Assessment of Air Quality in Manjunatha Nagara, Bangalore Urban

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Abstract- *The study reveals that Air Pollution in Manjunath Nagar, Bangalore has been monitored. The Pollutants measured to assess air quality have been the concentration of particulate matter ($PM_{2.5}$), & (PM_{10}) Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Ammonia (NH_3). The data were collected from sampling site of the city. In Manjunath Negara, (Residential area) Pollutants SO_2 NO_2, NH_3 were found to be below acceptable limits defined by the National Ambient Air Quality. Concentration of PM_{10} Increasing Due to heavy traffic and Other Metrological Data, in sampling site of the city. Concentration of $PM_{2.5}$ was found gradually increasing in Residential area.*

Keywords- $PM_{2.5}$, PM_{10}, SO_2, NO_2, NH_3 Air Quality Index.

I. INTRODUCTION

The existence of living organisms depends on the available natural resources that also regulate ecosystems. Atmospheric conditions are one of the resources that play a significant role in balancing these ecosystems. This atmosphere spacesuit of the biosphere held by force of gravity it is a mixture of different gases [1]. These gases vary in proportions due to various anthropogenic activities in urban and rural regions. In particular, the urban regions that have concentrated population and industries that lead to drastic changes in the proportions of these gases [2]. This cause the degradation of air quality that may result in Global Warming, cardiovascular and respiratory diseases, asthma, and cancer lung diseases in humans [3]. Poor air quality is a result of various activities like emission from both artificial and natural, including daily works. In cities, pollutant gases like SO_2 and NO_2 produced by Industrial works and in most urban areas, emissions from transportation of vehicles, were major contributor of harmful pollutants such as NO_2 and Particulate Matter [4].

II. STUDY AREA

For this present study, to establish AQI of urban Area, Bangalore city, capital of Karnataka was selected. The Bangalore City Corporation limits are enclosed longitude and latitude are shown in table 1.1. It is considered as one of the major Industrial, commercial and educational center & Technology center. Urbanization in India is more rapid around national capital and state headquarters. The city has taken dubious distinction of being the fastest growing metropolis in the country. The polarized development has significant impact on culture, economy and growth of not only surrounding areas but also on the City itself. Fig 1.1 shows the sampling stations are considered.

Table 1: Details of Sampling Locations

Sl. No	Sampling Locations	Location	Distance wrt Yashwanthpura police Station	Zone Type	Latitude & Longitude
1	Manjunath Nagar, Bangalore	60 feet road	7.2 km	Residential	12.98^0 N 77.55^0E

Figure 1. Location of Study Area in Bangalore

III. METHODOLOGY

Determination of concentration of PM2.5, PM10 and Gaseous Pollutant such as SO2, NO2, and NH3 was carried out as per guidelines given by CPCB (2009) India.

A. Meteorological Data

Meteorological data plays a very vital role in interpreting the ambient air Pollutants data since the ambient air is very dynamic. It is essential to understand the relation between meteorological factors and ambient air quality to correctly interpret the data and also to detect the source of Pollution. The ambient air quality is not influenced only by the rate at which pollutants are released but also by some physical parameters like meteorological conditions, wind speeds, direction of wind, temperature, humidity etc. which influence the concentration of Pollutants by dispersion or diffusion. Bangalore city has a tropical climate. It is more vehicular density and populated area and well establishing place for industries also. Thus the weather is typically hot and humid. The Meteorological data needed for the study was collected from the Climate.

B. Air Sampling Method

Gravimetric method was followed in PM2.5 & PM10, SO2 Improved West and Geake Method NO2 Modified Jacob & Hochheieser,NH3 Non dispersive Infrared (NDIR) Spectroscopy analysis. After due analysis of PM2.5 PM10, SO2, NO2, & NH3 the samples for the period from Dec 2016 to May 2017 were treated and analyzed for different Pollution. Monitoring was carried out once in a monthly on 24 hours basis with a sampling frequency of 8 hours. For each month, 2 days samples were collected. All these samples were processed together on basis of day. Thus, number of samples is 5 for 6 months for one location so, a total of 90 samples were processed, 30 samples for each locations. The mean value calculated gives the status of pollution level of studied area. Test results and other related data are compiled and processed to meet the objectives of study. The data and results are presented in tables and also graphically to have the glimpse of the study. Based on the data, discussions were presented location wise and then together.

