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Statistical Analysis of Ambient Air Quality in Aurangabad City, Maharashtra, India

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Abstract

A statistical analysis of ambient air in Aurangabad City (M.S.) during the year 2005-2010 and its concentration of SO_2, NO_X, RSPM and SPM are monitored at selected three residential site during rainy, winter and summer season. Results shows that SO_2, NO_X, RSPM are well below the permissible limit and SPM is above the permissible limits. The sampling sites are a heavy traffic intersection cum residential area located within the Aurangabad City. It is observed that pollutant values always exceed the NAAQS value throughout the sampling. The annual mean values for all sampling sites and the statistical calculations made on data shows SO_2, NO_X year wise and sidewise significant and RSPM and SPM year wise non-significant and sidewise significant. This study is that the data collected year wise for all parameters on different sites and concentration is also discussed. One of the major sources of air pollution in Aurangabad (M.S.) is the area pollutions from dense residential, heavy vehicles, industries etc.

Keywords: Ambient air quality; SO_2; NO_X; RSPM; SPM

Abbreviations: RSPM: Respirable suspended particulate matter (Size less than 10 μm); SPM: Suspended particulate matter (Size: 10 μm-100 μm); NAAQS: National ambient air quality standards; HVS: High Volume Sampler; EPA: Environmental Protection Agencies; CPCB: Central Pollution Control Board; ANOVA: Analysis of Variance; AAQM: Ambient Air Quality Monitoring; df: Degree of freedom; SS: Sum of square; MSS: Mean of sum of square; f: Coefficient factor.

Introduction

Aurangabad (Aurang City) is named after the Mughal Emperor Aurangzeb. The city is a tourism hub, surrounded by many historical monuments, including the Ajanta and Ellora Caves. Aurangabad is titled "The City of Gates" and was declared "Tourism Capital of Maharashtra". By population it is 5th largest city in Maharashtra after Mumbai, Pune, Nagpur and Nasik.

The concept of Air Quality Index was introduced by the Environmental protection agency (EPA) in USA to measure the pollution levels due to major air pollutants [1,2]. Air pollution may have adverse impacts on human health [3-5] as well as the health of other living entities, man-made heritage and life support system. Both National and state authorities have taken up necessary regulatory steps and reduce ambient air pollution [6]. Unplanned urbanization and industrialization are causing deterioration of the environment [7-9] and particulate matter were observed during winters and low concentrations during monsoon months [10] similar observation were reported in Bikaner [11]. The data compiled by MPCB for the year 2013-2014 at 72 AAQM stations shows air quality were found to moderate and below [12]. All observed values of PM10 were higher than National Ambient Air Quality Standards. Similarly PM10 values for Jhansi city [13] and Kakinada city were found to exceed prescribed limits as stipulated by CPCB [14]. Moderately polluted category for the city of Vapi, India and PM10 was observed to be a critical pollutant [15]. Quality of life in Aurangabad city and it is necessary to analyzed the air quality and investigate the impact of ambient air pollutant. The sampling sites are dense traffic area and commercialized shopping Centre located in the Centre of Aurangabad city. Ambient air monitoring at the three different sites in Aurangabad city for three seasons was conducted in order to calculate the concentration on SO_2, NO_X, and RSPM and SPM in the ambient air. The experimental study was conducted in Aurangabad (M.S.) and statistically analyzed the parameters SO_2, NO_X, RSPM and SPM. SO_2 and NO_X were in the permissible limit but RSPM and SPM were increased.

Materials and Methods

Study area

Aurangabad is historical city located in the state of Maharashtra, India. The materials and methods used in this study are described in details including the chemicals, glassware's, instruments High Volume Sampler (HVS) and procedures used for sampling site selection, sampling of ambient air, statistical analysis of pollutants i.e., SO_2, NO_X, RSPM and SPM concentration as per the standards recommended by Ref. [16] shown in table was followed for fine particular sampling, High volume sampler [17-19] was used to monitor the ambient air quality and preweighed whatman Teflon filter papers were used to collect samples. Standard methods used for

SO_2 - West and Geake Method,

NO_X - Jacob and Hoccheiser Method,

RSPM and SPM - Gravimetric Method.

Statistical method used

Statistical analysis is an indispensable tool of research. Most of the advancements in knowledge has taken place because of experiments conducted with the help of statistical methods [20].

Standard deviation

Standard deviation is the positive square root of the arithmetic mean of the squares of the deviations of the given observation from their arithmetic mean. It is the most important for statistical predictions

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for various results of research and widely used measure of dispersion. It serve as a basis for measuring the correlation coefficient and statistical influences.

Analysis of variance (Anova)

It is used to study the significance of the difference of mean values of a large number of samples at the same time. It can also provide meaningful comparison of sample data. In ANOVA, a total of 'N' observations are divided into 'n' sizes for performing calculations [21]. Also, the comparison of observed concentration of pollutants is compared with the CPCB standard AAQM values.

