Government of Nepal
Ministry of Forests and Environment
Department of Environment
Babarmahal, Kathmandu

Status of Air Quality in Nepal
Annual Report, 2021

February, 2023

Authors:
Govinda Prasad Lamichhane
Nabina Maharjan
Bishnu Pandey
Prakash KC
Rajeshor Paudel
Sunita Khanal

Editor:
Shankar Prasad Paudel

Design and Layout:
Prakash K.C.

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Department of Environment,
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Foreword

Air pollution is one of the biggest environment problems today. It has caused an estimated 4.2 million premature deaths (WHO, 2021), and is also the cause of various respiratory and heart-related diseases. According to World health statistics 2022, almost all of the global population breathes air that exceeds WHO guideline limits. More than twenty percent of all cardiovascular disease related deaths are caused by air pollution-the equivalent of more than 3.5 million deaths every year. As per WHO, the number of individuals exposed to air pollution is continuously increasing, especially in low and middle-income countries like Nepal, and hence the evidence of air pollution-induced health issues is also increasing in these countries.

Various policies, acts and regulations of Nepal have addressed the issue of environment management. Article 30 of the Constitution of Nepal ensures the rights to live in a clean environment, management of which is under the concurrent powers at federal, provincial and local levels. There is a need of collaboration to maintain clean and healthy environment.

As a move towards creating a clean and healthy environment, the Department of Environment in collaboration with various government and intergovernmental organizations has established 27 real-time Air Quality Monitoring Stations in different parts of the country. The real-time data from these stations can be viewed at www.pollution.gov.np. The collected point data during the year 2016 to 2020 were analysed in the fiscal year 078/79. This year, data on particulate matter from 18 monitoring stations were analysed to prepare this report.

The report published last year consists of data analysis of all stations from the year 2016 to 2020. This year we present the data analysis report of the year 2021 for 17 stations where the required amount of data was available for particulate matters.

We are extremely grateful to Dr Pem Narayan Kandel, Former Secretary, Ministry of Forests and Environment for his encouragement to prepare this report. We are very grateful to Dr Ramesh Prasad Sapkota, Assistant Professor Tribhuvan University; Mr Sunny Maharjan, Meteorologist, Department of Hydrology and Meteorology; Dr Shiva Praveen Puppala, Senior Aerosol Scientist, ICIMOD; Dr Bhupesh Adhikari, Senior Air Quality Specialist, ICIMOD; Mr Sagar Adhikari, Air pollution Emission Research Associate, ICIMOD and Mr Suresh Pokhrel, Aerosol Measurement Research Associate, ICIMOD for their constructive comments and suggestions to prepare this report. Special thanks to Mr Shankar Prasad Paudel, Section Head of Environmental Pollution Monitoring and Regulation, and all other section heads for their active and productive comments and encouragement during report preparation. We appreciate the data analysis team members comprising of the environment inspectors –Mr Govinda Prasad Lamichhane, Ms Nabina Maharjan, Mr Bishnu Pandey, Mr Rajeshor Paudel, Mr Pakash K.C. and Ms Sunita Khanal for their continuous and rigorous hard work that has led to this report. Furthermore, a special thanks to all the staff of DoEnv, and everybody who has contributed to parts of this report, its editing and design.

The Department of Environment is always keen to receive suggestions for the betterment of our reports.

January, 2023

Nama Raj Ghimire
Director General

Office Address: Babarmahal, Kathmandu
Tel. No.: 01-4221797/4220837
Fax No.: 01-4221557
Email: info@doenv.gov.np
Website: www.pollution.gov.np

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Message

It is responsibility of Department of Environment to ensure the rights of the citizen to live in a clean and healthy environment as envisioned by the constitution of Nepal. The importance of air quality is evident as it has been addressed globally in the sustainable development goal and is also highly prioritized in the national level programs. The fifteenth five-year plan (FY 2019/20-2023/24) has envisioned to install 30 additional air quality station at different parts of the country by fiscal year 2080/81 and DoE is proactively working for its execution.

As a stepping stone to the objective, department is monitoring air quality of the country through twenty-seven (27) air quality monitoring stations, spreading all over the country, even though the journey of air quality monitoring is quite young and was incepted through installation of six (6) monitoring stations in 2016.

Department is continuously conducting monitoring and evaluation activities of the state of air quality in the country. In line to that, a study conducted by the department with technical support from ICIMOD in 2015, has identified 56 different locations throughout the country for installation of air quality monitoring stations in future. These locations were carefully identified on the basis of biophysical and anthropogenic factors affecting air quality so to generated reliable data.

Realizing the state of air pollution and its eternal importance, the department has established air quality monitoring station in different regions of the country- namely in very busy areas like Ratnapark, inside the world heritage sites like in Lumbini, near industrial areas like in Biratnagar along with very pristine and controlled area like in Rara National Park.

One of such results is the operation of real time air quality monitoring stations, that provide data of particulate matter every minute, and can be viewed form the website www.pollution.gov.np. Department processes and publishes annual report, which can be very beneficial for general public, policy maker, scientific researchers as well as students working in this field. Since the condition of air quality is directly related to human health and wellbeing, we believe that collection of data alone is not sufficient but rather its use for safeguarding human health and the environment. Hence, Department of Environment has taken this step to analyze the data and publish this report, so that it can be used at its optimum level to benefit every individuals and professionals.

Shiva Lal Tiwari
Director General
2023/04/26

Executive Summary

Since 2016 Department of Environment has established 27 Air Quality Monitoring Stations in different parts of Nepal with support from various governmental and intergovernmental organizations. The sole purpose of establishing these stations was to find the ground reality of air quality conditions in Nepal. All these stations measures PM_1, $PM_{2.5}$, PM_{10} and TSP. Beside these parameters, station at Ratnapark, Dhulikhel, and Lumbini have gaseous analyzer whereas Pulchok station has ozone analyser as well. In this report, data of $PM_{2.5}$, PM_{10} and TSP acquired from 17 stations were analysed for the year 2021. As Nepal does not have standard for PM_1, even though these stations provided data for PM_1, they were not subjected to analysis. The CSV formatted per minute data was cleaned and then analysed and visualized using R, R-studio and data analysis tool developed by ICIMOD. For $PM_{2.5}$ all data above 1500 µg m^{-3}, for PM_{10}, all data above 3000 µg m^{-3} and for TSP, all data above 5000 µg m^{-3} were removed as per the Quality Control (QC) rule set by Department of Environment. Daily data were analysed only when availability of hourly data was equal to or more than 80%. Additionally, monthly average was calculated from daily average only for those months where daily data availability was equal to or more than 50%. The seasonal average was also calculated from daily average only if the monthly average of at least 2 months of that season was available for winter, pre-monsoon and monsoon season. For post monsoon season average was calculated if monthly average is available for at least one month.

The analysis of data showed that air quality was found varied both temporally and spatially. The air quality status of Kathmandu Valley and Terai region was found poor especially in winter and pre-monsoon season. The compliance status of National Ambient Air Quality Standard 2012 was found very low in winter and pre-monsoon season. Incident of forest fire was the highest during March and April; precipitation was high during the monsoon season, both of which can be related to varied level of air pollution.

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Abbreviation

AQMS	Air Quality Monitoring Station
AQI	Air Quality Index
CSV	Comma-separated Values
DHM	Department of Hydrology and Meteorology
DoEnv	Department of Environment
DoFSC	Department of Forest and Soil Conservation
EDM	Environmental Dust Monitor
GoN	Government of Nepal
ICIMOD	International Centre for Integrated Mountain Development
L/m	Litre per minute
m	Meter
mm	Millimetre
NAAQS	National Ambient Air Quality Standards
NITC	National Information Technology Centre
PM_{10}	Particulate matter having aerodynamic diameter less than 10 micron
$PM_{2.5}$	Particulate matter having aerodynamic diameter less than 2.5 micron
PU	Pokhara University
TSP	Total Suspended Particulate
TU	Tribhuvan University
$\mu g\ m^{-3}$	Microgram per Cubic Meter
µm	Micro Meter

Chapter 1. : Introduction

1.1 Background

Air pollution sees no physical boundary; therefore, it is one of the most important environmental health problems affecting everyone either in high or low-income countries. Various studies show increasing trend in the level of ambient air pollution causing various chronic as well as acute diseases. People living in the low- and middle-income countries are exposed to the highest air pollution. Studies in air pollution, its affect and management strategies is the most to protect global population from problems related to air pollution.

The constitution of Nepal has ensured rights to live in clean and healthy environment as the fundamental right of every citizen. To implement this basic right, Nepal Government has enacted Environment Protection Act (EPA), 2019 which focuses on prevention and control of pollution and maintaining balance between environment and development. National Environment Policy 2019 and 15th Periodic development plan also focused to reduce pollution from different sectors. To ensure good air quality, Nepal Government has endorsed National Ambient Air Quality Standards, 2012 incorporating nine air quality parameters. Department of Environment under Ministry of Forests and Environment is a leading government agency to monitor the status of air quality based on NAAQS 2012 in Nepal.

Air quality monitoring is a basic foundation of air quality management. It provides an idea about the status of air quality of a place/region on the basis of which overall management policy and regulation can be promulgated. So it is very essential to undergo air quality monitoring before taking any action or measures of air quality control.

Nepal started its air quality monitoring activities in 1990 AD as campaign monitoring. The fixed monitoring stations were established in 2002 and data were collected until 2007. The monitoring gap remained in between 2008 to 2016 except few campaign monitoring. In 2015 Department of Environment in coordination with ICIMOD prepared a report named 'A Plan for Nepal's Air Pollution Monitoring Network" which identified 56 locations for the establishment of Air Quality Monitoring Stations. On the basis of this study Department of Environment started to establish real time monitoring stations throughout the country.

Since 2016, Department of Environment in collaboration with various government as well as intergovernmental organisation, established 27 Air Quality Monitoring Stations in various parts of the country as shown in figure 1.1.1.

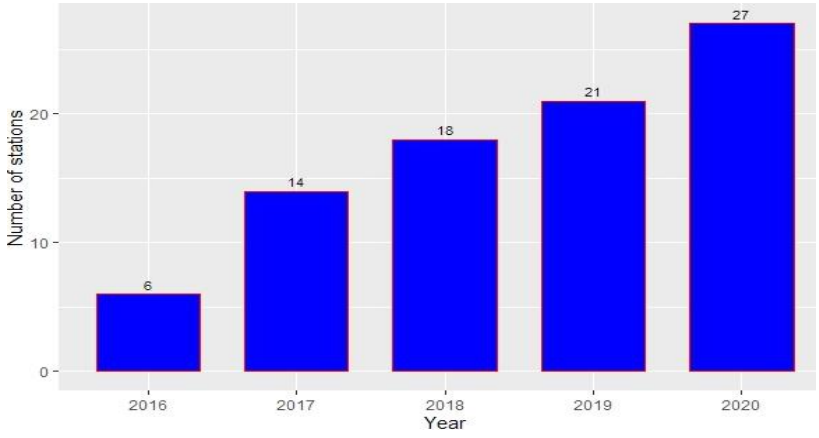


Figure 1.1.1: Trend of Real Time Air Quality Monitoring Stations

Of these 27 stations, the highest numbers of stations are located in Bagmati Province as shown in the figure 1.1.2.

Nepal Government has set and enforced National ambient air quality standard (NAAQS) and has a legal obligation to maintain this standard. This report has been prepared on the basis of data collected from 17 different Air Quality Monitoring Stations for 2021. All the monitoring stations measure PM_1, $PM_{2.5}$, PM_{10} and Total Suspended Particulate Matter. Since we do not have National Ambient Air Quality standard for PM_1, this is not included in this report.

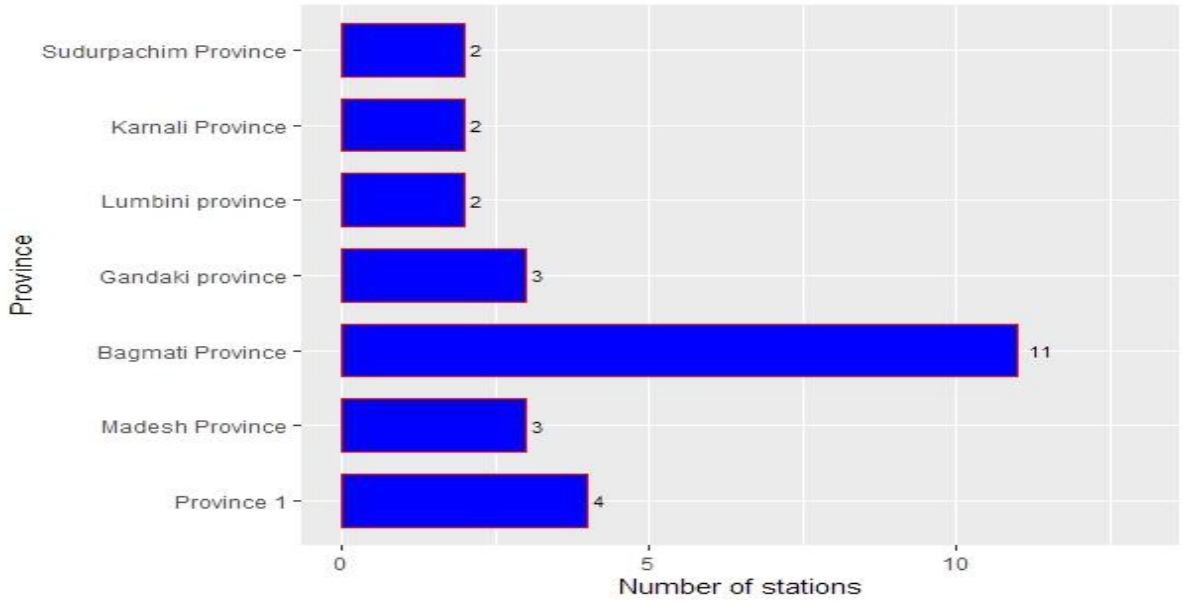


Figure 1.1.2: Province wise distribution of Air Quality Monitoring Station

1.2 Objectives

The overall objective of this report is to present the status of the air quality based on the data collected from the Air Quality Monitoring Stations for the year 2021.

The specific objectives are:

- To analyse $PM_{2.5}$, PM_{10}, and the Total Suspended Particulate Matter (TSP) data of different stations,
- To analyse the compliance status of $PM_{2.5}$, PM_{10}, and the Total Suspended Particulate Matter (TSP) data of different stations.

1.3 Air quality parameters monitored

The following parameters were monitored in the stations.

TSP: Includes all solid and liquid droplet particulate present in the air, aerodynamic diameter of which range from 0.25 µm to 100 µm.

PM_{10}: Includes particulate matter with an aerodynamic diameter less than or equal to 10 µm.

$PM_{2.5}$: Includes particulate matter with an aerodynamic diameter less than or equal to 2.5 µm diameter and is important in terms of health impacts.

1.4 Methods of air quality monitoring and data analysis

The Environmental Dust Monitor (Grimm EDM 180+) was used for air quality monitoring. It uses laser light-scattering technology for particle count. Particles contained in the sample air are classified by size and number in the measuring chamber using scattered light measurement. During the process, a small measuring volume is exposed to a laser with downstream optics. For environmental measurements, the concentration of solids is so low that statistically there is only one particle in the sensing volume. The scattered light emitted by each particle is captured by a second set of optics with an opening angle and a scatter angle, deflected to a detector by a mirror, and the light intensity is measured. The particle size is proportional to the intensity of the reflected beam of light. The count rate is derived from the number of particles and the volume flow rate. When the particle diameter and density are known; the particle mass can be derived from the particle count based on the assumption of a spherical shape.

A semiconductor laser serves as the light source in the EDM 180 spectrometer. In order to minimize the influence of the refraction indexes, the 90° scattered light is guided to a receiver diode by a mirror with an opening angle of approximately 120°. After amplification, the electrical signal of the diode is classified in 31 size channels according to the signal strength. This makes it possible to determine the grain size distribution of the particles. The sample flow rate of this instrument is 1.2 L/m.

1.1.1 Data acquisition

This instrument has the capacity to measure data for every six second but we are taking measurements every minute and get logged into the data logger in CSV data format. The data logger system of the station then sends those data to the central server located at the National Information Technology Centre (NITC), Singha Durbar, Kathmandu from where the point (per minute) data were downloaded.

1.1.2 Data cleaning

In order to prepare the data for analysis, per minute data obtained from the central server was first cleaned. For this purpose, different threshold values were given according to the parameters as:

- For $PM_{2.5}$, all data above 1500 µg m^{-3} was removed
- For PM_{10}, all data above 3000 µg m^{-3} was removed
- For TSP, all data above 5000 µg m^{-3} was removed

Additionally, all repeated data, along with negative and null data were cleaned.

1.1.3 Data Averaging

Daily data was calculated by averaging the minute data, which was done only when availability of minute data was equal to or more than 80%. Similarly, monthly average was calculated from daily average only for those months where daily data availability is equal to or more than 50%. The seasonal average is calculated from daily average only if the monthly average of at least 50 percent months of that season is available. Following months were considered for different seasons for seasonal data analysis:

- Winter season: - December of preceding year, January and February
- Pre-monsoon season: - March, April and May
- Monsoon season: - June, July, August and September
- Post-monsoon Season: - October and November

Histogram and Box-plot

The histogram was made from the point (a minute) data acquired from the central server. The mean value shown in the histogram is the mean of all minute data for the year 2021. Similarly, monthly box-plot and hourly box-plot were made from the point data. The point data within the hour of whole year was aggregated for calculating the hourly bar plot. For example, hourly average of 1 AM is the whole year aggregated data of 1 to 2 AM. Similarly, in diurnal box plot point data of a certain hour time of whole year was grouped.

The daily average is the average of point data of a day which is plotted in the annual graph. The monthly average is calculated from the daily average. The seasonal average is the average daily average data of all days for that season. For winter season, daily average data from December of the preceding year (here 2020) along with January and February of this year (2021) was used for winter season. Similarly, for per- monsoon data from March to May, for monsoon data from June to September, and for post-monsoon data from October and November were used.

"R", "R studio" program was used along with Excel and ICIMOD tool for data analysis (https://www.icimod.org/atmosphere/Data_Analysis_Atmosphere.zip.)

1.1.4 Calendar Plot

In calendar plot daily $PM_{2.5}$ data are visualized according to their Air quality index (AQI) group in calendar format. The AQI group and their respective colour code is as follows.

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 400	Hazardous	Maroon
401 to 500	Very Hazardous	Maroon

Each category corresponds to a different level of health concern. The six levels of health concern and what they mean are:

● "Good" AQI is 0 to 50. Air quality is considered satisfactory, and air pollution poses little or no risk.

● "Moderate" AQI is 51 to 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people.

● "Unhealthy for Sensitive Groups" AQI is 101 to 150. Although general public is not likely to be affected at this AQI range, people with lung disease, older adults and children are at a greater risk from exposure to ozone, whereas persons with heart and lung disease, older adults and children are at greater risk from the presence of particles in the air.

● "Unhealthy" AQI is 151 to 200. Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.

● "Very Unhealthy" AQI is 201 to 300. This would trigger a health alert signifying that everyone may experience more serious health effects.

● "Hazardous" AQI greater than 300. This would trigger a health warnings of emergency conditions. The entire population is more likely to be affected

1.5 National Ambient Air Quality Standards, 2012 (NAAQS)

The Government of Nepal has endorsed National Ambient Air Quality Standards in 2012. The NAAQS gives maximum concentration for major nine parameters including particulate matters and trace gases, heavy metal and others as shown in the table below.

Table 1.5.1: National Ambient Air Quality Standards, 2012

SN	Parameters	Units	Averaging time	Maximum concentration
1	TSP	$\mu g\ m^{-3}$	24-hr	230
2	PM_{10}	$\mu g\ m^{-3}$	24-hr	120
3	$PM_{2.5}$	$\mu g\ m^{-3}$	24-hr	40
4	Ozone	$\mu g\ m^{-3}$	8-hr	157
5	Sulphur Dioxide	$\mu g\ m^{-3}$	Annual	50
			24-hr	70
6	Nitrogen Dioxide	$\mu g\ m^{-3}$	Annual	40
			24-hr	80
7	Carbon monoxide	$\mu g\ m^{-3}$	8-hr	10,000
8	Lead	$\mu g\ m^{-3}$	Annual	0.5
9	Benzene	$\mu g\ m^{-3}$	Annual	5

Chapter 2. : Results

2.1 Air quality status – Bhimdatta

2.1.1 Introduction

Bhimdatta Air Quality Monitoring Station was established in the year 2020 in Bhimdatta Municipality of Kanchanpur district. It lies adjacent to the northern boundary of Bhimdatta Municipality office and just west to the Municipality office main gate. This station lies in the far western part of Nepal and represents the urban area. The major sources of air pollution in this area are vehicles and commercial activities.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180+	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.1.2 $PM_{2.5}$

Annual average

The $PM_{2.5}$ value ranged from 1 to 967.2 µg m^{-3}. The annual average $PM_{2.5}$ was found to be 69.6 µg m^{-3} exceeding the national standard of 40 µg m^{-3} (Figure 2.1.1).

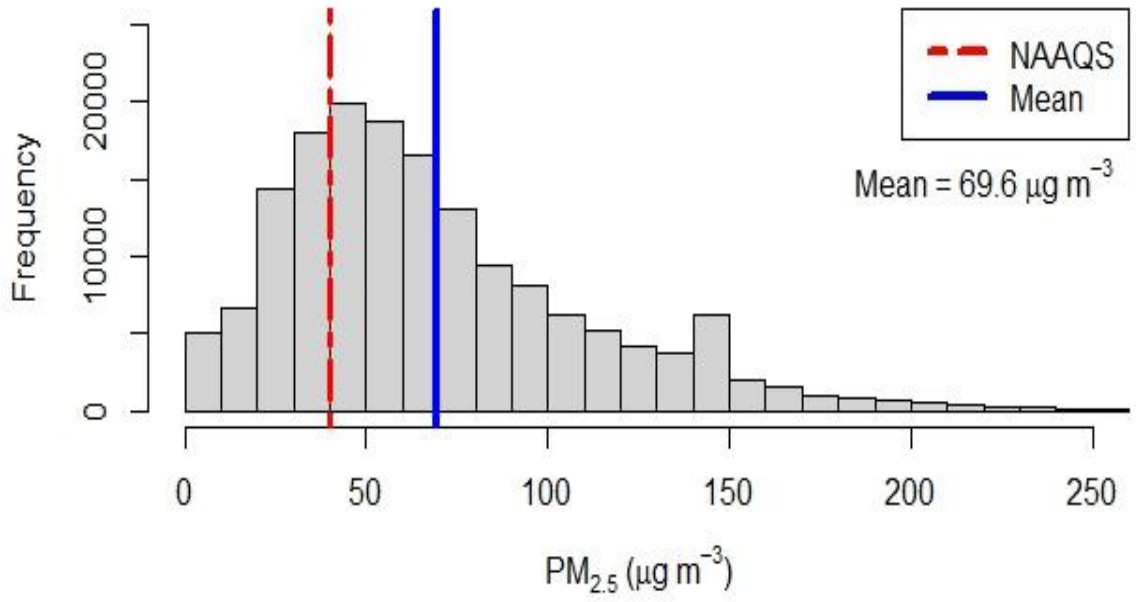


Figure 2.1.1: Histogram of $PM_{2.5}$

Diurnal Variation

The $PM_{2.5}$ value was found more in between 6 PM to 8 PM and in between 7 AM to 9 AM (figure 2.1.2). The box plot shows that mean value was found to be more than the median throughout the day except at 10 PM (figure 2.1.3).

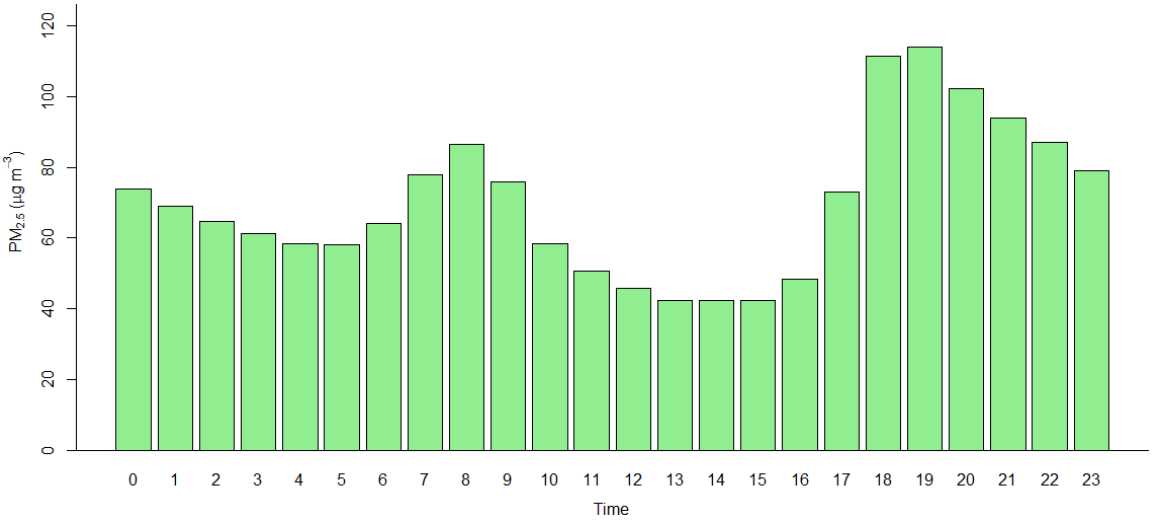


Figure 2.1.2: Hourly average of $PM_{2.5}$

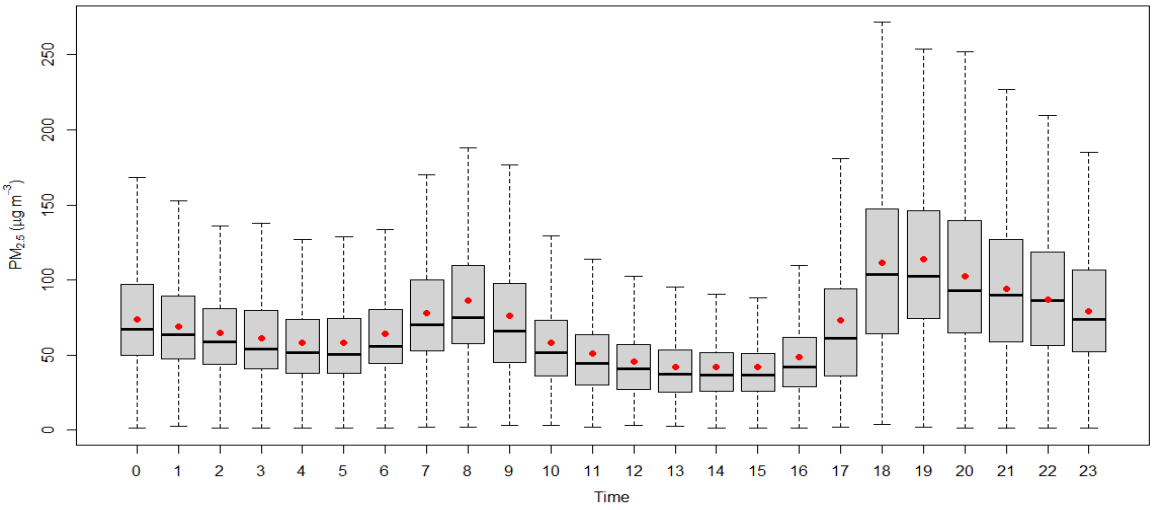


Figure 2.1.3: Diurnal variation of $PM_{2.5}$

Daily average

The daily average $PM_{2.5}$ values were found maximum in the month of February. Due to the data gap mainly of pre-monsoon and monsoon season, the year-round trend is not reflected by the figure (figure 2.1.4).

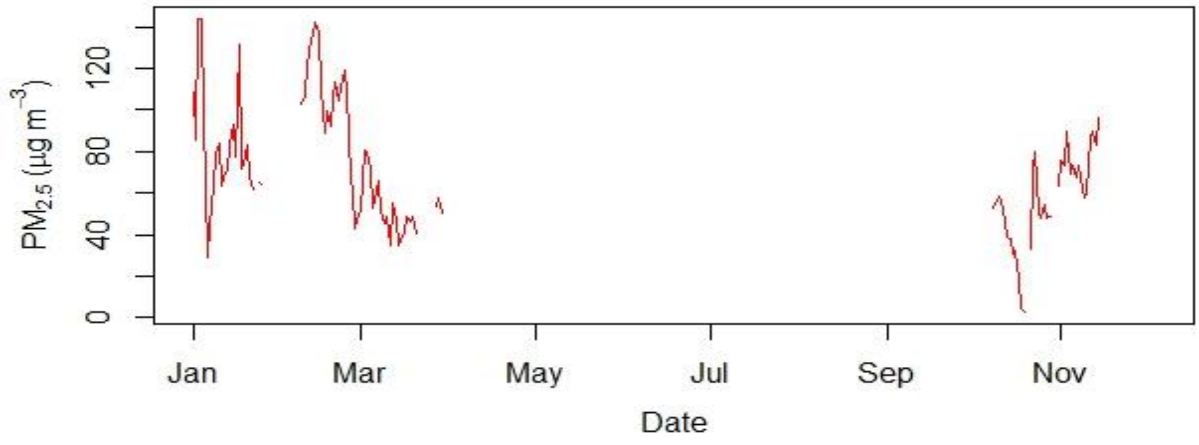


Figure 2.1.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

The monthly average value was found in between 44.46 µg m^{-3} to 102.61 µg m^{-3} with highest in February (102.61 µg m^{-3}) and lowest in October (44.46 µg m^{-3}). It was not calculated for April to September and November to December due to data gap (figure 2.1.5).

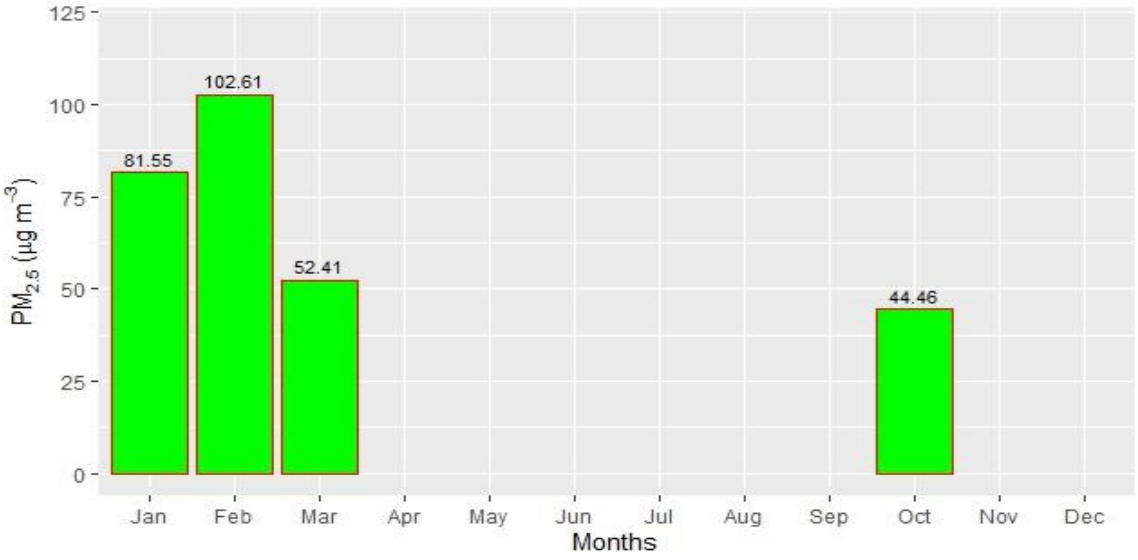


Figure 2.1.5: Monthly average $PM_{2.5}$

In the box plot, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. The box plot below shows low variation in $PM_{2.5}$ values in December and high variations in February. The mean value was found more than median for all month (figure 2.1.6).

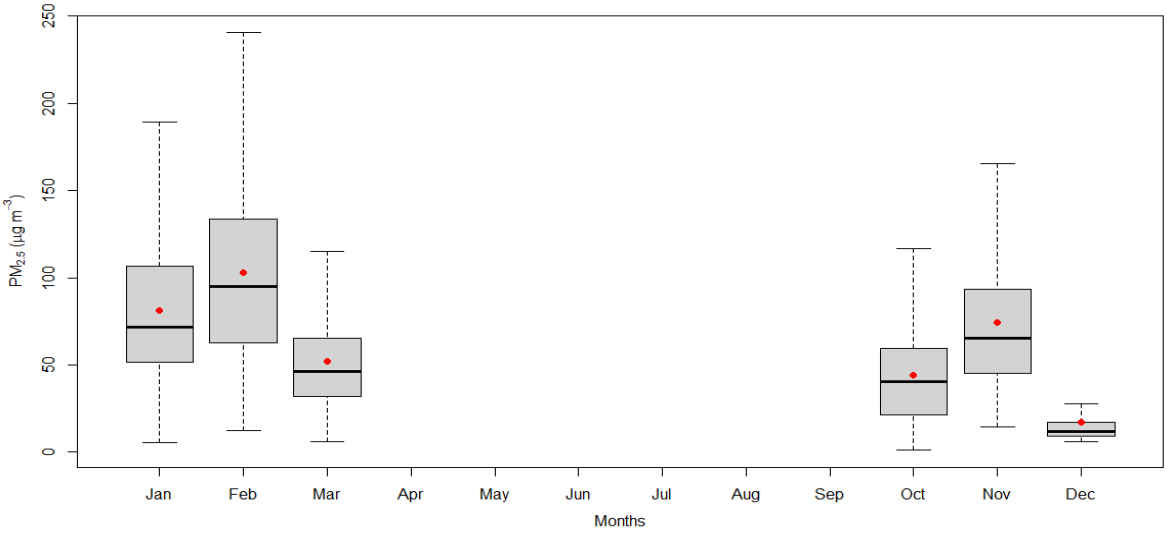


Figure 2.1.6: Monthly variation of $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during the winter season (91.03 µg m^{-3}) and the lowest during the post monsoon season (44.46 µg m^{-3}) as in figure 2.1.7. The seasonal average was not calculated for pre monsoon and monsoon season due to insufficient data.

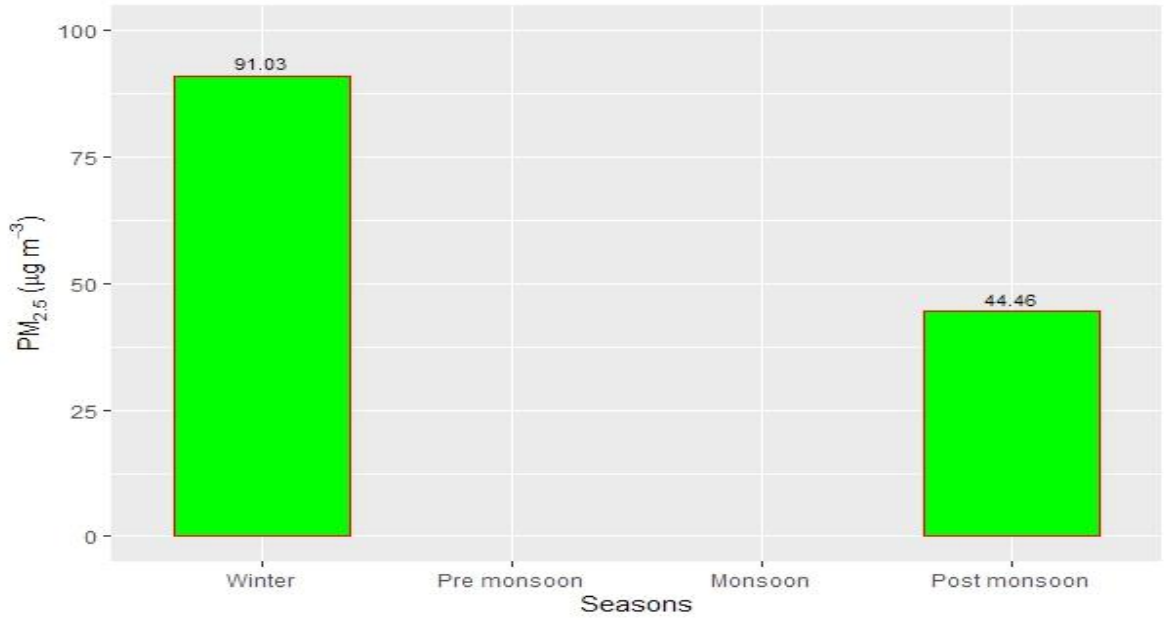


Figure 2.1.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 103 days of measurement, 91 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$. From April to September there is data gap so the exact figure of exceeding NAAQS is not reflected in the figure (figure 2.1.8).

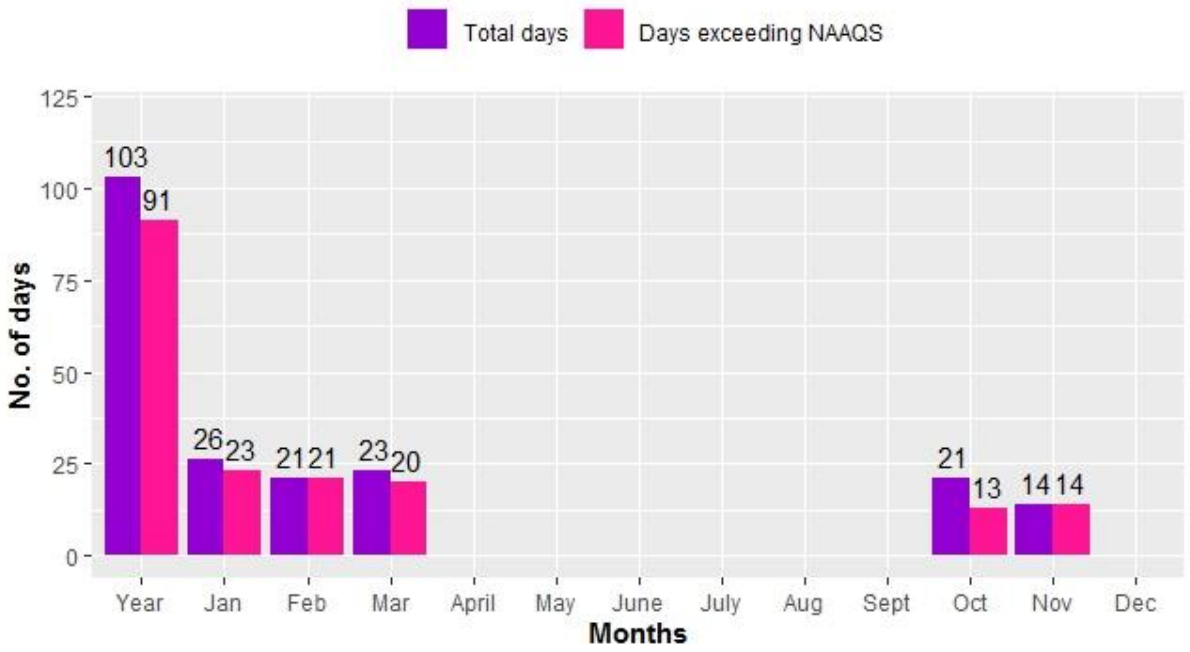


Figure 2.1.8: Compliance status of $PM_{2.5}$

2.1.3 PM_{10}

Annual Mean

The PM_{10} value ranged in between 1 to 2914.8 µg m^{-3}. The annual average PM_{10} was found to be 124.59 µg m^{-3} (Figure 2.1.9).

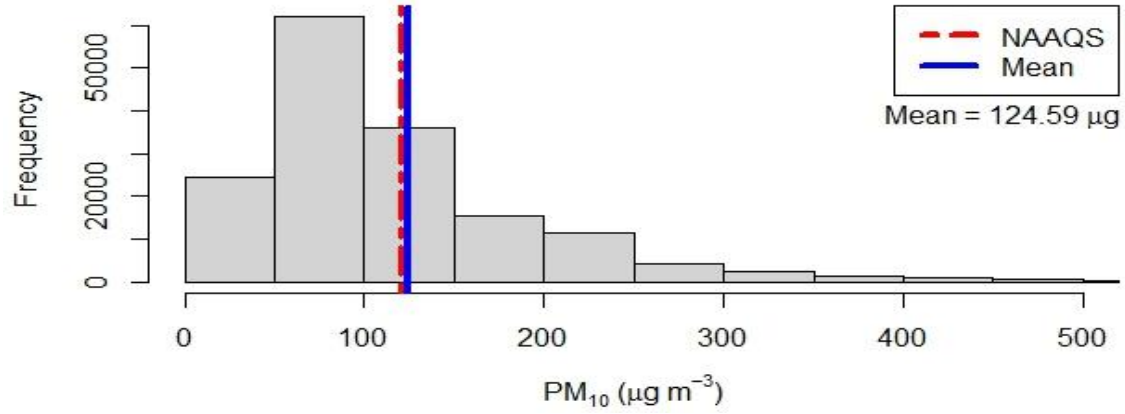


Figure 2.1.9: Histogram of PM_{10}

Diurnal Variation

The PM_{10} was found maximum in between 7 AM to 12 AM, decreased in the day time and then increases after 5 PM till 7 PM (figure 2.1.10). The box plot below shows that mean value was found to be more than the median throughout the day and the gap between mean and median found more in 5 PM and 6 PM (figure 2.1.11).

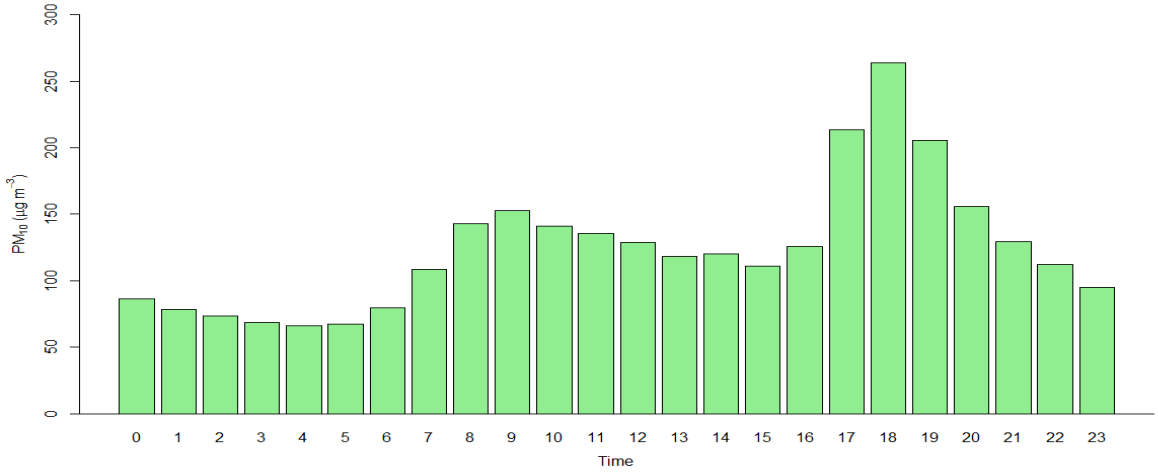


Figure 2.1.10: Hourly average of PM_{10}

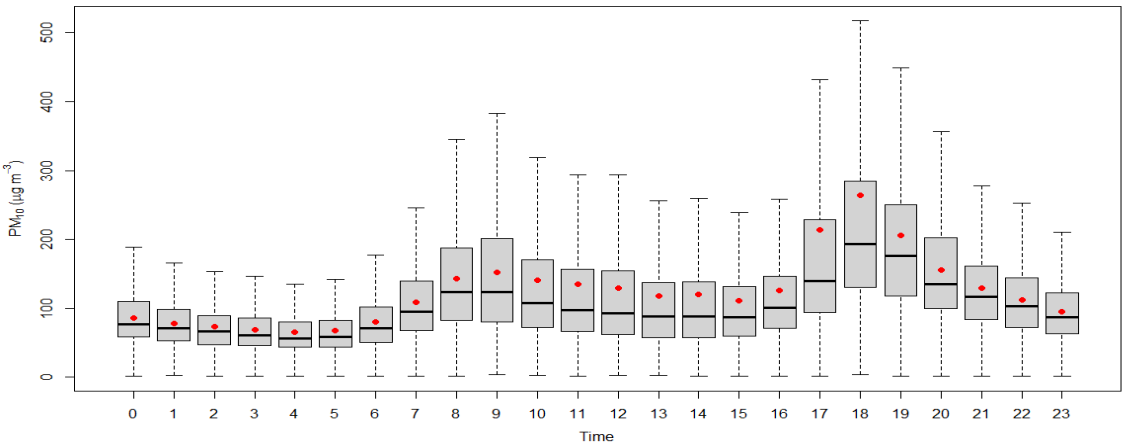


Figure 2.1.11: Diurnal variation of PM_{10}

Daily average

The daily average PM_{10} values were found maximum in the month of February. Due to the data gap mainly of pre-monsoon and monsoon season, the year-round trend is not reflected by the figure. (figure 2.1.12)

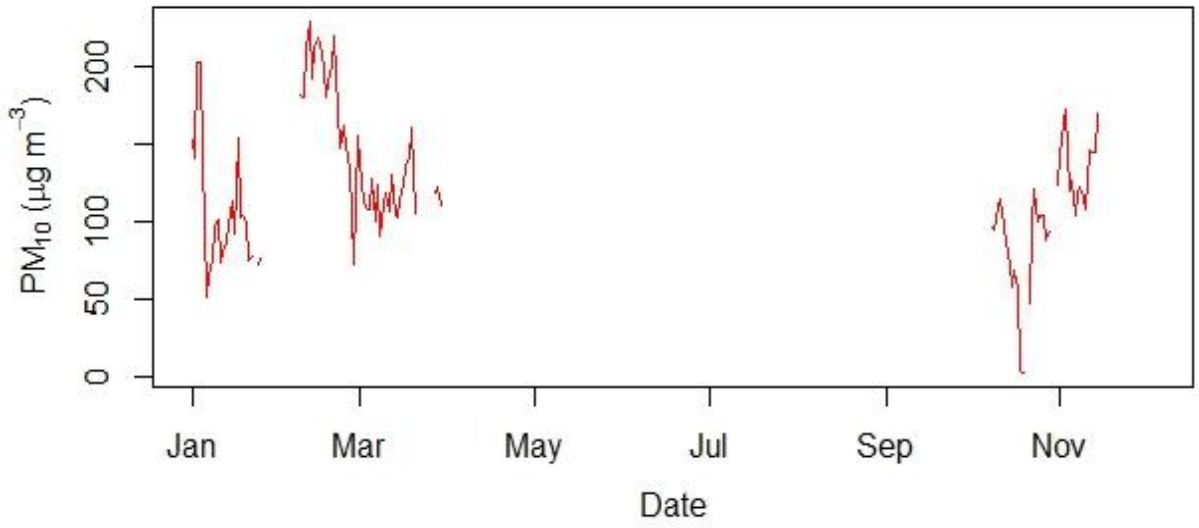


Figure 2.1.12: Daily mean concentration of PM_{10}

Monthly Variation

The monthly average value was found in between 83.3 µg m^{-3} to 177.86 µg m^{-3} with highest in February (177.86 µg m^{-3}) and lowest in October (83.3 µg m^{-3}). It was not calculated for April to September and November to December due to data gap. Therefore, the trend has not been reflected by the figure (figure 2.1.13).

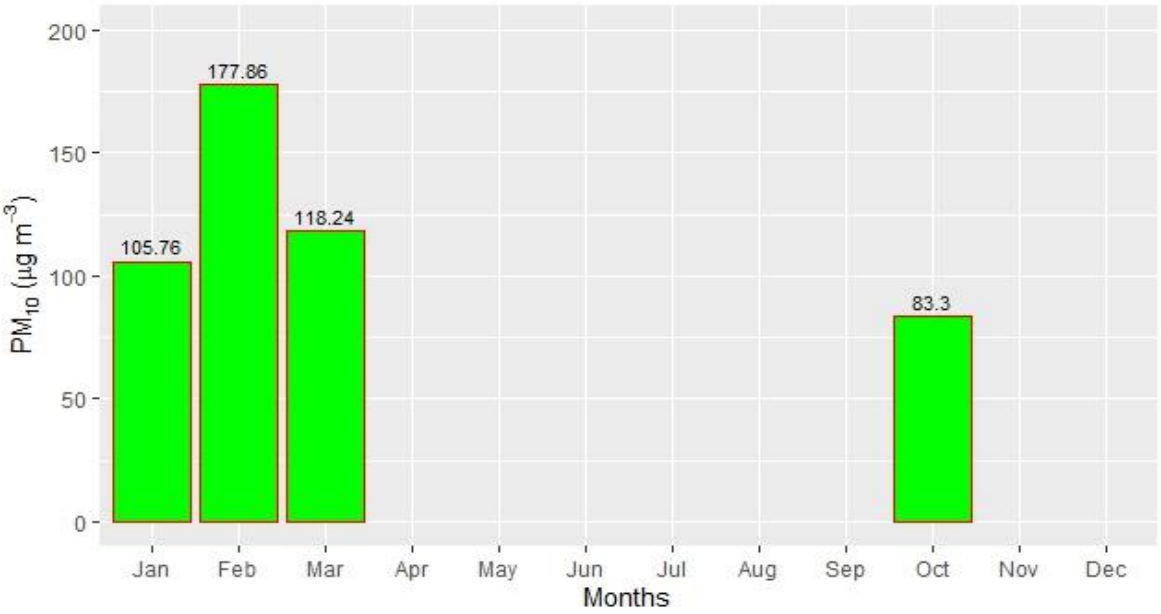


Figure 2.1.13: Monthly average of PM_{10}

The box plot below shows high variation in PM_{10} values in between February and March. The mean value was found more than median especially in February, March, November and December (Figure 2.1.14).

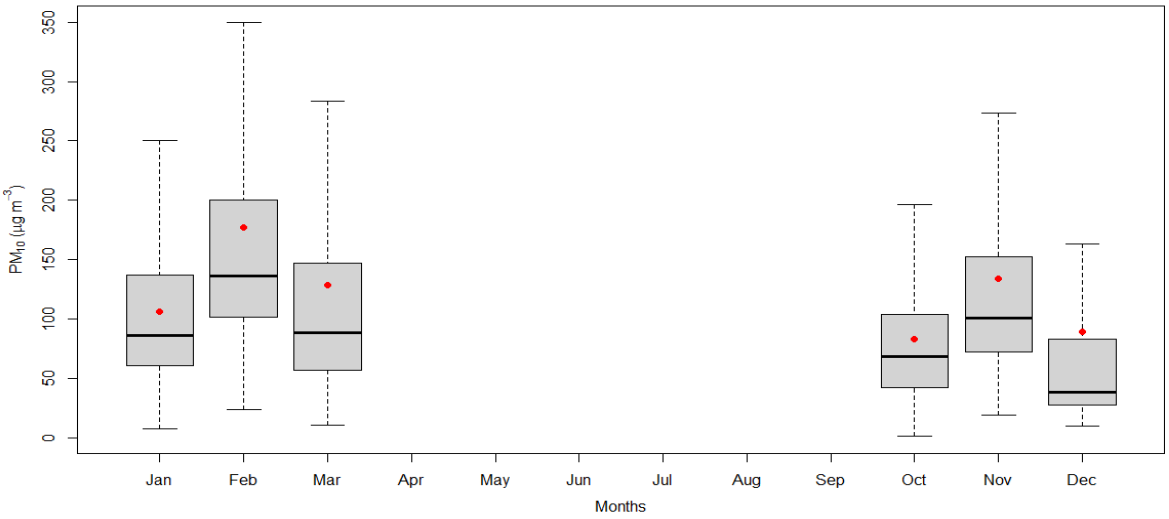


Figure 2.1.14: Monthly variation of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during the winter season (138.75 µg m^{-3}) and the lowest during the post monsoon season (83.3 µg m^{-3}) as in figure 2.1.15. The seasonal average was not calculated for monsoon season due to insufficient data.

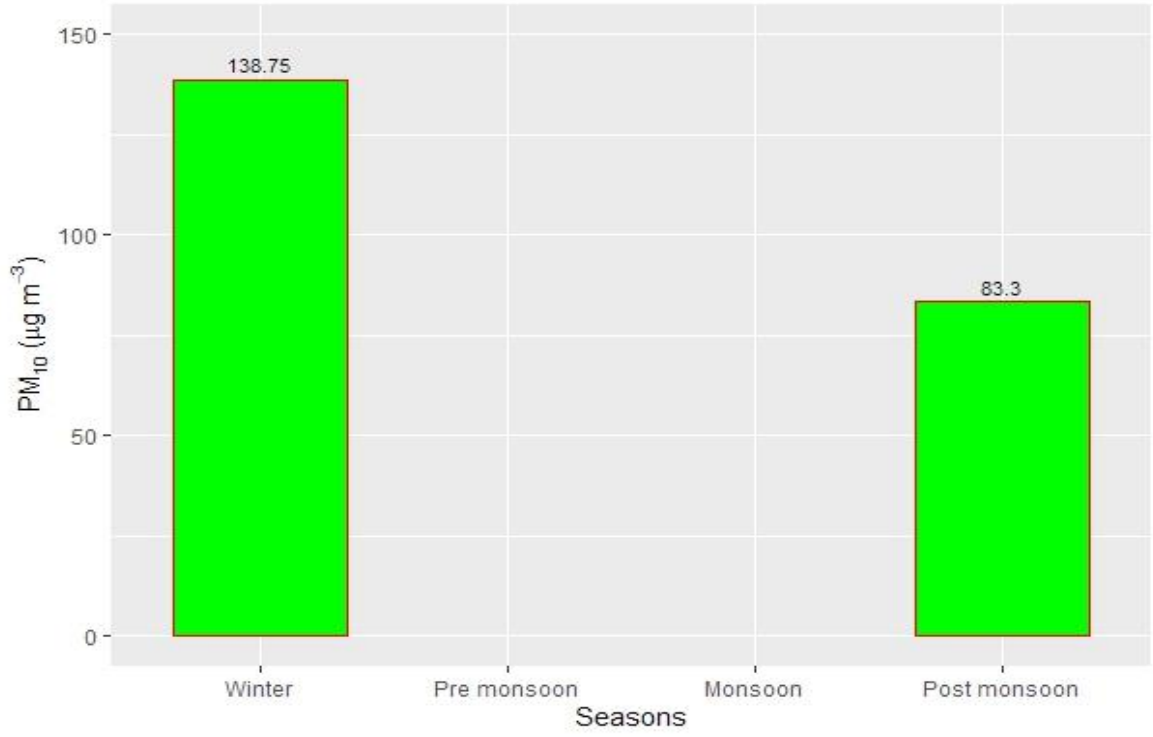


Figure 2.1.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards(NAAQS)

Out of 103 days of measurement, 45 days exceeded the National Ambient Air Quality Standard for PM_{10}. From April to September there is data gap so the exact figure of exceeding NAAQS is not reflected in the figure 2.1.16.

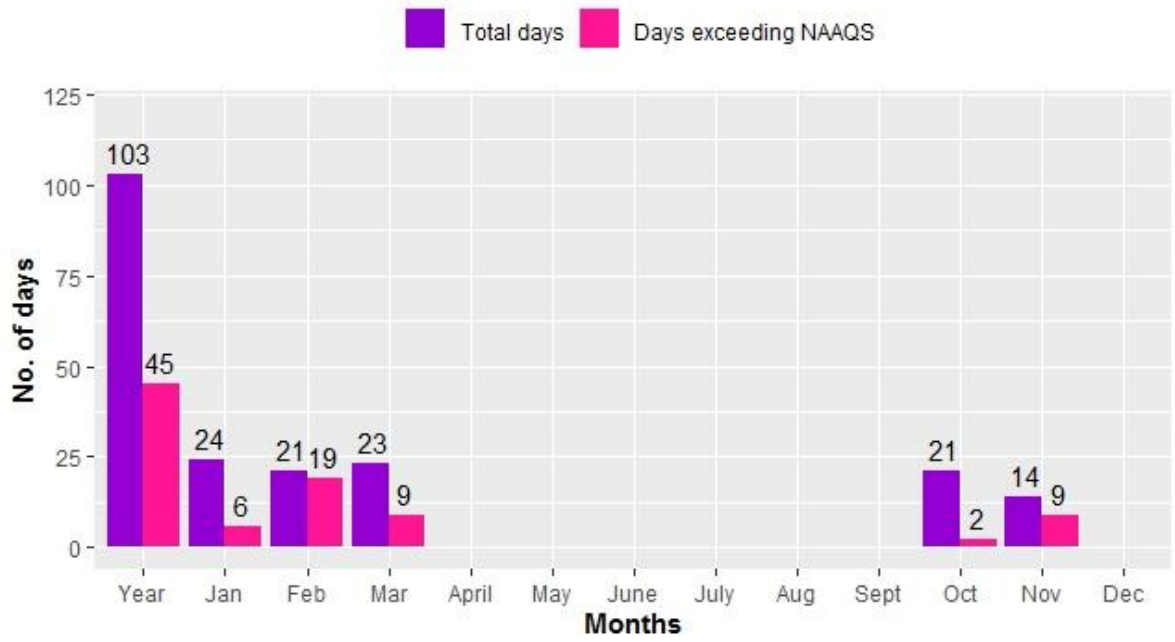


Figure 2.1.16: Compliance status of PM_{10}

2.1.4 TSP

Histogram

The TSP value ranged in between 1 to 4988 µg m^{-3}. The annual average TSP value was found to be 252.21 µg m^{-3} (Figure 2.1.17).

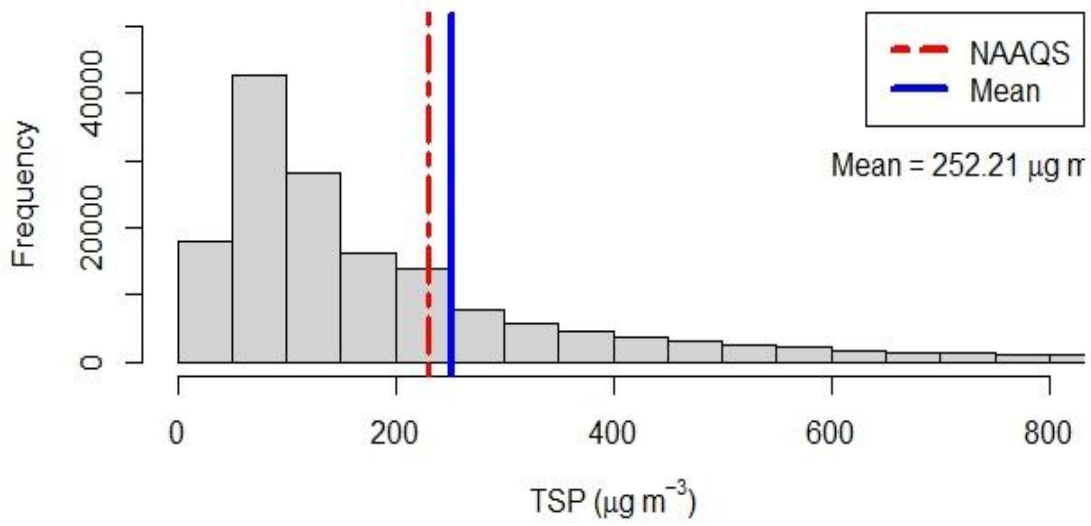


Figure 2.1.17: Histogram of TSP

Diurnal Variation

In contrast to the trend of $PM_{2.5}$ and PM_{10}, the TSP value slowly increased in the morning and found maximum in evening time especially in between 5 PM to 7 PM which gradually started to decrease then after (figure 2.1.18). The box plot below shows that mean value was found to be more than the median throughout the day and the gap is more during daytime (figure 2.1.19).

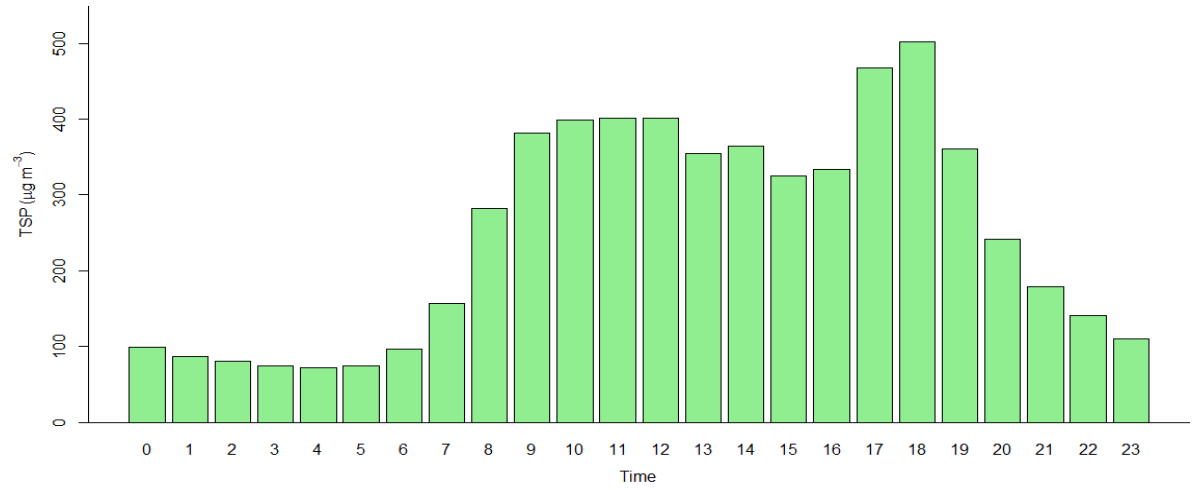


Figure 2.1.18: Hourly average of PM_{10}

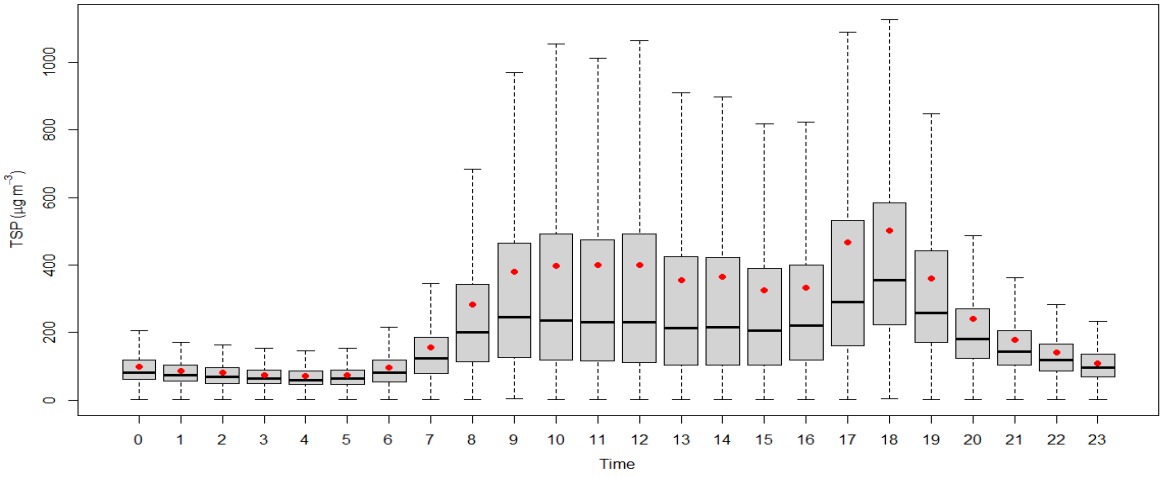


Figure 2.1.19: Diurnal variation of TSP.

Daily average

The daily average TSP values were found maximum in the month of March. Due to the data gap mainly of pre-monsoon and monsoon season, the year-round trend is not reflected by the figure 2.1.20.

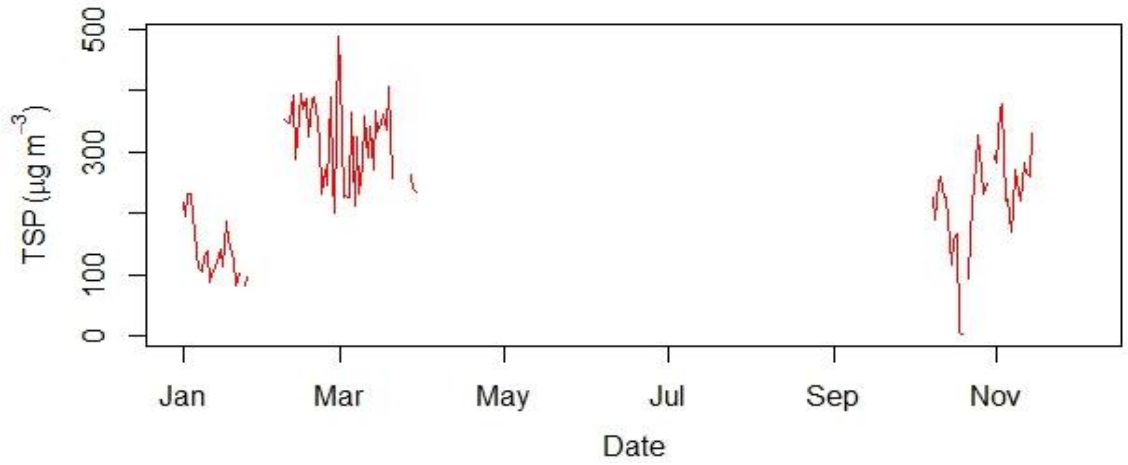


Figure 2.1.20: Daily average value of TSP

Monthly Variation

The monthly average value for February was found to be the highest (337.29 µg m^{-3}) and that of January was found to be the lowest (139.2 µg m^{-3}) while comparing with other months. It was not calculated for April to September and November to December due to data gap. Therefore, the trend has not been reflected by the figure 2.1.21.

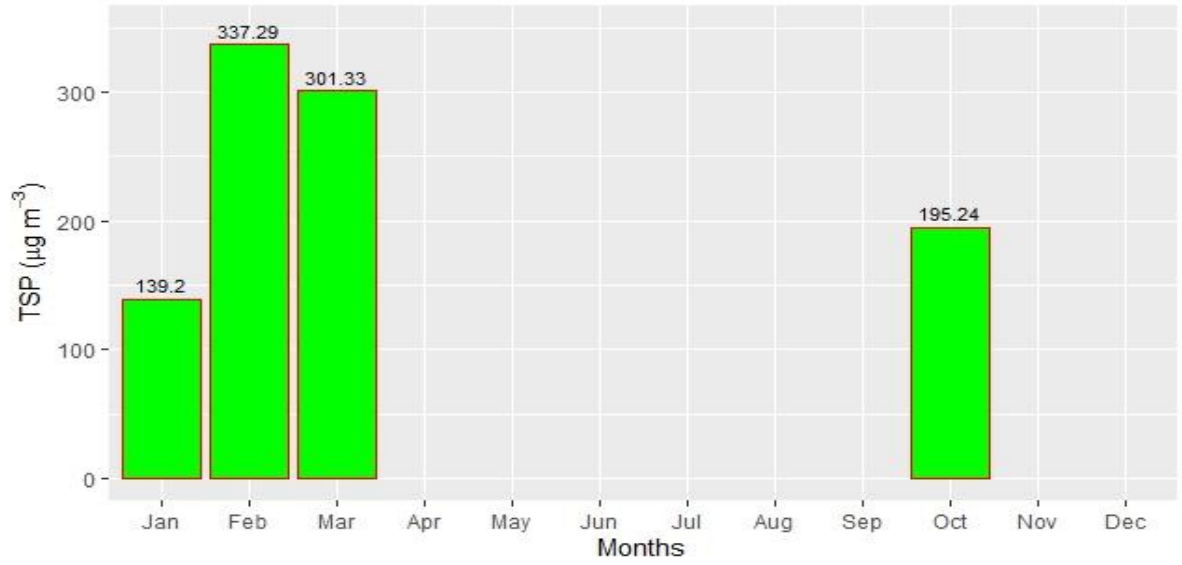


Figure 2.1.21: Monthly average of TSP

The box plot below shows high variation in February, March and December and less variation in January and October. The mean value was found more than median in every month while mean value is significantly higher than median in October to December and February to March as shown in figure 2.1.22.

