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Monitoring of Ambient Air Quality in India - A Review

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Abstract

Air pollution is a serious problem all over the world which causes terrific loss to human health and other living being. Sulphur Dioxide(SO_2),Nitrogen Dioxide(NO_2),Particulate Matter ($PM_{2.5}$, PM_{10}), Ozone(O_3), Lead (Pb), Carbon Monoxide(CO), Benzene(C_6H_6) and Nickel(Ni) are some of the parameters which have significant impact on environmental pollution. Purpose of this paper is to review the literature relating to the monitoring of ambient air pollution in India and compare the same with Indian National Ambient Air Quality Standards-2009 (Indian NAAQS-2009).

Keywords: Air pollution, CO, C_6H_6, Ni, NO_2, O_3, Pb, $PM_{2.5}$, PM_{10}, SO_2.

Introduction

In developing countries, the increased levels of urban air pollution are a major environmental problem. Pollution has become a great topic of debate at all levels in India and especially the air pollution because of the enhanced anthropogenic activities. Among the harmful chemical compounds entering into the atmosphere as a result of fossils fuels burning, are Carbon monoxide (CO), Sulfur Dioxide (SO_2) Nitrogen oxide (NO_X), and tiny solid particles–including lead from gasoline additive. The studies on air pollution in large cities of India showed that ambient air pollution concentrations are at such levels where serious health effects are possible. Continuous rise of population due to urban activities along with the lack of suitable measures for air pollution control means that there is a great potential that conditions may worsen in future in Indian cities. In the urban area the air quality is affected adversely due to emission and accumulation of SPM, RSPM, SO_2, and NOx. These all pollutants may pose harmful effect on human health, as exposure of these are associated with cardiovascular and respiratory disease, Neurological impairments, increased risk of preterm birth and even mortality and morbidity. Various studies conducted in India at various locations suggests that pollution levels varies significantly in different areas with reference to its location, time, period of sampling and climatic conditions. It has been found that SO_x and NO_x concentrations are within the permissible limits in many areas but SPM and PM_{10} concentrations are generally exceeding the limits as per Indian air quality guidelines.(NAAQS-2009).

On inhalation of carbon monoxide it combines selectively with hemoglobin of the blood (Hb) and form carboxyhemoglobin (COHb), resulting reduction in oxygen carrying capacity of blood. High carbon monoxide level is potentially deadly and fatal to human life as carbon monoxide is a very dangerous asphyxiant. carbon monoxide cause headache, fatigue, impaired judgment and dizziness, it also affects the functioning of heart and brain. (P. Balashanmugam *et al.*2012)

All atmospheric substance that are not gases but may be suspended droplets, solid particle or mixture of the two are generally referred to as particulates. Particulate matter causes respiratory problems like asthma, reduction in visibility and cancer. It also affects lungs and tissues.(D. S. Khandbhale *et al.*2013).

Oxides of nitrogen cause respiratory problem, asthma, lung irritation and pneumonia. Higher concentration of oxides of sulphur causes bronchitis. It 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.(P. 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 man.

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This article reviews the Air Quality Monitoring at following locations in India:

Puducherry

P. Balashanmugam *et al.* 2012 studied the quality of ambient air of puducherry,India. For ambient air quality monitoring eight sites were selected which have heavy traffic and commercial areas. SPM, NO_2, SO_X, and CO are the parameter for which continuous sampling has been carried out. sites of monitoring are indira Gandhi signal (1), Rajiv Gandhi signal(2), Bus stand(3), kanniyakoil(4), Nehru street(5), Tindivanam high road (6), Cuddalore main road(7), Muruga theatre junction(8). Monitoring of particulates was done by "High Volume Sampler". Wattman filter paper GF/A (20.3cmX 25.4cm) of HVS was kept at 15-34ºC, 50% relative humidity for 24 hr and weighed. The filter paper was placed in HVS on the filter holder and air was drawn through a 410 cm^2 portion of the filter at a flow rate of 1.80 LPM. The filter paper was removed after sampling and weighed. The mass concentration of particulate expressed in $\mu g/m^3$ and was calculated by measuring the mass of particulates collected and the volume of air sampled. For the monitoring of nitrogen oxides ambient air was continues drawn at a rate of 2LPM through 35ml of sodium hydroxide solution for 8 hr and Jacobs and Hochhesier method was used for estimation of NO_X. In the case of SO_x tetrachloromercurate solution was used and ambient air was continuous drawn at a rate of 1.5 LPM for 8 hour through it.

