Research Journal of Physical Sciences ISSN 2320–4796
Vol. **3(4),** 1-7, June **(2015)** *Res. J. Physical Sci.*

A Study of Air Quality Index in and Around Belagavi City, Karnataka State, India

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Available online at: www.isca.in
Received 8th May 2015, revised 13th May 2015, accepted 2nd June 2015

Abstract

Ambient Air Quality (AQI) of Belagavi city and its surroundings was monitored using a set of dust samplers, viz., APM-460, APM-550 and APM-433. The pollutants considered for the assessment of air quality were sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ammonia (NH_3) and particulate matter (PM_{10} and $PM_{2.5}$) which gave a measure of pollution content in the air. The sampling sites have been monitored for 24 hours on an 8 hourly basis in three different seasons in 2013 and 2014. Air quality was quantified in terms of concentrations of PM_{10}, $PM_{2.5}$, NO_2, SO_2 and NH_3. The results revealed that locations near Bus station and Macchae industrial area lie in the range of Moderate Air Pollution and Autonagar, Sadashivnagar and Kangralli village lie in the range of Light Air Pollution. Annual Air Quality index of presently selected sites of Belagavi has been determined to assess the degree of atmospheric pollution.

Keyword: Pollutants, air quality index, sulphur dioxide, nitrogen dioxide, ammonia, and particulate matters.

Introduction

When the humans are exposed to air pollution, it can cause respiratory related decreases and aggravate the conditions such as asthma, bronchitis etc (COPD)[1]. Energy needs of the industries and domestic activities are met by burning fuels which also emit poisonous wastes leading to air contamination[2]. Sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter (PM_{10} and $PM_{2.5}$) are known to be the major air pollutants in India[3,4]. Degradation of air quality in Indian cities is mainly due to emissions from the vehicles on road and railway tracks[5,6]. In the past few decades or so, there has been a tremendous raise in road transportation, increase in the number of fuel consuming vehicles and establishment of large number of industries have resulted in drastic increase in the concentration of gaseous and particulate matter in air[7,8].

Belagavi city is a district head quarter, fourth largest city in the state and has got good infrastructure and investor friendly environment. Belagavi is bordered with the states of Maharashtra and Goa and close to big twin cities Hubli - Darwad. It is very well connected to other parts of the country by road and rail. Due to these favorable prevailing conditions and Government's policy of globalization and open market system, Belagavi saw a rapid industrial growth in the past few years in terms of large and small scale industries. Consequent to these developments, air pollution in the city increased enormously. This has necessitated monitoring of air quality in the city and that has been carried out by us and presented in this research article.

Material and Methods

Instruments: Respirable Dust Sampler RDS (Envirotech APM 460 NL (PM_{10}): Respirable Dust Sampler has been used to monitor and measure the concentration of Suspended and Respirable Suspended Particulate Matter in the atmospheric air of the selected sampling sites[6].

Fine Particulate Sampler Envirotech APM 550 ($PM_{2.5}$): The APM 550 system has been used for sampling fine particles ($PM_{2.5}$ fraction). This equipment was a make of *United States Environmental Protection Agency* (USEPA) and meant for ambient air quality monitoring.

Gaseous Pollutants Sampler Envirotech APM 433 (NO_2, SO_2. and NH_3): The APM 433 Gaseous Pollutants Sampler has been used for indoor and outdoor Air Quality Monitoring. Gas pollutants were sampled using this instrument. Air was sucked in to the sampler through suitable reagents that absorb specific gases (pollutants) such as SO_2, NO_2, Cl_2, H_2S, NH_3, Formaldehyde, CS_2 and Mercaptons etc.

Study Area: The city of Belagavi (latitude is 15^0 $52^{'}$ N and Longitude is $74^0 34^{'}$E) is situated nearly 762 meters above sea level. It has a geographical spread of 98.04 sq.km and population of 4,778,439 (Census of India, 2011). Number of vehicles registered in Belgaum as on 2014 was 3.55 lakhs. The core area of Belgaum city is overcrowded and congested. The selected sampling sites include industrialized, heavy traffic, commercial, residential and less populated areas. The natures of the sites are described in Table-1.