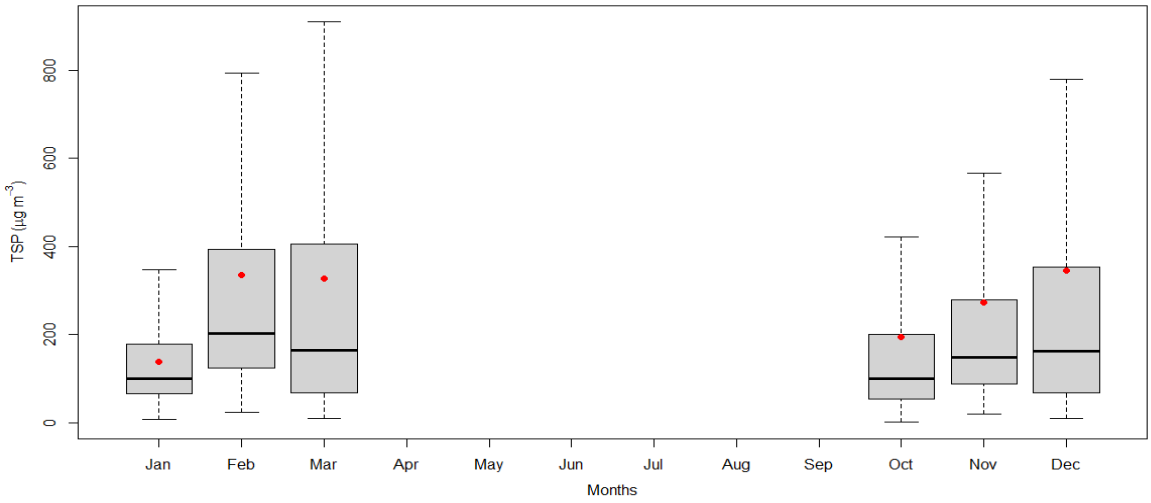


Figure 2.1.22: Monthly variation of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during the winter season (219.02µg m^{-3}) and the lowest during the post monsoon season (195.24 µg m^{-3}) as in figure

2.1.23. The seasonal average was not calculated for pre monsoon and monsoon season due to insufficient data.

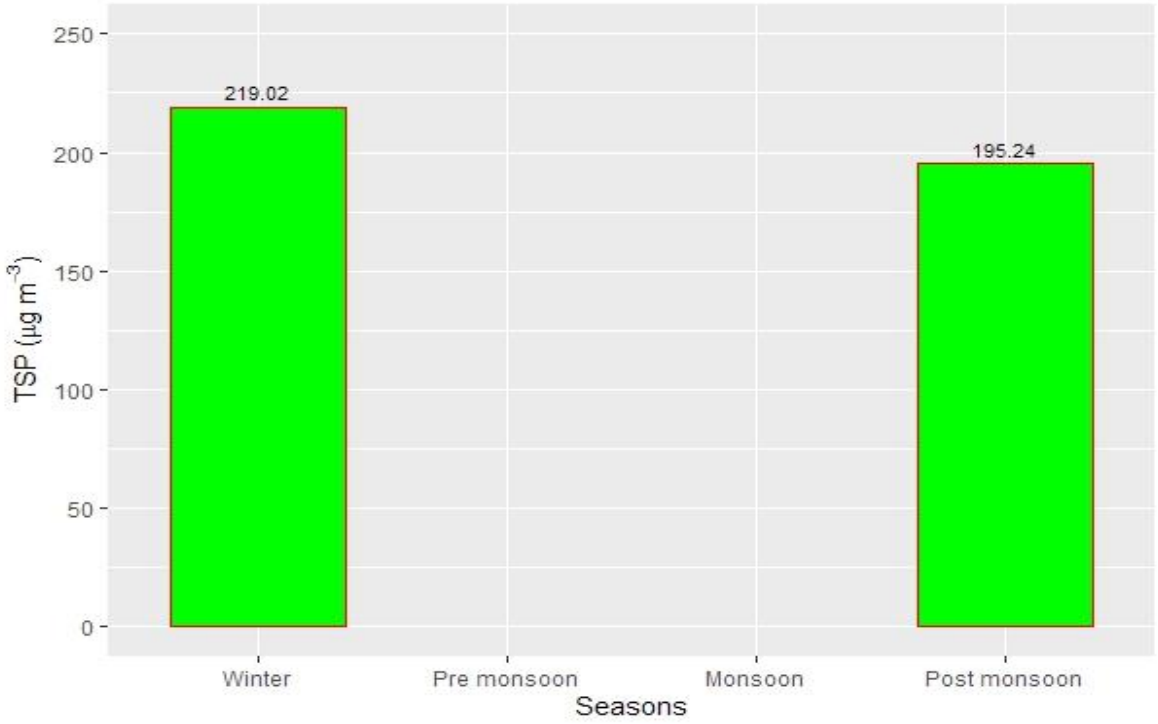


Figure 2.1.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 103 days of measurement, 58 days exceeded the National Ambient Air Quality Standard for TSP i.e., 230µg m^{-3}. From April to September there is data gap so the exact figure of exceeding NAAQS is not reflected in the figure 2.1.24.

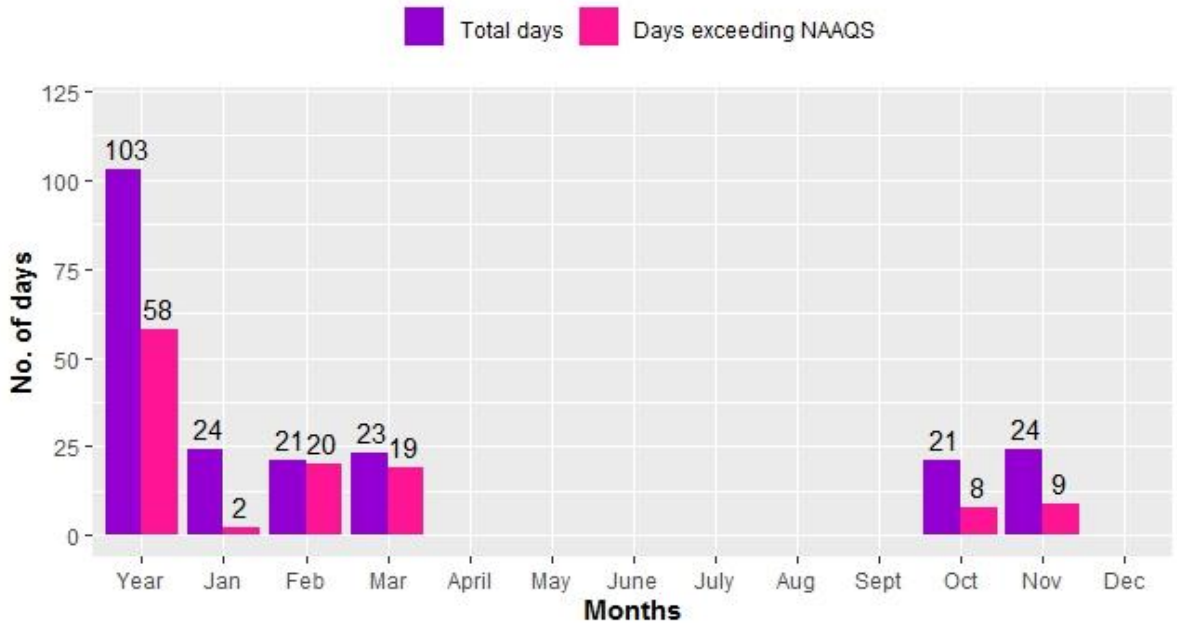


Figure 2.1.24: Compliance status of TSP

Calendar Plot

The following figure 2.1.25 shows the calendar plot for $PM_{2.5}$ based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to unhealthy level in January, February and few days in March, October and November.

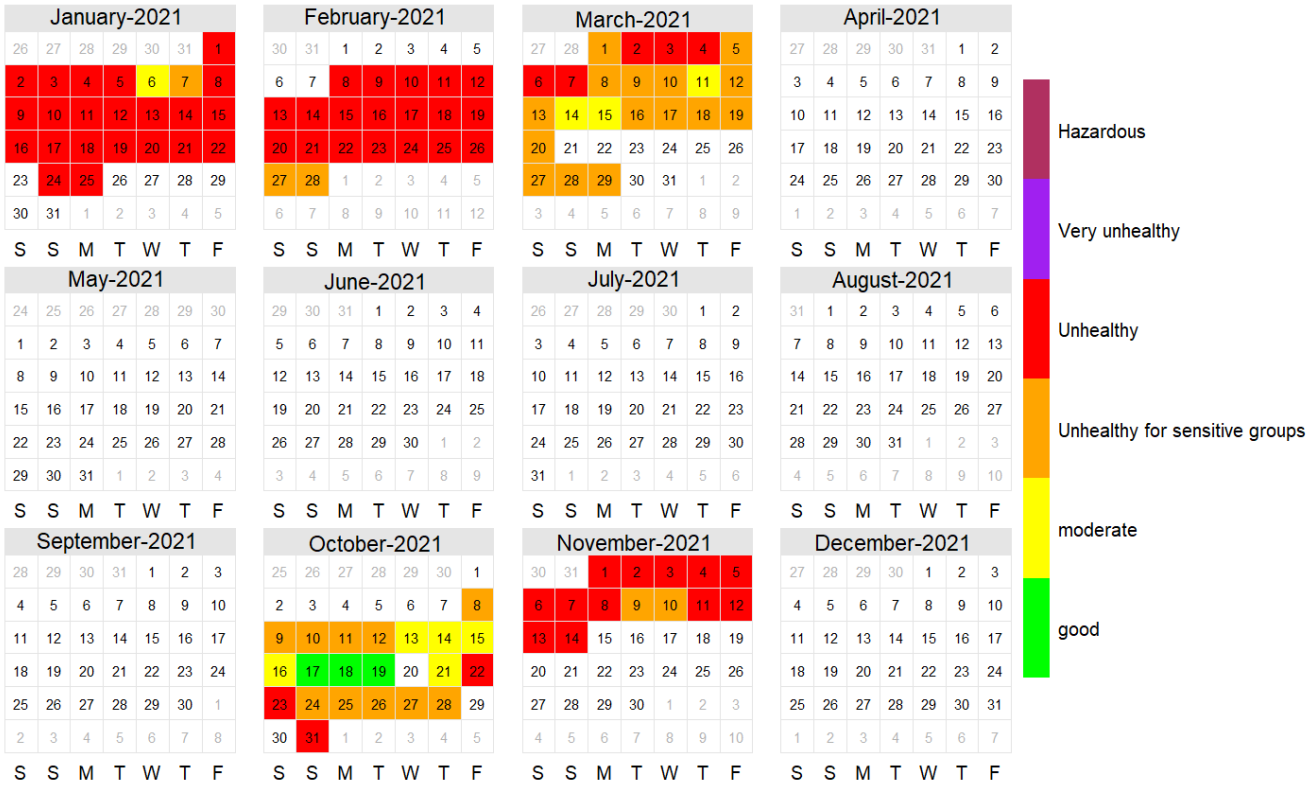


Figure 2.1.25: Calendar plot for $PM_{2.5}$ for the year 2021

2.2 Air quality status – Dhangadhi

2.2.1 Introduction

In Dhangadhi Air Quality Monitoring Station was established at Khulla Manch in the year 2020. The station lies in the centre of Dhangadhi city and represents the urban area. Dhangadhi lies in the south western part of Nepal. The main sources of pollution are vehicles and industries. Burning of agricultural residue is commonly done during pre-monsoon season. Since this is near to border trans boundary air pollution is also an issue of this location.

The Station is installed with following instruments:

SN	Name of Instrument	Number of instrument
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.2.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Dhangadhi Station was observed to range from 1 to 1498.7 µg m^{-3} (Figure 2.2.1). The mean of the $PM_{2.5}$ point data was observed to be 63.82 µg m^{-3}.

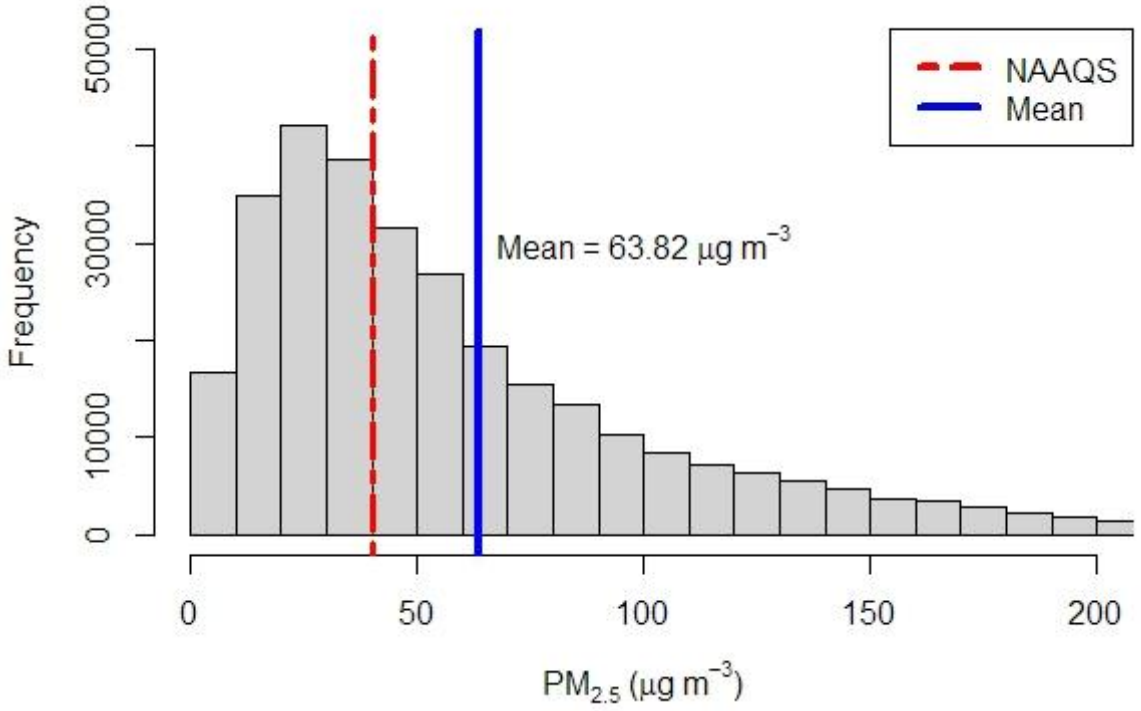


Figure 2.2.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.2.2 shows $PM_{2.5}$ peaks at 7 AM and at 7 PM to 11 PM. It shows during day time (11 AM- 4 PM) $PM_{2.5}$ is relatively low**.** The variation is found high during 7 AM and 7 PM. The mean value is found to be more than the median throughout the day.

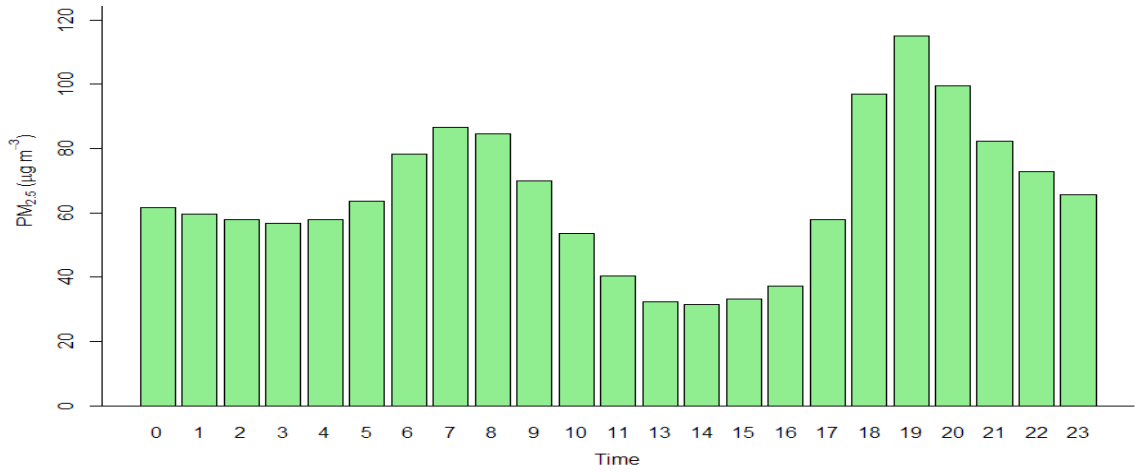


Figure 2.2.2: Hourly average of $PM_{2.5}$

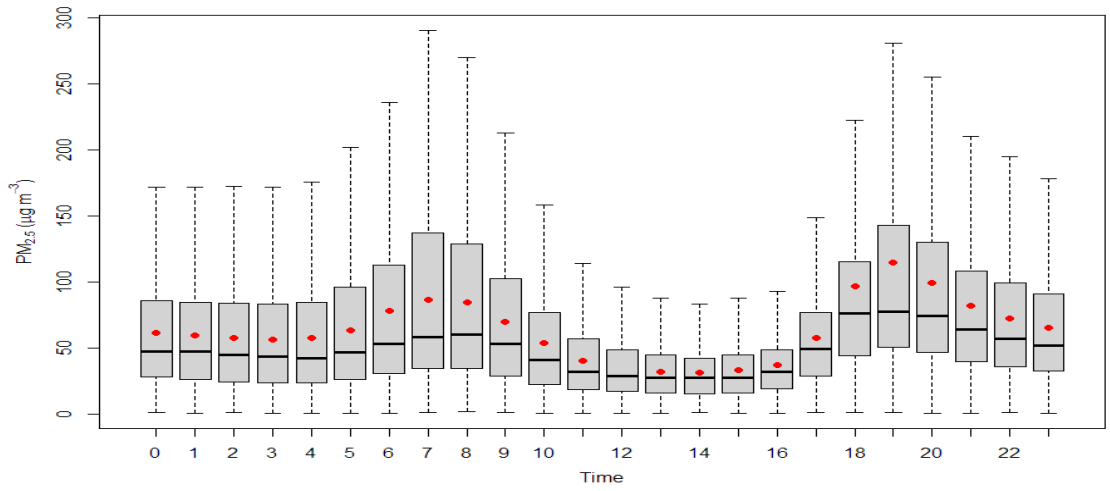


Figure 2.2.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variation of $PM_{2.5}$ is shown in figure 2.2.4. Higher concentration can be seen during pre-monsoon season whereas lower concentration was observed during monsoon and post-monsoon season. However, lots of data is missing during monsoon season and winter season.

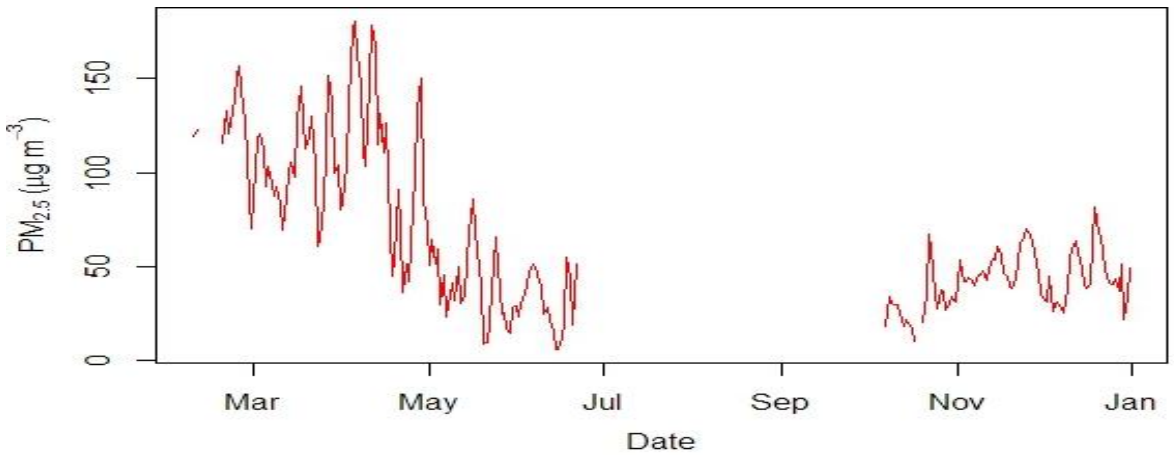


Figure 2.2.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during April whereas less during May to December. The mean value was found more than median during February, March, and April.

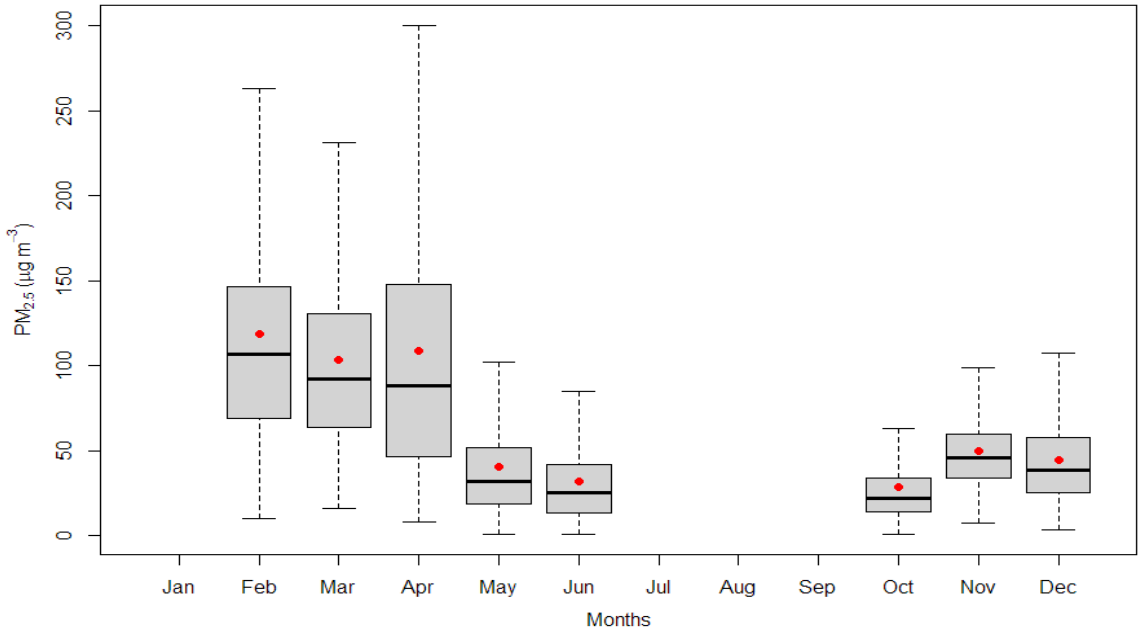


Figure 2.2.5: Monthly variation of $PM_{2.5}$

The monthly average of February was found to be highest (123.25 µg m^{-3}) and that of October was found to be lowest (30.37 µg m^{-3}) while comparing with other months as shown in figure 2.2.6 below. Monthly average was not calculated or January, July, August and September was not calculated due to insufficient data.

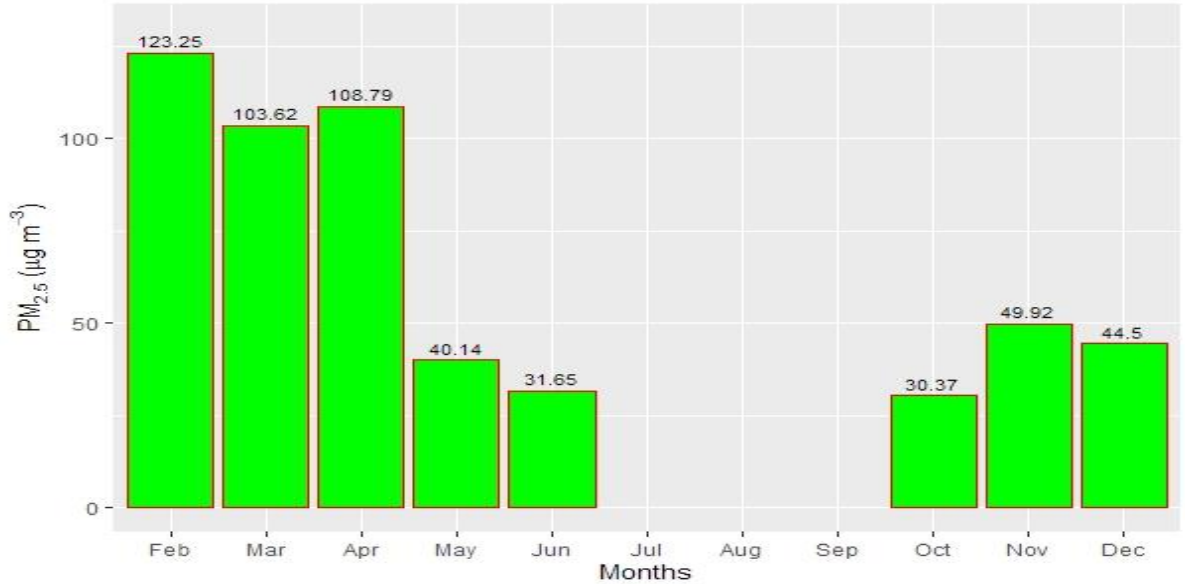


Figure 2.2.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during the winter season (135.53 µg m^{-3}) and the lowest during the post monsoon season (41.43 µg m^{-3}) as in figure 2.2.7. The seasonal average was not calculated for monsoon season due to insufficient data.

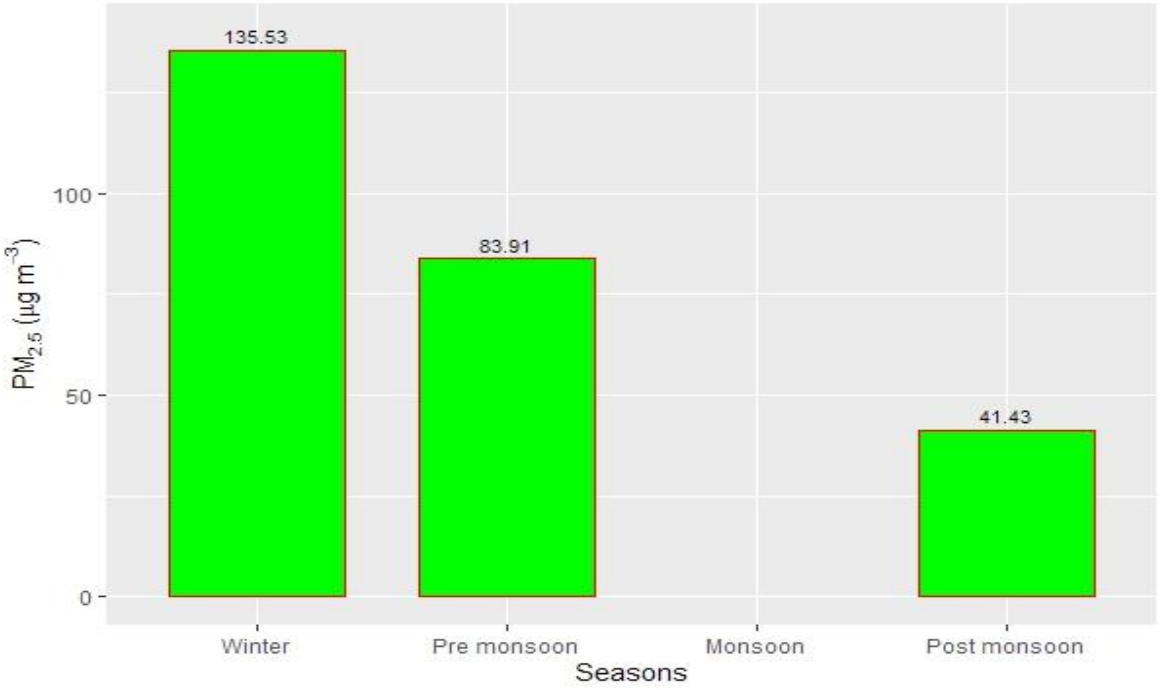


Figure 2.2.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 210 days of measurement, 142 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$.

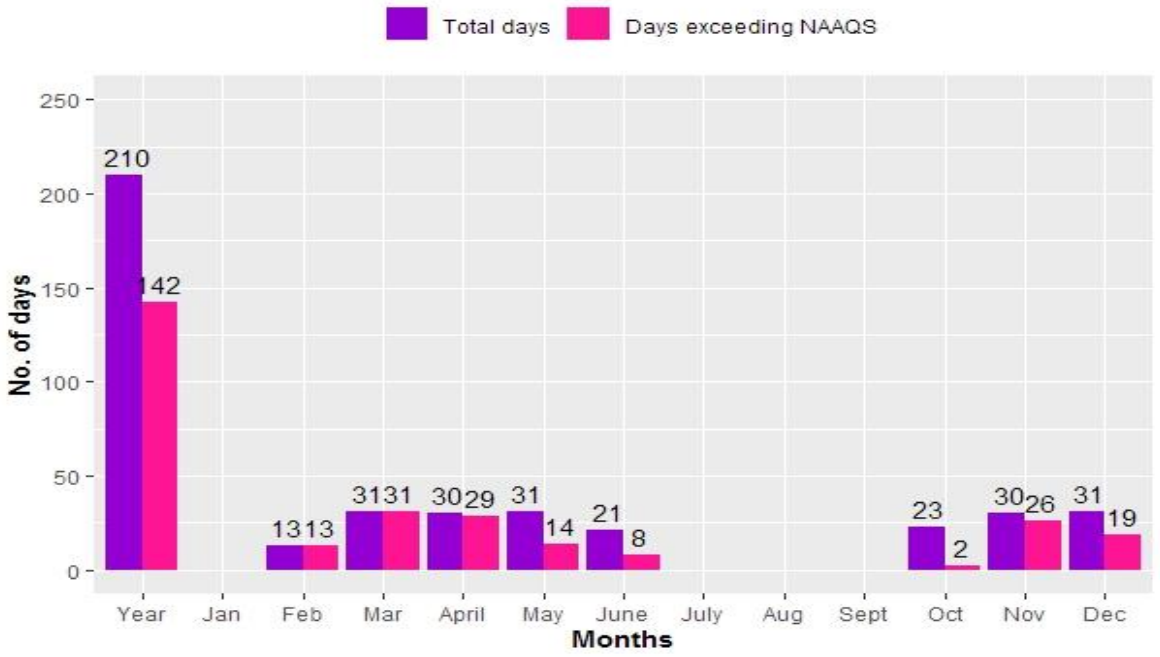


Figure 2.2.8: Compliance status of $PM_{2.5}$

2.2.3 PM_{10}

Histogram

PM_{10} in Dhangadhi Station was observed to range from 1 to 2995.5 µg m^{-3} (Figure 2.2.9). The mean of the PM_{10} point data was observed to be 123.1 µg m^{-3}.

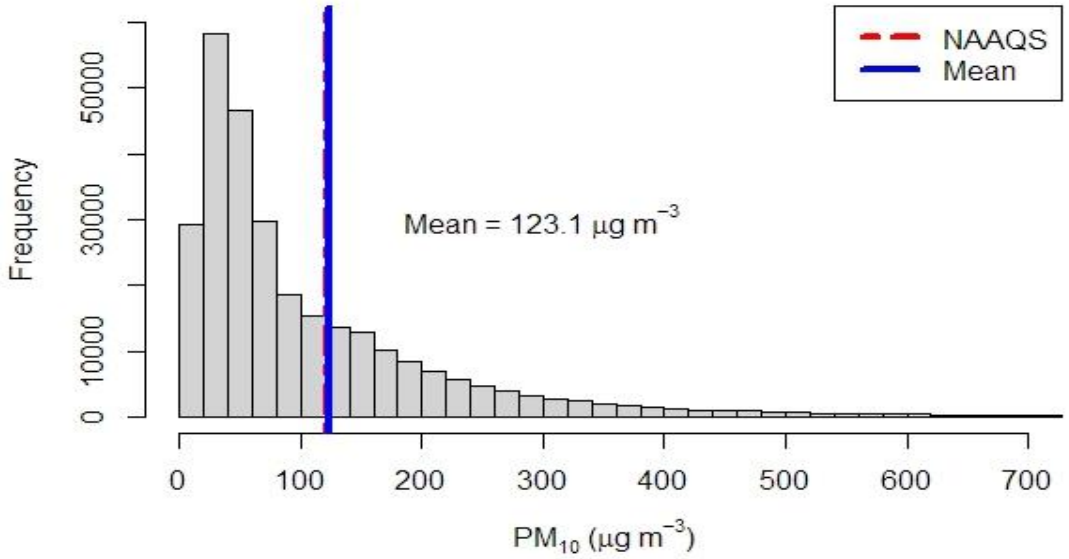


Figure 2.2.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.2.10 shows PM_{10} peaks at 8 AM and 7 PM. This shows PM_{10} is much higher during evening. The mean value is found to be more than median throughout the day. The variation is also high at 7 PM.

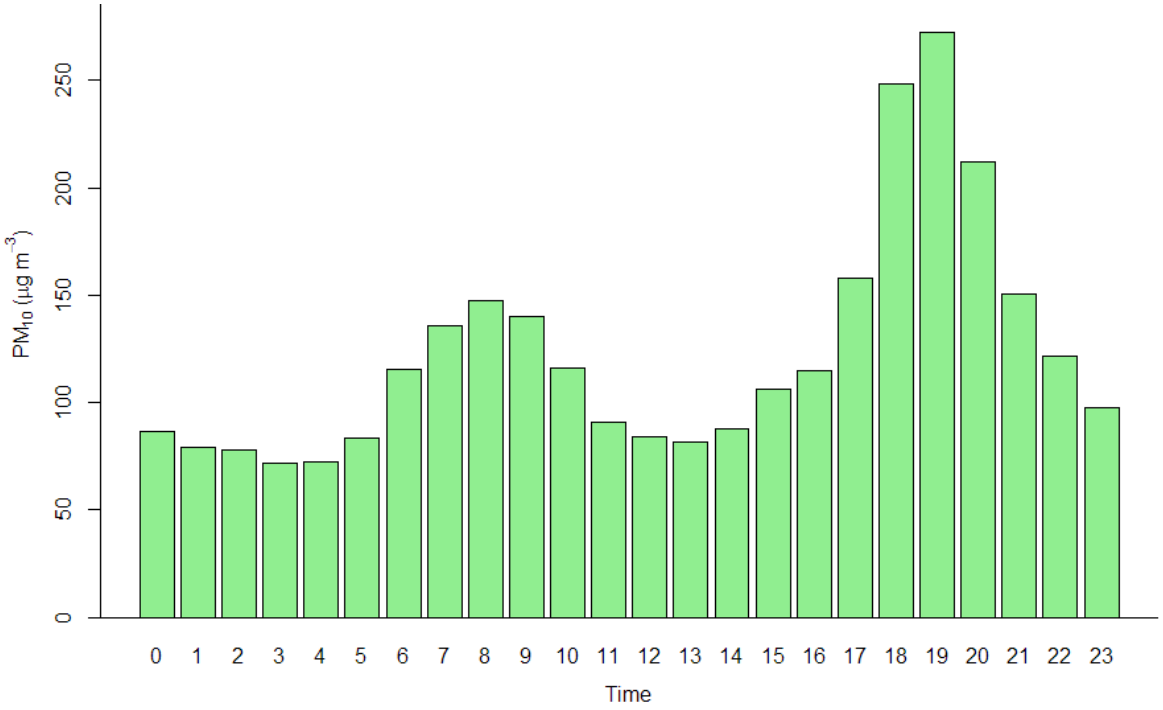


Figure 2.2.10: Hourly average of PM_{10}

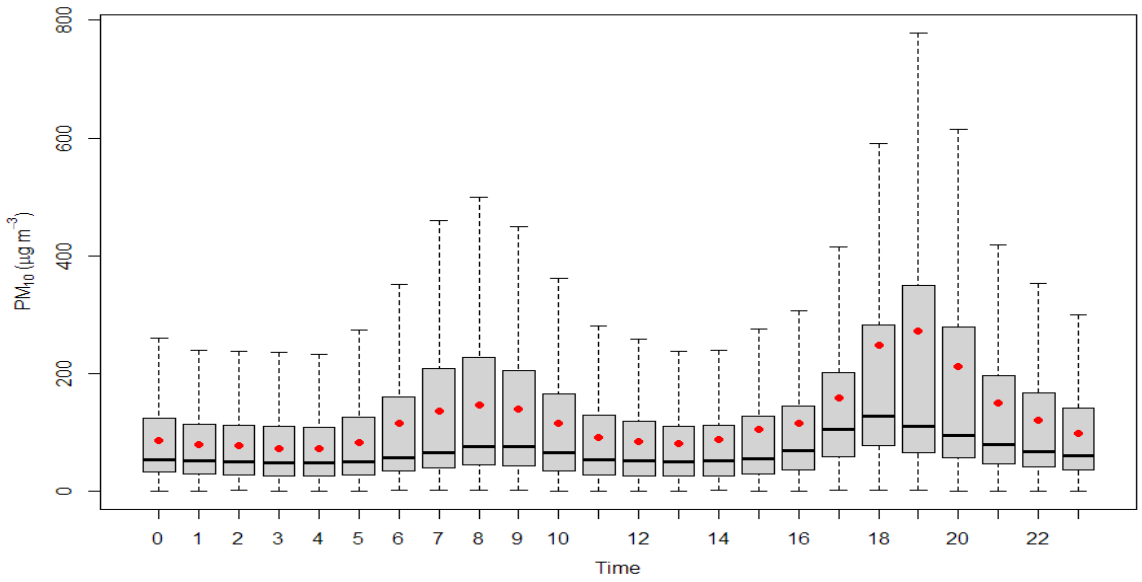


Figure 2.2.11: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.2.12. Higher concentration can be seen during winter and pre-monsoon season whereas lower concentration was observed during monsoon and post monsoon season.

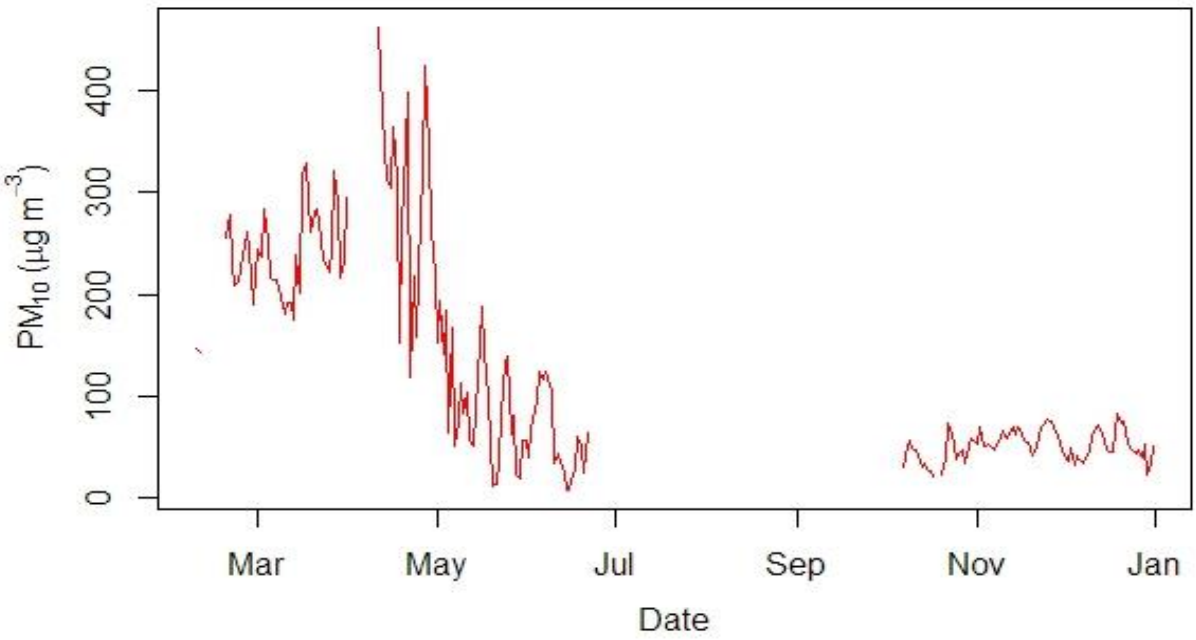


Figure 2.2.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during October, November and December. The mean value was found more than the median during February to June.

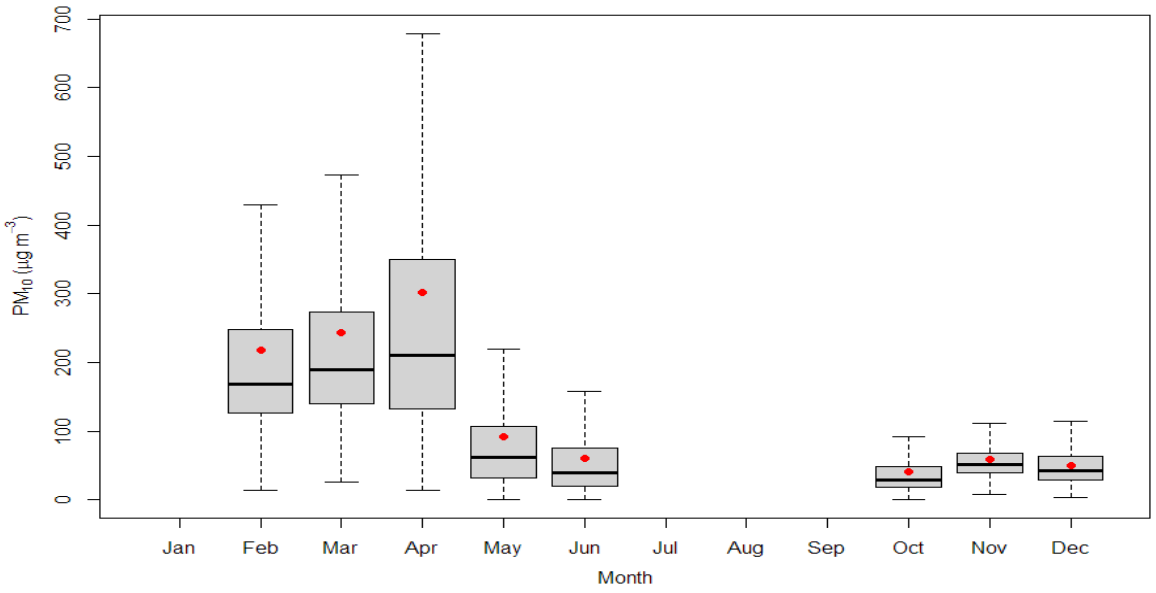


Figure 2.2.13: Monthly variation of PM_{10}

The monthly average for April was found the highest (299.3 µg m^{-3}) and that of October was found lowest (43.22µg m^{-3}) while comparing with other months as shown in figure 2.2.14. Monthly average for January, July, August and September was not calculated due to insufficient data.

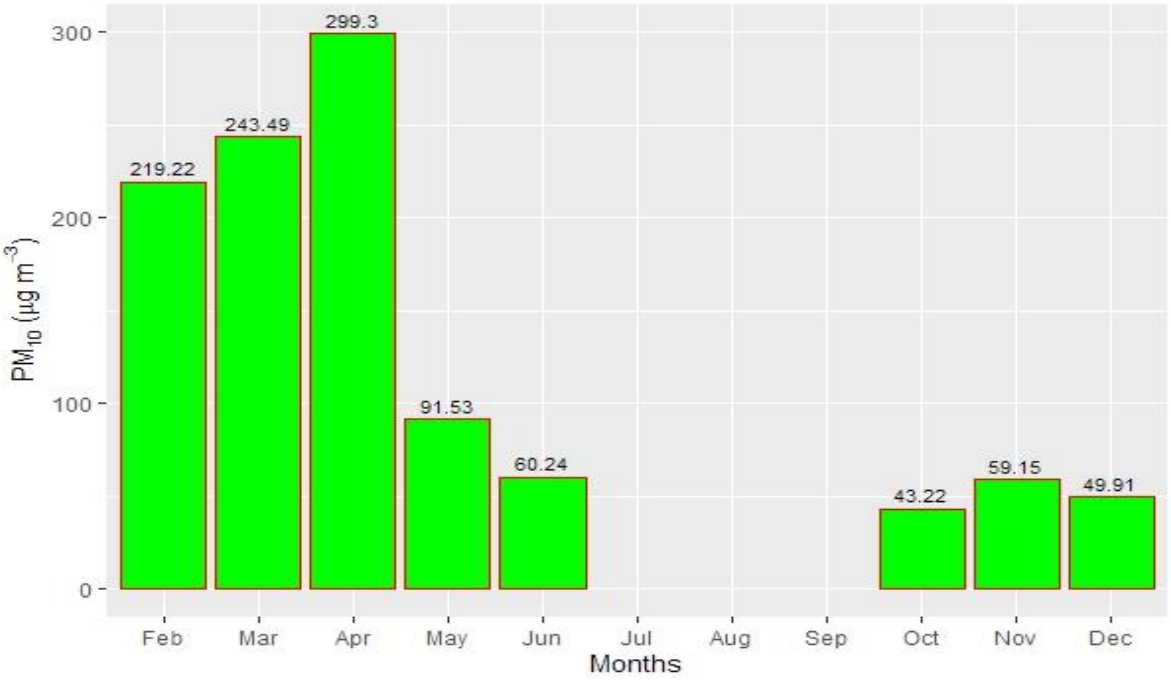


Figure 2.2.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be almost similar in winter and pre-monsoon season (200.33 µg m^{-3} and 199.65 µg m^{-3} respectively) while in post monsoon it was much lower (52.23 µgm^{-3}). Seasonal average was not calculated for monsoon season due to insufficient data.

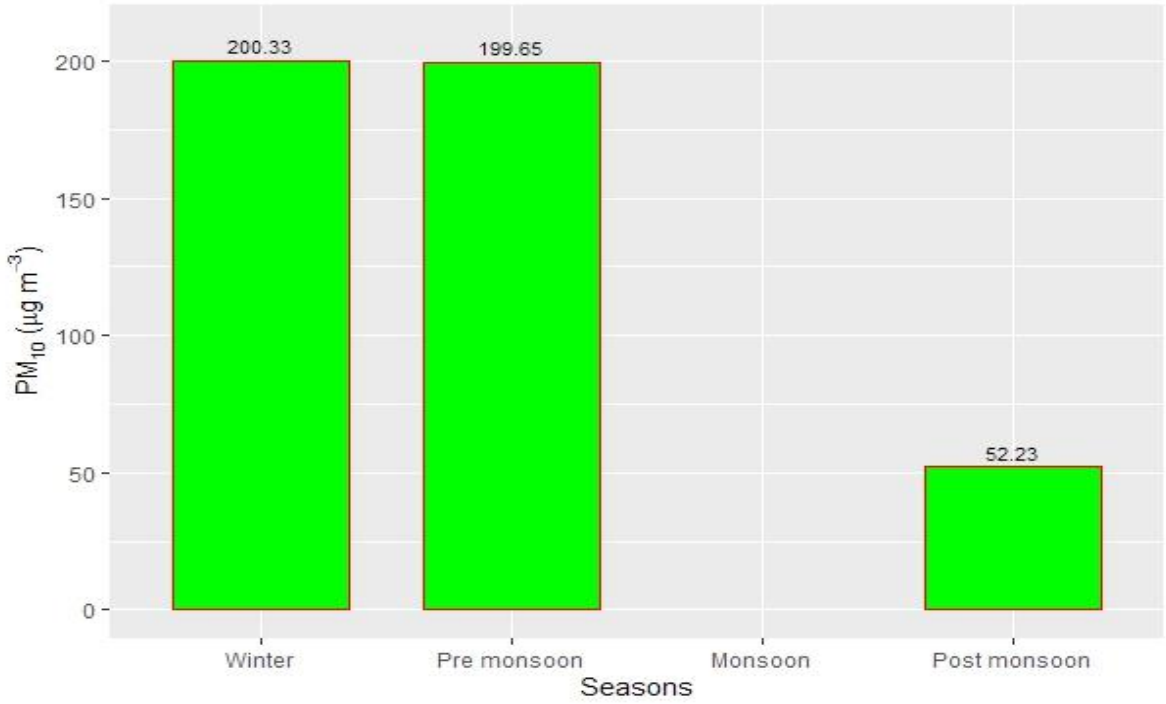


Figure 2.2.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 200 days of measurement, 74 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. During October, November and December none of the days exceed NAAQS as shown in figure 2.2.16.

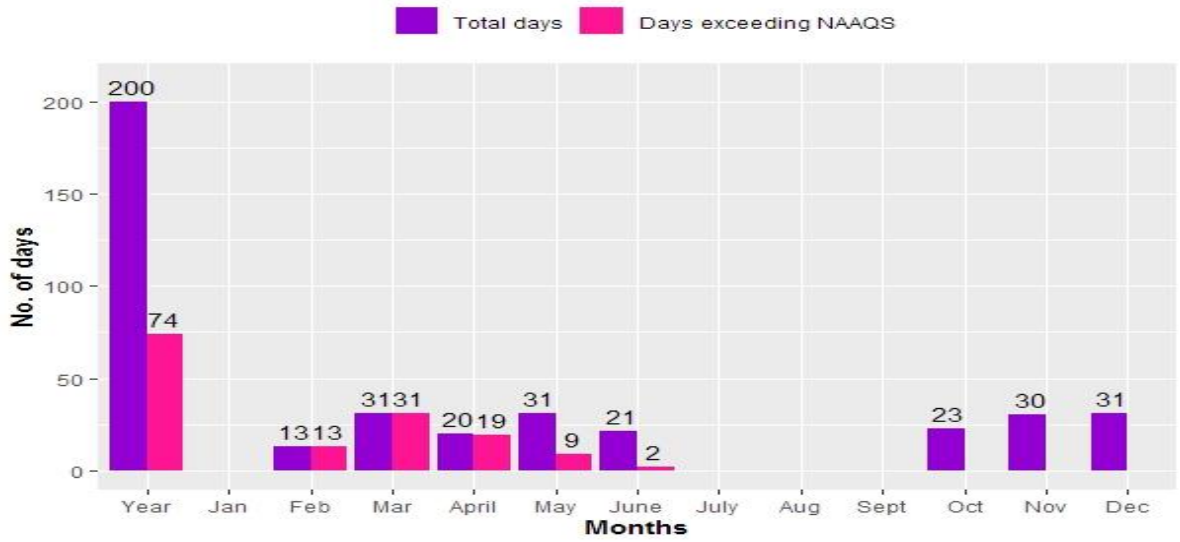


Figure 2.2.16: Compliance status of PM_{10}

2.2.4 TSP

Histogram

TSP in Dhangadhi Station was observed to range from 1 to 4999.7 µg m^{-3} (Figure 2.2.17). The mean of the TSP point data was observed to be 267.5 µg m^{-3}.

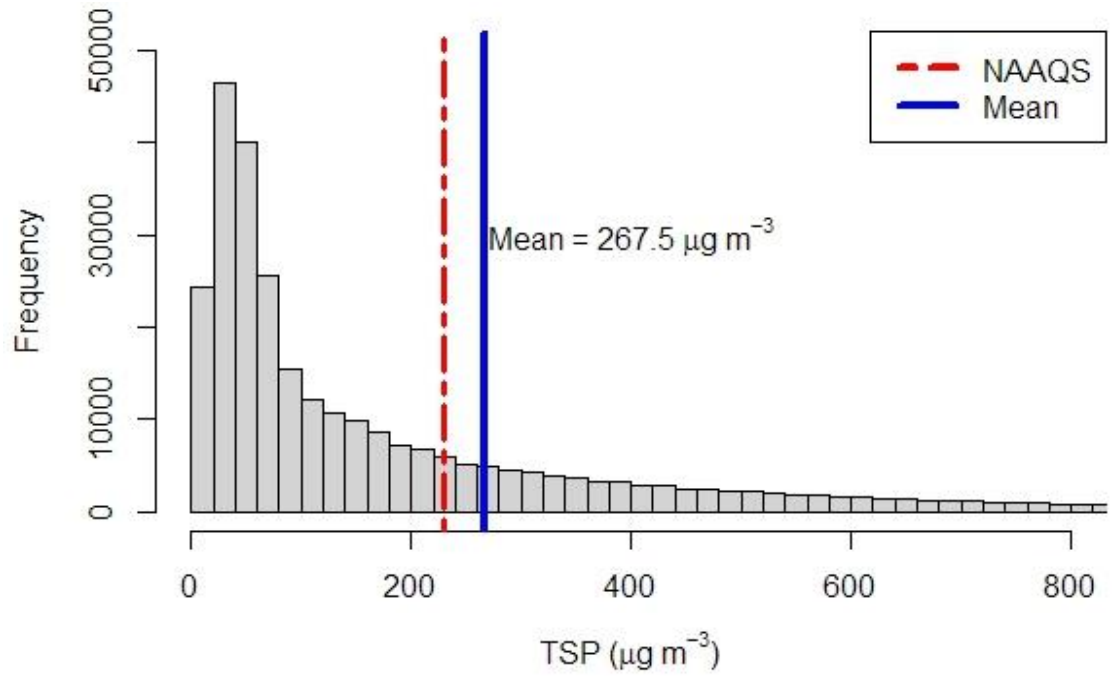


Figure 2.2.17: Histogram of TSP

Diurnal Variation

Figure 2.2.18 shows TSP peaks at 9 AM and 6 PM. This shows TSP is much higher during evening. The mean value is found to be more than median throughout the day. The variation is also high at 7 PM.

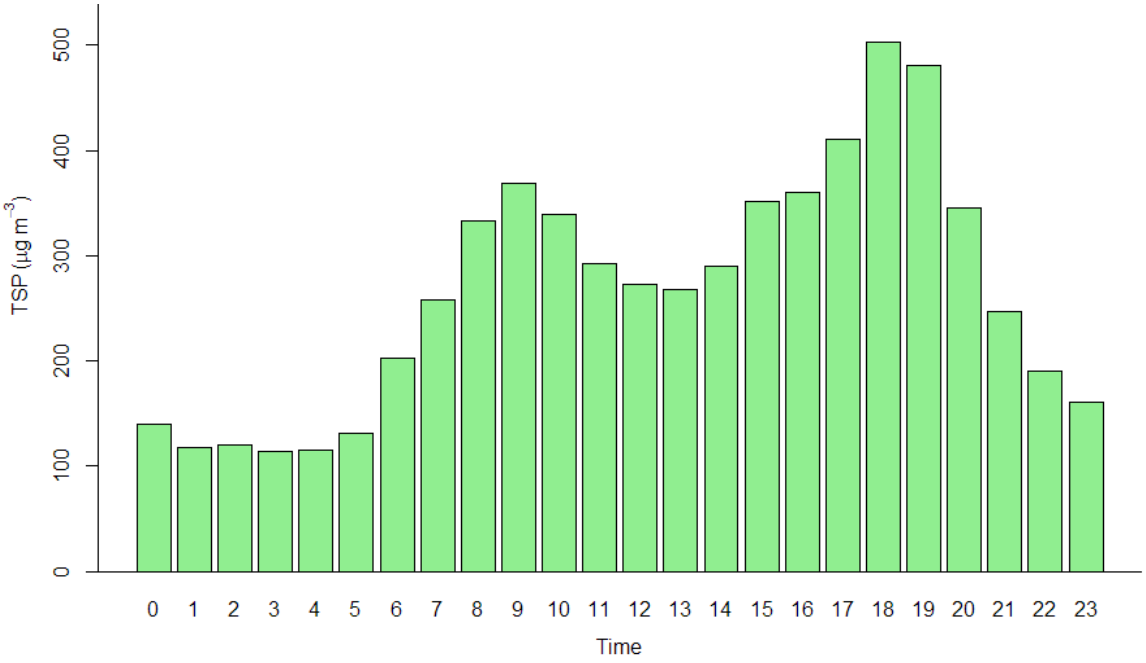


Figure 2.2.18: Hourly average of TSP

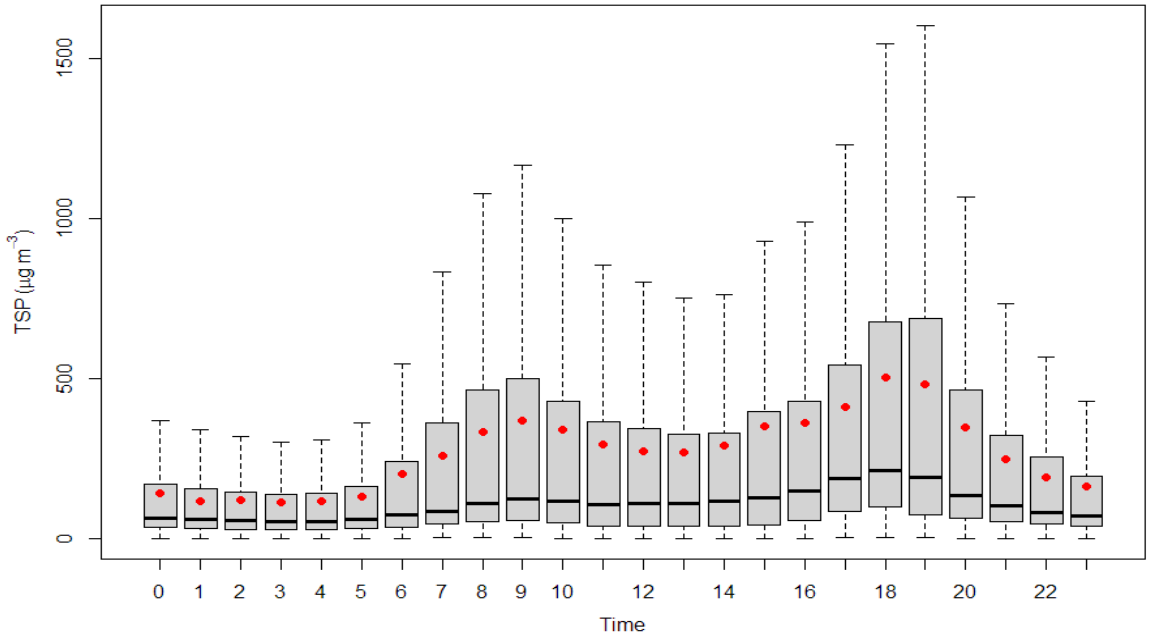


Figure 2.2.19: Diurnal variation of TSP.

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.2.20. Higher concentration can be seen during winter and pre-monsoon season whereas lower concentration was observed during monsoon and post monsoon season.

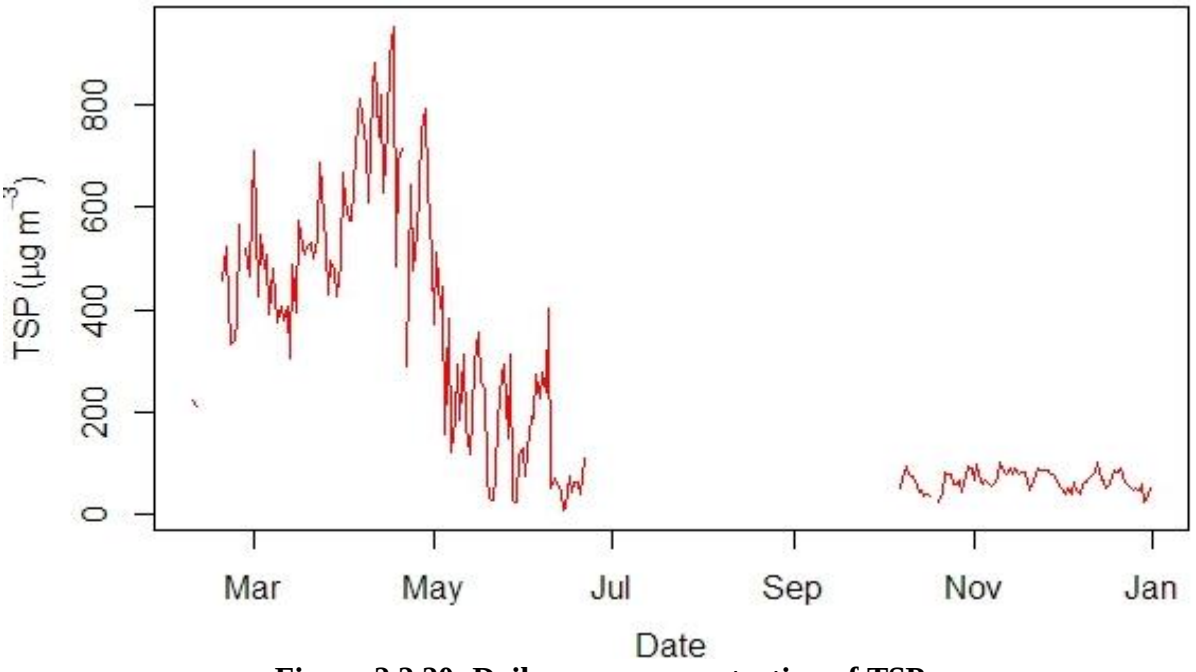


Figure 2.2.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during October, November and December. The mean value was found more than median during February to June.

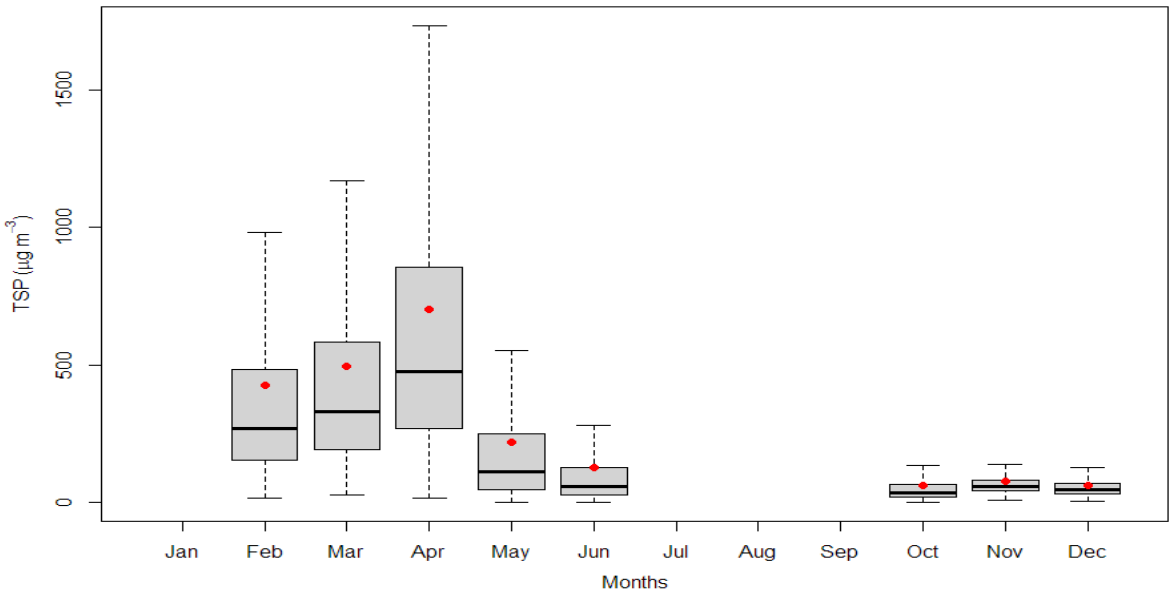


Figure 2.2.21: Monthly variation of TSP

The monthly average for April was found to be the highest (681.97 µg m^{-3}) and that of December was found to be the lowest (60.38 µg m^{-3}) while comparing with other months as shown in figure 2.2.22. Monthly average for January, February, July, August and September was not calculated due to insufficient data.

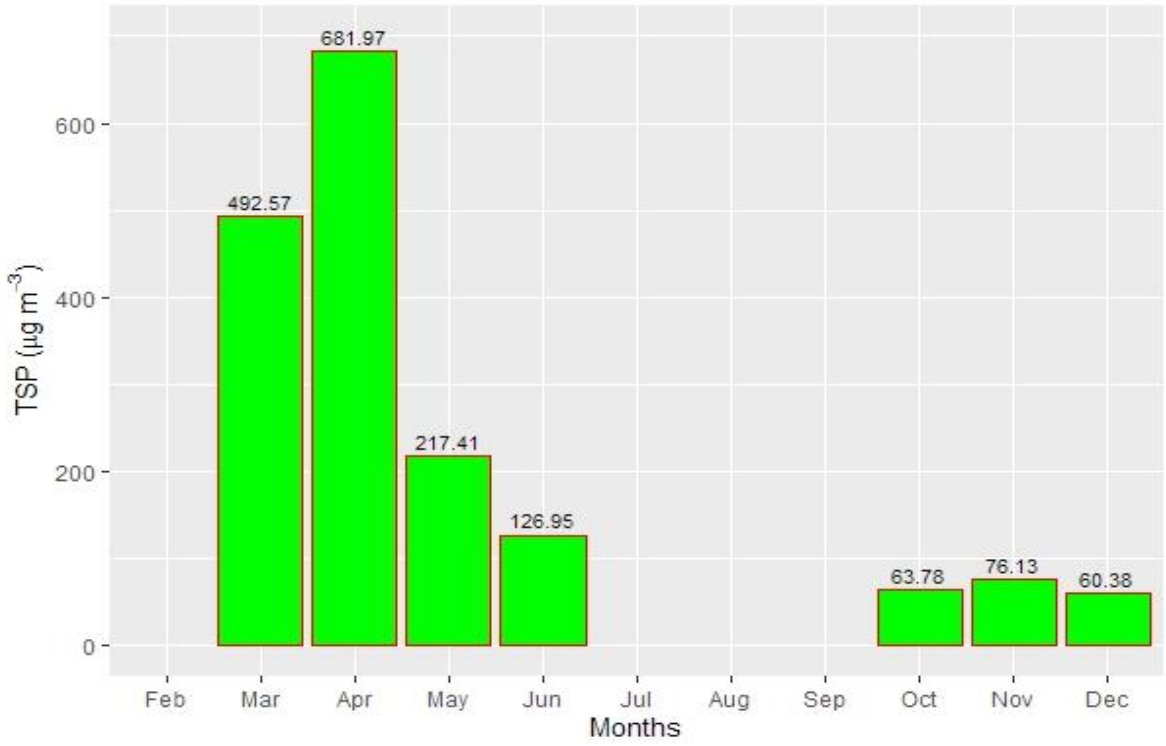


Figure 2.2.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be 459.19 µg m^{-3} and 11.32 µg m^{-3} during pre- and post-monsoon season. Seasonal average was not calculated for winter and monsoon season.

