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Research Article

STATISTICAL ANALYSIS OF AMBIENT AIR QUALITY POLLUTION DATA OF AURANGABAD CITY

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ABSTRACT

Air quality monitoring study in Aurangabad city at three different points, Collector Office, Aurangapura and CADA Office was undertaken. Twenty-four hours air monitoring sampling was carried out by using Resparable Suspended particulate matter sampler during a week in the months. The study period from Feb.-2011 to Jan-2016. Air Quality Index (AQI) and Time Series Analysis for Seasonal variation was employed for analysis of ambient air quality monitoring data. The criteria for pollutants included in the study were Sulphur dioxide (SO2), Oxides of nitrogen (NOx), Resparable Suspended Particulate Matter (RSPM) and SPM (>10 micron dust Particals). The results indicated that the RSPM and SPM extensively contribute toward air pollution at this location through out study period.

INTRODUCTION

Decrease in air quality is a cause of concern since it affects the human health. The economic growth coupled with rapid urbanization, increased number of vehicles, industrial and human activities are responsible for the changes in the air quality. This has attracted attention of the Government, society and many researchers. The air pollution costs society in terms of damage to human health, buildings, vegetation, lowered visibility and increased green house gases.

Air quality index (AQI) is the key tool used for the assessment of ambient air quality. It was introduced by Environmental protection agency (EPA), USA to measure the levels of pollution due to major air pollutants. Air quality index has been used as an indication of the air pollution. Data is taken from Maharashtra pollution control board website; to study was aimed to monitor the ambient air quality at CADA Office, SBES College Campus and Collector Office, Aurangabad city.

The sampling was done using Respirable dust sampling machine. The parameters monitored were sulphur dioxide (SO_2), oxides of Nitrogen (NOx), Respirable suspended particulate matters (RSPM) and SPM (> 10 Micron Particles). The sampling was carried out for 24 hours. The concentration of the pollutants was calculated in micrograms per cubic meter ($\mu g/m^3$). RSPM is recorded using gravimetric method. Air is drawn into a covered housing and through a filter (Glass fibre filter) by means of high-flow-rate blower at a flow rate (1.13 to 1.70 m^3 / min or 40 to 60 ft min) that allows suspended particles having diameters of less than100m (Aerodynamic diameter) to pass to the filter surface. The mass concentration of suspended particulate in the ambient air ($\mu g/m^3$) is computed by measuring the mass of collected particulate and the volume of air sampled. The air samples were collected to measure Sulphur dioxide and oxides of Nitrogen for 24 hours and were analyzed by using Central Pollution Control Board guidelines for analysis for these gaseous pollutants. The RSPM and SPM was sampled by the gravimetric method at an interval of 8 hours, three samples were collected for 24 hours.

Various researchers has studied the air pollution and its major pollutants Rao MN, Rao HVN (1989), Hemavathi and ShobhaJagannath (2006), Hari Om Gupta and Brij Mohan sharama (1995), Lu, H. (2002), Reddy M. K. and MotatiSuneela (2000), Senthilnathan T and Rajan R.D. (2003),

Someshwara Rao N, Gunaseelan K, Praksam N K and Srinivasa S.S. (1999), Hai-Dong, Kan And Bing-Heng Chen (2004), R.K. Srivastava and Rajasree Sarakar (2010), etc..

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The prescribed air quality index (AQI) and National ambient air quality standards (NAAQS) are shown in table 1and 2, respectively.

Table 1 Rating scale of AQI Values

Index values(µg/m3)	Remarks
0 – 25	Clean air (CA)
26 – 50	light air pollution(LAP)
51 – 75	Moderate air pollution(MAP)
76 – 100	Heavy air pollution (HAP)
> 100	Severe air pollution (SAP)

Table 2 National Ambient Air quality Standards (NAAQS)

Pollutant	Time weight	Concentration in ambient air quality (µg/m3)			Method of measurement
		Industrial	Residential	Sensitive	
SO_2	24 hrs	120	80	30	High volume sampling average.
NOx	24 hrs	120	80	30	
RSPM	24 hrs	150	100	75	
SPM	24 hrs	500	200	100	

