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Effect of Temperature, Humidity and other Physical Parameters on Air Pollution in and Around Belagavi, Karnataka, India

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Abstract

Air pollution in and around the Belgavi city has been monitored. The pollutants measured to assess air quality have been the concentration of Sulphur dioxide (SO_2), Nitrogen dioxide NO_2, Ammonia (NH_3), Particulate Matter 10 (PM_{10}) and Particulate Matter 2.5 ($PM_{2.5}$). The data were collected from five sampling sites of the city. In Belagavi city, Pollutants SO_2, NO_2, NH_3 were found to be below acceptable limits defined by the National agencies which are meant for air quality management. Concentration of PM_{10} was found to be equal to the permissible limits in commercial area and small scale industrial area and exceeded the permissible limits in large scale industrial area. Concentration of $PM_{2.5}$ was greater than permissible limits in heavy traffic and commercial areas, and almost twice more than the limits in the large scale industrial area, and lies far below the permissible limits in other sampling sites of the city.

Keywords: Pollutants, sulphur dioxide, nitrogen dioxide, ammonia, particulate matter.

Introduction

Clean air is essential for good health of humans, animals and birds. All the countries in the world are facing a common problem of air pollution. When the air pollution exceeds acceptable limits, it causes serious problems to human health[1]. The understanding of quality of air requires the knowledge of many branches of Science such as Physics, Chemistry, Zoology, Geography etc[2]. According to the World Health Organization (WHO), millions of untimely deaths are occurring due to the urban air pollution created from burning of solid fuels[3]. Most of the deceases due to air pollution are from developing nations[4]. As per WHO's 2014 report, around seven million people were died in 2012. Of these, one in eight was due to air pollution[5]. Certain guidelines have been framed to monitor and control air quality so that health problems due to air pollution can be reduced[6].

As per the estimations of Central Pollution Control Board (2010) of India, air around many of the Indian cities contains particulate matter (PM) far exceeds the safe limit set by the World Health Organization standards. Particulate matter (PM) in air is defined to be a complex multiphase system consisting of particle sizes ranging from 2.5µm to 10µm. People dying in India due to pollution caused asthma decease are much more than other countries[7]. In house air pollution caused by cooking fires and outdoor air pollution due to vehicular fuel burning and industrial smoke are known to inflict more deaths in India[8]. According to the World Bank, annually India is paying heavy price due its environmental degradation. Estimations hint that if India achieves a reduction in PM content of 30% by 2030, it would save US $105 billion on health spending. It is quoted that there are about 23 major Indian cities having more than a million population measures air pollution which exceed WHO standards (Gupta et.al 2002). Nanoparticles (dust particles of size few nanometers) have also been claimed to affect adversely the cardiopulmonary system. Cities produce high levels of pollution and they are densely populated and therefore, people living in them are the ones largely affected by air pollution[9].

The reason for faster urbanization of Belagavi city in Karnataka, India is due to being a district head quarter and fourth largest city in Karnataka State. It is bordered with the States of Maharashtra and Goa and close to twin cities Hubli-Darwad. It is well connected to other parts of the country by road and rail. Recently, Belgaum has witnessed tremendous growth in large and small scale industries and also in trade and other commercial activities. Contamination of air in Belgavi city is increasing continuously due to industrial and vehicle emissions. This has necessitated monitoring of air quality in the city and that has been carried out by us and presented in this communication.

Material and Methods

Instruments: Respirable Dust Sampler RDS (Envirotech APM 460 NL (PM_{10}): Respirable Dust Sampler has been used to monitor the concentration of Suspended Particulate Matter and Respirable Suspended Particulate Matter in air.

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

Gaseous Pollutants Sampler Envirotech APM 433 (NO_X, 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. In the sampler, air has been sucked through appropriate reagents that have absorbed certain gaseous pollutants such as SO2, NO_2, Cl_2, H_2S, NH_3, Formaldehyde, CS_2 etc.

Study Area: The city of Belgaum (latitude is 15^0 52^1 N and Longitude is $74^0 34^1$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 Belgavi 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.

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

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

Sample collection and preparation: RDS, 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. Using APM samplers the sample was collected at the height of 10 feet for 24 hours on 8 hourly basis. An average sample flow rate was maintained to be $1.1 m^3$/min. Gas pollutants sampler was also operated for 24 hours on 4 hourly bases. At each site, samples were collected for a month during each of the three seasons; Monsoon, Winter and Summer.