SPM concentration exceeded the limit at all the eight sampling sites. CO concentration crossed the limit at seven sites out of eight sites. SO_2 was within limit at all eight sites. NO_2 level crossed the limit at all eight sites.

The concentration of SPM, CO, SO_2, NO_2 at various sites are given in table-1:

Table 1. Concentration of pollutants at various sites

Location	CO 2mg /m^3	SPM 200µg /m^3	SO_2 80µg /m^3	NO_2 80µg /m^3
Indira Gandhi signal	2.4	284.20	51.05	92.76
Rajiv Gandhi signal	2.4	377.75	79.91	124.03
Bus stand	2.4	388.72	52.625	91.35
Kanniyakoil	2.4	297.72	54.541	92.196
Nehru street	2.4	296.33	64.31	106.37
Tindivanam high road	2.4	334.52	67.97	112.37
Cuddalore main road	2.4	252.63	52.05	84.45
Muruga theatre junction	1.2	258.79	44.14	84.86

Rohtak City

Rohtak city is located at 70 km from Delhi having an area of 441100 hac. Six sites of sampling which are university campus, Delhi bye pass, Medical mor, New bus stand, Bhivani stand and Hissar rod. Ambient Air Quality monitoring was done using "High Volume Sampler"(Envirotech APM-415-411), 8 hour daily for suspended particulate matter and 4 hour daily for gaseous pollutants with a frequency of once in a week in winter, summer and monsoon. The work of Vineeta shukla *et al.*2010 showed variation in the pollutant level during winter, summer and monsoon season in the city.

Sulphur dioxide (SO_2): The concentrations of SO_2 at University campus, Hissar road, Medical mor, New bus stand, Delhi bye pass and Bhiwani stand were 12.97, 32.03, 20.08, 22.68, 18.43 and 28.59 $\mu g/m^3$ in summer; 14.00, 38.52, 24.68, 22.13, 29.35 and 38.38 $\mu g/m^3$ in winter; and 9.25, 29.39, 17.62, 21.38, 18.41 and 27.21 $\mu g/m^3$ in monsoon seasons respectively.

The levels of SO_2 were below the permissible limit (80 $\mu g/m^3$) as prescribed by NAAQS in all the three seasons at all six sites. SO_2 was found to be minimum at University campus in monsoon season and maximum in winter season at Hissar road (Vineeta shukla *et al.* 2010).

The concentrations of NO_2 at University campus, Hissar road, Medical mor, New bus stand, Delhi bye pass and Bhiwani stand were 42.59, 117.90, 79.99, 81.54, 86.26 and 118.35 $\mu g/m^3$ in winter; 40.02, 113.73, 79.13, 75.41, 84.36 and 105.14 $\mu g/m^3$ in summer and 37.59, 93.75, 54.04, 70.24, 63.53 and 89.90 $\mu g/m^3$ in monsoon seasons respectively . NO_2 level exceeds the prescribed NAAQS (80 $\mu g/m^3$) at New bus stand, Delhi bye pass, Bhiwani stand and Hissar road in winter, at Delhi bye pass, Bhiwani stand and Hissar road in summer and at Bhiwani stand and Hissar road in monsoon season. NO_2 level remains within safety limit (Vineeta shukla *et al.* 2010) at Medical mor and University campus in all the three seasons. The mean NO_2 concentration was observed minimum at University campus in monsoon seasonand maximum at Bhiwani stand in winter season.

The mean values of O_3 at University campus, Hissar road, Medical mor, New bus stand, Delhi bye pass

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and Bhiwani stand were 6.94, 81.95, 12.93, 22.27, 19.60 and 68.26 µg/m^3 in summer; 4.38, 53.81, 6.82, 20.50, 18.82 and 51.62 µg/m^3 in winter and 2.95, 36.01, 7.12, 19.19, 12.35 and 27.24 µg/m^3 in monsoon seasons respectively . O_3 peak level was found to be higher in summer season in comparison to monsoon and winter seasons. The mean level of O_3 remains within safety limit at all the sites. O_3 was found to be minimum at University campus in monsoon season and maximum in summer season at Hissar road. (Vineeta shukla *et al.*2010).