Sample collection and preparation: Envirotech, model APM–460, APM-550 and APM-433 respirable dust samplers were used for the sampling of PM_{10}, $PM_{2.5}$ and gases such as SO_2, NO_2, NH_3 etc. These samplers were used at a height of 10 feet for 24 hours on 8 hourly basis. An average flow rate in the sampler was maintained to be $1.1m^3$/min. Gaseous pollutants sampler was also operated for 24 hours but on 4 hourly basis. At each site, samples were collected for a period of one month during each of the three seasons Monsoon, winter and summer[9].

PM_{10} samples were collected in microfiber filter papers (PTFE) of size 20.3 x 25.4cm and $PM_{2.5}$ samples in filter papers (TFM) of size 47mm. The filters were fixed to the respirable dust sampler. Filter papers were treated before and after the sampling. The treatment of the paper was done in moisture-free desiccators and then dried in oven for 24 hours. Filters were weighed in a digital balance before and after the sampling. Meteorological parameters such as temperature, wind velocity and relative humidity were also recorded during the sampling period and the same were used for air quality evaluation[6]. Analysis of the data was done as per standard Gravimetric method.

In the sampler APM-433, air is sucked through suitable reagents which would absorb specific gaseous pollutants like SO_2, NO_2, and NH_3. These absorbents were collected in separate sampling bottles at an interval of 4 hours. About 18 samples were collected at each sampling site. The collected samples were analyzed by following standard wet chemistry method.

Air Quality Index (AQI): The Air Quality Index (AQI) describes overall ambient air status and indicates the trend of a particular place based on specific standard. Air quality is enumerated in terms of AQI as, it reveals the cumulative effect of all the pollutants. The values have been determined using a tool used by EPA[6] and other agencies which is given by,

$$AQI = \frac{1}{5} \times \left(\frac{IPM_{10}}{SPM_{10}} + \frac{IPM_{2.5}}{SPM_{2.5}} + \frac{ISO_2}{ISO_2} + \frac{INO_2}{SSO_2} + \frac{INH_3}{SNH_3} \right) \times 100$$

Where, IPM_{10}, $IPM_{2.5}$, ISO_2, INO_2 and INH_3 correspond to individual measured values of particulate matters PM_{10} and $PM_{2.5}$, Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2) and Ammonia (NH_3). The terms SPM_{10}, $SPM_{2.5}$, SSO_2, SNO_2 and SNH_3 correspond to standard values of particulate matter PM_{10} and $PM_{2.5}$, SO_2, NO_2 and NH_3 respectively which are the standards approved by the Central Pollution Control Board of India (CPCB). Higher level of air pollution is indicated by the higher value of AQI and that carried greater health risk. The ranges of AQI and health hazards associated with each range of AQI are mentioned in table-2[10].

Results and Discussion

The obtained seasonal concentration of PM_{10}, $PM_{2.5}$, SO_2, NO_2, and NH_3 are recorded in table-3 and table- 4[11-12]. From these two tables it can be seen that there are considerable variations in the pollution level over different seasons.

Table-1
Sampling sites selected for the study in Belgaum city

Site	Description of the site	Code no
Near K.S.R.T.C.Bus station	Heavy traffic, maximum commercial activities	A1
Auto Nagar Industrial area	Small scale industries functioning, moderate traffic	A2
Sadashivnagara	Residential area with moderate traffic	A3
Machhe Industrial area	Large scale industries functioning, Moderate traffic	A4
Kangralli village	Extension area with less traffic, thin population	A5

Table-2
Describes the Range of Air Quality Index and its Associated Potential Health Effect

AQI Value	REMARKS	Health Concern
00 – 25	Clean air (CA)	None/minimal health effect
26-50	Light air pollution (LAP)	Possible respiratory or cardiac effect for most sensitive
51-75	Moderate air pollution (MAP)	Increasing symptoms of respiratory and cardiovascular illness
76-100	Heavy air pollution (HAP)	Aggravation of heart diseases
>100	Severe air pollution (SAP)	Serious aggravation of heart and lung diseases Risk of death in children and elder people.

