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Study on Temporal and Spatial Variation of $PM_{2.5}$ on South Delhi

Javed Iqbal Siddiqui[1,*], Syed Khursheed Ahmad[1]

[1]*Department of Civil Engineering, Al Falah School of Engineering and Technology, Alfalah University, Dhauj, Faridabad, Haryana, India*

[*]*Corresponding Author: Javed Iqbal Siddiqui*

ABSTRACT

A high pollution level of $PM_{2.5}$ particles is dangerous and harmful to human health as it causes deep penetration into the lungs. It can reach the alveolar region as well as have the potential to reduce the visibility of environment. A key objective of this work is to understand the patterns of spatial and temporal variability of pollutants, particularly $PM_{2.5}$. Ten stations have been selected for the monitoring of $PM_{2.5}$ for 24 hour duration in south Delhi at residential, institutional, commercial and industrial area. Portable Aerosol spectrometer model 1.108 (Real time GRIMM Dust monitor) has been used. The average concentration of $PM_{2.5}$ is found 109µg/m^3 at Jamia Nagar, 115µg/m^3 at Jasola, 113µg/m^3 at Zakir Nagar, 114µg/m^3 at New Friends Colony, 117µg/m^3 at Abul Fazal Enclave, 119µg/m^3 at Shaheen Bagh, 121µg/m^3 at East of Kailash, 124µg/m^3 at Nehru Place, 122µg/m^3 at Maharani Bagh, 126µg/m^3 at Lajpat Nagar. These observed concentrations are significantly higher than National Ambient Air Quality (NAAQ) standards, suggesting poor quality of air at South Delhi which requires action by public authorities at the national, regional and local levels to improve the air quality.

Keywords: Urban area, air quality, monitoring, $PM_{2.5}$

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I. INTRODUCTION

Urban air pollution is a major health and environmental concern worldwide, and the levels are extremely high in Delhi. This work is focused on the spatial and temporal variability of air pollutant concentration ($PM_{2.5}$) in South Delhi. Rapid economic development, industrial expansion and urbanization led to serious air pollution problems, increasingly occurrence of haze or smog episodes characterized by the high fine particulate matter levels. Urban $PM_{2.5}$ originates mainly from sources such as traffic-related emissions, road/soil dust, biomass burning, construction and agriculture activities as well as regional transported aerosols. Chronic exposure to $PM_{2.5}$ has negative effects on human health, including increased morbidity from respiratory problems, cardiovascular problems and lung cancer. The air quality has worsened due to the rapid social and economic development in recent years due to which more attention required on the studies of $PM_{2.5}$. Therefore, long-term $PM_{2.5}$ concentration monitoring and accurate estimations of $PM_{2.5}$ concentrations have become crucial to epidemiological research. Fine particulate matter ($PM_{2.5)}$ are tiny particles in the air that reduce visibility and cause the air to appear hazy when levels are elevated and concern for people's health as well. These smaller particles penetrate deep into the lungs and can reach the alveolar region. According to the World Health Organization (WHO), air pollution is responsible for 7 Million deaths worldwide every year.