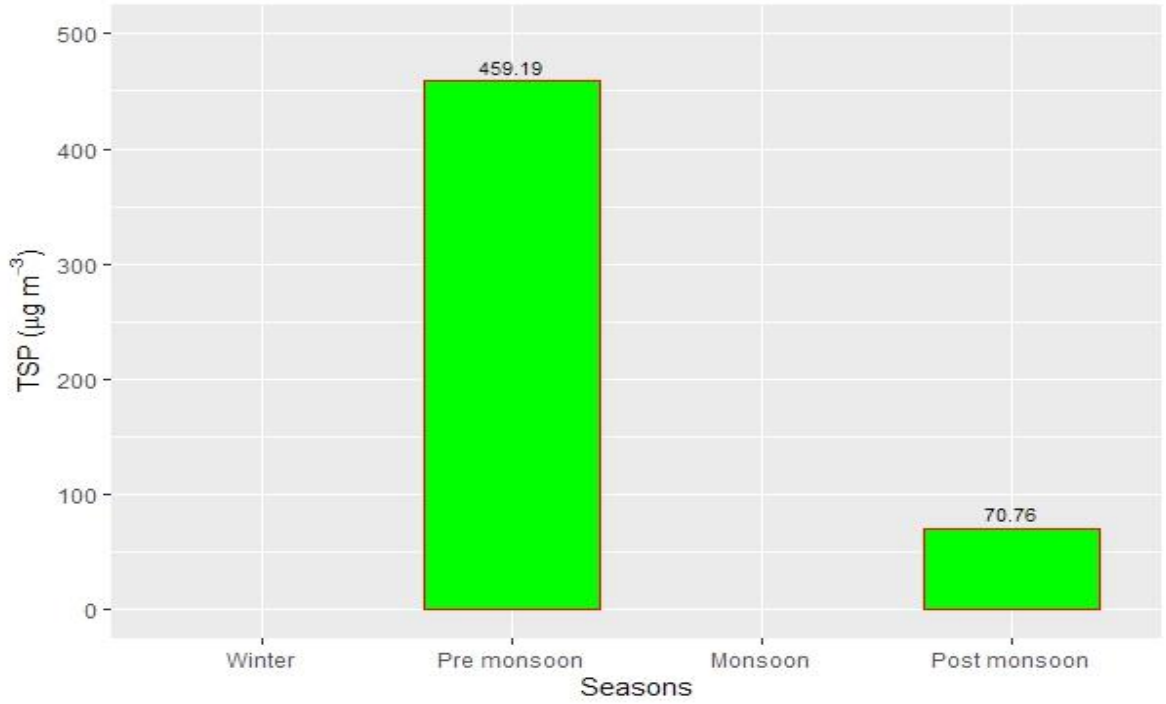


Figure 2.2.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 208 days of measurement, 88 days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}. During October, November and December none of the days exceed NAAQS as shown in figure 2.2.24.

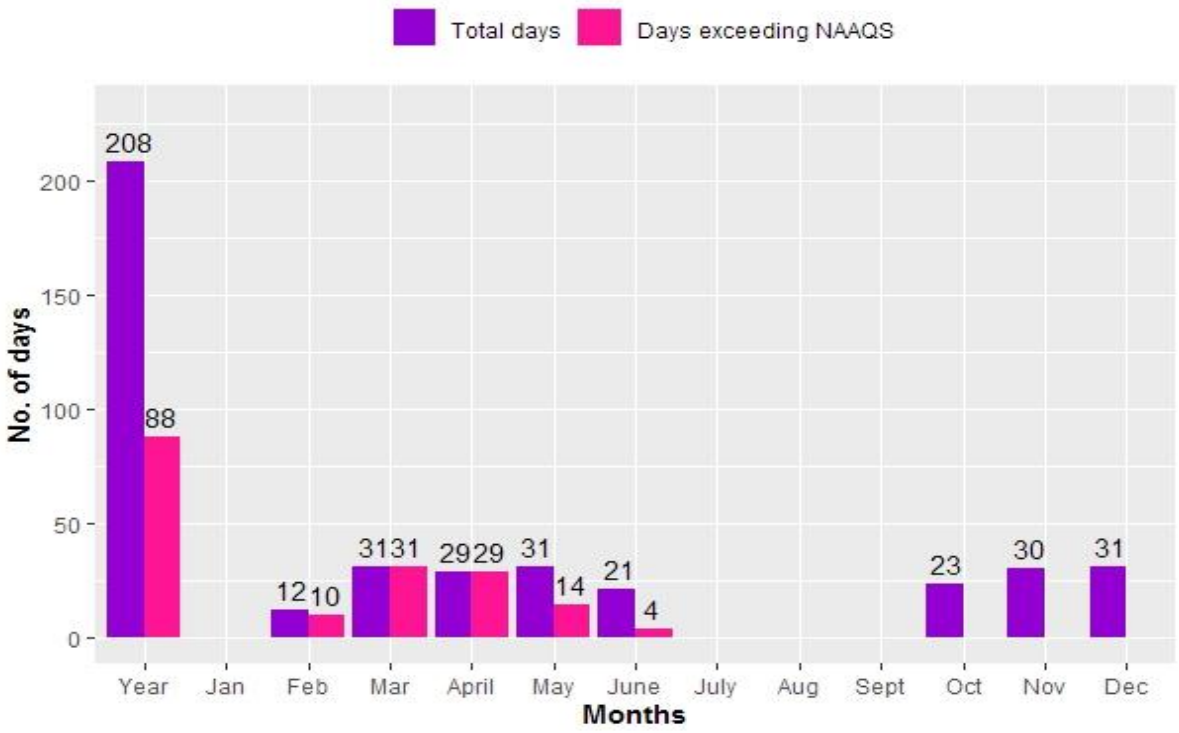


Figure 2.2.24: Compliance status of TSP

Calendar Plot

Calendar plot is prepared for $PM_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to very unhealthy level during 4, 5,6,11 and 12th day of April and was unhealthy during February, March and few days in April, November and December.

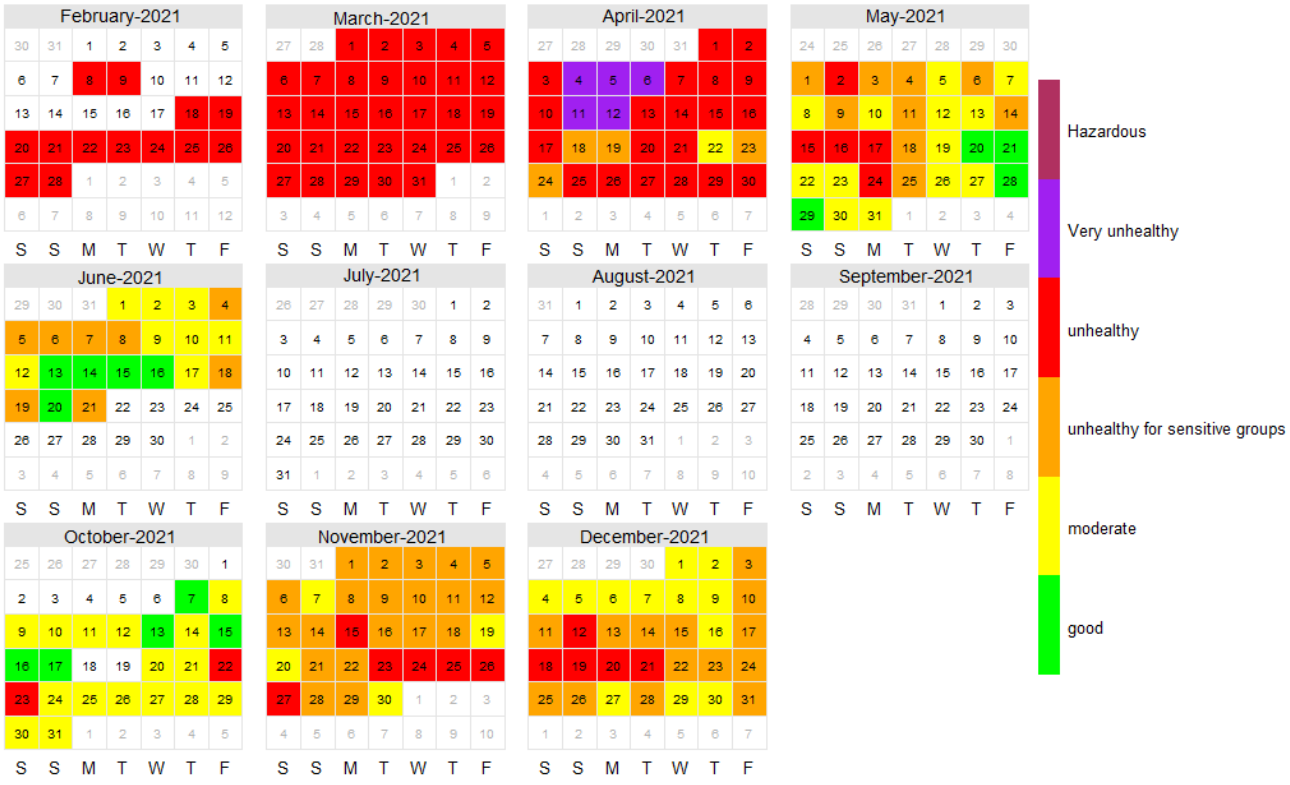


Figure 2.2.25: Calendar plot for $PM_{2.5}$ for the year 2021

2.3 Air quality status – Rara

2.3.1 Introduction

Inside the premises of Rara National Park, the Rara Air Quality Monitoring Station was established in the year 2020. It lies in Mugu district of Karnali Province. This station represents air quality of high mountain (also stated as background AQMS). Hence the major source of air pollution in this area is either forest fire or pollutants transported because of various meteorological processes.

The Station is installed with following instruments:

SN	Name of Instrument	Number of instrument
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.3.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Rara Station was observed to range from 0.3 to 646 µg m^{-3} (Figure 2.3.1). The mean of the $PM_{2.5}$ point data was observed to be 16.8 µg m^{-3}.

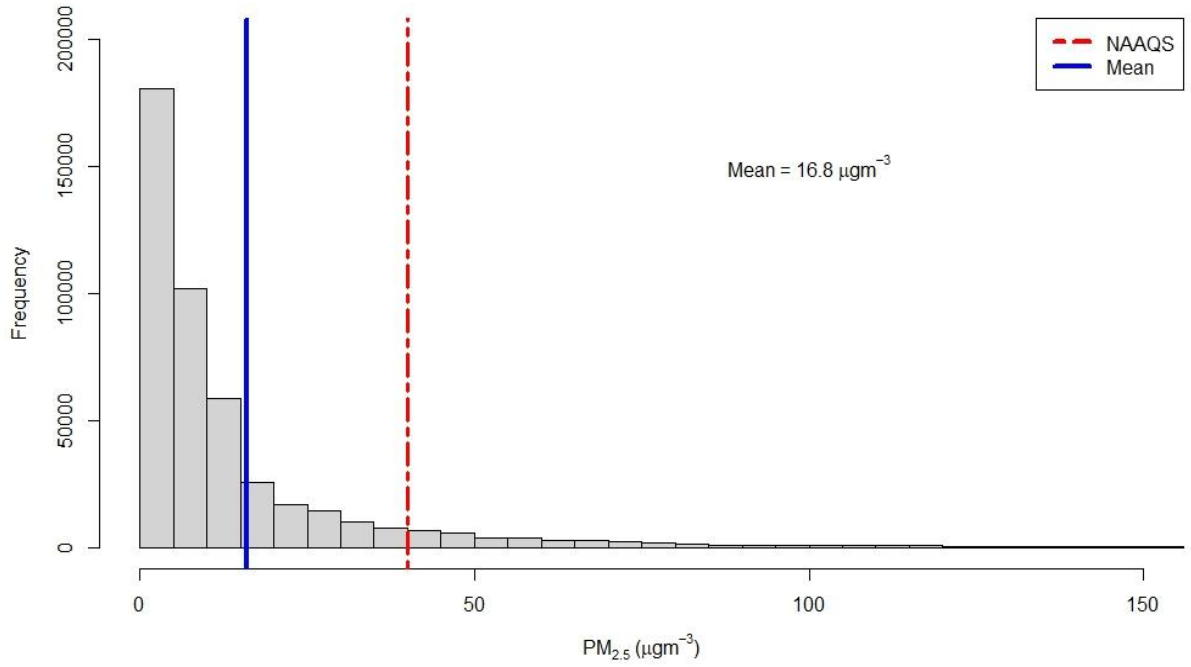


Figure 2.3.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.3.2 shows $PM_{2.5}$ peaks at 12 AM to 1 AM and at 10 PM to 11 PM. The diurnal variation was found high during 1 to 2 AM as well as 10 to 11 PM. The mean value was found to be more than the median throughout the day as in figure 2.3.3 below.

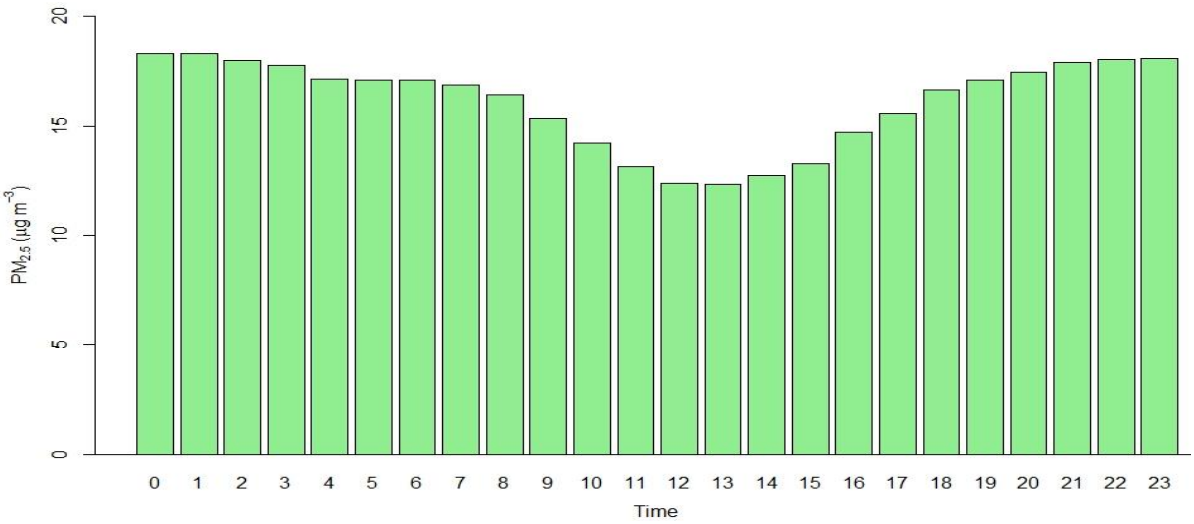


Figure 2.3.2: Hourly average of $PM_{2.5}$

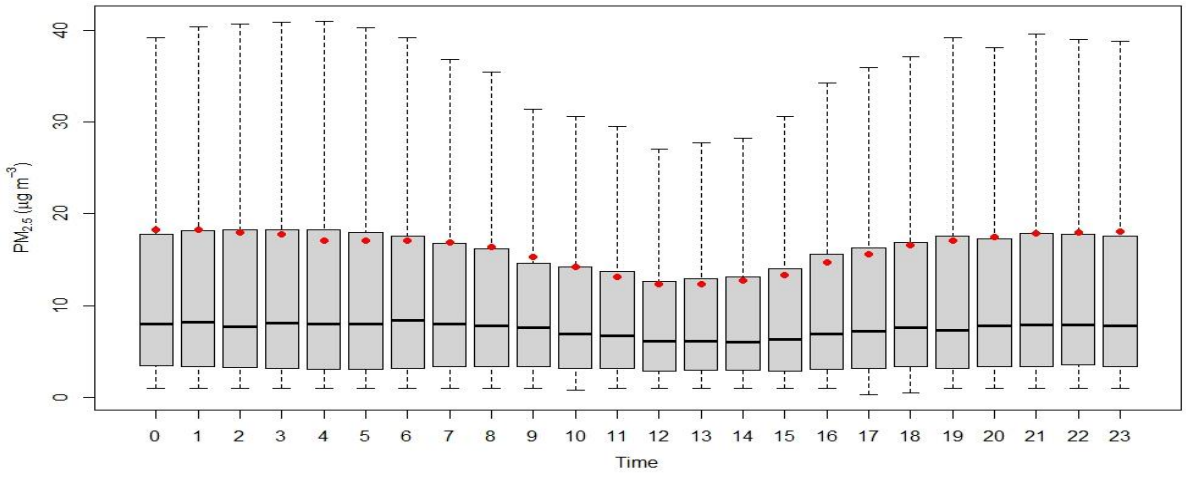


Figure 2.3.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variation of $PM_{2.5}$ is shown in figure 2.3.4. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post-monsoon season.

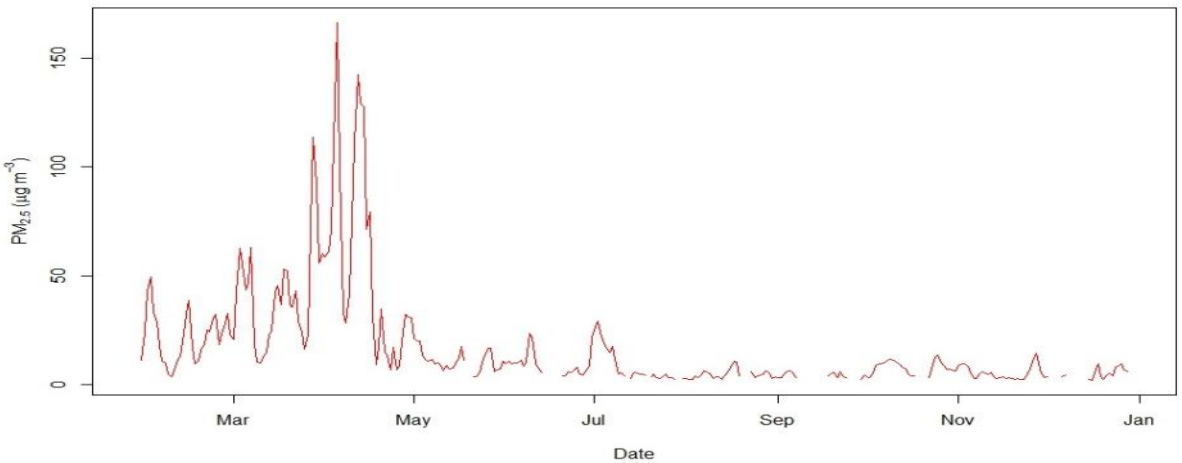


Figure 2.3.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during April whereas less during August and September. The mean value was found more than median during January, February, March, April and June.

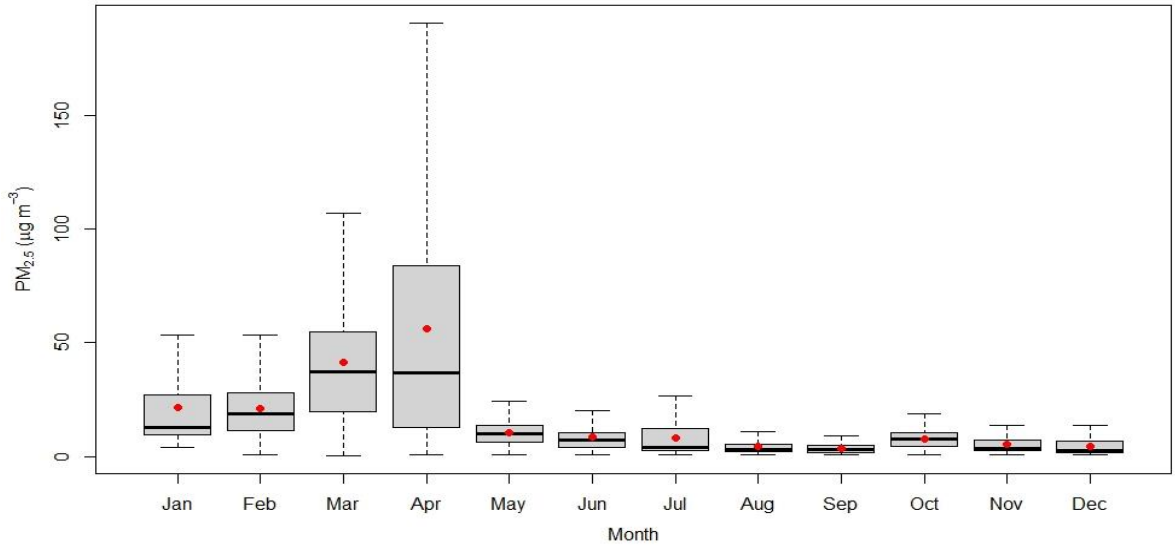


Figure 2.3.5: Monthly variation of $PM_{2.5}$

The monthly average of April was found to be highest (56 µg m^{-3}) and that of September was found to be lowest (4.09 µg m^{-3}) while comparing with other months as shown in figure 2.3.6 below.

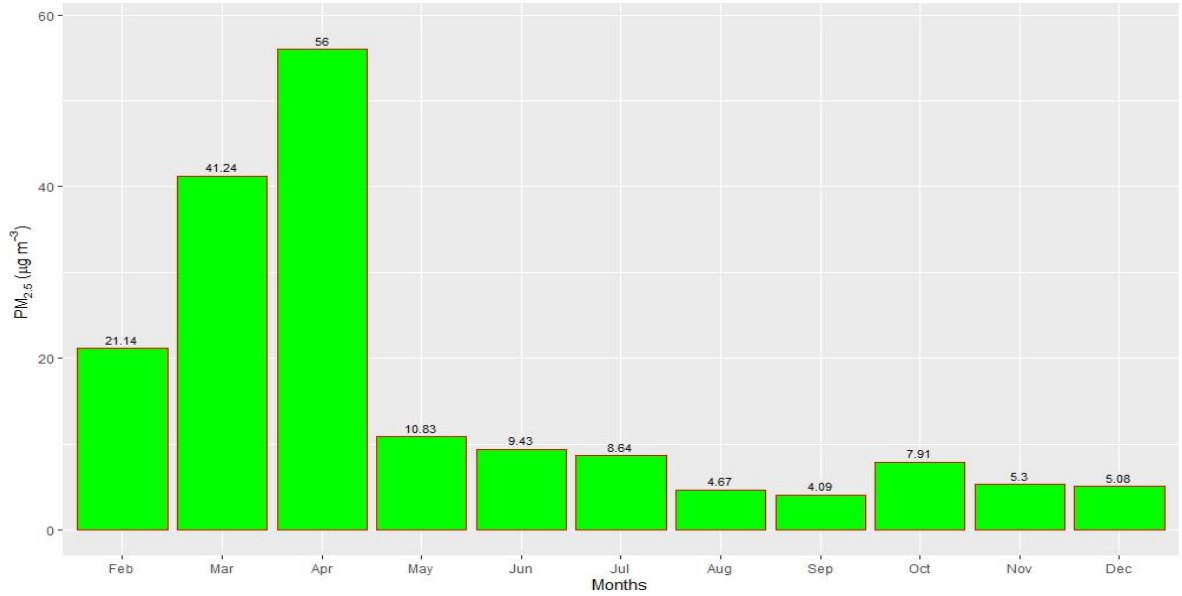


Figure 2.3.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during the pre-monsoon season (35.36 µg m^{-3}) and the lowest during the monsoon season (6.53 µg m^{-3}) as in figure 2.3.7.

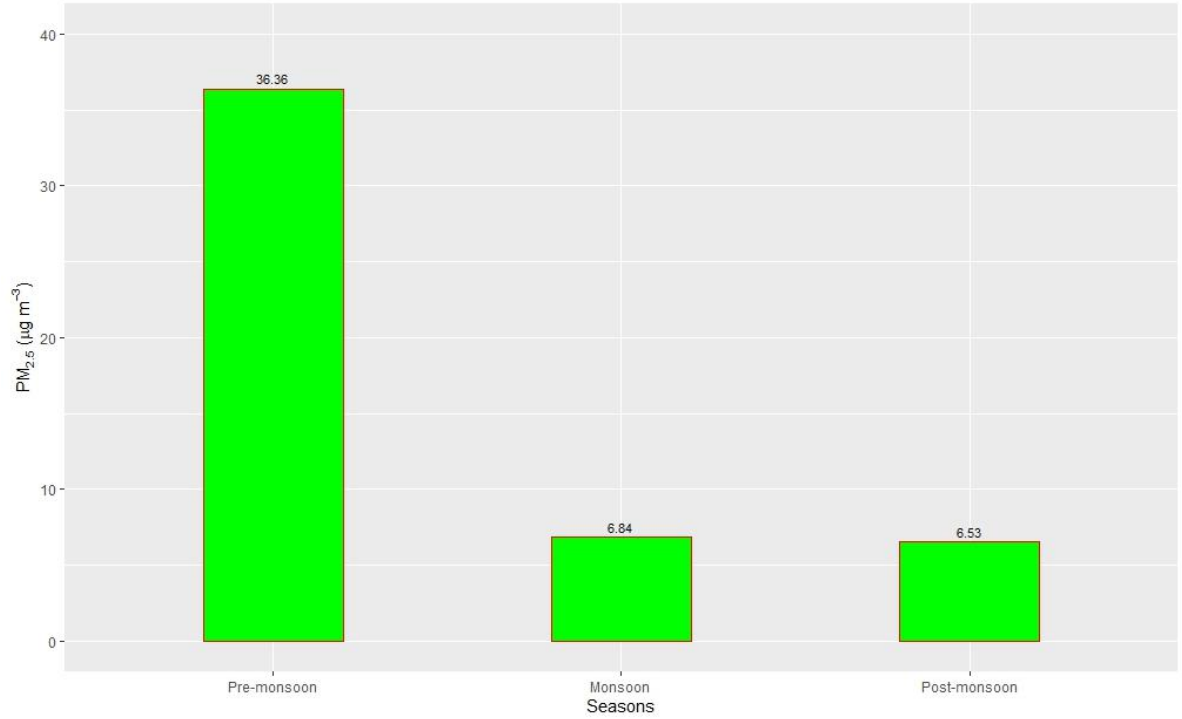


Figure 2.3.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 294 days of measurement, only 32 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$. From May to December none of the days exceed NAAQS of 40 µg m^{-3} as shown in figure 2.3.8.

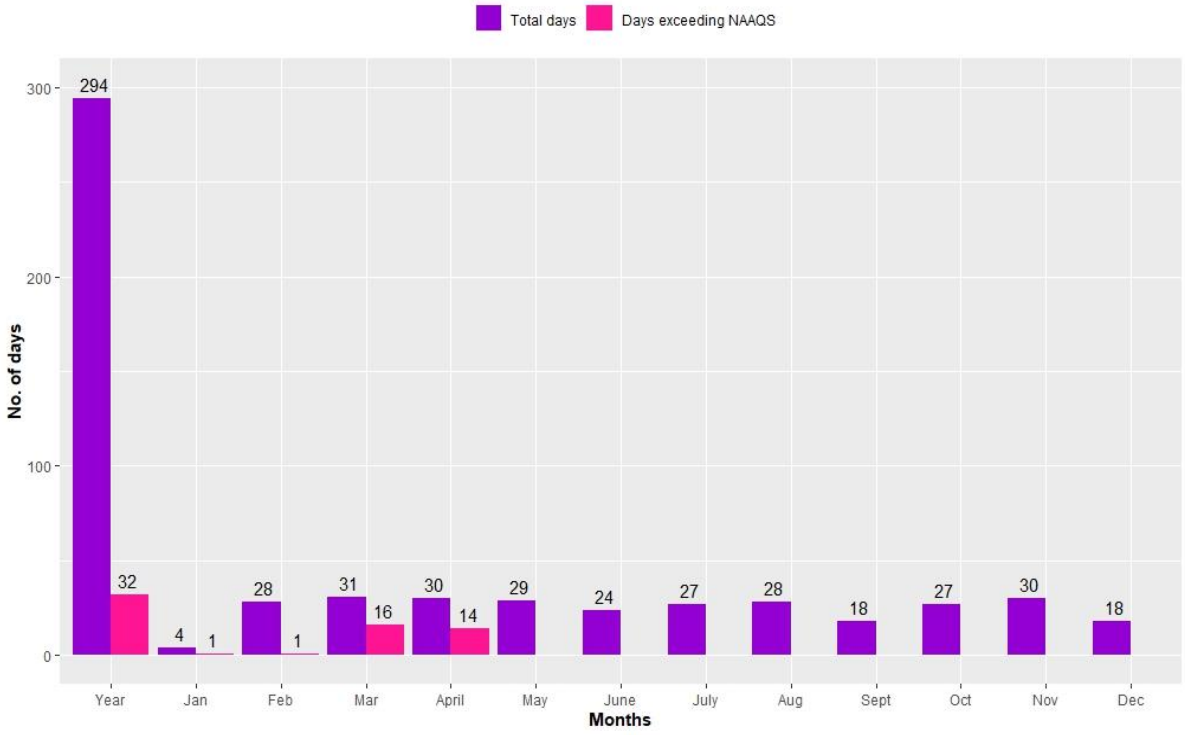


Figure 2.3.8: Compliance status of $PM_{2.5}$

2.3.3 PM_{10}

Histogram

PM_{10} in Rara Station was observed to range from 0.3 to 1000.3 µg m^{-3} (Figure 2.3.9). The mean of the PM_{10} point data was observed to be 21.80 µg m^{-3}.

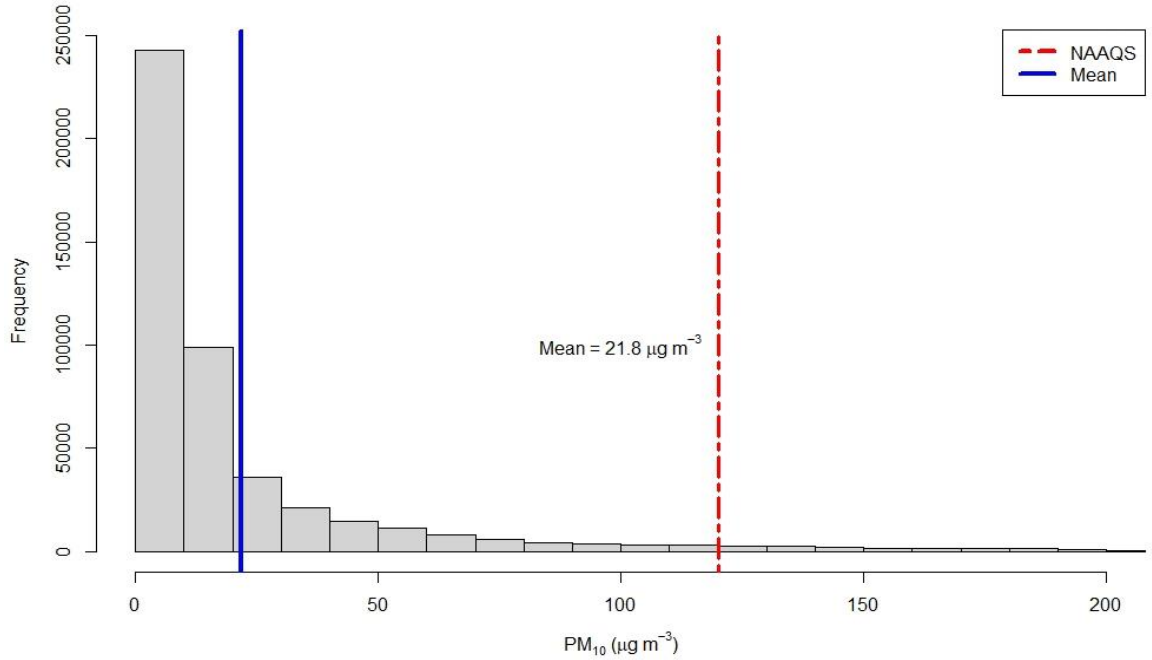


Figure 2.3.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.3.10 shows PM_{10} peaks at 12 AM to 1 AM and at 9 PM to11 PM. The diurnal variation is found high during 7 PM. The mean value is found to be more than median throughout the day as in figure 2.3.11.

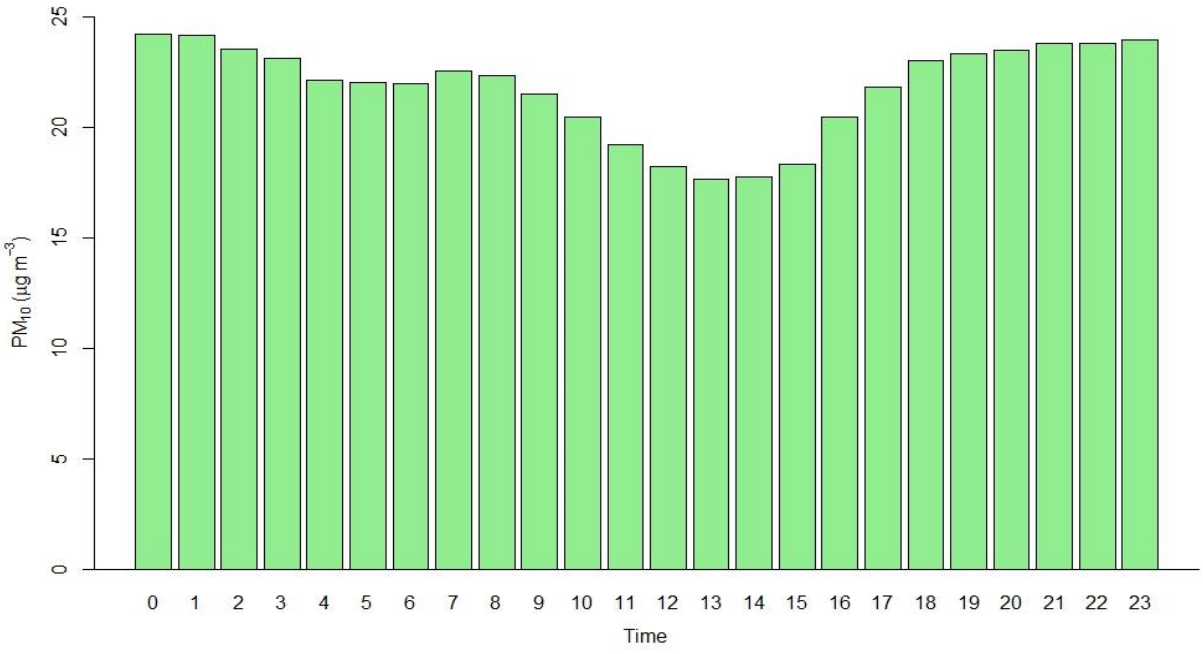


Figure 2.3.10: Hourly average of PM_{10}.

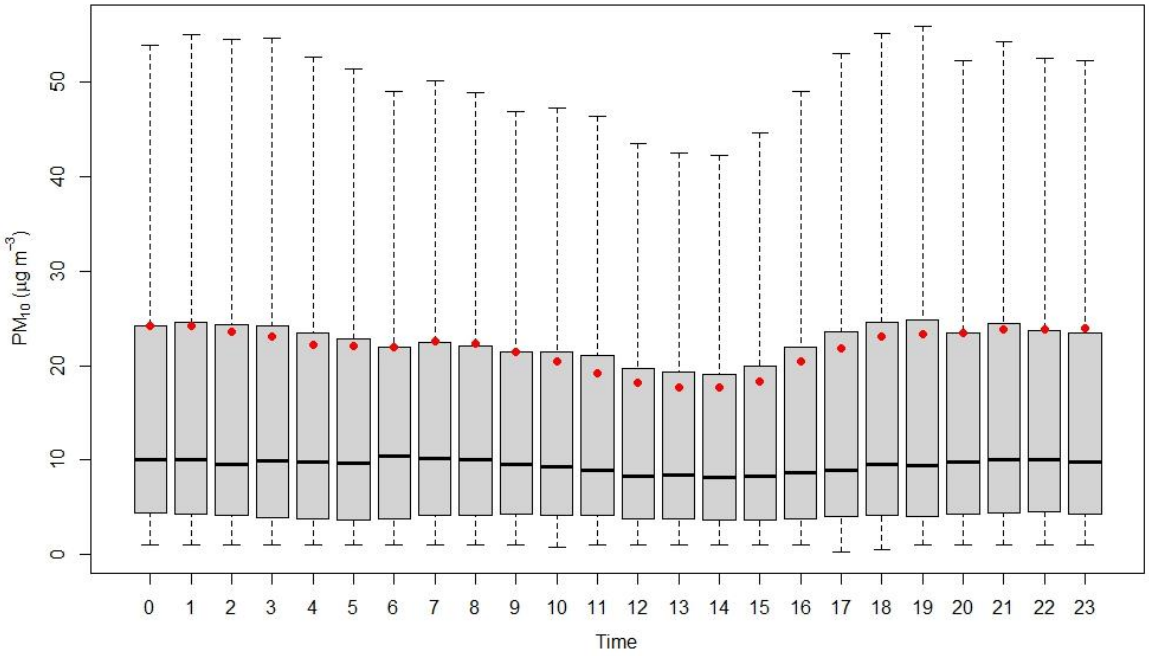


Figure 2.3.11: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.3.12. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post-monsoon season.

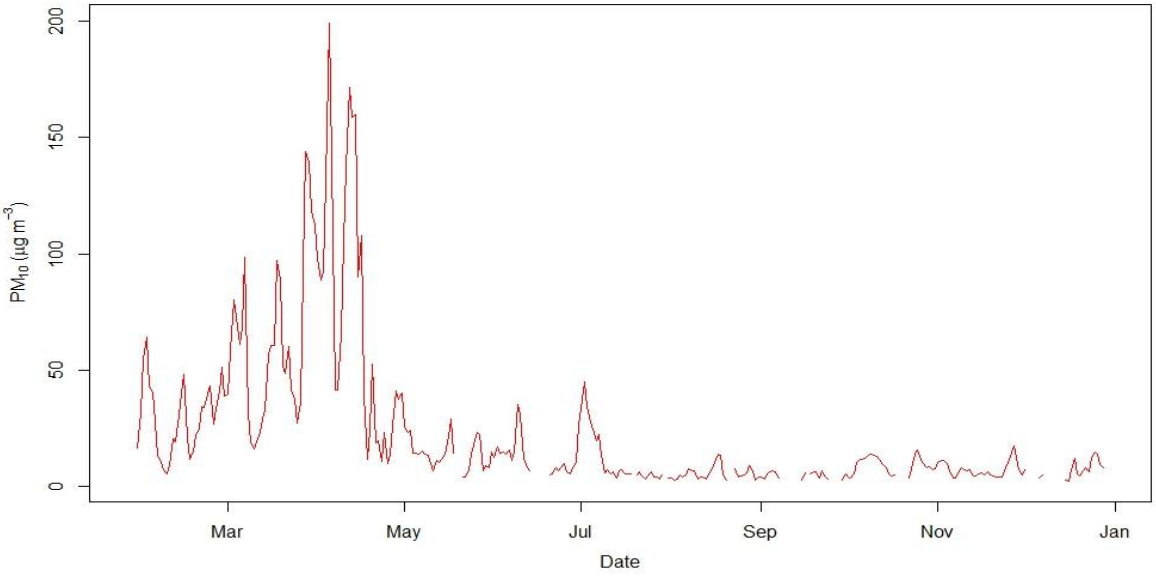


Figure 2.3.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during September. The mean value was found more than the median during January, February, March, April, June and July.

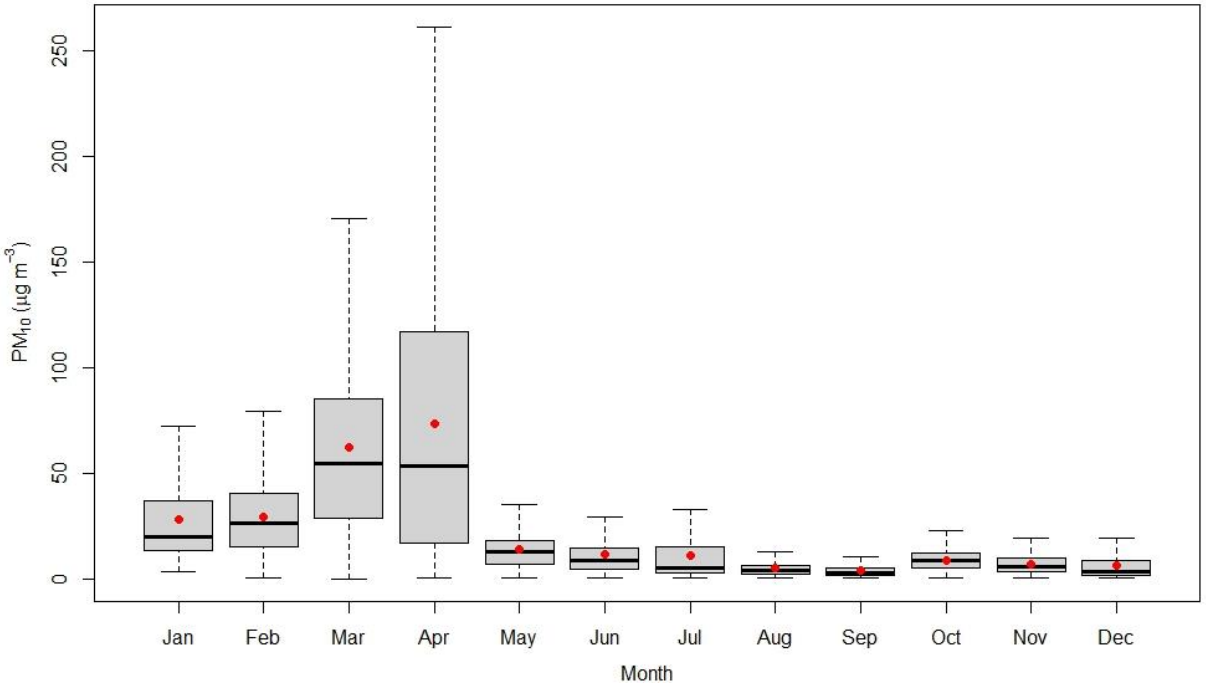


Figure 2.3.13: Monthly variation of PM_{10}

The monthly average for April was found the highest (73.33 µg m^{-3}) and that of September was found lowest (4.81 µg m^{-3}) while comparing with other months as shown in figure 2.3.14.

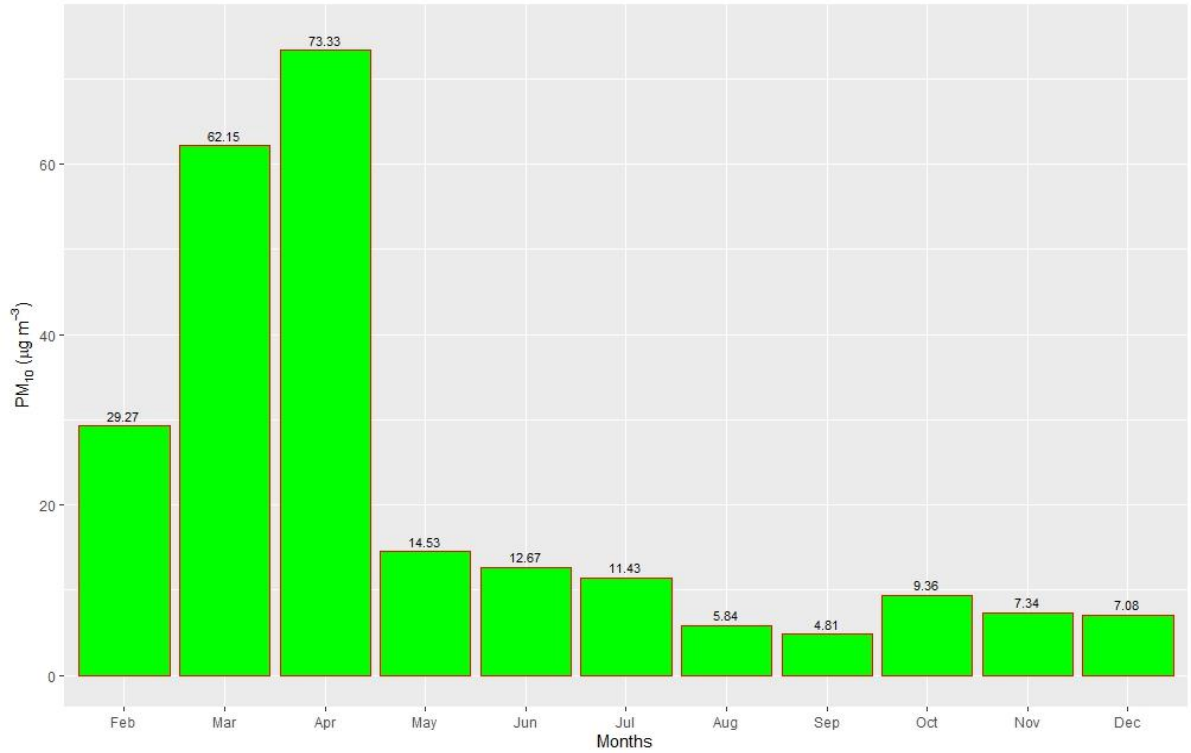


Figure 2.3.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during pre-monsoon season (50.53 µg m^{-3}) and the lowest during post-monsoon season (8.29 µg m^{-3}) as in figure 2.3.15.

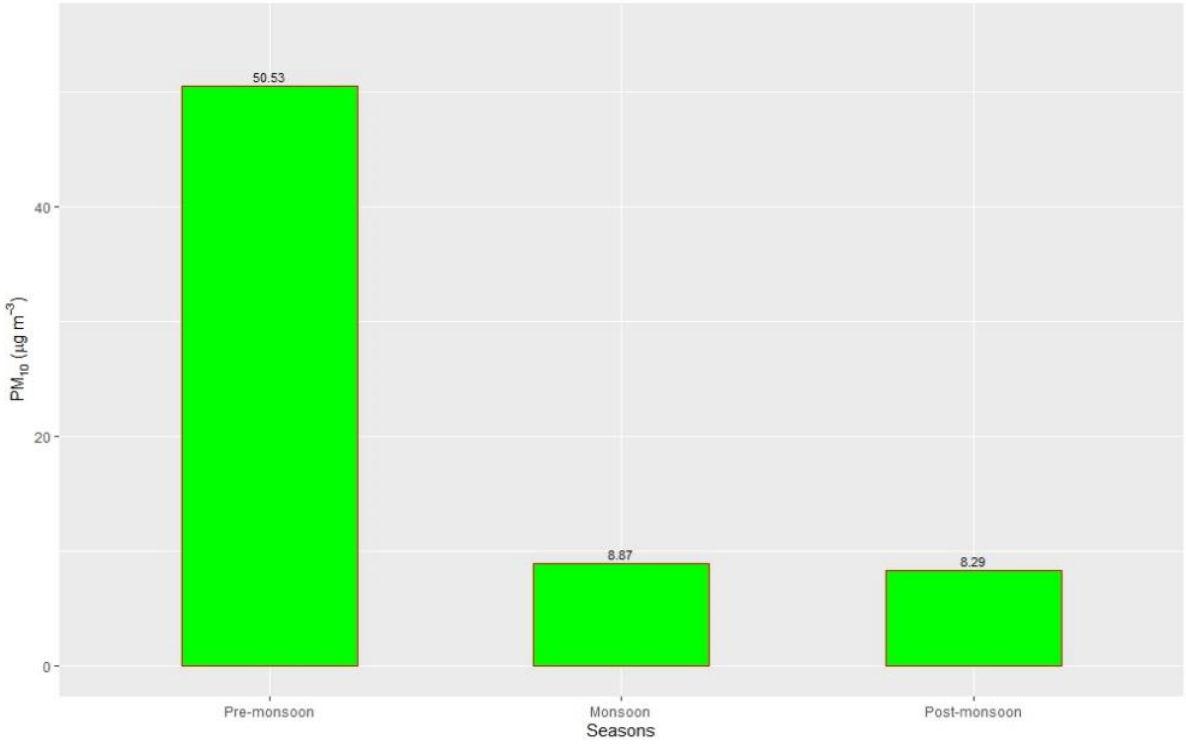


Figure 2.3.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 301 days of measurement, only 9 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. During January, February, May to December none of the days exceed NAAQS as shown in figure 2.3.16.

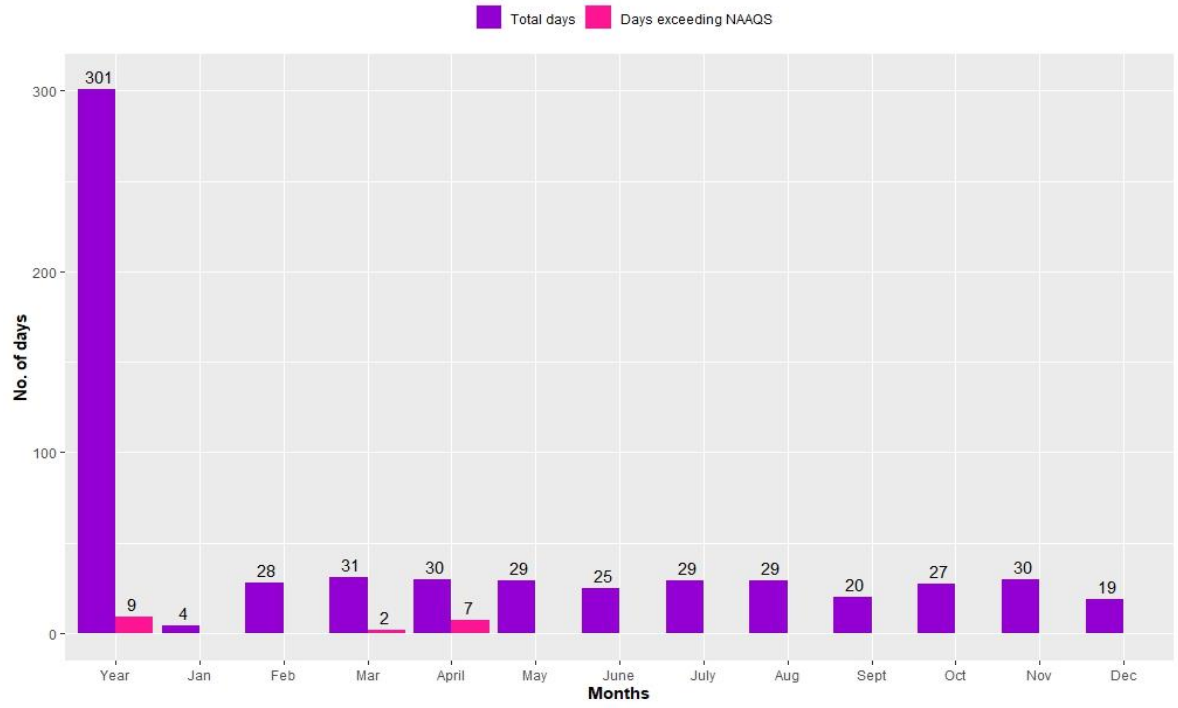


Figure 2.3.16: Compliance status of PM_{10}

2.3.4 TSP

Histogram

TSP in Rara Station was observed to range from 0.3 to 3219 µg m^{-3} (Figure 2.3.17). The mean of the TSP point data was observed to be 30.86 µg m^{-3}.

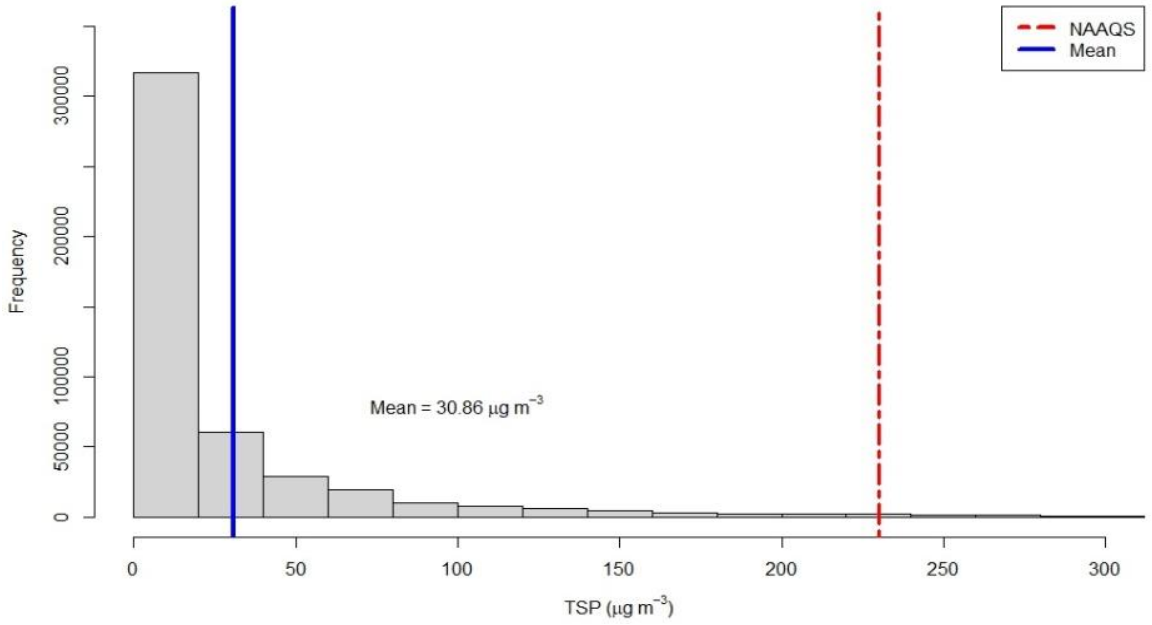


Figure 2.3.17: Histogram of TSP

Diurnal Variation

The Figure 2.3.18 shows TSP peaks at 12 AM and at 5 PM. The diurnal variation is found high during 5 PM. The mean value is found to be more than median throughout the day as in figure 2.3.19.

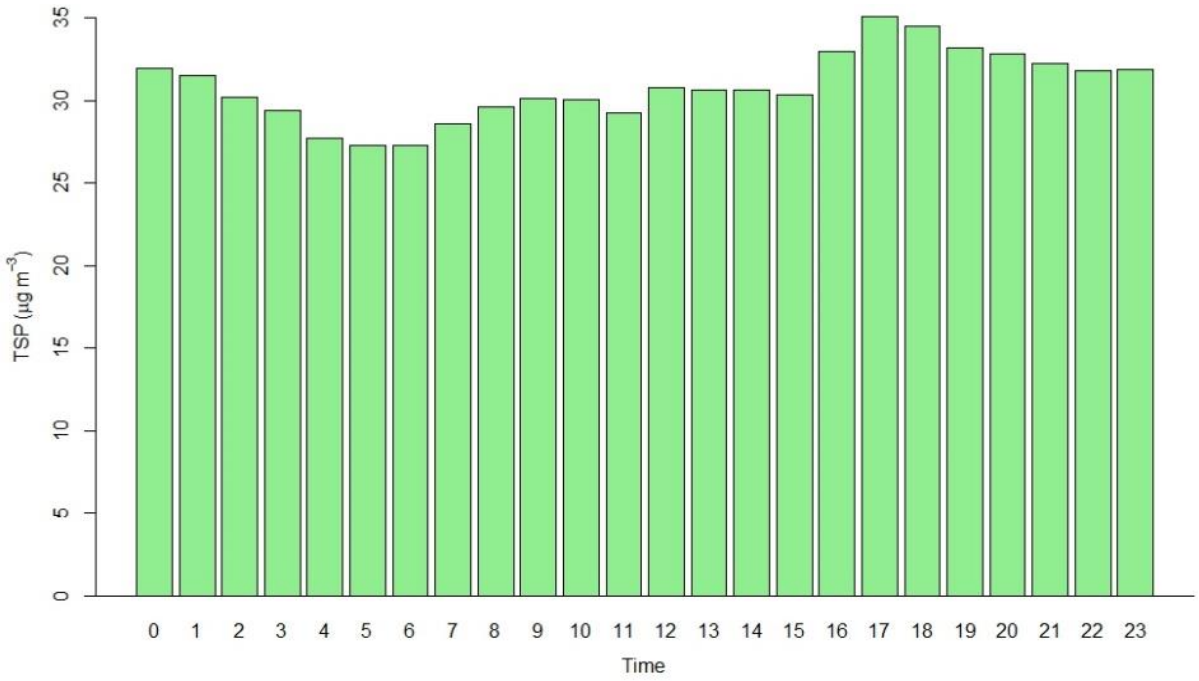


Figure 2.3.18: Hourly average of TSP

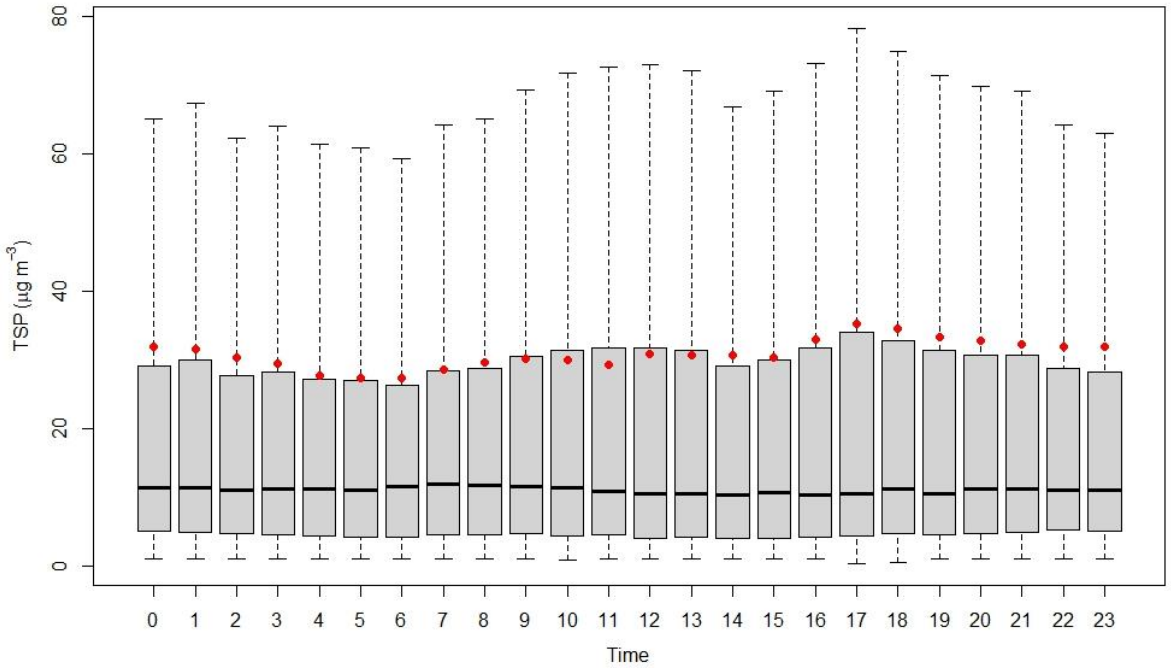


Figure 2.3.19: Diurnal variation of TSP

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.3.20. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post-monsoon season.

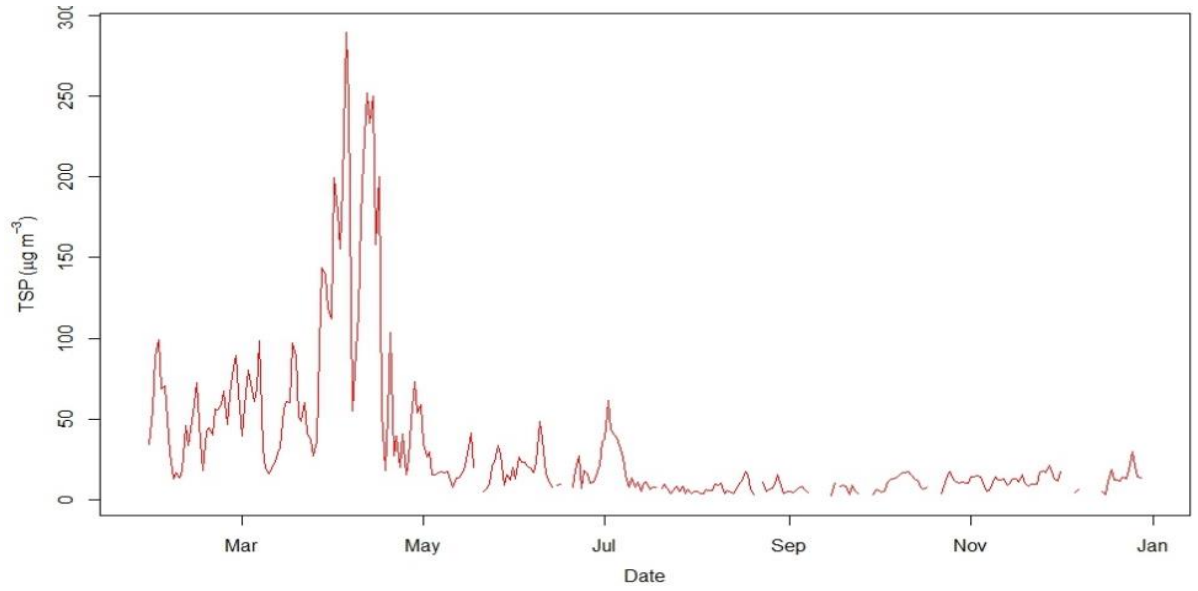


Figure 2.3.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during August and September. The mean value was found more than median during January to July and November and December.

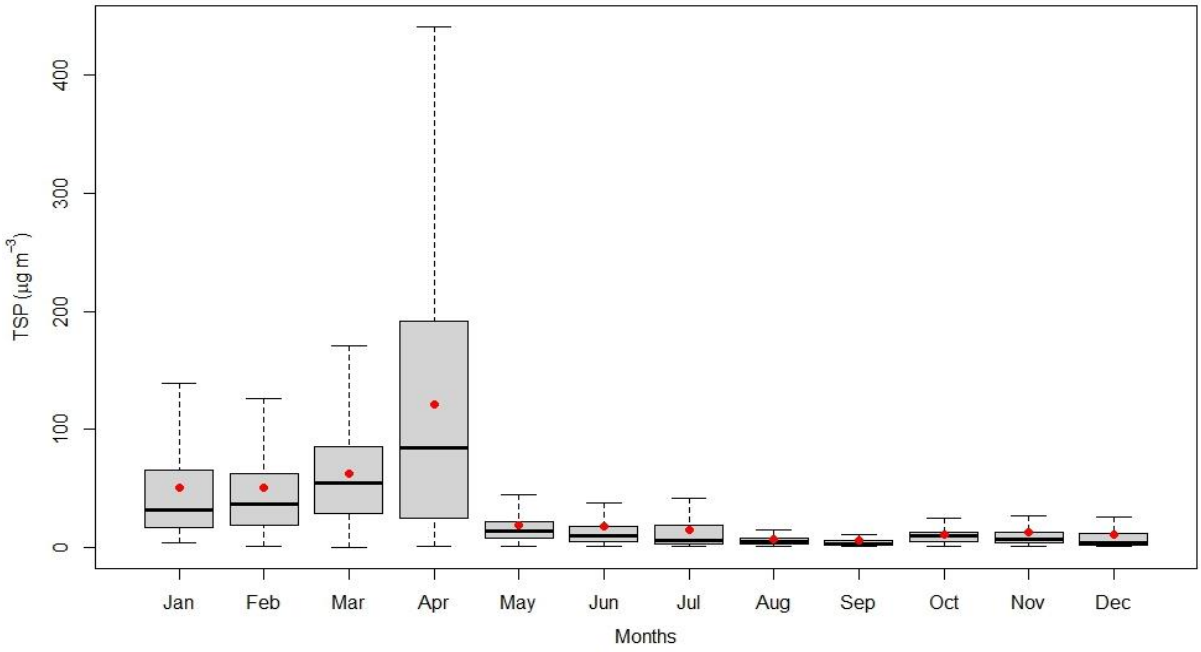


Figure 2.3.21: Monthly Box plot of TSP

The monthly average for April was found to be the highest (120.91 µg m^{-3}) and that of September was found to be the lowest (6.13 µg m^{-3}) while comparing with other months as shown in figure 2.3.22.

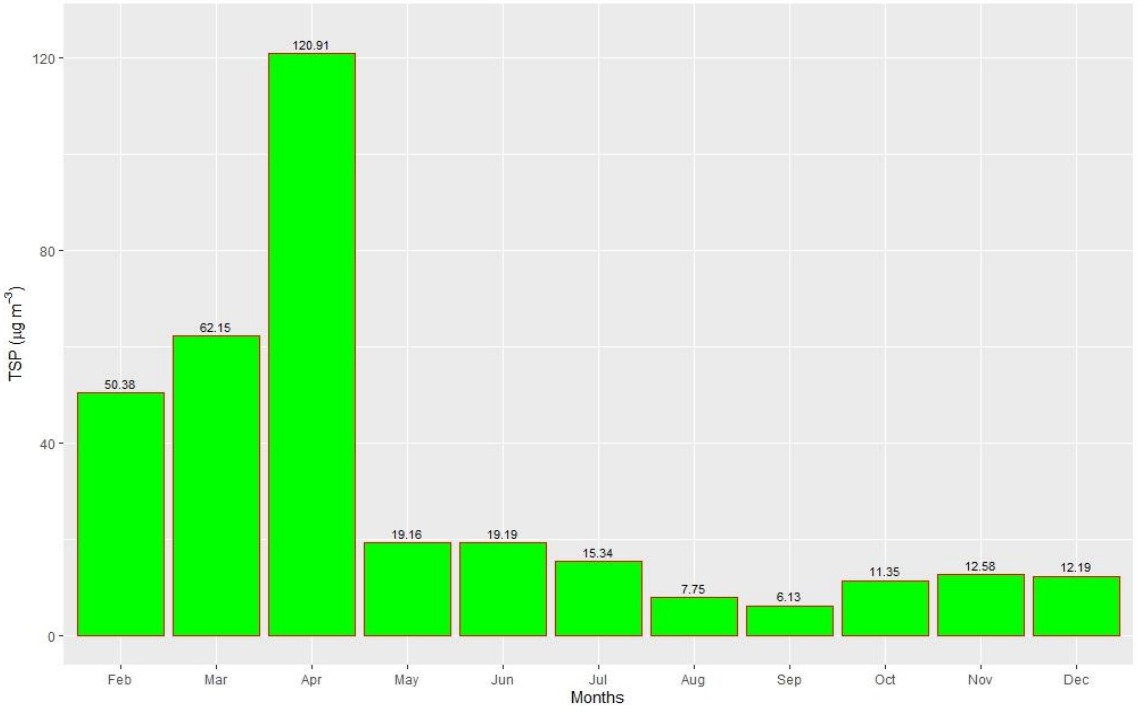


Figure 2.3.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during the pre-monsoon season (67.89 µg m^{-3}) and the lowest during the post-monsoon season (11.99 µg m^{-3}) as in figure 2.3.23.

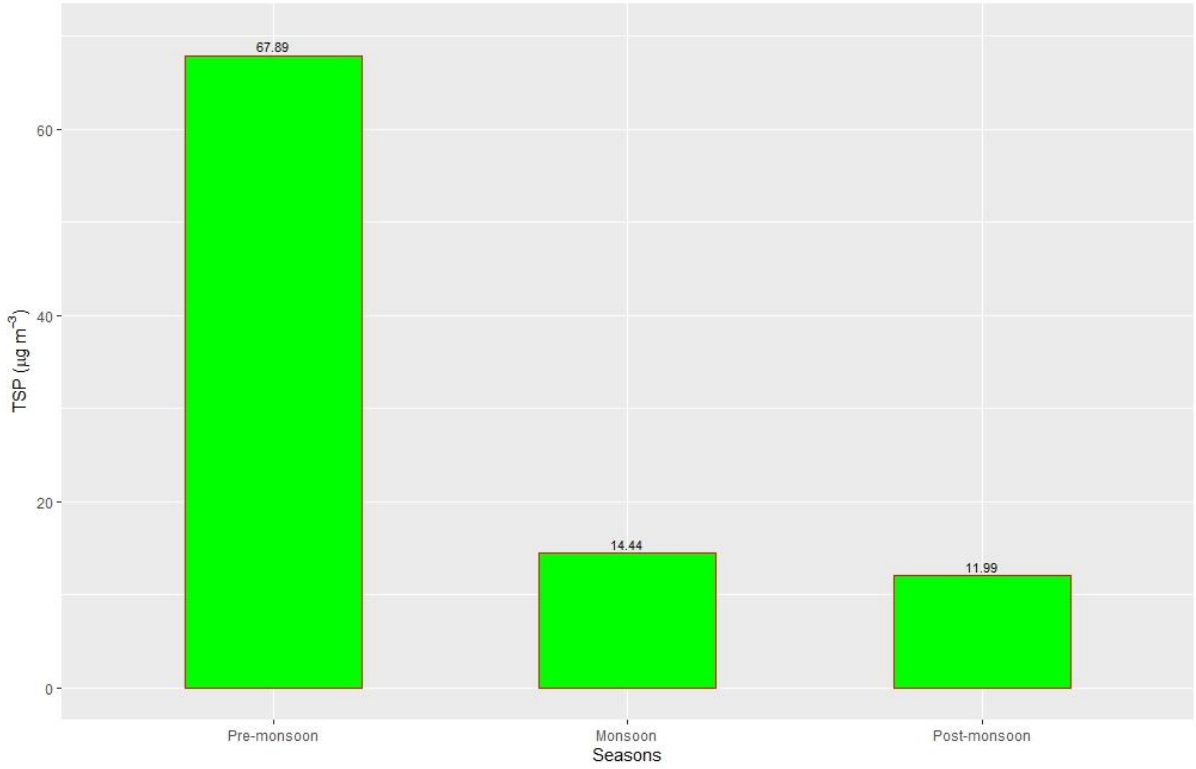


Figure 2.3.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 303 days of measurement, only five days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}. All the days exceeding the NAAQS lie in April month as shown in figure 2.3.24.