PM_{10} samples were collected using microfiber filter paper (PTFE) of size-20.3x25.4cm and $PM_{2.5}$ samples were collected in filter paper (TFM) of size 47mm. The filters were fitted with a respirable dust sampler. The filter papers have been treated before and after the sampling, in moisture-free desiccators and then dried in an oven for 24 hours. Filters were weighed in a digital balance before and after the sampling. The meteorological parameters such as temperature, wind velocity and relative humidity were recorded during the days of sampling. The collected meteorological data has been used for evaluation. Analysis of the data was done by following the standard Gravimetric method.

Also, air was sucked through suitable reagents into the sampler APM-433. The specific gaseous pollutants like SO_2, NO_2, and NH_3 were absorbed by the reagents. The 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.

Measurement of other Physical parameters: Physical parameters such as wind speed, wind direction, temperature, humidity, solar radiation and rainfall affects concentration of pollutants in the study area[10]. Therefore, these parameters have been recorded over different seasons and are shown in table-2.

Meteorological Parameters: Wind speeds in different seasons have been recorded from Sambra Meteorological Station, Belgaum. In summer, the speed of the wind was in the range from 10.8 m/s to 18 m/s. In winter, the highest percentage of wind blows with speed in the range from 3.6 m/s to 10.8 m/s. The calm conditions were 28.496 of the month. In monsoon, the highest percentage of wind blows with speed in the range from 13.6 m/s to 20.4 m/s. The calm conditions were 15.455 of the month.

Table-2
Average temperature, Relative Humidity and number of Rainy days

Month and Year	Average maximum temperature, ^{0}C	Average minimum temperature, ^{0}C	Average relative humidity %	Number of rainy days
September 2013	30	20	83	10.6
October 2013	31	20	69	6.1
November 2013	31	16	57	3.3
December 2013	31	12	52	0.0
January 2014	31	14	46	0.0
February 2014	33	17	42	0.1
March 2014	38	21	42	1.0
April 2014	39	21	52	3.8
May 2014	37	20	68	6.3

Temperature: The variation in surface temperature controls the atmospheric convection[11]. This in turn affects the concentration of pollutants. The temperature was recorded in the study area using a thermometer and that was found to be in the range between 20^0C and 30^0C during September 2013, 12^0C and 31^0C during December and, 20^0C–37^0C during May. The minimum temperature of 12^0C was recorded during December 2013 and maximum of 37^0C during May 2014. The monthly maximum and minimum temperature recorded from 15th September-2013 to May- 2014 are depicted graphically in figure-1.

Annual Rainfall: The annual rain fall recorded from Sambra Meteorological station, annual rainfall was 1031mm. The present study area has a probability of getting rain in the range between 750mm to 800mm.The amount of rain fall affects humidity in the area. The humidity in turn changes concentration of pollutants in the region. The average rain fall noted during the period September-2013 to May-2014 is shown graphically in figure-2.