Kumar and Joseph (2006) had worked on $PM_{2.5}$ and PM_{10} to understand the fine particle pollution in compliance with ambient air quality standards in Mumbai (India). The average $PM_{2.5}$ concentration at ambient and at was 43µg/m3.The research was initiated to study the air quality in the city of Kanpur (India) in terms of PM_{10} and $PM_{2.5}$. From three sampling locations total forty-seven 24-h samples were collected for $PM_{2.5}$ and PM_{10} during October 2002–February 2003 at these locations. PM_{10} (45–589µg m^{-3}), $PM_{2.5}$ (25–200µg m^{-3}). Atinder Pal Singh (2014) had worked on the temporal characteristics of aerosols mass concentration (PM_{10}, $PM_{2.5}$, and PM1), size distribution and optical depth from December 2011 to November 2013 over Patiala. PM10, PM2.5, and PM1 varied from 71 to 221, 27 to 92, and 17 to 75µg/m3, respectively, with the highest concentration of PM10 during summer of 2012, and PM2.5 & PM1 during autumn of 2013. The research was initiated to study the air quality in the city of Lucknow. Particulate fractions viz.; PM2.5, PM10 and SPM were reported to be exceeded the National Ambient Air Quality Standards (NAAQS) limits in most of the studies. The research was initiated to study the air quality in the city of Delhi (India), between 2008 and 2011, averaged 123±87µg/m^3 for $PM_{2.5}$ and 208±137µg/m^3 for PM_{10}, both exceeding the national annual ambient standards of 40µg/m^3 and 60µg/m^3. The study presents data on the size characterization concentration of PM_{10} and $PM_{2.5}$. These particulate concentrations were monitored from October-07 to March-09 indoors and outdoors of five roadside and five urban homes using Grimm aerosol spectrometer in Agra, India. Annual average concentrations of coarse particles (PM_{10}) indoor and outdoor were 247µg m^{-3} and 255µg m^{-3} at roadside houses and 181µg m^{-3} and 195µg m^{-3} at urban houses. For fine particles ($PM_{2.5}$) the annual mean concentrations were 161µg m^{-3} and 160µg m^{-3} at roadside houses and 109µg m^{-3} and 123µg m^{-3} at urban houses. Total concentrations and speciation of metals had been studied in TSP of Guiyang by Wu et al. (2008) from April 2006 and January 2007 in PR China. The total average concentrations of five sites were found as 263 and 75.5µg /m3 for SPM and PM10. Mahmud et al. 2008, Dhaka, Aerosol particulate matters and heavy metal concentrations were measured in Dhaka. The overall average concentrations of TSP, PM10 and PM2.5 were 68, 43 and 35µg/m3 respectively. The Canadian NAPS (National Pollution Surveillance air network**)** has produced one of the largest and more geographically diverse databases. A maximum of ten and a minimum of two years of data are available for 19 Canadian locations. Amongst all locations and all 24-hour measurements, the 10th and 90th percentile TSP concentrations were 22 and 98µg m-^{3}, respectively. A majority of the PM_{10} concentration was below 47µg m-^{3} and most of the $PM_{2\ 5}$ concentrations across Canada were below 26µg m-3. At Switzerland collocated parallel measurements of PM2.5 and PM10 were conducted at 7 sites in January 1998, constituting now one of the longest comparative data sets for PM2.5 and PM10 in Europe. The range of the long-term mean concentrations of PM2.5 was between 7.9µg/m^3 at Chaumont and 24.4µg/m^3 in Lugano.

II. MATERIALS AND METHOD

Under the provisions of the Air (Prevention & Control of Pollution) Act, 1981, the CPCB has notified fourth version of National Ambient Air Quality Standards (NAAQS) in 2009. This revised national standard aims to provide uniform air quality for all, irrespective of land use pattern, across the country.

2.1 SAMPLING SITE SELECTION

The sampling locations have been described in the below table. The sampling sites have been selected in institutional area, commercial area, residential area as well as industrial area.

S.N	Location	Address Location	Latitude (Degree N)	Longitude (Degree E)
1	Jamia Nagar	Jamia Millia Islamia	28.5621	77.2841
2	Jasola	Sports Stadium	28.5473	77.2891
3	Zakir Nagar	DDA Park	28.5691	77.2786
4	New Friends Colony	Community Centre	28.5675	77.2691
5	Abul Fazal Enclave	God Grace School	28.5592	77.2933
6	Shaheen Bagh	EID GAH	28.5513	77.2970
7	East of Kailash	SFS	28.5583	77.2531
8	Maharani Bagh	Near CRRI	28.5715	77.2640
9	Nehru Place	EROS H.O	28.5503	77.2502
10	Lajpat Nagar	Central Market	28.5677	77.2433

2.2MONITORINGINSTRUMENTDESCRIPTION

The optical display of the device consists of a LCD with 2 x 16 digits. The display indicates the results, date, time, location, battery status, storage interval etc. The instrument has an internal 80 kByte memory.

The instrument has 10 functional keys with (ON/OFF**)**. In order to switch off the instrument, the ON/OFF key must be pressed for approximately one second till a beep will sound. The air enters the device via the sample inlet and is forwarded in a straight short way into the optical chamber. The aerosol spectrometer can be power supplied by a mains adapter. The serial interface is a 9-pin socket located at the front panel of the device via this interface the dust monitor can be controlled and measurement data can be sent to an external printer or PC. The sample air is sucked in through a gravimetric filter after leaving the optical chamber. This filter serves as dust collector and can be used for gravimetric controls of the optical gained measurement results. The model designation and serial number 8 digits are named on the label on the rear panel of the device. 1.2 liter air per minute which have been sucked in through the sample inlet at the front panel leave the sample outlet on the rear panel of the device. The sample outlet is covered by an end cap. In order to take the lead storage battery in or out of the device the securing button has to be pressed. The battery engages with an audible clicking. The lead storage battery enables an off line power supply of the dust monitor for 6 to 8 hours.