Table-3
Seasonal mean concentration of PM_{10} and $PM_{2.5}$ in three different seasons

Sampling Station	PM_{10} (µg/m^3)			$PM_{2.5}$ (µg/m^3)		
	Rainy season	Winter season	Summer season	Rainy season	Winter season	Summer Season
A1	100.00	88.30	92.00	59.30	59.30	58.00
A2	78.66	76.60	71.00	19.60	19.60	28.00
A3	50.00	46.60	49.00	10.60	10.30	15.00
A4	137.00	143.00	155.00	64.60	66.00	66.00
A5	43.00	41.30	45.00	9.60	9.60	14.00

Table-4
Seasonal Mean Concentration of SO_2, NO_2 and NH_3 in three different seasons

Sampling Station	SO_2 (µg/m^3)			NO_2 (µg/m^3)			NH_3(µg/m^3)		
	Rainy Season	Winter Season	Summer Season	Rainy Season	Winter Season	Summer Season	Rainy Season	Winter Season	Summer Season
A1	12.57	12.20	15.08	44.60	36.91	43.59	6.69	3.21	6.92
A2	8.94	8.12	9.31	36.90	30.96	36.70	6.97	4.16	7.60
A3	4.02	3.81	4.81	11.11	8.95	11.11	7.46	5.73	7.06
A4	18.85	18.46	18.31	20.26	19.88	17.80	7.96	4.24	8.07
A5	3.49	3.17	3.66	7.96	6.59	7.96	7.97	11.26	7.27

Table-5
Air Quality Index of Belagavi

S. No	Sampling Station	AQI
1	A1	52.34
2	A2	33.39
3	A3	17.67
4	A4	60.64
5	A5	16.28

Sulphur dioxide (SO_2): SO_2 level was found to be maximum at site A4 followed by the sites A1 and A2 during all the seasons.

Nitrogen dioxide (NO_2): The mean value of NO_2 was found to be high at site A1 followed by the sites A2 and A4. Minimum levels of $NO_2$was found in site A5. At all the studied sites and in all the three seasons, average measured level of NO_2 was found to be less than the permissible limit of 80 µg/ m^3 as fixed by NAAQS[13].

Ammonia (NH_3): The mean value of NH_3 was found to be much less compared to SO_2 and NO_2. At site A5, NH_3 was more than other site. However average level of NH_3 present was below permissible limits 400 µg/ m^3 as prescribed by NAAQS. During Winter NH_3 content was maximum at A5 and minimum at site A1. No much variation in NH_3 concentration was found between sites during rainy and summer seasons.

PM_{10}: Concentration of PM_{10} was measured to be high at site A4 during all the three seasons. The site A1 and A2 measured second and third highest levels of $PM_{10.}$ The average level of PM_{10} at A2, A3 and A5 was below the permissible limit of 100 µg/ m^3 prescribed by NAAQS and above permissible limit at A4 site and, close to permissible limit at A1 in all the three seasons.

$PM_{2.5}$: The level of pollutant $PM_{2.5}$ was found to be slightly more than permissible limit of 60µg/ m^{3}at site A4 and close to the permissible level at site A1 and much below permissible level at the remaining three sites during all the three seasons.

In order to give a clear picture of seasonal variations of the presently studied air pollutants, the observed variations of the pollutants are depicted in Figure-1 to Figure-5 in the form of bar graphs.