MATERIALS AND METHODS

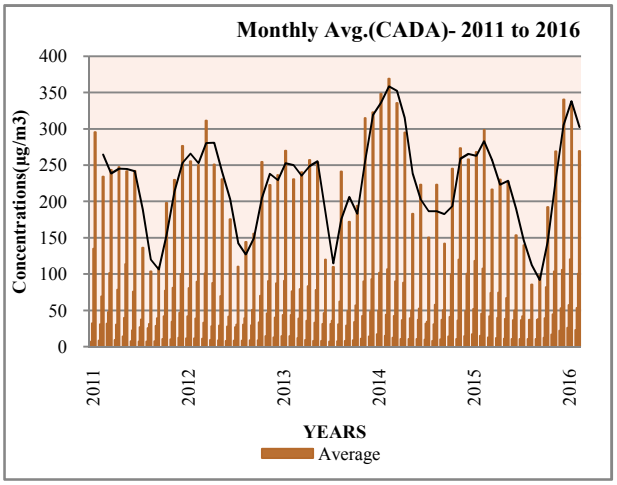
The eight days in month, data of *SO_2,NOx* and *RSPM* is collected from website of Maharashtra Pollution Control Board for the period of Feb.-2011 to Jan-2016 for CADA Office, SBES College Campus and Collector Office, Aurangabad.. This station is in residential area. Air Quality Index (AQI) was calculated with the concentration values using the following formula (Rao and Rao 1989),

$$AQI = 1 / 3 [(SO_2)/ SSO_2 + NOx / SNOx + RSPM / SRSPM] x100$$

Where SO_2, NOx and RSPM represent the individual concentration and SSO_2, SNOx and SRSPM represents the ambient air quality standard for SO_2, NOx and RSPM respectively.

RESULTS AND DISCUSSION

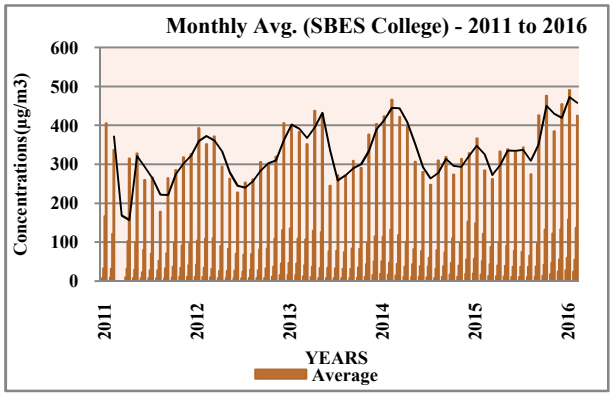
The Monthly average values of concentration of three pollutants *SO_2, NOx* and *RSPM* at for CADA Office, SBES College Campus and Collector Office, Aurangabad are represented graphically in Graphs 1,2,3. below:



Graph-1:C.A.D.A. Office, Garkheda Graphical Representation Monthly Average Data

Above graphs shows a histogram for RSPM and SPM values concentrations for different stations of Aurangabad city, But overall, the graph shows SO2and NOX within the permissible limit of the national standards, but overall graph shows that the RSPM and SPM values are greater than National ambient air quality standards.

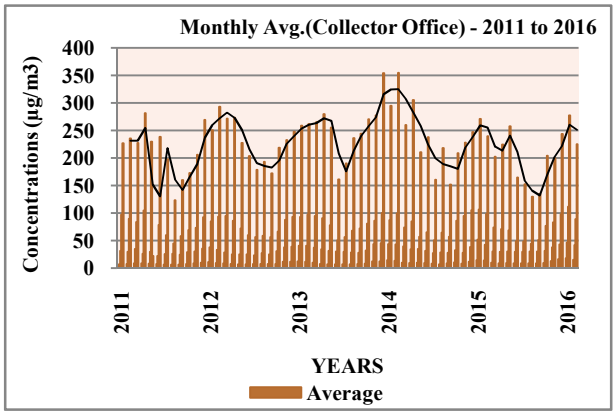
Location: SBES College Campus, Aurangabad



Graph-2 Graphical Representation monthly average Data

Above graphs shows a histogram for RSPM and SPM values concentrations for different stations of Aurangabad city, But overall, the graph shows SO2and NOX within the permissible limit of the national standards, but overall graph shows that the RSPM and SPM values are greater than National ambient air quality standards.

Location: Collector Office



Graph-3 Graphical Representation monthly average Data:

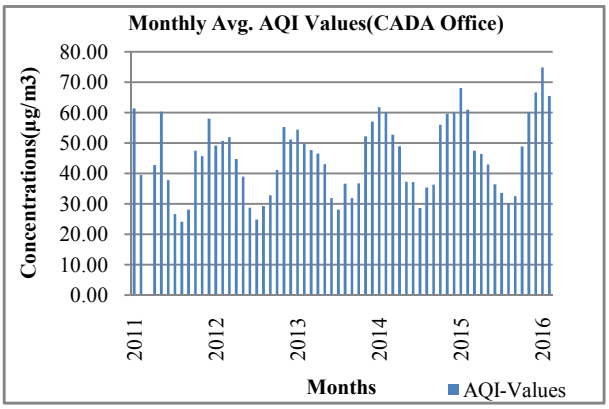
Monthly Avg. Values of Concentration of SO_2, NOx, RSPM and SPM

From above observation tables and graphs, it is observed that the concentrations of sulphur dioxide (SO2), NOx and were within the permissible limit under NAAQS, except sometimes the SPM values were more sometime were high during the entire study period. It may be due to high traffic at surrounding the for CADA Office, SBES College Campus and Collector Office, Aurangabad.