Suspended particulate matter (SPM): The mean values of SPM at University campus, Hissar road, Medical mor,
New bus stand, Delhi bye pass and Bhiwani stand were 354.93, 1216.37, 704.56, 686.86, 678.70 and 1025.39 µg/m^3 in summer; 404.54, 1310.76, 757.22, 756.87, 771.44 and 1146.13 µg/m^3 in winter and 245.14,915.91, 593.86, 607.12, 414.72 and 785.74 µg/m^3 in monsoon seasons respectively.SPM was found to be lowest at University campus in monsoon season and highest at Hissar road in winter season. The level of SPM was observed above the safety limit (Vineeta shukla *et al.*2010) in all the three seasons at all the sites, except University campus in monsoon season.

Uttarakhand

The study of Jagdish Meena P. *et al.*2012 presented the data of the ambient air quality status of residential area of Himalayan region viz. Garhwal (New Tehri) and Kumaon (Muktheshwar) in state of uttarakhand India. There were two manual station set up at both the place New Tehri and Muktheswar.24 hourly monitoring was carried out at each station and ambient air quality was monitored in two phases. First one was on December 2010 and second one on June 2011. Respirable dust sampler (APM-460NL)/High Volume Sampler was used for monitoring of ambient air. Suspended particulate matter collected on EPM 2000 filter paper for 8 hr and gaseous sampling was conducted for 4 hr in respective of absorbing media. After the sampling following results were obtained:

The concentration of various pollutants like PM_{10},SO_X,NO_X,Benzo(a)Pyrene, Benzene, Toluene, Lead and Nickel in µg/m^3 were 15, 6.5, 6, 0.5,BDL, BDL, BDL, BDL at southy coat New Tehri,27,8, 6.25, 0.6, BDL,BDL, BDL, BDL at THDC,new Tehri,10, 4, 7, 1.15, at Hotel Krishna and 23, 4, 6.5, 0.2, BDL, BDL, BDL, BDL respectively for phase one. In phase I all the pollutants were within the limits as per (NAAQS-2009). In phase II monitoring the concentration of various pollutants like PM_{10}, SO_X, NO_X, Benzo (a) Pyrene, Benzene, Toluene, Lead and Nickel in µg/m^3 were 22, 4, 10, BDL, BDL, BDL, BDL, BDL at Southey coat New Tehri, 32, 4, 5, 1.5, BDL, BDL, BDL, BDL at THDC, New Tehri and 23, 4, 12, 1.5, BDL, BDL, BDL, BDL, at Mukteshwar respectively. The phase II monitoring was carried out in only 3 places instead of 4 places. In phase two monitoring it was found that all the parameters were within the limits of NAAQS-2009 (Jagdish Meena P. *et al.*2012).

Nashik City

D. S. Khandbahale *et al.*2013 determined the levels of pollutants like SO_X, NO_X and SPM on three representative sites viz. Industrial (I), Commercial(C) and Residential(R) of Nashik city. The selected sites for Ambient Air Quality Monitoring were places of maximum pollution and heavy traffic. A continuous sampling had been carried out at all three sites.
Site 1:- VIP Company, MIDC areas, Satpur, Nashik: this site represents the industrial site.
Site 2:- RTO colony tank, Pandit colony, Nashik: this site represents the residential area.
Site 3:- NMC building, min road, Nashik: this site represents the commercial area. All the sites have two way traffic system, open loop signal control and high vehicle density.
Level of SPM crossed the limit at all the sites but SO_X and NO_X were not exceeded the limit at all sites.(D. S. Khandbahale *et al.*2013) Summary of ambient air quality Data is given in Table 2:

