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Meteorological Influence on the Ambient Air Quality of Bhadravathi Town, Karnataka, India

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Abstract

Deteriorating air quality of urban areas is due to large scale urbanization and globalization leading to unsustained development with a great impact on human health, agriculture, climate and ecosystem. The weather elements greatly affect the distribution and concentration of different air pollutants at a particular area and hence the present study was undertaken with an objective of monitoring selected meteorological parameters of specific areas of the town and to correlate them with the pollutants. Sampling site III was the most polluted of all the sampling sites. SPM concentration exceeds but SO_2 and NO_2 were well below the permissible limit. Wind direction and wind speed were found to have a significant influence on the distribution of air pollutants in the sampling sites.

Keywords: Air quality, meteorological parameters, Correlation.

Introduction

Quality of air in urban areas is getting deteriorated mainly due to large scale industrialization, automobiles and globalization leading to unsustained development with a great impact on human health, agriculture, climate and ecosystem[1,2]. Gases, solids and aerosols from the natural and anthropogenic sources greatly affect the natural atmospheric composition. Gases such as carbon dioxide, methane and ozone are responsible for the increased green house effect and global warming whereas oxides of nitrogen and sulphur contribute towards acid rain. Suspended particulates are considered to be of significant importance as they along with the other gases cause smog formation and can affect the ecosystem by acting on the organisms and humans especially in elderly and children who are more susceptible to these pollutants.

Meteorology is the science of weather. The weather elements and meteorological conditions including certain meteorological parameters like wind speed, wind direction, temperature, atmospheric stability, rainfall, etc, greatly affect the distribution and concentration of different air pollutants at a particular area[3]. The world has seen disasters where higher concentration of air pollutants along with adverse weather conditions was responsible for the degree of impact[4]. Various investigations have been made both of invitro and epidemiological importance to know the effect of air pollutants. Experimental animals like guinea pig, dogs and cats were exposed to various amounts of pollutants and the effects have been enumerated viz. difference in average daily weight gain[5] and increased pulmonary resisistance with increase in dose of sulphur dioxide[6,7]. A study involving cattle on inhalation of nitrogen dioxide resulted in frequency of methemoglobinemia, pulmonary lesions, severe dyspnea and death. Plant *Euonymus japonica* increased stomatal conductance on exposure to 100 ppb NO_2[8], but reduced stomatal conductance at higher concentrations[9]. Maximum ambient SO_2 and NO_2 resulted in reduced growth and yield, ascorbic acid content and photosynthetic pigments[10]. Epidemiological studies indicated that air pollutants would be able to increase prevalence of allergy with production of IgE; they could increase the severity of asthma[11] and hospital visits pertaining to cardio vascular and respiratory deseases[12], when exposed with the adverse weather conditions. The present study was undertaken with an objective of monitoring selected meteorological parameters of specific areas of the town and to correlate them with the pollutants. Ambient air quality and statistical correlation of the criteria pollutants, SPM, SO_2 and NO_2 along with meteorological parameters have been discussed in this paper.

Material and Methods

Ambient air quality monitoring was conducted using Envirotech designed High Volume Air Sampler (APM 410) operated at suction rate of 1.2 m^3/min for eight hours. SPM was collected on a pre-weighed glass fiber filter paper (GF/FA) of 20.3 x 25.4 cm size. The filter paper was re-weighed after sampling for gravimetric evaluation of SPM and the value of SPM was reported in $\mu g/m^3$. SO_2 and NO_2 concentration were also determined. Estimation was carried out by West and Gaeke method for SO_2; Jacob and Hochheiser modified (Na-Arsenate) method for NO_2.

Wind speed, temperature, humidity and rainfall were studied using anemometer, standard thermometer, hygrometer and standard rainguage respectively. Monthly average of selected air quality parameters have been correlated with meteorological parameters using SPSS 20 package.