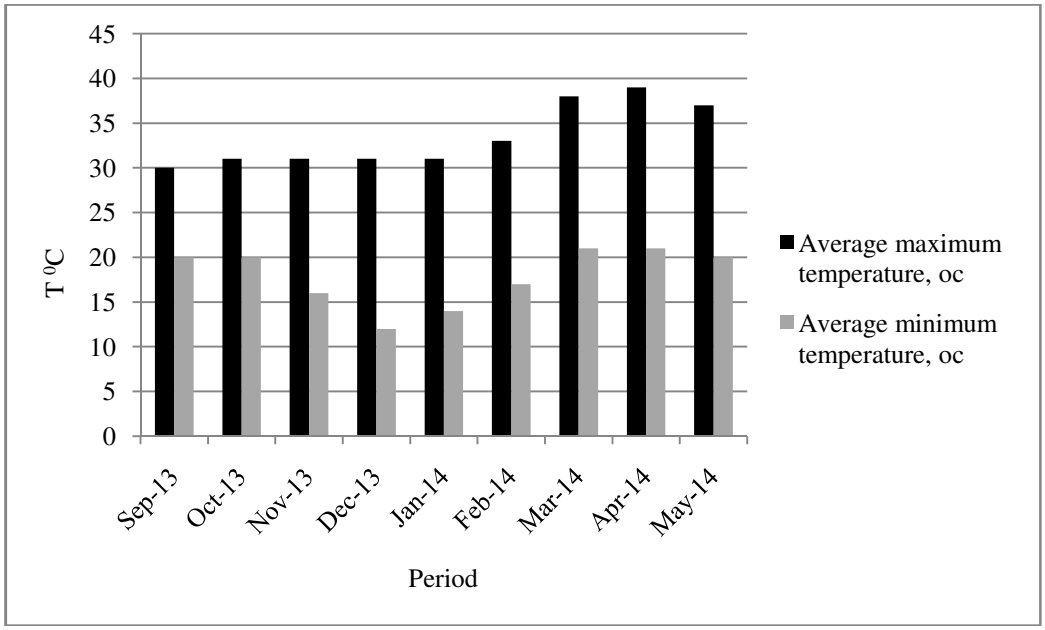

Figure-1
Bar graph indicating temperature variation during sampling period

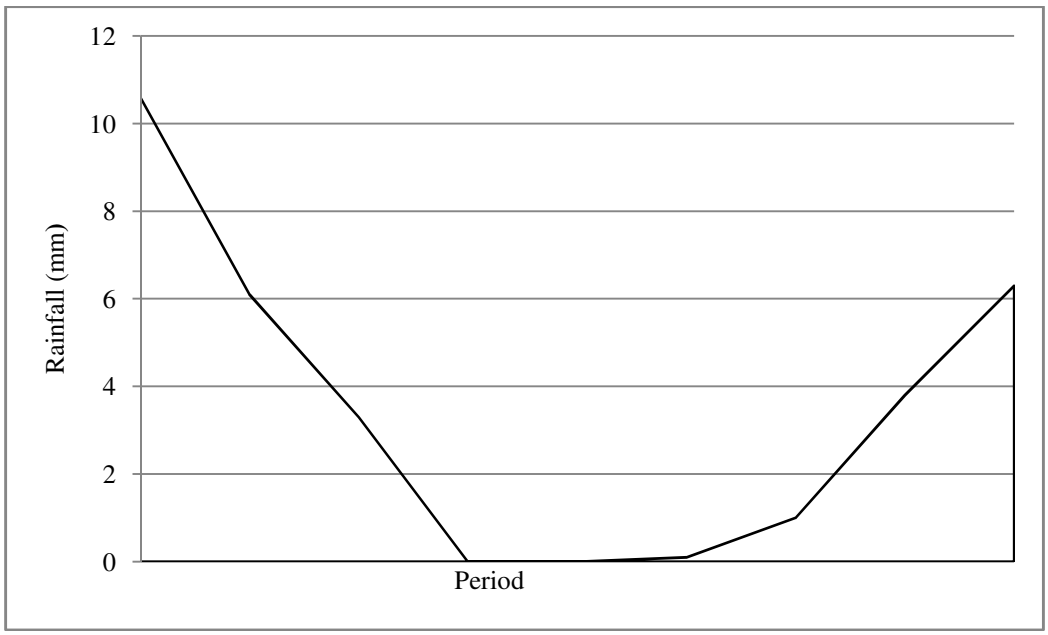

Figure-2
Average rainfall days during September 2013 to May 2014

Relative Humidity (RH): The recorded relative humidity during Sept 2013 to May 2014 was in the range of 42% to 82%. Maximum RH of 82% was noted during Sept 2013. Minimum RH of 42% was noted during Feb 2014, shown in figure-3.

Results and Discussion

Effects of ambient conditions such as temperature and relative humidity on pollutants SO_2, NO_2, NH_3, PM_{10} and $PM_{2.5}$ were analyzed and qualitative results are presented in the Tables 3-7 and the same are graphically represented in figures-4 to 8.