Monthly AQI and rating scale values are shown as below

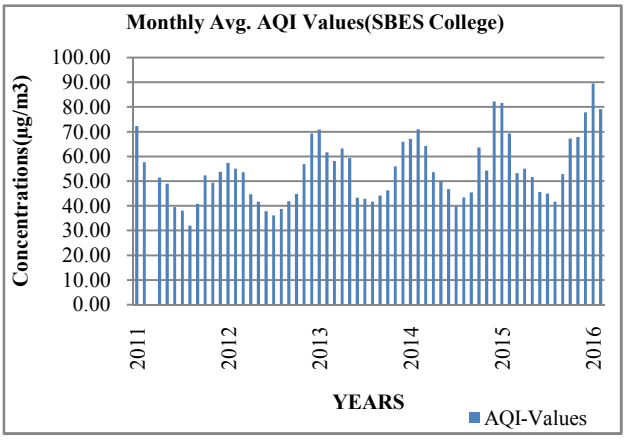
Graphs 4, 5, 6: AQI and Rating scale for AQI values at for CADA Office, SBES College Campus and Collector Office, Aurangabad, from Feb-2011 to Sept.-2015:

C.A.D.A. Office, Garkheda



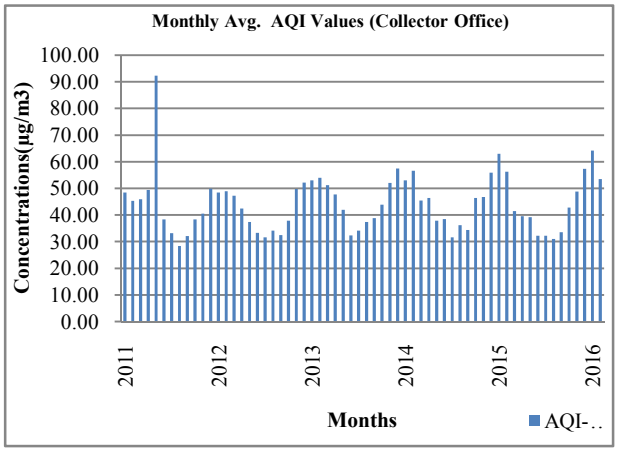
Graph-4 Graphical Representation of Data

Location: SBES College Campus, Aurangabad



Graph-5 Graphical Representation of Data

Location: Collector Office

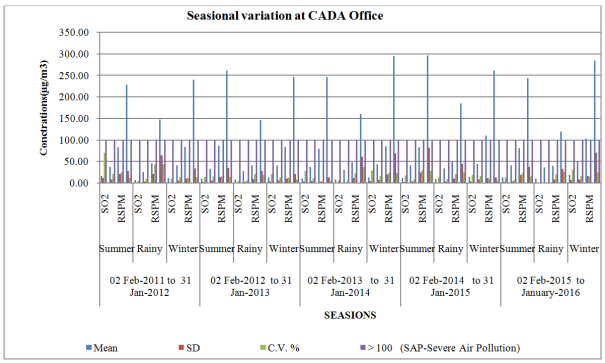


Graph-6 Graphical Representation of Data

From the above tables and graphical representation, it is observed that the Moderate and Heavy air pollution from the month of Feb-2011 to Jan-2016. The graphical representation of this AQI values against monthly averages are shown above.

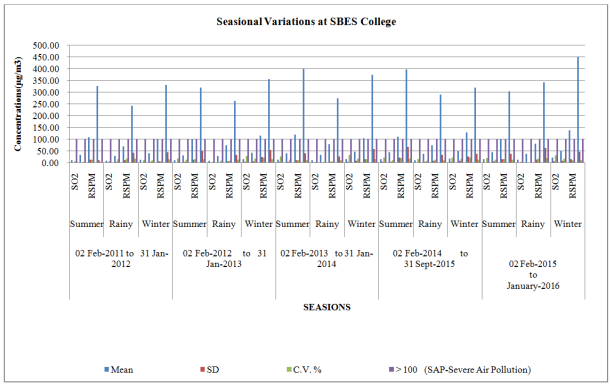
Seasonal Variations of the different pollutants