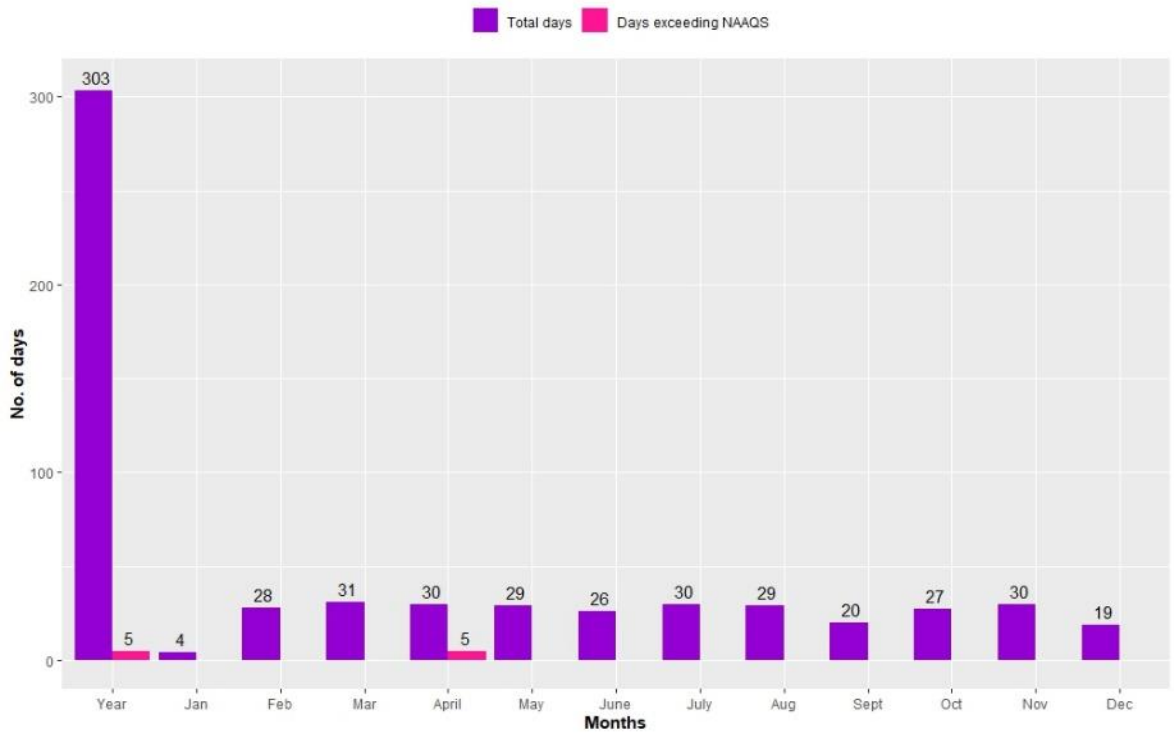


Figure 2.3.24: Compliance status of TSP

Annual Average

The annual average of $PM_{2.5}$, PM_{10} and TSP is shown in figure 2.3.25.

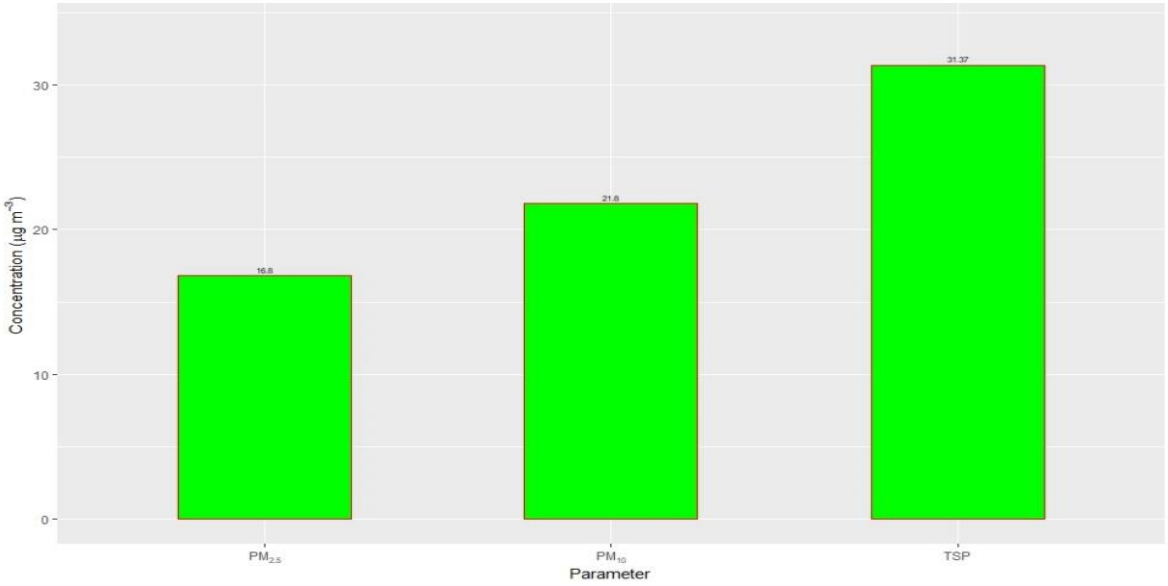


Figure 2.3.25: Annual average of $PM_{2.5}$, PM_{10} and TSP

Calendar plot

Calendar plot is prepared for PM $_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to very unhealthy level in 5th April and was unhealthy during few days in March and April.

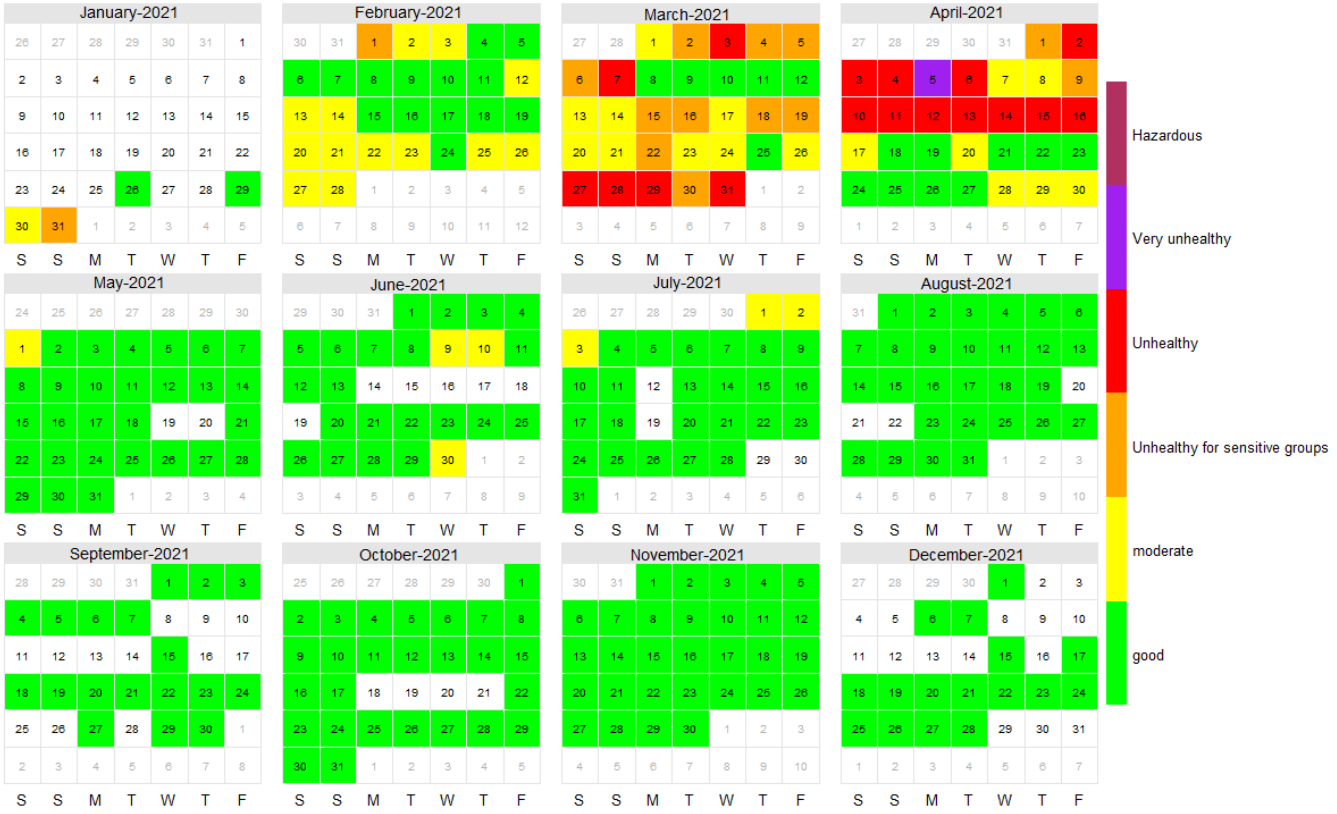


Figure 2.3.26: Calendar plot for $PM_{2.5}$ for the year 2021

2.4 Air quality status – Nepalgunj

2.4.1 Introduction

Nepalgunj Air Quality Monitoring Station was established in the year 2018. It lies inside District office of Banke. It represents the urban area. Hence the major source of air pollution in this area is vehicles and commercial activities.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Number of instrument
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.4.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Nepalgunj Station was observed to range from 1.5 to 685.6 µg m^{-3} (Figure 2.4.1). The mean of the $PM_{2.5}$ point data was observed to be 69.25 µg m^{-3}.

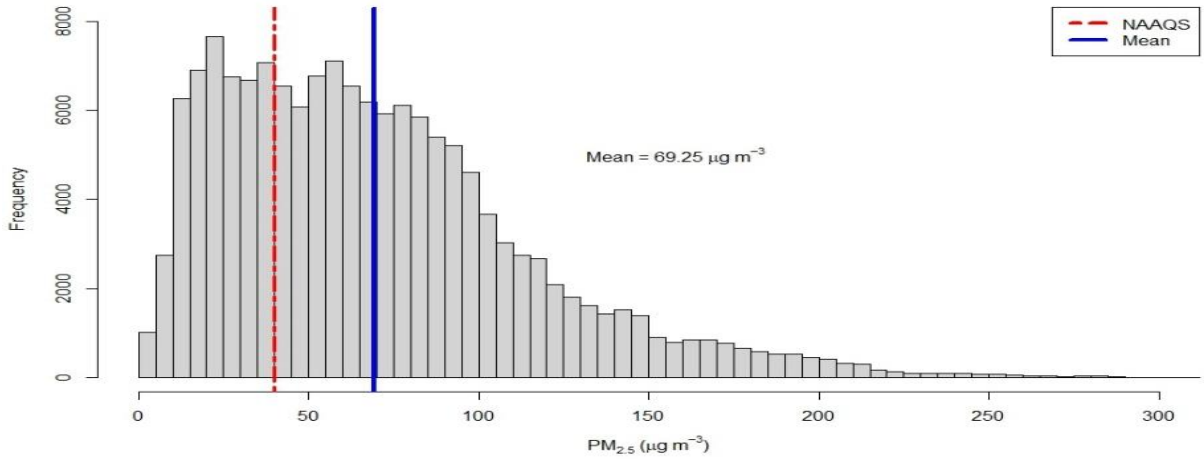


Figure 2.4.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.4.2 shows $PM_{2.5}$ peaks at 7 AM to 8 AM and at 8 PM. The mean value is found to be more than the median throughout the day.

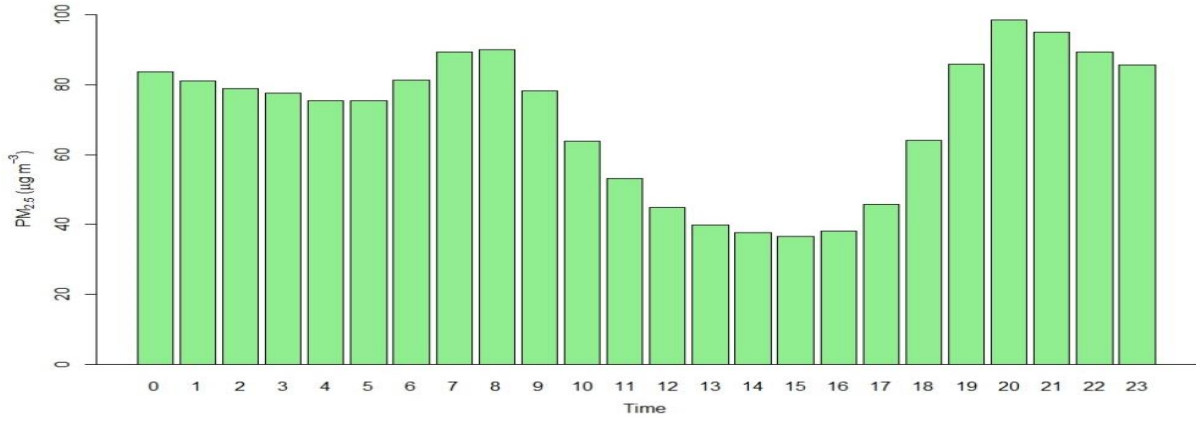


Figure 2.4.2: Hourly average of $PM_{2.5}$

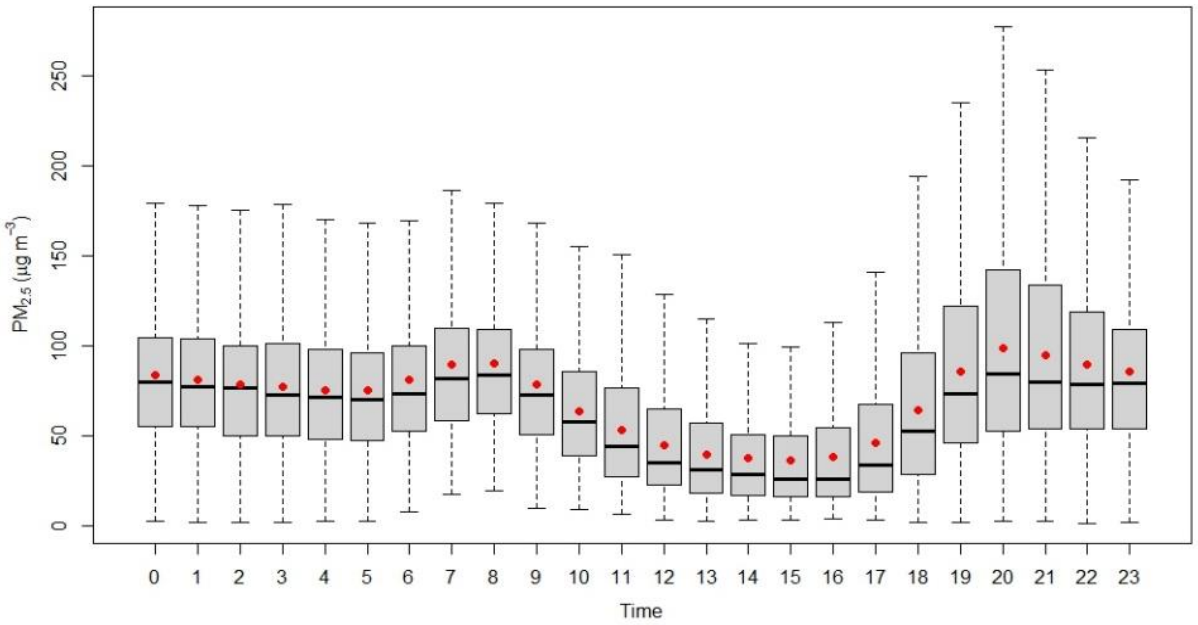


Figure 2.4.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variation of $PM_{2.5}$ is shown in figure 2.4.4. Higher concentration can be seen during January. High data gap can be seen during May to December.

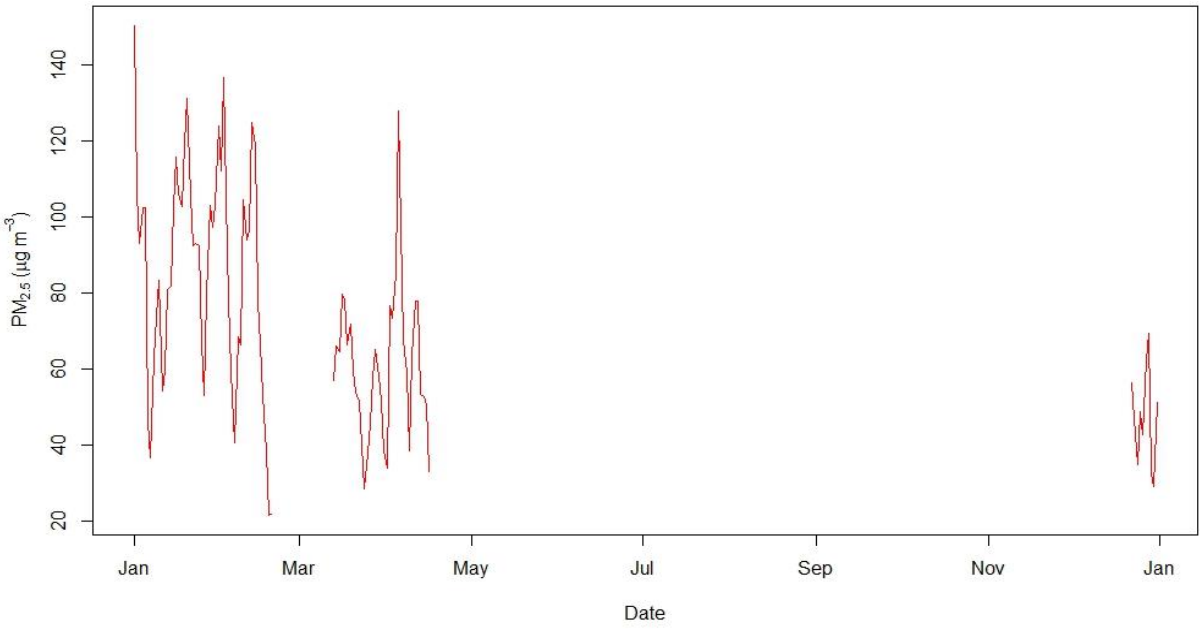


Figure 2.4.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during April whereas less during August. The mean value was found more than median during all months as shown in figure 2.4.5.

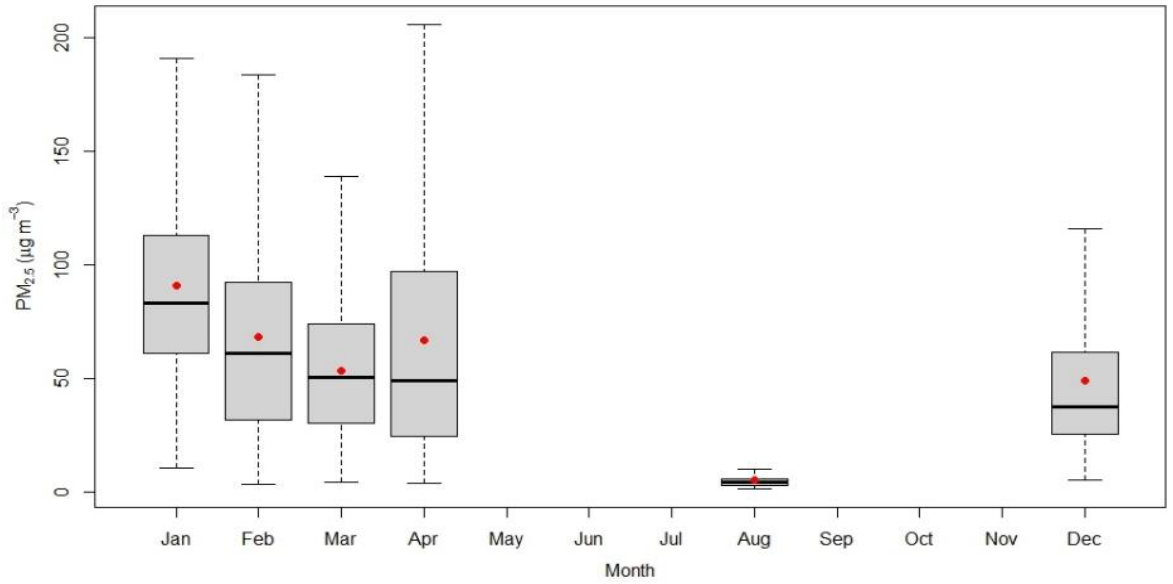


Figure 2.4.5: Monthly variation of $PM_{2.5}$

The monthly average of January was found to be highest (91.07 µg m^{-3}) and that of March and August was found to be lowest (56.45 µg m^{-3}) while comparing with other months as shown in figure 2.4.6 below. Monthly average was not calculated for remaining months due to insufficient data.

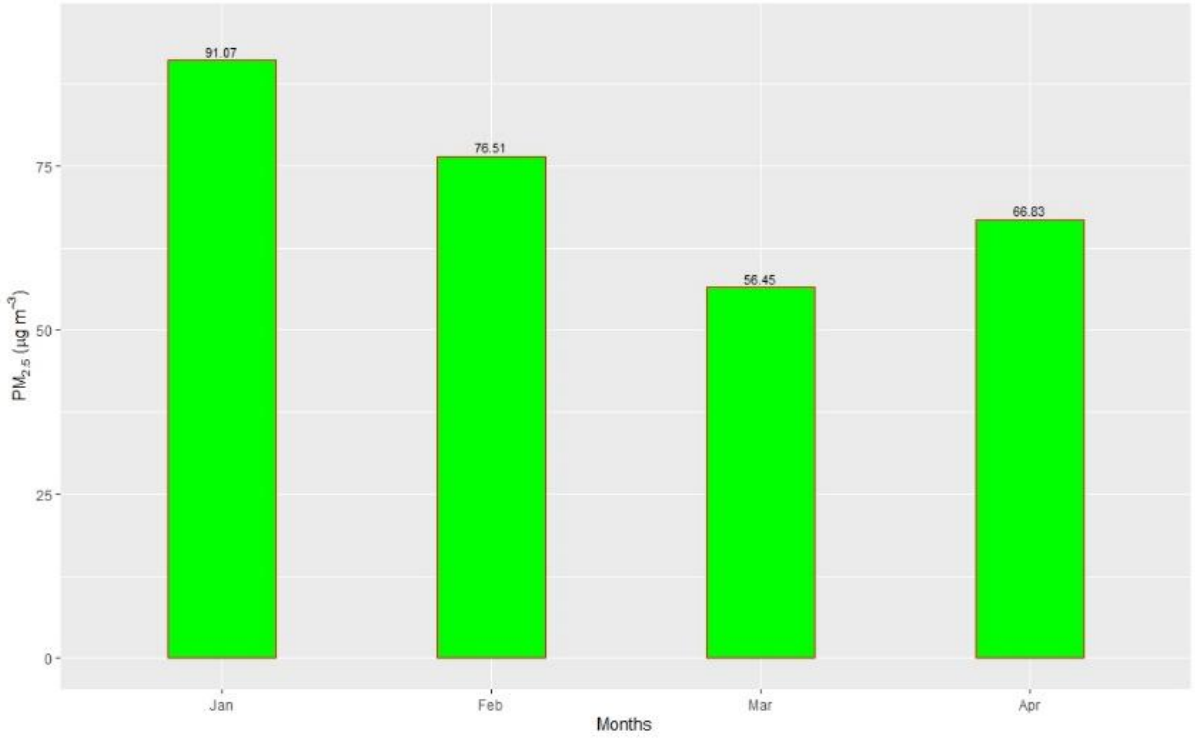


Figure 2.4.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during the winter season (97.82 µg m^{-3}) and the lowest during the pre-monsoon season (61.19 µg m^{-3}) as in figure 2.4.7. Seasonal average was not calculated for monsoon and post monsoon season due to insufficient data.

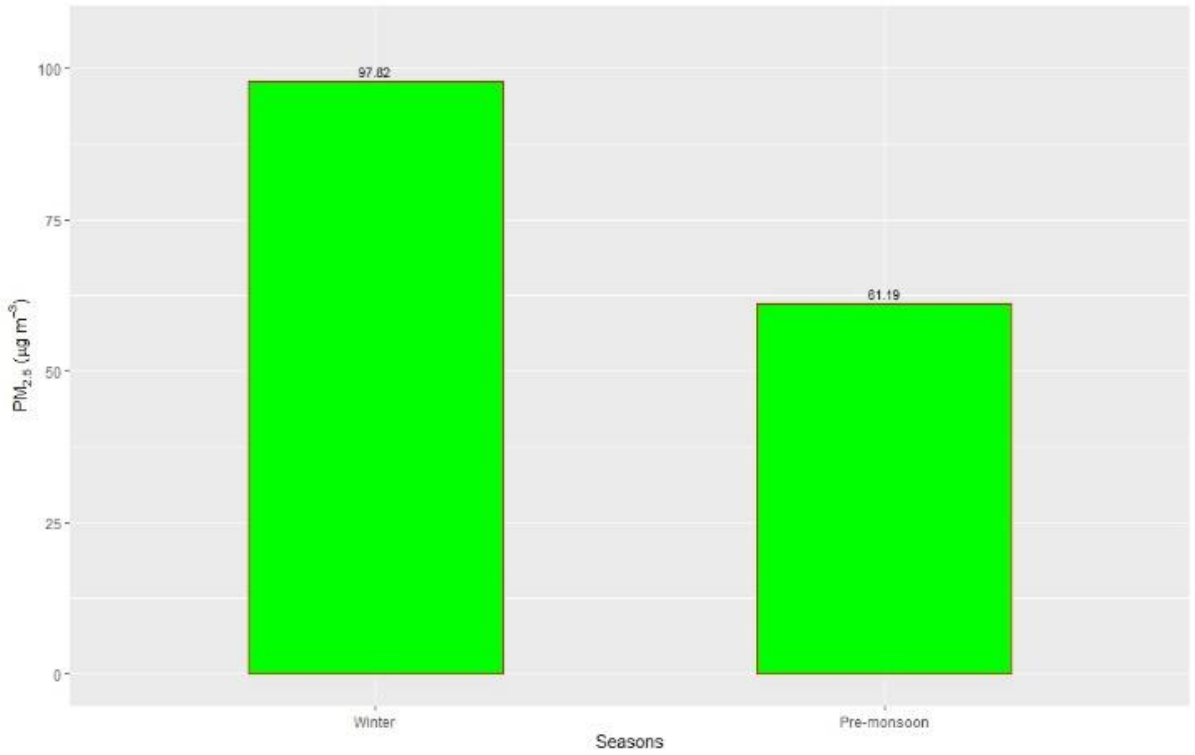


Figure 2.4.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 95 days of measurement, 82 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$ as shown in figure 2.4.8.

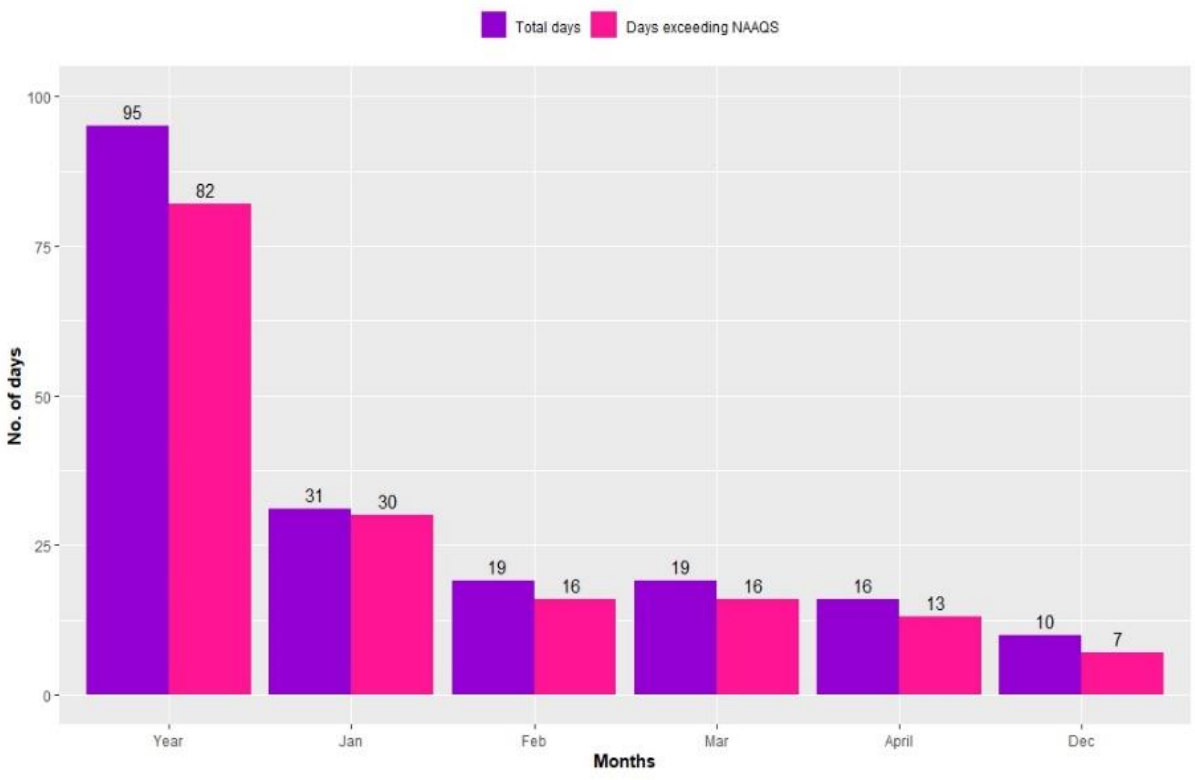


Figure 2.4.8: Compliance status of $PM_{2.5}$

2.4.3 PM_{10}

Histogram

PM_{10} in Nepalgunj Station was observed to range from 1.5 to 1200.5 µg m^{-3} (Figure 2.4.9). The mean of the PM_{10} point data was observed to be 80 µg m^{-3}.

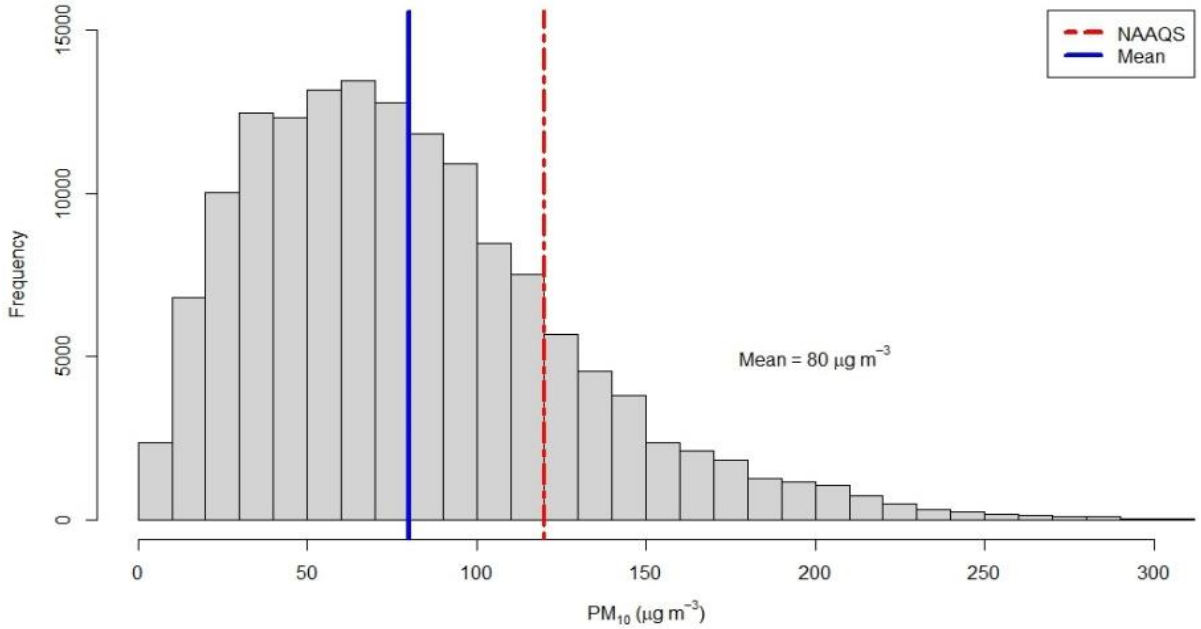


Figure 2.4.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.4.10 shows PM_{10} reaches highest at 7 AM to 8 AM which starts falling slowly till 5 PM and starts again rising peaks at 8 PM then again starts falling.

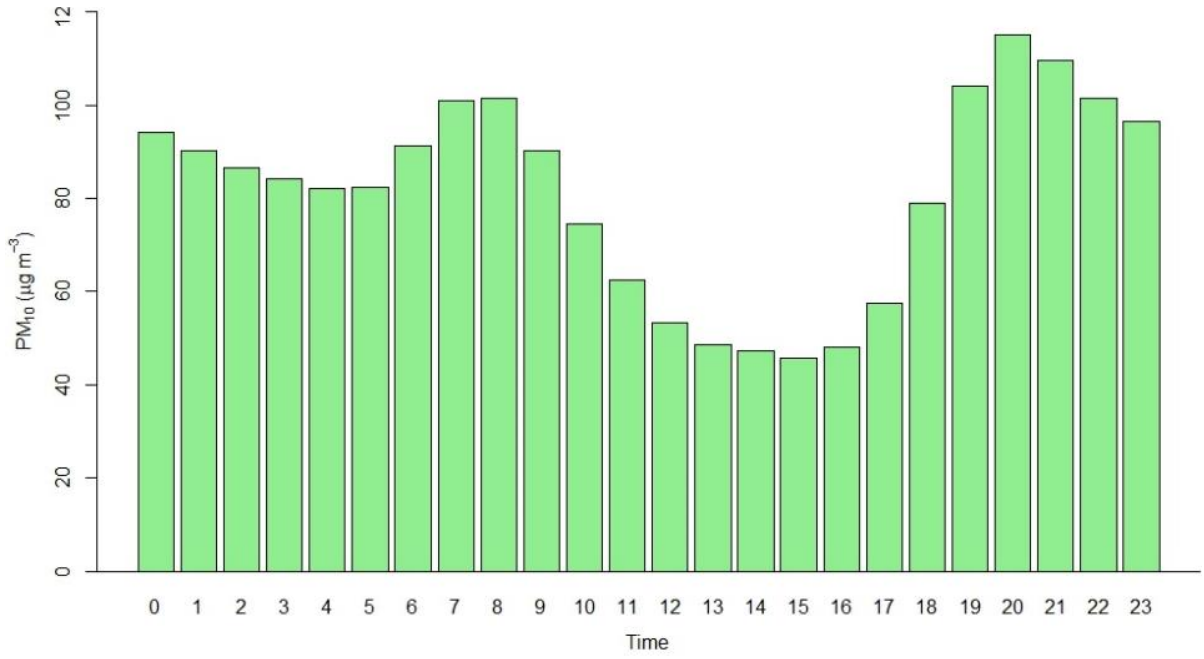


Figure 2.4.10: Hourly average of PM_{10}.

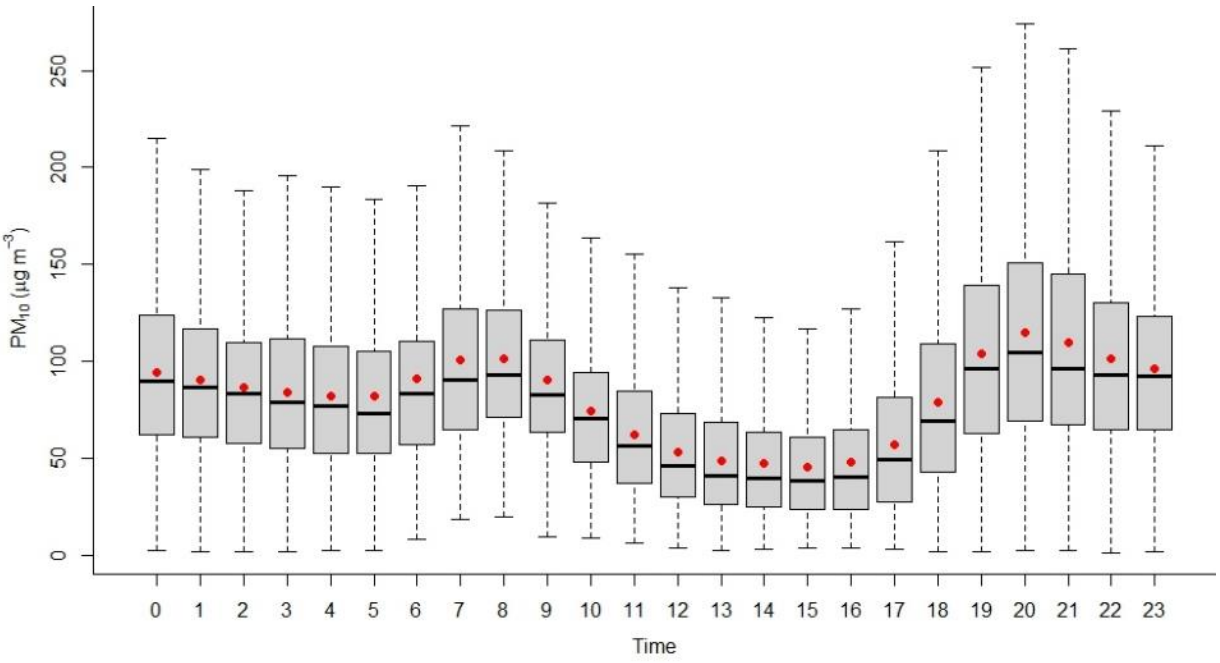


Figure 2.4.11: Diurnal variation of PM_{10}.

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.4.12. Higher concentration can be seen during January.

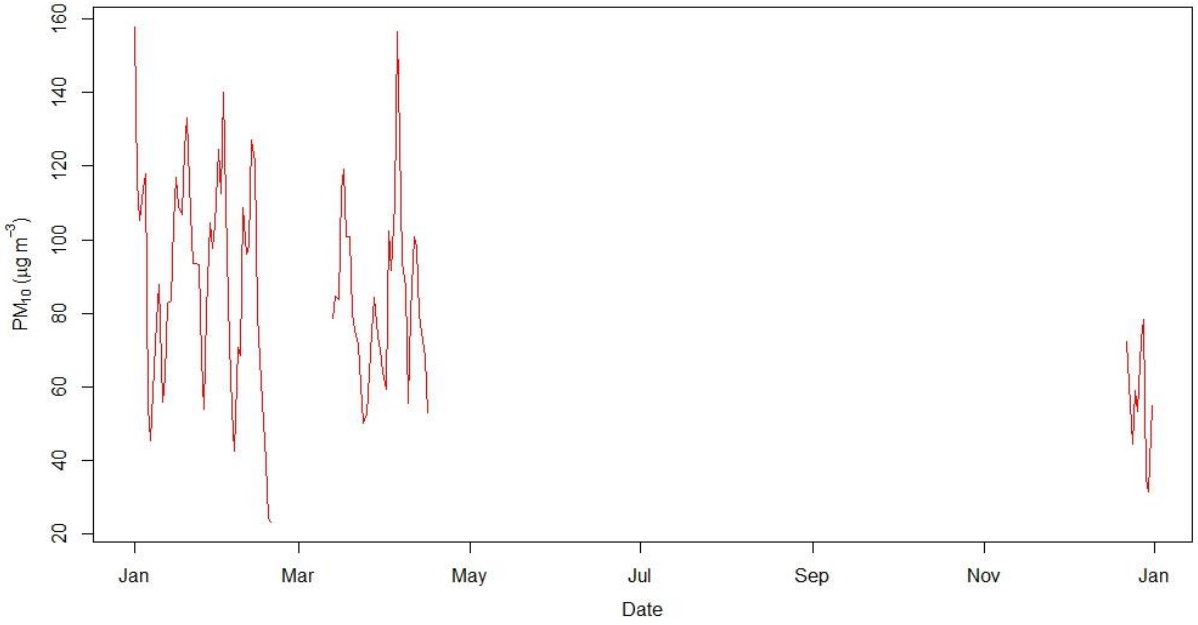


Figure 2.4.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during August. The mean value was found more than the median during January, February, March, April and December.

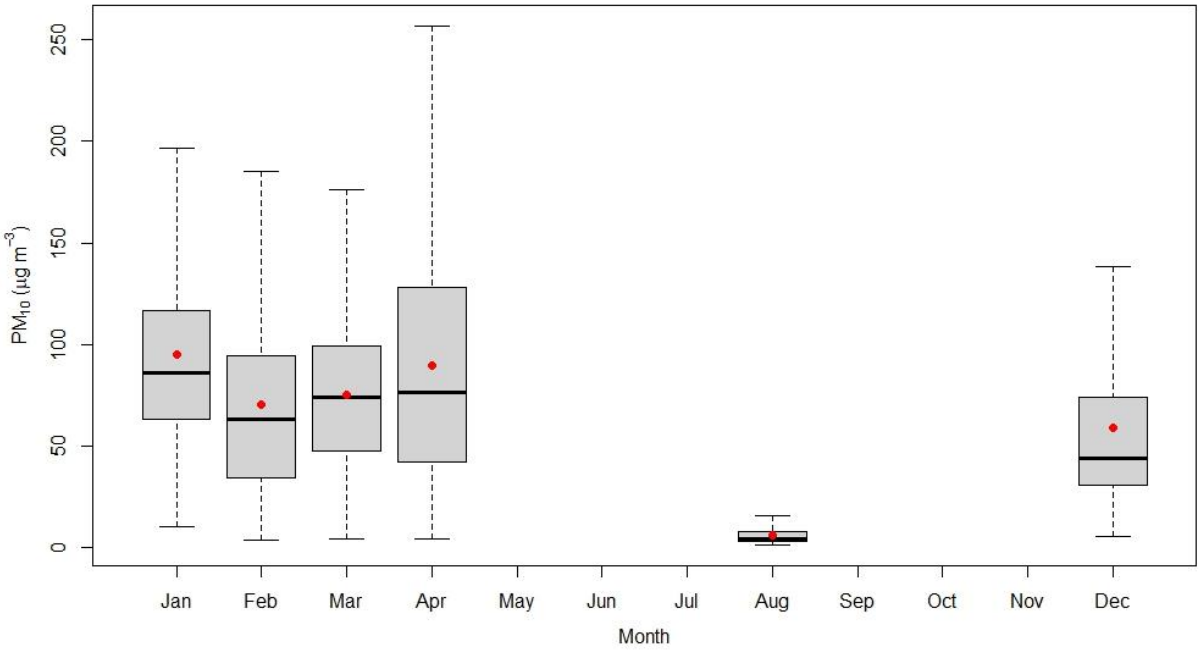


Figure 2.4.13: Monthly variation of PM_{10}

The monthly average for January was found the highest (94.89 µg m^{-3}) and that of February was found lowest (78.83 µg m^{-3}) while comparing with other months as shown in figure 2.4.14. The monthly average was not calculated for remaining months due to insufficient data.

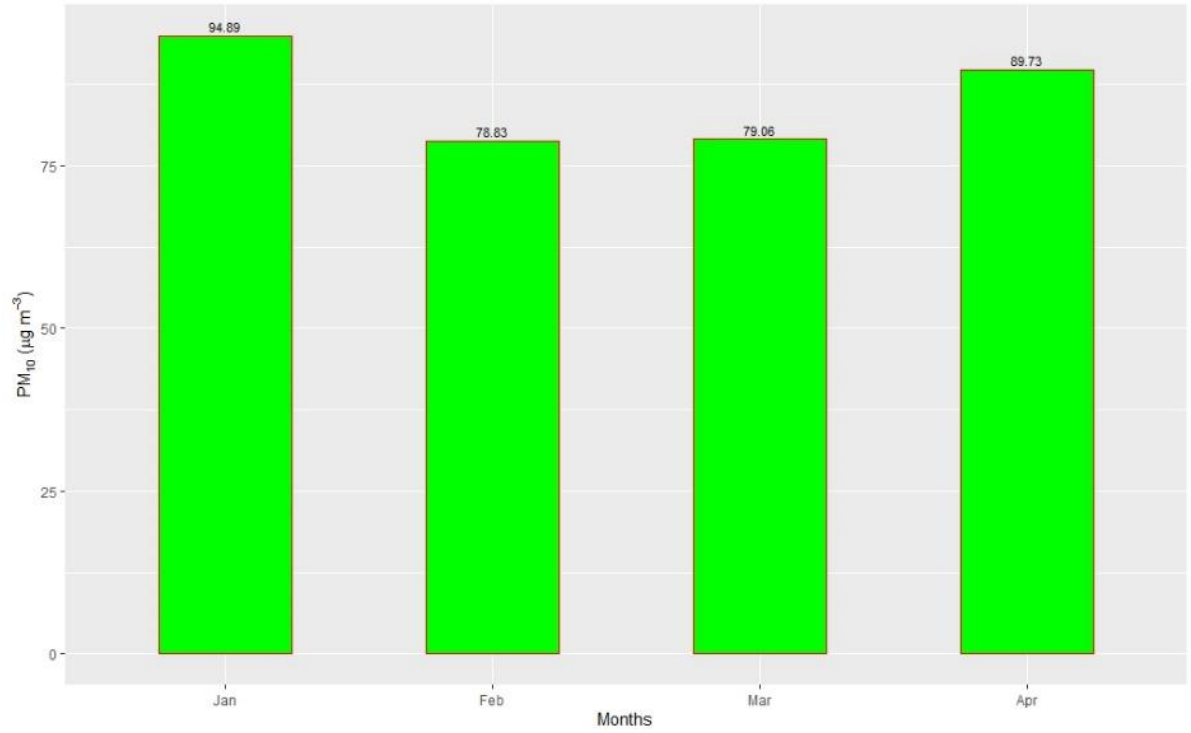


Figure 2.4.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during winter season (104.88 µg m^{-3}) and the lowest during pre-monsoon season (83.94 µg m^{-3}) as in figure 2.4.15. Seasonal average was not calculated for monsoon and post monsoon season due to insufficient data.

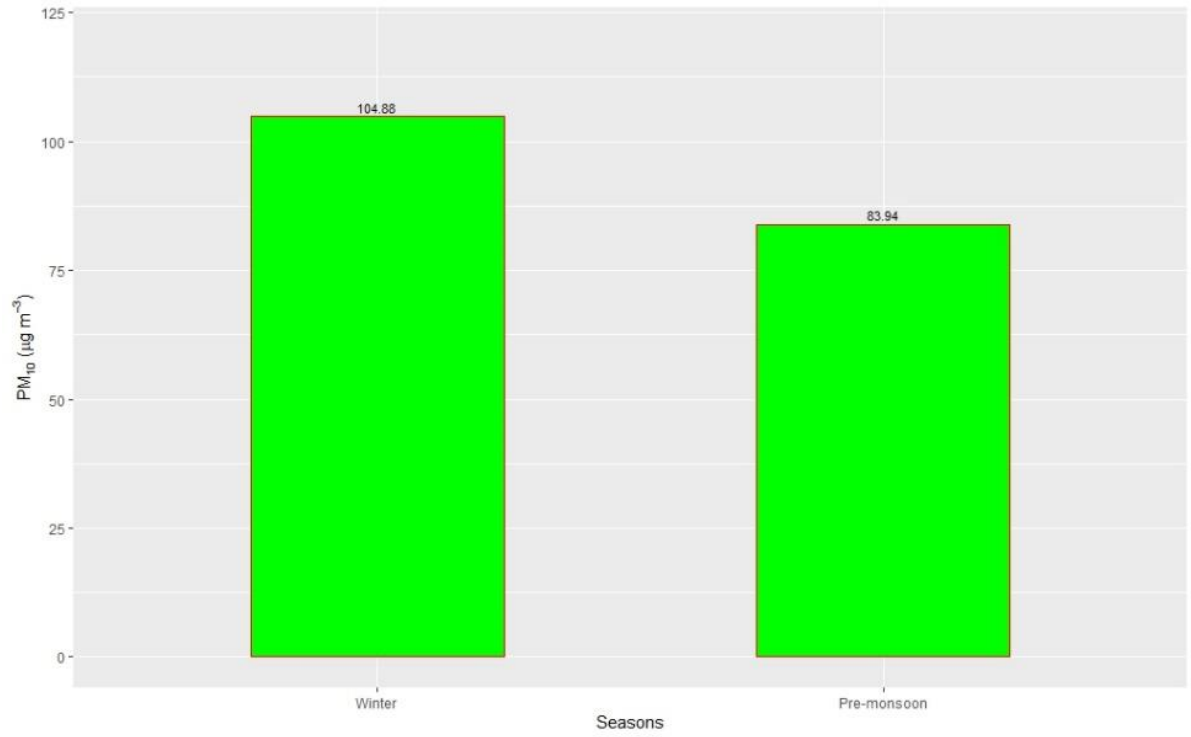


Figure 2.4.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 95 days of measurement, 9 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. March and December has none of the days exceed NAAQS as shown in figure 2.4.16.

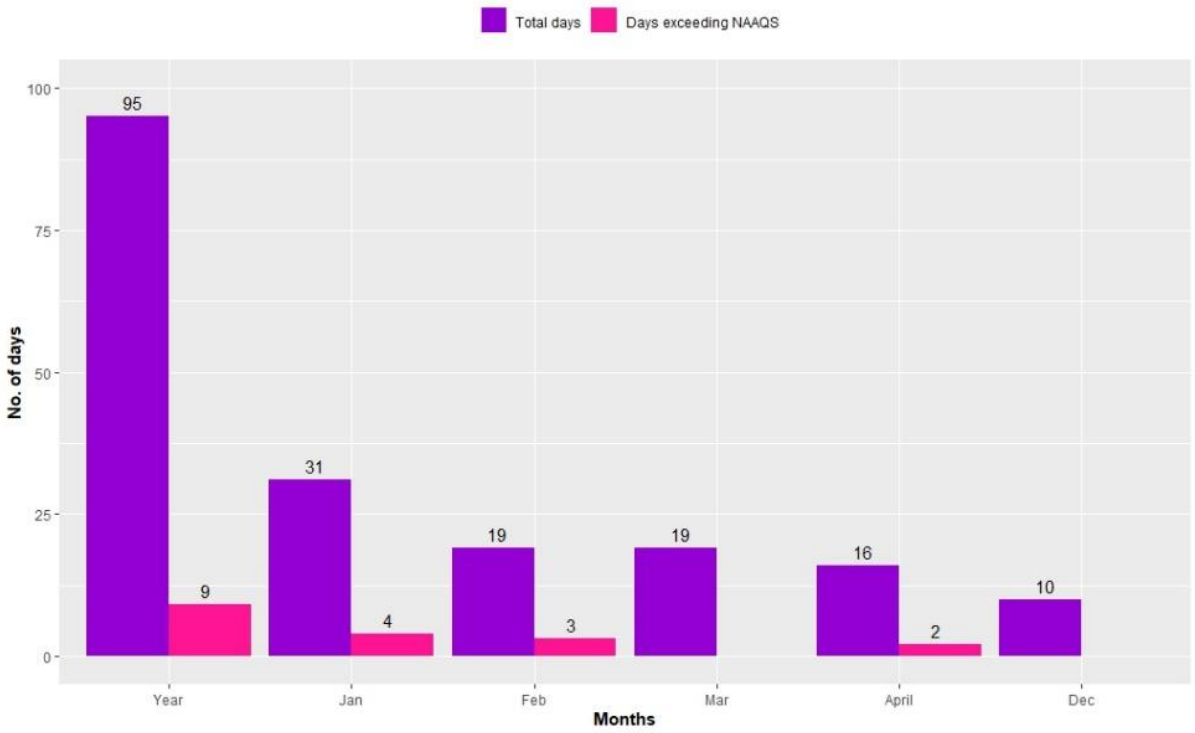


Figure 2.4.16: Compliance status of PM_{10}

2.4.4 TSP

Histogram

TSP in Nepalgunj Station was observed to range from 1.5 to 4585.2 µg m^{-3} (Figure 2.4.17). The mean of the TSP point data was observed to be 84.69 µg m^{-3}.

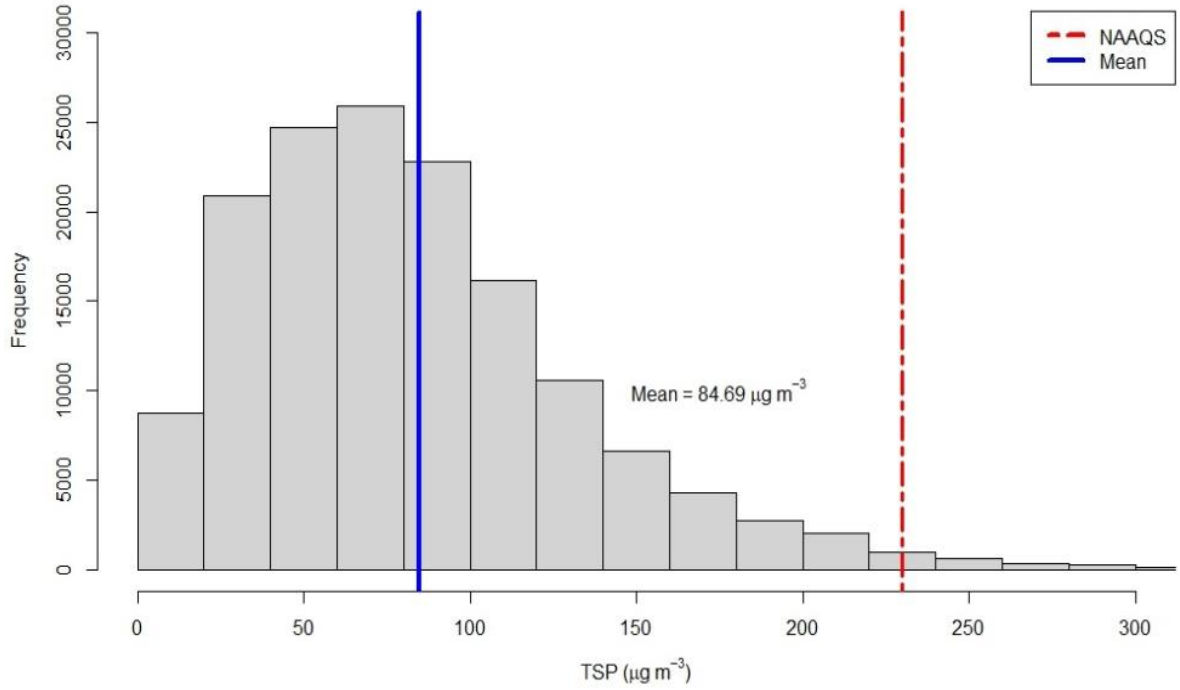


Figure 2.4.17: Histogram of TSP

Diurnal Variation

The Figure 2.4.18 shows TSP peaks at 8 AM and 8 PM. During day time the mean is much higher compared to the median value.

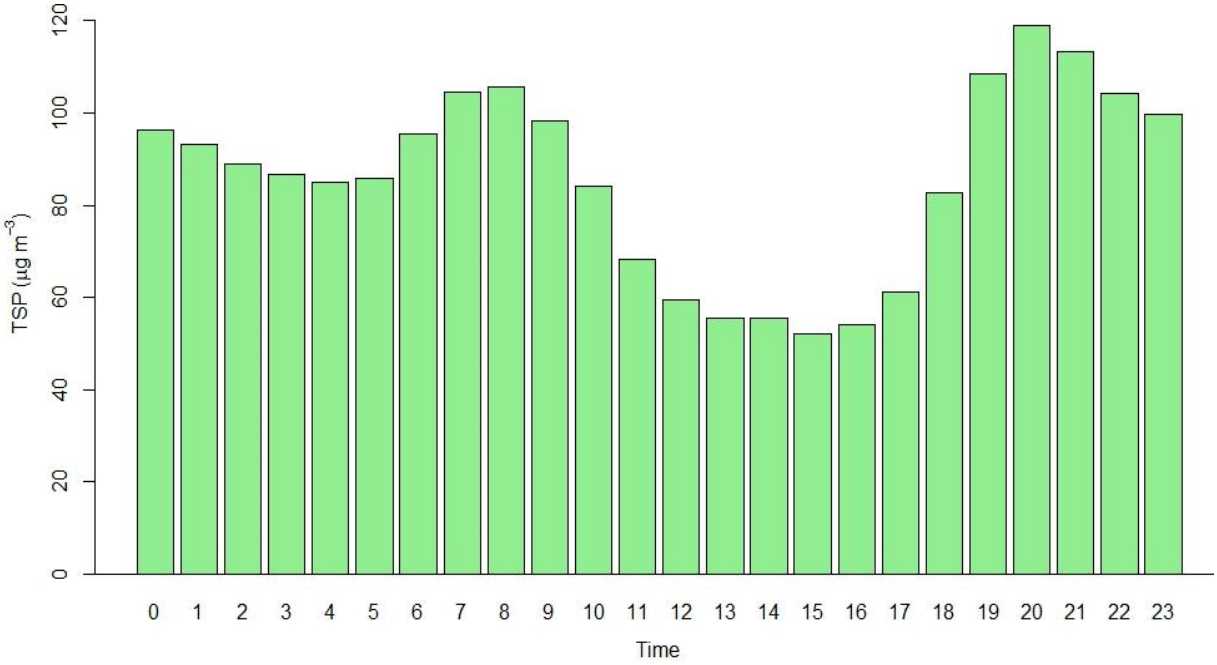


Figure 2.4.18: Hourly average of TSP

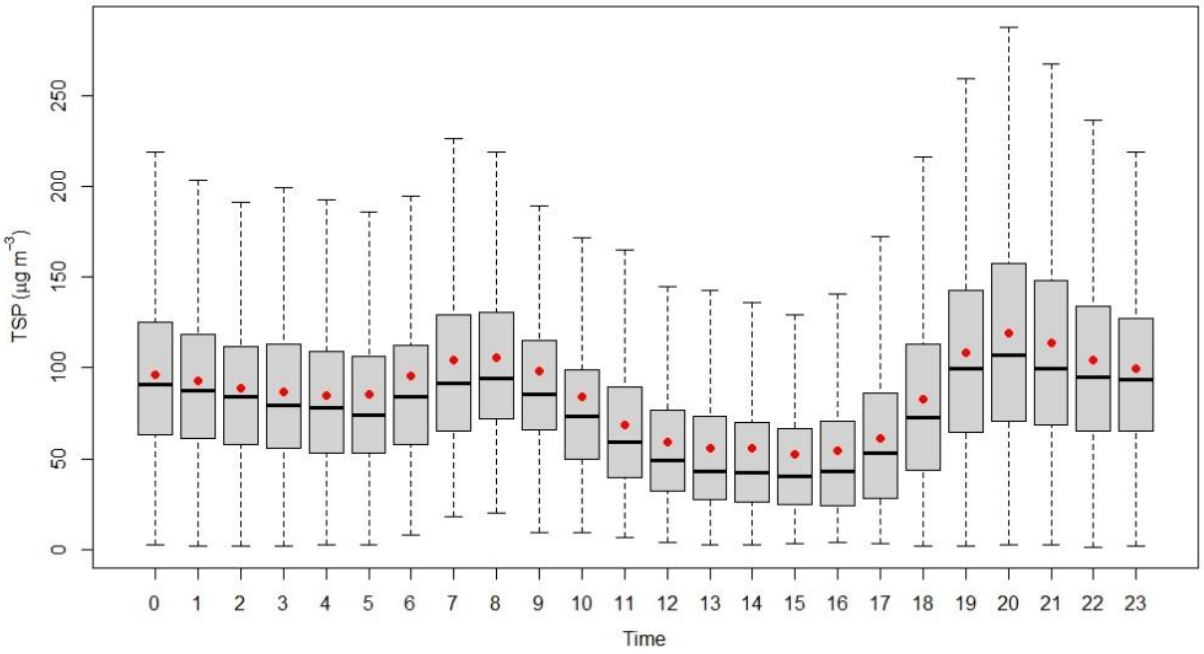


Figure 2.4.19: Diurnal variation of TSP.

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.4.20. Higher concentration can be seen during April.

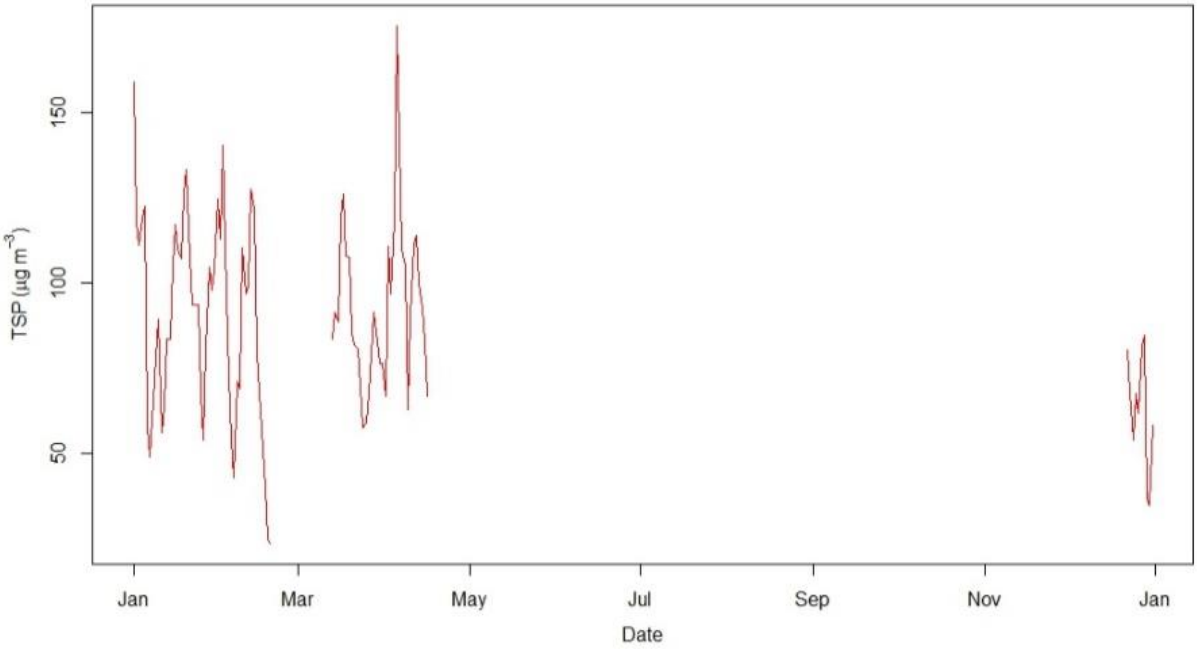


Figure 2.4.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during August. The mean value was found more than median in every month.

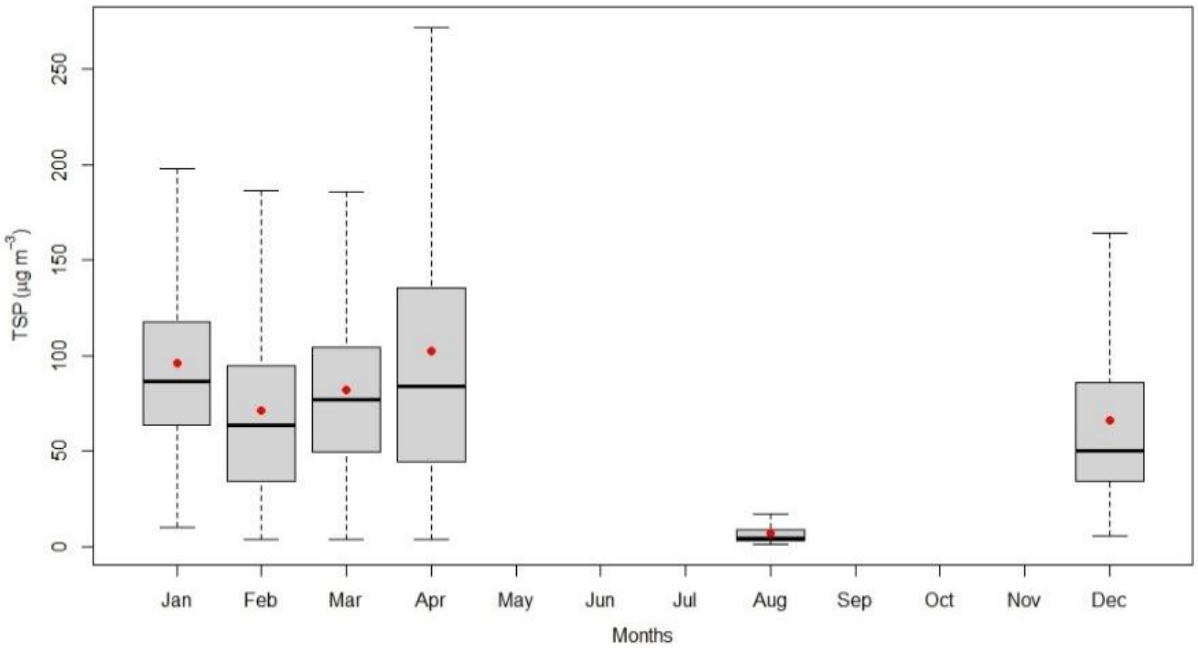


Figure 2.4.21: Monthly variation of TSP

The monthly average for January was found to be the highest (94.89 µg m^{-3}) and that of February was found to be the lowest (78.83 µg m^{-3}) while comparing with other months as shown in figure 2.4.22.

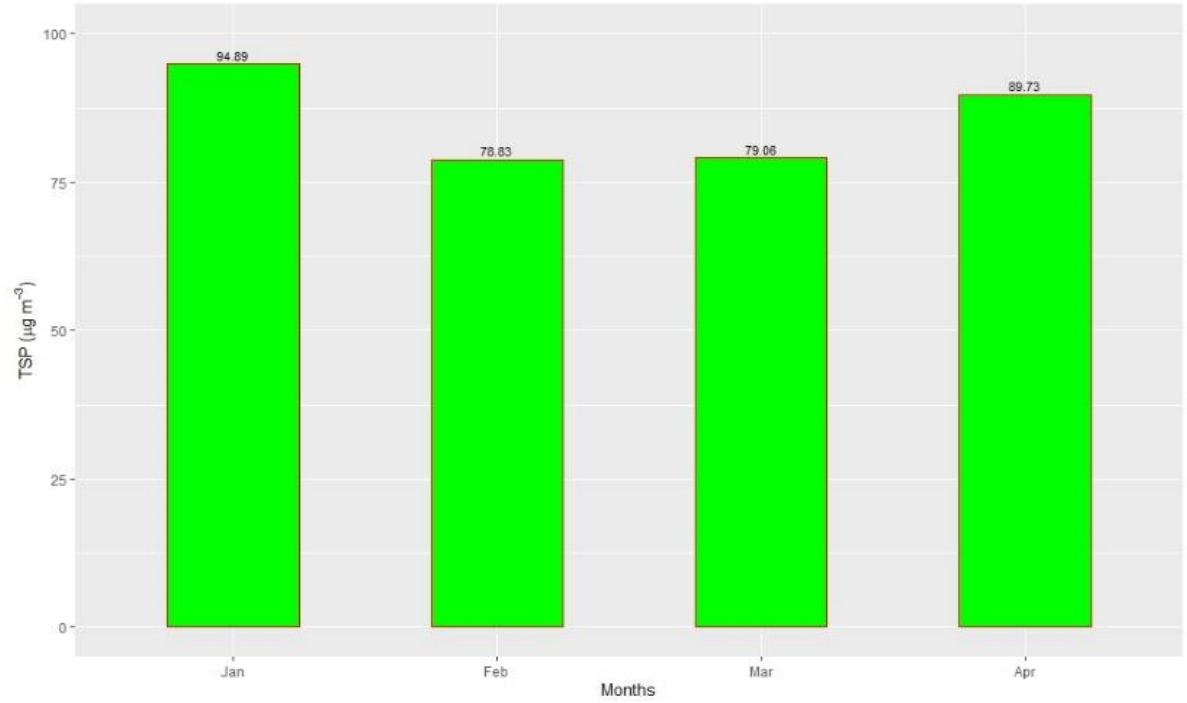


Figure 2.4.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during the winter season (106.73 µg m^{-3}) and the lowest during the pre-monsoon season (93.64 µg m^{-3}) as in figure 2.4.23. Seasonal average for monsoon and post monsoon season was not calculated due to insufficient data.

