Assessment of Ambient Air Quality in Mysore City

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ABSTRACT: Air pollution is worldwide phenomena and growing threat to human health and the natural environment. The ambient air quality monitoring is necessary as it is related to health of the citizens, spread of diseases and other conditions within a city. The present study is to assess the ambient air quality in Mysore city. Four sampling locations are selected with different anthropogenic activities i.e. residential, sensitive, commercial and industrial were identified in the city. The samples were collected for Suspended Particulate Matter (SPM), Sulphur dioxide (SO_2), and Nitrogen dioxide (NO_2) during February to April 2013 using High volume air sampler. Criteria pollutants SPM, SO_2 and NO_2 measured in the sampling locations were found to be well within the prescribed standard. The values were relatively high in commercial and industrial areas compared to other areas. A study was conducted to know about the existing and proposed land use of the city. The population projection and the vehicular density in Mysore city shows an increasing trend leading to change in the existing land use pattern, increase in the traffic and reduction of greenery and lung spaces affecting the air quality in the city. It can be concluded that Mysore city is a strong case for continuous monitoring of ambient air quality due to chances of increase in the pollutants level in the future.

Keywords: Air pollution, Air quality, Land use, Mysore city, Wind rose.

I. INTRODUCTION

Air pollution worldwide is a growing threat to human health and the natural environment. Air pollution may be described as contamination of the atmosphere by gaseous, liquid, or solid wastes or by-products that can endanger human health, welfare of plants and animals, attack materials, damage monument, reduce visibility and produce undesirable odors. Although some pollutants are released by natural sources like volcanoes, coniferous forests, and hot springs, the effect of this pollution is very small when compared to that caused by emissions from industrial sources, power plant and heat generation, waste disposal, and the operation of internal combustion engines. Fuel combustion is the largest contributor to air pollutant emissions, caused by man, with stationary and mobile sources equally responsible. The air pollution problem is encountered outdoor as well as indoor. Now-a-days, air over major cities throughout the world has become overburdened with gases produced by automobiles and industrial units. With passage of time, people realized that polluted air has serious effects on their health, climate and economics. Environmental pollution, which is commonly thought to be the result of man's action in general and industrial revolution in

particular is preceded by man himself. The natural processes such as volcanic eruption, forest fire, dust storms etc., are the sources of major pollutants. The magnitude of the problem of environmental pollution increased immensely with industrialization and urbanization. The man's contribution to pollution through industries and automobiles has suppressed nature's contribution by thousand folds. The pollution load has reached an alarming level in highly industrialized countries, which leads to reduction in scavenging action of the atmosphere.

II. MATERIALS AND METHODOLOGY

Mysore city is the second largest in the state of Karnataka and is a well known tourist destination. It is also known as the cultural city of Karnataka and the city of palaces. It is located at 140 km South of Bangalore Metropolitan city and lies at 76°46' E longitude and 12°8' N latitude (770 m above the MSL). In olden days (1950 and before) Mysore was regarded as one of the cleanest and unpolluted city. However, these days, due to rapid industrialization and commercialization, the level of pollution has increased rapidly. In the present study, the Mysore city map was divided into north, south, east and west direction taking into account north-east, north-west, south-east and south-west direction. Based on this four locations were selected as follows:

1) North-West: KSPCB (Industrial area)

2) North-East: VTU building, ring-road (Sensitive area)

3) South-West: Bogadi (Residential area)

4) South-East: K.R circle (KSRTC Building) (Commercial area)

