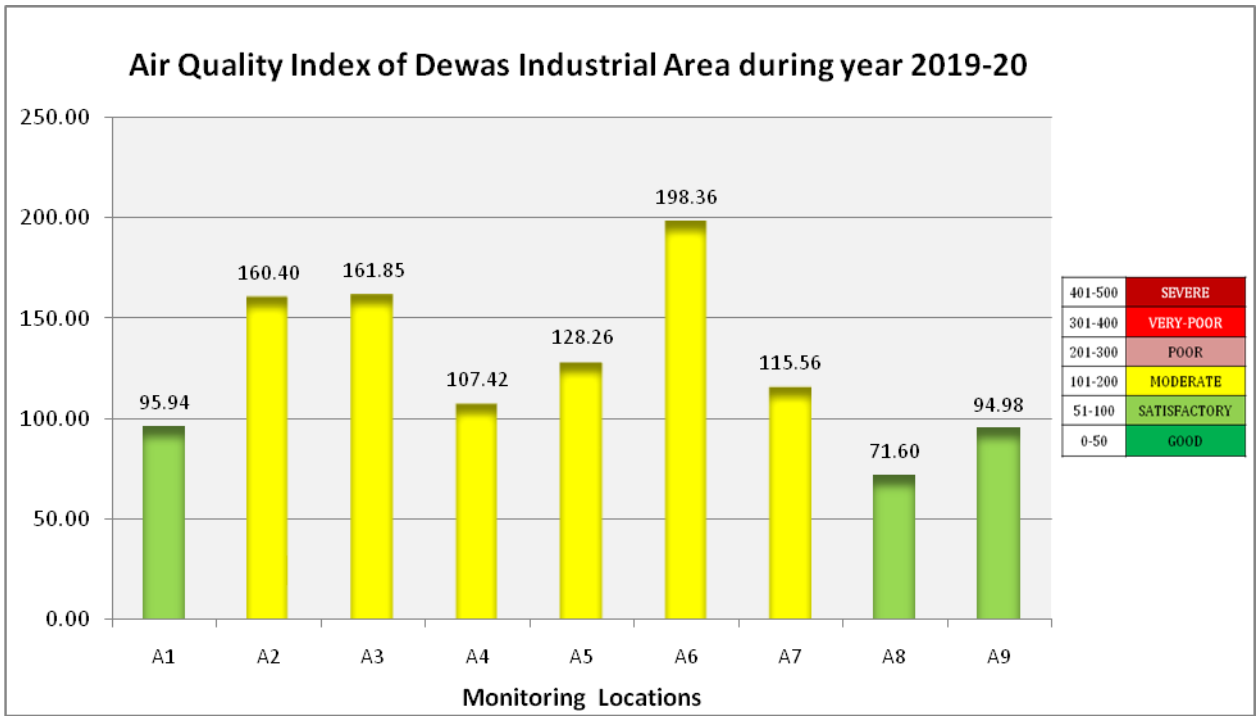

Figure 5: Air Quality Index of Dewas industrial area during year 2019 -20

4. CONCLUSION

Ambient air may cause serious aggravation of heart or lung disease, it is indication of increased risk of cardio respiratory symptoms in general population in Dewas industrial area of Madhya Pradesh, India. The study revealed that average concentration of gaseous pollutants i.e. NO_2, SO_2, O_3, NH_3, C_6H_6 in ambient air are well within standard limits at all selected locations however particulate matter (PM_{10}, $PM_{2.5}$) and heavy metals (Pb, As, Ni) levels were found exceeding the National Ambient Air Quality Standards 2009 at few monitoring locations. Benzo (a) Pyrene (BaP) – particulate phase in ambient air was not detected during this study. Air Quality Index was moderate (107.42-198.36) at six locations and satisfactory (71.60-95.94) at three locations in Dewas industrial area. Overall ambient Air Quality Index of Dewas industrial area was observed, satisfactory to moderate during this study.

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