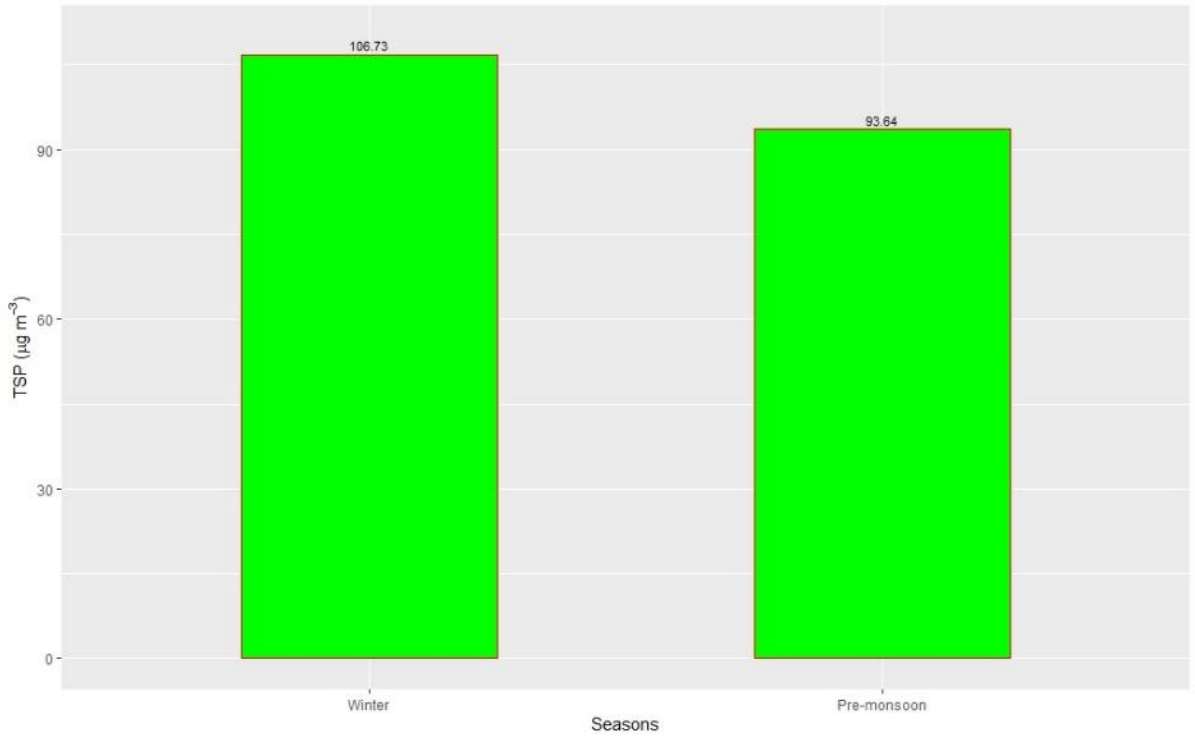


Figure 2.4.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 95 days of measurement, none of the days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}.

Calendar Plot

Calendar plot is prepared for $PM_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to unhealthy level during January, February, and few days in March and April.

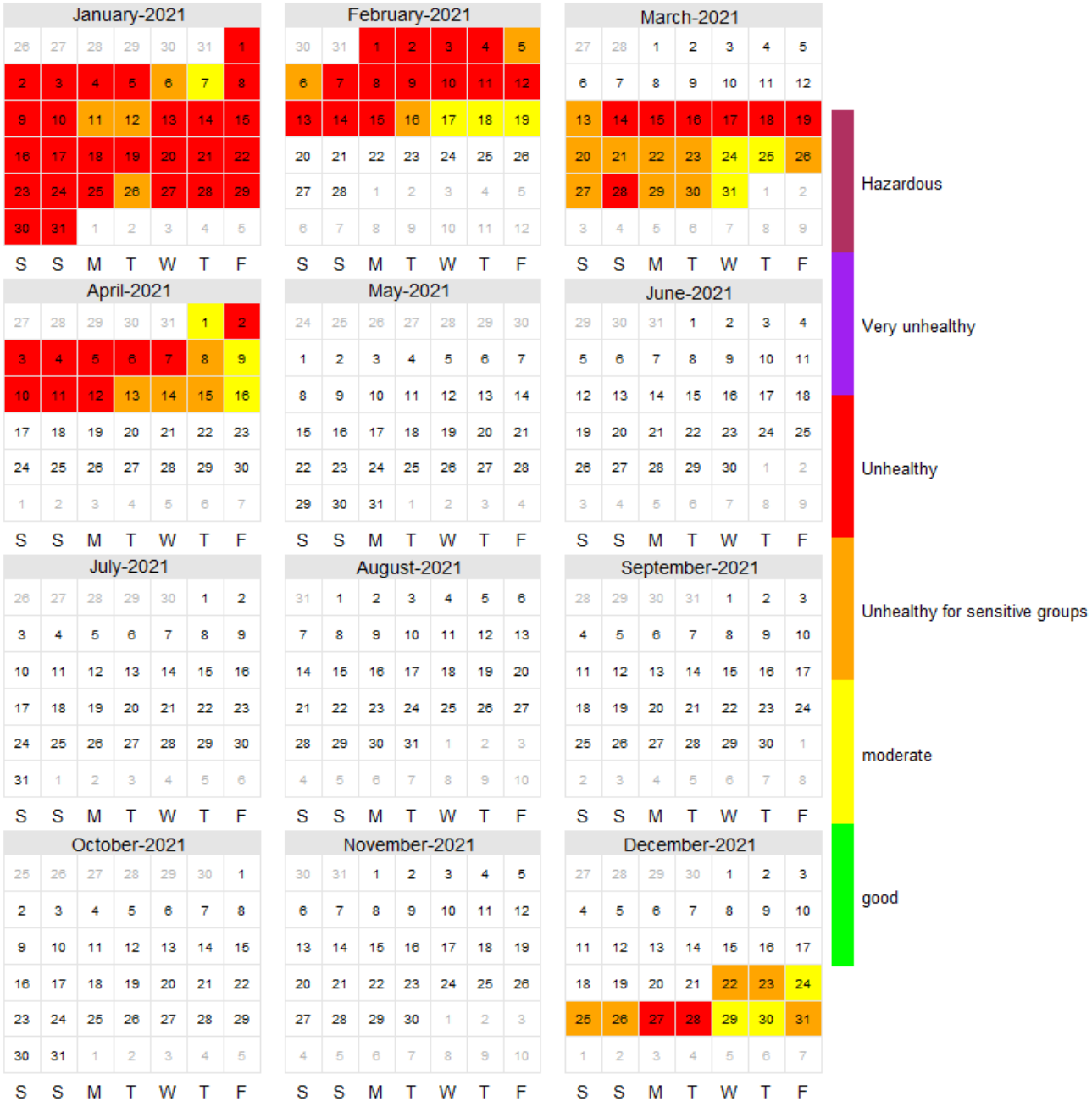


Figure 2.4.24: Calendar plot for $PM_{2.5}$ for the year 2021

2.5 Air quality status – Dang

2.5.1 Introduction

Dang air quality monitoring is near to Ghorahi Rampur road. It was established in 2018 AD. It lies in Dang district of Lumbini Province. This station represents air quality of semi urban area. Hence the major source of air pollution in this area is either local or pollutants transported because of various meteorological processes.

The Station is installed with following instruments:

SN	Name of Instrument	Number of instrument
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.5.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Dang Station was observed to range from 1 to 1464 µg m^{-3} as shown in Figure 2.5.1. The mean of the $PM_{2.5}$ point data was observed to be 34.56 µg m^{-3}.

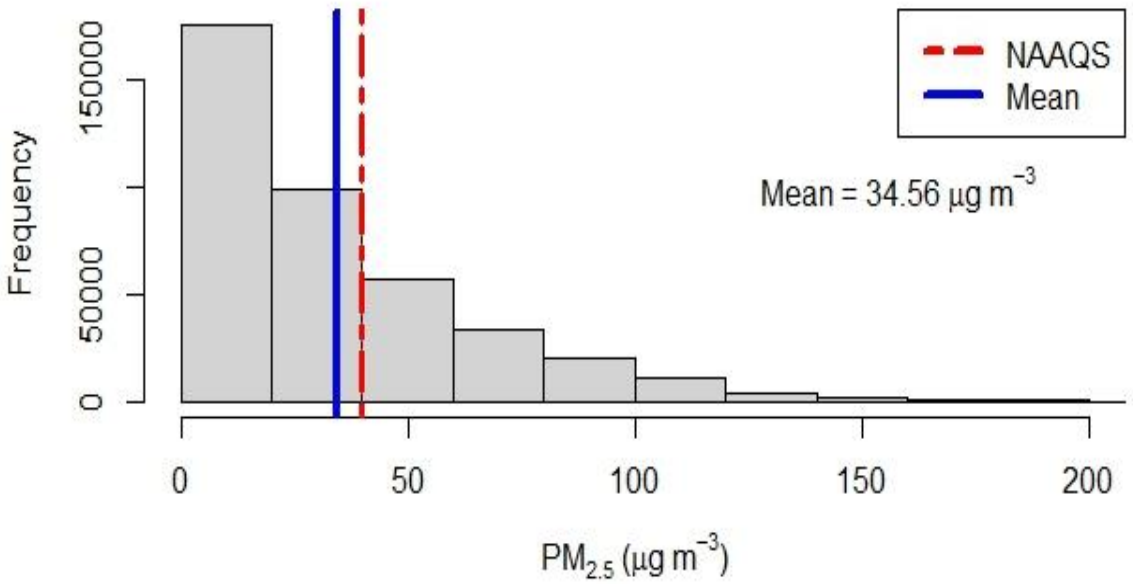


Figure 2.5.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.5.2 shows $PM_{2.5}$ peaks at 7 AM. The diurnal variation is also found high during the same time in the evening. The mean value is found to be more than the median throughout the day.

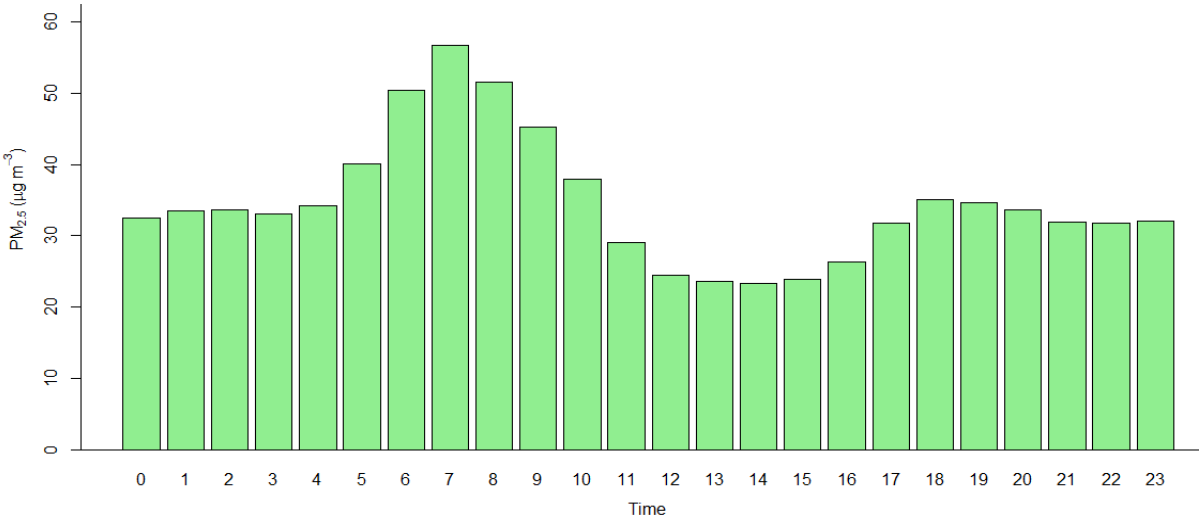


Figure 2.5.2: Hourly average of $PM_{2.5}$

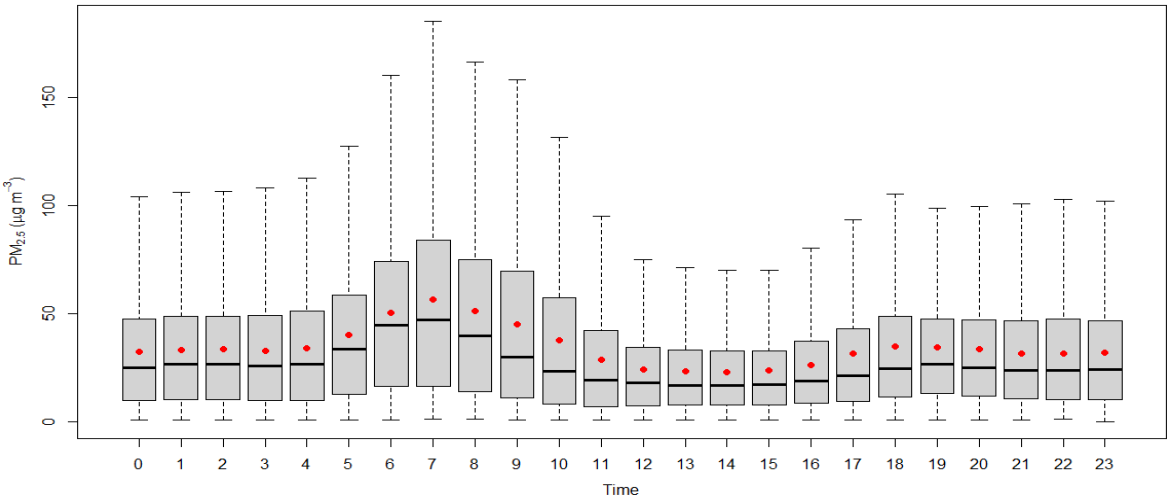


Figure 2.5.3: Diurnal variation of $PM_{2.5}$

Daily variation:

The daily average variation of $PM_{2.5}$ is shown in figure 2.5.4. Higher concentration can be seen during winter and pre-monsoon days whereas lower concentration was observed during monsoon season.

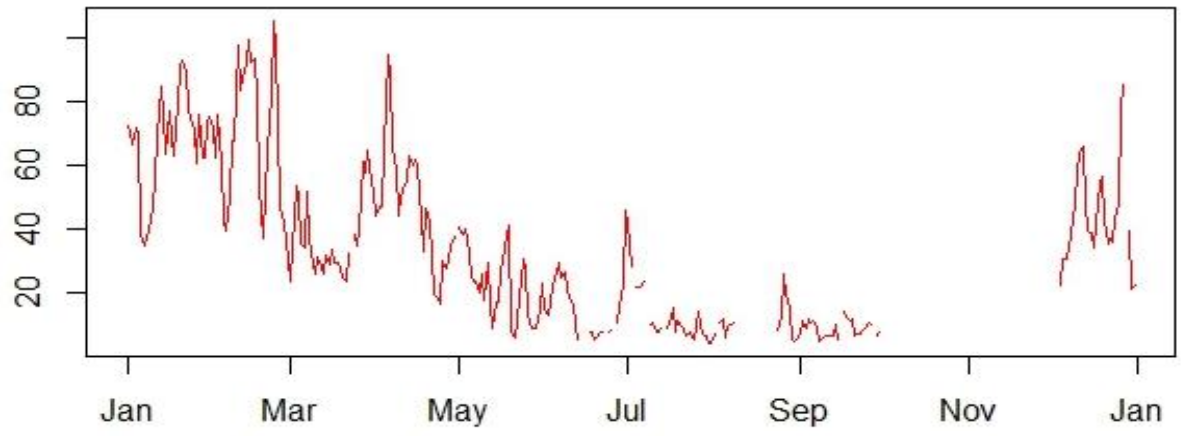


Figure 2.5.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation:

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during February whereas less during August and September. The mean value was found more than median in all months except January.

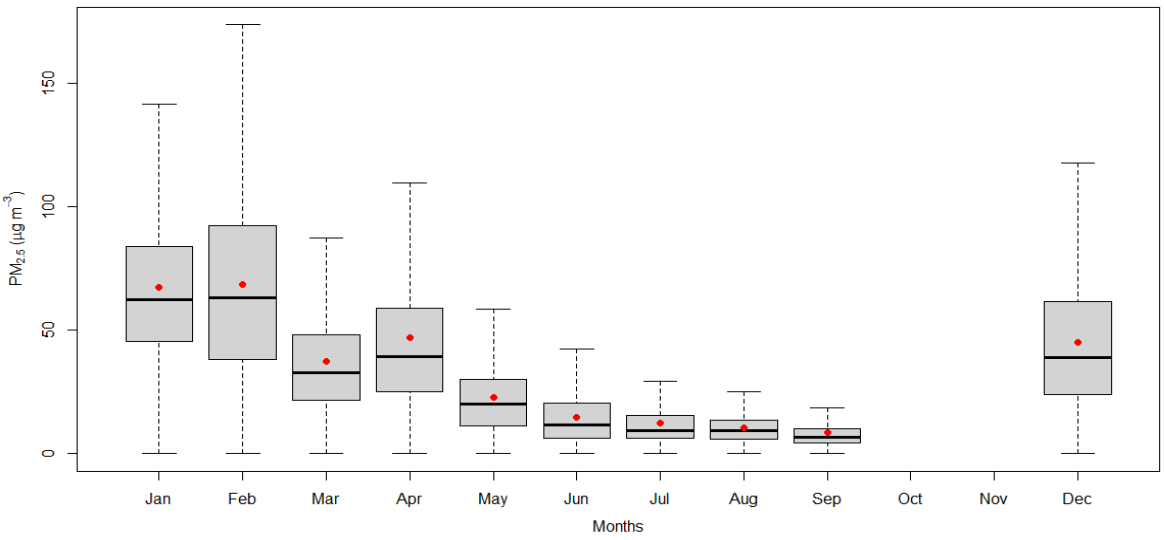


Figure 2.5.5: Monthly variation of $PM_{2.5}$

The monthly average of February was found to be highest (68.63 µg m^{-3}) and that of September was found to be lowest (8.68 µg m^{-3}) while comparing with other months as shown in figure 2.5.6 below.

Figure 2.5.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during winter season (65.78 µg m^{-3}) and the lowest during the monsoon season (12.01 µg m^{-3}) as in figure 2.5.7. Seasonal average was not calculated for post monsoon season due to insufficient data.

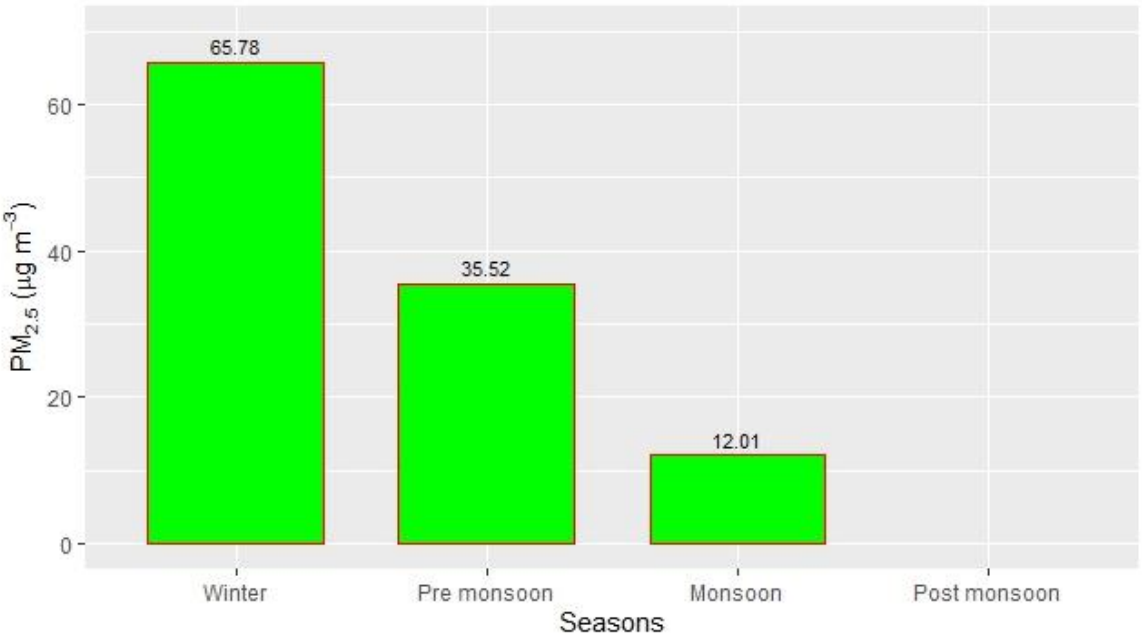


Figure 2.5.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 272 days of measurement, only 96 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$ violations was observed to be more frequent in winter season as shown in figure 2.5.8.

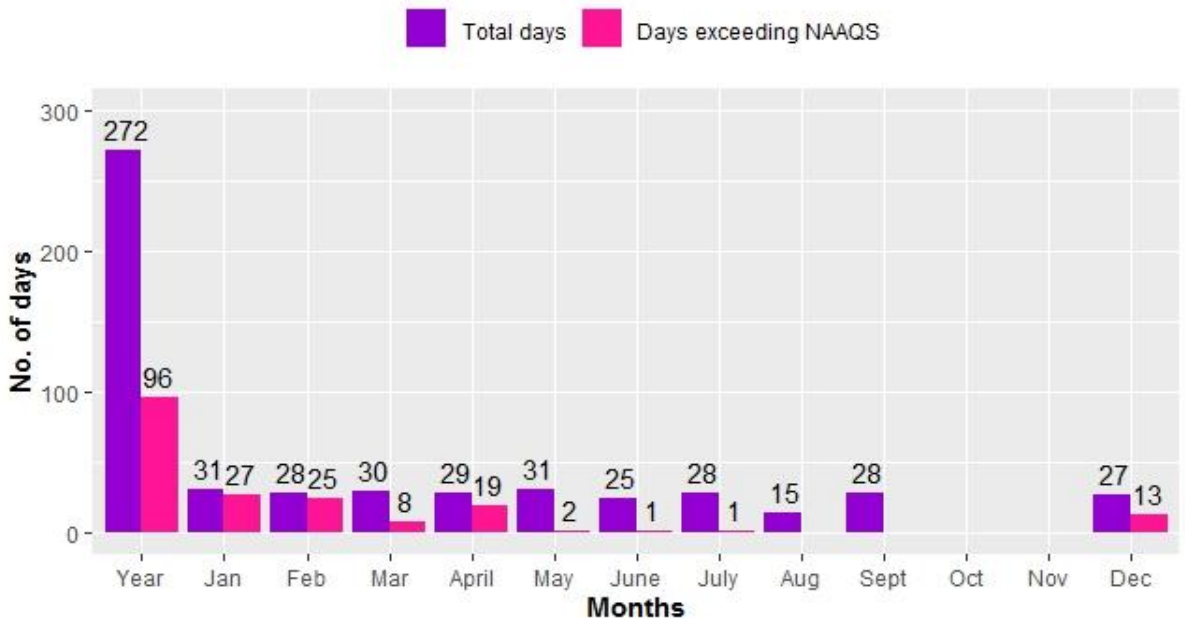


Figure 2.5.8: Compliance status of $PM_{2.5}$

2.5.3 PM_{10}

Histogram:

PM_{10} in Dang Station was observed to range from 1 to 2930 µg m^{-3} (Figure 2.5.9). The mean of the PM_{10} point data was observed to be 49.93 µg m^{-3}.

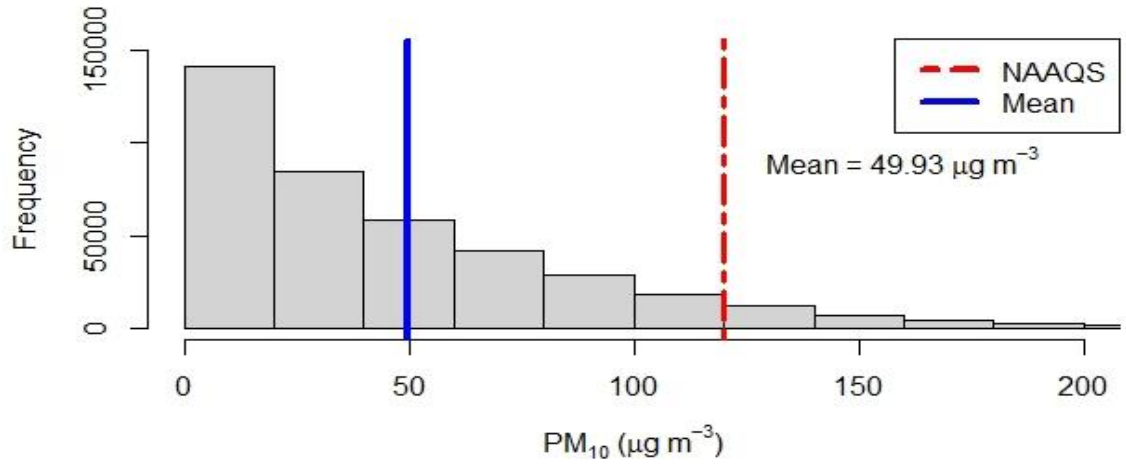


Figure 2.5.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.5.10 shows PM_{10} peaks at 6 AM to 10 AM iand at 5 to 6 PM. The diurnal variation is found high during late morning. The mean value is found to be more than median throughout the day.

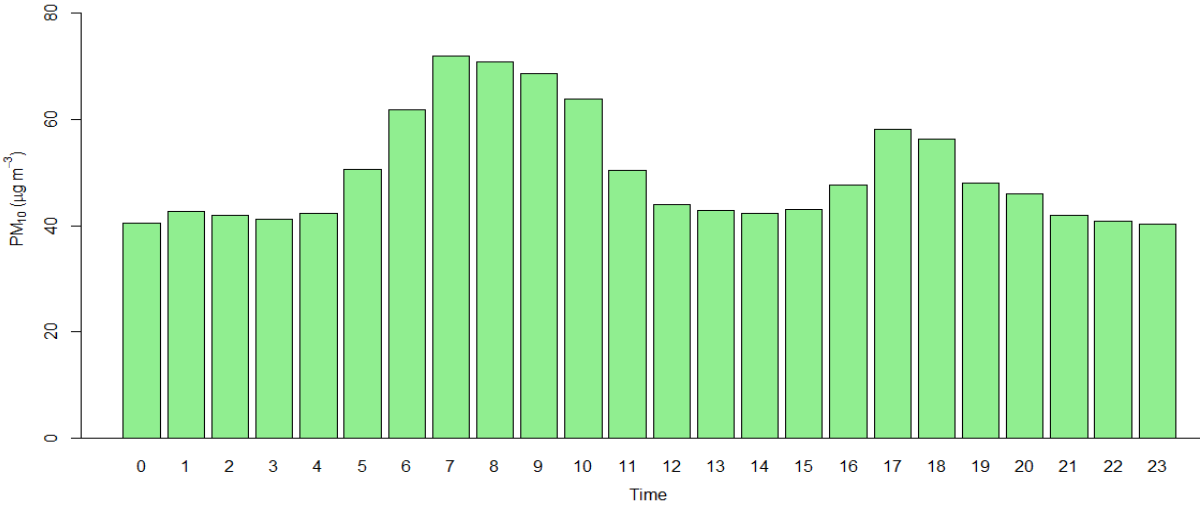


Figure 2.5.10: Hourly average of PM_{10}

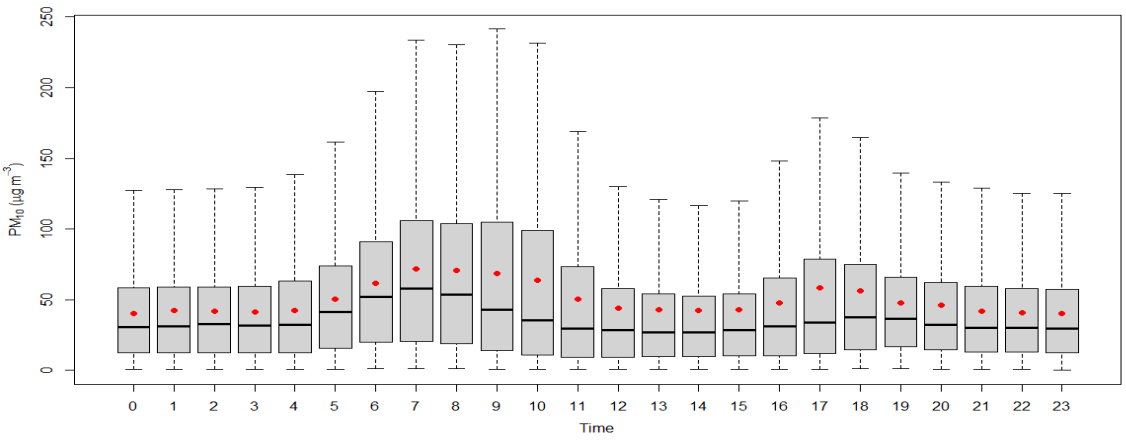


Figure 2.5.11: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.5.12. Higher concentration can be seen during April whereas lower concentration was observed during monsoon season.

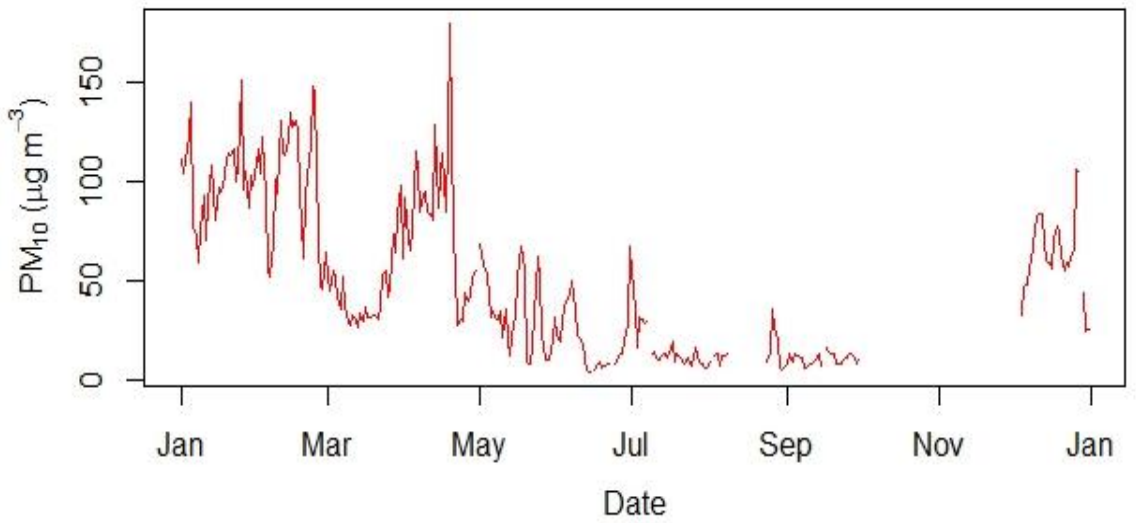


Figure 2.5.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during February whereas less during September.

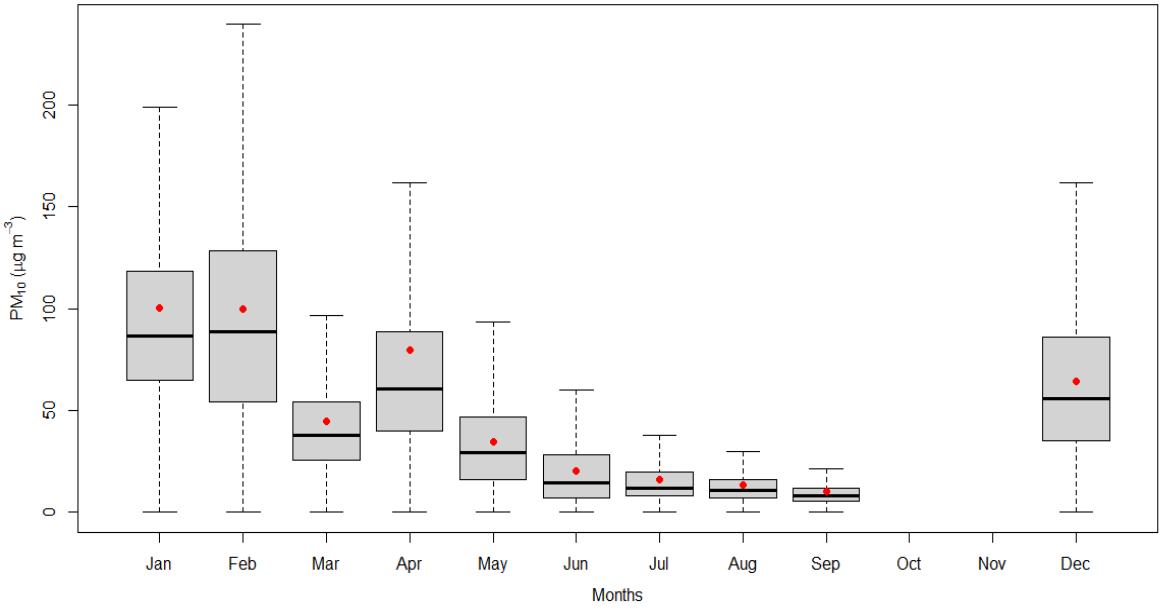


Figure 2.5.13: Monthly variation of PM_{10}

The monthly average for January was found the highest (100.21 µg m^{-3}) and that of September was found lowest (10.66 µg m^{-3}) while comparing with other months as shown in figure 2.5.14.

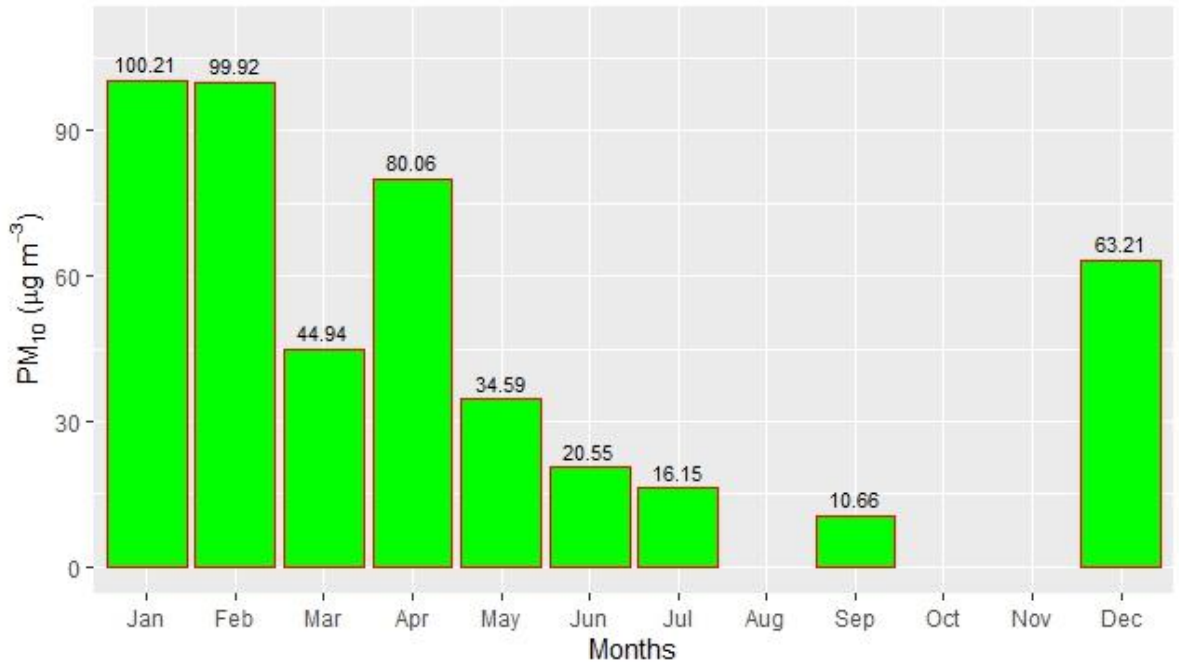


Figure 2.5.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during winter season (98.77 µg m^{-3}) and the lowest during monsoon season (15.43 µg m^{-3}) as in figure 2.5.15. Seasonal average was not calculated for Post monsoon season due to insufficient data.

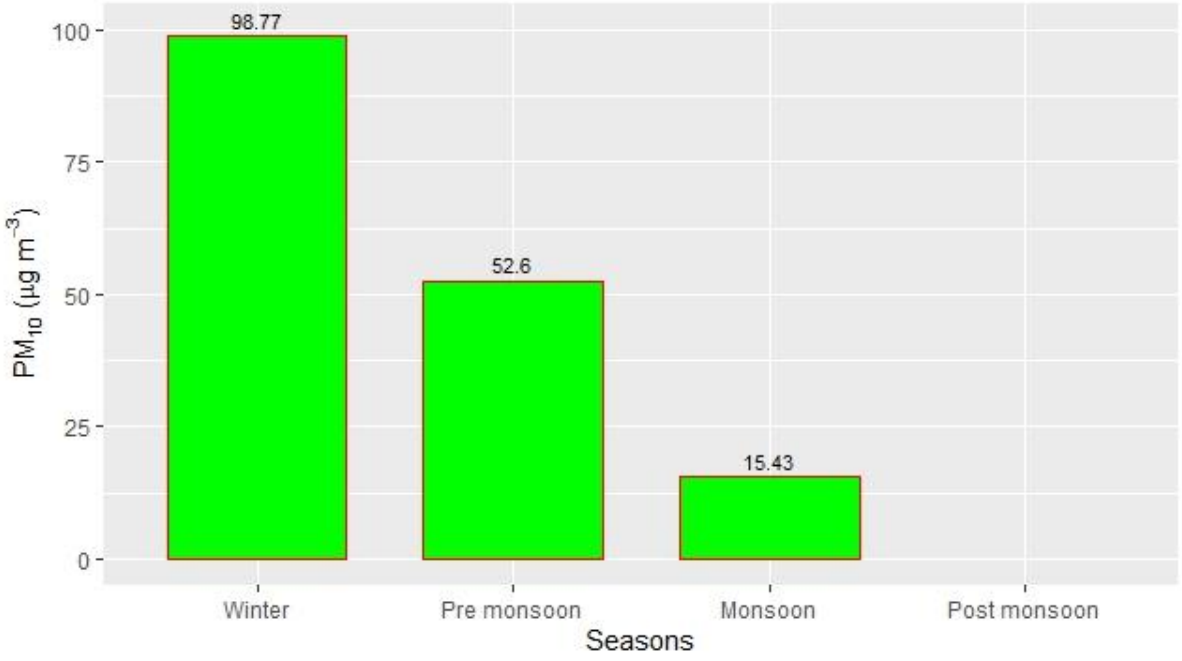


Figure 2.5.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 279 days of measurement, only 15 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10} as shown in figure 2.5.16.

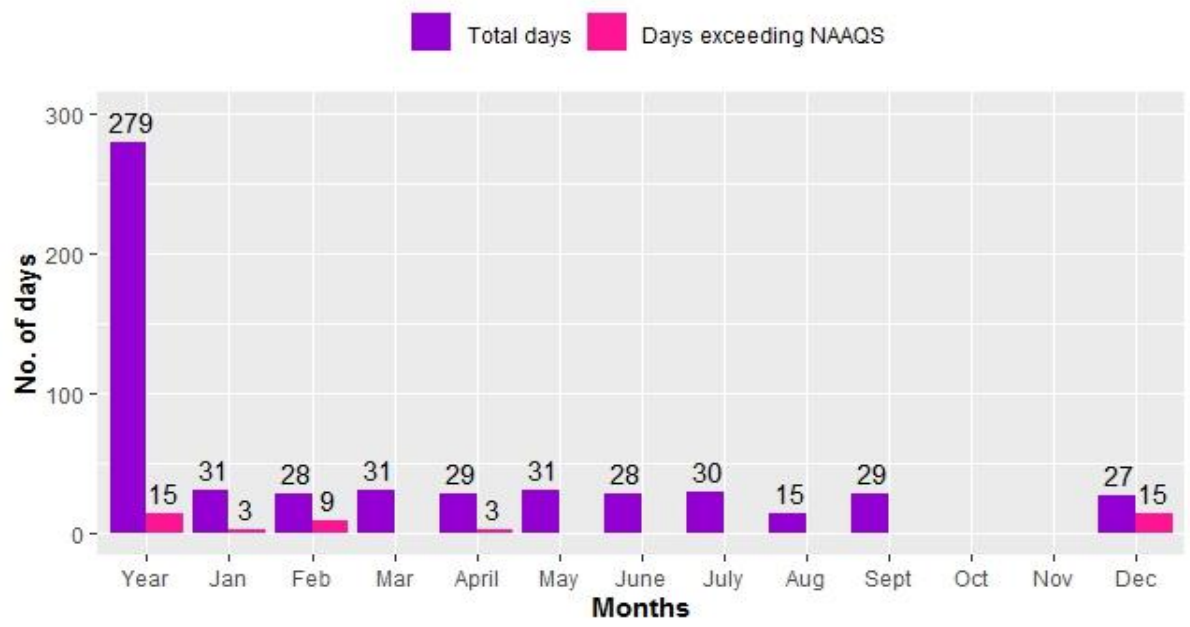


Figure 2.5.16: Compliance status of PM_{10}

2.5.4 TSP

Histogram

TSP in Dang Station was observed to range from 1 to 4965 µg m^{-3} (Figure 2.5.17). The mean of the TSP point data was observed to be 78.7 µg m^{-3}.

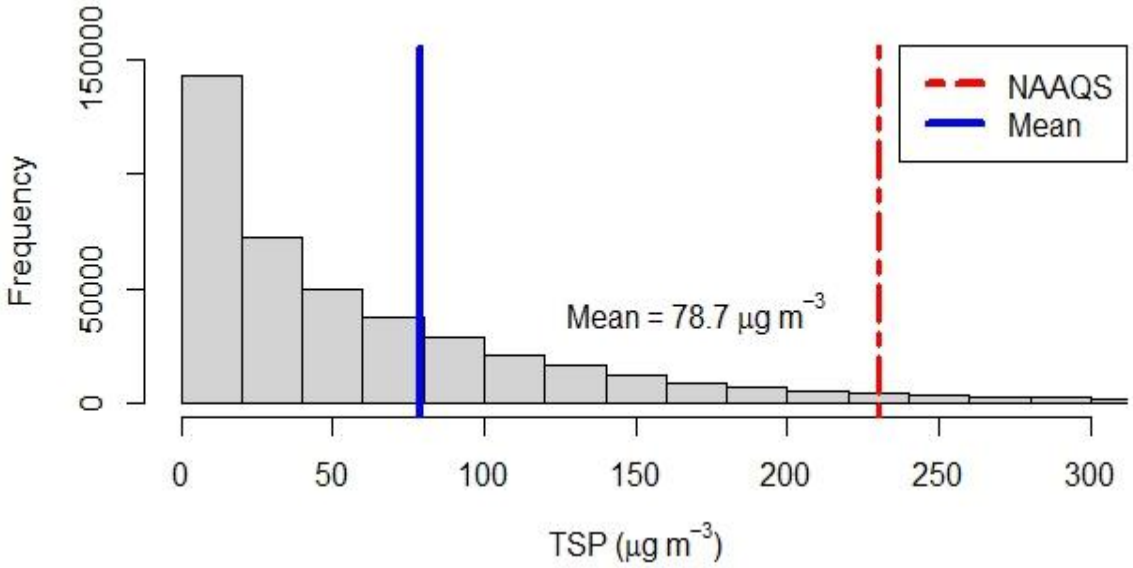


Figure 2.5.17: Histogram of TSP

Diurnal Variation

The Figure 2.5.18 shows TSP peaks during afternoon and evening. The diurnal variation is found high during late morning. The mean value is found to be more than median throughout the day.

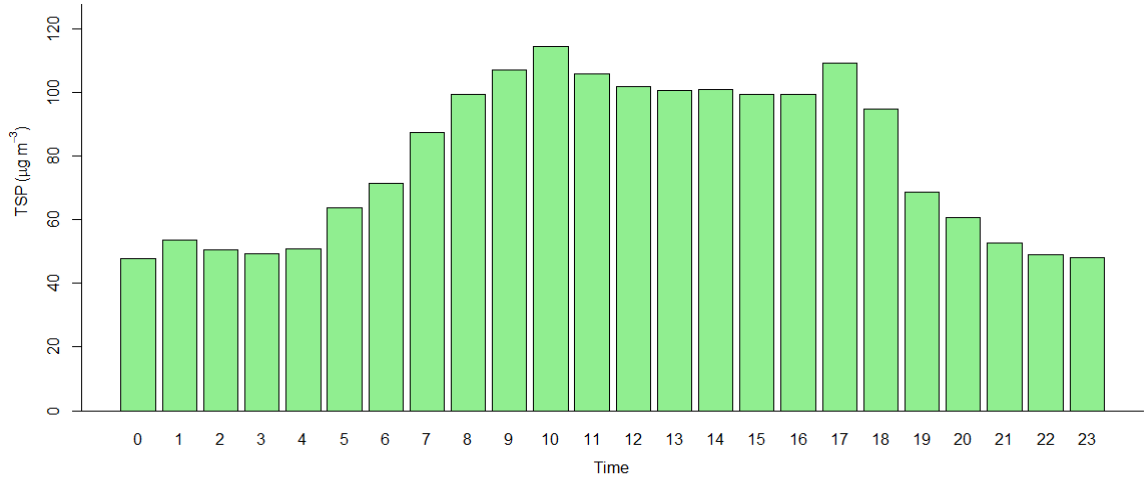


Figure 2.5.18: Hourly average of TSP

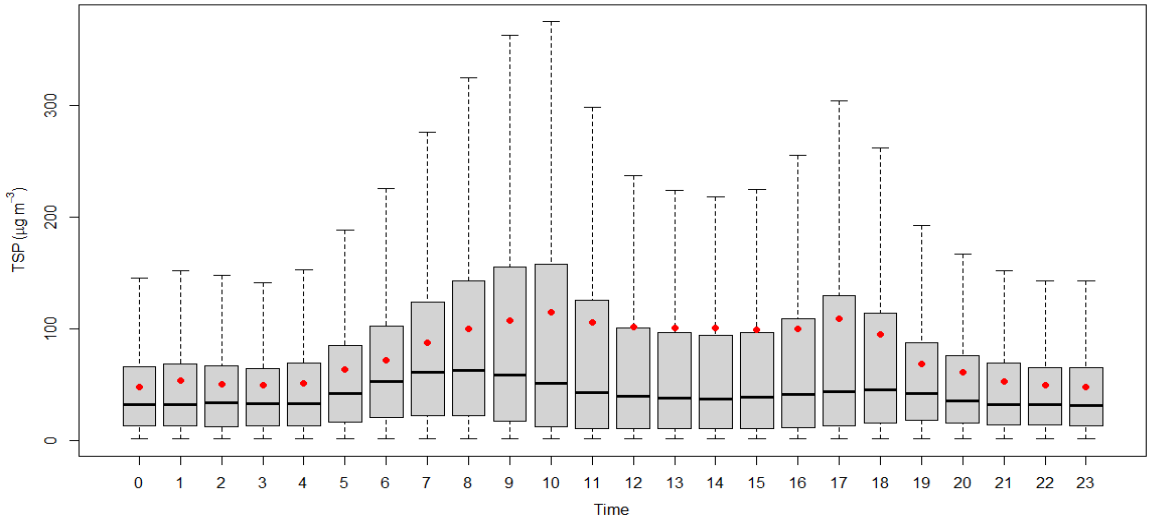


Figure 2.5.19: Diurnal variation of TSP

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.5.20. Higher concentration can be seen during April whereas lower concentration was observed during monsoon.

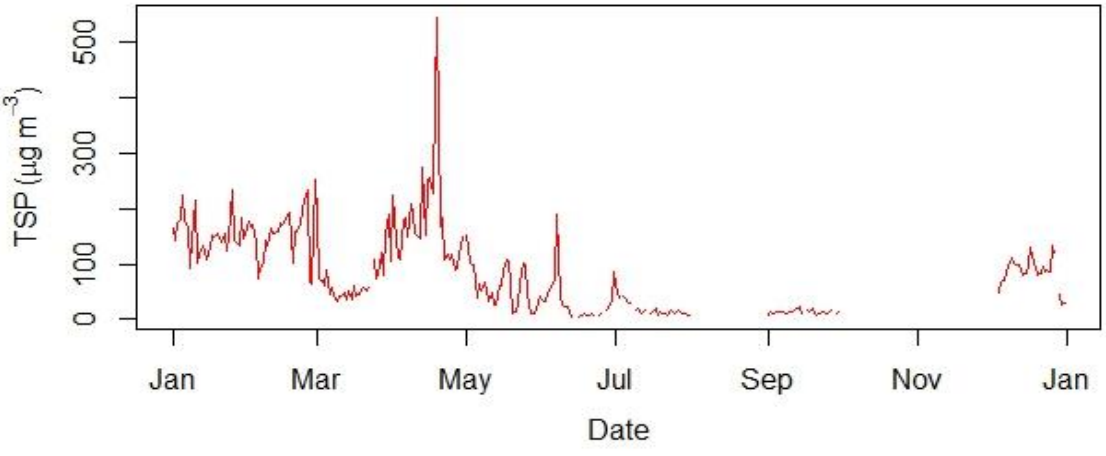


Figure 2.5.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during September. The mean value was found more than median in all months except February.

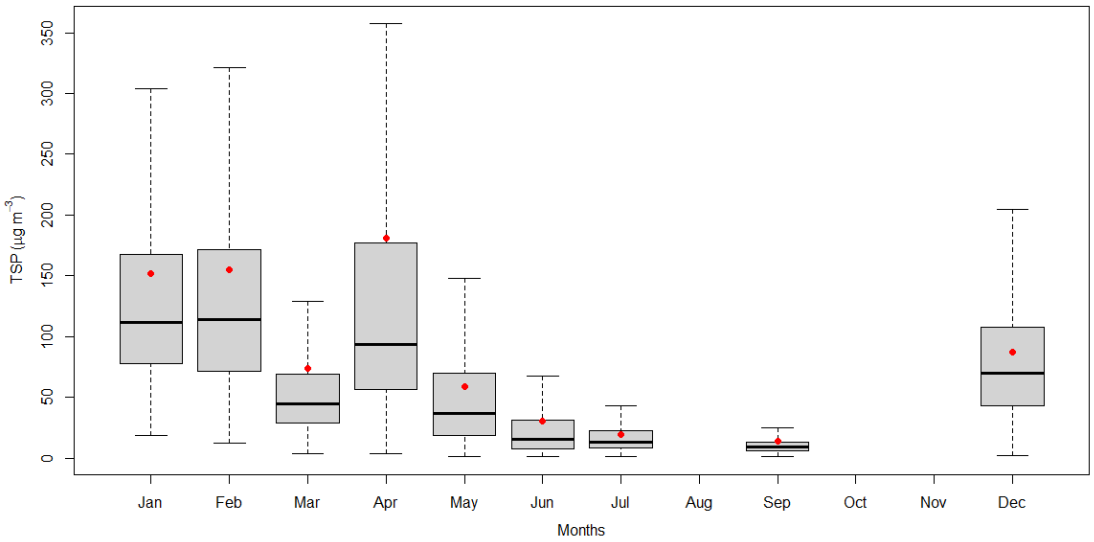


Figure 2.5.21: Monthly variation of TSP

The monthly average for April was found to be the highest (183.58 µg m^{-3}) and that of September was found to be the lowest (14.07 µg m^{-3}) while comparing with other months as shown in figure 2.5.22.

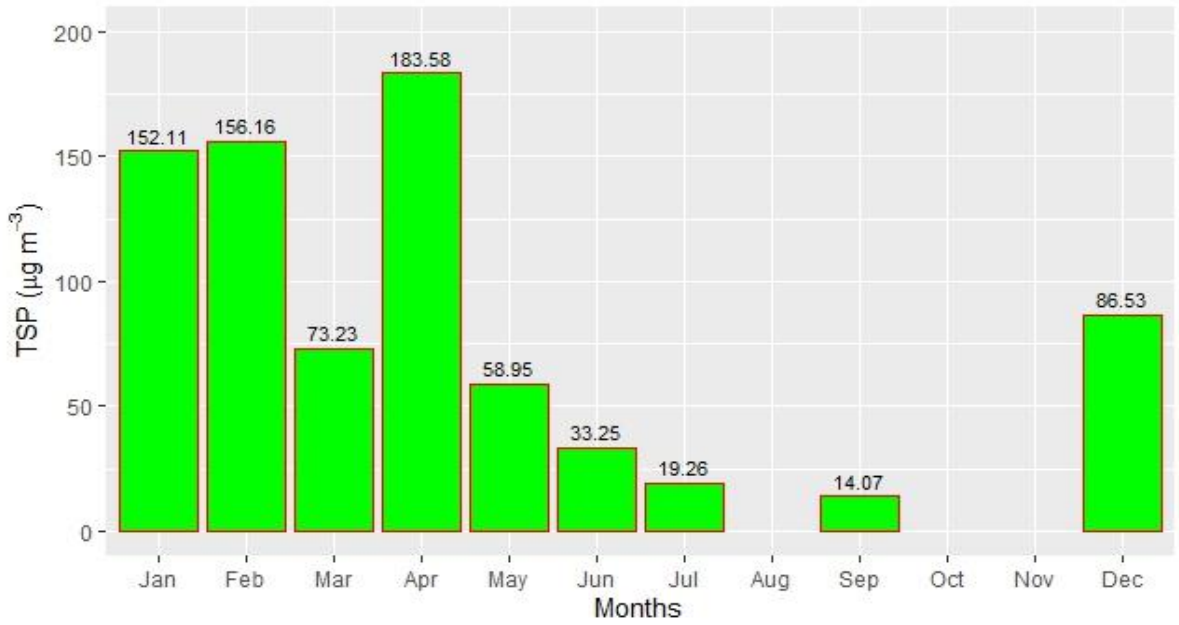


Figure 2.5.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during winter (150 µg m^{-3}) and the lowest during the monsoon season (21.92 µg m^{-3}) as in figure 2.5.23. seasonal average was not calculated for Post monsoon season due to insufficient data.

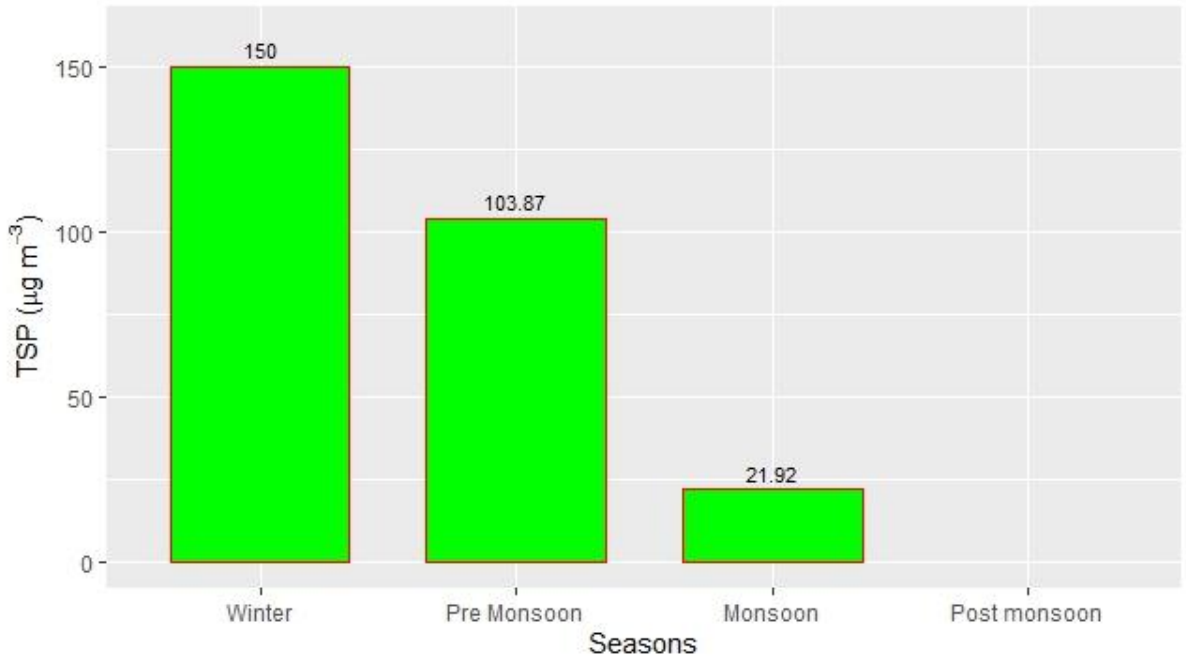


Figure 2.5.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 258 days of measurement, only 8 days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3} as shown in figure 2.5.24.

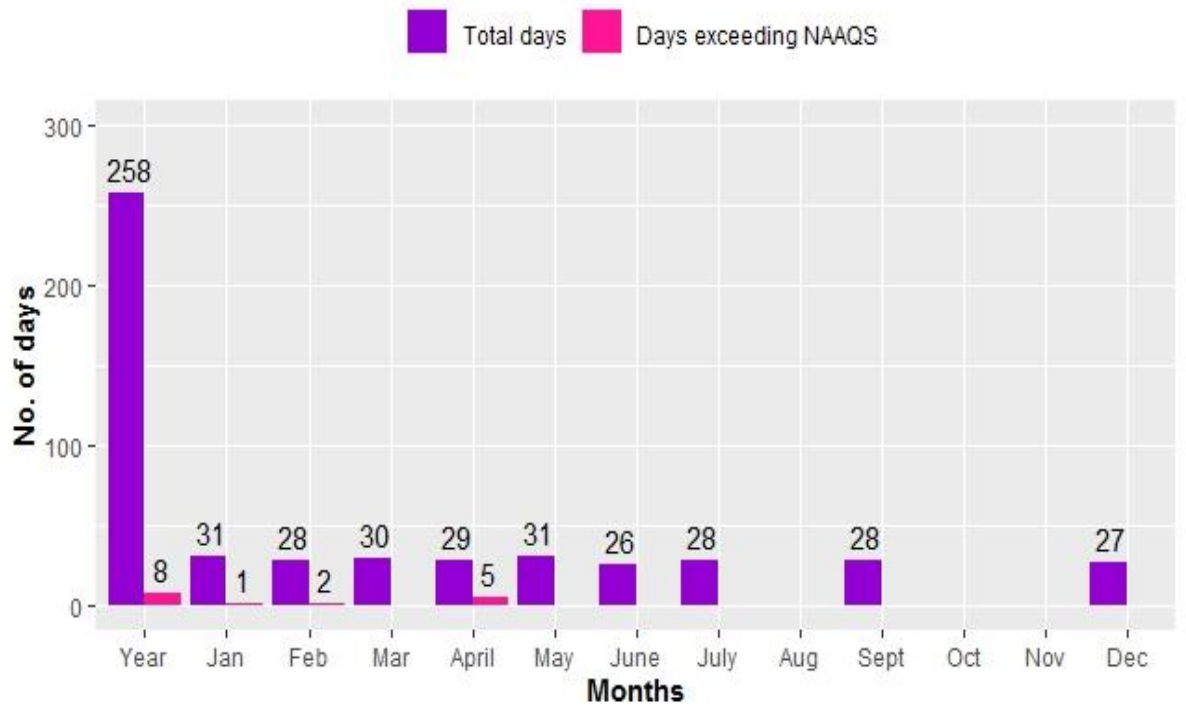


Figure 2.5.24: Compliance status of TSP

Calendar Plot:

Calendar Plot in figure 2.5.25 shows that most of the days in the months of December, January, February and March are unhealthy whereas most of the days in monsoon months i.e. June, July, August and September are good.

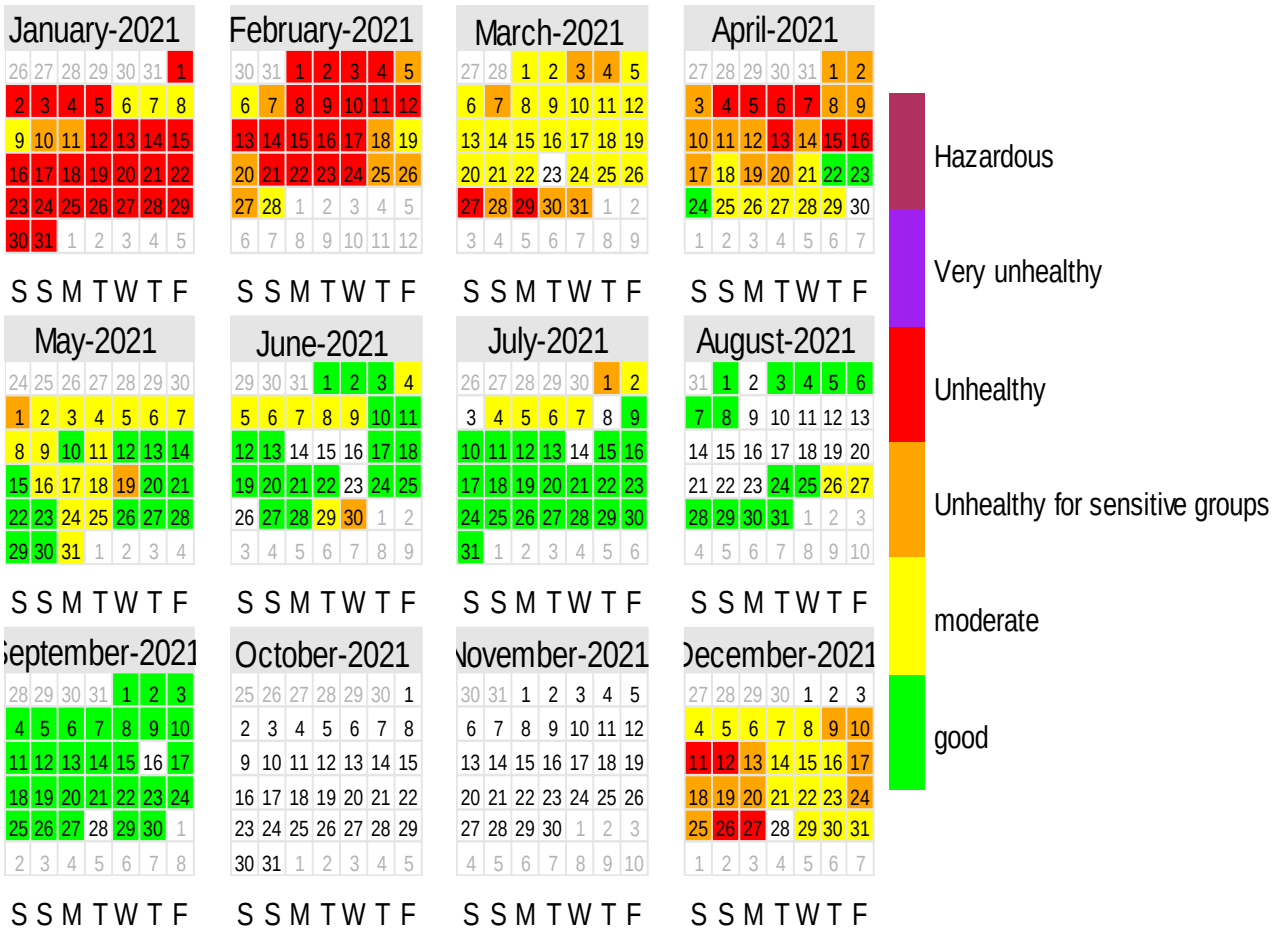


Figure 2.5.25: Calendar plot for $PM_{2.5}$ for the year 2021

2.6 Air quality status – Gandaki Boarding School, Pokhara

2.6.1 Introduction

Goandaki Boarding School lies in Pokhara Metropolitan city. This station was established in 2017. Pokhara is center of Ganadaki Province. Though it lies on the outskirts of the city, now this area is also heavily urbanized. So this station also represents the urban areas. Vehicles are the major source of pollution. Besides emissions from fires in the other regions is also transported to Pokhara.

The Station is installed with following instruments:

SN	Name of Instrument	Number of instrument
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.6.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Gandaki Boarding School Station was observed to range from 1 to 1481.5 µg m^{-3} (Figure 2.6.1). The mean of the $PM_{2.5}$ point data was observed to be 58.64 µg m^{-3}.

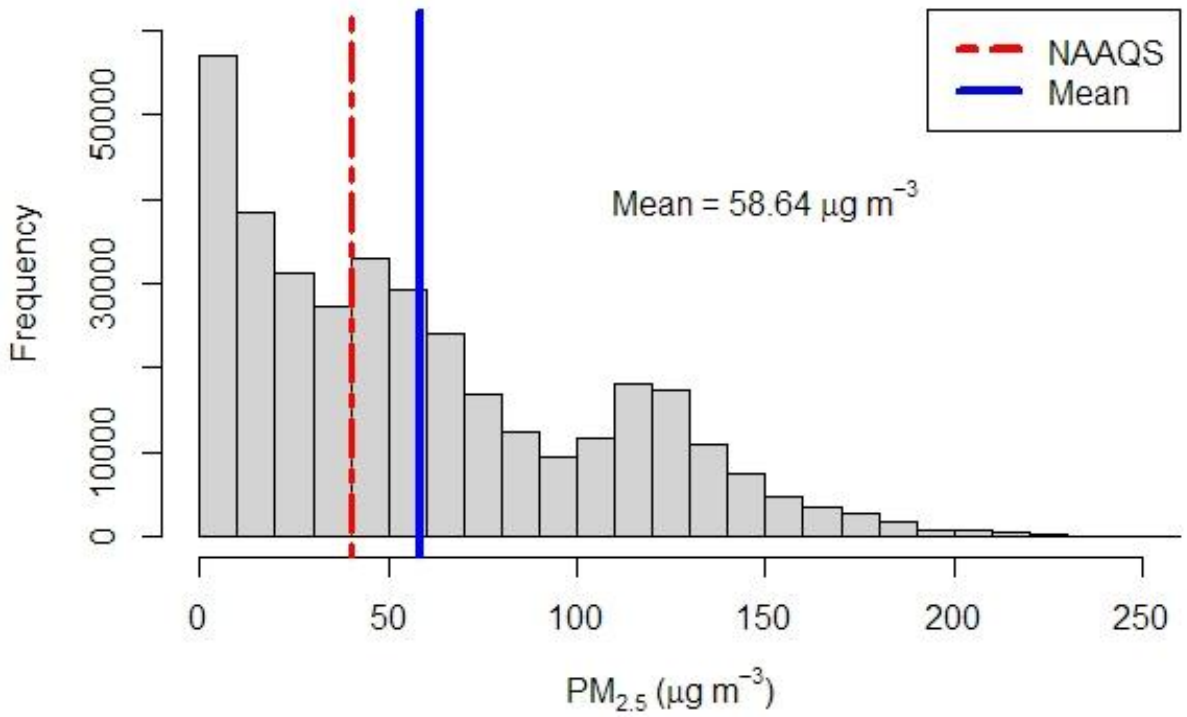


Figure 2.6.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.6.2 shows $PM_{2.5}$ peaks at 9 AM to 10 AM and 6 PM to 7 PM. At 8 AM mean and median is almost same in other time mean is higher than median.