Table 2. Ambient Air Quality Data

Site	SO_X µg/m^3	NO_X µg/m^3	SPM µg/m^3
1	23	25	201
2	21	24	230
3	21	24	256

Jaipur City, Rajasthan

Anand Kumar *et al.*2011 made an attempt to express the Ambient Air Quality of Jaipur city in the form of Air Quality Index (AQI). For Ambient Air Quality monitoring twelve sites in residential, industrial and commercial areas of the city were selected. The study was carried out to evaluate Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), sulphur dioxide (SO_2) and oxides of nitrogen (NOx) by sampling for a period of 24 hrs in winter season of the year, 2009-2010. The results showed that SPM concentrations in the area of study were varied between maximum i.e. 854.33 µg/m^3 and minimum i.e. 79.81 µg/m^3. RSPM in the study area ranges between maximum of 340.85 µg/m^3 and

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minimum of 46.64 µg/m^3. This exceeds the CPCB prescribed values except Tilak Nagar. Sulphur dioxide in the study areas ranged between the minimum value i.e.11.67 µg/m^3 and maximum value i.e.39.76 µg/m^3. Oxides of nitrogen in the study area ranged between maximum of 61.86 µg/m^3 and minimum of 16.55 µg/m^3. The values of AQI for the ambient air qualities of the sampling sites were calculated from the data obtained and is given in Table 3. The Air Quality Index values in the study areas were vary between maximum of 102.71 and minimum of 52.04. The results of air quality monitoring show that the pollution concentrations were highly variable at different sampling sites. Particulate pollutants concentration exceeded the permissible standards in all sites except Tilak Nagar. The concentrations of gaseous pollutants were observed to be within permissible limits in all the sites.

Table 3. Index values of air quality index calculation

Index Value	Remarks
0-25	Clean air
26-50	Light air pollution
51-75	Moderate air pollution
76-100	Heavy air pollution
Above 100	Severe air pollution

Table 4. Air Quality Index at sampling sites

Zone	Station	AQI	Remarks
Residential	Tilak Nagar	52.04	Light
	Vidyadhar Nagar	73.28	Moderate
	Transport Nagar	77.21	Heavy
	Vaishali Nagar	59.67	Moderate
	Mansarovar	61.03	Moderate
Industrial	VKIA	91.35	Heavy
	MNIA	74.44	Moderate
	Jhotwara Industrial Area	73.32	Moderate
Commercial	Govt. Hostel Circle	82.59	Heavy
	Ajmeri Gate	84.07	Heavy
	Sahkar Circle	86.83	Heavy
	Chandpole	102.71	Severe

Pune

The ambient air quality of pune city was carried out at selected location. Three locations SNDT college (karve road), Swargate (Jedhe Chowk) and Deccan (karve road) were selected. The selection of sites was based on the traffic density, pollution status and traffic congestions. The frequency of sampling was once in a week for six month i.e. from June 2006 to November 2006. The sampling was done at a height 10 m above road level. About 22 samples were collected from each sampling location i.e. total 66 number of samples. The sampling was done using calibrated Respirable dust sampler (RDS)(Envirotech model APM 460 BL) with a flow rate of 1.1m^3/min equipped with glass fiber filter paper (whatmann 41 GF/A). The parameters were lead oxide and particulate matter with size less than 10 micron (PM_{10}). The PM_{10} was monitored for 12 hrs and analyzed gravimetrically. Lead oxide concentration was determined spectrophotometrically (AAS). The average level of PM_{10} and lead oxide were 120.35 µg/m^3 and 0.65 µg/m^3 respectively. The results (Table 5) showed that lead oxide concentration was decreased and well within the ambient air quality standard of 0.75µg/m^3 where as the PM_{10} concentration was very high as compare to 60 µg/m^3 of standard. (M. R. Gidde-2007)

Table 5. Average concentration of pollutants

Sites	Month	PM_{10} µg/m^3	Pb µg/m^3
SNDT college	JUNE	134	0.027
	JULY	128	0.023
	AUGUST	113	0.170
	SEPTEMBER	119	0.345
	OCTOBER	123	0.345
	NOVEMBER	115	1.775
SWARGATE	JUNE	137	0.151
	JULY	128	0.223
	AUGUST	102	0.195
	SEPTEMBER	102	0.154
	OCTOBER	129	0.099
	NOVEMBER	106	0.821
DECCAN	JUNE	132	0.138
	JULY	101	0.178
	AUGUST	114	0.153
	SEPTEMBER	142	0.363
	OCTOBER	126	0.225
	NOVEMBER	116	1.309