Seasonal average values of SO2, NOx and RSPM along with standard deviation, coefficient of variation and air quality index are listed in following Tables. The concentration of various pollutants at CADA Office, SBES College Campus and Collector Office, Aurangabad in all seasons shown below:



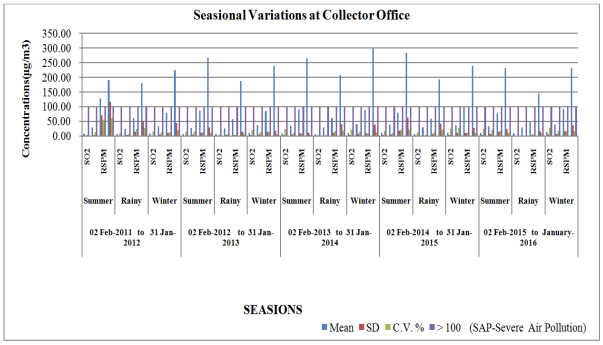
Graph-7 Graphical Representation of Data:

SBES College station, only the graphical representation of concentration are shown below



Graph-8 Graphical Representation of Data

Collector Office station, only the graphical representation of concentration are shown below



Graph-8 Graphical Representation of Data

Through out study period the above three stations data shows that seasonal variations of SO2, NOx, RSPM and SPM, above tables, It is observed that variability of SO2 Nox,RSPM and SPM are shown above tables. When we consider AQI and rating scale for SPM of Summer and winter seasons the air pollution at CADA Office, SBES College Campus and Collector Office, Aurangabad is moderate and heavy air pollution respectively.

TableNo.-3 The Concentration of various pollutants at CADA Office

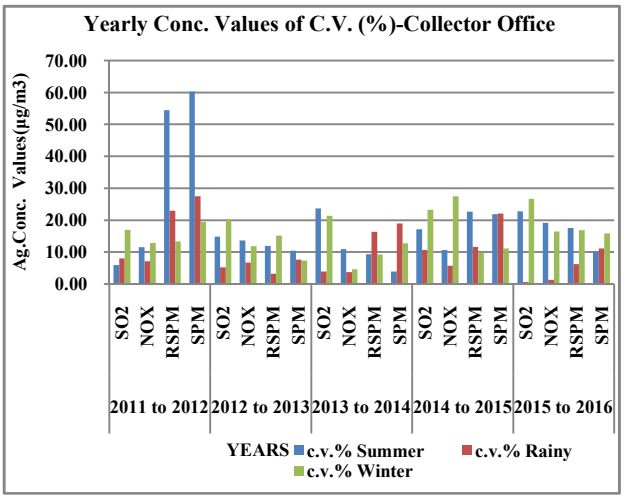
Location :C.A.D.A. Office , Garkheda Aurangabad							
Years	Seasons	Months	Parameters (µg/m3)	Mean	SD	C.V. %	AQI
02 Feb-2011 to 31 Jan-2012	Summer	Feb to May	SO2	16.02	11.23	70.11	49.82
			NOX	37.01	7.90	21.35	
			RSPM	83.18	20.87	25.09	
			SPM	227.88	27.23	11.95	
	Rainy	Jun to Sept.	SO2	7.19	0.31	4.32	29.15
			NOX	26.02	2.62	10.08	
			RSPM	45.94	20.09	43.73	
			SPM	147.77	64.41	43.59	
	Winter	Oct to Jan	SO2	11.17	1.06	9.48	50.08
			NOX	41.18	5.16	12.54	
			RSPM	84.80	10.30	12.15	
			SPM	239.95	33.85	14.11	
02 Feb-2012 to 31 Jan-2013	Summer	Feb to May	SO2	10.04	1.39	13.85	46.60
			NOX	32.25	4.81	14.91	
			RSPM	86.92	12.99	14.94	
			SPM	260.79	35.06	13.44	
	Rainy	Jun to Sept.	SO2	8.34	0.43	5.10	28.92
			NOX	28.63	1.59	5.57	
			RSPM	40.55	8.28	20.41	
			SPM	146.34	27.25	18.62	
	Winter	Oct to Jan	SO2	12.61	2.60	20.64	50.51
			NOX	40.77	5.30	13.00	
			RSPM	84.79	9.75	11.50	
			SPM	245.75	20.69	8.42	
02 Feb-2013 to 31 Jan-2014	Summer	Feb to May	SO2	10.86	3.00	27.59	46.71
			NOX	37.79	4.59	12.16	
			RSPM	79.33	2.96	3.74	
			SPM	245.51	12.23	4.98	
	Rainy	Jun to Sept.	SO2	7.66	0.40	5.23	32.12
			NOX	30.78	1.06	3.45	
			RSPM	48.31	10.79	22.34	
			SPM	160.72	60.12	37.41	
	Winter	Oct to Jan	SO2	12.80	3.77	29.45	51.94
			NOX	43.45	6.99	16.09	
			RSPM	85.49	19.83	23.20	
			SPM	295.06	68.75	23.30	
02 Feb-2014 to 31 Jan-2015	Summer	Feb to May	SO2	12.12	2.16	17.81	49.80
			NOX	40.46	3.33	8.23	
			RSPM	83.67	24.05	28.74	
			SPM	295.66	81.04	27.41	
	Rainy	Jun to Sept.	SO2	9.50	1.19	12.49	34.40
			NOX	34.16	3.22	9.42	
			RSPM	48.63	10.05	20.66	
			SPM	184.69	44.48	24.08	
	Winter	Oct to Jan	SO2	14.09	2.56	18.14	60.93
			NOX	44.51	7.35	16.51	
			RSPM	109.53	11.05	10.08	
			SPM	261.14	12.47	4.78	
02 Feb-2015 to January-2016	Summer	Feb to May	SO2	12.65	1.58	12.52	49.44
			NOX	41.36	3.06	7.40	
			RSPM	80.81	18.11	22.41	
			SPM	243.13	37.39	15.38	
	Rainy	Jun to Sept.	SO2	10.60	0.05	0.47	33.20
			NOX	36.85	0.33	0.89	
			RSPM	40.28	7.89	19.58	
			SPM	119.30	32.53	27.27	
	Winter	Oct to Jan	SO2	19.31	5.97	30.94	62.64
			NOX	48.61	8.18	16.83	
			RSPM	103.01	15.77	15.31	
			SPM	284.56	69.56	24.44	