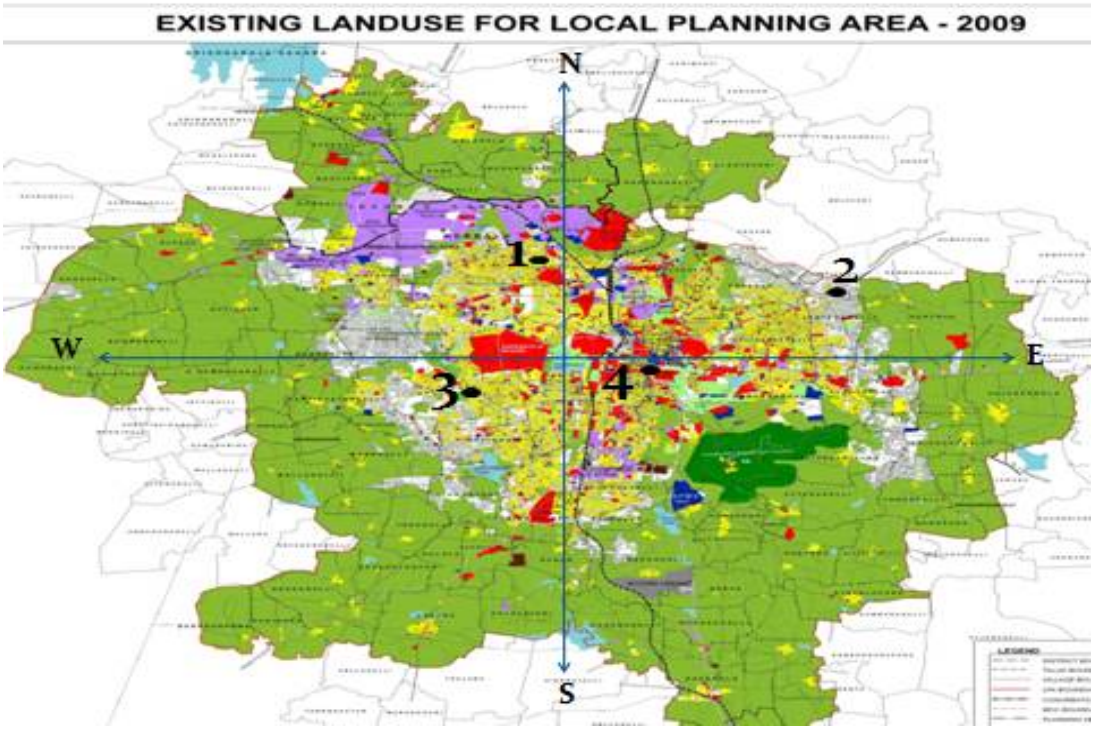
As KSPCB is located in the industrial area, near the ring road at the outskirts of Mysore city, hence KSPCB Regional office building itself will be identified as a representative station for air monitoring for industrial area of Mysore.

Visvesvaraya technological University (VTU) building is situated in Sathgalli area, near outer ring road. As it is situated near Narayana Hrudhayalaya Hospital, we have considered this station as a sensitive area in our study.

Bogadi is one of the developing area, and many layouts are likely to come up in this area. So it is identified as the residential area in our study.

K.R.Circle is one of the most traffic junctions in Mysore and is located in the heart of the city and this area has been identified as a commercial area in our study.

The ambient air quality parameters such as SPM, NO_2 and SO_2 and wind speed were analyzed using High Volume Air Sampler. High volume air sampler was used for the collection of suspended particulate matter. It is provided with a gas kit attachment for the measurement of SO_2 and NO_2. The mass concentration of SPM in the ambient air was calculated by taking difference between the final and initial weight of the filter paper and dividing by the volume of air sampled. The collected samples of SO_2 and NO_2 were analysed in the laboratory using modified West and Gaeke method and Jacob Hochheiser modified method, respectively.



1- KSPCB Building 3- Bogadi

2- VTU Building 4- K.R Circle

Figure 1: Mysore city map showing four sampling locations

III. RESULTS AND DISCUSSION

Variation of SPM, SO_2 and NO_2 in ambient air in selected sampling locations of Mysore city

The present study indicates the air quality status of Mysore City at four sampling location. The concentrations of SPM during the sampling period at four sampling locations are shown in the Table 1; it shows that suspended particulate matter (SPM) concentration in the study area varied between 12.3 to 62 µg/m^3. The particulate matter concentration in the KSPCB (industrial area) and is more when compared to other locations may be due to industrial activities and vehicular emission.

The concentrations of SO_2 during the sampling period at four sampling locations are shown in the Table 2; it shows that sulphur dioxide (SO_2) concentration in the study area varied between 5.2 to 11.4 µg/m^3. The sulphur dioxide concentration in the K.R circle (commercial area) is more when compared to other locations may be due to vehicular emission and commercial activities.