Study area: Bhadravathi lies in the central part of Karnataka state, in the south-east corner of Shivamogga district. The latitude and longitude coordinates are 13°50'N and 75°42'E. It has a population of 3, 38,989 as per 2011 census with an altitude of 1900 ft (580 m) above the sea level. It lies on the banks of river Bhadra; the town has two major industries i.e VISL (Vishveshvaraiah Iron and Steel Limited) and MPM (Mysore Paper Mills) in the heart of the city. The selection of sampling sites was based on the location, population, regional background and other such factors. All the sampling sites fall under the category of residential area (table-1).

Table-1
Selected sampling sites for air pollution monitoring in the study area

Sl.No	Sampling sites
1.	Hosamane (Sampling Site I)
2.	Huttha colony(Sampling Site II)
3.	New Town(Sampling Site III)
4.	Sathya Sai School(Sampling Site IV)

Results and Discussion

Air quality: The results showed that SPM ranged between 54-496 μg/m^3 with an average of 267.18 μg/m^3. Sampling site III had the highest concentration of SPM followed by II, IV and I with an average concentration of 302.91 μg/m^3, 265.58 μg/m^3, 262 μg/m^3 and 238.25 μg/m^3, respectively. NO_2 concentration was found to be between 0-71.25 μg/m^3 with an average of 26 μg/m^3 during the sampling period. Sampling site III had the highest concentration of NO_2 followed by IV, II and I with an average concentraton of 29.58μg/m^3, 26.5μg/m^3, 25.43 μg/m^3 and 22.47μg/m^3 respectively. SO_2 ranged between 0-21 μg/m^3 with an average of 11.39μg/m^3 from all the sampling sites. Sampling site III had the highest concentration of SO_2 followed by II, IV and I with an average concentraton of 14.20 μg/m^3, 13.14μg/m^3, 10.35 μg/m^3 and 7.85μg/m^3 respectively (figure-2,3,4).

All the sampling sites are exeeding the permissible limit with respect to SPM. The average concentration of NO_2 was well within the permissible limit and SO_2 average concentration was well below the permissible limit (table-5) prescribed by the CPCB (Central Pollution Control Board).

Correlation with meterological parameters: SPM Vs meteorology: Results reveal that the wind velocity has a negative but significant correlation with SPM at sampling site II ($r=-0.644$, $p<0.05$) and IV($r=-0.604$, $p<0.05$). The other two sites also have a negative but moderately significant correlation. SPM has a negative but significant correlation at 0.01 level with rain fall (-0.737, -0.915, -0.840, -0.854 for SS I, SS II, SS III and SS IV respectively) at all the sampling sites. Temperature has a positive correlation at all the sites except sampling site I with less significant values. Humidity has positive and less significant correlation at all the sampling sites (table-2).