CADA Office station, from the above table and graph, in the year 2011-12 variability of SO_2 was more or less some in summer (70.11%) and winter (9.48%). It was more stable in Rainy season (4.32%). As regards Nox the variability was less in winter (12.54%) and maximum in summer (21.35%). was in winter (12.14%) and it was maximum 43.73% in Rainy season. In case of SPM the stability was in summer (11.95%) and it was maximum 43.59% in Rainy season.

In the year 2012-13 variability of SO_2 was more or less some in winter(20.64%) and summer (13.85%). It was more stable in Rainy season (5.10%). As regards Nox the variability was less

in winter (13.00%) and maximum in summer (14.91%). In Rainy season it was 5.57%.

Seasons wise Coefficient of variation (C.V.%) values



Graph -9 The graphical representation of C.V.(%) are shown below

In case of RSPM the stability was in winter (11.50%) and it was maximum 20.41% in Rainy season. In case of SPM the stability was in winter (11.95%) and it was maximum 18.62% in Rainy season.

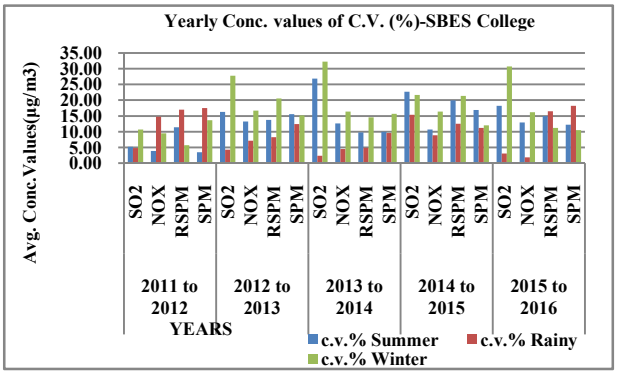
In the year 2013-14 variability of SO_2 was more or less some in winter(29.45%) and summer (27.59%). It was more stable in Rainy season (5.23%). As regards Nox the variability was less in Summer (12.16%) and maximum in Winter (16.09%). In Rainy season it was 3.45%. In case of RSPM the stability was in Summer (3.74%) and it was maximum 23.20% in Winter season. In case of SPM the stability was in Summer (4.98%) and it was maximum 37.41% in Rainy season.

In the year 2014-15 variability of SO_2 was more or less some in winter (18.14%) and summer (17.81%). It was more stable in Rainy season (12.49%). As regards Nox the variability was less in rainy (9.42%) and maximum in winter (16.51%). In summer season it was 8.23%. In case of RSPM the stability was in winter (10.08%) and it was maximum 28.74% in summer season. In case of SPM the stability was in winter (4.78%) and it was maximum 27.41% in Summer season.

