Asian Journal of Chemistry Vol. 18, No. 4 (2006), 2479–2486

Ambient Air Quality Scenario in and Around Some Areas of South West of Madhya Pradesh, India

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An attempt to identify the distribution of SPM, SO_2, NO_x and O_3 in Dewas, Pithampur, Nagda, Nayagaon-Khor and Nimbaheda industrial area in South West of Madhya Pradesh, India were identified and monitored with standard protocol. The annual SPM load in the regions ranged between 204–459 μg/m^3 at about 1 km and 79–154 μg/m^3 at 5 km. As regards SO_2, the annual average is between 5–44 μg/m^3 with a minimum concentration in cement zone, *i.e.*, 5 μg/m^3 at 1 km in prevailing wind direction. Also, NO_x levels range between 17–52 μg/m^3 and O_3 concentration 9 to 32 μg/m^3. But the range of cumulative load of all these pollutants become too high in the host zone of 1–2 km (the industrial pockets), *i.e.*, 218–618 μg/m^3 and remains as much as 302 μg/m^3 at about 5 km. The results indicated that, though the levels of SPM, SO_2 and NO_x are below the standard limits laid by the Ministry of Environment, for the individual pollutants, but cumulatively the load is considerably high and appears to be detrimental to both flora and fauna of the region.

Key Words: Ground level ozone, Host zone, Ambient air quality, Cumulative pollution load.

INTRODUCTION

Ambient air quality is an important factor which can change substantially due to various activities as air pollutants do not remain confined near the point source/ sources of emission but spread over far off distances. After emission air pollutants get diluted, disperse and travel long distances with air masses passing through the source. The pollutants once released into the air cannot be stopped or curtailed and ultimately travel long in the air[1].

Decentralization and dispersion of industry to rural areas and long range transport of air pollutants have serious consequences for crop plants[2]. Problems of air pollution are specially more pronounced in developing countries like India, which suffer from acute problems of resource constraints and at the same time are in great hurry for rapid industrial development[3].

Though global air pollution and atmospheric load of air pollutants occupy a crucial role in environment management policy at world level, the regional air pollution problems cannot be ignored because they often pose both local episodic conditions and induce chronic injury to plant and human life as well as edaphic ecosystem[4–8]. Such regional programmes have been launched and executed in Europe as well as in USA[9].

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The investigation covers a gradient analysis of total pollution load at all selected areas in industrial zones. Air pollutants in combination may induce antagonistic or synergistic impacts on plants depending upon the specific pollutants and their concentrations, exposure duration and environmental conditions[10–13]. Plants/crops play a large part of the interaction with the ambient air quality as they form a large part of composition in nature and are also sensitive[14].

This study is an attempt to identify the extent of the distribution of air pollutants in these areas.

EXPERIMENTAL

An extensive sampling programme was designed for the period 1999–2002 including all the seasons of these three years.

Sites and Sampling Points

The industrial areas selected for the study were Dewas, Pithampur, Nagda, Nayagaon-Khor in Madhya Pradesh and Nimbaheda in Rajasthan of the Indian subcontinent (Table-1).

TABLE-1
DETAILS OF THE SITES, LOCATIONS AND CLIMATIC CONDITIONS

S. No.	Name of site	Location	Longitude, latitude and geology
1.	Dewas	SW M.P.	22°20′ to 12°44′ N 75°21′ to 35°45′ E
2.	Pithampur	SW M.P.	22°36′ to 22°44′ N 75°25′ to 75°45′ E
3.	Nagda	SW M.P.	32°27′ N 75°25′10″ E
4.	Nayagaon-Khor	Border of M.P. and Rajasthan	24°07′10″ N to 75°58′10″ E
5.	Nimbaheda	Rajasthan	24°07′10″ N 75°58′10″ E

In the above study areas wind direction and deflection ranged throughout the year largely between West-North-East, since it is a well-established fact that the maximum load of pollutants occurs in the vicinity of the source, *i.e.*, 0.5–1.5 km area. This criterion was effectively applied in the selection of sites. At different directions up to 5 km sites were marked in up and prevailing wind. Depending on the wind directions and deflections during the three seasons sampling fields were selected around the industrial area. After visual survey sampling fields were marked in upwind direction at about 1–1.5 km as reference zone (RZ) and in the prevailing wind direction at 1–1.5 km as host zone (HZ), 2–2.5 km as moderately affected zone (MAZ) and 4.5–5 km as least affected zone (LAZ) respectively.