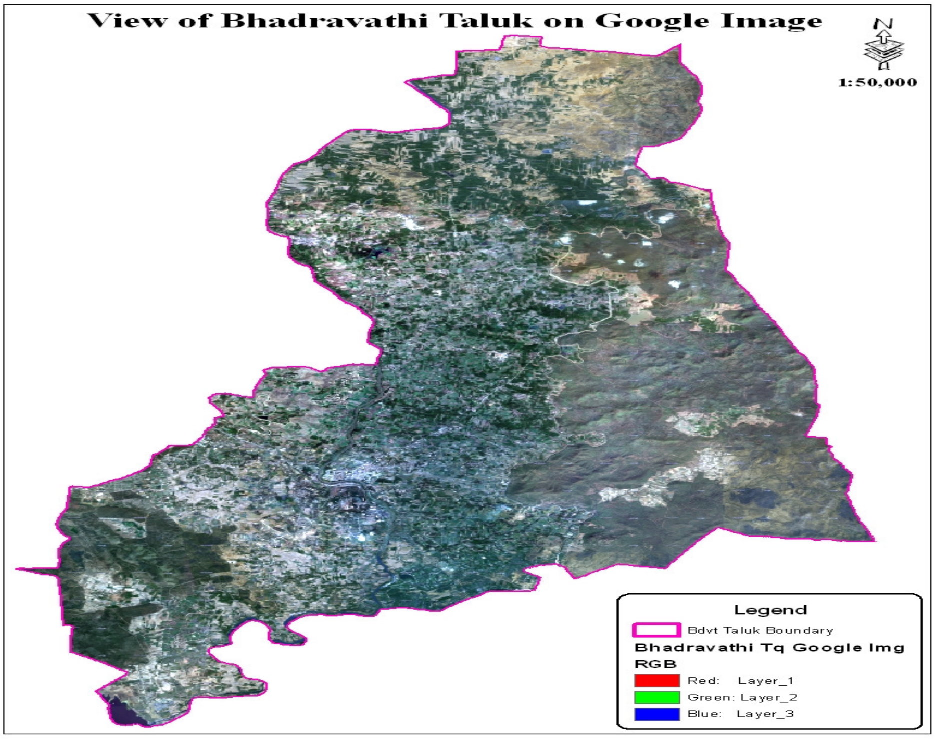

Figure-1
View of Bhadravathi Taluk on Google Image

Table-2
Correlation of SPM with the selected weather parameters at different sampling sites, N=12

SPM		Wind Velocity	Rain Fall	Temperature	Humidity
SAMPLING SITE-1	r	-.536	-.737**	-.240	.373
	Sig. (2-tailed)	.073	.006	.453	.233
SAMPLING SITE-2	r	-.644*	-.915**	.136	.194
	Sig. (2-tailed)	.024	.000	.674	.546
SAMPLING SITE-3	r	-.506	-.840**	.025	.497
	Sig. (2-tailed)	.094	.001	.939	.100
SAMPLING SITE-4	r	-.604*	-.854**	.035	.166
	Sig. (2-tailed)	.038	.000	.914	.607

*. Correlation is significant at 0.05 level (2-tailed). **. Correlation is significant at 0.01 level (2-tailed).