Table-3
Concentration of SO_2 in µg/m^3, NAAQS permissible limit of SO_2 = 80 µg/m^3

Sampling location	September 2013	December 2013	May 2014
A1	12.57	12.20	15.08
A2	8.94	8.12	9.31
A3	4.02	3.81	4.81
A4	18.85	18.46	18.31
A5	3.49	3.17	3.66

Table-4
Concentration of NO_2 in µg/m^3, NAAQS permissible limit of NO_2 = 80µg/m^3

Sampling location	September 2013	December 2013	May 2014
A1	44.60	36.91	43.59
A2	36.90	30.96	36.70
A3	11.11	8.95	11.11
A4	20.26	19.88	17.80
A5	7.96	6.59	7.96

Table-5
Concentration of NH_3 in µg/m^3, NAAQS permissible limit of NH_3= 400µg/m^3

Sampling location	September 2013	December 2013	May 2014
A1	6.69	3.21	6.92
A2	6.97	4.14	7.60
A3	7.46	5.73	7.06
A4	7.96	4.24	8.07
A5	7.97	11.26	7.27

Table-6
Concentration of $PM_{2.5}$ in µg/m^3, NAAQS permissible limit PM_{10} = 60µg/m^3

Sampling location	September 2013	December 2013	May 2014
A1	59.30	59.30	58.00
A2	19.60	19.60	28.00
A3	10.60	10.30	15.00
A4	64.60	66.00	66.00
A5	9.60	9.60	14.00

Table-7
Concentration of PM_{10} in µg/m^3, NAAQS permissible limit PM_{10} = 100 µg/m^3

Sampling location	September 2013	December 2013	May 2014
A1	100.00	88.30	92.00
A2	78.66	76.60	71.00
A3	50.00	46.60	49.00
A4	137.00	143.00	155.00
A5	43.00	41.30	45.00