2.3 MONITORING PROCEDURE

The monitoring has been done at one hour interval at all selected stations by GRIMM Portable Laser Aerosol spectrometer and Dust Monitor Model 1.108 which have been built for continuous measurement of airborne particles. The data can be displayed as particle concentration in the unit µg/m^3. The measuring principle is the light scattering of single particles with a semiconductor laser as light source. Inside the measuring cell the scattering light is being led directly and via a mirror with a wide opening angle onto the detector.

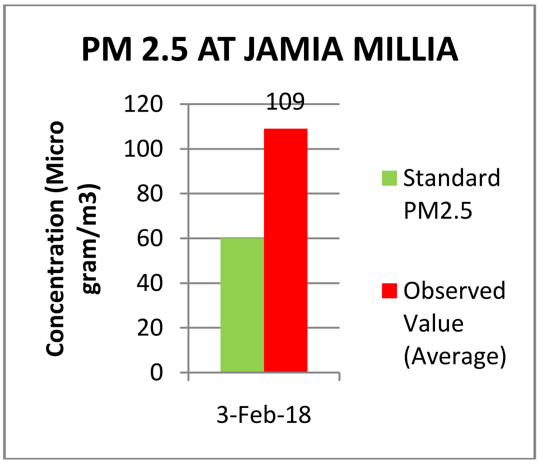
The detector is positioned in the right angle to the incident laser beam. This setup of the detector is denominated as 90° scattering light detection. Therefore even very small particles down to 0.25µm respectively 0.3µm can be detected. If a particle crosses the laser beam, it creates a light pulse. This instrument possesses 15 size channels. This way the particle size distribution can be measured which provides the basis for the calculation of the dust mass. The sample air is sucked through the measuring cell and a gravimetric filter by means of an internal volume flow controlled pump. The pump also conveys the rinsing air, which is gained out of the pump's exhaust air via a zero filter and being held constant by a rinsing air control. The rinsing air protects the laser optics just as other components of the optical measuring cell from pollution and serves during the self-test as particle-free reference air. The self-test lasts about 30 seconds. Afterwards the actual measurement starts and the LCD-display shows continuously every six seconds the data. This enables real-time measurements of the dust concentration. At the same time all measuring results will be transmitted to the storage card and data can be transmitted to an external PC or printer.

III. RESULTS AND DISCUSSION

The results along with standard values are described with the respective location, time and place with the comparative analysis of permissible standard.

3.1 Results Of Pm$_{2.5}$ At Jamia Nagar

Fig 1 shows the variation of PM$_{2.5}$ in 24 hours at Jamia Nagar. The concentration monitored value with permissible standards shows that the monitored value is always higher than the prescribed standards. Average value of PM$_{2.5}$ is found 109µg/ m^3.



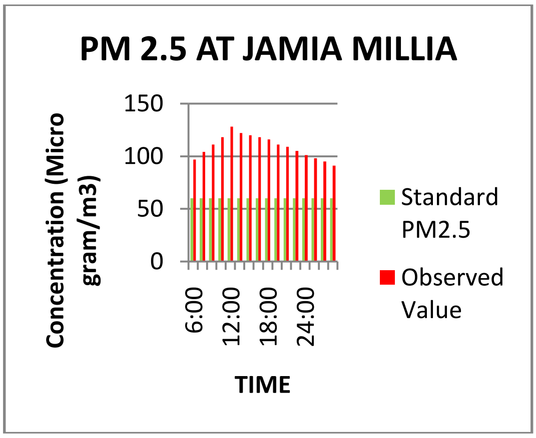


Fig 1: Comparative Analysis of PM$_{2.5}$ with permissible standard.

3.2 Results Of Pm$_{2.5}$ At Jasola

Fig 2 shows the variation of PM$_{2.5}$ in 24 hours at Jasola. The concentration monitored value with permissible standards shows that the monitored value is always higher than the prescribed standards. Average value of PM$_{2.5}$ is found 115µg/ m^3.