In the year 2015-16 variability of SO_2 was more or less some in winter(30.94%) and summer (12.52%). It was more stable in Rainy season (0.47%). As regards Nox the variability was less in Summer (7.40%) and maximum in Winter (16.83%). In Rainy season it was 0.89%. In case of RSPM the stability was in winter (15.31%) and it was maximum 22.41% in Summer season. In case of SPM the stability was in Summer (15.38%) and it was maximum 27.27% in Rainy season.

Location: SBES College Campus, Aurangabad:

SBES College station, from the above table and graph, in the year 2011-12 variability of SO_2 was more or less some in Winter (10.71%) and Summer(5.15%). It was more stable in Rainy season (4.78%). As regards Nox the variability was less in winter (9.42%) and maximum in Rainy (14.75%). In Summer season it was 3.86%. In case of RSPM the stability was in winter (5.65%) and it was maximum 16.99% in Rainy season. In case of SPM the stability was in summer (3.47%) and it was maximum 17.54% in Rainy season.



Graph-10 The graphical representation of C.V.(%) are shown below

In the year 2012-13 variability of SO_2 was more or less some in winter(27.79%) and summer (16.26%). It was more stable in Rainy season (4.23%). As regards Nox the variability was less in Summer (13.22%) and maximum in Winter (16.73%). In Rainy season it was 7.09%. In case of RSPM the stability was in Rainy (8.24%) and it was maximum 20.60% in Winter season. In case of SPM the stability was in Rainy (12.43%) and it was maximum 15.61% in Summer season.

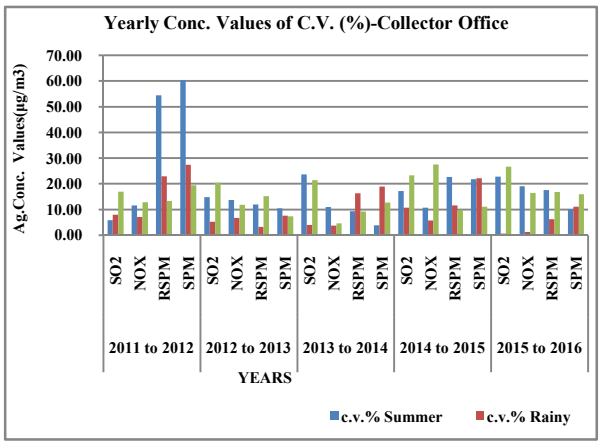
In the year 2013-14 variability of SO_2 was more or less some in winter(32.23%) and summer (26.84%). It was more stable in Rainy season (2.32%). As regards Nox the variability was less in Summer (12.58%) and maximum in Winter (16.38%). In Rainy season it was 4.44%. In case of RSPM the stability was in Rainy (4.90%) and it was maximum 14.54% in Winter season. In case of SPM the stability was in Rainy (9.57%) and it was maximum 15.62% in Winter season.

In the year 2014-15 variability of SO_2 was more or less some in Summer (22.66%) and Winter (21.72%). It was more stable in Rainy season (12.34%). As regards Nox the variability was less in Summer (10.64%) and maximum in winter (16.36%). In Rainy season it was 8.88%. In case of RSPM the stability was in Rainy (12.54%) and it was maximum 21.40% in Winter season. In case of SPM the stability was in Rainy (11.22%) and it was maximum 16.89% in Summer season.

In the year 2015-16 variability of SO_2 was more or less some in winter(30.75%) and summer (18.17%). It was more stable in Rainy season (3.08%). As regards Nox the variability was less in Summer (12.97%) and maximum in Winter (16.19%). In Rainy season it was 1.87%. In case of RSPM the stability was in winter (11.20%) and it was maximum 16.50% in Rainy season. In case of SPM the stability was in Winter (10.44%) and it was maximum 18.20% in Rainy season.

Location: Collector Office

Collector Office station, from the above table and graph, in the year 2011-12 variability of SO_2 was more or less some in Winter (16.99%) and Rainy (8.00%). It was more stable in Summer season (5.87%). As regards Nox the variability was less in Summer (11.56%) and maximum in Winter (12.85%). In Rainy season it was 7.08%. In case of RSPM the stability was in Rainy (22.98%) and it was maximum 54.47% in Summer season. In case of SPM the stability was in Winter (19.45%) and it was maximum 60.28% in Summer season.



Graph-11 The graphical representation of C.V.(%) are shown below

In the year 2012-13 variability of SO_2 was more or less some in winter(20.38%) and summer (14.84%). It was more stable in Rainy season (5.18%). As regards Nox the variability was less in winter (11.80%) and maximum in summer (13.68%). In Rainy season it was 6.70%. In case of RSPM the stability was in Rainy (3.24%) and it was maximum 15.19% in Winter season. In case of SPM the stability was in winter (7.36%) and it was maximum 10.42% in Summer season.