Experimental Results and Discussion

Experimental Results: Annual average concentration of AAQM-December 2005 to November 2010.

Discussion

The data on four parameters i.e., SO_2, NO_X, RSPM, SPM sampling on three sites i.e., Collector Office, CADA Office, S.B. College and five years i.e., 2005-06, 2006-07, 2007-08, 2009-10 (Table 1 and Figures 1-4) were statistically analysed for analysis of variance (ANOVA) and presented in four tables, each for the four parameters under investigation (Tables 2-5). The average values have been given in Table 6.

During five years, the value of SO_2 ranges from 5.15 in 2006-07 to 7.38 in 2008-09. The NO_X content was maximum (25.15) during 2008-09 while minimum (18.54) during 2005-06.

Parameter	Station Code	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	CPCB Std.
SO_2	Site-01	4.88	4.88	6.35	6.93	5.96	80 µg/m³
	Site-02	5.54	5.27	7.40	7.24	6.34	
	Site-03	5.24	5.30	7.20	7.96	7.50	
NO_X	Site-01	14.96	14.88	15.71	23.39	19.00	80 µg/m³
	Site-02	20.43	22.23	20.54	24.58	19.71	
	Site-03	20.23	21.47	19.52	27.48	21.61	
RSPM	Site-01	75.89	52.25	57.22	91.50	69.06	100 g/m³
	Site-02	78.96	76.80	75.95	65.84	66.21	
	Site-03	97.60	84.34	85.06	105.34	97.19	
SPM	Site-01	158.17	119.45	159.49	244.07	168.74	200 µg/m³
	Site-02	189.19	227.53	213.81	206.54	172.51	
	Site-03	248.26	309.01	309.05	342.92	258.48	

Table 1: Data on four parameters. Source: MPCB* (Maharashtra Pollution Control Board). Site 01: Collector Office, Aurangabad; Site 02: CADA Office, Garkheda, Aurangabad; Site 03: S.B. College, Aurangabad.

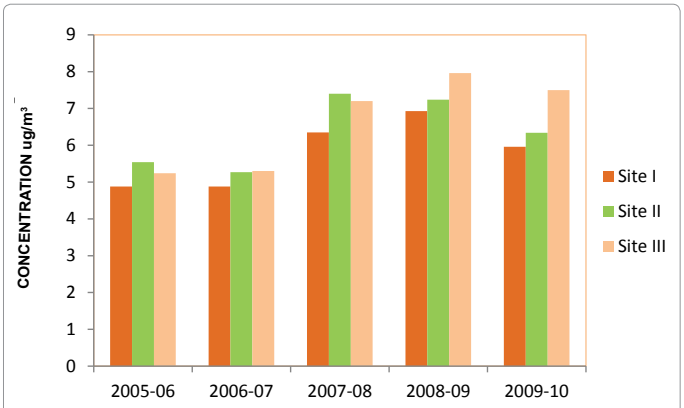

Figure 1: Annual average concentration of SO_2 (Dec. 2005 to Nov. 2010).

The variation in both of the parameters (SO_2 and NO_X) during 5 years was statistically significant. The values of RSPM and SPM ranged between 71.13-87.56 and 198.54-227.45 respectively, however, the year wise variation among them was statistically non-significant.

Significant variation in all the four parameters at three different locations was observed. The values of almost all parameters were found to be higher at site No. 03 (S.B. College) while minimum at Collector Office, Aurangabad. This may probably be due to the heavy traffic and human activities at S.B. College as compared to that near Collector Office, which is located in the outskirts of main city market of Aurangabad (Table 7). The overall findings thus suggested that the magnitude of these pollutants varied with location depending on human activities at a given place.

Studies on relationship (co-relation) among the four parameters are given in Table 8. Significant positive co-relation between SPM and other parameters was observed, indicating that the presence of SPM on other three Air Quality parameters, as SPM showed significant positive co-relation with SO_2, NO_X and RSPM.

Conclusion

The preliminary statistical analysis of SPM data collected from the sampling site is given in table. The annual mean values of SPM concentration are higher than allowed values and are found to exceed the NAAQS value throughout the sampling period by a very large amount. SPM concentrations are not constant and very wide. The

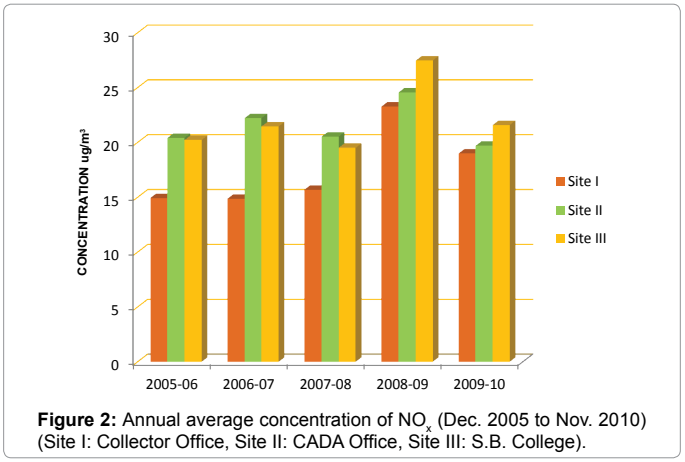

Figure 2: Annual average concentration of NO_x (Dec. 2005 to Nov. 2010) (Site I: Collector Office, Site II: CADA Office, Site III: S.B. College).