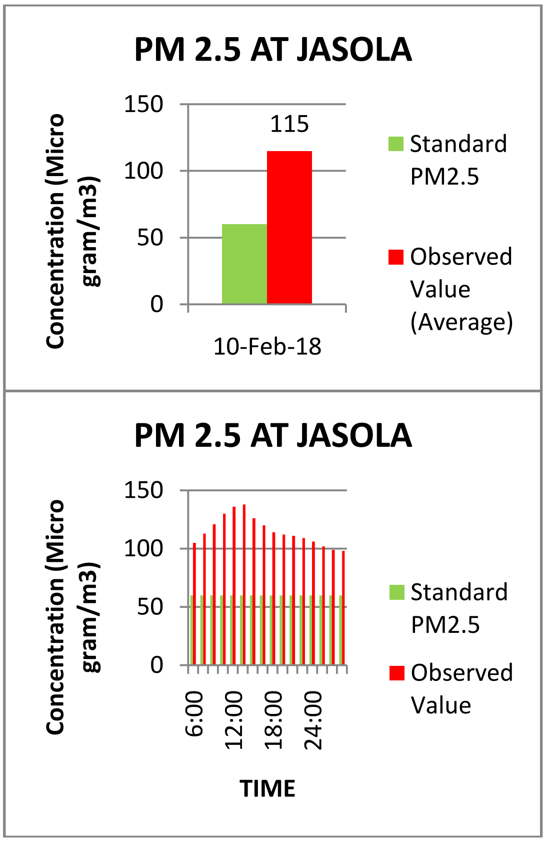
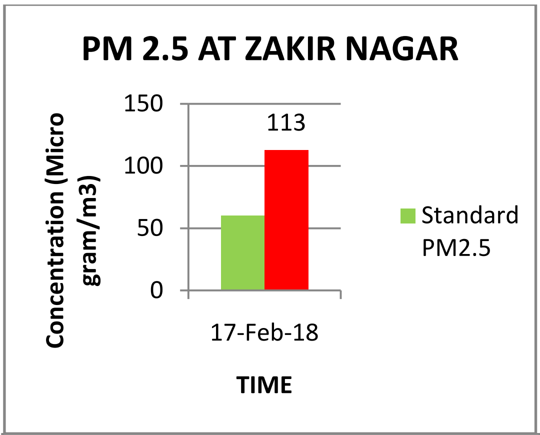


Fig 2: Comparative Analysis of PM $_{2.5}$ with permissible standard.

3.3 Result, Pm$_{2.5}$ At Zakir Nagar

Fig 3 shows the variation of PM$_{2.5}$ in 24 hours at Zakir Nagar. The concentration monitored value with permissible standards shows that the monitored value is always higher than the prescribed standards. Average value of PM $_{2.5}$ is found 113µg/ m^3.



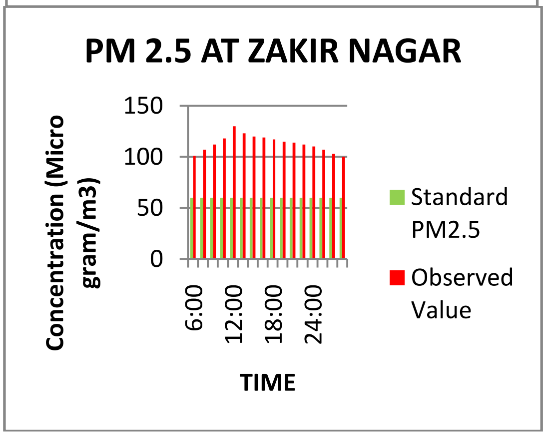
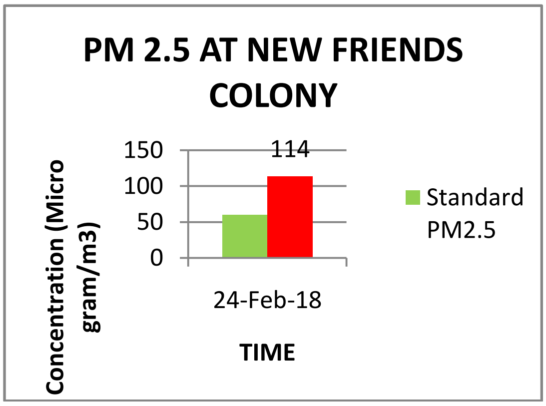


Fig 3: Comparative Analysis of $PM_{2.5}$ with permissible standard.

3.4 Results Of $Pm_{2.5}$ At New Friends Colony

Fig 4 shows the variation of $PM_{2.5}$ in 24 hours at New Friends Colony. The concentration monitored value with permissible standards shows that the monitored value is always higher than the prescribed standards. Average value of $PM_{2.5}$ is found 114µg/ m^3.