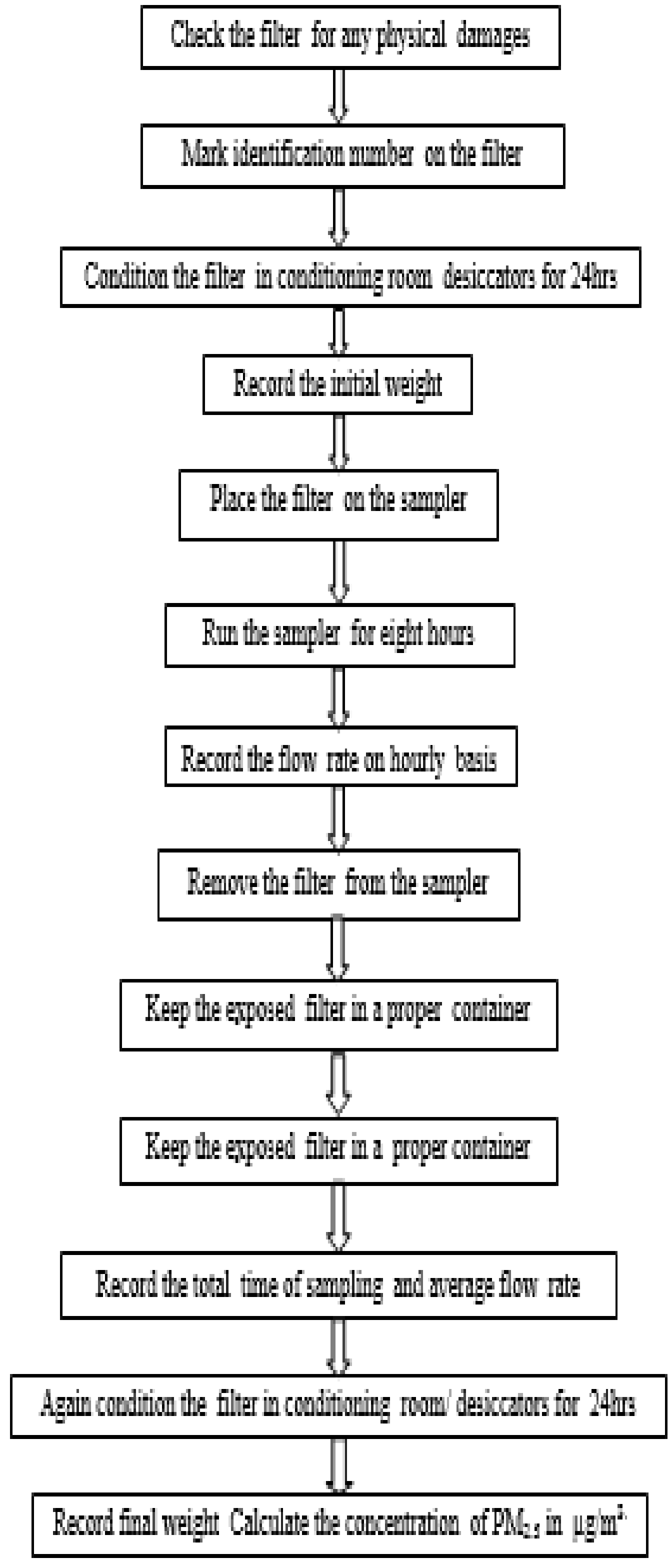


Figure 2. Flow Diagram for Procedure of PM2.5

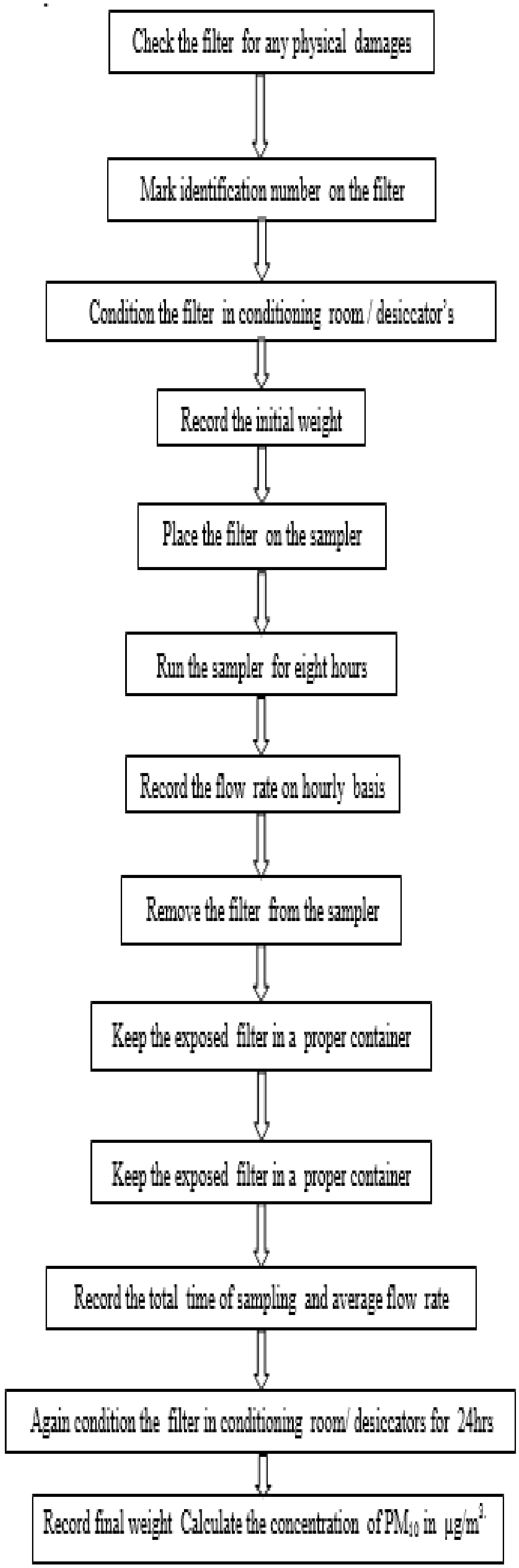


Figure 3. Flow Diagram for Procedure of PM10

