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Trends and Management of Air Pollution: Assessment of Major Cities in India

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Abstract
Air pollution has emerged as one of the leading risk factors contributing to national burden of disease in India. This study examined the trends of air pollution in India over the period from 1995-2008. The analysis revealed a wide variation in the time series of annual measurements of SO_x, NO_x, SPM and RSPM at various cities in India. The mean of Annual average concentration of sulphur di oxide was found to be higher for Bangalore and Kolkata(19.5, 19.7$\mu g/m^3$).The oxides of nitrogen were found to be higher for Kolkata and Delhi(48.80$\mu g/m^3$,40.86$\mu g/m^3$).The levels of RSPM was found to be significantly higher for Ahmadabad ,Delhi and Kolkata(165,163,126$\mu g/m^3$).Similarly the levels of SPM was found to be higher for Delhi and Kolkata(385, 301$\mu g/m^3$). The other important point in SO_2 levels is decreasing at all cities, which is largely attributed to sulphur reduction in diesel. The variation in annual average concentrations during different years may be due to multiple factors including meteorology, neighbourhood activity pattern or levels during monitoring period etc.
Keywords: national burden, RSPM, air quality standard, sulphur reduction.average concentration

Introduction

The trends of air pollution have undergone significant changes in India within the last few years. Air pollution is one of the leading risk factors contributing to national burden of disease in India(World Health Organisation, 2002).Several recent time series studies conducted world- wide have found relatively low levels of air pollutants that are below national standards were associated with adverse effects on mortality and morbidity(Dockery; American Thoracic Society; Petroeschevsky A;Gouveia; Wong, T.W.;Galan, I.,; Chew).Children's and infants are among the most vulnerable for several reasons. They spend a substantial amount of time outdoors which increases exposure to ambient air pollutants. Levels of ambient air pollution uniformly exceed the recently revised WHO air quality guideline (AQG) levels (WHO, 2006) across most cities in India, with almost 80 non attainment cities and towns and 24 critically polluted hotspots identified by the Central Pollution Control Board(CPCB), Government of India(CPCB, 2009).An estimated 120,600 deaths are attributed to outdoor air pollution each year in India(WHO, 2002).

Methodology

Ambient air quality is being monitored under National Ambient Air Quality Monitoring Program (NAMP), coordinated by Central Air Pollution Control Board (CPCB) in over 215 cities/towns including the six project cities. It covers 520 operating stations spread over 26 states and 5 Union Territories. The table below shows the number of sanctioned and operating air quality monitoring stations till 31st March, 2012.Secondary data was collected through the website and various publications of CPCB and the Ministry of Environment and Forest.

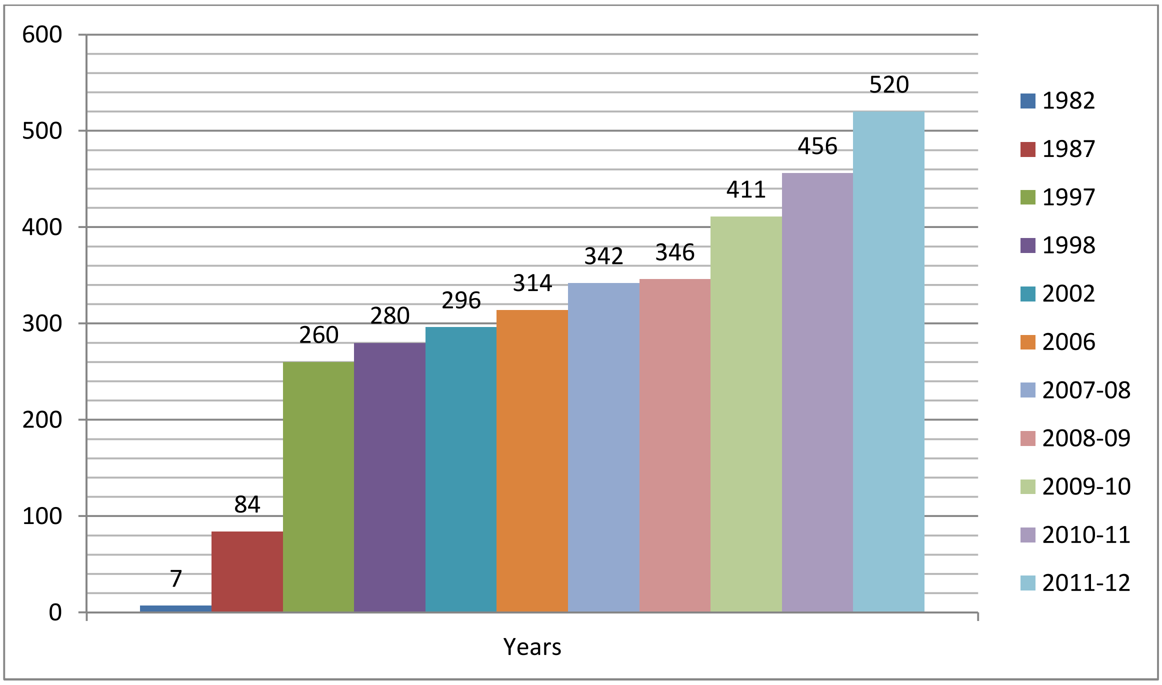

Figure 1 Growth of operating ambient air quality monitoring network

The secondary data was gathered from the online resources of Central Pollution Control Board for a period of 1995 to 2008.