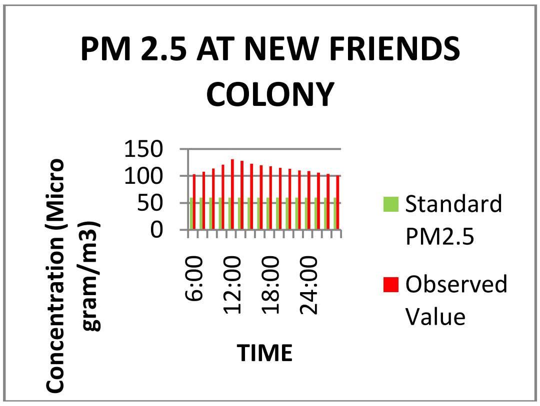
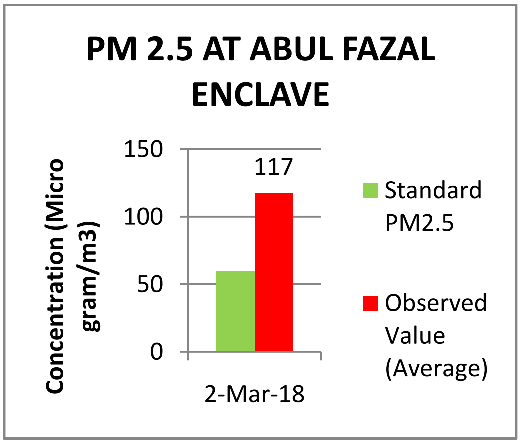


Fig 4: Comparative Analysis of $PM_{2.5}$ with permissible standard

3.5 Results Of $Pm_{2.5}$ At Abul Fazal Enclave

Fig 5 shows the variation of $PM_{2.5}$ in 24 hours at Abul Fazal Enclave. The concentration monitored value with standards shows that the monitored value is always higher than the prescribed standards. Average value of $PM_{2.5}$ is found 117µg/ m^3.



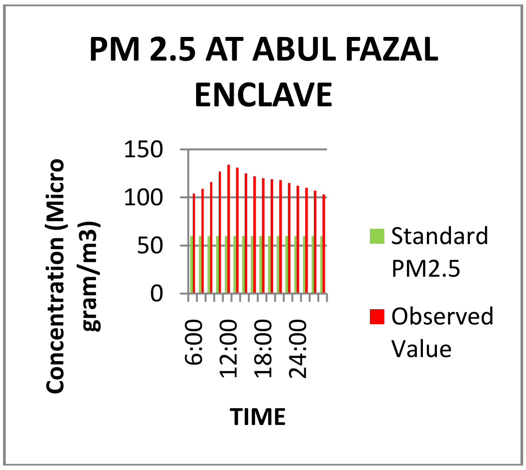
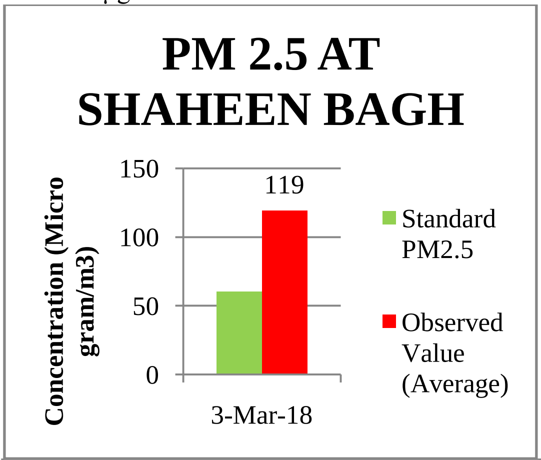


Fig 5: Comparative Analysis of $PM_{2.5}$ with permissible standard.

3.6 Results Of $Pm_{2.5}$ At Shaheen Bagh

Fig 6 shows the variation of $PM_{2.5}$ in 24 hours at Shaheen Bagh. The concentration monitored value with permissible standards shows that the monitored value is always higher than the prescribed standards. Average value of $PM_{2.5}$ is found 119µg/ m^3.