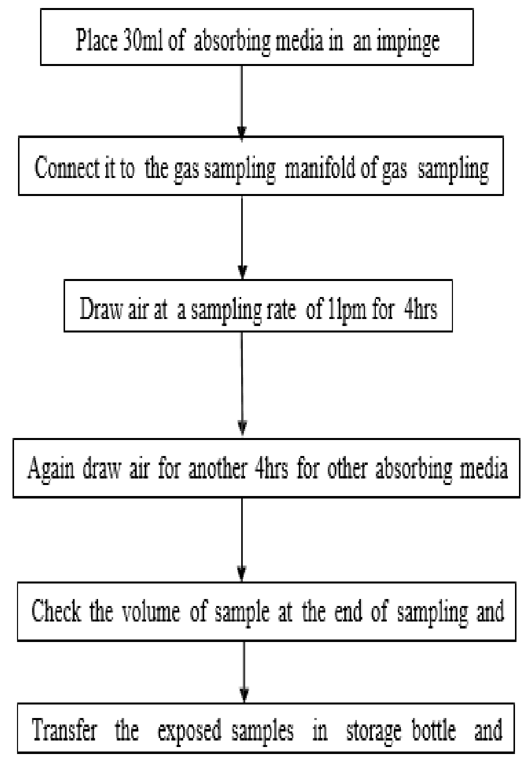


Figure 4. flow Diagram for Monitoring of SO2, NO2, NH3

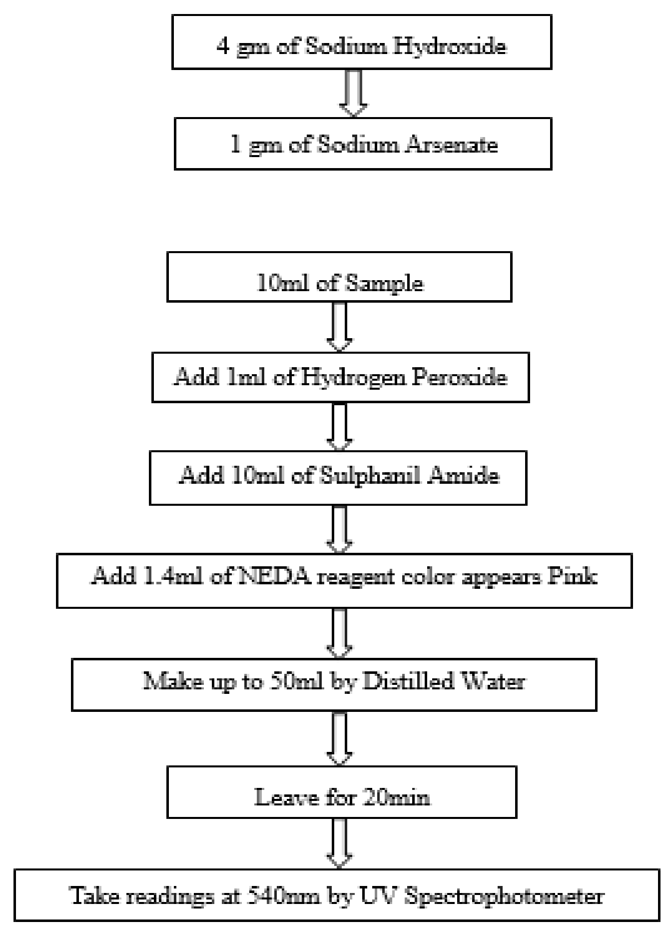
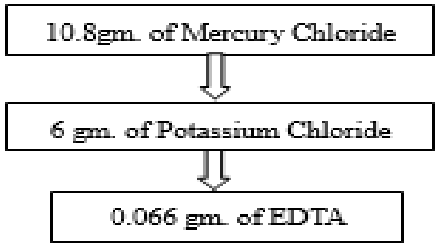