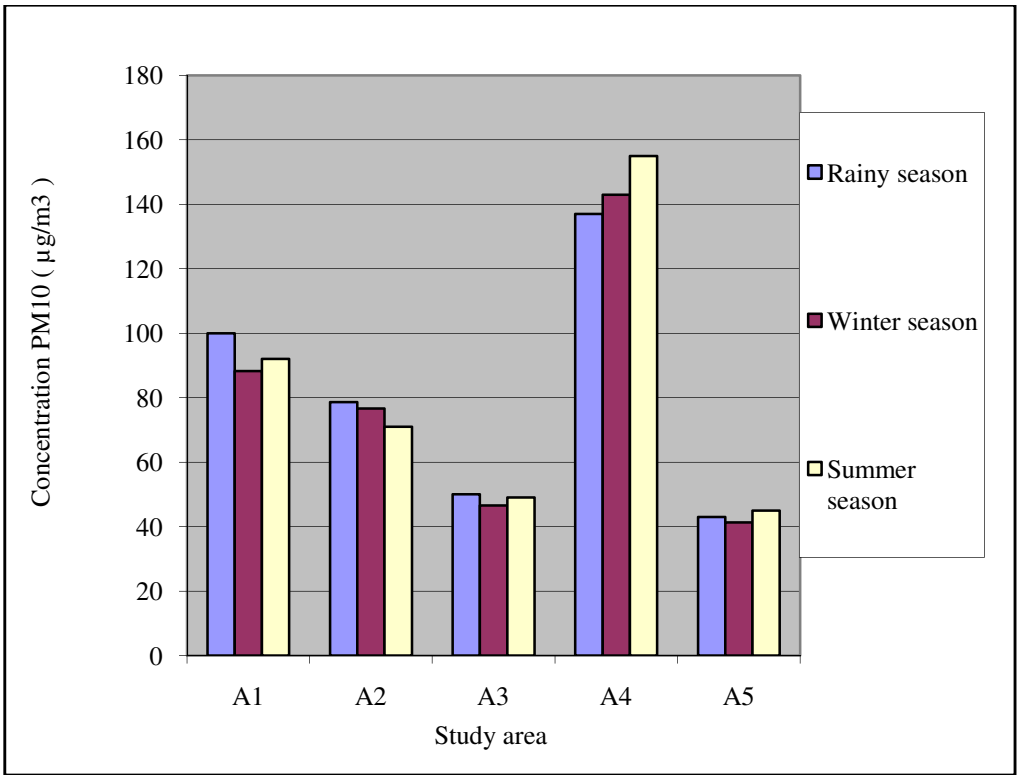

Figure-1
Seasonal variation of PM_{10} concentration

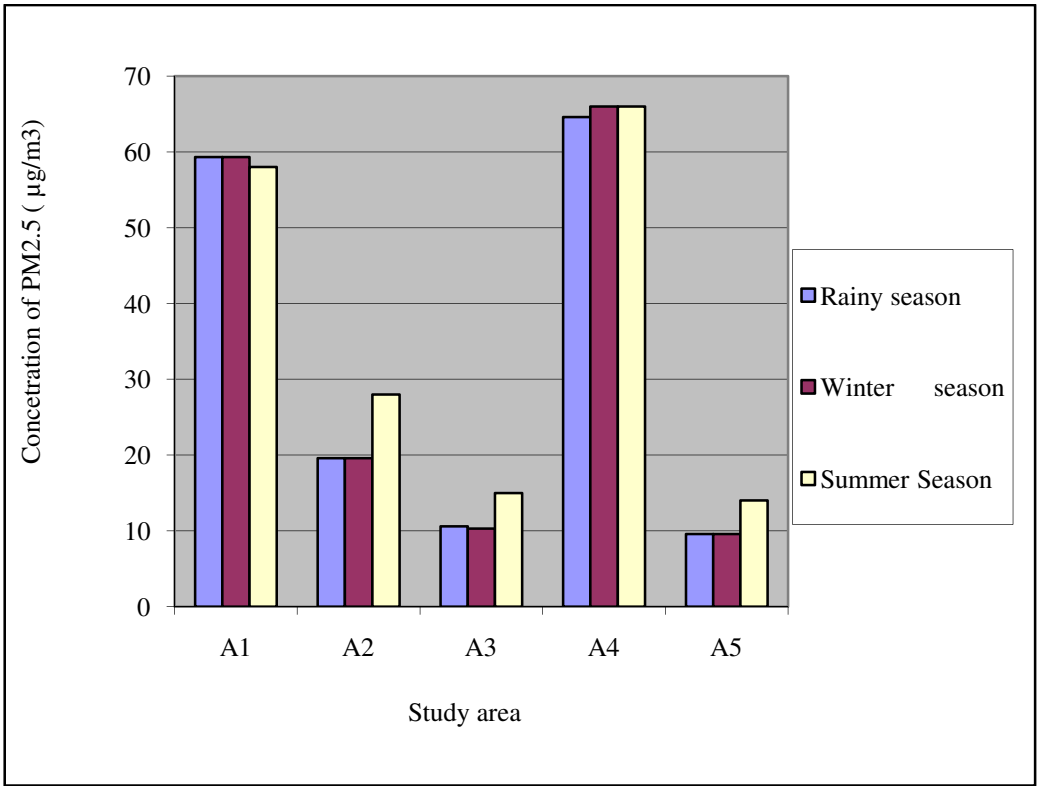

Figure-2
Seasonal variation of $PM_{2.5}$ concentration

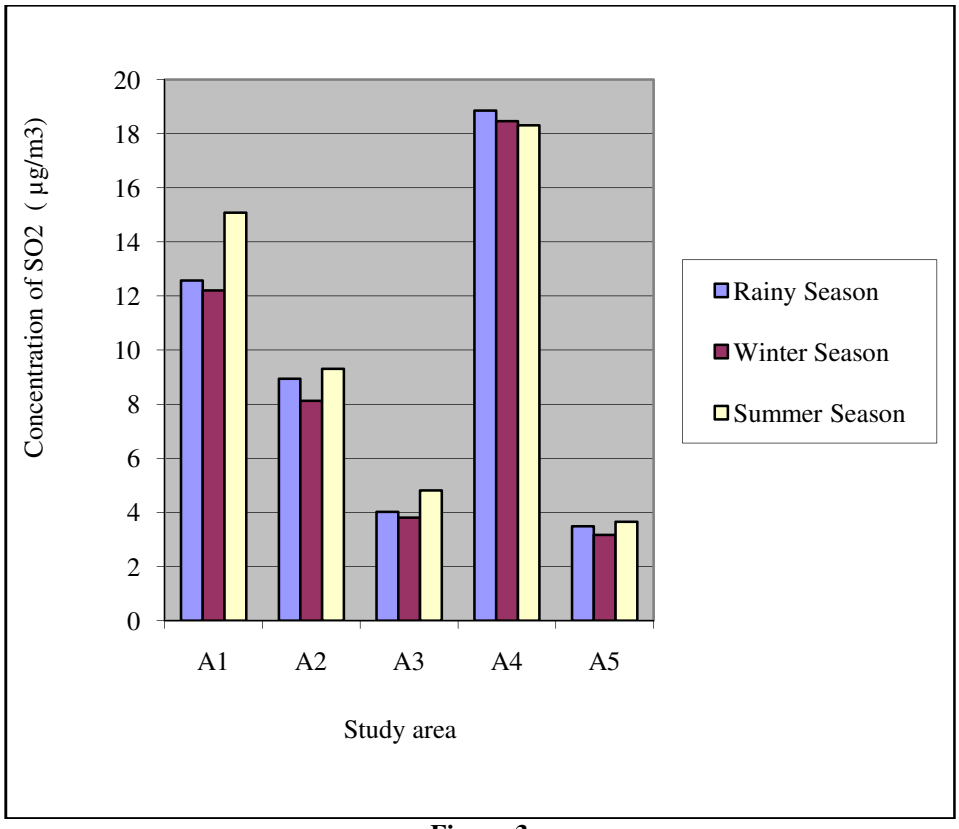

Figure-3
Seasonal variation of SO_2 concentration

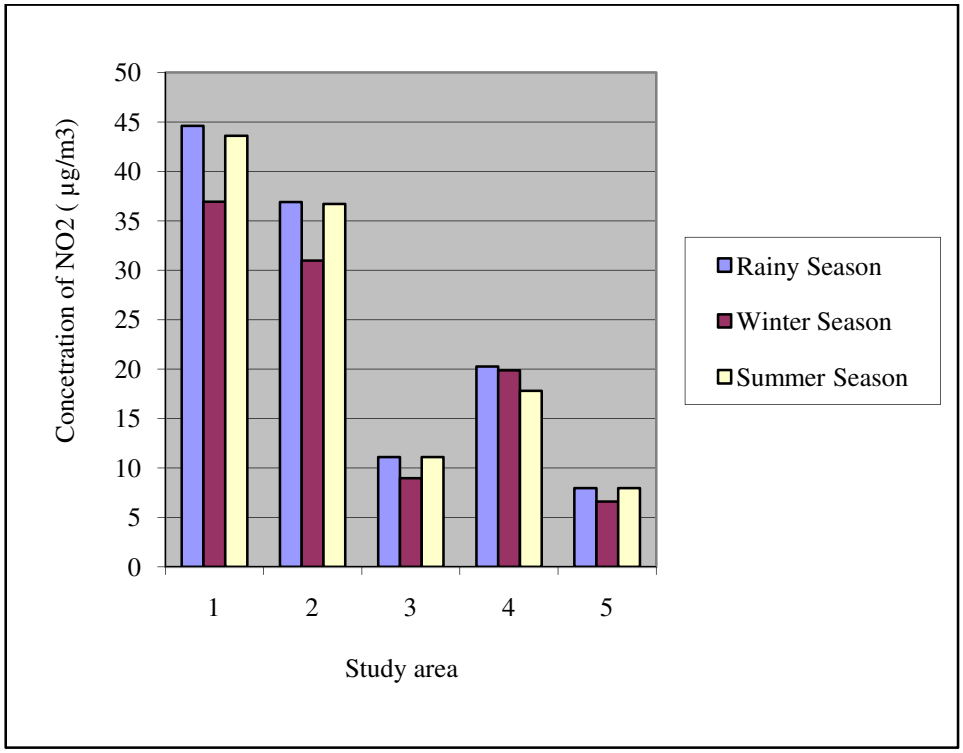

Figure-4
Seasonal variation of NO_2 concentration