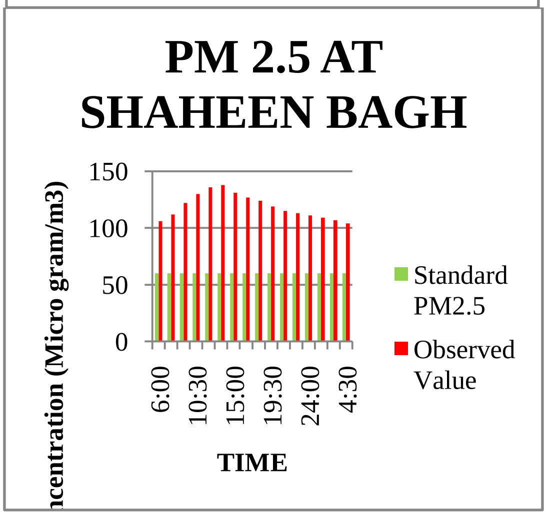
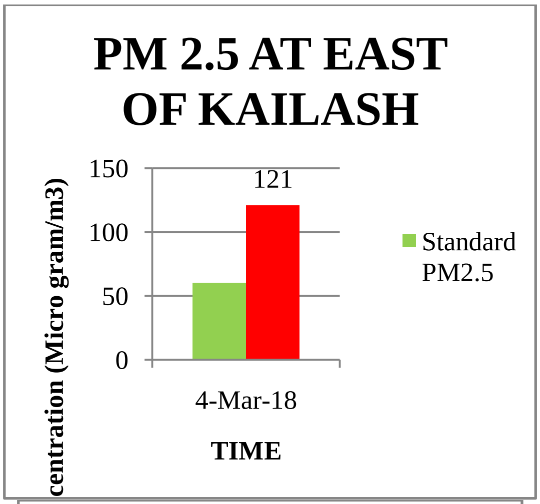


Fig 6: Comparative Analysis of $PM_{2.5}$ with permissible standard.

3.7 Results Of $Pm_{2.5}$ At East Of Kailash

Fig 7 shows the variation of $PM_{2.5}$ in 24 hours at East of Kailash. The concentration monitored value with permissible standards shows that the monitored value is always higher than the prescribed standards. Average value of $PM_{2.5}$ is found 121µg/ m^3.



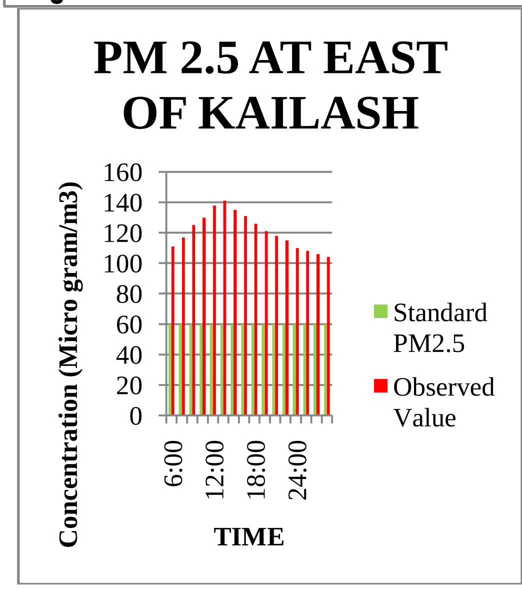


Fig 7: Comparative Analysis of $PM_{2.5}$ with permissible standard.

3.8 Results Of $Pm_{2.5}$ At Maharani Bagh

Fig 8 shows the variation of $PM_{2.5}$ in 24 hours at Maharani Bagh. The concentration monitored value with permissible standards shows that the monitored value is always higher than the prescribed standards. Average value of $PM_{2.5}$ is found 122µg/ m^3.