Ambient Air Quality Sampling

Sampling schedule was prepared on monthly basis. The protocol observed for SPM was 24 h. average/day with two days per week and for gaseous analysis one day/week with 4 observations per day with 2 h intervals as TGM reads concentration instantaneously.

Ambient Air Quality Monitoring

Ambient air quality monitoring was done with various equipments adopting APHA[15] protocol:

1. Suspended particulate matter (SPM): High volume sampler (Kimoto-120, Japan).
2. Oxides of sulphur (SO_2, West and Gaeke)[16]: Toxic gas monitor-555 (CEA, USA).
3. Oxides of nitrogen (NO_x, Griess and Saltzman)[17]: Toxic gas monitor-555 (CEA, USA).
4. Ozone (O_3) (Byers and Saltzman)[18]: Portable gas sampler (Netel NPM-PS-1, India) and UV-Vis spectrophotometer, Toshniwal, TSUV-75, India.

RESULTS AND DISCUSSION

The scenario of air pollution in these five sites reveals that on the basis of total load of SPM, SO_2, NO_x and O_3, all the areas experience the air pollution stress with about 300–540 $\mu g/m^3$ of the total pollution load in the nearby areas. While at longer distance (about 5 km) the total pollution load ranged between 150–260 $\mu g/m^3$ as against 80–155 $\mu g/m^3$ in the opposite wind direction at 500 m (Table-2).

TABLE-2
SUSPENDED PARTICULATE MATTER SPM ($\mu g/m^3$) AT DIFFERENT STUDY AREAS DURING 1999–2002

S.No.	Area	Years	Distances				
			RZ	HZ	MAZ	LAZ	Area Av.
1	Dewas	1999–00	94.50	340.50	308.50	169.50	228.25
		2000–01	78.00	342.00	293.50	168.50	220.50
		2001–02	85.00	323.00	313.00	172.50	223.38
		Average	**85.83**	**335.16**	**305.00**	**170.16**	**224.04**
2	Pithampur	1999–00	64.00	223.50	160.50	94.50	135.63
		2000–01	61.00	271.50	163.00	104.00	149.88
		2001–02	54.00	252.00	162.00	115.00	145.75
		Average	**59.67**	**249.00**	**161.84**	**104.50**	**143.75**
3	Nagda	1999–00	59.50	243.00	189.50	150.00	160.50
		2000–01	48.00	158.50	114.00	76.50	99.25
		2001–02	63.00	211.50	161.50	131.50	141.88
		Average	**56.83**	**204.34**	**155.00**	**119.34**	**133.88**
4	Nayagaon-Khor	1999–00	115.00	264.00	196.50	140.00	178.88
		2000–01	63.00	250.50	180.50	112.50	151.63
		2001–02	75.50	249.50	183.50	117.50	156.50
		Average	**84.50**	**254.67**	**186.84**	**123.34**	**162.34**
5	Nimbaheda	1999–00	157.00	428.50	295.50	208.50	272.38
		2000–01	95.50	480.00	356.00	195.00	281.63
		2001–02	125.00	467.00	391.00	193.50	294.13
		Average	**125.83**	**458.50**	**347.50**	**227.83**	**289.92**

The results clearly show that Nimbaheda is most polluted among all areas and Pithampur is the least polluted area. SPM concentration was maximum at Nimbaheda; it might be due to cement production, mining activity, etc. But at Nayagaon-Khor, another cement area, SPM load ranges between 110–300 $\mu g/m^3$ which does not exceed the standard limit laid by Ministry of Environment and Forest or Central Pollution Control Board, New Delhi for industrial areas, *i.e.*, 500 $\mu g/m^3$. It may be due to efficient ESP's and bag filters responsible for control of SPM emission.

Sulphur dioxide concentration in ambient air of different sites in all industrial areas attained a maximum level of 47 g/m^3 at host zone (HZ) in gaseous polluted areas while at cement producing zone the levels ranged between 2–6 $\mu g/m^3$ at HZ (Table-3). The concentration decreases with increasing distances in the area Dewas, Pithampur and Nagda. Such trend is not observed in Nimbaheda and Nayagaon-Khor; this may be due to modification in coal quality and technology inputs.