In the year 2013-14 variability of SO_2 was more or less some in Summer(23.66%) and Winter (21.39%). It was more stable in Rainy season (3.96%). As regards Nox the variability was less in Winter(4.65%) and maximum in Summer (10.97%). In Rainy season it was 3.70%. In case of RSPM the stability was in Winter (9.19%) and it was maximum 16.31% in Rainy season. In case of SPM the stability was in Summer (3.87%) and it was maximum 18.92% in Rainy season.

In the year 2014-15 variability of SO_2 was more or less some in Winter(23.24%) and summer (17.16%). It was more stable in Rainy season (10.68%). As regards Nox the variability was less in Summer (10.65%) and maximum in winter (27.50%). In Rainy season it was 5.68%. In case of RSPM the stability was in Rainy (11.64%) and it was maximum 22.66% in summer season. In case of SPM the stability was in winter (11.14%) and it was maximum 22.11% in Reany season.

In the year 2015-16 variability of SO_2 was more or less some in winter(26.68%) and summer (22.77%). It was more stable in Rainy season (0.65%). As regards Nox the variability was less in Winter (16.47%) and maximum in Summer (19.11%). In Rainy season it was 1.30%. In case of RSPM the stability was in Rainy(6.26%) and it was maximum 17.51% in Summer season. In case of SPM the stability was in Summer (10.09%) and it was maximum 15.89% in Winter season.

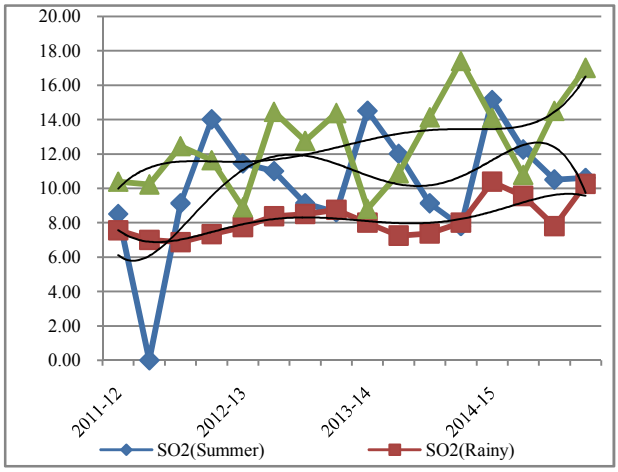
Through out study period the above three stations data shows that seasonal variations of SO2, NOx , RSPM and SPM, above tables, It is observed that variability of SO2 Nox,RSPM and SPM are shown above tables.

When we consider AQI and rating scale for SPM of Summer and winter seasons the air pollution at CADA Office, SBES College Campus and Collector Office, Aurangabad is moderate and heavy air pollution respectively.

Time series analysis

Location :C.A.D.A. Office, Garkheda Aurangabad:
Time series analysis was performed to fit the trend line to seasonal SO_2 values. The best fitted equation for SO_2 in Rainy season is given below which is selected on the basis of coefficient of determination R^2 is,

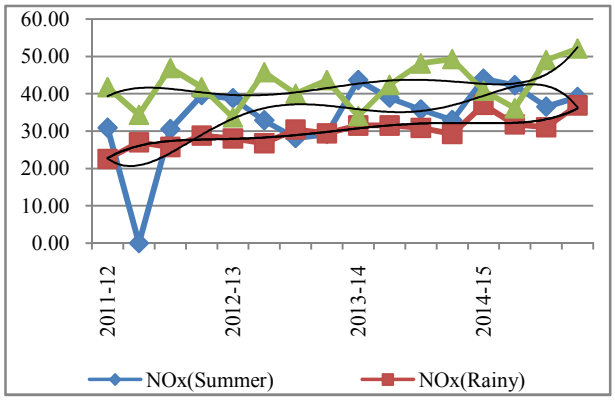
$Y(Rainy) = -0.000x^5 + 0.010x^4 - 0.173x^3 + 1.186x^2 - 3.178x+9.710$ with $R^2 = 0.529$
$Y(winter) = 0.000x^5 - 0.013x^4 +0.196x^3 - 1.313x^2 +3.973x + 7.136$ with $R^2 = 0.343$
$Y(summer) = -0.000x^5 + 0.033x^4 - 0.487x^3 + 2.962x^2 - 5.974x+9.573$ with $R^2 = 0.330$



Graph- 12 Actual and estimated SO2 for summer, rainy and winter season

Time series analysis was performed to fit the trend line to seasonal NOx values. The best fitted equation for NOx in Rainy season is given below which is selected on the basis of coefficient of determination R^2 is,