The concentrations of NO_2 during the sampling period at four sampling locations are shown in the Table 3; it shows that nitrogen dioxide (NO_2) concentration in the study area varied between 5.2 to 23.3 µg/m^3. The nitrogen dioxide concentration in the K.R circle (commercial area) is more when compared to other locations may be due to vehicular emission with average one hour vehicular traffic density of 7,581, commercial activities and it is surrounded by city bus stand and sub urban bus stand which occupy the major chunk of the transportation land use.

The trends in the level of pollutants such as SPM, SO_2, NO_2 monitored during the sampling period are presented in Figure 2, Figure 3 and Figure 4 respectively.

Table 1: Concentration of SPM (µg/m³) during the sampling period at four sampling locations

Locations	Concentration of SPM (µg/m³)		
	February	March	April
VTU building	12.3	22.1	28.7
Bogadi	25	29.8	33.5
K.R circle	60	60	58
KSPCB	62	58.6	63

Table 2: Concentration of SO_2 (µg/m³) during the sampling period at four sampling locations

Locations	Concentration of SO_2 (µg/m³)		
	February	March	April
VTU building	5.2	7.8	8.7
Bogadi	7	8.6	10.8
K.R circle	9.8	11.4	10.8
KSPCB	9.7	10.9	10.8

Table 3: Concentration of NO_2 (µg/m³) during the sampling period at four sampling locations

Locations	Concentration of NO_2 (µg/m³)		
	February	March	April
VTU building	5.2	5.5	6
Bogadi	4.7	5.3	7.4
K.R circle	22.7	23.4	25
KSPCB	20.4	23	23.5

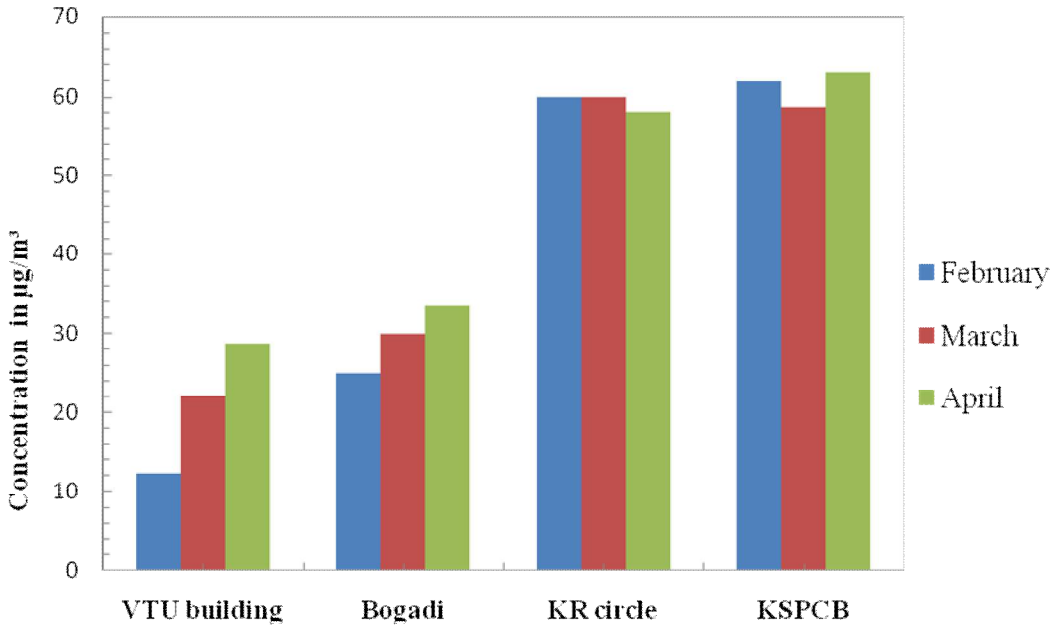


Figure 2: Concentration of SPM (µg/m³) during the three months at four sampling location