Data

Sulphur di oxide(μg/m^3)

City	Ahmadabad	Bangalore	Chennai	Delhi	Hyderabad	Kolkata	Mumbai
1995	32.00	18.20	21.70	23.50	17.20	35.70	31.10
1996	25.00	20.70	8.10	17.30	16.80	21.30	18.00
1997	15.10	27.90	15.90	16.30	16.40	1.00	25.10
1998	13.10	20.30	12.60	15.40	11.80	34.30	11.50
1999	12.20	38.20	11.90	17.50	14.00	44.50	14.90
2000	8.40	20.70	12.50	15.20	12.40	17.40	12.10
2001	10.00	20.00	17.00	13.00	10.00	18.00	16.00
2002	12.30	13.40	19.90	11.30	7.27	11.40	9.07
2003	16.00	12.00	15.00	10.00	6.00	17.00	8.00
2004	15.70	8.50	12.20	9.89	5.63	9.33	6.67
2008	12.30	15.20	9.50	6.60	5.50	7.70	8.70

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ahmadabad	11	8.40	32.00	15.6455	6.93186
Bangalore	11	8.50	38.20	19.5545	8.11559
Chennai	11	8.10	21.70	14.2091	4.17312
Delhi	11	6.60	23.50	14.1809	4.66543
Hyderabad	11	5.50	17.20	11.1818	4.59865
Kolkata	11	1.00	44.50	19.7845	13.31266
Mumbai	11	6.67	31.10	14.6491	7.64055
Valid N (listwise)	11				

Oxides of Nitrogen(μg/m³)

Ahmadabad	Bangalore	Chennai	Delhi	Hyderabad	Kolkata	Mumbai
18.80	20.00	17.50	47.20	37.80	29.90	64.20
14.80	28.00	9.00	39.70	25.00	29.30	35.30
20.00	20.40	13.00	34.00	30.70	30.00	34.30
21.00	25.00	16.70	33.90	30.80	32.00	19.50
33.00	27.10	10.70	35.70	24.30	30.50	29.60
28.60	40.20	14.40	39.90	25.20	34.80	25.50
39.00	23.00	18.00	37.00	31.00	74.00	23.00
31.80	25.50	18.40	37.30	25.50	81.70	17.40
25.00	35.00	26.00	42.00	26.00	71.00	21.00
24.30	51.80	16.80	46.10	30.30	59.70	18.30
20.00	40.80	15.40	56.70	26.20	64.00	39.30

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ahmedabad	11	14.80	39.00	25.1182	7.26647
Banglore	11	20.00	51.80	30.6182	10.07738
Chennai	11	9.00	26.00	15.9909	4.49610
Delhi	11	33.90	56.70	40.8636	6.86896
Hyderabad	11	24.30	37.80	28.4364	4.09128
Kolkata	11	29.30	81.70	48.8091	21.12858
Mumbai	11	17.40	64.20	29.7636	13.63233
Valid N (listwise)	11				

SPM(μg/m³)

	Ahmadabad	Bangalore	Chennai	Delhi	Hyderabad	Kolkata	Mumbai
1995	251.00	156.00	127.00	411.00	178.00	354.00	210.00
1996	254.00	176.00	115.00	402.00	177.00	498.00	213.00
1997	235.00	187.00	107.00	343.00	144.00	312.00	298.00
1998	201.00	153.00	127.00	379.00	213.00	279.00	187.00
1999	351.00	146.00	88.00	388.00	209.00	308.00	221.00
2000	393.00	153.00	92.00	381.00	163.00	315.00	252.00
2001	343.00	148.00	98.00	346.00	157.00	251.00	231.00
2002	281.00	149.00	132.00	427.00	161.00	256.00	225.00
2003	256.00	163.00	155.00	355.00	164.00	251.00	224.00
2004	244.00	153.00	136.00	374.00	196.00	266.00	247.00
2008	220.00	273.00	142.00	433.00	225.00	225.00	260.00

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ahmedabad	11	201.00	393.00	275.3636	60.66180
Banglore	11	146.00	273.00	168.8182	36.78537
Chennai	11	88.00	155.00	119.9091	21.66312
Delhi	11	343.00	433.00	385.3636	30.65705
Hyderabad	11	144.00	225.00	180.6364	26.36389
Kolkata	11	225.00	498.00	301.3636	75.16152
Mumbai	11	187.00	298.00	233.4545	29.74345
Valid N (listwise)	11				

	Ahmadabad	Bangalore	Chennai	Delhi	Hyderabad	Kolkata	Mumbai
1999	161.00	72.00	71.70	172.00	127.00	140.00	115.00
2000	237.00	89.70	65.00	155.00	98.00	145.00	107.00
2001	198.00	68.00	77.60	146.00	68.80	117.00	67.20
2002	169.00	64.30	74.80	158.00	71.00	128.00	68.70
2003	154.00	76.00	86.00	151.00	64.00	121.00	70.00
2004	152.00	69.00	60.00	149.00	71.00	134.00	78.00
2008	88.00	100.00	63.00	214.00	85.00	103.00	127.00