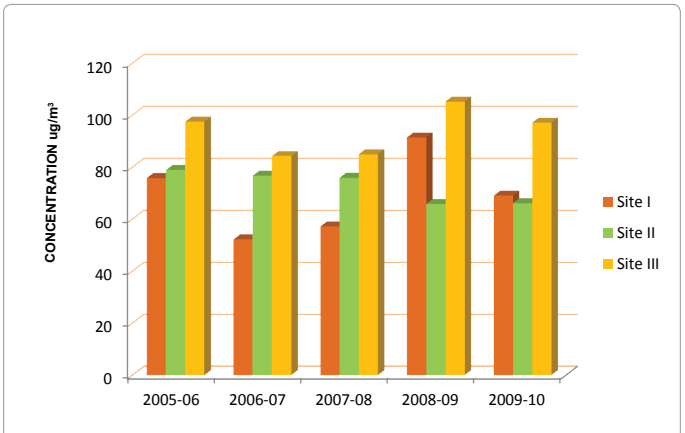

Figure 3: Annual average concentration of RSPM (Dec. 2005 to Nov. 2010).

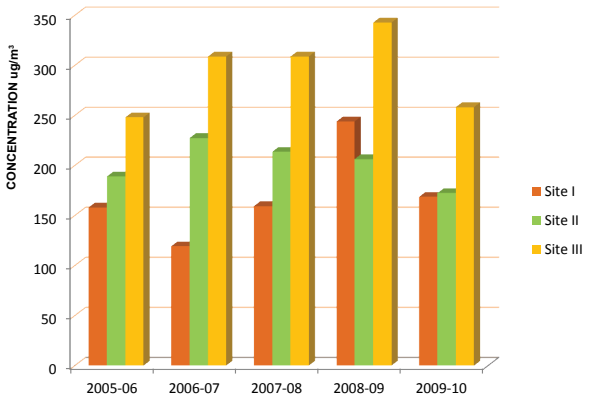

Figure 4: Annual average concentration of SPM (Dec. 2005 to Nov. 2010) (Site I: Collector Office, Site II: CADA Office, Site III: S.B. College).

Source	df	SS	MSS	f
Year	4	12.60	3.15	26.03**
Site	2	1.83	0.91	7.55*
Error	8	0.97	0.12	
Total	14	15.39	1.10	

Table 2: ANOVA - SO_2.

Source	df	SS	MSS	f
Year	4	90.44	22.61	10.05**
Site	2	59.37	29.69	13.19**
Error	8	18.00	2.25	
Total	14	167.81	11.99	

Table 3: ANOVA - NO_X.

Source	df	SS	MSS	f
Year	4	600.17	150.04	1.42 NS
Site	2	1804.37	902.19	7.55*
Error	8	842.85	105.36	
Total	14	3247.39	231.96	

Table 4: ANOVA - RSPM.

Source	df	SS	MSS	f
Year	4	8658.31	2164.58	2.26 NS
Site	2	41137.36	20568.68	21.43**
Error	8	7638.69	959.84	
Total	14	57474.36	4105.81	

Table 5: ANOVA - SPM.

Parameter	2005-06	2006-07	2007-08	2008-09	2009-10
SO_2	5.22	5.15	6.98	7.38	6.60
NO_X	18.54	19.53	18.59	25.15	20.11
RSPM	84.15	71.13	72.94	87.56	77.49
SPM	198.54	218.66	227.45	264.51	199.91

Table 6: Average values.

Site	SO_2	NO_X	RSPM	SPM
01	5.80	17.59	69.18	169.984
02	6.36	21.50	72.75	201.916
03	6.64	22.06	94.03	293.544

Table 7: Over all findings.

analysis of variance (ANOVA) test has been performed for the data collected for SPM. 'F' test values calculated for the data collected show very low when compared with the tabulated value. The high values of SPM concentration are common in the ambient air of Aurangabad city.

	SO_2	NO_X	RSPM	SPM
SO_2	0	-0.109	-0.144	0.557
NO_X		0	0.519	0.782
RSPM			0	0.833
SPM				0

Table 8: Correlation coefficient.

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