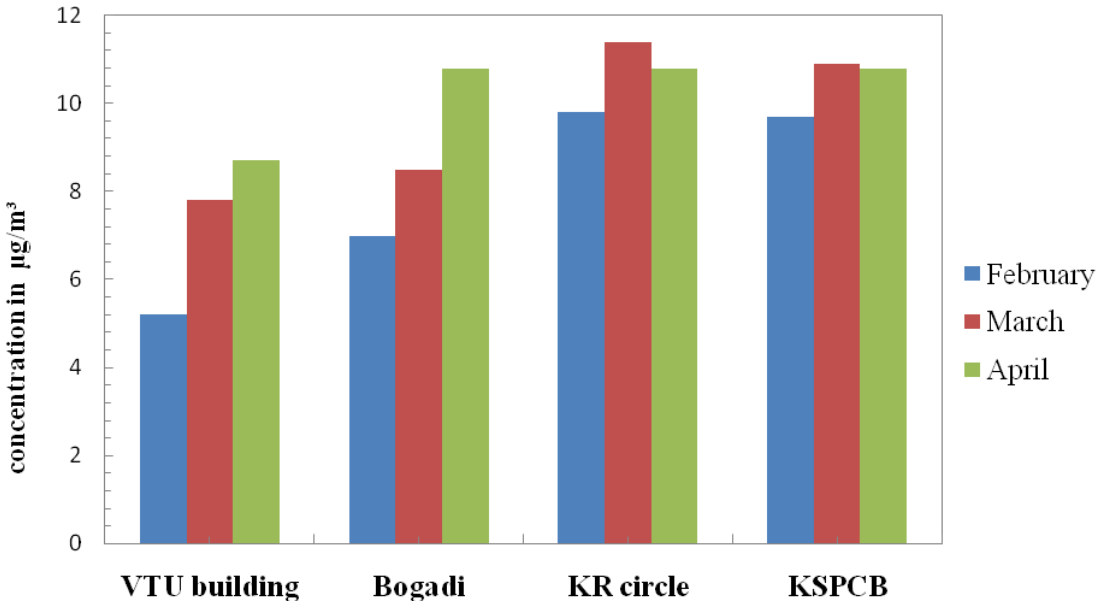


Figure 3: Concentration of SO_2 (µg/m³) during the three months at four sampling location

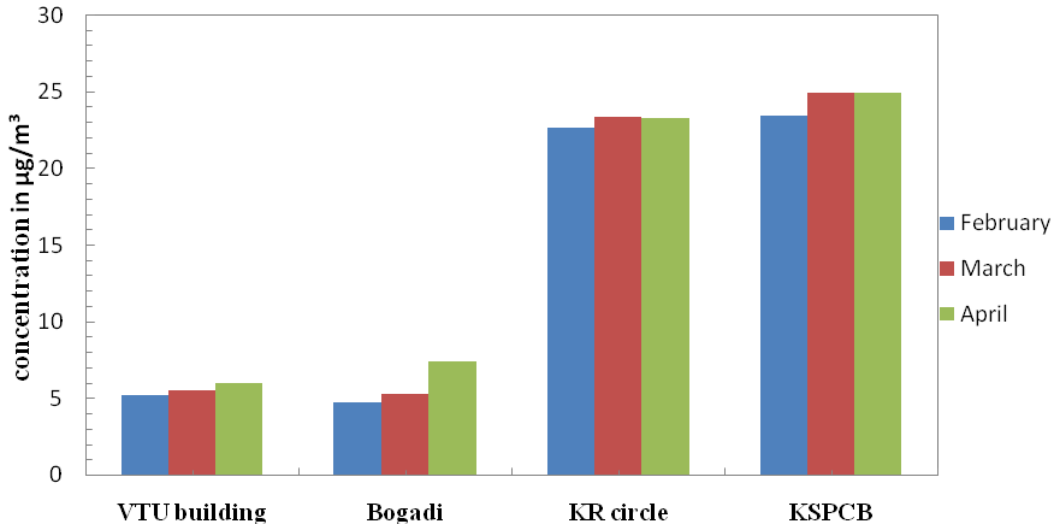


Fig 4: Concentration of NO_2 (µg/m³) during the three months at four sampling location

Air quality and urban land use planning

Mysore city is a Heritage city with more percentage of greenery and with enough lung spaces. It is one of the important tourist destinations in India and rewarded as the second cleanest city in India as per 2010 survey. Mysore is the second largest and one of the important cities in Karnataka after Bangalore where urban sprawl is taking place at a faster rate and some of the issues are discussed below.