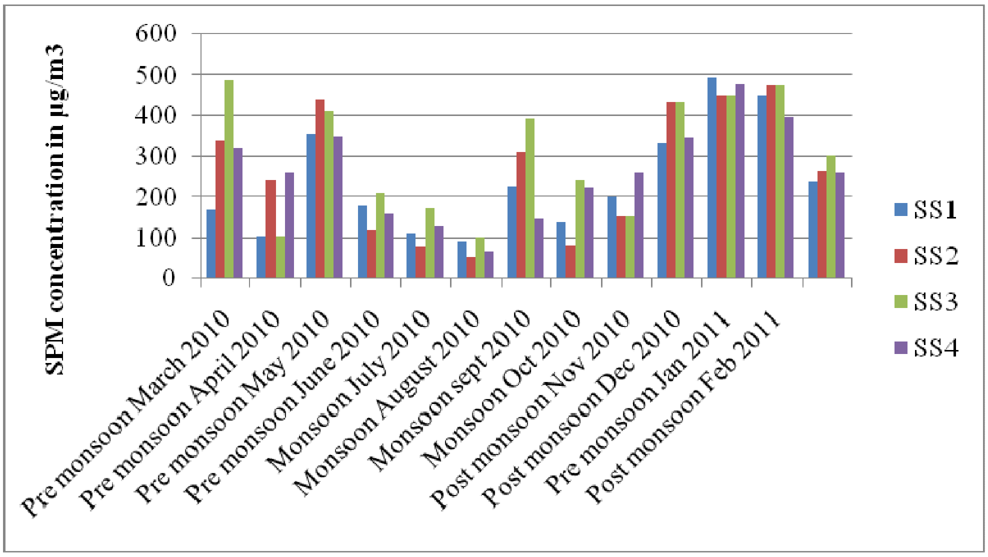

Figure-2
Monthly variation of SPM in all the selected sampling sites

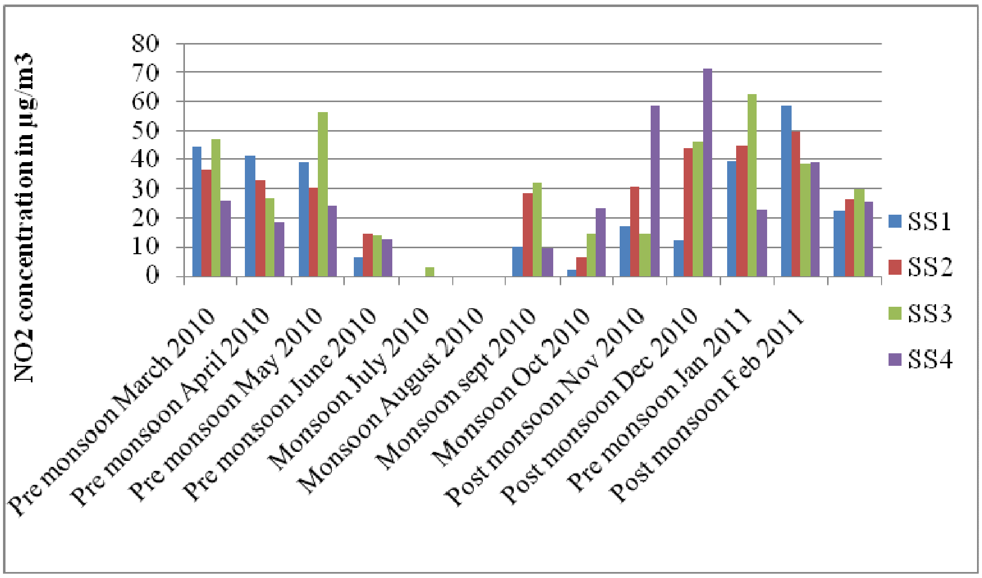

Figure-3
Monthly variation of NO_2 in all the selected sampling sites

NO_2 Vs meteorology: The wind velocity was found to have a negative but significant correlation with NO_2 at 0.05 level at sampling site III (r=-0.665) and IV (r=-0.648), whereas, negative but less significant correlation was observed in the other two sites. Pertaining to the rain fall, NO_2 has a negative but significant correlation at 0.01 level but sampling site II was having negative but moderately significant value (r=-0.763, -0.508, -0.870, -0.910 at SS I, SS II, SSIII and SS IV respectively) at all the sampling sites. Temperature has a positive correlation at all the sites except sampling site II which is nearer to significant values. Humidity is having a positive and less significant correlation with NO_2 at all the sampling sites except SS I (table-3).

SO_2 Vs meteorology: Rainfall has a negative but moderately significant correlation at 0.01 level except at SS IV (r=-0.572, -0.556, -0.560, -0.732 at SS I, SS II, SS III and SS IV respectively) at all the sampling sites for SO_2. The wind velocity is having negatively moderate significant correlation for SO_2 at all the sampling sites. Temperature is having positive correlation at all sites. Humidity is having a negative but less significant correlation with SO_2 at sampling sites III and IV (table-4).

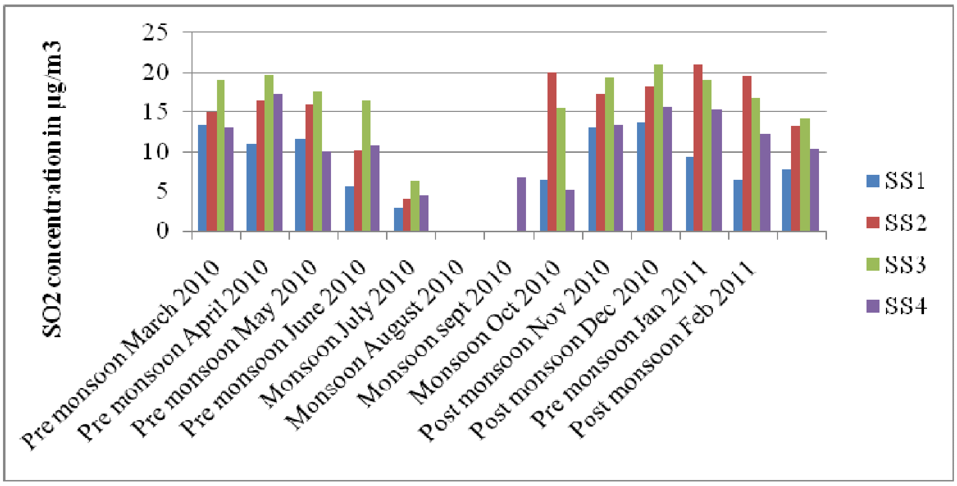

Figure-4
Monthly variation of SO_2 in all the selected sampling sites

Table-3
Correlation of NO_2 with the selected weather parameters at different sampling sites, N=12