TABLE-3
SULPHUR DIOXIDE CONCENTRATION ($\mu g/m^3$) AT DIFFERENT STUDY AREAS DURING 1999–2002

S.No.	Area	Years	Distances				
			RZ	HZ	MAZ	LAZ	Area Av.
1	Dewas	1999–00	4.50	47.50	32.50	15.00	24.88
		2000–01	3.50	42.00	24.00	20.50	22.50
		2001–02	4.00	43.00	32.00	19.50	24.63
		Average	**4.00**	**44.50**	**29.50**	**18.28**	**24.07**
2	Pithampur	1999–00	5.00	42.00	23.50	11.50	20.50
		2000–01	3.00	29.50	23.00	8.00	15.88
		2001–02	7.00	37.00	27.50	11.00	20.63
		Average	**5.00**	**36.17**	**24.67**	**10.17**	**19.00**
3	Nagda	1999–00	3.50	38.00	24.50	13.50	19.88
		2000–01	2.50	34.00	20.50	12.50	17.38
		2001–02	4.50	40.50	23.00	17.00	21.25
		Average	**3.50**	**37.50**	**22.67**	**14.34**	**19.50**
4	Nayagaon-Khor	1999–00	1.00	5.50	9.50	7.50	5.88
		2000–01	0.00	4.50	5.00	3.00	4.17
		2001–02	0.50	5.50	7.00	5.00	4.50
		Average	**0.75**	**5.17**	**7.00**	**5.84**	**4.69**
	Nimbaheda	1999–00	0.00	2.00	3.00	6.00	3.67
		2000–01	0.00	3.00	3.00	2.50	2.83
		2001–02	3.50	6.50	4.00	6.00	5.00
		Average	**3.50**	**5.84**	**3.33**	**5.59**	**4.57**

Oxide of nitrogen (NO_x) in ambient air at selected sites ranged between 25–60 $\mu g/m^3$ at Dewas while area average ranged between 36–58 $\mu g/m^3$ at HZ, 37–41 $\mu g/m^3$ at MAZ and 21–31 $\mu g/m^3$ at LAZ (Table-4). The NO_x concentration at RZ varied between 9–19 $\mu g/m^3$ in upwind direction. All these industrial zones are intersected with highways and probably this could be the reason for increased NO_x concentration in these areas.

TABLE-4
CONCENTRATION OF OXIDE OF NITROGEN ($\mu g/m^3$) AT DIFFERENT STUDY AREAS DURING 1999–2002

S.No.	Area	Years	Distances				
			RZ	HZ	MAZ	LAZ	Area Av.
1	Dewas	1999–00	11.50	59.50	37.00	18.50	31.63
		2000–01	10.50	60.00	43.50	29.50	35.88
		2001–02	11.00	56.00	43.00	27.50	34.38
		Average	**11.00**	**58.50**	**41.16**	**25.16**	**33.96**
2	Pithampur	1999–00	11.00	50.00	39.50	19.50	30.00
		2000–01	10.00	37.00	32.00	23.00	25.50
		2001–02	13.00	49.00	38.50	22.00	30.63
		Average	**11.34**	**45.34**	**36.67**	**21.50**	**28.71**
3	Nagda	1999–00	7.50	59.00	38.00	17.00	30.38
		2000–01	9.50	48.00	37.00	24.50	29.75
		2001–02	9.00	58.00	43.50	24.50	33.75
		Average	**8.67**	**55.00**	**39.50**	**22.00**	**31.29**
4	Nayagaon-Khor	1999–00	18.00	25.50	39.50	24.50	26.88
		2000–01	14.50	36.50	37.00	20.50	27.13
		2001–02	21.00	29.00	39.00	17.00	26.50
		Average	**17.84**	**30.34**	**38.50**	**20.64**	**26.83**
5	Nimbaheda	1999–00	20.00	38.00	43.50	28.50	32.50
		2000–01	17.50	46.50	39.50	32.50	34.00
		2001–02	19.00	52.00	39.50	32.50	35.75
		Average	**18.83**	**45.50**	**40.83**	**31.17**	**34.08**

Ground level ozone (O_3) is produced photochemically and its transport is light intensity dependent. In all studied zones ozone concentration ranged between 9–32 $\mu g/m^3$ (Table-5).

For the first time in the region ground level ozone monitoring was carried out. It is known that ozone follows the diurnal cycles, *i.e.*, low concentration at night and higher concentration during midday[19].