Table 4: Existing land use of Mysore city

Land use category	Area in acre
Residential	17378
Commercial	1170
Industrial	3234
Public/semi-public	3820
Public utility	264
Open space	1893
Traffic and transport	8363
Agriculture	30068
Water body	807
Forest	1851
Total area	**68854**

The Table 4 show the existing land use of Mysore city. The existing land use pattern of the city shows that the residential area occupies 17378 acres. The dominant other uses being the industrial use and the public and semi public use totally accounting for 68854 acres. The total area of open spaces is around 1893 acres accounting for 2.62% of the total

developed area. Increase in population and unbridled urbanization of Mysore city has taken away open spaces and agricultural areas around the Mysore city, as the city continues to expand horizontally. Mysore city has been observed to be a multifunctional town having characters of trade and commerce cum industries cum administration.

Table 5: Population projection for Mysore city by MUDA

	As per census 2001	**Trend method**		
		2011	**2021**	**2031**
Mysore city	7,99,228	11,19,031	14,95,764	20,01,000

The projected population is an assessment based on the assumption that the rates, at which the city has grown during the previous decades would continue even during the coming decades upto the design period (2031) and future population has been projected using the trend method. The Table 5 shows an increasing trend in population each decade. It is observed that many rural pockets immediately around the Mysore city is already showing growth trend and many pockets of land around the villages have already been either converted for non agricultural or they are recommended for the changes of land use. Mysore City has witness tremendous population growth after 2001, due to establishment of new industries, information technology parks, new educational institutions etc. As the city is being connected to state capital Bangalore through a new dedicated express highway, it is estimated that the city will grow at a much faster rate due to large scale population migration. The population is booming, demanding increase in public amenities like transportation, leading to increase in traffic density and thus the vehicular emissions. So some of the villages around Mysore such as Nagavala, Bommenahalli, Manikyapura, Varuna, Kamarahalli in Yewala Hobli, Dhanagalli, Daripura and Baradanapura of Jayapura hobli are displaying a signs of development and hence these villages can be incorporated under the Mysore Local Planning Area to foster their orderly growth and develop them as decentralized satellite townships which will help in the decongestion of Mysore city in future.

Table 6: Proposed land use (2031) for Mysore city

Land use category	**Area in acre**
Residential	36962
Commercial	1872
Industrial	4513
Public/semi-public	4796
Public utility	332
Open space	3914
Traffic and transport	10649
Agriculture	2336
Water body	876
Forest	1848
Special agricultural zone	749
Total area	**68,853**

As per the Table 6 the Mysore city occupies a total area of 68853 acres. The residential, industrial and commercial areas occupies 36962, 4513 and 1872 acres, respectively which shows an increase in the area from the existing land use. Mysore city has radial and gridiron pattern road network with arterial roads originating from the city centre. The road network of the city includes three ring roads viz. outer ring road, intermediate ring road and inner ring road and also arterials roads, sub-arterial roads, collector roads and others. The existing road network can be grouped and conceived as a system of ring roads, in combination of several important roads of the city, including the various radial roads which emanate from the city towards the other urban centers in the region.

Table 7: Vehicles registered in RTO, Mysore

Vehicle category	Year			
	2010	**2011**	**2012**	**2013 (upto March)**
2- wheeler	17,994	21,268	24,176	6892
Light Motor Vehicle (LMV)	4,319	4,136	4,381	1364
Heavy Motor Vehicle (HMV)	1,826	2,120	2,510	639
Total	24,139	27,524	31,067	8,895

It is evident from the Table 7 that almost all types of vehicles have been growing steadily at a rate of around 11.8%. It may be observed that 2-wheeler vehicles have been growing at relatively faster rate. At this growth rate there will be a further increase in the vehicular density in the upcoming years and will have an effect on the traffic conditions of the city roads. The city is assuming importance in the region, in view of the all-round development experienced in the recent years, which ensures further growth of the city and region. As a result there is a need to provide diversion of the regional traffic, which is not meant for the city. The existing outer ring road is already performing this role on the western side of the city and to a certain extent on the eastern part also. However, in view of the growth of the city beyond the outer ring road, there is a need to think about the peripheral road links around the Mysore city. The traffic on the state highways, which do not intend entering the city can make use of the peripheral roads avoiding traffic congestions in the city.