Hosur Town, Tamilnadu

Harikrishnan S. *et al.*2012 studied the ambient quality of air in Hosur, tamilnadu. Under the provision of the Air Act, 1981, the CPCB has introduce 4th version of National Ambient Air Quality Standard (NAAQS-2009). The aim of this revised national standard is to provide uniform air quality for all. There are 12 identified health based parameter which are to measure at national level. Three

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locations nearby Hosur Bus Stand, nearby SIPCOT II and nearby Gandhi road were selected for monitoring. These locations cover the major part of the Hosur where the busy roads meet and bus terminals through they are receiving higher emissions. The results showed that PM_{10} concentration varies between 45-127 µg/m^3 where $PM_{2.5}$ concentration was higher at all three locations. This value are higher than the 24 hrs PM_{10} (100 µg/m^3) and around higher than 24 hrs $PM_{2.5}$ (60 µg/m^3) National Ambient Air Quality Standard prescribed by the CPCB of India.

Cuttack District, Odisha

The research of Pradeepta k. Bhuyan *et al.*2010 shows the use of Air Quality Index (AQI) describing air pollution in choudwar area of Cuttack district. AQI was computed for ten sampling station in the choudwar area within the radius of 10kms from core zone. Agrahat(1),Nergundi Railway station(2), Narapada(3), Kapeleshwar(4), khutuni(5),Ghantikhal(6),near arati steel(7), dautatabad(8), kayalapada(9) and Gurudijhatia(10) are ten sites selected for air sampling. Out of these four stations (4, 5, 6, 7) are located in industrial belt and other six stations are located in rural area. During the study period SPM was found to be minimum(102.2 µg/m^3) at rural area i.e. site 3 in monsoon 2007 and maximum at industrial area i.e. site 4 in post monsoon 2007 and pre monsoon 2008. NO_2 was found to be minimum (12.8 µg/m^3) at rural area i.e. site 3 in pre monsoon 2007, 2008 and maximum (38.3 µg/m^3) at industrial site i.e. site 6 in post monsoon 2008. SO_2 was found to be minimum (0.8 µg/m^3) at rural area i.e. site 1 in pre monsoon 2007 and maximum (8.4 µg/m^3) at industrial area i.e. site 4 in post monsoon 2007, 2008. The average value of AQI at site 1, 2, 4,5,6,7 and 8 are 53.3, 57.7, 57.6, 69.0, 68.7, 70.9 and 53.6, respectively which shows Moderate air pollution and at site 3, 4 and 5 are 44.4, 49.7 and 48.6 which shows light air pollution.

New Delhi

Prakash Mamta *et al.*2010 analyzed the status of ambient air in Delhi city by employing the Air Quality Index (AQI). 24 hourly average concentrations of four major pollutant such as SPM, RSPM, SO_2 and NO_2 were analyzed at three different locations (industrial at Mayapuri, commercial at town Hall and Residential at Sarojini) for a year 2009. Sampling was carried out using HVS and RDS at the flow rate of 0.8-1.3 m^3/min. average concentration of SPM at all three sites ranged between 160-1009 µg/m^3 at industrial, 160-1140 µg/m^3 at commercial and 72-831 µg/m^3 at residential site while RSPM varies from 62-664 µg/m^3 at industrial,48-619 µg/m^3 at commercial and 28-483 µg/m^3 at residential site. Average concentration of SO_2 and NO_2 at all the sites ranged between 2-28 µg/m^3 and 17-110 µg/m^3, at industrial,2-28 µg/m^3 and 15-107 µg/m^3 at commercial and 2-18 µg/m^3 and 16-94 µg/m^3 at residential sites respectively. The AQIs were calculated using IND-AQI procedure. The calculated AQI values for 24 hourly average NO_2 and SO_2 concentrations were categorized as good to moderate and good during the study period at all three sites. AQI value estimated for SPM showed about 62% in industrial, 55% in commercial and 47% in residential under very poor category while AQI values for RSPM varied about 54% in industrial,42% in commercial and 59% in residential sites under poor category. Over all AQI was found to fall under the category of poor to very poor due to RSPM and SPM respectively. Daily average concentration and AQI for particulate matter shows a maximum pollutant concentration during winter months and general trend of minimum values occurs in monsoon.