Figure 6. flow Diagram for Laboratory Analysis of SO2



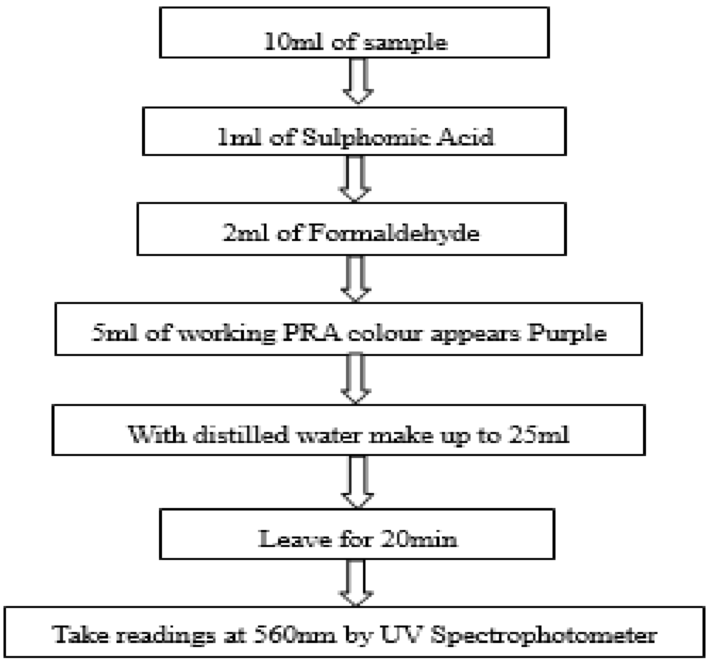
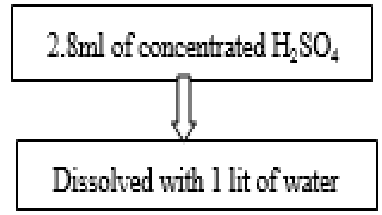


Figure 5. flow Diagram for Laboratory Analysis of NO2



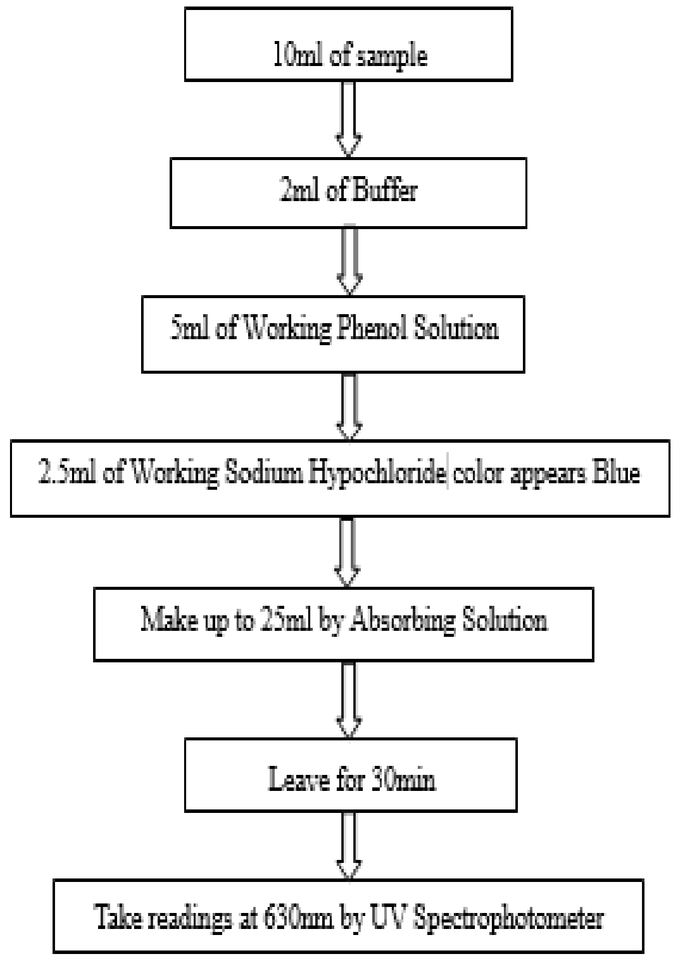


Figure 7. flow Diagram for Laboratory Analysis of NH3

D. Standards for National Ambient Air Quality

National Ambient Air Quality Standards Notified by Government of India are placed in Table 2.