RSPM ($\mu g/m^3$)

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ahmedabad	7	88.00	237.00	165.5714	45.68317
Banglore	7	64.30	100.00	77.0000	13.05488
Chennai	7	60.00	86.00	71.1571	9.16803
Delhi	7	146.00	214.00	163.5714	23.79676
Hyderabad	7	64.00	127.00	83.5429	22.41122
Kolkata	7	103.00	145.00	126.8571	14.46177
Mumbai	7	67.20	127.00	90.4143	25.16389
Valid N (listwise)	7				

The mean of Annual average concentration of sulphur di oxide was found to be higher for Bangalore and Kolkata(19.5, 19.7$\mu g/m^3$).The oxides of nitrogen were found to be higher for Kolkata and Delhi(48.80$\mu g/m^3$,40.86$\mu g/m^3$).The levels of RSPM was found to be significantly higher for Ahmadabad ,Delhi and Kolkata(165,163,126$\mu g/m^3$).Similarly the levels of SPM was found to be higher for Delhi and Kolkata(385, 301$\mu g/m^3$).

The variation in annual average concentrations during different years may be due to multiple factors including meteorology, neighbourhood activity pattern or levels during monitoring period etc.

Category	Metropolitan Cities(Population >10 lacs)		
	SO_2	NO_2	PM_{10}
Not Exceeding NAAQs	35	30	3
Exceeding NAAQs	0	5	31
Total Cities	35	35	34

Table: Number of metropolitan cities exceeding the NAAQs (Based on Annual Average data), 2010

Results and Discussion

The analysis revealed a wide variation in the twelve years time series of hourly measurements of SO_x, NO_x, SPM and RSPM at various cities in India. In recent years a large number of studies of health impact of suspended particulate air pollution have been undertaken in developing countries(WHO, 1997).These studies show remarkable consistency in the relationship between changes in daily ambient suspended particulate levels and changes in mortality(ICMR, 2001).Smith(1996) estimated the health risk from exposure to particulate air pollution by applying the mean risk unit ambient concentrations based on the results of some urban epidemiological studies(WHO, 1996; Hong et.al.,1997). Except for Chennai, annual RSPM standard (60 $\mu g/m^3$) exceeds in all cities in all years (2000-2006). It is closely followed by Delhi. The concentration of RSPM (Respirable Suspended Particulate Matter) for 2011-12 for Delhi was 184-486 $\mu g/m^3$. However in past three years, Mumbai shows slight rising trends for RSPM.

Generally, NO_2 levels are within the air quality standard in all cities. In past three years, Bangalore and Pune have shown decreasing trends in NO_2. For Delhi the levels of NO_2 were 34-78 $\mu g/m^3$ for 2011 and 53-130 $\mu g/m^3$ for 2012. However, a close examination of other cities shows a definite increasing trend of NO_2.

SO_2 levels are within the annual standard in all cities. The other important point in SO_2 levels is decreasing at all cities, which is largely attributed to sulphur reduction in diesel. The variation in annual average concentrations during different years may be due to multiple factors including meteorology, neighbourhood activity pattern or levels during monitoring period etc.

Management of Air Pollution

The exponential growth of India's economy over the past few decades is responsible for much of the problem of air pollution. This hugely ballooning demography is responsible for 39 percent of Indian consumption now; by

2025, this number will rise to 70 percent (Sequeira, J., 2008).Alternatively there has been a rise in the number of vehicles on road which again is contributing to the increasing trends of air pollution. Air pollution reduction strategies will need to consider a) populations at risk because of biologically based susceptibility, age and so on; b) fuels used for energy production; c) indoor air pollution and d) consumer and personal products with the same pollutants as outdoor air (Bachmann, 2007; Chow et.al., 2007; Kaner et.al., 2010; Mitchell et.al., 2007; Nazarenko et. al., 2010; Zhu et.al., 2008).Besides these the following management practices could be adopted:

- Land use planning in the form of properly demarcated areas as industrial, commercial and residential should be developed so as to minimize the health impacts on residents.
- Car pooling and systematic public transport systems need to be developed to curb pollution levels.
- Vehicles and automobiles using alternate energy must be encouraged by the Government.
- Keeping in view the scenario monitoring activities in India should be expanded to cover more pollutants and a wider geographical area. This will help in the assessment of root cause of pollution in these areas.
- Further there is a tremendous need for increasing the awareness levels among citizens so that they act and think in a sustainable manner.

Conclusion

The burgeoning problem of air pollution has lead to an increase in diseases in India. There has been an appreciable correlation between the mortality rates and the increasing levels of SPM and RSPM in various cities. The study focussed on the levels of air pollution across a decade in the major cities of India. The increasing trends from 1995 to 2008 suggest that there has been an appreciable increase in SPM and RSPM in major cities of the country. The problem requires effort from both the Government and citizens so that it could be effectively managed. Alternate energy sources

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