Udaipur, Rajasthan

Kapoor *et al.2013* calculated the mean concentrations of SO_2, NO_2 SPM and RSPM in urban, industrial and forest areas of Udaipur for two years i.e. from September, 2010 to August, 2012.Rajpura Dariba mines, Hindustan Zinc Smelter, Debari, Madri Industrial Area and Sukher are some places of Udaipur which was selected for Sampling. Minimum three recording was taking out in a day i.e. morning, noon and evening hours and polythene bags were used for bring the samples to laboratory. The concentration of NO_x was measured by modified Jacob and Hochheiser while SO_x was measured by Modified West and Gaeke method. CO was measured by carbon monoxide analyser and particulate matter was measured using filter paper. It has been found that concentration of suspended particulate matter (SPM) ranges between 118.39 (rainy season) to 528.56 (summer season) µg/m^3. SO_2 ranges between 6.29(rainy season) to 68.27(winter season) µg/m^3 , NO_2 ranges between 4.33(rainy season) to 42.09 (winter season) µg/m^3 and CO between 304.62(rainy season) to 1620.54(winter season) µg/m^3 during the study period.

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Air Quality Status in Metropolitan Cities during Year 2011

CITY	Total No. of Operating Stations	Annual Average in µg/m^3		
		SO_X	NO_X	PM_{10}
AHMEDABAD	6	14	25	83
SURAT	3	20	29	106
VADODARA	4	18	30	92
RAJKOT	2	13	18	98
FARIDABAD	2	20	43	174
JAMSHEDPUR	2	26	48	152
DHANBAD	1	35	36	207
RANCHI	1	18	35	165
BANGALORE	9	4	28	91
KOCHI	7	3	13	38
KOZHIKHODE	2	2	8	46
THRISSUR	1	2	14	33
MALLAPURAM	1	2	5	30
THIRUVANANTHAPURAM	4	10	23	58
KOLLAM	2	4	20	53
INDORE	3	12	14	132
BHOPAL	4	4	16	170
JABALPUR	1	2	25	73
GWALIOR	2	12	20	311
MUMBAI	3	5	33	116
PUNE	4	32	58	113
NAGPUR	7	8	35	108
NASHIK	4	25	27	96
AURANGABAD	4	8	31	83
LUDHIANA	4	11	28	221
AMRITSAR	2	14	26	210
JAIPUR	6	6	37	139
JODHPUR	6	5	23	168
KOTA	3	7	31	139
CHENNAI	11	9	24	92
COIMBATORE	3	4	26	102
MADURAI	3	11	24	44
KANPUR	9	10	31	183
GHAZIABAD	2	31	39	231
AGRA	6	3	23	155
VARANASI	2	17	20	127
MEERUT	2	5	45	123
ALLAHABAD	2	5	20	258
LUCKNOW	5	8	33	185
KOLKATA	10	12	65	113

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ASANSOL	3	7	56	145
HYDERABAD	9	5	28	74
VISAKHAPATNAM	8	13	21	80
VIJAYAWADA	2	6	11	90
PATNA	2	4	36	158
CHANDIGARH	5	2	16	102
RAIPUR	3	15	42	310
DURG-BHILAINAGAR	4	8	22	104
DELHI	11	6	61	222

Source: Annual report 2011-2012, Central Pollution Control Board (CPCB)

Conclusion

A brief review on monitoring of ambient air quality parameters such as Sulphur Dioxide(SO_2),Nitrogen Dioxide(NO_2),Particulate Matter ($PM_{2.5}$,PM_{10}), Ozone(O_3), Lead(Pb), Carbon Monoxide(CO), Benzene(C_6H_6) and Nickel(Ni) has been presented. Health effects, seasonal variations and characteristics have been discussed. It have been found that the concentration of above mentioned parameter are found to be highest at industrial site, followed by commercial sites and lowest at residential and rural sites.

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