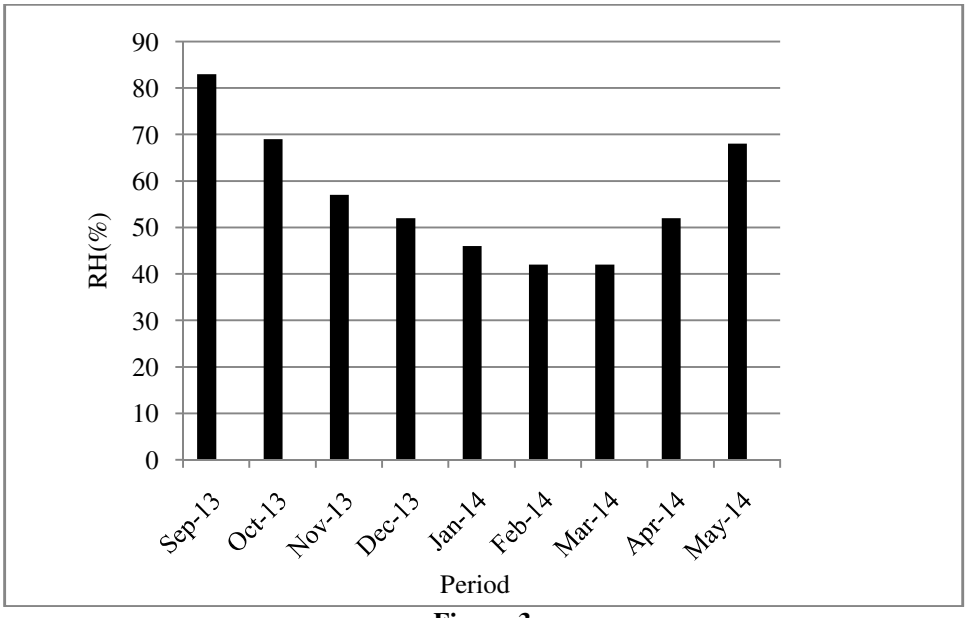

Figure-3
Variation of R.H % during September 2013 to May 2014

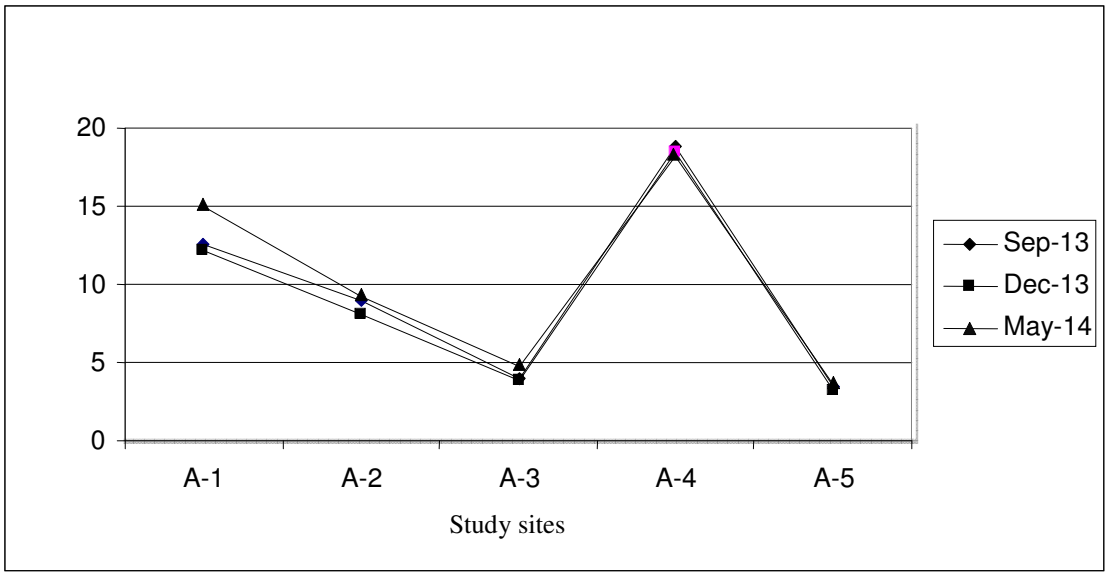

Figure-4
Concentration SO_2 at the studied sites

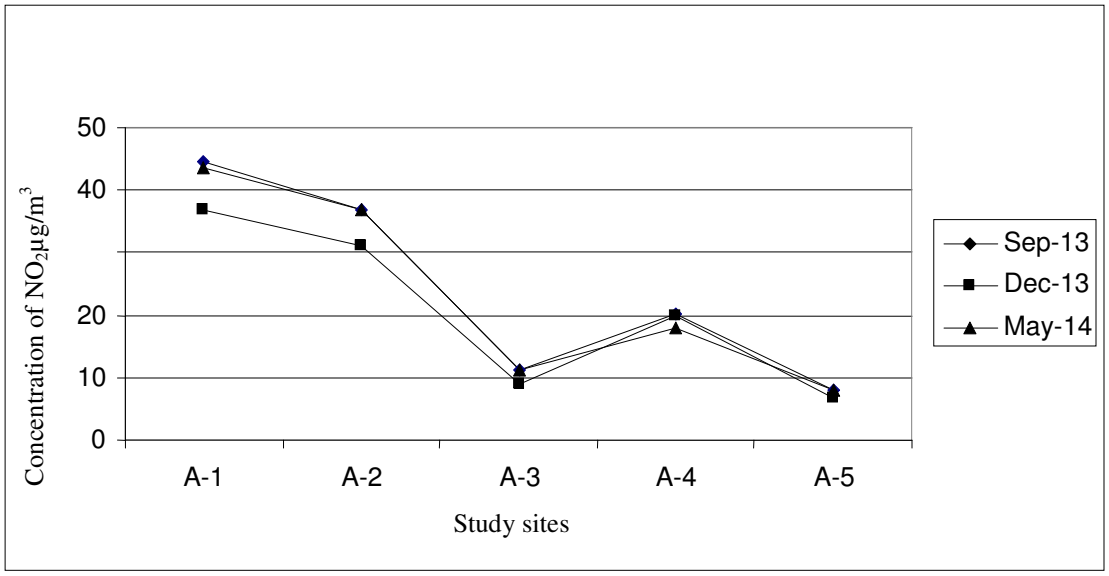

Figure-5
Concentration of NO_2 at the studied sites

At A4 site, SO_2 of maximum concentration was found during all the three months. At A5 site, minimum concentration of SO_2 was observed during all the three months. At A1 site, during May 2014 (summer) SO_2 was found to be more than other seasons. This may be due to the fact that A1 is a commercial and heavy traffic area as RH was around 68%, temperature was in the range 37 ^{0}C to 20 ^{0}C, and average rainy days of the month was 6.3days during May. A2 site is an area of small scale industries with minimum traffic and therefore, SO_2 concentration in that area has been found to be same for all the three months. At A3 site which is a residential area with minimum traffic and nominal commercial activities, SO2 concentration has been found to be least without much seasonal variation. A4 Site is an area of large scale industries and in that concentration of SO_2 has been to be high in all the three months. A5 Site is a village near Belgaum, the concentration of SO_2 in that area has been found to be very low. It can be pointed out that concentration SO_2 in the studied area lies far below the prescribed limits by NAAQS which is about 80µg/m^3.