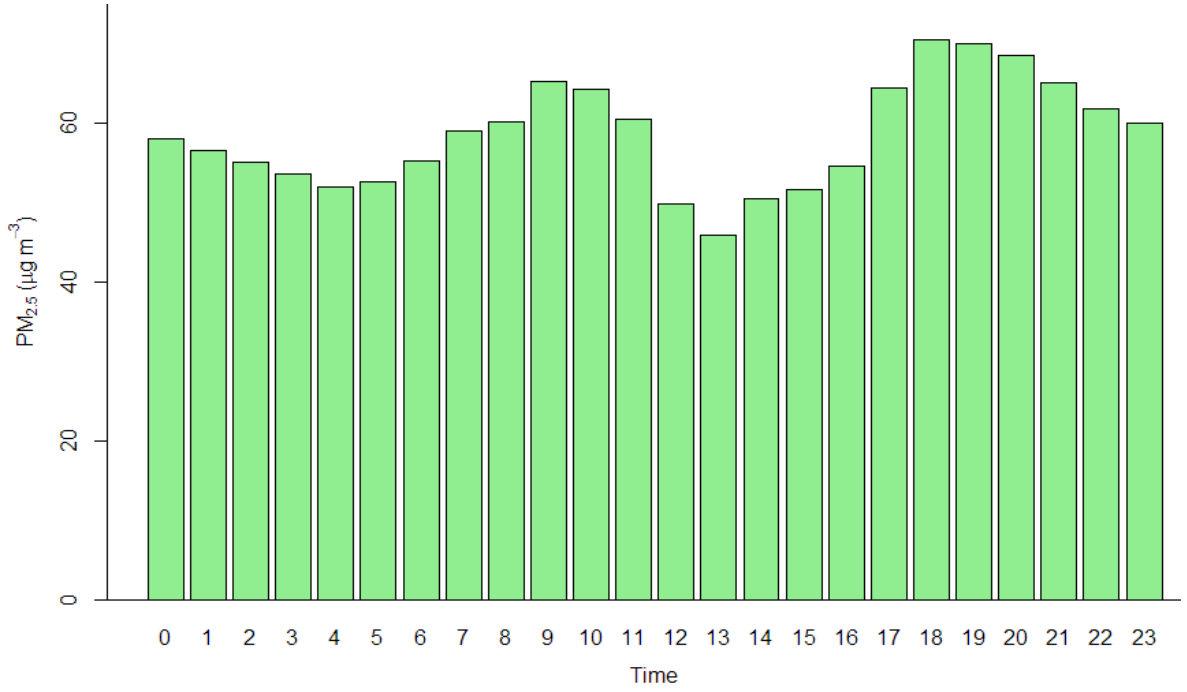


Figure 2.6.2: Hourly average of $PM_{2.5}$

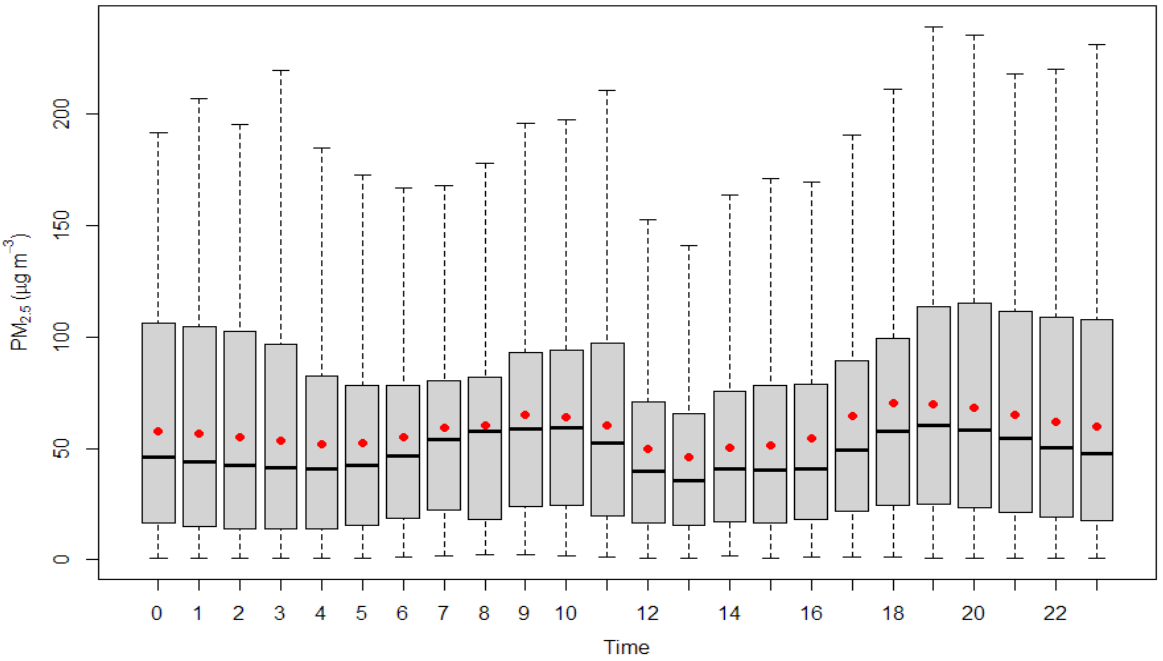


Figure 2.6.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variation of $PM_{2.5}$ is shown in figure 2.6.4. Higher concentration can be seen during April whereas lower concentration was observed during monsoon season. A lot of data is missing from May to October.

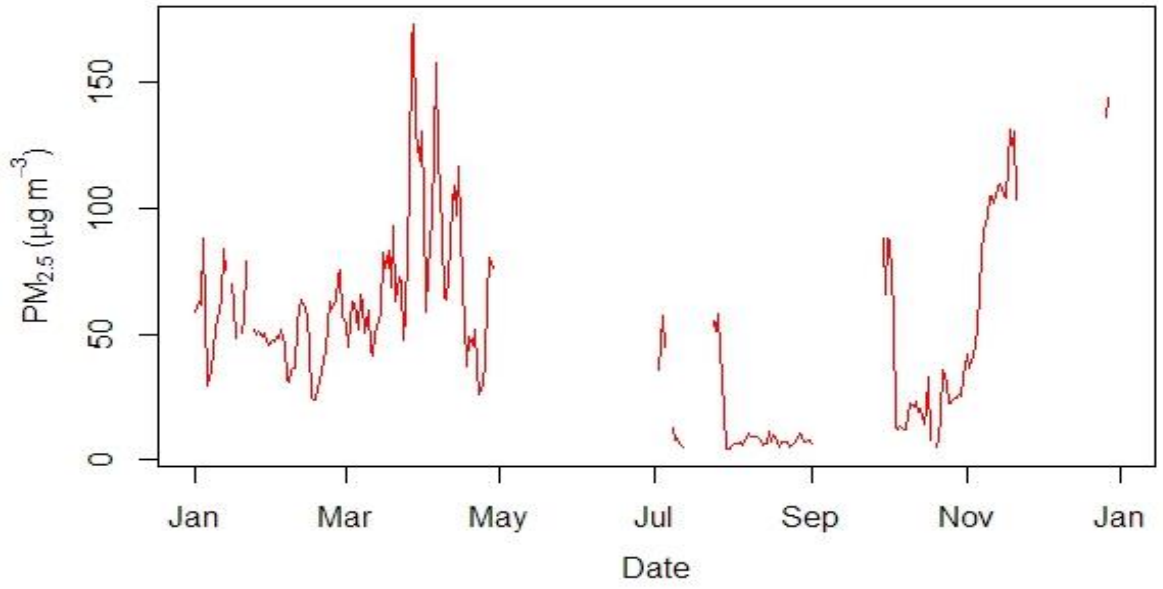


Figure 2.6.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during November whereas less during August. The mean value was found more than median during March, April, July, September and October while mean was less than median in November.

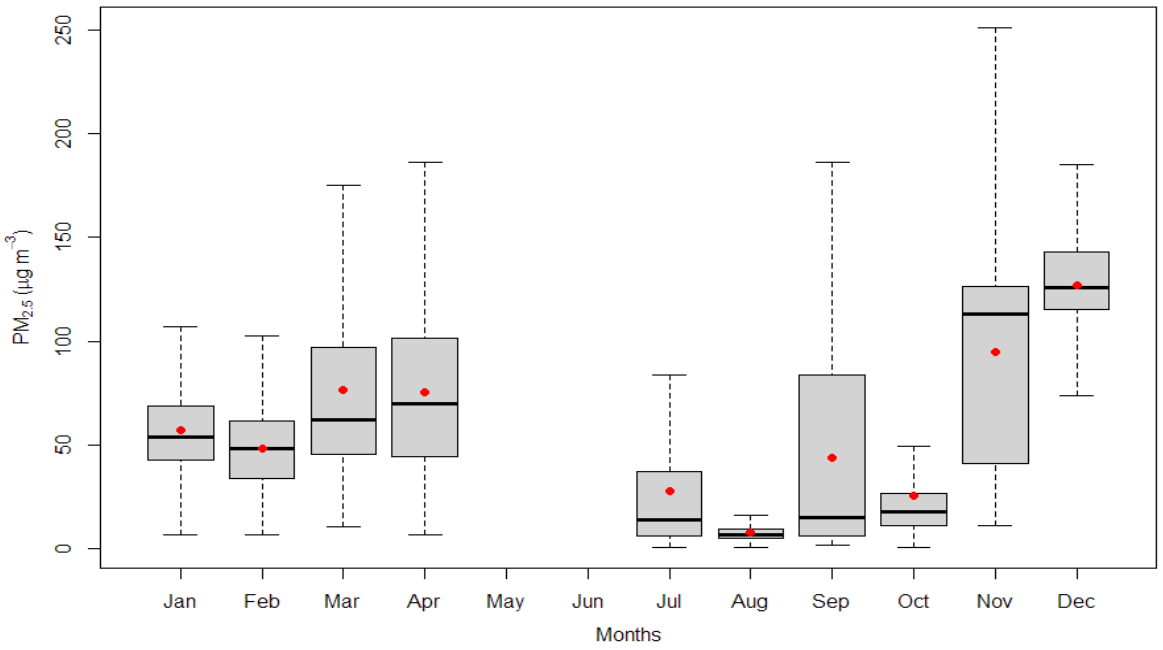


Figure 2.6.5: Monthly variation of $PM_{2.5}$

The monthly average of November was found to be highest (89.84 µg m^{-3}) and that of August was found to be lowest (7.69 µg m^{-3}) while comparing with other months as shown in figure 2.6.6 below. The monthly average was not calculated for the month of May, June and September due to insufficient data.

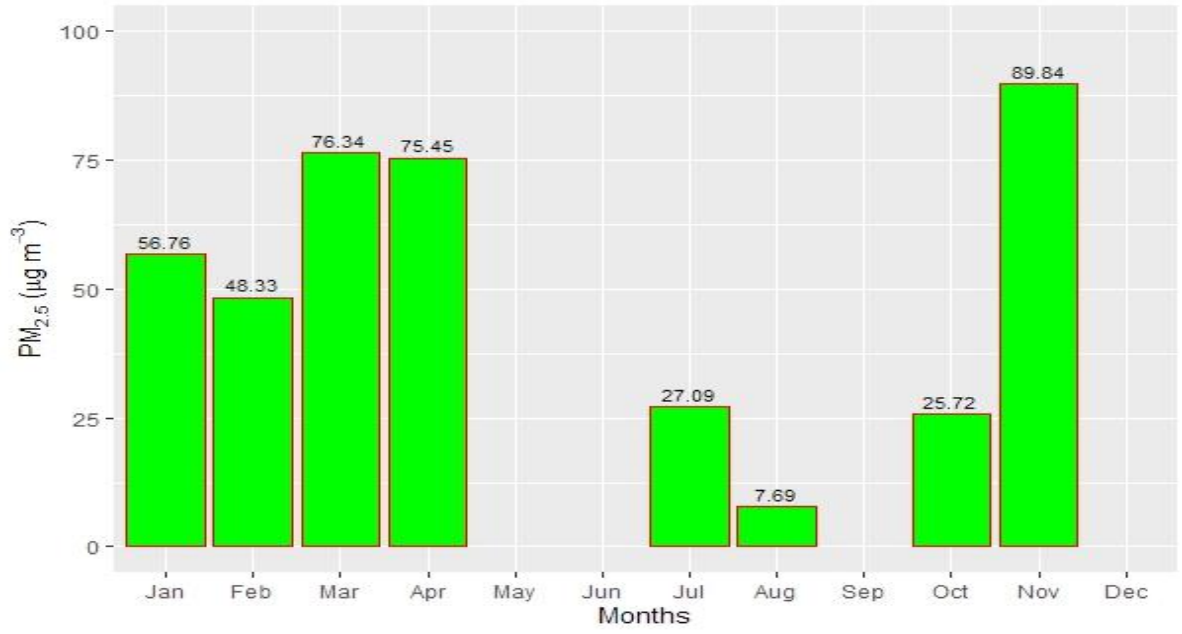


Figure 2.6.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during the pre-monsoon season (75.91 µg m^{-3}) and the lowest during the monsoon season (16.48 µg m^{-3}) as in figure 2.6.7.

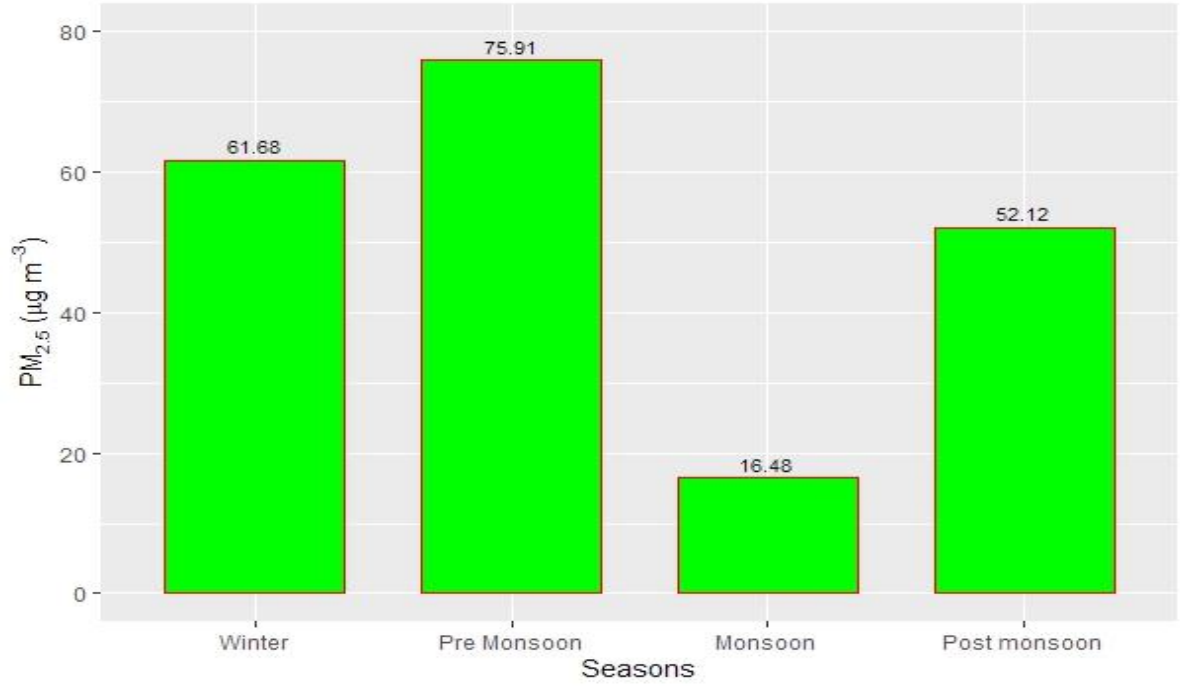


Figure 2.6.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 222 days of measurement, 134 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$ as shown in figure 2.6.8. From January to April and in November noncompliance was seen higher.

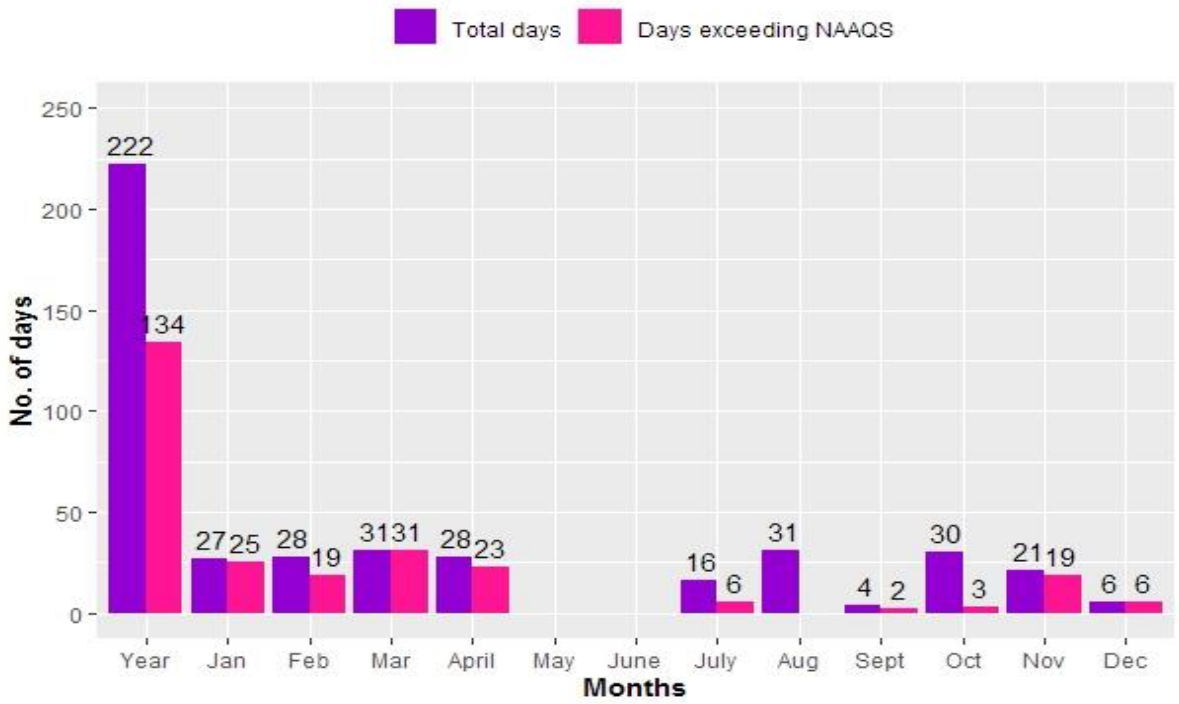


Figure 2.6.8: Compliance status of $PM_{2.5}$

2.6.3 PM_{10}

Histogram

PM_{10} in Gandaki Boarding School Station was observed to range from 1 to 2877.1 µg m^{-3} (Figure 2.6.9). The mean of the PM_{10} point data was observed to be 67.9 µg m^{-3}.

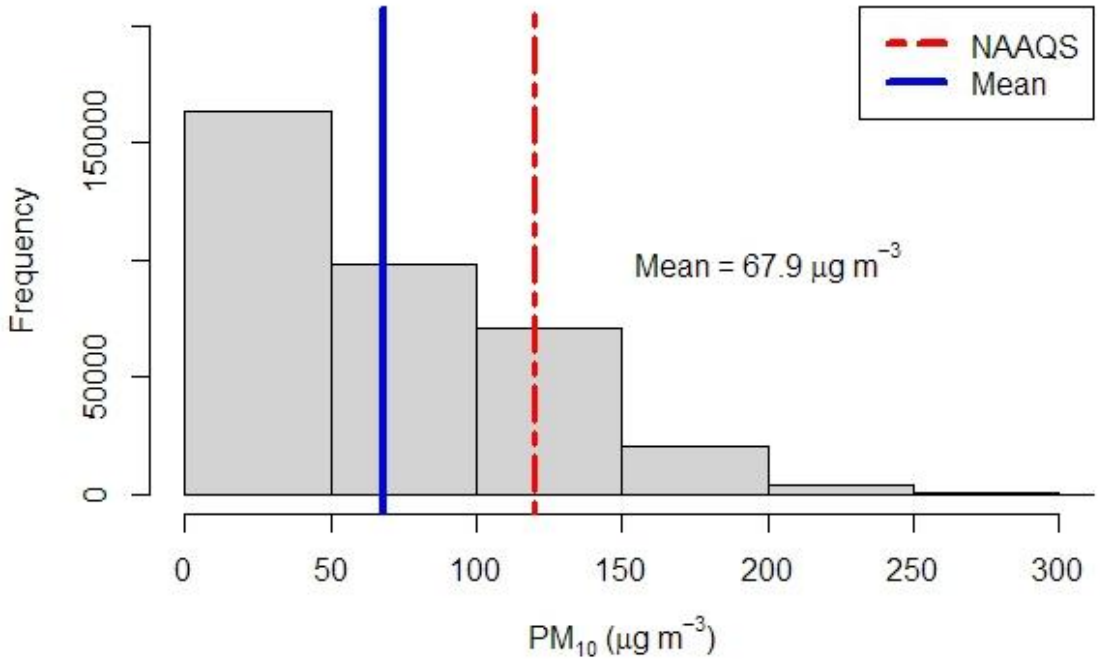


Figure 2.6.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.6.10 shows PM_{10} peaks at 9 AM to 10 AM and at 6 PM. The mean value is found to be more than median throughout the day except at 8 AM when mean and median are almost same.

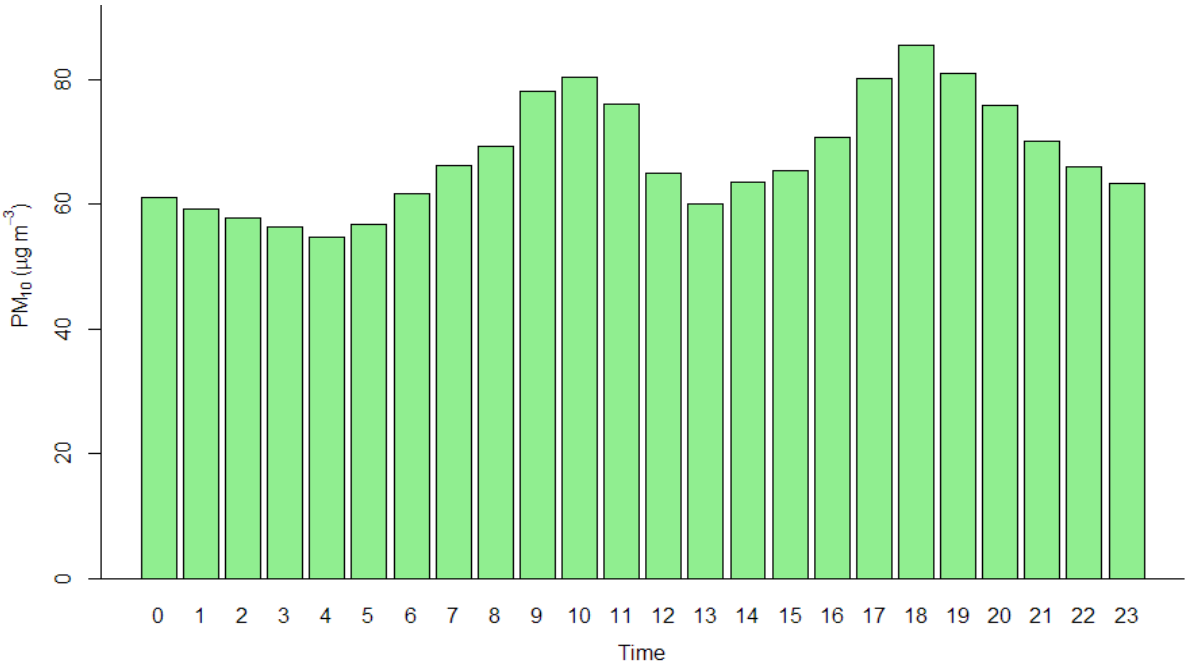


Figure 2.6.10: Hourly average of PM_{10}.

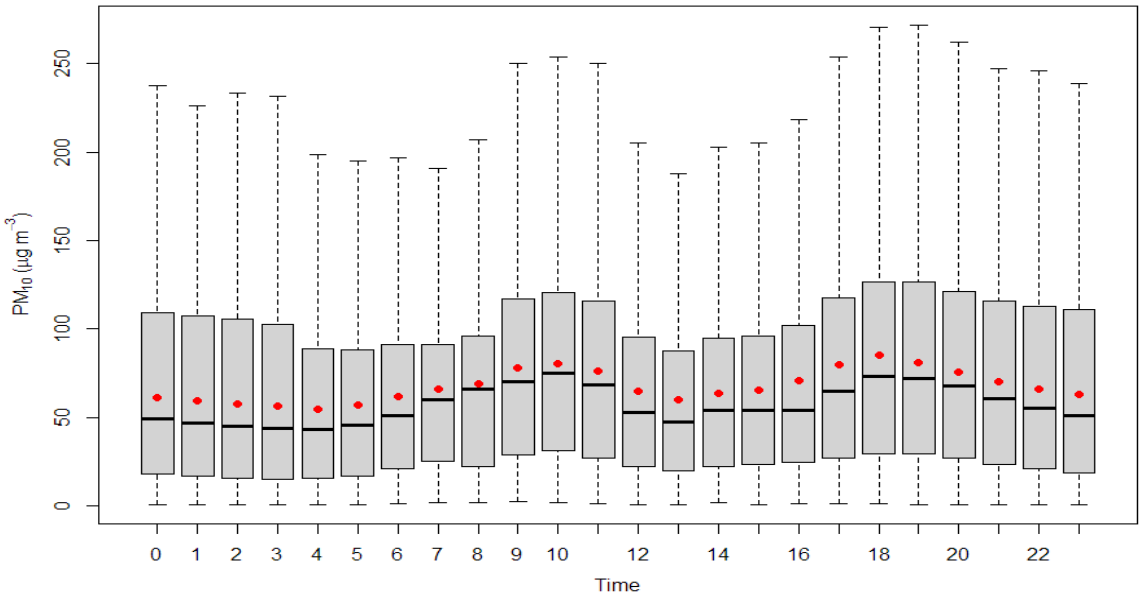


Figure 2.6.11: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.6.12. Higher concentration can be seen during April whereas lower concentration was observed during monsoon season. There is lot of data gap in the monsoon season.

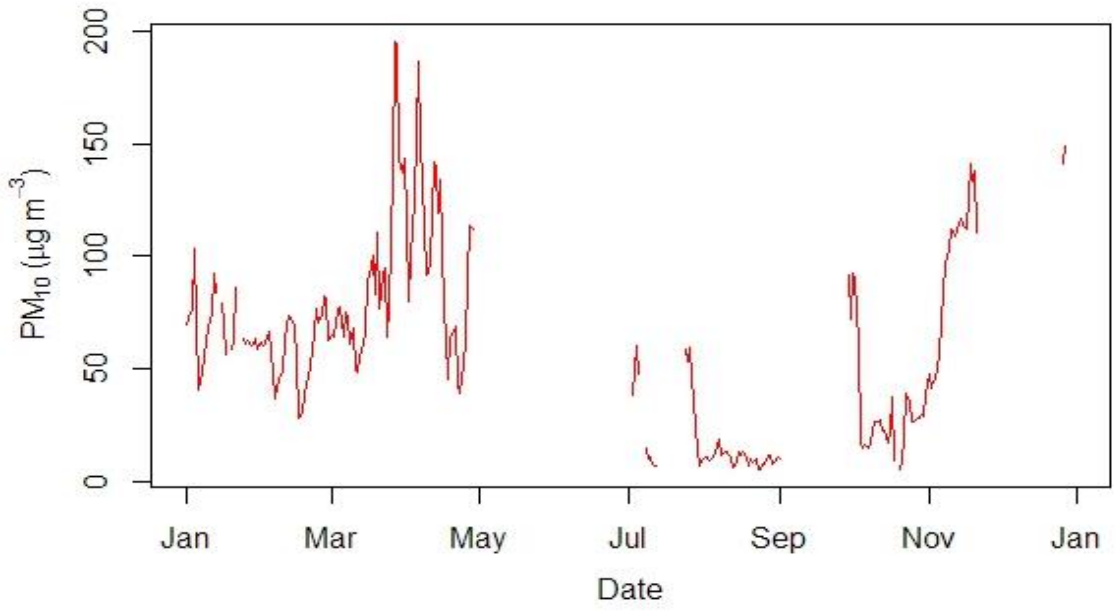


Figure 2.6.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during November whereas less during September. The mean value was found more than the median during March, July, September and October while in November mean is less than median.

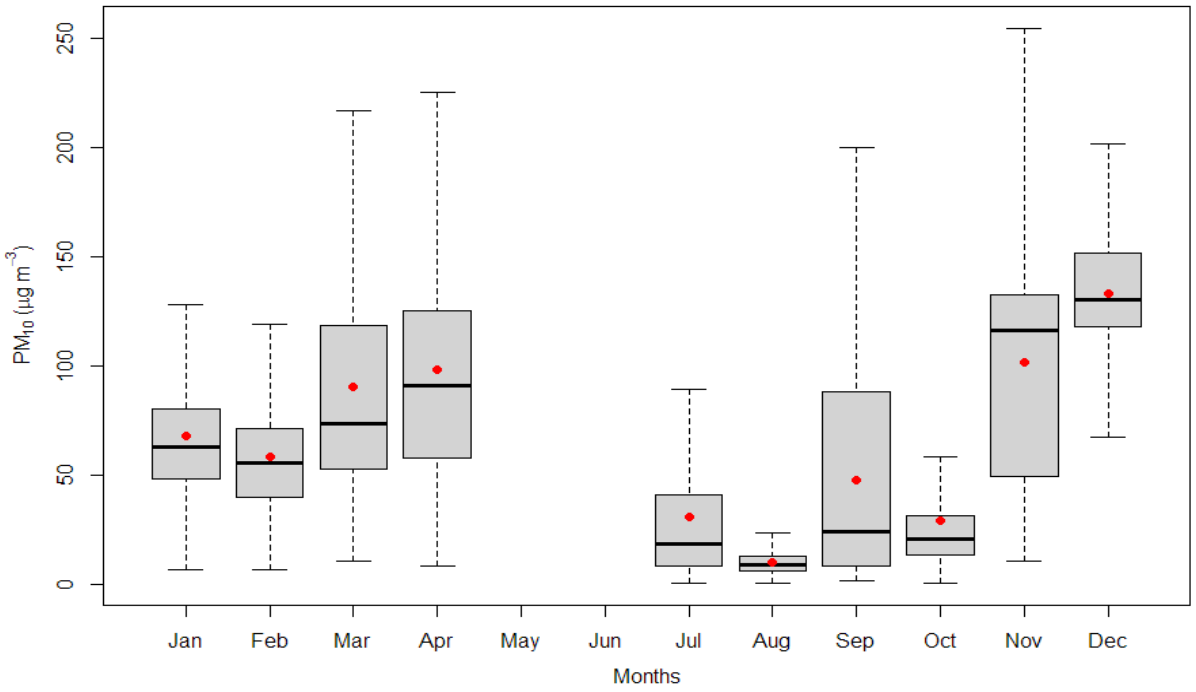


Figure 2.6.13: Monthly variation of PM_{10}

The monthly average for April was found the highest (97.87 µg m^{-3}) and that of August was found lowest (10.55 µg m^{-3}) while comparing with other months as shown in figure 2.6.14.

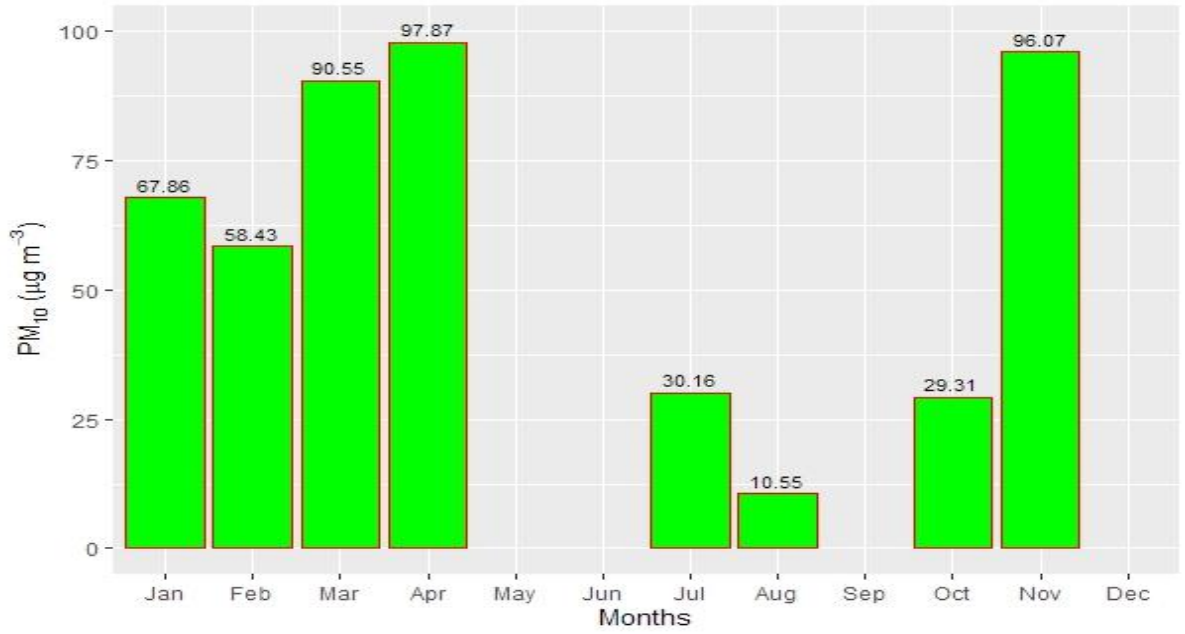


Figure 2.6.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during pre-monsoon season (94.02 µg m^{-3}) and the lowest during monsoon season (19.51 µg m^{-3}) as in figure 2.6.15.

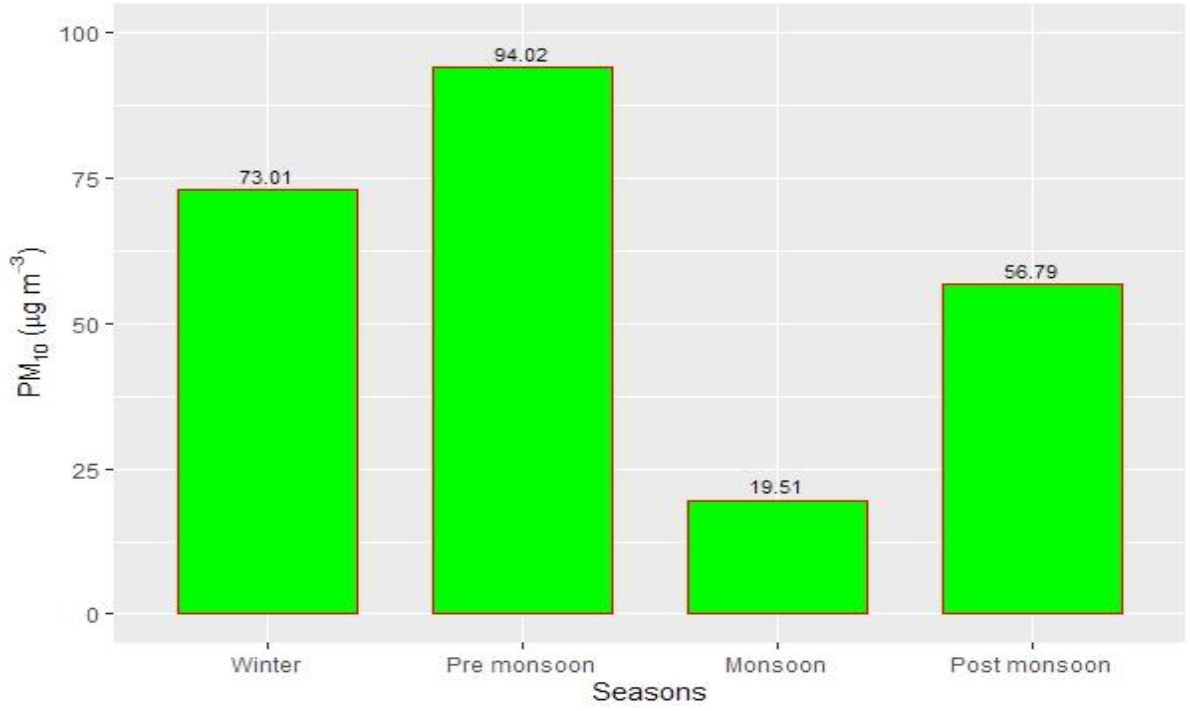


Figure 2.6.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 222 days of measurement, only 20 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. During January, February, July, August, September and October none of the days exceed NAAQS as shown in figure 2.6.16.

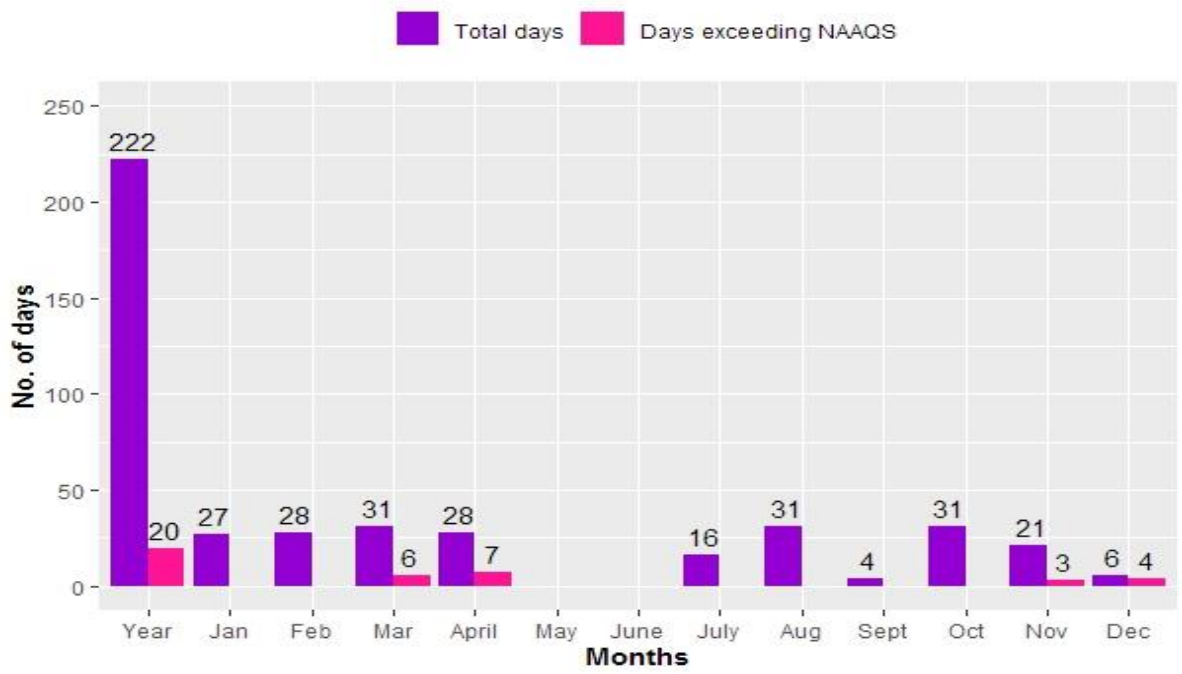


Figure 2.6.16: Compliance status of PM_{10}

2.6.4 TSP

Histogram

TSP in Gandaki Boarding School Station was observed to range from 0.3 to 4987.3 µg m^{-3} (Figure 2.6.17). The mean of the TSP point data was observed to be 95.05 µg m^{-3}.

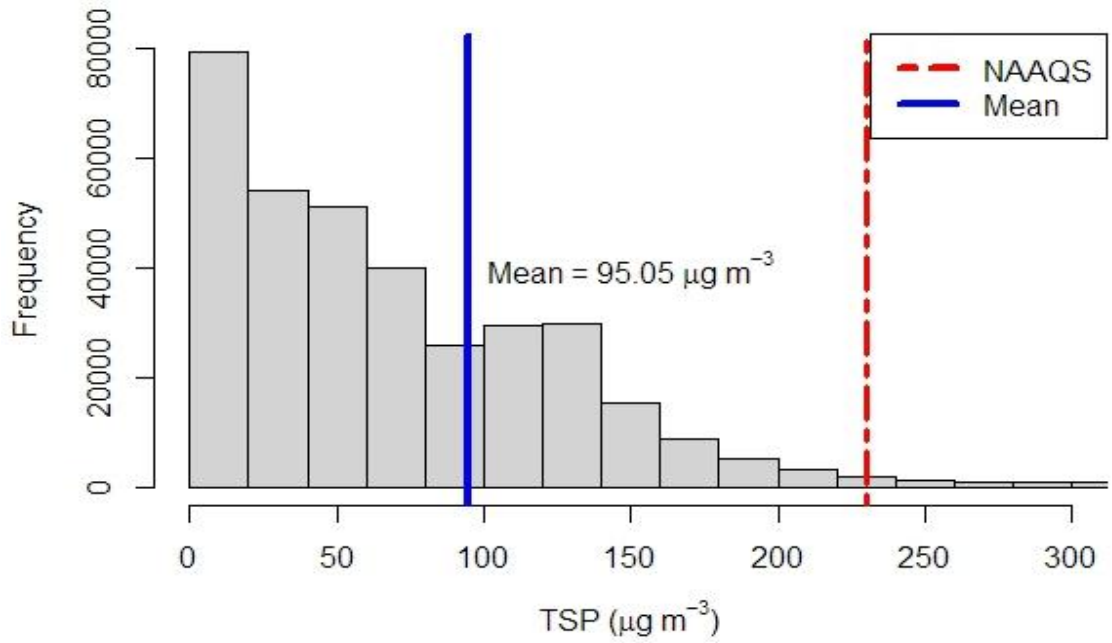


Figure 2.6.17: Histogram of TSP

Diurnal Variation

The Figure 2.6.18 shows TSP peaks at 10-11 AM and at 5 PM. The mean value is found to be more than median throughout the day.

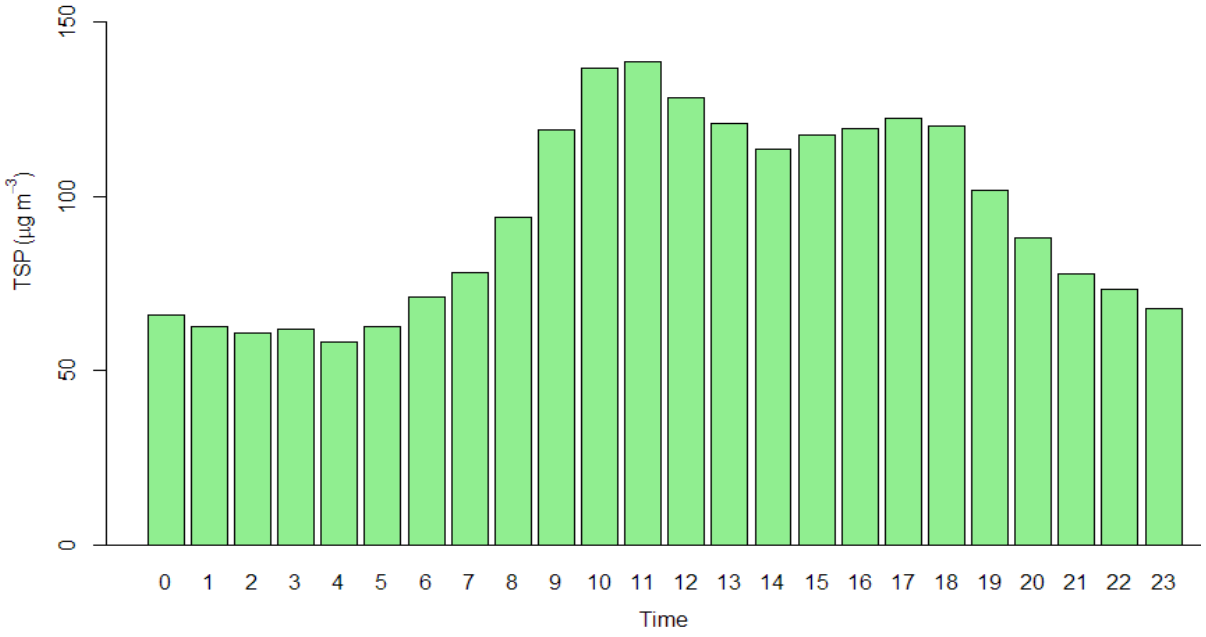


Figure 2.6.18: Hourly average of TSP

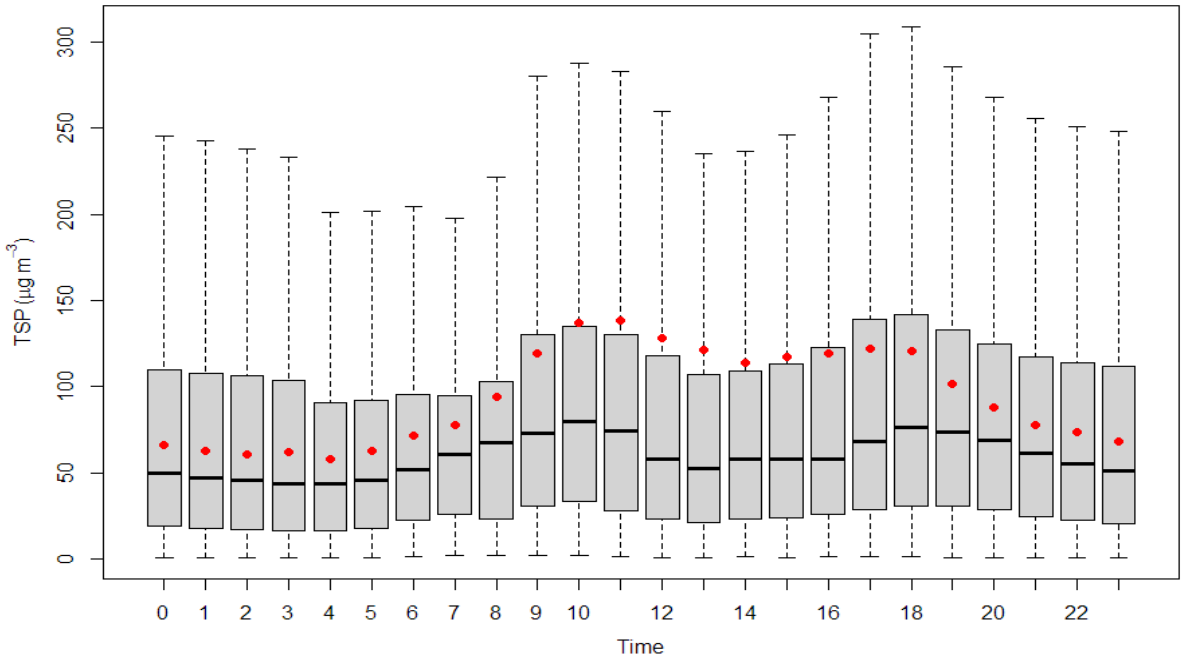


Figure 2.6.19: Diurnal variation of TSP

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.6.20. Higher concentration can be seen during April whereas lower concentration was observed during monsoon season.

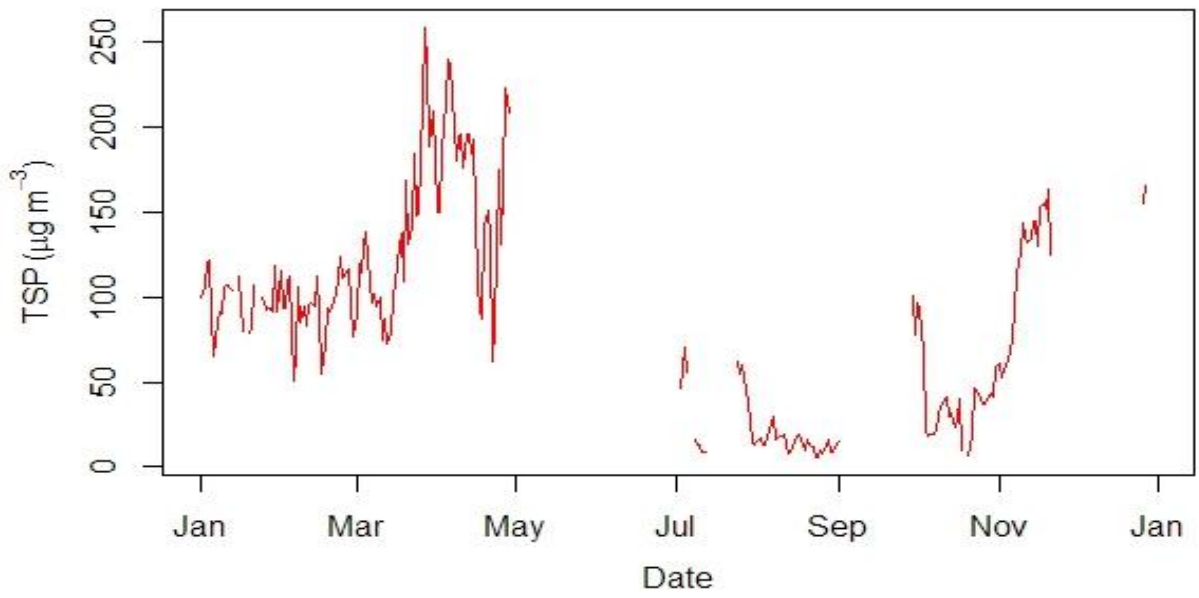


Figure 2.6.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during August and October. The mean value was found almost similar in August and September in rest of the month it is more than median.

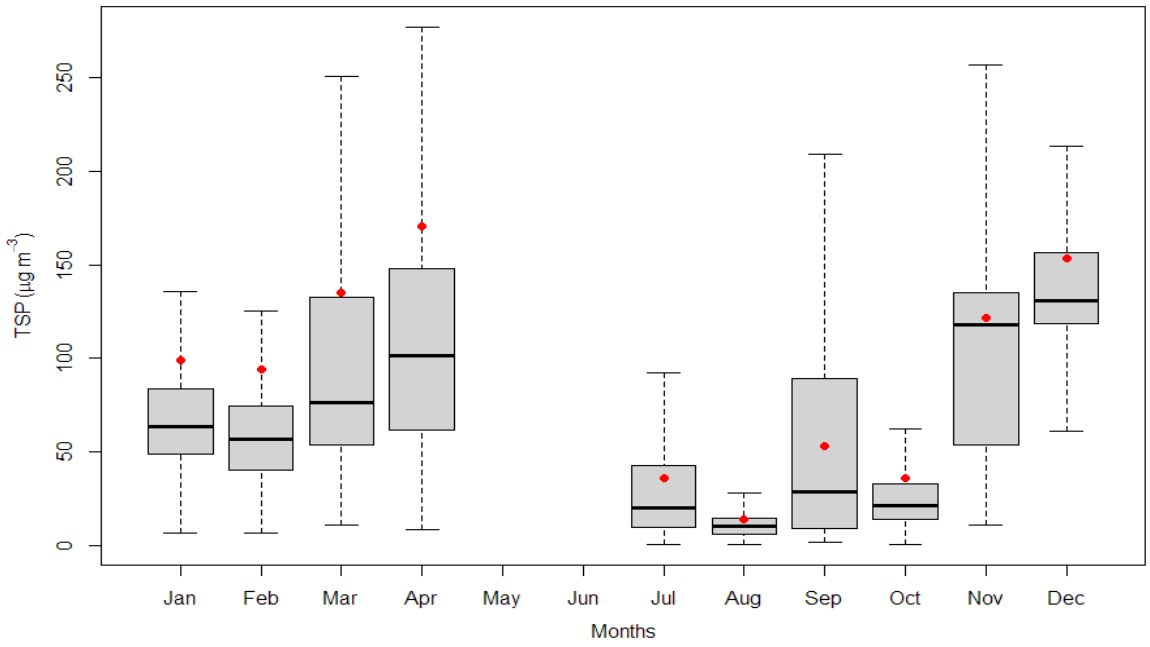


Figure 2.6.21: Monthly variation of TSP

The monthly average for April was found to be the highest (166.95 µg m^{-3}) and that of August was found to be the lowest (14.07 µg m^{-3}) while comparing with other months as shown in figure 2.6.22.

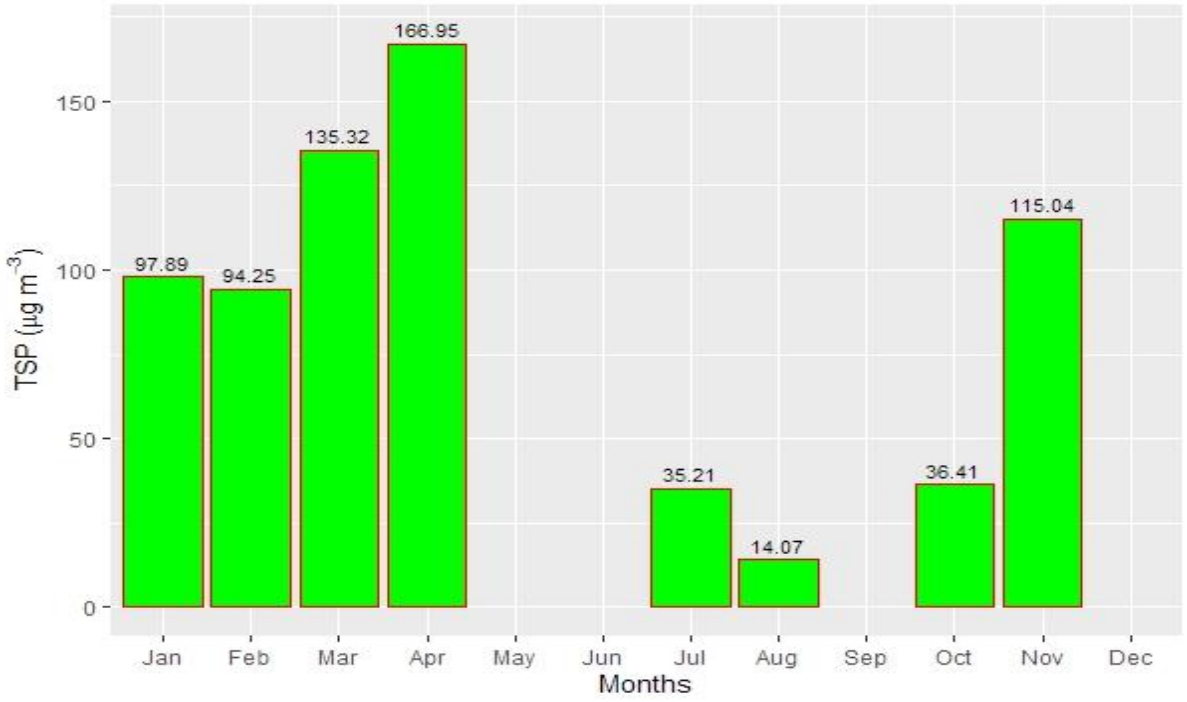


Figure 2.6.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during the pre-monsoon season (150.33 µg m^{-3}) and the lowest during the monsoon season (23.66 µg m^{-3}) as in figure 2.6.23.

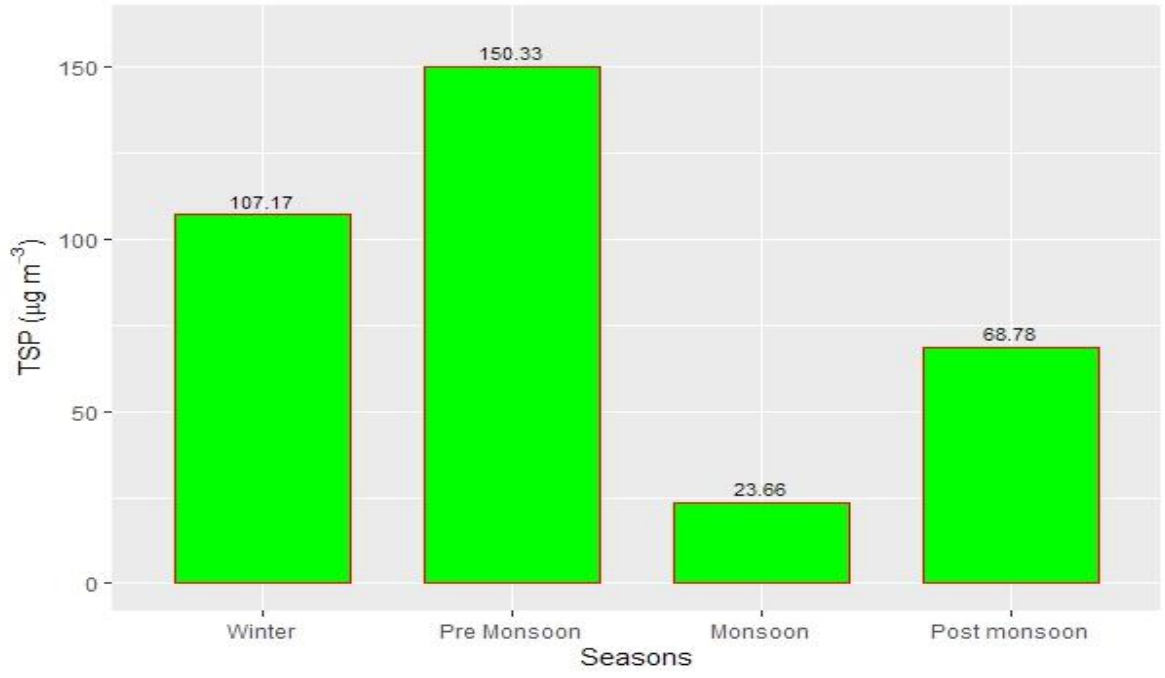


Figure 2.6.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 222 days of measurement, only 4 days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}. Out of those 4 days 2 days are in March and 2 days in April.

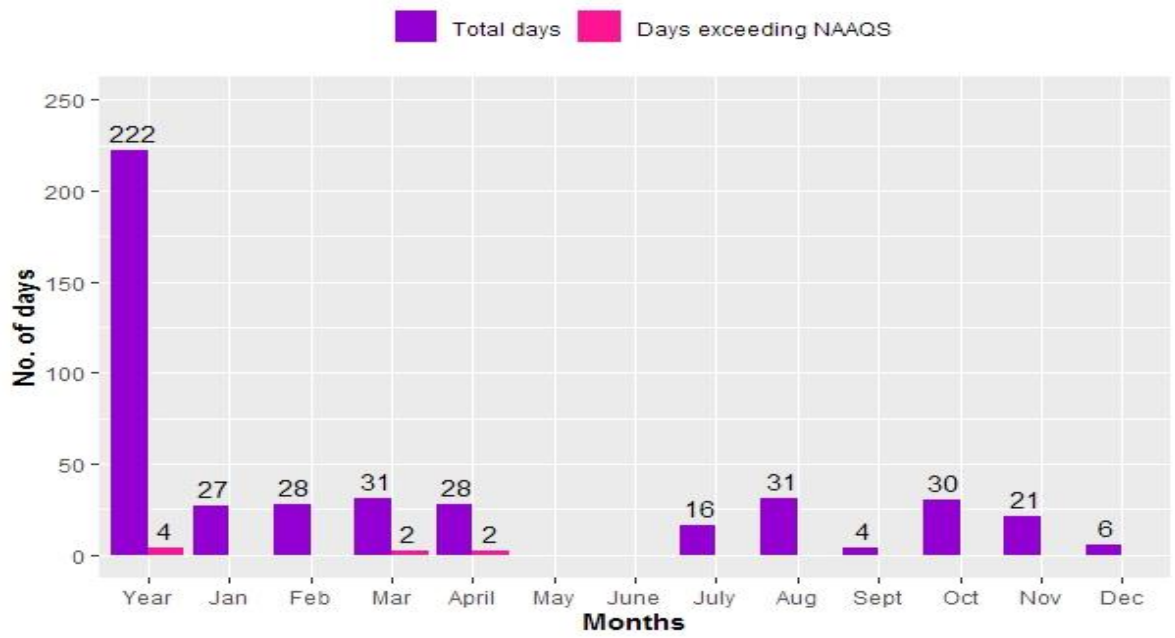


Figure 2.6.24: Compliance status of TSP

Calendar Plot

Calendar plot is prepared for PM $_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to very unhealthy level in 27th and 28th of March and was unhealthy during remaining months except during August.

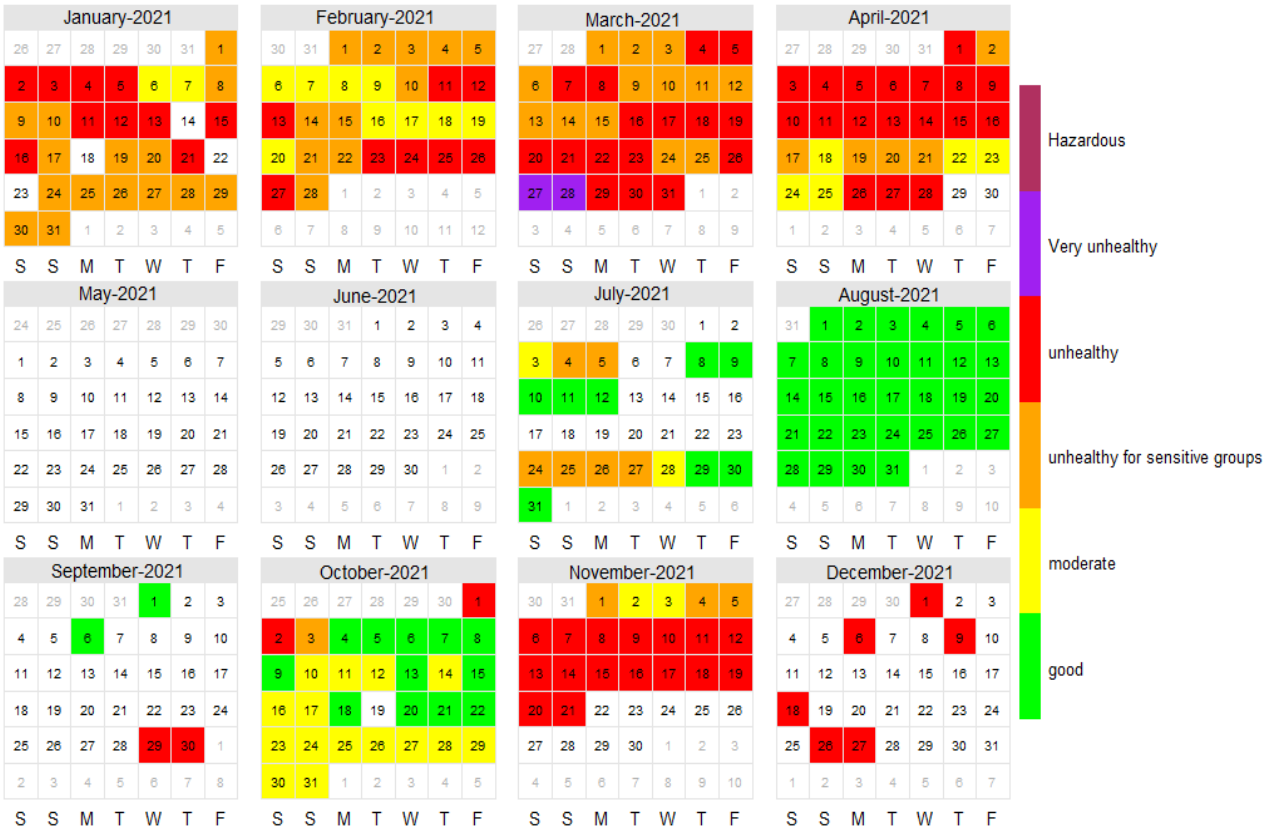


Figure 2.6.25: Calendar plot for $PM_{2.5}$ for the year 2021

2.7 Air quality status – Pokhara University, Pokhara

2.7.1 Introduction

Pokhara University, Pokhara Air Quality Monitoring Station was established in the year 2017. It lies inside premises of Girls hostel of Pokhara University. It represents the urban area. The major source of air pollution in this area is vehicles and commercial activities.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Number of instrument
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.7.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in PU, Pokhara Station was observed to range from 1 to 1443.7 µg m^{-3} (Figure 2.7.1). The mean of the $PM_{2.5}$ point data was observed to be 32.84 µg m^{-3}.

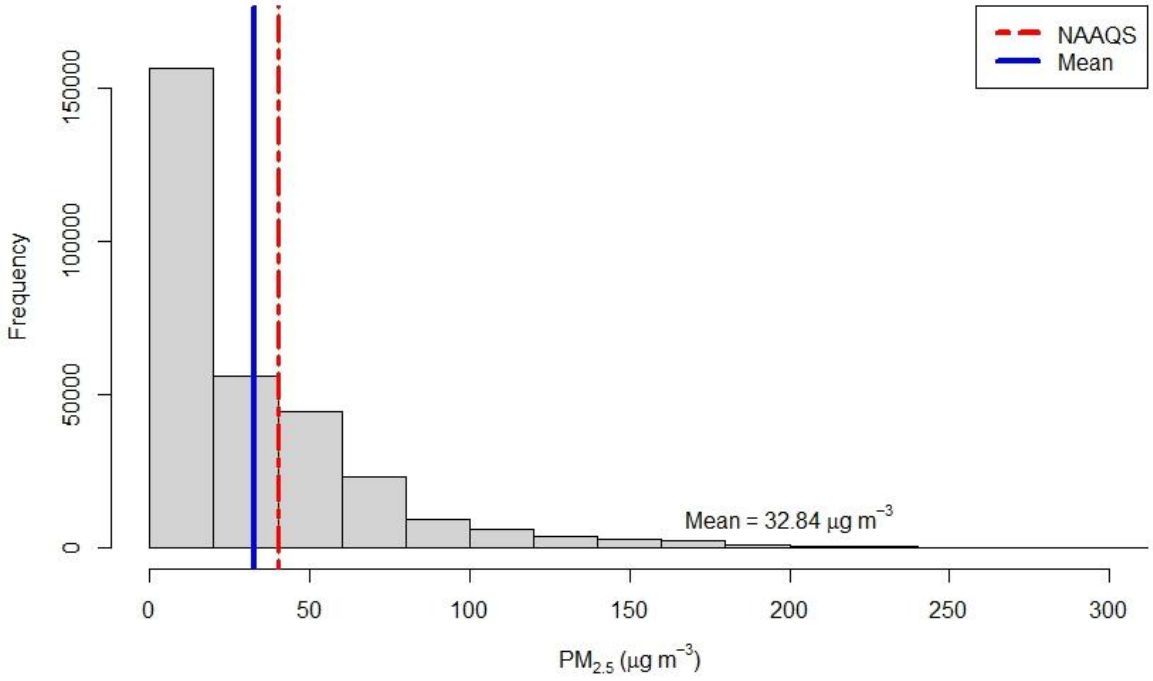


Figure 2.7.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.7.2 shows $PM_{2.5}$ peaks at 7 AM and at 7 PM to 8 PM. The mean value is found to be more than the median throughout the day.