Table 2. Natinal Ambient Air Quality Standars(2010)

Pollutants	**Time weighted average**	**Ambient air Concentration**		**Measurements and Methods**
		Industrial reside ntial and rural	Sensitive areas such as residential, rural,	

Particulate matter (size less than 3	Annual 24 hours	40 60	40 60	Gravimetric TEOM Beta attenuation
Particulate Matter(size less than (10µg/m^3)	Annual 24 hours	60 100	60 100	Gravimetric
Sulphur Dioxide (SO_2µg/m^3)	Annual 24 hours	50 80	20 80	Improved West Gaeke method-
Nitrogen Dioxide (NO_2µg/m3)^3	Annual 24 hours	40 80	30 80	Jacob& Hochhesier Method
Ammonia (NH3µg/ m^3)	8 hours 1 hours	100 400	100 400	Non dispersive Infrar ed(ND IR)

E. Air Quality Index (AQI)

AQI method helps to evaluate and classify the ambient air. The consecutive number of observation, measure and indicator or the major concentration monitored and subsequently calculate or convert into the AQI (Table 3) by using the standard formula
[16].

Table 3. Shows the Air Quality Categories Based on AQI [16]

Classes	AQI Ranges	Ambient air quality
I	0-	Goo
I	51-100	Satisfactory
II	101-200	Moderately polluted
I	201-300	Po
V	301-400	Very poor
V	>4	

The Index air quality pollutant for each pollutant calculation using this formula.

Q=V*100/Vs

Q = Quality rating.
V = the absorbed value of the pollutants.
Vs = Standard value recommended for that pollutants.

The total n indicates the number of pollutant consider for monitoring the air
G= Anti log [(loga + logb + logc± logx) / n]

G= Geometric mean

n = the number of values quality rating.

F. Factor Analysis

It is obvious from above categorization. The location in either of the first two categories are actually not meeting the standards, although, with varying magnitude (CPCB). Those falling in the third category are meeting the standards as of now but likely to exceed the standards in future if pollution continuous it and is increase and not controlled however, the location in low pollution category have a rather clean air quality and such areas are to be maintained at low pollution level by way of adopting preventive and control measures of air pollution, the pollution control classification Given in Table 4

Table 4. Factor Analysis Categories (CPCB)

Pollutant level	Annual mean concentration range (g/m^3)					
	Industrial, residential, rural and other area			Ecologic , residential, rural		
	SO_2	NO_2	PM_{10}	SO_2	NO_2	NH_3
Low(L)	0-25	0-20	0-30	0-10	0-15	0-30
Moderate(M)	26-25	21-40	31-60	11-20	16-30	31-60
High(H)	51-75	41-60	61-90	21-30	31-45	61-90
Critical (c)	>75	>60	>90	>30	>45	>90

Table 5. Sources and Effects of Common Air Pollutants [15]

Pollutant	Main Source	Major Effect on Air Quality and Climate Change
Particulate Matter ($PM_{2.5}$ & PM_{10})	Combustion process from industries and transport, Dust and sandstones	Affects human health, Provides a negative Contribution to radiative forcing.
Nitrogen Dioxide (NO_2)	Burning of fossil fuels, example generating of electric power, road transport	Its promotes ozone formation, NO_2 health Affect for human, & green-house effect, cooling of atmosphere affected by nitrates & acidification, eutrophication.
Sulphur0Dioxide (SO_2)	Burning of fossil fuels example Combustion from industries and domestic	It causes atmosphere cooling, Health affect For human, acidification in environment.
Ammonia(NH_3)	This is mainly production and management of manor & livestock formation and slurry.	It helps to formation of aerosol of sulphate and nitrate its affect to human health, atmosphere cooling, eutrophication & acidicifacation in surrounding environment.