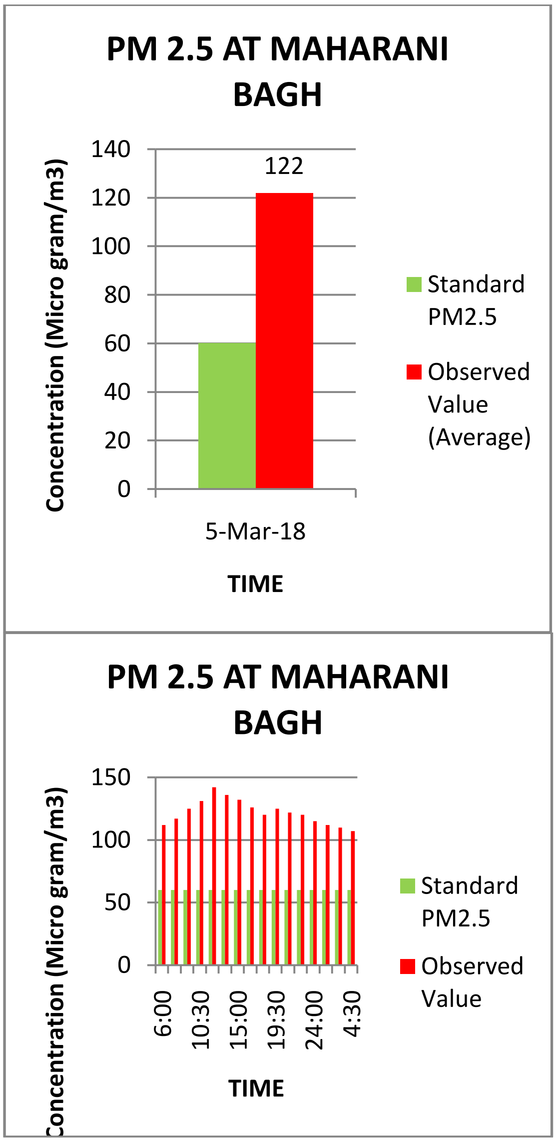


Fig 8: Comparative Analysis of $PM_{2.5}$ with permissible standard.

3.9 Results Of $Pm_{2.5}$ At Nehru Place

Fig 9 shows the variation of $PM_{2.5}$ in 24 hours at Nehru Place. The concentration monitored value with permissible standards shows that the monitored value is always higher than the prescribed standards. Average value of $PM_{2.5}$ is found 124µg/ m^3.

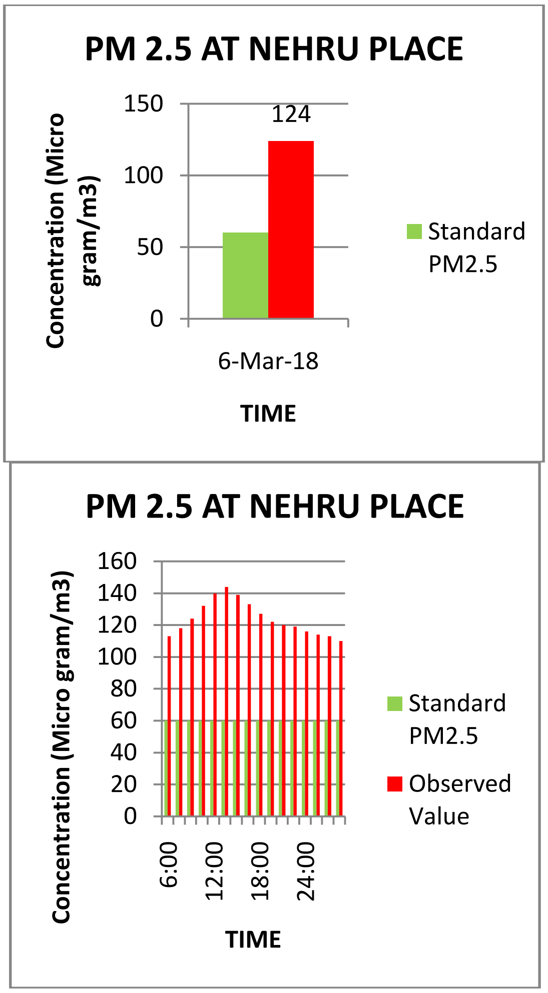
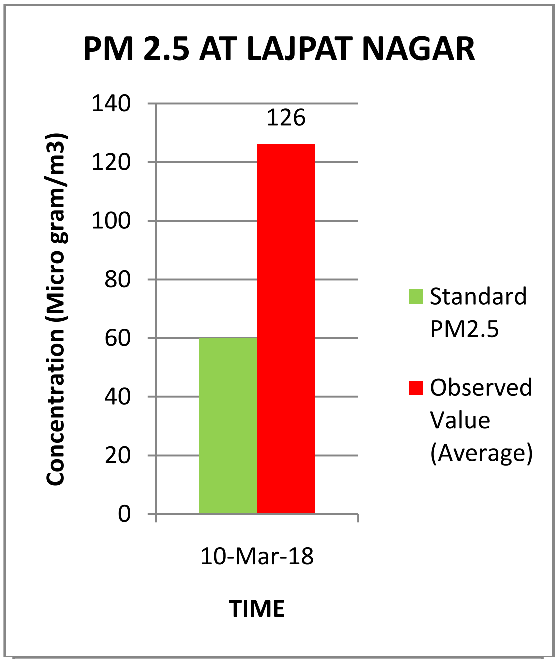


Fig 9: Comparative Analysis of $PM_{2.5}$ with permissible standard.

3.10 Results Of Pm 2.5 At Lajpat Nagar

Fig 10 shows the variation of $PM_{2.5}$ in 24 hours at Lajpat Nagar. The concentration monitored value with permissible standards shows that the monitored value is always higher than the prescribed standards. Average value of $PM_{2.5}$ is found 126µg/ m^3.