At A1 site, concentration of NO_2 is found to be maximum in September-2013 and minimum in December-2013. NO_2 concentration at A1 is more than the measured values in other four sites. This may be due to the fact that A1 site is a heavy traffic prone and has high RH value of 83% in September-2013. Concentration of NO_2 at A2 site is found to be less than A1 for

all the three months. A3 site showed even less NO_2 concentration compared to A1 site. A4 site measured NO_2 levels higher than that measured in small scale industrial area A2. For all the three months, site A5 showed low levels of NO_2 compared to other four sites. NO_2 concentration at A1 site is more than half the prescribed limit of 80µg/m^3 by NAAQS. At the remaining four sites NO_2 concentration is much below NAAQS limit.

Concentration of NH_3 is far below the permissible limits in the studied area. Maximum concentration of 11.26µg/m^3 was measured in December 2013 at A5 site and this may be attributed to the fact that A5, site is a village where bio-degradation is more.

At A1 site, the concentration of $PM_{2.5}$ has been found to be high in all the three months of the study period which is very close to the NAAQS limit of 60µg/m^3. This could be due to the fact that A1 site is a heavy traffic area with busy commercial activity surrounded. A2 site measured second highest levels of $PM_{2.5}$. This site is surrounded by number of small scale industries which ejects lot of air pollutants into the atmosphere.