Table 6. Pollutants Sources and their Effects [15]

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Sulphur Dioxide (SO_2)	Burning of fossil fuels example Combustion from industries and domestic	It causes atmosphere cooling, Health affect for human, acidification in environment.
Ammonia(NH_3)	This is mainly Production and management of manor & livestock formation and slurry.	It helps to formation of aerosol of sulphate and nitrate its affect to human health, atmosphere cooling, eutrophication & acidicifacatio

G. Calculation

(i) Calculation of PM2.5

PM2.5 = (Mf – Mi) /Vx 102 µg

V = Qavg x Vt 10-3 m3

PM2.5 = M2.5 /V

Where,

PM2.5 = mass concentration of PM2.5 in µg/m3.

W1= Initial weight of the filter in g

W2 = Final weight of the filter in g

V= Volume of air sampled in m3

103 = Conversion factor of g to µg

(ii) Calculation of PM10

PM10 =V= (Q). (t)

Where, V = volume of air, m3

Q = average sampling rate, m3/min, t = time in minutes.

 Calculation of PM10 concentration in ambient air: PM10 = [(W2 -W1) *10 6]/ V

Where,

PM10 = mass concentration of PM10 in µg/m3.

W1= Initial weight of the filter in g

W2 = Final weight of the filter in g

V= Volume of air sampled in m3

106 = Conversion factor of g to µg

(iii) Calculations for SO2

NO2 = (As- Abs) ×CF×VS1000 / VAVT

As = sample absorbance

Abs = reagent blank absorbent

CF = Calibration factor

VS = volume of air sample in ml

VA = volume of air sample in lit

VT = volume of air a liquid taken for analysis.

(iv) Calculations for NO2

NO2 = (As-Ab)×CF×Vs×1000 / VA×Vt×0.82

As=sample absorbance

Ab = reagent blank absorbent

CF = calibration factor

VS = volume of air sample in ml

VA = volume of air sample in lit

Vt = volume of air a liquid taken for analysis in ml

(v) Calculations for NH3

C NH3 = (As-Ab)×CF/Va

C NH3 = Concentration of Ammonia in mg/m3

As=sample absorbance

Ab = reagent blank absorbent

CF = calibration factor

VS = volume of air sample in ml

Va = volume of air a sampled im m3

IV. RESULTS AND DISCUSSIONS

A. PM10 concentrations

PM10, PM2.5, SO2, NO2, & NH3 concentrations are fully Complied with National Standards complied with the National Standards PM10 (100), PM2.5 (60), SO2 (80), NO2 (80) & NH3 (400) µg/m3 .During the entire study period PM2.5 varied from (41.11), PM10 (63.84), SO2 (1.01-3.9), NO2 (5.03 7.10), NH3 (6.65-8.11) µg/m3 was recorded in the month of Feb. PM10 44µg/m3 value was recorded in the month of April 2017 and the maximum monthly value of 54µg/m3 was recorded in the month of March. And for PM2.5 the minimum monthly value 63 µg/m3 value was recorded in the month of May 2017 and maximum monthly value 84 µg/m3 was recorded in the month of Dec 2016, The gaseous Pollutant of SO2 The minimum monthly varies 1.01µg/m3 value was recorded in the month of Jan 2017 and the maximum monthly value of 3.9µg/m3 was recorded in the month of April.For NO2 minimum monthly varies 5.03 µg/m3 value was recorded in the month of Feb 2017 and the maximum monthly value of 7.10µg/m3 was recorded in the month of April, for NH3 minimum monthly varies 6.65µg/m3 value was recorded in the month of Jan 2017 and the maximum monthly value of 8.11µg/m3 was recorded in the month of Feb. The slightly higher value may be due to heavy speed and direction which is common in Bangalore. In general, the data was hovering around without much significant variations and trend either. Season wise, wind wise.

Table 7. Pollutant Monitored at in Manjunath Nagar

Month (2017)	Season	PM2.5	Volume of Air	PM10	Volume of Air	Total PM	SO2	NO2	NH3	AQI
Units		$\mu g/m^3$	L min^{-1}	$\mu g/m^3$	in (m^3)	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
Dec 16	Winter	44.20	22.97	84.32	1598.4	128.52	1.10	6.69	7.20	33.90
Jan 19		46.29	22.89	78.69	1620	124.98	1.013	6.9	6.65	33.50
Feb 25		41.11	23.11	68.7	1605.6	109.81	2.17	5.03	8.11	29.65
Mar 27	Summer	54.00	16.87	63.00	1580	117.00	2.80	6.00	8.00	33.20
April 16		44.00	22.60	69.50	1608	113.50	3.90	7.10	7.40	31.75
May 6		41.40	24.00	63.00	1580	104.40	2.20	5.80	7.00	34.50

Note: *exceeding the permissible limit, + Annual permissible limit:

B. Seasonal Variation

Table 8: seasonal variation in Manjunath Nagar

Locations 1	Summer	Winter
Units	$\mu g/m^3$	$\mu g/m^3$
$PM_{2.5}$	43.86	46.86
PM_{10}	77.23	65.16
SO_2	1.42	2.29
NO_2	6.2	6.3
NH_3	7.32	7.4

Particulate matter are exceeding the permissible limits annually and also daily variations are found to be high, seasonal variations for scenario analysis are with respect to particulate matter and wind speed and direction only.
Winter Integrating the wind speed, direction and the pollutant concentration in a particular location, the areas that are prone to higher risk are to be identified. This justifies the areas that are at a risk.