NO_2		Wind velocity	Rain fall	Temperature	Humidity
SAMPLING SITE-1	r	-.363	-.763**	.433	-.001
	Sig. (2-tailed)	.245	.004	.160	.997
SAMPLING SITE-2	r	-.572	-.508	-.112	.241
	Sig. (2-tailed)	.052	.092	.730	.451
SAMPLING SITE-3	r	-.665*	-.870**	.197	.167
	Sig. (2-tailed)	.018	.000	.540	.603
SAMPLING SITE-4	r	-.648*	-.910**	.074	.074
	Sig. (2-tailed)	.023	.000	.819	.820

*. Correlation is significant at the 0.05 level (2-tailed).**. Correlation is significant at the 0.01 level (2-tailed).

Table-4
Correlation of SO_2 with the selected weather parameters at different sampling sites, N=12

SO_2		Wind velocity	Rain fall	Temperature	Humidity
SAMPLING SITE-1	r	-.467	-.572	.369	.024
	Sig. (2-tailed)	.126	.052	.238	.940
SAMPLING SITE-2	r	-.413	-.556	.080	.026
	Sig. (2-tailed)	.182	.061	.805	.937
SAMPLING SITE-3	r	-.279	-.560	.256	-.045
	Sig. (2-tailed)	.380	.059	.421	.888
SAMPLING SITE-4	r	-.434	-.732**	.186	-.249
	Sig. (2-tailed)	.159	.007	.564	.435

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Table-5
Permissible limits (National Ambient Air Quality Standards)

Pollutants	Time-weighted average	Concentration in ambient air			Method of measurement
		Industrial Areas	Residential, Rural & other Areas	Sensitive Areas	
SulphurDioxide (SO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3	Improved West and Geake Method Ultraviolet Fluorescence
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	
Oxides of Nitrogen as (NO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3	Jacob and Hochheiser Modified (Na-Arsenite) Method Gas Phase Chemiluminescence
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m^3	140 µg/m^3	70 µg/m^3	High Volume Sampling, (Average flow rate not less than 1.1 m3/minute).
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3	

*Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval. **24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

Discussion: Winter seasonal concentration (maximum, min and average) of all the parameters under study were high compared to summer and rainy season. Similar results were obtained for SO_2 and NO_2 by Sayanti Kar and Phalguni Mukherjee[13] and for SPM by Gupta et al., (2002)[14] which might be due to the temperature inversion which is characterised by less or relatively no movement of wind aiding in the buildup of higher concentration of pollutants in the study area[15,16] (wind speed, 1-2 Km/h). Summer concentration was relatively less compared to winter. Rainy season was characterised by least concentration in comparison to winter and summer due to higher rainfall which reduced SPM and gaseous pollutants.

The average concentration of SPM, SO_2 and NO_2 were highest at SS III followed by SS II, SS IV and SS I, respectively in the study period; reason might be the location of the sampling site with respect to the seasonal changes in the wind direction. NNE, NE, E, SW in summer, NW, SW, SSW, W in rainy, E, SE, NNE, NE, E in winter were the predominant wind directions and NW, SWW in summer, SE, NE in rainy, SW, SWW were the less predominant wind directions during the study period. Less significant values in correlation were found during the study which might have resulted due to the less variant humidity values. Rain fall, wind direction and wind speed were found to have a significant influence on the distribution of air pollutants in the sampling sites.

Conclusion

The investigation reveals that SPM concentration is exceeding the permissible limit at all the sampling sites whereas SO_2 and NO_2 concentration is well below the permissible limit. Higher concentration of SPM results in pulmonary problems to the residents of the town. Rain fall, wind direction and wind speed being the major influential weather parameters play a vital role in the distribution of air pollutants. Winter concentrations of pollutants are higher compared to the other seasons due to which there is a possibility of discomfort for the residents who are sensitive to these pllutants. Hence, there is an urgent need for monitoring the pollutant levels in this industrial town.

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