A wind rose is a class of diagrams designed to show the distribution of wind direction experienced at a given location, over a considerable period. In other words, the wind rose shows the prevailing direction of wind. Wind roses may be constructed from the data obtained over a given period of time such as a particular month or season or a year.

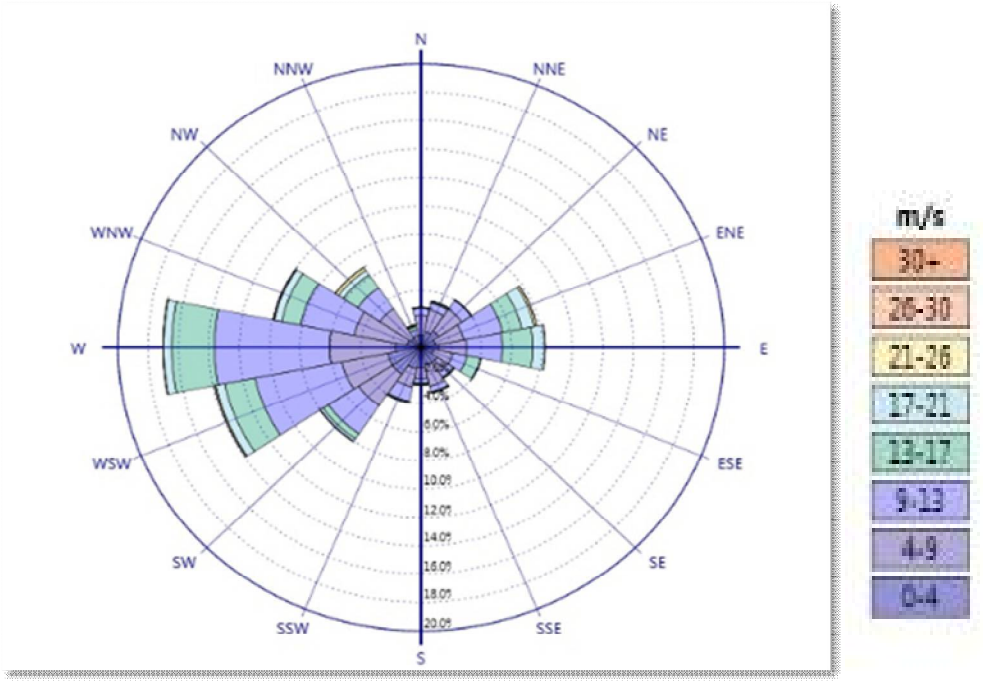


Figure 5: Wind rose diagram for Mysore city from January to March

The wind rose diagram for Mysore city during the period of January to March 2013 obtained using the software Autodesk Vasari is as shown in the Fig 5. The direction and speed of the surface winds govern the drift and diffusion of air pollutants emitted near the ground level. The higher the wind speed at or near the point of source, the pollutants are carried rapidly from the source. From the Figure 5 we can see that there is very less wind speed of around 17 to 21 m/s towards North-west direction. In Mysore local planning area, the major industrial area has been developed by KIADB (Karnataka Industrial Areas Development Board), in the Hebbal Industrial area. Similarly such industrial areas have been developed in Thandavapura and Nanjangud. Industrial area exists at five places namely Hebbal, Belavadi, Hootgalli, belagola and metagally. The Hebbal industrial area is located in the North-West direction of Mysore city with major industries like Bharat Earth movers Limited (BEML), Kirloskar, Vikrant Tyres, Jay bearings, Automotive Axel etc. During the period of January to March there will be high production in the industries leading to release of large amount of air pollutants. As the pollutants are released from the chimneys of the industries, they will not get dispersed and diluted due to low wind speed. This results in accumulation of pollutants at the source which will increase the ground level concentration of the pollutants leading to health impacts of the residents in the surrounding area. However the industries such as JK tyres and Falcon Tyres do not contribute to any air pollution at present but in future there are chances of increase in the air pollution leading to serious problems if proper measures are not taken. Hence the industrial area should be separated from other areas by green belts.