In residential area, north to south wind direction (3.6-5.7 m/s) is dominant. The seasonal variations indicted that during winter the exceedances factor (EF) for particulate matter though moderate (EF<1) will have high impact on the area located in the southern part of location 1(Gopalanagar).

Table 9. Exceedence Factor for the Pollutant Monitored at Manjunatha Nagar

Month (2017)	$PM_{2.5}$ $\mu g/m^3$	PM_{10} $\mu g/m^3$	SO_2 $\mu g/m^3$	NO_2 $\mu g/m^3$	NH_3 $\mu g/m^3$
Dec 16	0.74	0.84	0.013	0.08	0.072
Jan 19	0.77	0.79	0.013	0.09	0.067
Feb 25	0.68	0.69	0.027	0.06	0.08
Mar 27	0.9	0.63	0.035	0.07	0.08
April 16	0.73	0.70	0.049	0.09	0.074
May 6	0.69	0.63	0.027	0.07	0.07

Wind Velocity Wind Direction

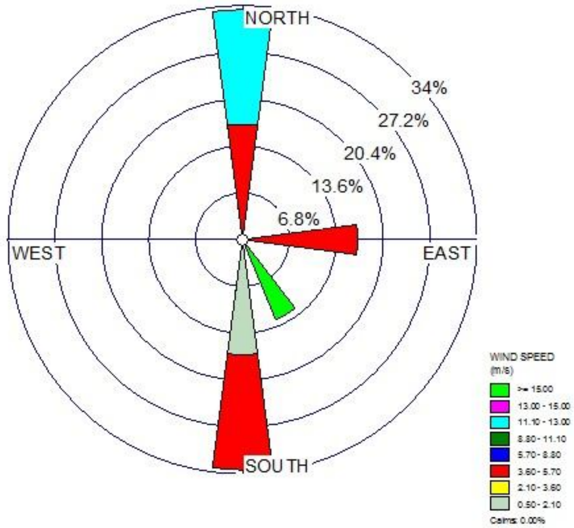

Figure 8. Wind rose Diagram for December

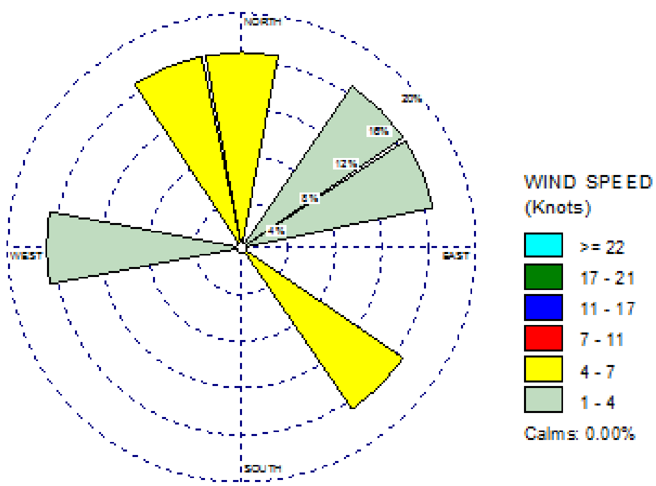

Figure 9. Wind rose Diagram for March

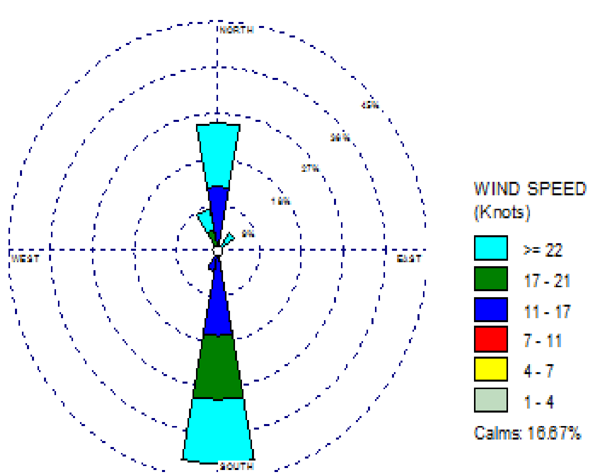

Figure 10. Wind rose Diagram for April

V. CONCLUSION

Monthly increasing trend in PM were observed and hence monitoring of represented samples indicated that in locations.

a) Summer- Manjunath Nagar increasing PM2.5 is at risk.
b) Winter- Manjunath Nagar leading the pollution. It is at risk with PM2.5 and PM10.