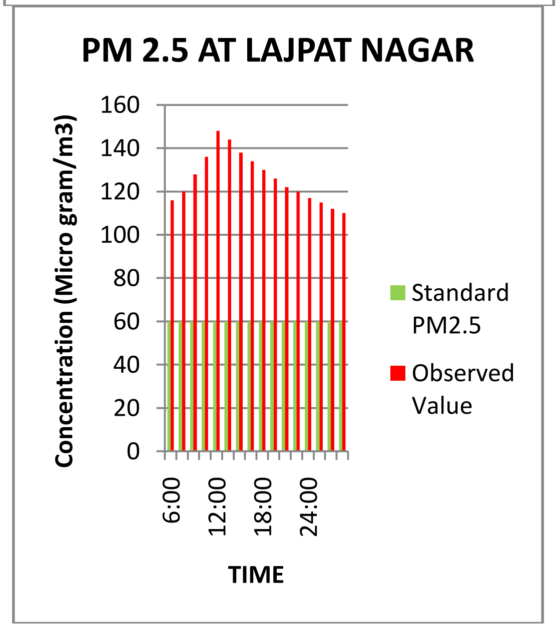


Fig 10: Comparative Analysis of $PM_{2.5}$ with permissible standard.

3.11 Comparative Analysis With Previous Data

Fig 11 shows the comparative analysis of present study with previous data of $PM_{2.5}$ at South Delhi. The average concentration of $PM_{2.5}$ (for 10 stations) has been observed 118µg/m3 in 2018. The average concentration value of previous data was 108µg/m3 in 1998-2014. Average growth percent in $PM_{2.5}$ at South Delhi is found as 2.5µg/m3 per year.

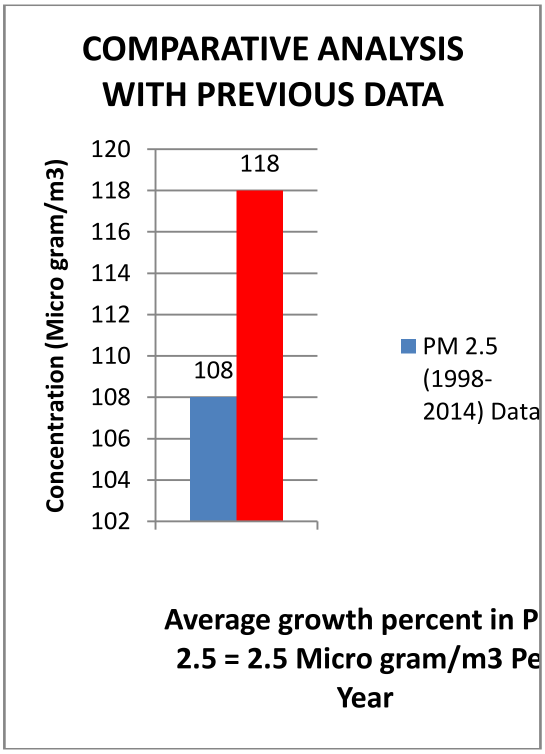


Fig 11: Comparative Analysis of present study with previous data.

IV. CONCLUSIONS

Conclusive remarks observed in monitoring and analysis of air quality for different sites of South Delhi identified that the particulate matter is the main air pollutant in the city. Most of the time particulate fractions ($PM_{2.5}$) exceeded the NAAQS limits. Sometimes monitored values are twice the prescribed standard value. The pollution levels in the city have increased in time and average growth percent in $PM_{2.5}$ is found 2.5µg/m^3 per year. High traffic densities and abnormal meteorological factors adversely influenced the ambient air quality of the city. Degraded air quality has adverse effects on buildings, materials, human health and plants. Historical monuments and materials surface get decolorized and degraded due to air pollutants. The observed high values of $PM_{2.5}$ (average for 10 stations is 118µg/m^3) suggested that the inhalation of polluted air induces irritation of respiratory tract and may lead to accumulation in human body as well as the substantial burden of diseases, potential risk of cancer and premature death. Fine particulate matters are the carriers of metals and are loaded with reactive species which can pierce the very old vehicles could be some of the steps to stop further deterioration of the cities air quality. There is an urgent need to adopt suitable strategies for air quality control to improve the urban air quality. Exposure to the air pollutants is largely beyond the control of individuals and requires action by the public authorities at the national, regional and local levels.

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