The Table 8 and Table 9 describe the air quality in KSPCB Building and K.R.Circle of Mysore city for the last fourteen years, which has been monitored by KSPCB. The table shows that the concentrations of the pollutants are within the permissible limits and there is no much variation in the pollutant concentrations from year to year. This shows that the air quality in Mysore city is comparatively good.

Table 8: Annual Ambient Air Quality in KSPCB Building, Mysore

YEAR	PARAMETERS		
	SO_2	NO_2	SPM
1998-1999	32	28	81
1999-2000	31	27	89
2000-2001	30	30	81
2001-2002	20	29	109
2002-2003	20	27	103
2003-2004	11	17	92
2004-2005	11	21	80
2005-2006	21	34	76
2006-2007	15	23	81
2007-2008	13	19	76
2008-2009	14.8	20.3	95
2009-2010	12	31.7	78
2010-2011	10.6	25.4	86
2011-2012	11	21.4	96

Table 9: Annual Ambient Air Quality in K.R Circle, Mysore

YEAR	PARAMETERS		
	SO_2	NO_2	SPM
1998-1999	31	26	81
1999-2000	30	26	145
2000-2001	29	28	116
2001-2002	19	30	112
2002-2003	20	27	107
2003-2004	11	18	96
2004-2005	11	20	91
2005-2006	22	34	92
2006-2007	16	22	93
2007-2008	14	19	85
2008-2009	15.7	20.5	99
2009-2010	13.4	34.8	102
2010-2011	11	25.4	94
2011-2012	11	21.6	101

From the study conducted, the concentration of the pollutants such as SPM, SO_2, NO_2 are within the NAAQS (National Ambient Air Quality Standards). The pollutants concentration shows an increasing trend from the month of February to April due to the climate changes like Temperature, Humidity, and Wind speed, but do not exceed the limit.

IV. CONCLUSIONS

- The results obtained from the measurement of SPM, SO_2 and NO_2 from February to April 2013 in the selected sampling locations are well below the National Ambient Air Quality Standard. The concentration of pollutants varies with season, temperature, wind speed, vehicular density and industrial activities, etc.
- The population projection in Mysore city shows an increasing trend leading to change in the existing land use pattern, increase in the vehicular density and reduction of greenery and lung spaces affecting the air quality in the city.
- There is an ever increasing demand of personal vehicles in the city which substantially contributes towards emissions of NO_x, SO_x, CO, VOCs and other pollutants. Thus, there is a need to encourage the mass transit system and effective measure to relieve traffic in towns in the city.
- The wind rose plot from January to March indicates that maximum distribution of pollutant is towards North-West direction with low wind speed. As the industrial area is located in this direction surrounded by few residential areas, there are chances of affecting the health of the residents, if the pollutants are not properly dispersed.
- The proposed land use plan map of the city shows proposal of residential areas within the industrial area which may negative impact and affect the health of the residents. So the industrial area should be separated from other areas by green belts.
- However, at present the level of pollutants are below the standard and as the city is undergoing rapid urbanization there are chances of increase in air pollution in future. So Mysore city is a stronger case for continuous monitoring of ambient air quality.

V. RECOMMENDATIONS

- Mysore should have a Continuous Ambient Air Quality Monitoring Station. So that the Public can know the quality of air at a particular time from an electronic display board installed on top of the station. The constant display of air quality will create awareness among the people.
- There is a need to plan for peripheral roads around the Mysore city to divert the traffic on the state highway which do not intent to enter the city thus avoiding traffic congestions in the core of the city.
- Proper segregation of zones is required for the upcoming residential layouts from the industrial areas, as zoning protects residential areas from the harmful invasions of commercial and industrial uses and at the same time promotes the orderly development of industrial and commercial areas.

- Proper air quality management programmes; improve traffic flow and control which requires good city road network; improve fuel quality through reduction of sulphur; Proper legislative frame work to regulate and control vehicle emission in the city.
- Establishment of Satellite Townships around Mysore city to avoid congestions in the city.

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