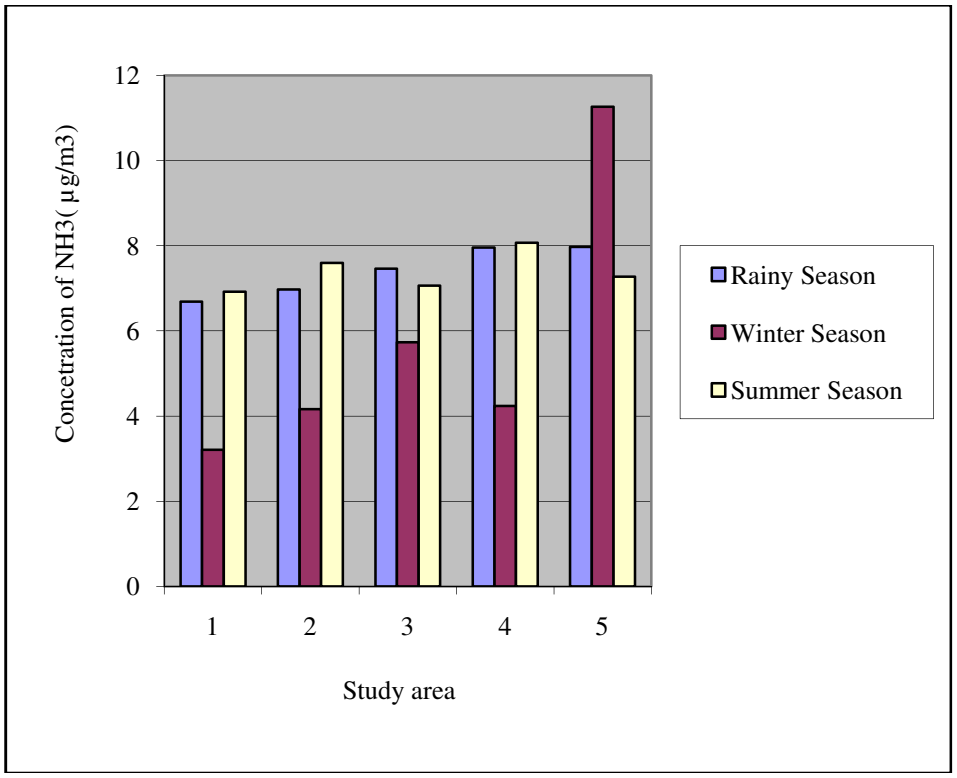

Figure-5
Seasonal variation of NH_3 concentration

Conclusion

The AQI at different sites in and around Belgavi city were measured and they revealed that Sadashiv Nagar (A3), Kangralli Village (A5) and Auto Nagar (A2) are fairly clean. Areas around bus station (A1), Macche Industrial area (A4) are moderately polluted. Air pollution near bus station and Industrial areas may due to vehicle emissions near bus station and industrial wastes in the industrial areas. Meteorological factors such as temperature, wind velocity and humidity are also found to affect air pollution.

For the first time AQI were measured and reported for the sampled sites as mentioned in this article.

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