TABLE-5
GROUND LEVEL OZONE CONCENTRATION ($\mu g/m^3$) AT DIFFERENT STUDY AREAS DURING 1999–2002

S.No.	Area	Years	Distances				
			RZ	HZ	MAZ	LAZ	Area Av.
1	Dewas	1999–00	10.50	17.00	21.00	13.00	15.38
		2000–01	6.50	13.50	15.00	9.00	11.00
		2001–02	4.50	26.00	21.50	14.00	16.50
		Average	**7.17**	**18.83**	**19.17**	**12.00**	**14.29**
2	Pithampur	1999–00	14.50	12.00	15.00	10.00	12.88
		2000–01	7.00	22.00	21.50	9.50	15.00
		2001–02	6.50	20.50	21.50	16.00	16.13
		Average	**9.33**	**18.17**	**19.33**	**11.83**	**14.67**
3	Nagda	1999–00	13.00	29.50	26.00	19.50	22.00
		2000–01	8.00	32.50	25.50	13.50	19.88
		2001–02	8.50	31.00	28.50	22.50	22.63
		Average	**9.83**	**31.00**	**26.67**	**18.50**	**21.50**
4	Nayagaon-Khor	1999-00	14.50	19.50	24.50	20.00	19.63
		2000–01	7.50	20.50	20.50	11.50	15.00
		2001–02	6.00	15.00	21.50	19.50	15.50
		Average	**9.33**	**18.34**	**22.17**	**17.00**	**16.71**
5	Nimbaheda	1999–00	10.00	24.00	21.50	26.50	20.50
		2000–01	5.50	31.00	32.00	24.50	23.25
		2001–02	7.50	27.00	22.50	17.50	18.63
		Average	**7.67**	**27.34**	**25.34**	**22.84**	**20.80**

The cumulative effect of air pollution is the real issue of the ambient air quality which has been brought into focus through this study. Individually all the pollutants found in air are quite below the limits prescribed by the Ministry of Environment & Forest or Central Pollution Control Board[3], New Delhi and more interestingly the SO_2 and NO_x concentrations were quite below the standard limits prescribed for industrial areas. But our observation is that these individual pollutants including ozone, in totality, are quite enough to be considered as effective for certain damage to the ecosystem components including crops. A perusal of the total cumulative pollution load picture exhibits that the total load in the host zone and the moderately affected zone in summer season ranges about 3 to 3.4 times more while in winter season it is 3.5 to more than 4 times over the reference zone. However, in least affected zone the levels were nearly double the reference zone (Table-6).

High pollutant concentration during winter season could be due to the

meteorological conditions, *i.e.*, low temperature and wind velocity, causing low inversion rates. This might have lessened the transportation of pollutants to further distances. However, during summer months high wind velocities might have transported pollutants to a greater distance in the adjoining areas.

TABLE-6
CUMULATIVE POLLUTION LOAD CONCENTRATION ($\mu g/m^3$) AT DIFFERENT STUDY AREAS DURING 1999–2002

S.No.	Area	Years	Distances				
			RZ	HZ	MAZ	LAZ	Area Av.
1	Dewas	1999–00	121.00	464.50	399.00	216.00	300.13
		2000–01	98.50	485.50	382.50	227.50	298.50
		2001–02	104.50	448.00	409.50	233.50	298.88
		Average	**108.00**	**457.00**	**397.00**	**225.67**	**296.92**
2	Pithampur	1999–00	94.50	327.50	238.50	135.50	199.00
		2000–01	81.00	360.00	239.50	144.50	206.25
		2001–02	80.50	358.50	237.00	164.00	210.00
		Average	**85.33**	**348.66**	**238.33**	**148.00**	**205.08**
3	Nagda	1999–00	83.50	369.50	278.00	200.00	232.75
		2000–01	68.00	264.50	197.00	127.00	164.13
		2001–02	85.00	341.00	256.50	195.50	219.50
		Average	**78.83**	**327.83**	**243.83**	**174.10**	**206.15**
4	Nayagaon-Khor	1999–00	143.50	296.50	270.00	192.00	225.50
		2000–01	85.00	312.00	243.00	147.50	196.88
		2001–02	103.00	299.00	250.50	159.00	202.88
		Average	**107.52**	**302.50**	**254.49**	**166.83**	**207.84**
5	Nimbaheda	1999–00	187.00	492.50	363.50	269.50	328.13
		2000–01	118.50	560.00	430.50	254.50	340.88
		2001–02	154.00	564.00	457.002	49.50	356.13
		Average	**153.83**	**537.16**	**417.00**	**258.50**	**341.62**

There is deterioration of ambient air quality over the years at all the study sites in all the areas.

ACKNOWLEDGEMENTS

The authors extend thanks to ICAR, Ministry of Agriculture, Government of India for sponsoring the project and to Head, IEMPS, Vikram University for providing necessary facilities.

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(*Received*: 2 February 2005; *Accepted*: 21 March 2006) AJC-4748