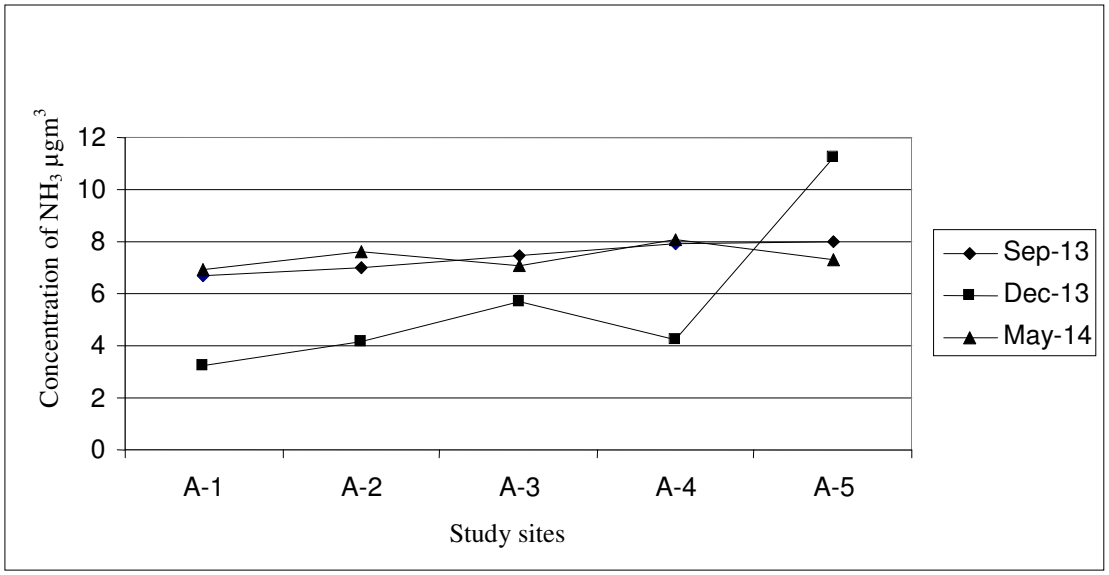

Figure-6
Concentration of NH_3 at studied sites

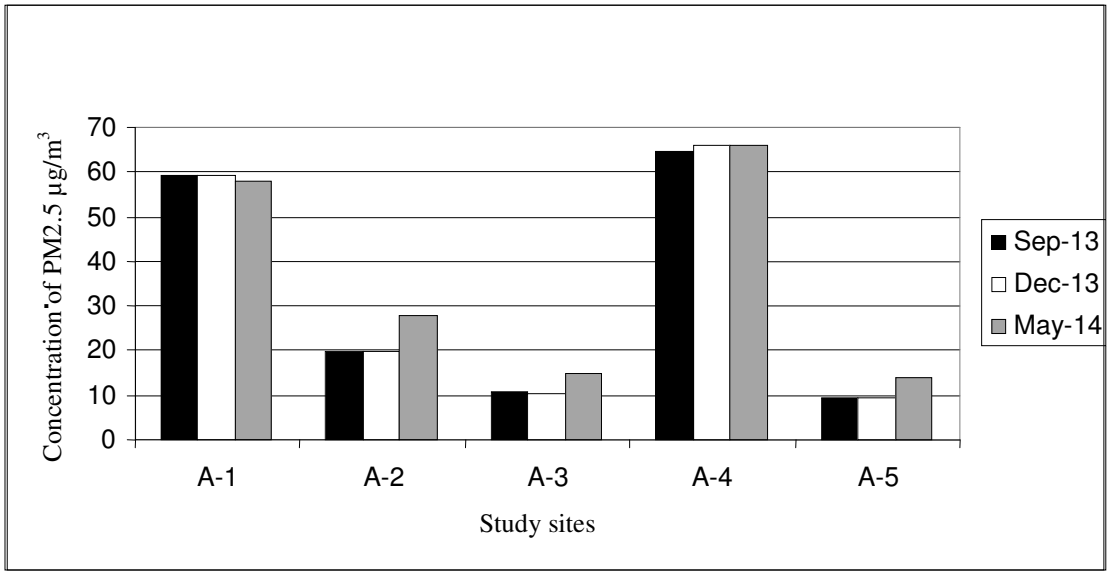

Figure-7
Concentration of $PM_{2.5}$ at studied sites

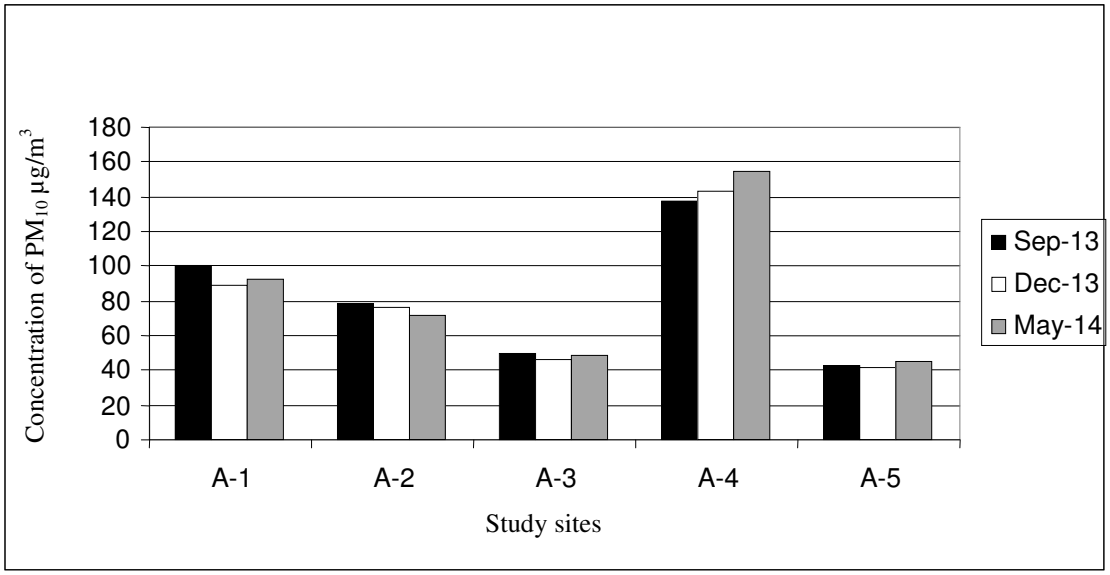

Figure-8
Concentration of PM_{10} at studied sites

A3 site being the residential area and having very minimum vehicle traffic measured low levels of $PM_{2.5}$. A4 site is a large scale industrial area where $PM_{2.5}$ has been found to be maximum exceeding prescribed limits. For all the three months, $PM_{2.5}$ has been measured to be more than the safe limits. A5 site is a village area where $PM_{2.5}$was minimum except during May 2014 in which it has reached the levels of A3 site[12].