- The analysis indicates the levels of PM2.5 in area which are mostly affected influential change in most daily life activities a significant increase in aspects of vehicular emission, industrialization (heavy duty and light industry), constructions, populations growth, commercial activities, etc. which have caused the positive trends in PM2.5 concentrations. Mean concentration of Fine Particulate matter is slightly high (54.00) in Manujnath Nagar.
- The effect of exposure to PM10 (84.32) in Manjunath Nagar is rising compare to old data but statistically significant in relation to the general mortality pattern. Hospitals, Schools, Play homes or playground sports activities should not be their due to increasing trend.
- NO2, SO2, NH3 are displayed lower level in urban area it largely results from traffic and metrological conditions The trend of the pollutant concentration of NO2, SO2, NH3 are found to be increasing comparatively with past data.

REFERENCES

[1] Hamza Ahmad Isiyaka and Azman Azid (2015), "Air quality pattern assessment in Malaysia using multivariate techniques", Malaysian Journal of Analytical Sciences, Vol. 19, No. 5, pp. 966-978.

[2] Marcellin Adon, Ve ronique Yoboue, Corinne Galy Lacaux, Catherine Liousse, Babakar Diop, El Hadji Thierno Doumbia, Eric Gardrat, Seydi Ababacar Ndiaye, Christian Jarnot (2016), "Measurements of NO2, SO2, NH3, HNO3 West African urban environments", Atmospheric Environment, Vol.135, pp.31-40.

[3] Viney P.Aneja, A. Agarwal, Paul A. Roelle, Sharon B. Phillips (2001), "Measurement and Analysis of Criteria Pollution in New Delhi, India", Environmental International, Vol. 27, pp.35-42.

[4] Chatrapatty Bhugwant and Philippe Bremaud (2001), "Simultaneous Measurements of Black Carbon, PM10, Ozone and NOx Variability at a Locally Polluted

Island in the Southern Tropics", Journal of Atmospheric Chemistry, Vol.39, pp.261-280.

[5] Central Pollution Control Board, (CPCB) (2009) - National Ambient Air Quality Index, Bulletin of National Ambient Air Quality

[6] Rajiv Ganguly and Shabnam Thapa (2016), "An assessment of ambient air quality in Shimla city", Research article, Vol. 111, pp.509-516.

[7] Jason Jingshi, Boi Faltings, Olga Saukh, David Hasenfratz and Jan Beutel (2012), Sensing the Air We Breathe-The Open Sense Zurich Dataset", Artificial Intelligence Laboratory, Switzerland, pp.3-6.

[8] Y.M.Fahmy, P.Fornasiero S. Zinoview and S. Mertus (2007),"Air Pollution Control Technologies", International Center for Science and high technology, Reference Book.

[9] Xiaoping Wang, Denise L. Mauzerall (2006), "Evaluating impacts of air pollution in China on public health: Implications for future air pollution and energy policies", Atmospheric Environment, Vol. 40, pp.1706-1721.

[10] Brendan O'Leary, John J. Reiners Jr. Xiaohong Xu, Lawrenec D (2016), "Identification and influence of spatial-temporal outliers in urban air quality measurements", Atmospheric Environment, Vol.73, pp.55-65.

[11] Federico Karagulian, Claudio A. Belis, Carlos Francisco C. Dora, Annette M Pruss-Ustun, Sophie Bonjour, Heather Adair-Rohani, Markus Amann (2015), "Contributions to cities ambient particulate matter (PM): A systematic review of local source contributions at global level, Atmospheric Environment, Vol. 120, pp.475-483.

[12] Liousse C, Assamoi E, Criqui P, Granier C, Rosset R (2014), "African combustion mission explosive growth from 2005 to 2030", Environ. Res.Lett, Volume. 9, pp.1-5.

[13] Sahoo D., Dash A.K., Sahu S.K. (2017), "Ambient air quality monitoring and health impact study of air pollution near Joda of Keonjhar, Odisha, India", International Journal of Engineeing Sciences and Research Technology, Vol. 6, pp.1 -5