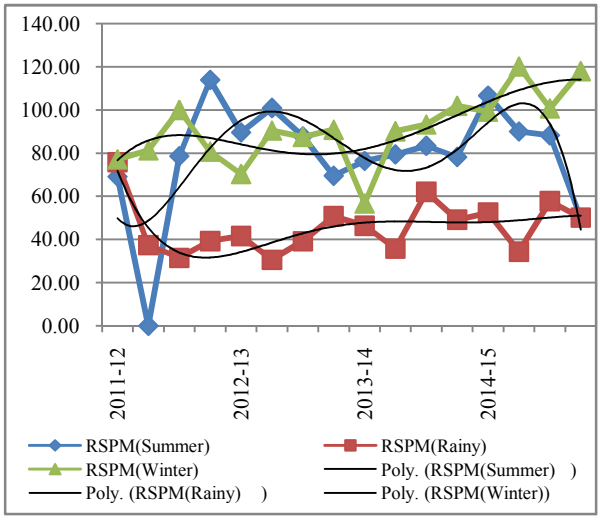
$Y(Rainy) = -0.000x^5 - 0.025x^4 +0.394x^3 - 2.772x^2 + 9.175x+15.99$ with $R^2 = 0.760$
$Y(summer) = -0.002x^5 + 0.085x^4 - 1.293x^3 + 8.327x^2 - 18.91x+34.42$ with $R^2 = 0.388$
$Y(winter) = 0.001x^5 - 0.045x^4 +0.663x^3 - 4.143x^2 +10.63x + 32.19$ with $R^2 = 0.290$



Graph-13 Actual and estimated NOx levels for Summer, Rainy and winter season

Time series analysis was performed to fit the trend line to seasonal RSPM levels in air. The best fitted equation for RSPM in winter season is given below which is selected on the basis of coefficient of determination R^2 is,

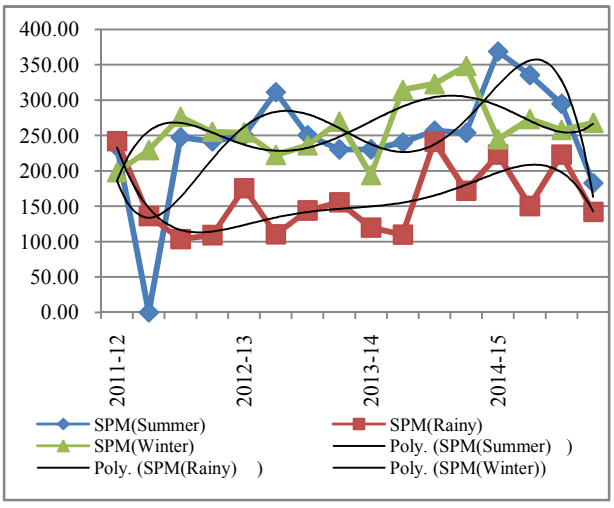
Y (winter) = $0.000x^5 - 0.037x^4 + 0.826x^3 - 7.467x^2 + 26.38x + 56.87$ with $R^2 = 0.586$
Y(Rainy) = $-0.001x^5 + 0.086x^4 - 1.726x^3 + 15.82x^2 - 63.05x + 120.6$ with $R^2 = 0.580$
Y(Summer) = $-0.010x^5 + 0.408x^4 - 5.772x^3 + 33.67x^2 - 67.56x + 89.07$ with $R^2 = 0.579$



Graph-14 Actual and estimated RSPM levels in air for Summer, Rainy and winter season

Time series analysis was performed to fit the trend line to seasonal SPM levels in air. The best fitted equation for SPM in summer season is given below which is selected on the basis of coefficient of determination R^2 is,

Y(Summer) = $-0.036x^5 + 1.503x^4 - 21.99x^3 + 138.1x^2 - 333.7x + 402.0$ with $R^2 = 0.623$
Y (winter) = $0.016x^5 - 0.726x^4 + 11.74x^3 - 82.94x^2 + 246.9x + 11.49$ with $R^2 = 0.530$
Y(Rainy) = $-0.012x^5 + 0.553x^4 - 8.977x^3 + 68.51x^2 - 235.8x + 408.9$ with $R^2 = 0.512$



Graph-14 Actual and estimated RSPM levels in air for Summer, Rainy and winter season

CONCLUSION

It is concluded that RSPM and SPM extensively contribute towards air pollution at this location throughout study period. When SPM parameter is considered, there is moderate and heavy air pollution. For reducing this, a systematic traffic management, expansion of greenery or green belt and category wise distribution of vehicles split up on other routes in reducing the air pollution.

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