At A1 site, the concentration of PM_{10} has reached the critical limits in september-2013 which is almost same as the prescribed limit of 100µg/m^3 during December-2013 and May-2014. At A2 site, the concentration of PM_{10} was found to be around 80µg/m^3 in all the three months of study period. A3 and A5 sites had minimum PM_{10} levels in all the three months. These two sites are in non traffic and non-commercial areas. At A4 site, the areas of large scale an industry which showed concentration of PM10 to be high and has crossed the prescribed limits of NAAQS[13] during all the months of the study period.

Conclusion

For the first time the effect of industries, urbanization and vehicle emissions on air quality in and around Belgavi city has been experimentally studied. Meteorological data of temperature, relative humidity, wind speed and rain fall recorded during the sampling period, has been used to understand the changes occurring in the pollution levels of sampled area.

It is concluded that the dispersion of suspended particulate matter (PM_{10}, $PM_{2.5}$) and gases such as SO_2, NO_2, and NH_3 in the atmosphere in the sampled area are greatly affected by meteorological parameters. Our monitoring of the pollutants at the receptor zones revealed that the Industries play very important role in air quality. On the basis of these factors, monitoring of air pollutants has been carried out in and around Belgaum city, Karnataka state, India. PM_{10} and $PM_{2.5}$ were found in high concentration in the heavy industrial and heavy traffic areas. This indicates that industrialization and automobile emission are associated closely with healthy hazards.

References

1. Taisa S. Lira and Marcos A. et.al, Air Quality prediction in Uberlandia, Brazil, using linear models and neural networks. 17th European Symposium on Computer Aided Process Engineering*, Elsevier*, **(2007)**

2. Fahimeh Hosseinibalam and Azadeh, Influence of Meteorological Parameters on Air Pollution in Isfahan, International Conference on Biology, Environment and Chemistry, *IPCBEE*, **46 (2012)**

3. Madhukar R and Srikantaswamy S., Assessment of Air Quality in Bidadi Industrial Area, Ramanagaram Disrict, Karnataka, India, *Journal of Environmental Science, Computer Science and Engineering and Technology;* **2(4)**, 1135-1140 **(2013)**

4. Doreena Dominick and Mohd Tlib Latif et al., An assessment of influence of meteorological factors on PM_{10} and NO_2 at selected stations in Malaysia, *Sustain Environ. Res*., **22(5)**, 305-315 **(2012)**

5. Carrie V. Breton and Amy Marutani. N., Air Pollution and Epigenetics: Recent Findings *Curr Envir Health Rpt*, **1,** 35–45 DOI 10.1007/s40572-013-0001-9, **(2014)**

6. Anilkender Kumar and Pramila Goyal, Forecasting of air quality in Delhi using principal component regression technique*, Atmospheric Pollution Research,* 2436-2444,

(2011)

7. Avnish Chaunhan, Mayank Pawar and Rajeev Kumar, Ambient Air Quality Status in Uttarakhand (India); A case Study of Haridwar And Dehradun Using Air Quality Index*, Journal of American Science*, **6(9**) **(2010)**

8. Sascha Hanninger, Urban Climate and Air Pollution in Kigali, Rwanda, *The seventh international conference on Urban Climate- Yokohama, Japan*, 29 June- 3 July **(2009)**

9. Vineeta Shukla, Poonam Dalall and Dhruva Chaudhry, Impact of vehicular exhaust on ambient air quality of Rohtak city, India, *Journal of Environmental Biology*, **31(6)** 929-932 **(2010)**

10. Ramaswamy Jayamurugan, Kumaravel B. and Palanivelraja S., Influence of Temperature, Relative Humidity and Seasonal variability on Ambient Air Quality in a Coastal Urban Area, *International Journal of Atmosperic Sciences Article, ID 264046*, (**2013)**

11. Sonal Verma S. and Birva Desai, Effect of Meteorological Conditions on Air Pollution of Surat City, *J. Int. Evironmental Application and Science,* **3(5)**, 358-367 **(2008)**

12. Chaloulakou A and Kassomenos P et.al, Measurements of PM_{10} and $PM_{2.5}$ Particle concentration in Athens, *Greece. Atmospheric Environment*, **37**, 649-660 **(2003)**

13. NAAQS, National Ambient Air Quality Standards (NAAQS), *Gazette of India, New Delhi, India,* **(2009)**