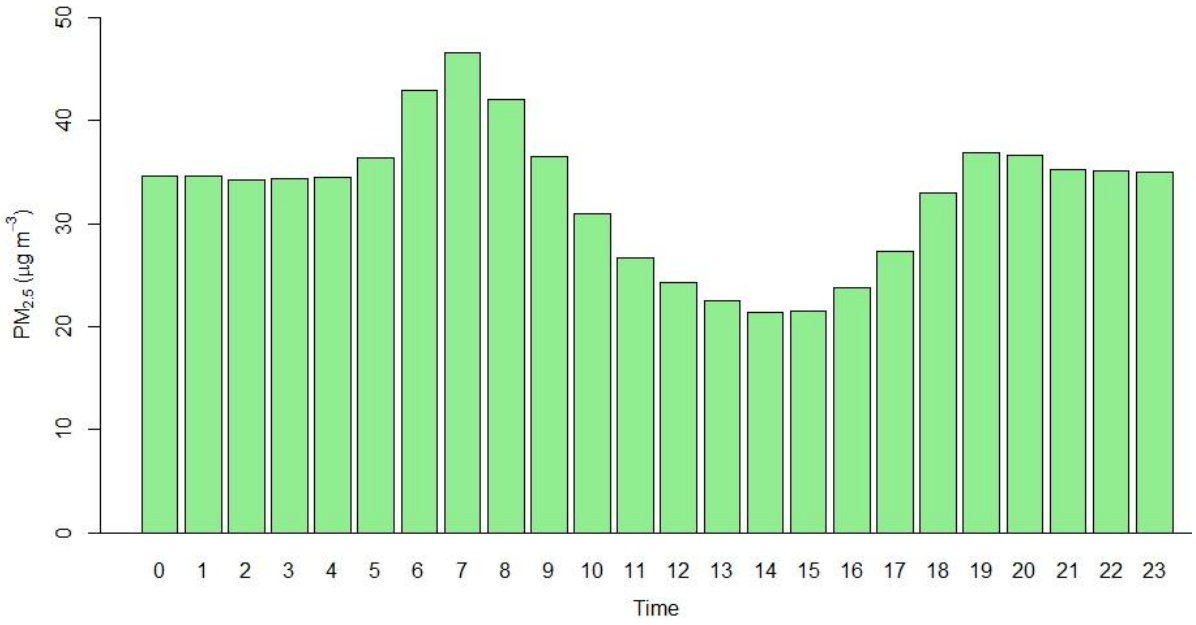


Figure 2.7.2: Hourly average of $PM_{2.5}$.

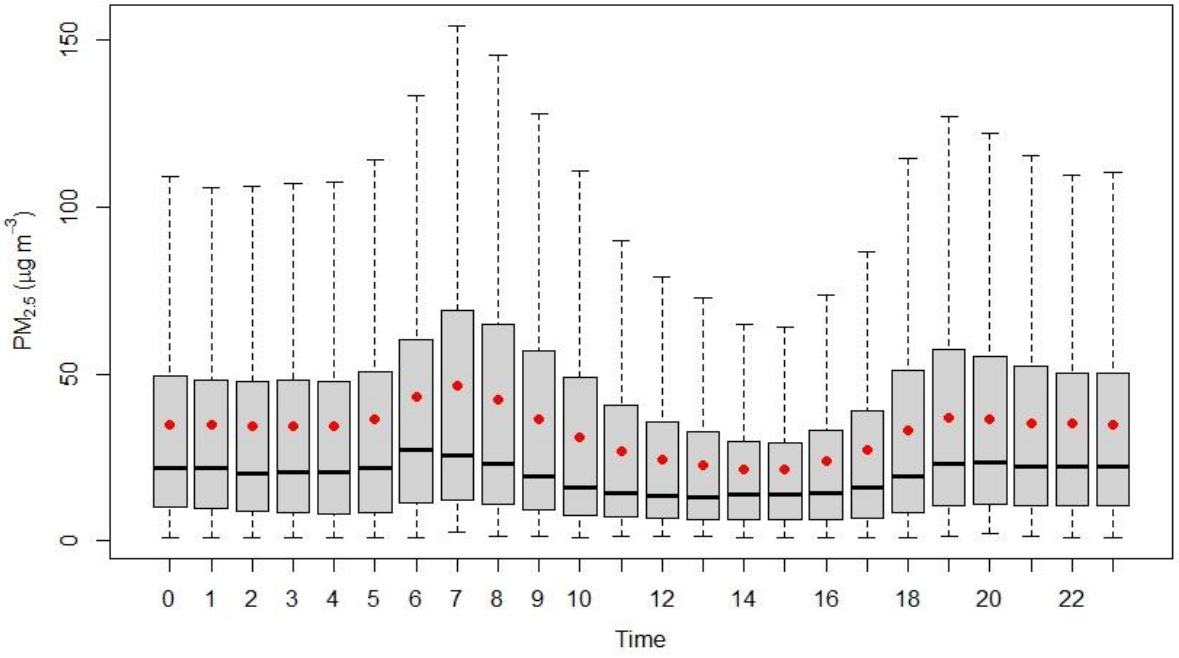


Figure 2.7.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variation of $PM_{2.5}$ is shown in figure 2.7.4. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post-monsoon season.

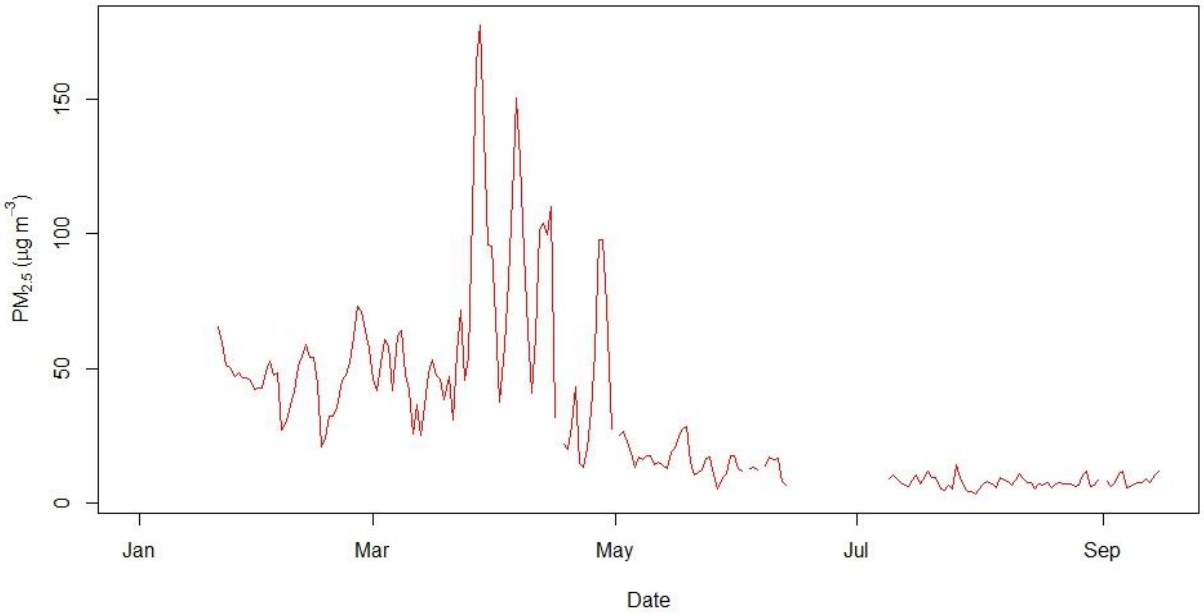


Figure 2.7.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during April whereas less during August. The mean value was found more than median during March and April.

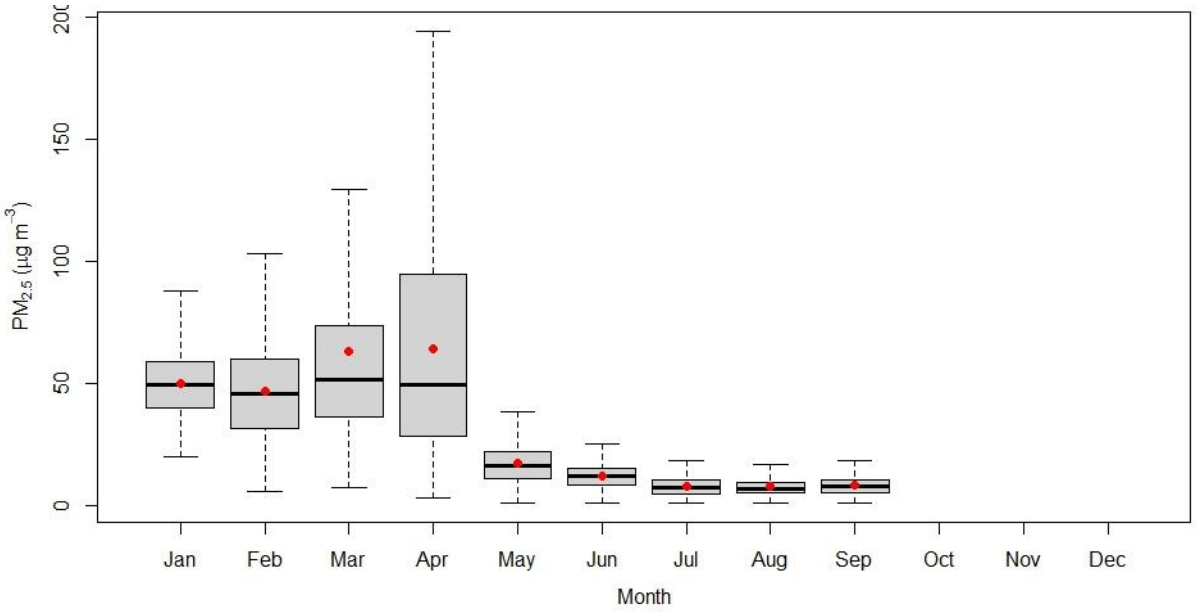


Figure 2.7.5: Monthly variation of $PM_{2.5}$

The monthly average of April was found to be highest (65.33 µg m^{-3}) and that of August was found to be lowest (7.57 µg m^{-3}) while comparing with other months as shown in figure 2.7.6 below. Monthly average was not calculated for January, October November and December due to insufficient data.

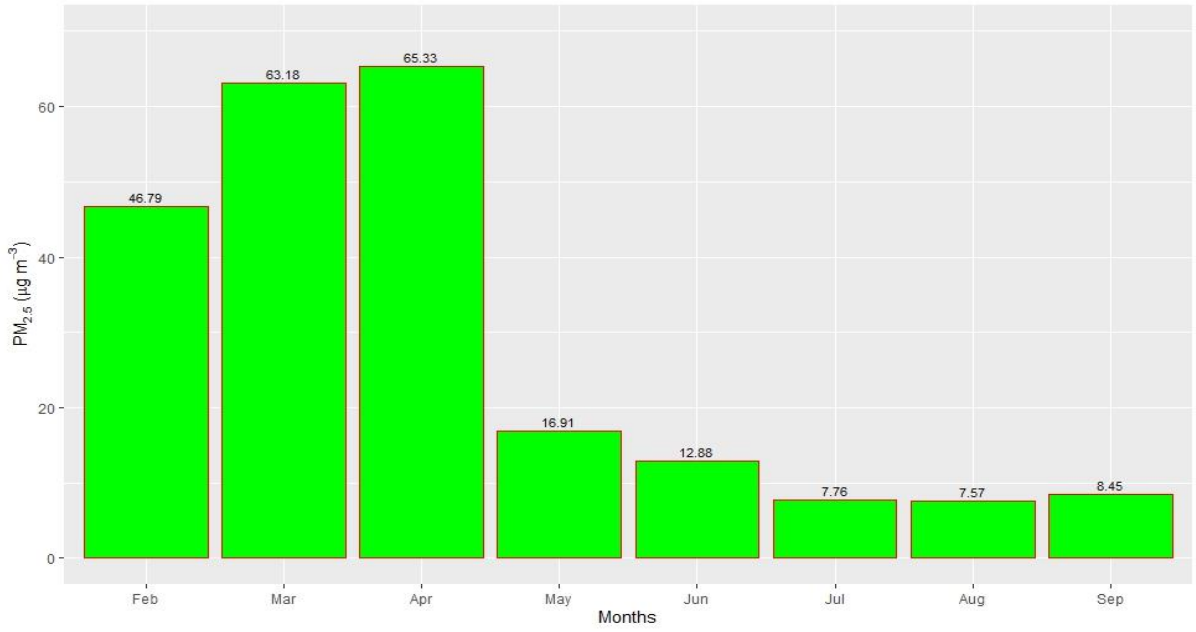


Figure 2.7.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during pre-monsoon season (48.45 µg m^{-3}) and the lowest during the monsoon season (8.52 µg m^{-3}) as in figure 2.7.7. Seasonal average was not calculated for post monsoon season due to insufficient data.

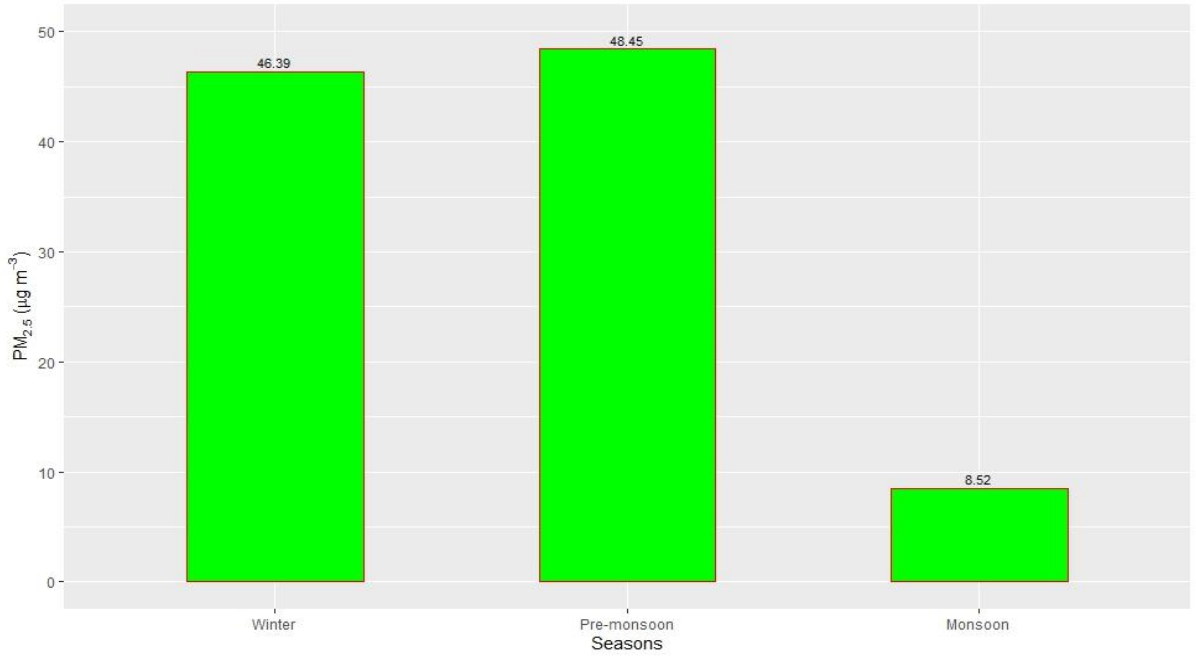


Figure 2.7.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 208 days of measurement, 75 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$. From May to September none of the days exceed NAAQS of 40 µg m^{-3} as shown in figure 2.7.8.

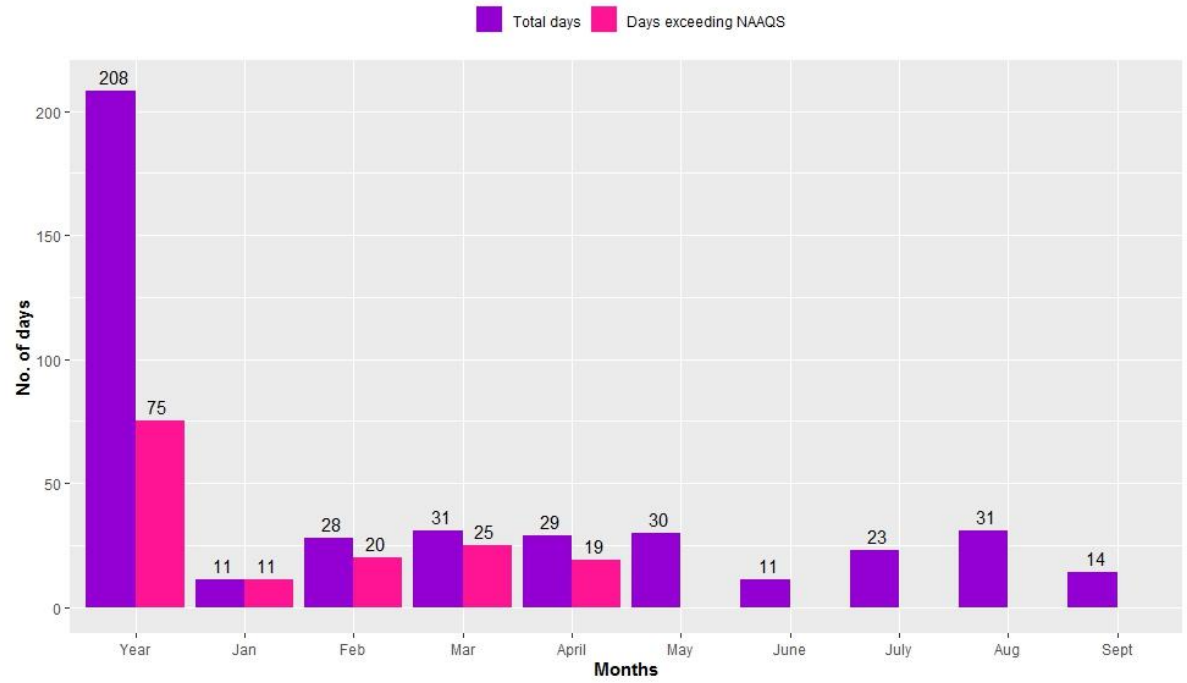


Figure 2.7.8: Compliance status of $PM_{2.5}$

2.7.3 PM_{10}

Histogram

PM_{10} in PU Pokhara Station was observed to range from 1 to 2948.1 µg m^{-3} (Figure 2.7.9). The mean of the PM_{10} point data was observed to be 43.06 µg m^{-3}.

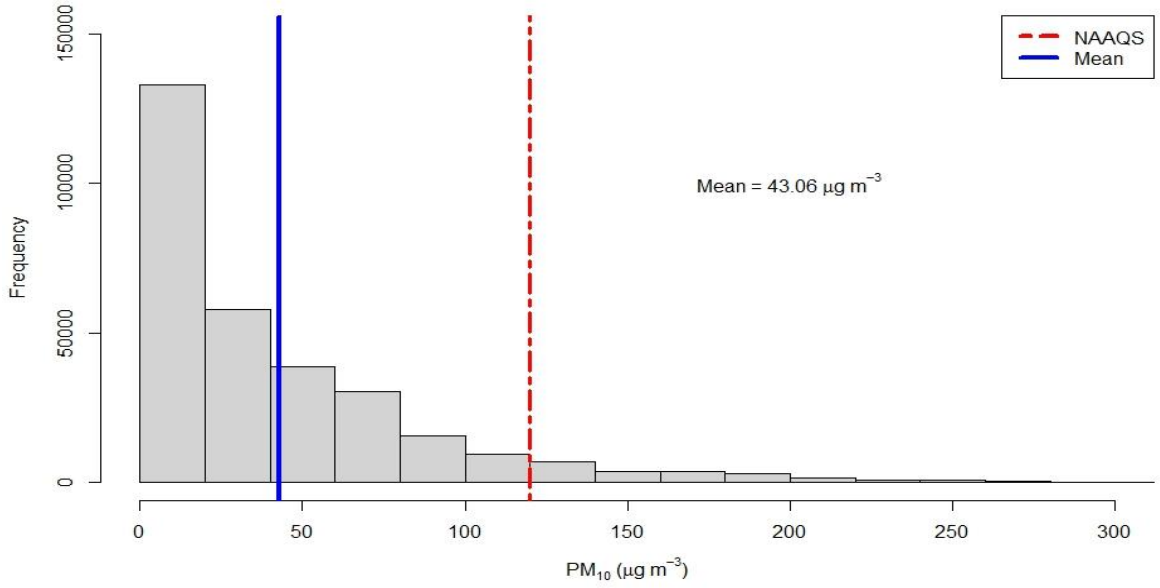


Figure 2.7.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.7.10 shows PM_{10} peaks at 7 AM then starts falling slowly till 3 PM and starts again rising peaks at 6 PM then again starts falling.

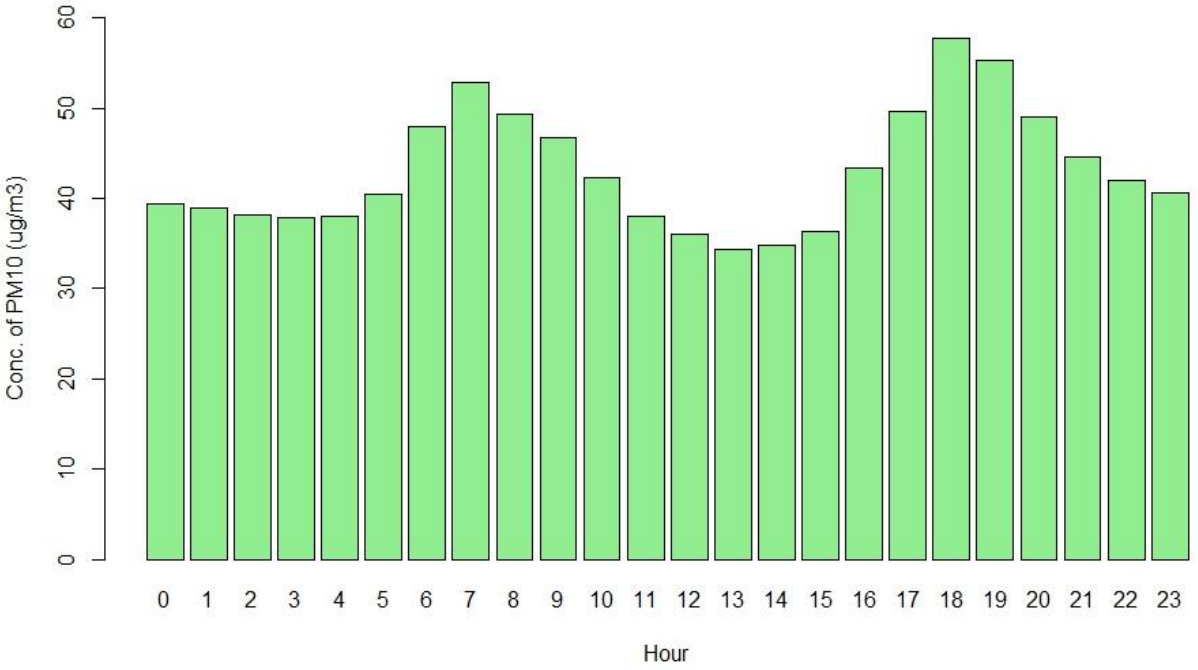


Figure 2.7.10: Hourly average of PM_{10}

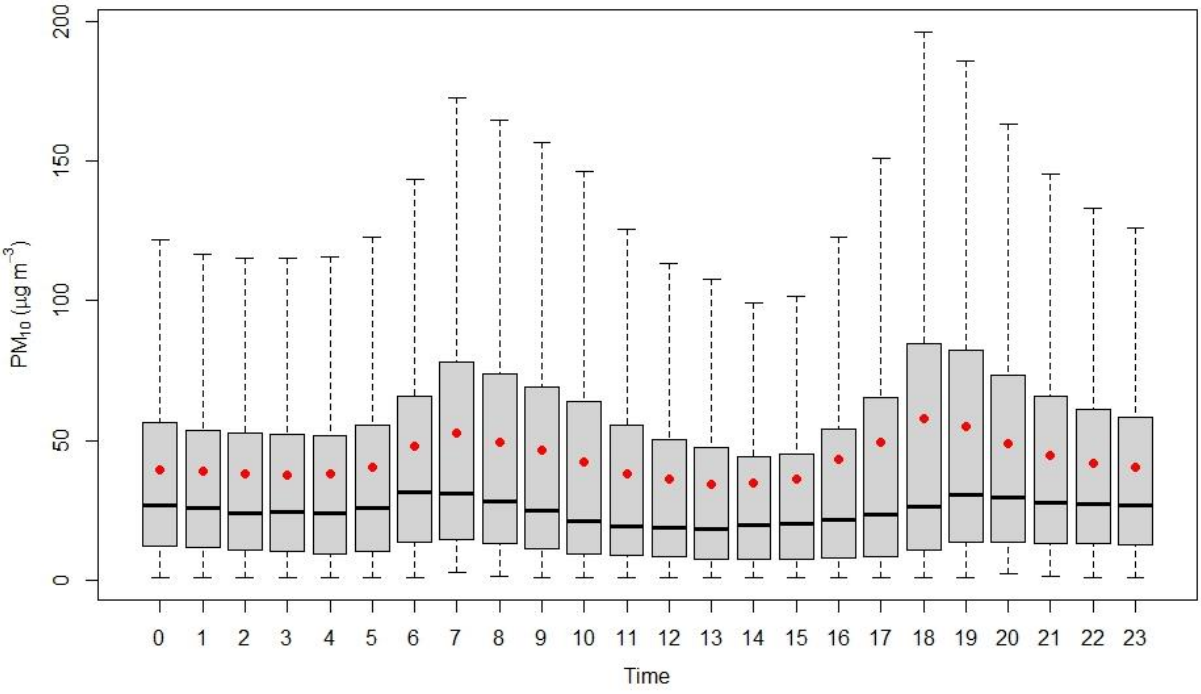


Figure 2.7.11: Diurnal variation of PM_{10}.

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.7.12. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post monsoon season.

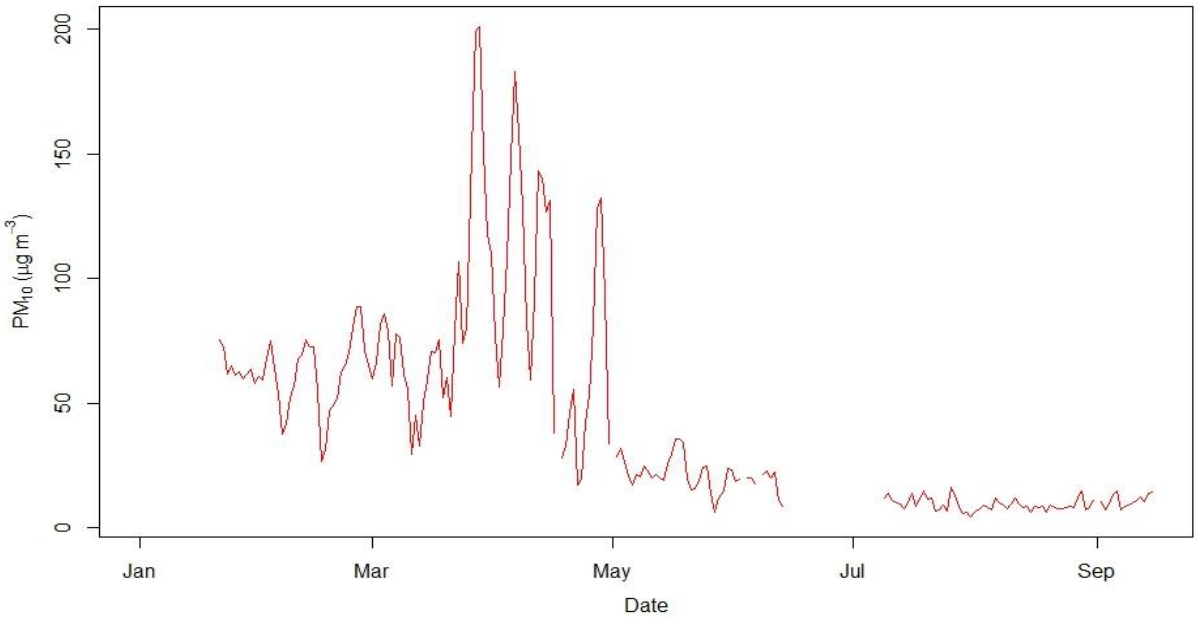


Figure 2.7.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during August. The mean value was found more than the median during January to April.

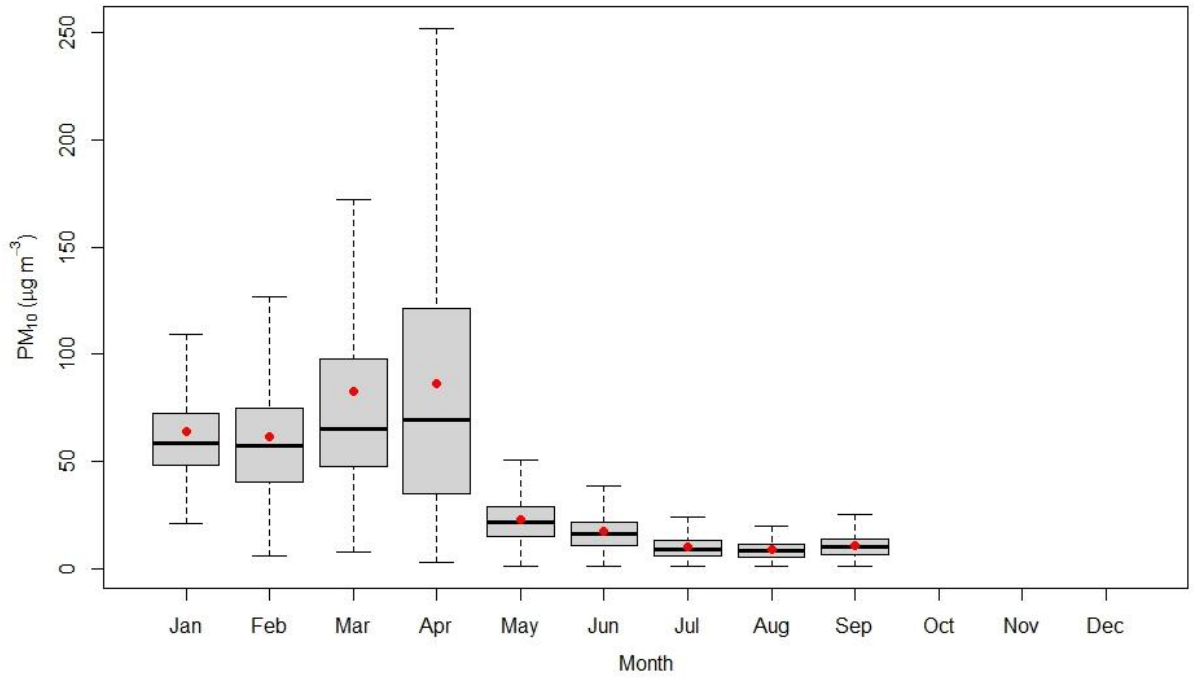


Figure 2.7.13: Monthly variation of PM_{10}

The monthly average for April was found the highest (86.83 µg m^{-3}) and that of August was found lowest (8.77 µg m^{-3}) while comparing with other months as shown in figure 2.7.14. The monthly average was not calculated for January, October, November and December due to insufficient data.

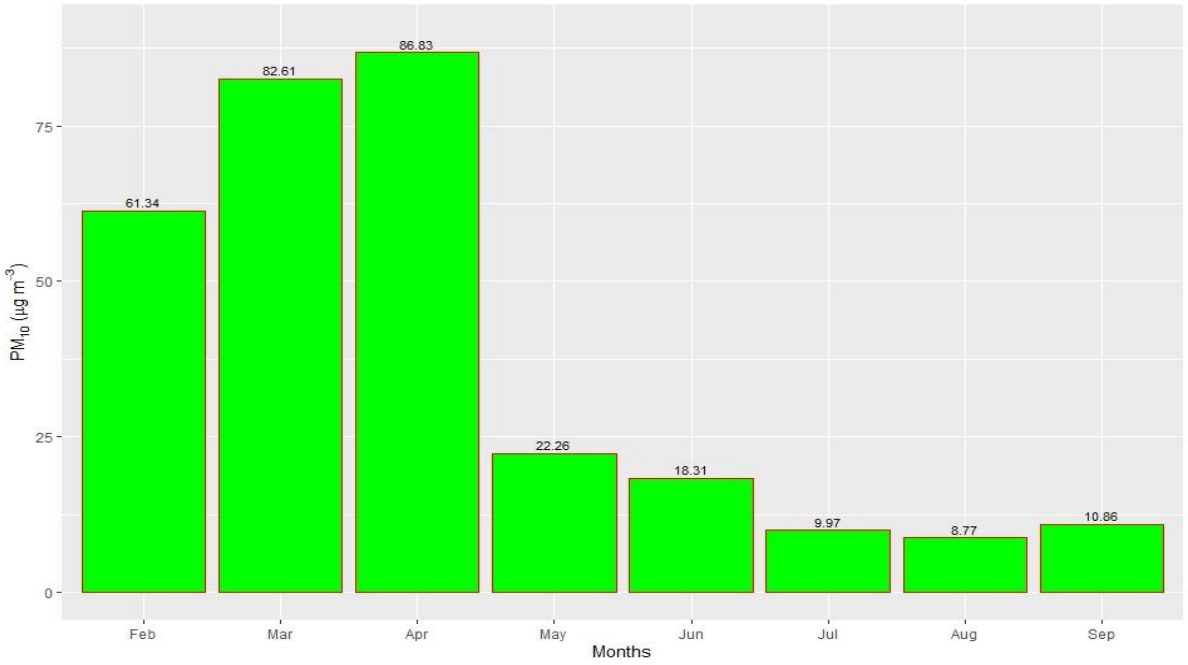


Figure 2.7.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during pre-monsoon season (63.85 µg m^{-3}) and the lowest during monsoon season (10.82 µg m^{-3}) as in figure 2.7.15. Seasonal average was not calculated for post monsoon season due to insufficient data.

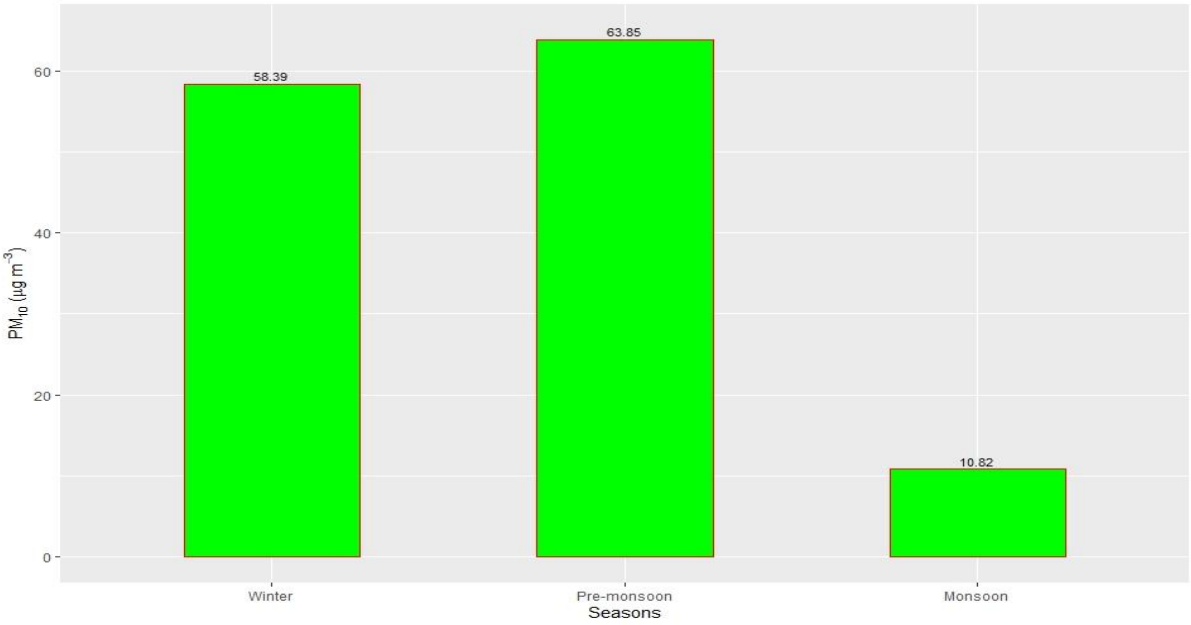


Figure 2.7.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 208 days of measurement, 14 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. From January, February, May to September none of the days exceed NAAQS as shown in figure 2.7.16.

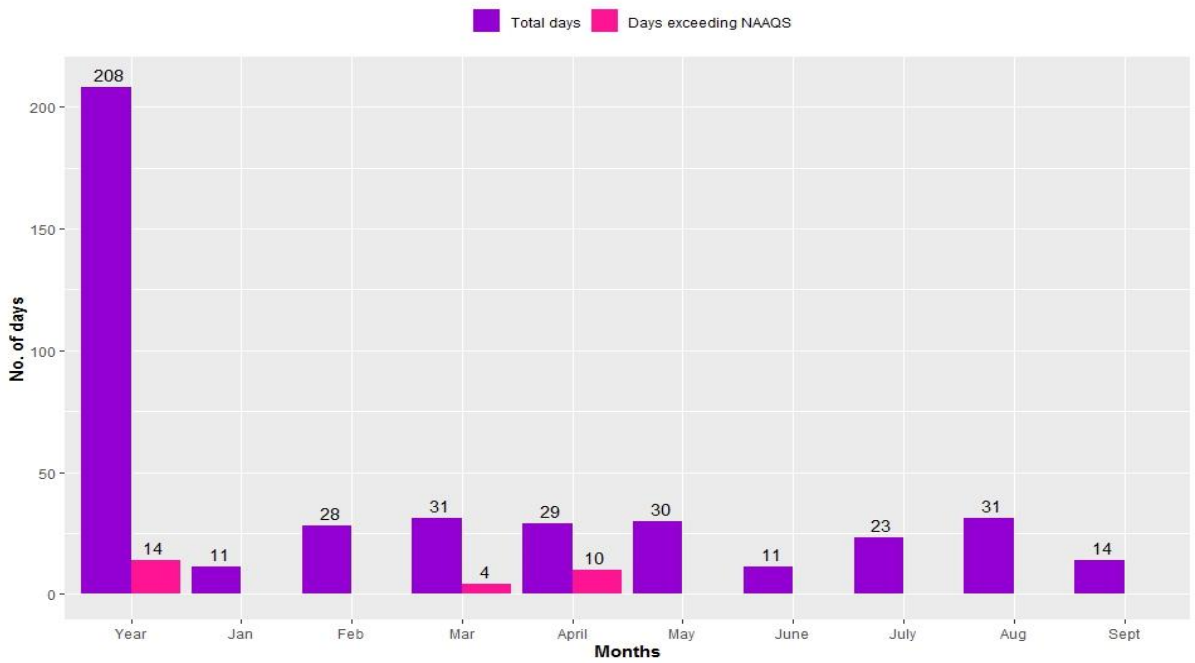


Figure 2.7.16: Compliance status of PM_{10}

2.7.4 TSP

Histogram

TSP in PU Pokhara Station was observed to range from 1 to 4990.5 µg m^{-3} (Figure 2.7.17). The mean of the TSP point data was observed to be 67.28 µg m^{-3}.

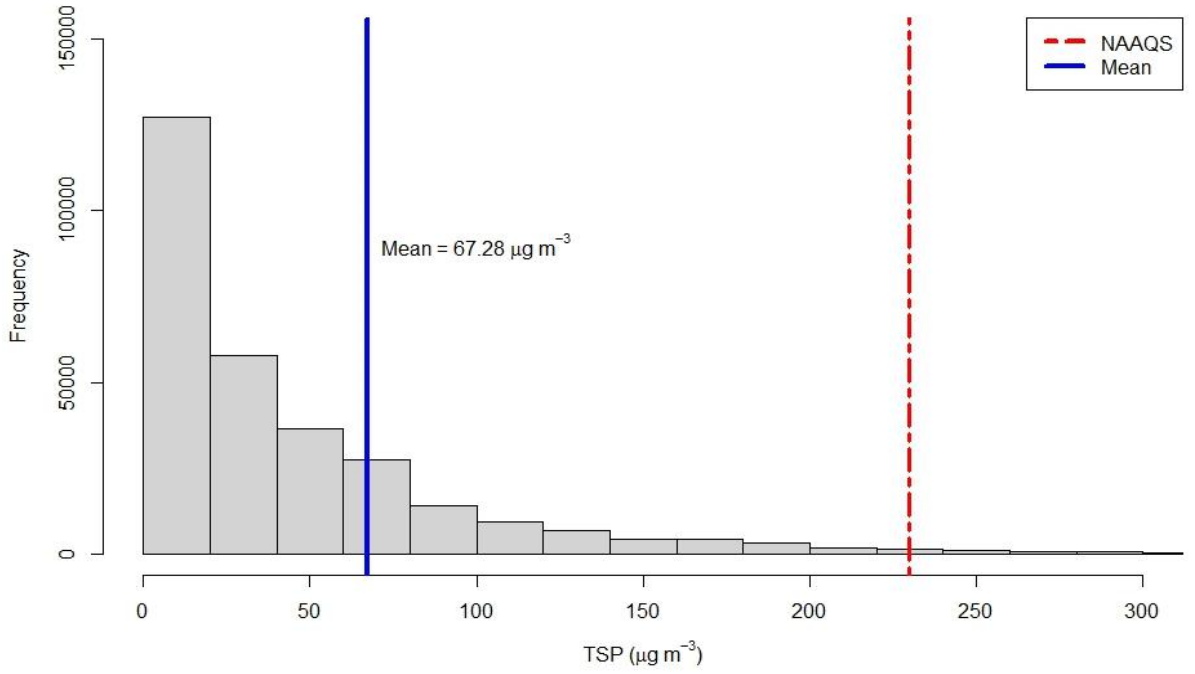


Figure 2.7.17: Histogram of TSP

Diurnal Variation

The Figure 2.7.18 shows TSP peaks at 4 PM and 5 PM. During day time the mean is much higher compared to the median value.

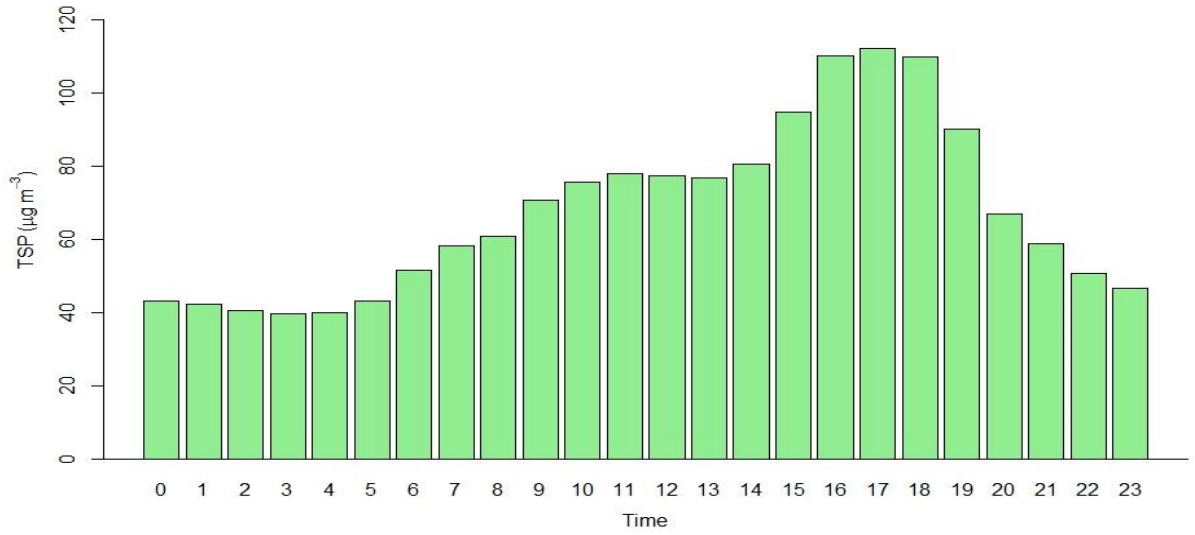


Figure 2.7.18: Hourly average of TSP

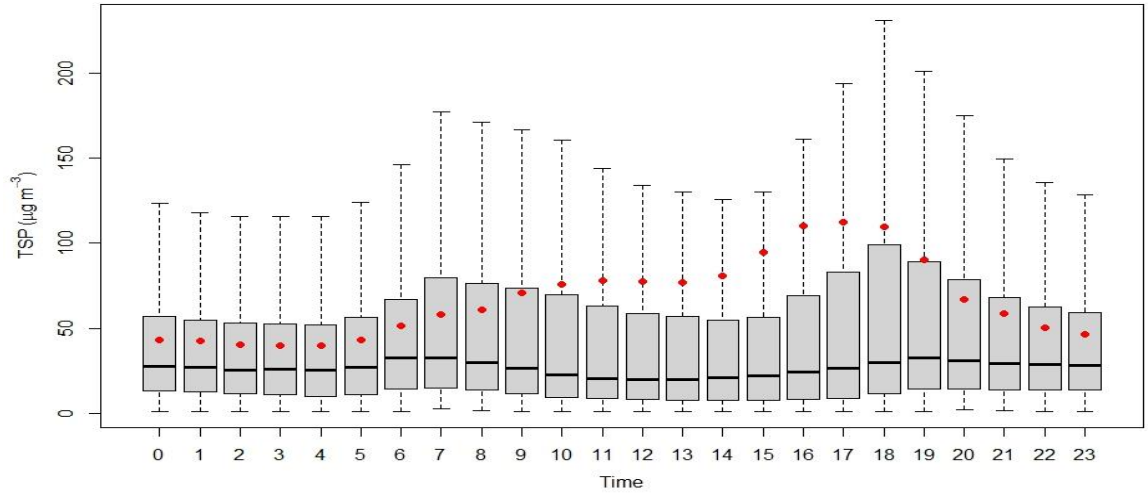


Figure 2.7.19: Diurnal variation of TSP

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.7.20. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post monsoon season.

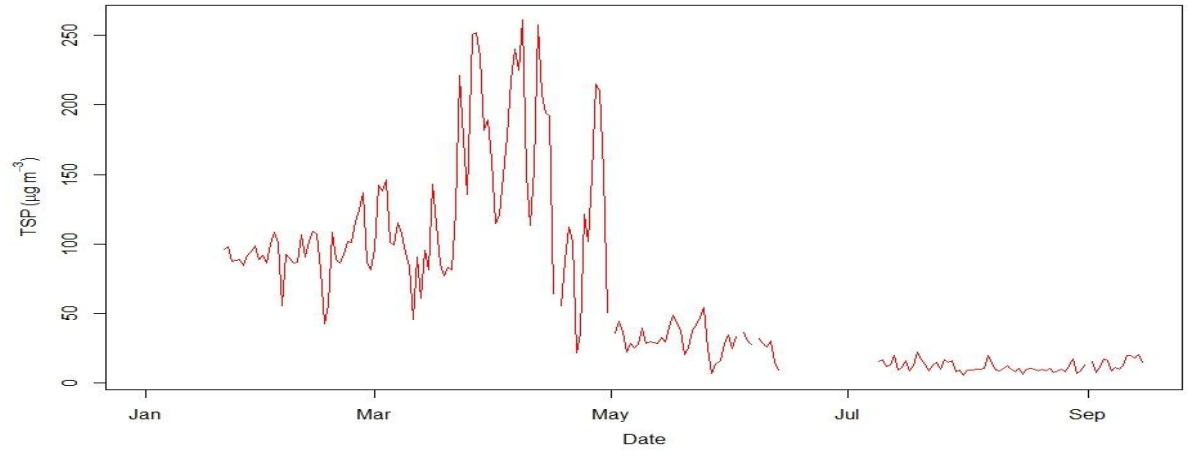


Figure 2.7.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the inter-quartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicates mean concentrations. High variation was seen during April whereas less during August. The mean value was found more than median in most of the month.

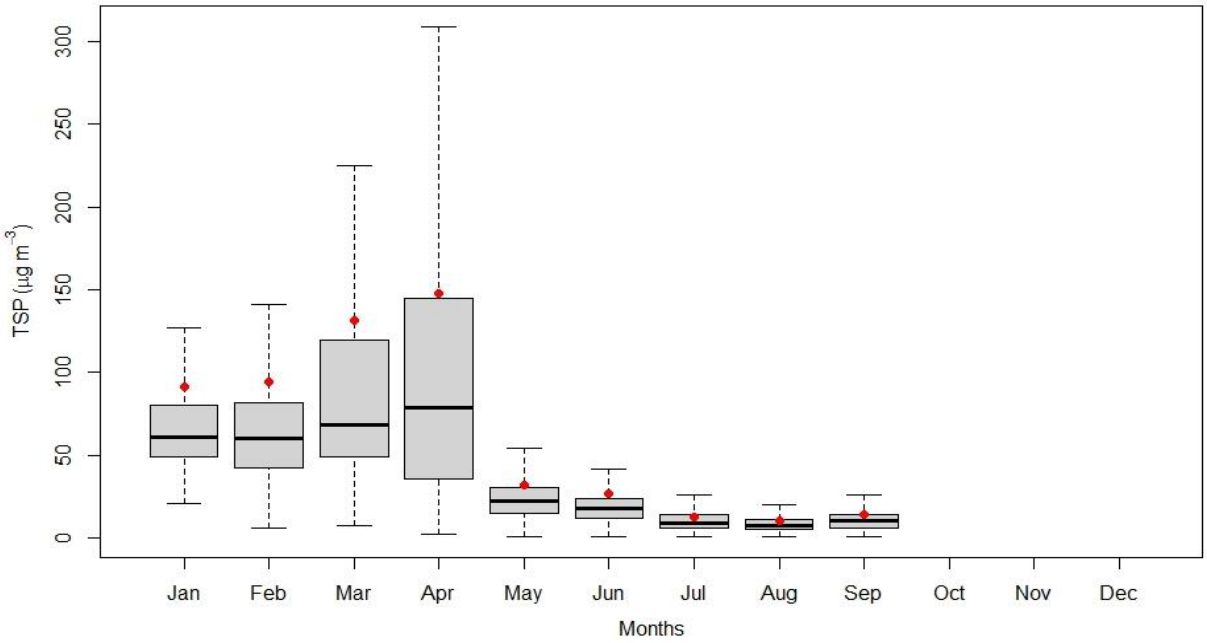


Figure 2.7.21: Monthly variation of TSP

The monthly average for April was found to be the highest (146.72 µg m^{-3}) and that of August was found to be the lowest (10.29 µg m^{-3}) while comparing with other months as shown in figure 2.7.22.

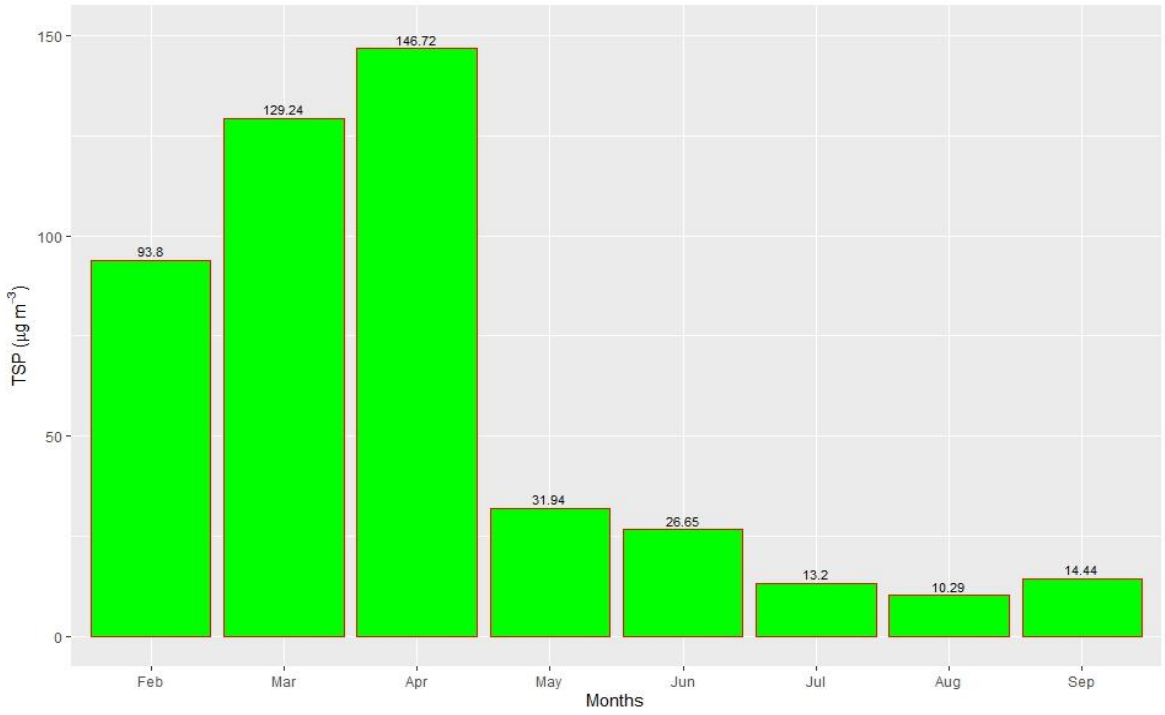


Figure 2.7.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during the pre-monsoon season (102.44 µg m^{-3}) and the lowest during the monsoon season (14.15 µg m^{-3}) as in figure 2.7.23. Seasonal average for post monsoon season was not calculated due to insufficient data.

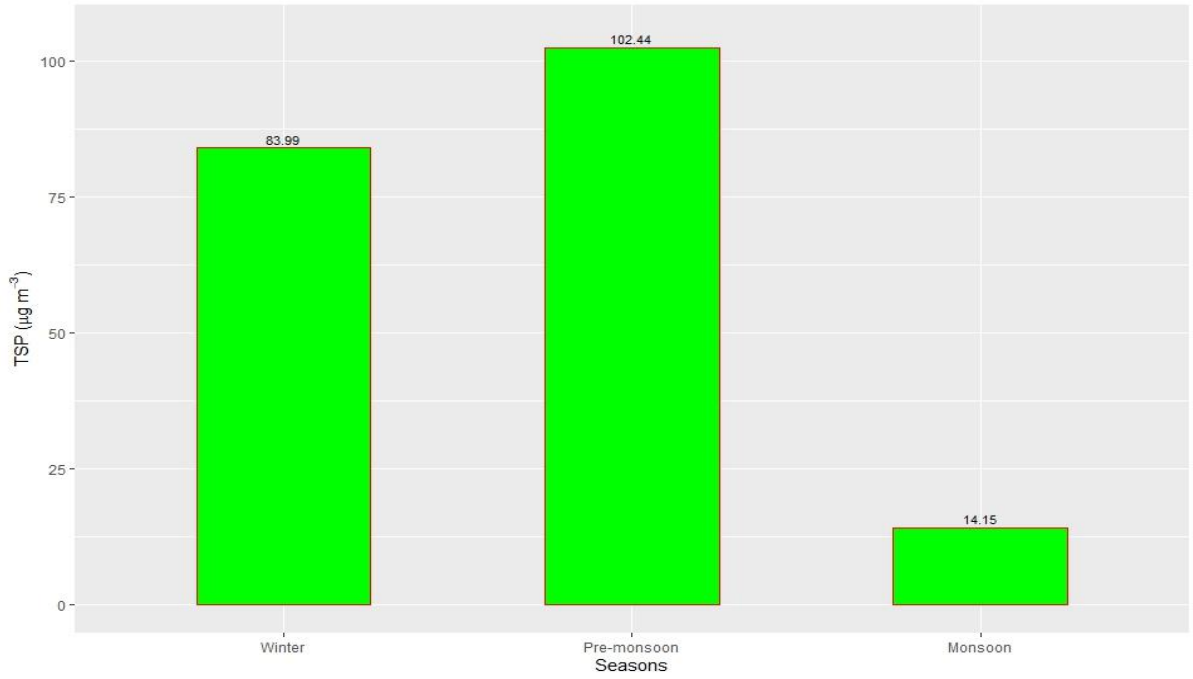


Figure 2.7.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 208 days of measurement, 6 days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}. Beside March and April months none of the days of remaining months exceed NAAQS as shown in figure 2.7.24.

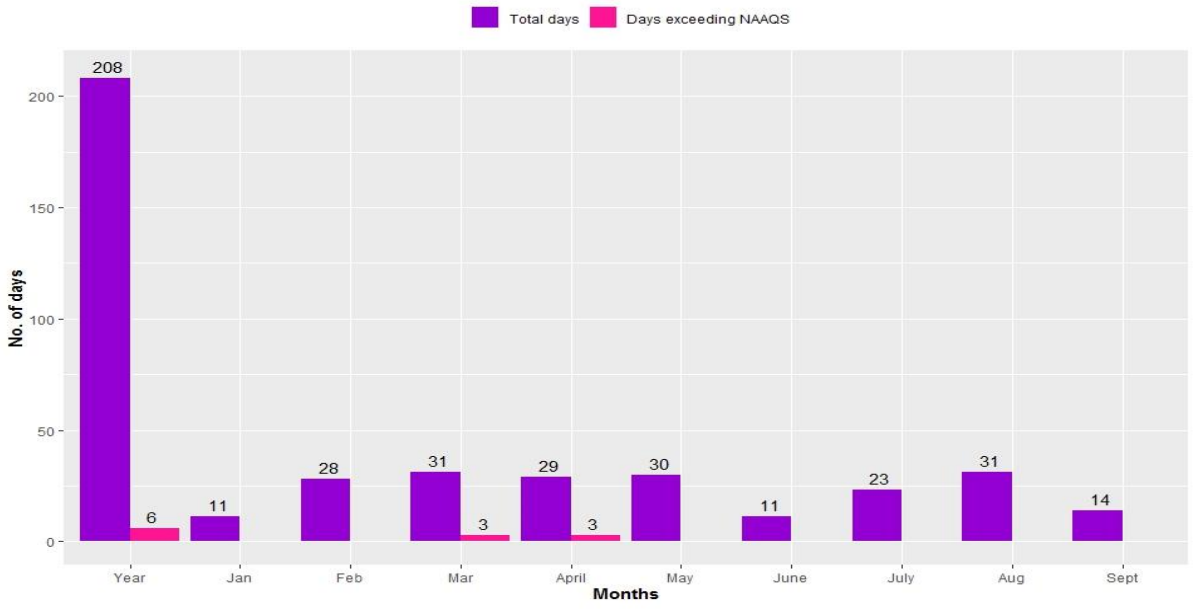


Figure 2.7.24: Compliance status of TSP

Calendar Plot

Calendar plot is prepared for PM $_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to very unhealthy level in 27th and 28th of March and was unhealthy during few days in February, March and April.

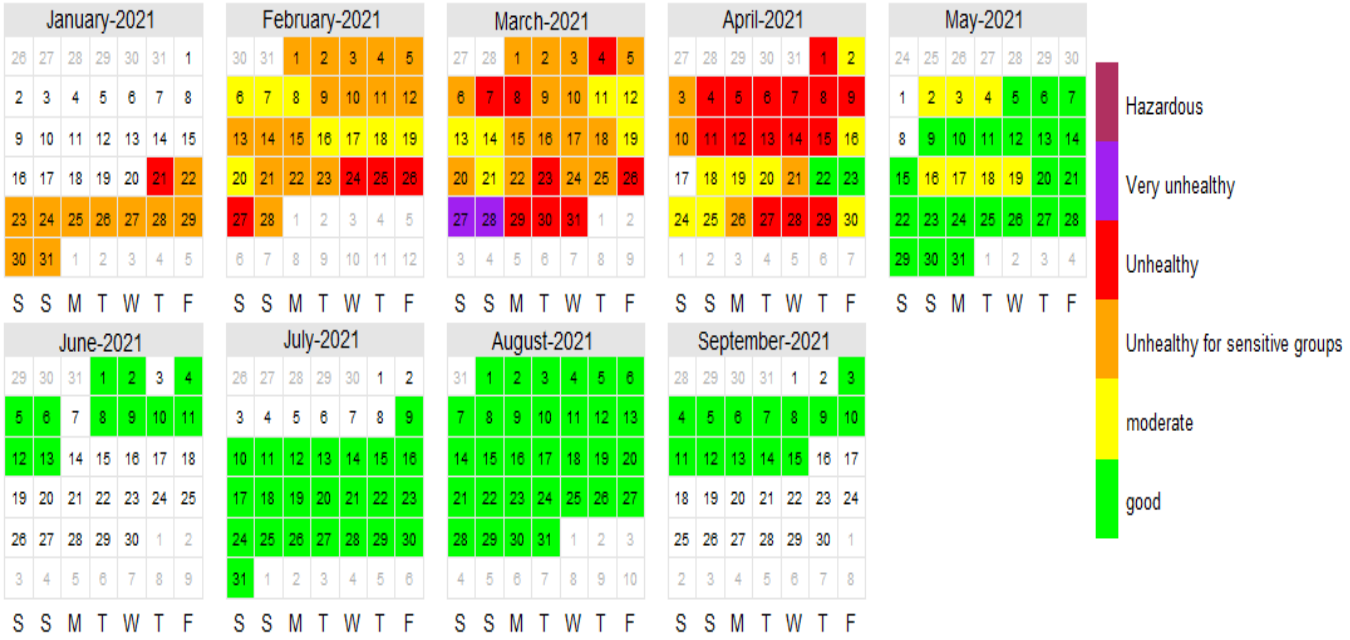


Figure 2.7.25: Calendar plot for $PM_{2.5}$ for the year 2021

2.8 Air quality status –Bhaisipati

2.8.1 Introduction

Bhaisipati Air Quality Monitoring Station was established in the year 2017. It lies inside the premises of Bhaisipati housing office at Lalitpur. This station represents the urban area. The major source of air pollution in this area is vehicles and commercial activities.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.8.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Bhaisipati Station was observed to range from 1 to 1344 µg m^{-3} (Figure 2.8.1). The mean of the $PM_{2.5}$ point data was observed to be 42.45 µg m^{-3}.

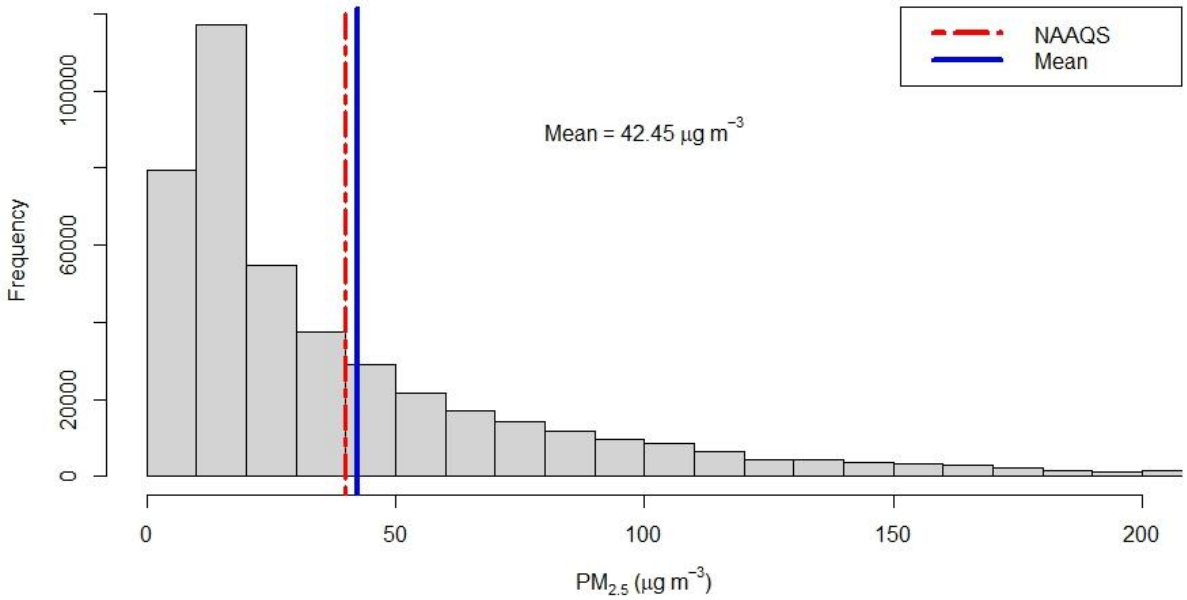


Figure 2.8.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.8.2 shows $PM_{2.5}$ peaks at 7 AM to 8 AM and at 7 PM to 8 PM. The mean value is found to be more than the median throughout the day (figure 2.8.3).

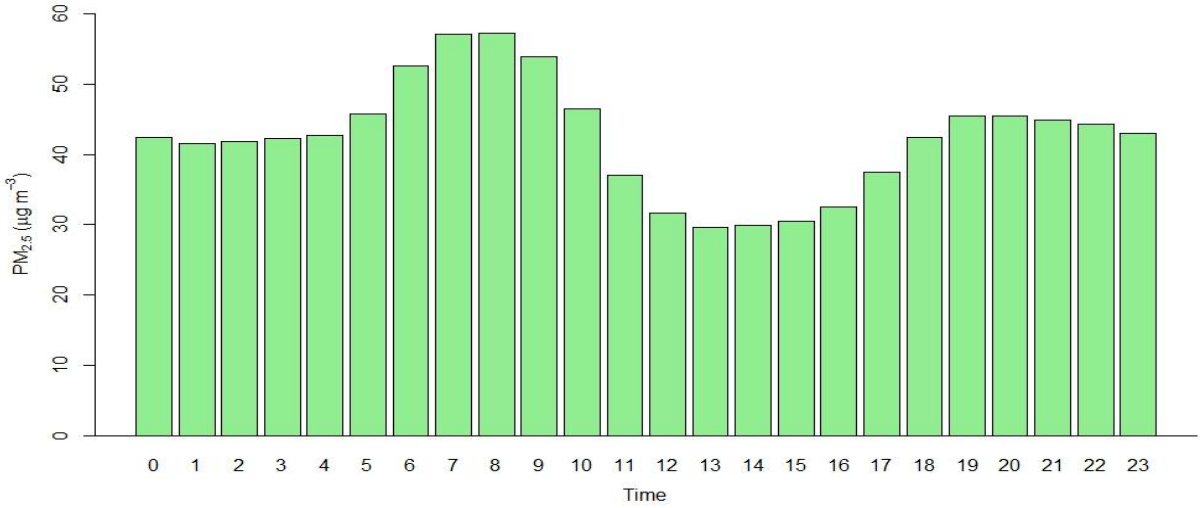


Figure 2.8.2: Hourly average of $PM_{2.5}$

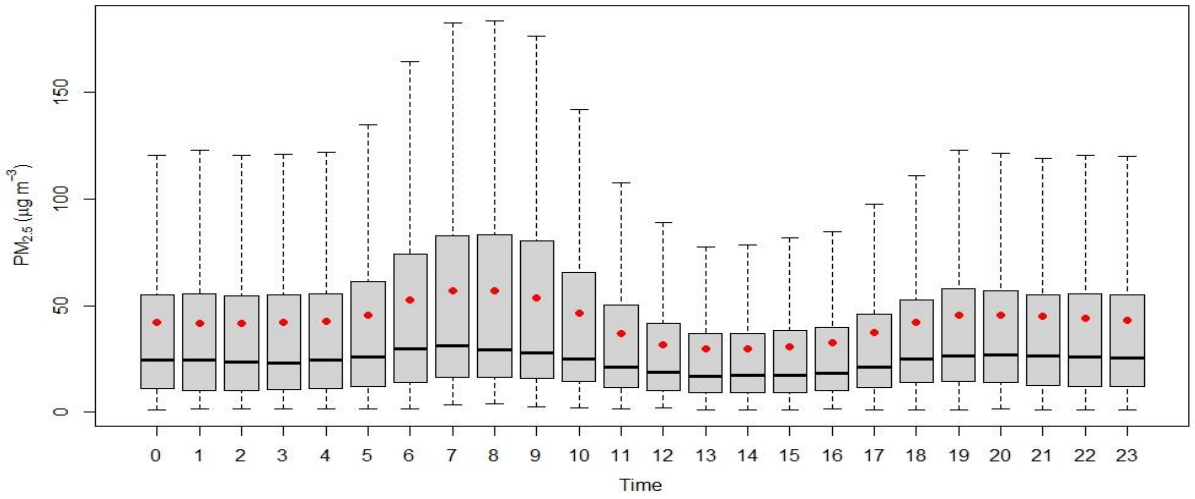


Figure 2.8.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variations of $PM_{2.5}$ is shown in figure 2.8.4. Higher concentration can be seen during January and April whereas lower concentration was observed during monsoon and post-monsoon season.

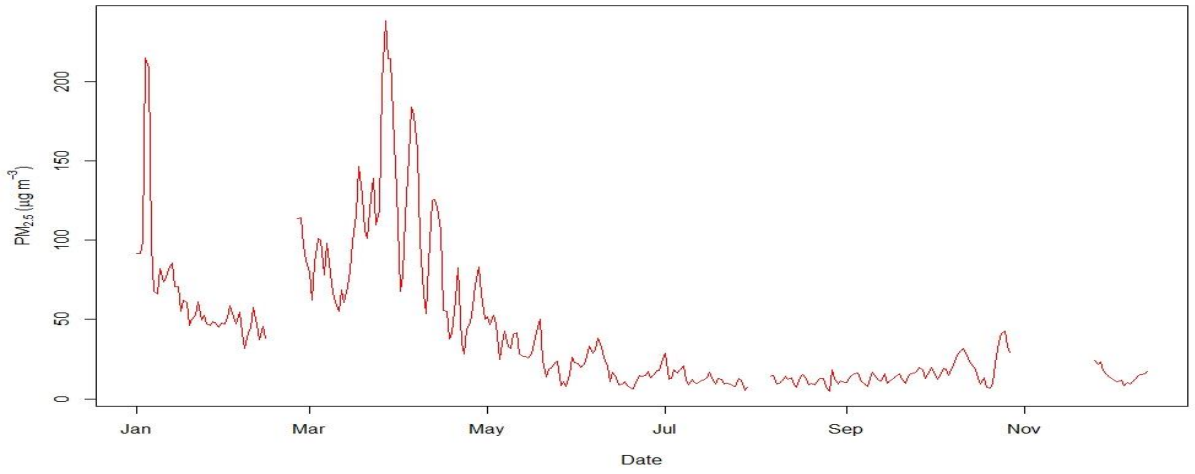


Figure 2.8.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during March and April whereas less during June to September and during November and December. The mean value was found more than median during January to April.

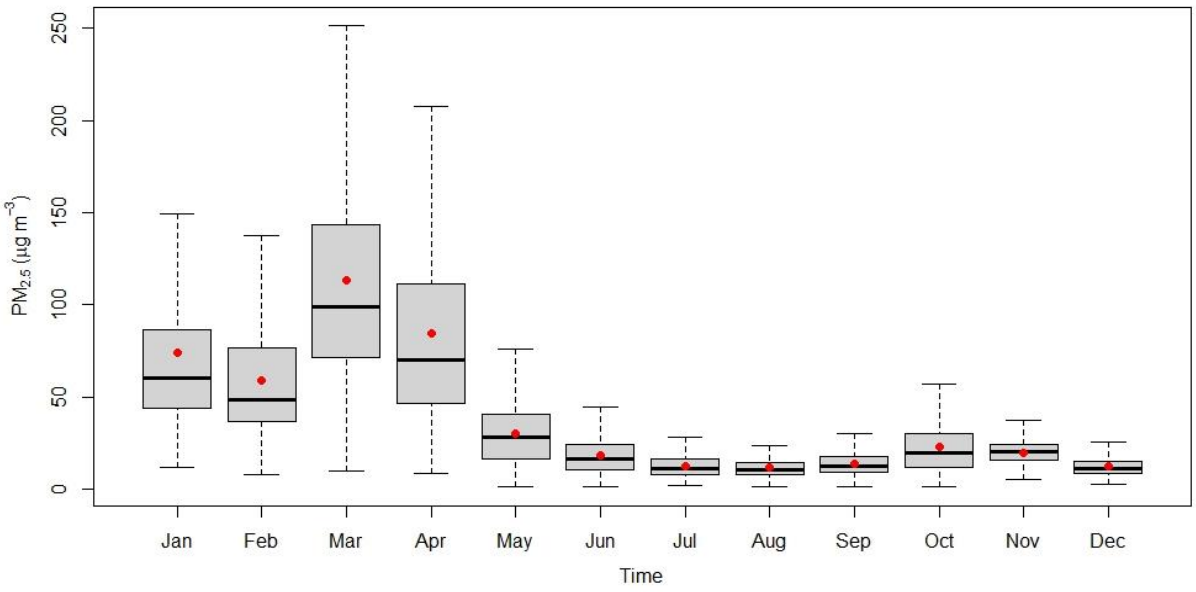


Figure 2.8.5: Monthly variation of $PM_{2.5}$

The monthly average of March was found to be highest (113.05 µg m^{-3}) and that of August was found to be lowest (11.42 µg m^{-3}) while comparing with other months as shown in figure 2.8.6 below.

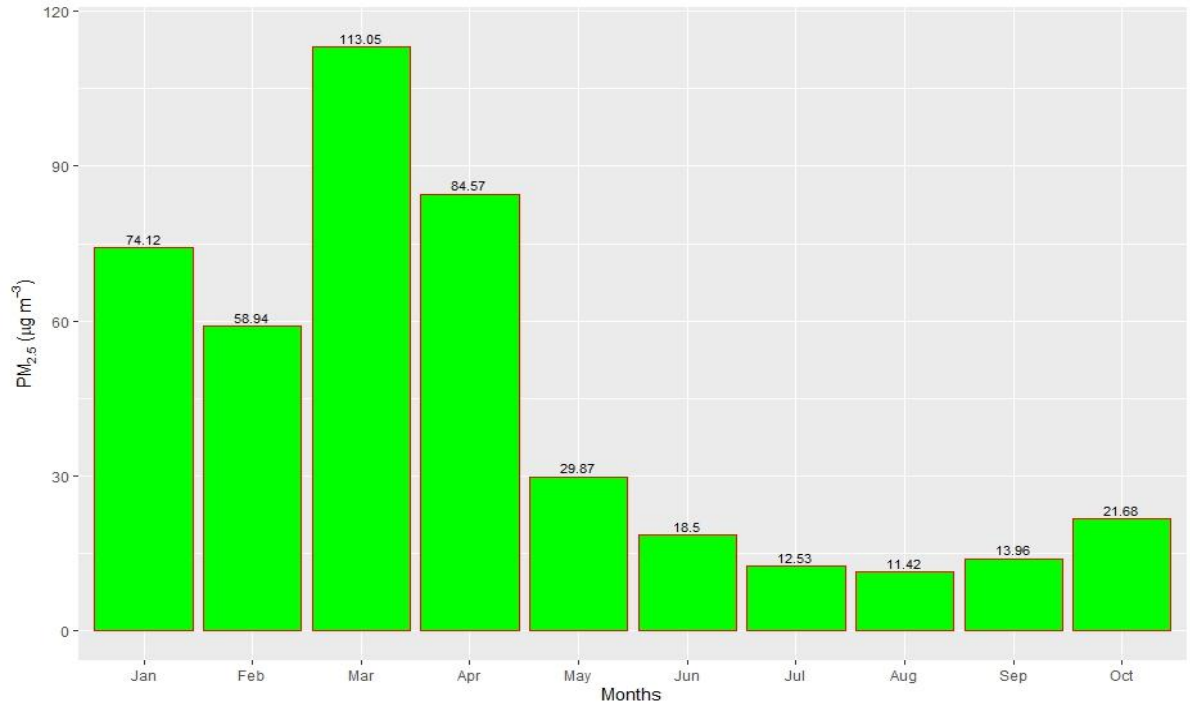


Figure 2.8.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during the pre-monsoon season (75.73 µg m^{-3}) and the lowest during the monsoon season (14.12 µg m^{-3}) as in figure 2.8.7. Seasonal average was not calculated for post monsoon season due to insufficient data.

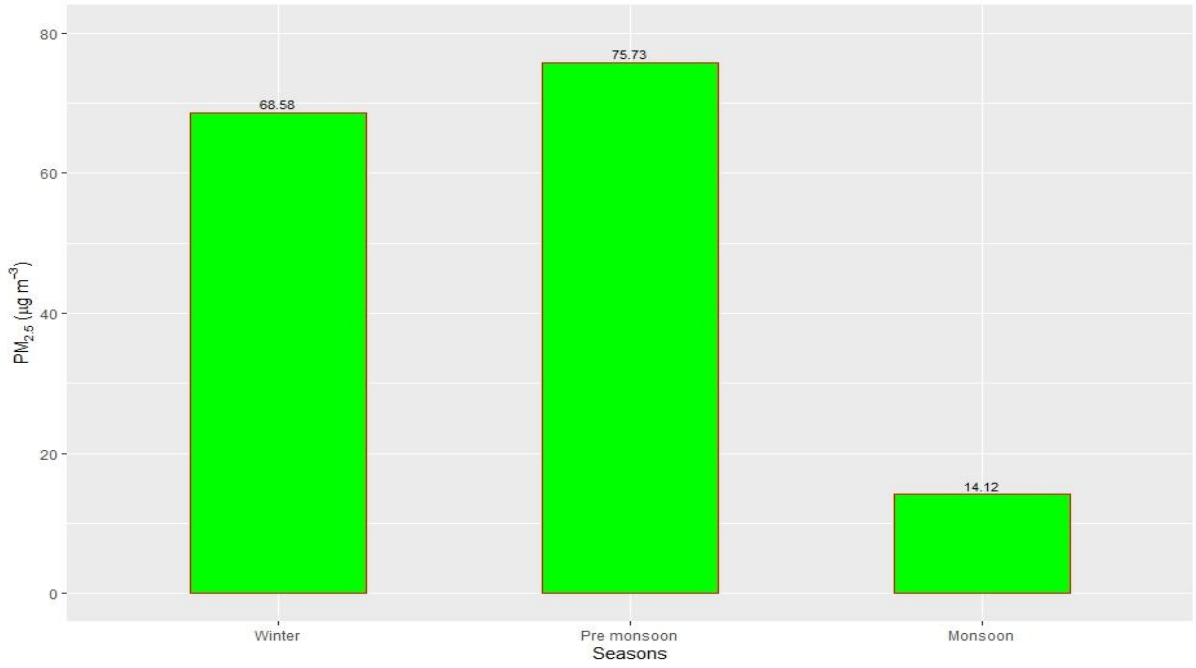


Figure 2.8.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 302 days of measurement, 115 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$ as shown in figure 2.8.8.

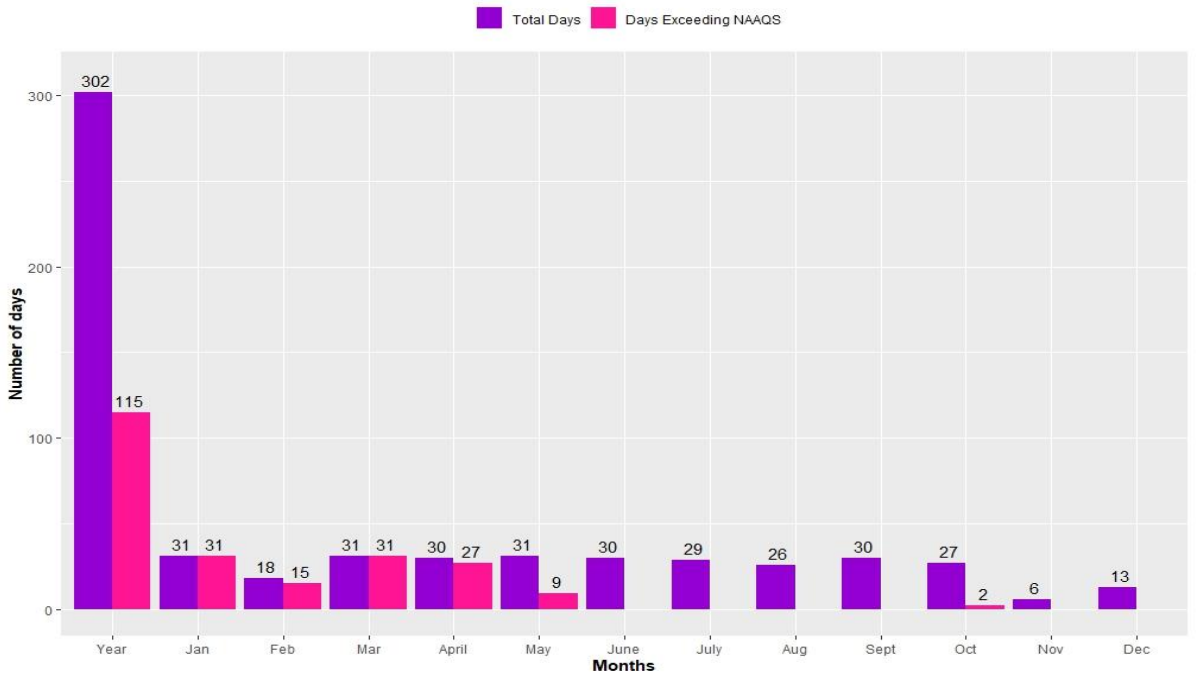


Figure 2.8.8: Compliance status of $PM_{2.5}$

2.8.3 PM_{10}

Histogram

PM_{10} in Bhaisipati Station was observed to range from 1 to 2907.1 µg m^{-3} (Figure 2.8.9). The mean of the PM_{10} point data was observed to be 71.92 µg m^{-3}.

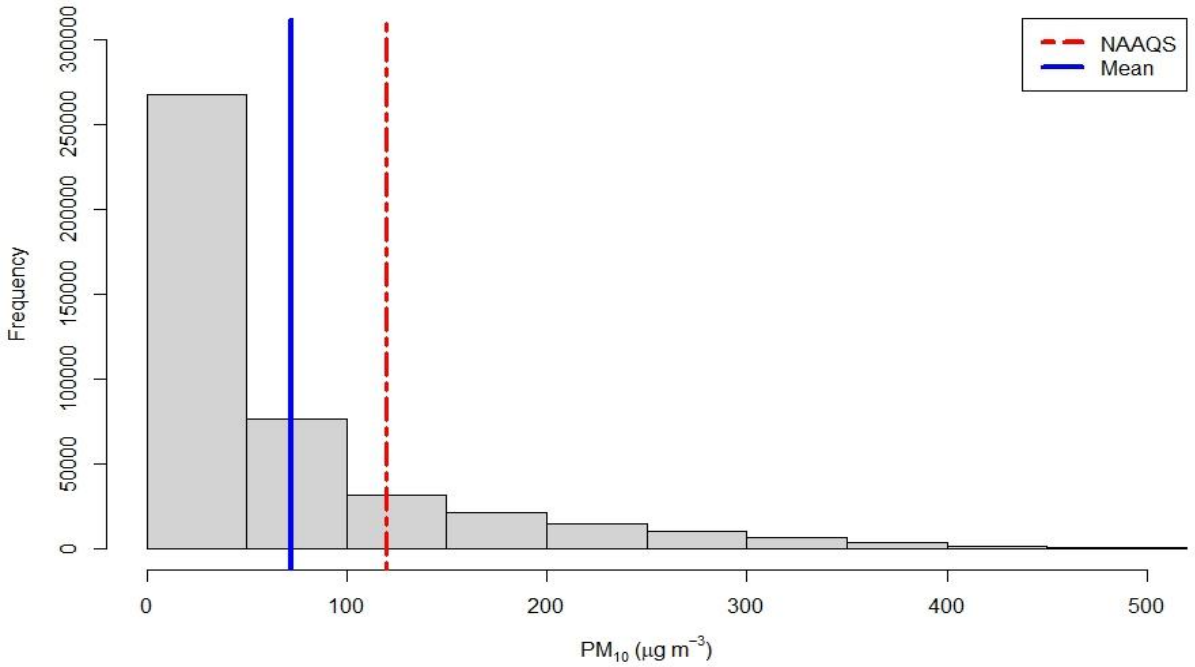


Figure 2.8.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.8.10 shows PM_{10} peaks at 9 AM then starts falling slowly till 4 PM and starts again rising peaks at 5 PM then again starts falling.

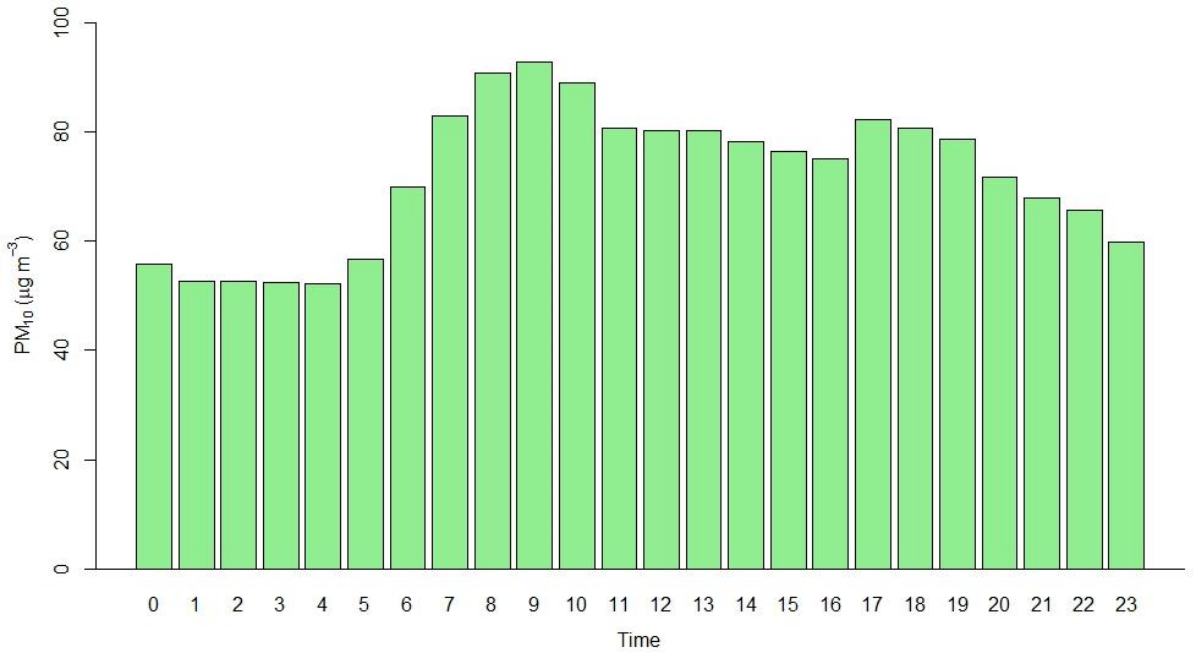


Figure 2.8.10: Hourly average of PM_{10}

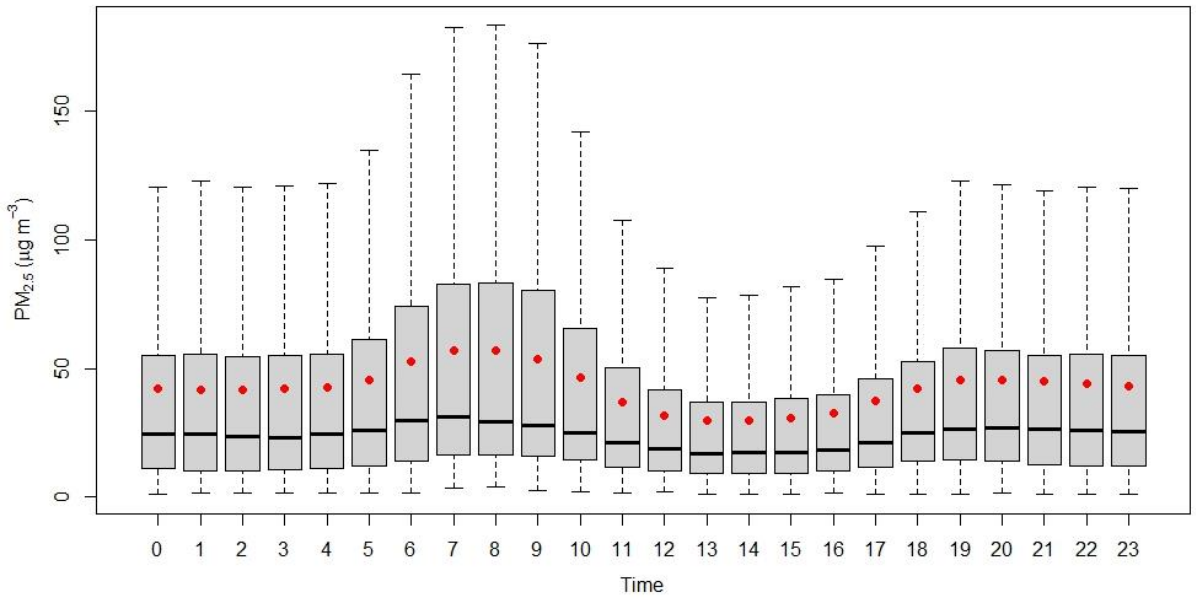


Figure 2.8.11: Diurnal variation of PM_{10}.

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.8.12. Higher concentration can be seen during January and April whereas lower concentration was observed during monsoon season.

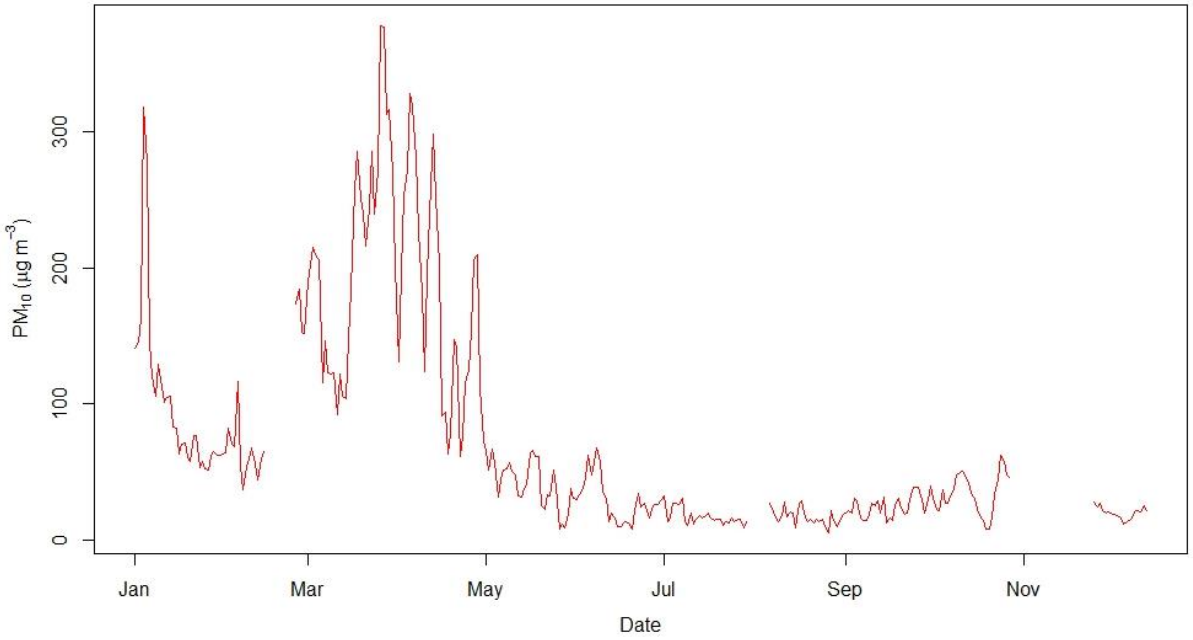


Figure 2.8.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly $PM_{10,}$ the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during March and April whereas less during July, August and December. The mean value was found more than the median during January, February, March, and April.

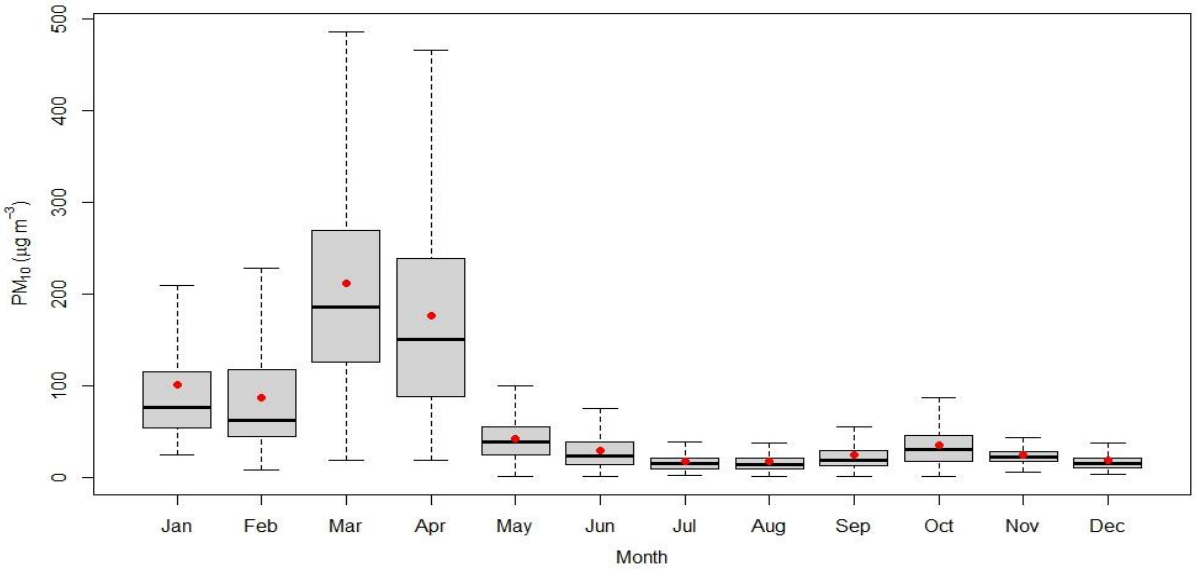


Figure 2.8.13: Monthly variation of PM_{10}

The monthly average for March was found the highest (211.26 µg m^{-3}) and that of July and August was found lowest (17.42 µg m^{-3}) while comparing with other months as shown in figure 2.8.14.

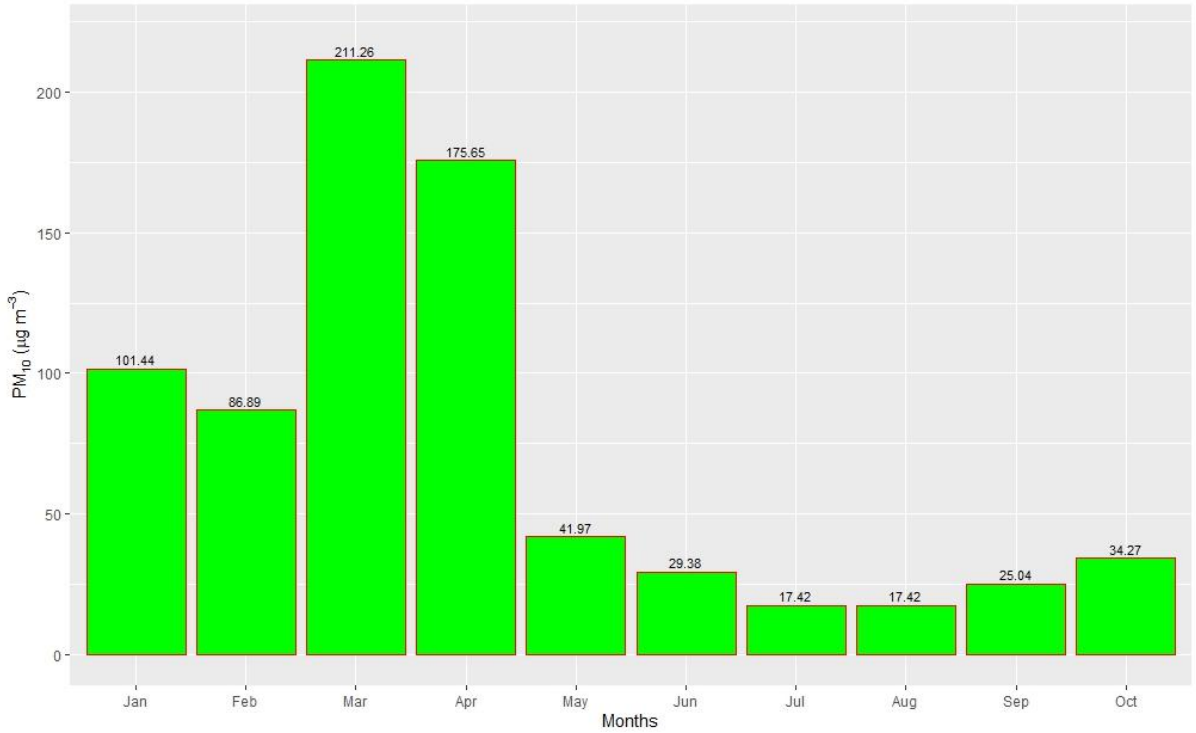


Figure 2.8.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during pre-monsoon season (142.6 µg m^{-3}) and the lowest during monsoon season (22.52 µg m^{-3}) as in figure 2.8.15. Seasonal average was not calculated for post monsoon season due to insufficient data.

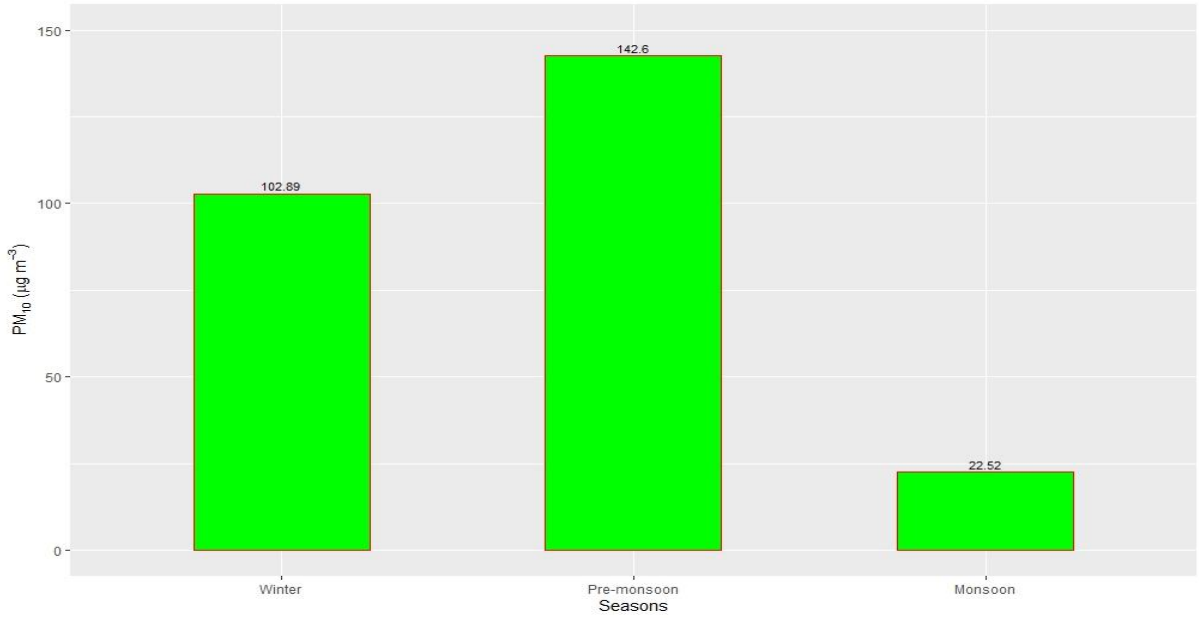


Figure 2.8.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 302 days of measurement, 60 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. From May to December none of the days exceed NAAQS as shown in figure 2.8.16.

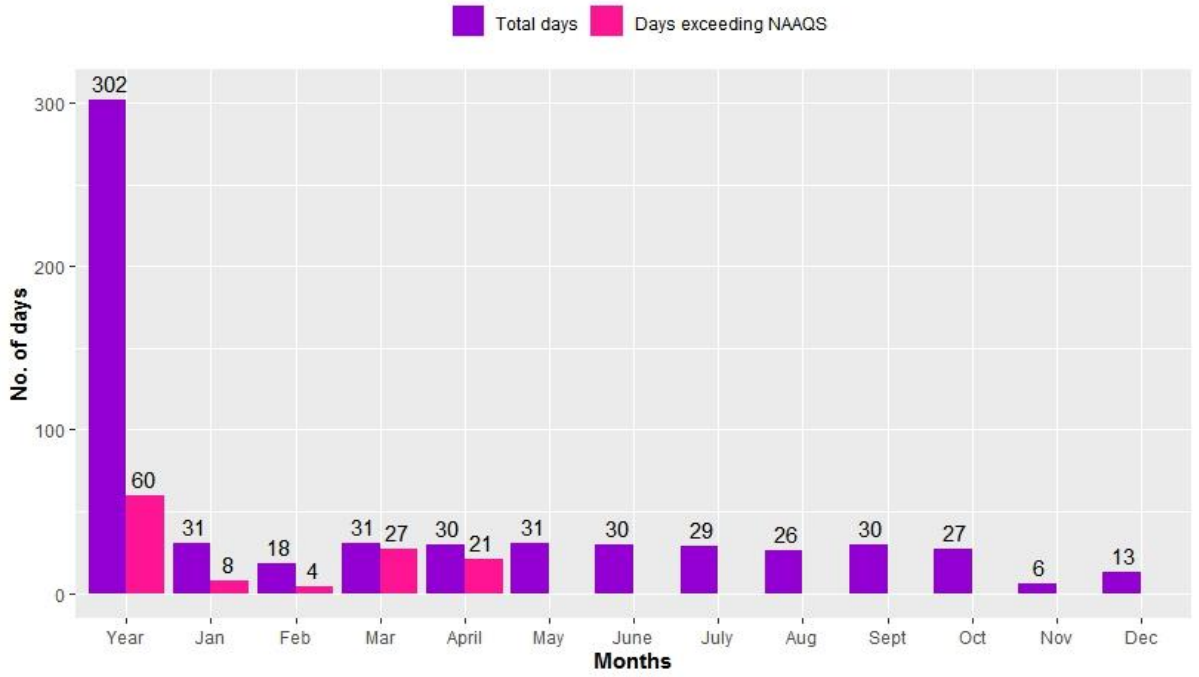


Figure 2.8.16: Compliance status of PM_{10}

2.8.4 TSP

Histogram

TSP in Bhaisipati Station was observed to range from 1 to 4950.7 µg m^{-3} (Figure 2.8.17). The mean of the TSP point data was observed to be 137.6 µg m^{-3}.

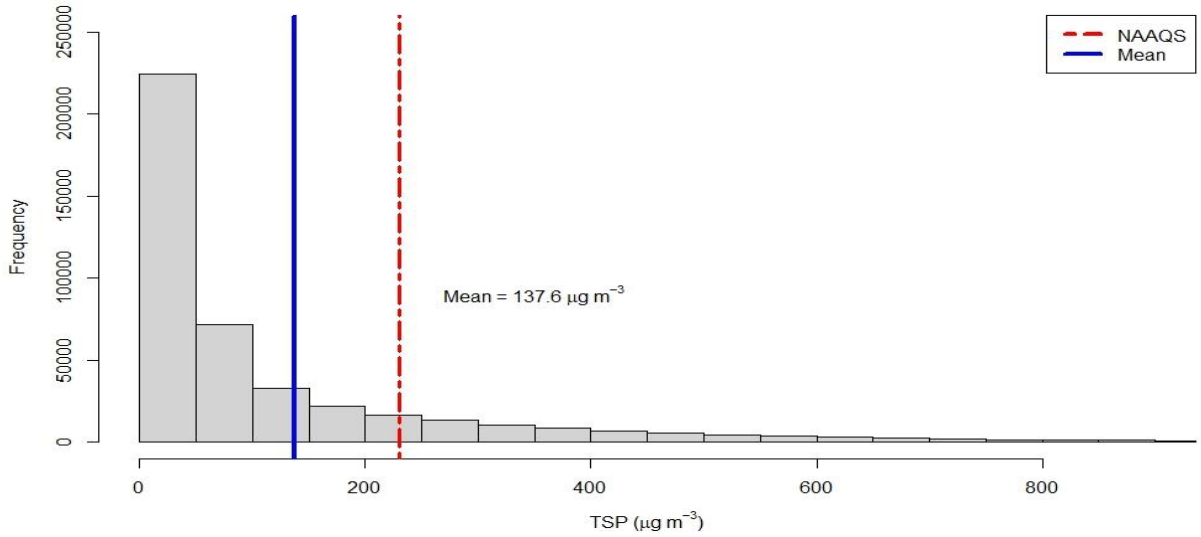


Figure 2.8.17: Histogram of TSP

Diurnal Variation

The Figure 2.8.18 shows TSP peaks at 1 PM and 2 PM. During day time the mean is much higher compared to the median value.

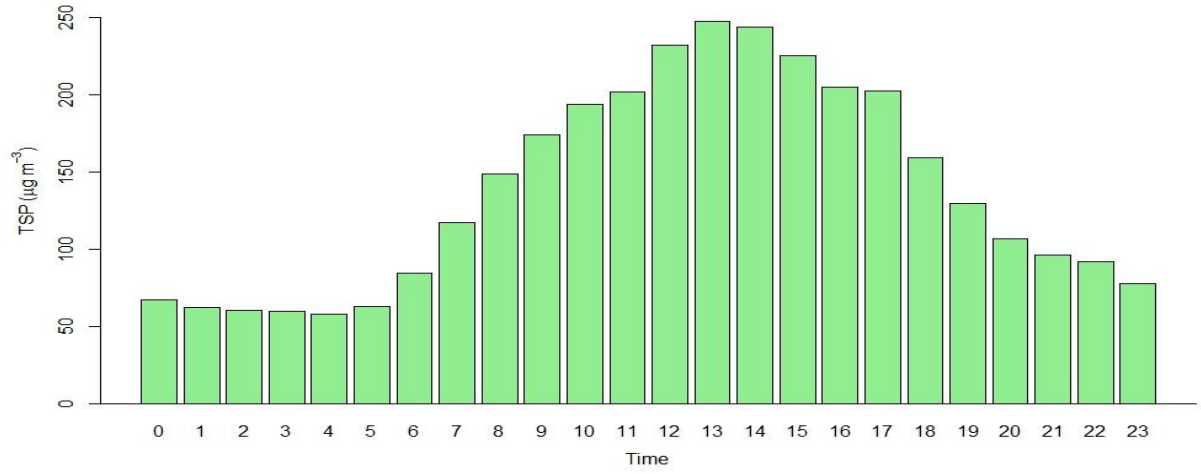


Figure 2.8.18: Hourly average of TSP

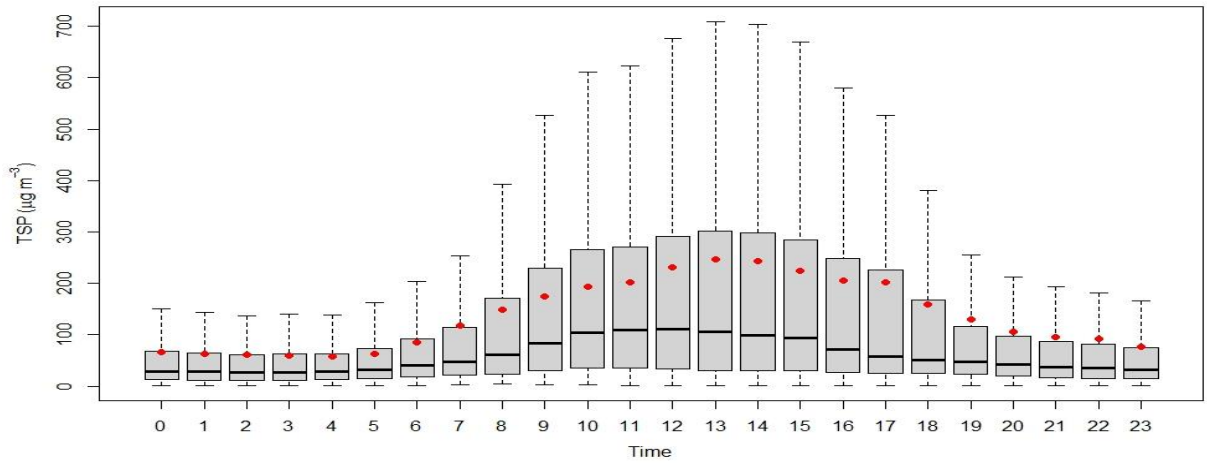


Figure 2.8.19: Diurnal variation of TSP.

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.8.20. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post monsoon season.

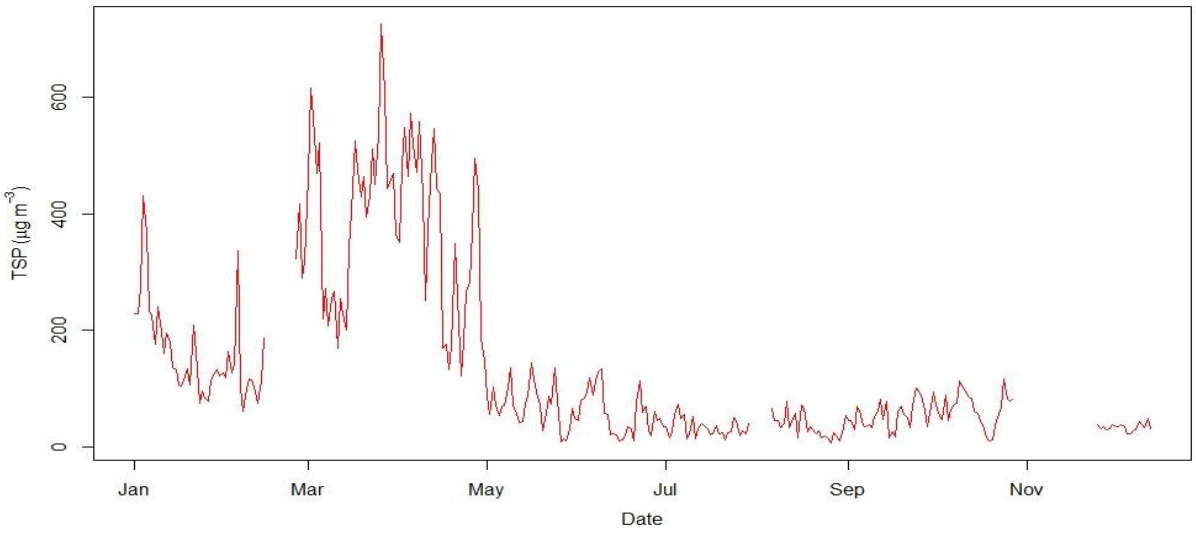


Figure 2.8.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during March and April whereas less during July and August. The mean value was found more than median in every month.

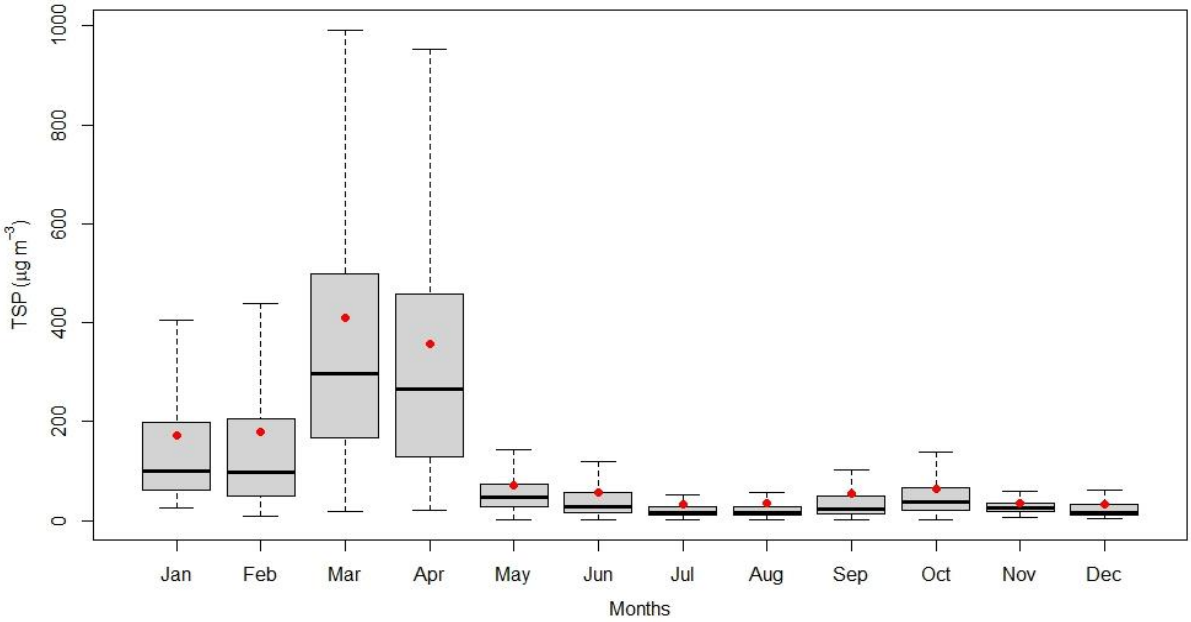


Figure 2.8.21: Monthly variation of TSP

The monthly average for March was found to be the highest (411.01 µg m^{-3}) and that of July was found to be the lowest (31.84 µg m^{-3}) while comparing with other months as shown in figure 2.8.22.

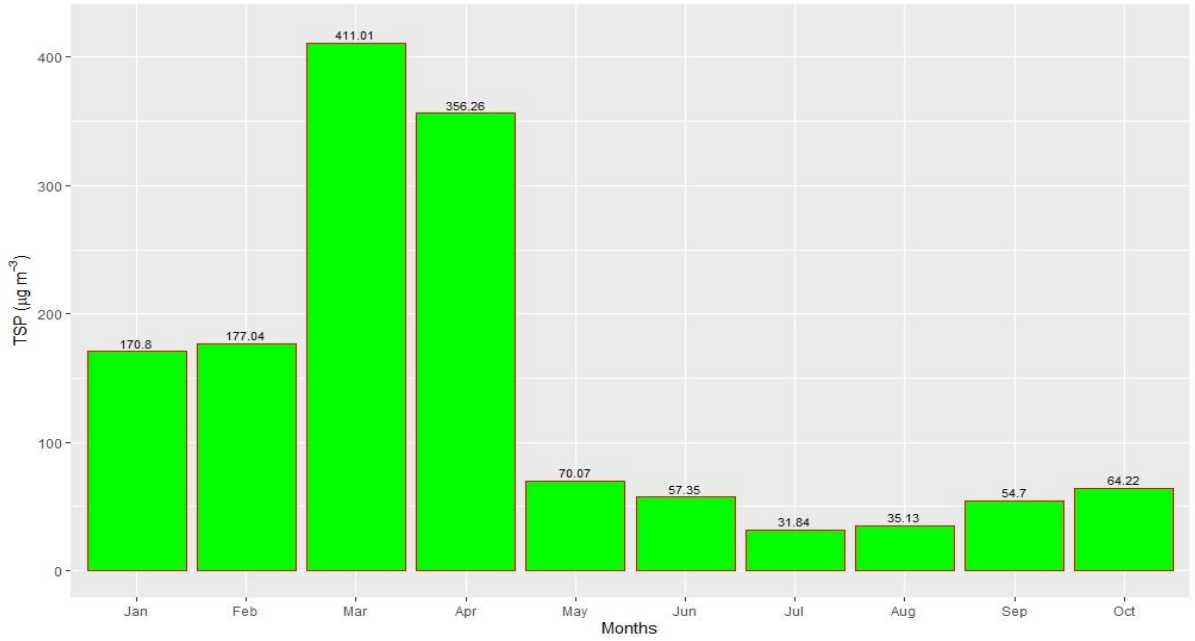


Figure 2.8.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during the pre-monsoon season (278.27 µg m^{-3}) and the lowest during the monsoon season (45.2 µg m^{-3}) as in figure 2.8.23. Seasonal average for post monsoon season was not calculated due to insufficient data.

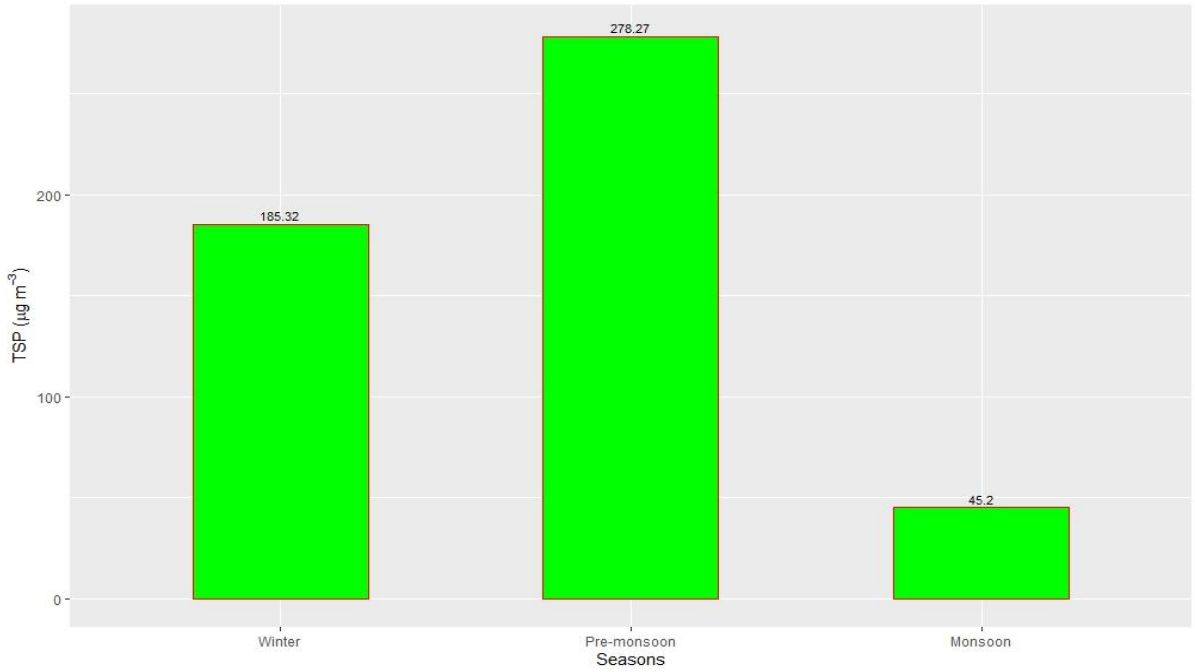


Figure 2.8.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 302 days of measurement, 58 days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}. From May to December none of the days exceed NAAQS as shown in figure 2.8.24.

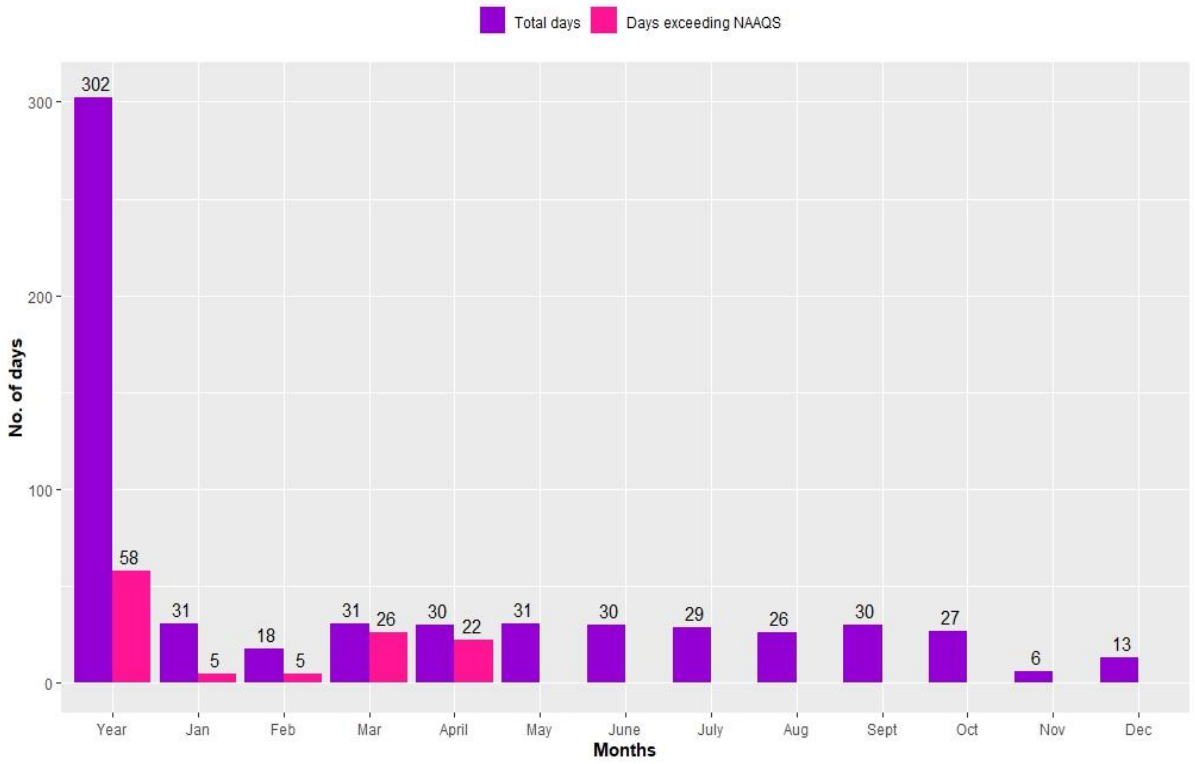


Figure 2.8.24: Compliance status of TSP

Annual Average

The annual average of $PM_{2.5}$, PM_{10} and TSP is shown in figure 2.8.25.

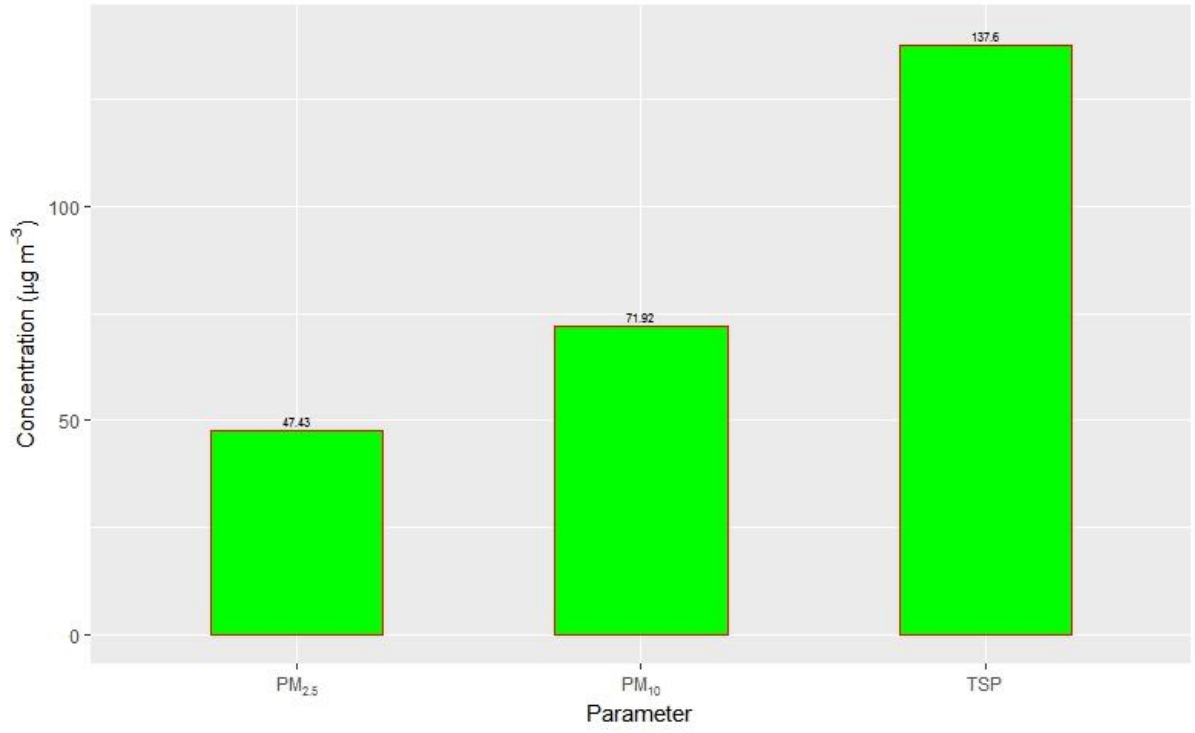


Figure 2.8.25: Annual average of $PM_{2.5}$, PM_{10} and TSP

Calendar Plot

Calendar plot is prepared for $PM_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to very unhealthy level in 4and 5th of January, 26th to 30th of March and 5th and 6th of April.

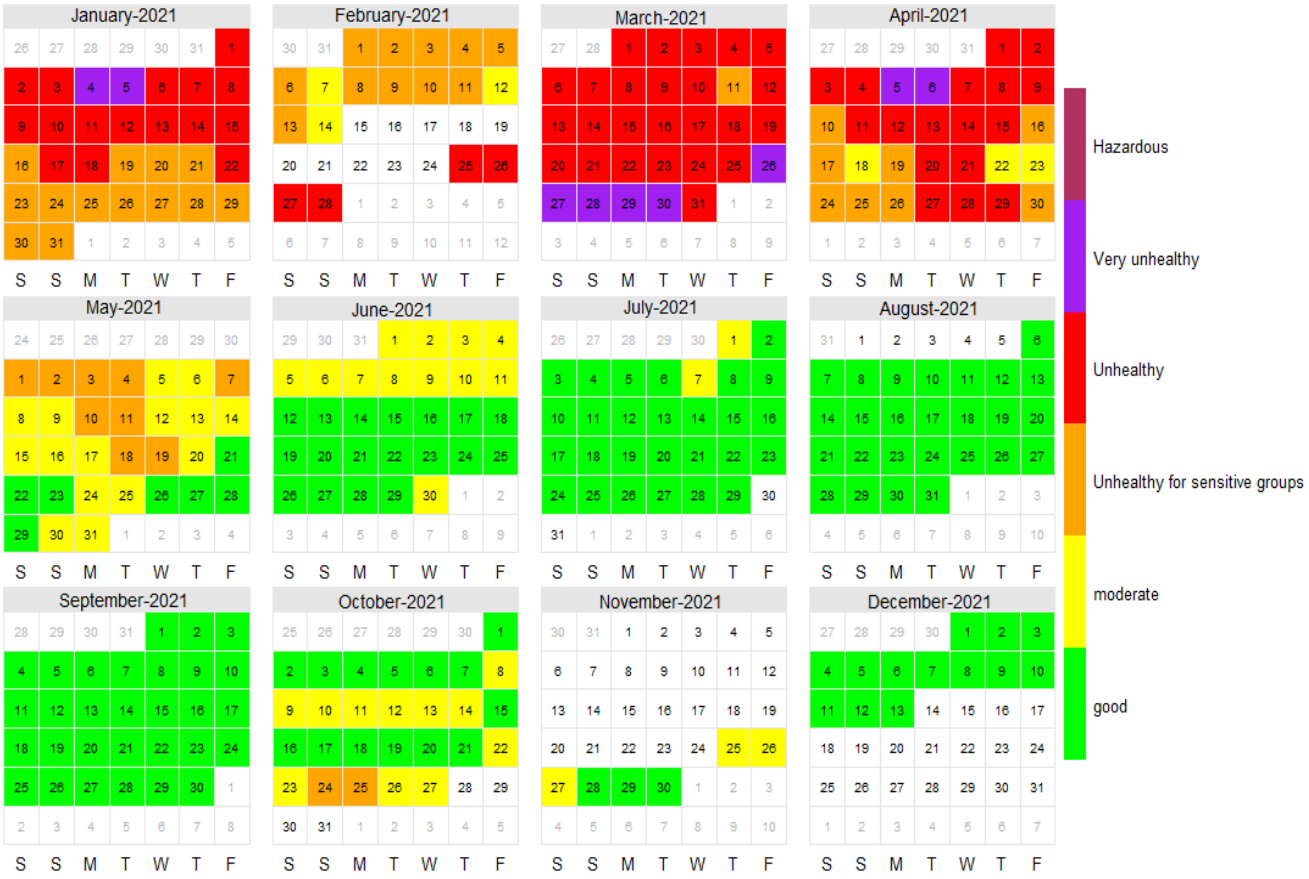


Figure 2.8.26: Calendar plot for $PM_{2.5}$ for the year 2021

2.9 Air quality status – Bhaktapur

2.9.1 Introduction

Bhaktapur Air Quality Monitoring Station was established in the year 2017. It lies inside the premise of Sainik Awasiya Mahavidyalaya, Sallaghari, Bhaktapur. This station lies in the eastern part of Kathmandu Valley and represents the semi urban area. The major source of air pollution in this area are vehicles and commercial activities.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.9.2 $PM_{2.5}$

Histogram

The $PM_{2.5}$ value ranged in between 0.80 to 1069 µg m^{-3}. The annual average $PM_{2.5}$ value was found to be 49.36 µg m^{-3} exceeding the national standard of 49.36 µg m^{-3} (Figure 2.9.1).

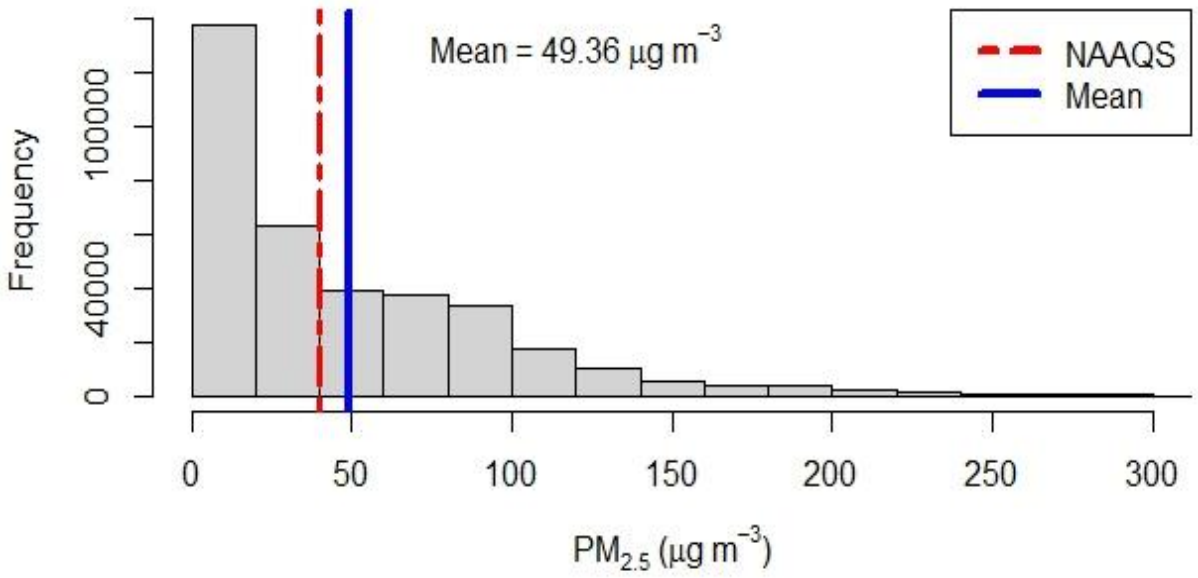


Figure 2.9.1: Histogram of $PM_{2.5}$

Diurnal Variation

The $PM_{2.5}$ value was found more in between 8 AM and in between 8 PM to 11 PM. The box plot shows that mean value was found to be more than the median throughout the day (figure 2.9.2).

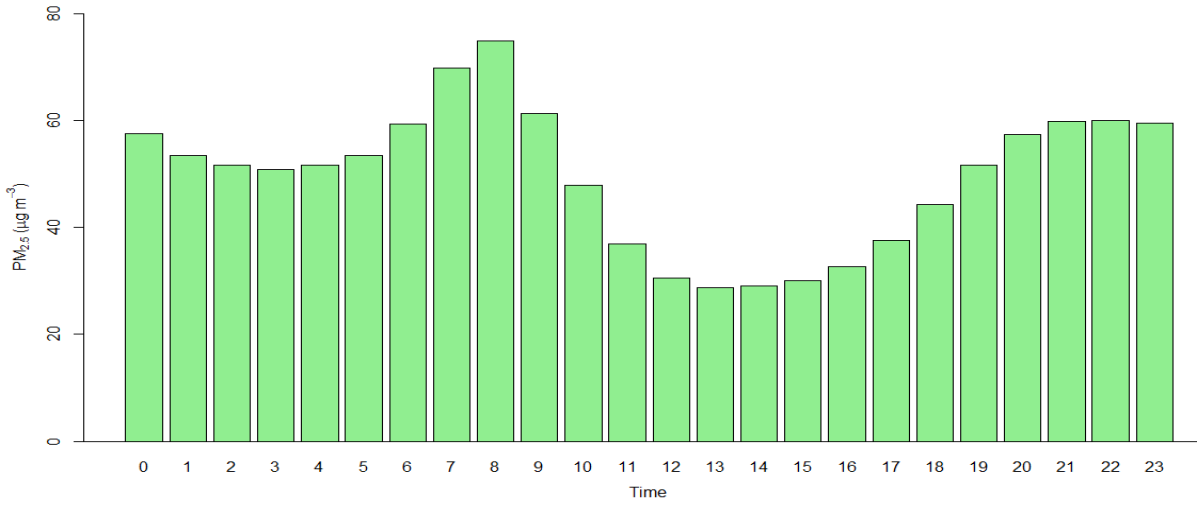


Figure 2.9.2: Hourly average of $PM_{2.5}$.

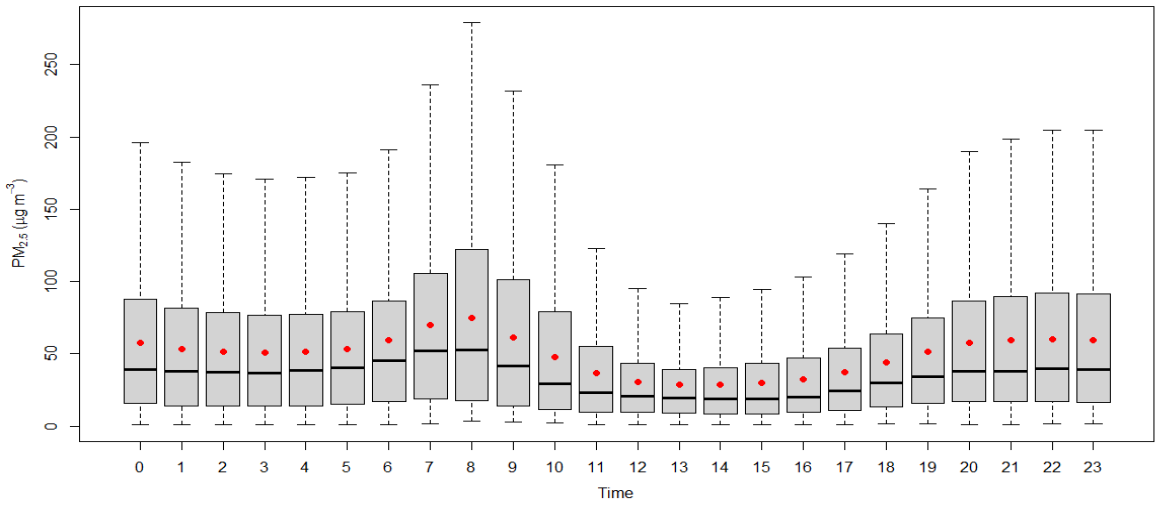


Figure 2.9.3: Diurnal variation of $PM_{2.5}$

Daily average

The daily average $PM_{2.5}$ values were found higher in between January to May and found maximum in the month of April. The values were found low in between June to November (figure 2.9.4).

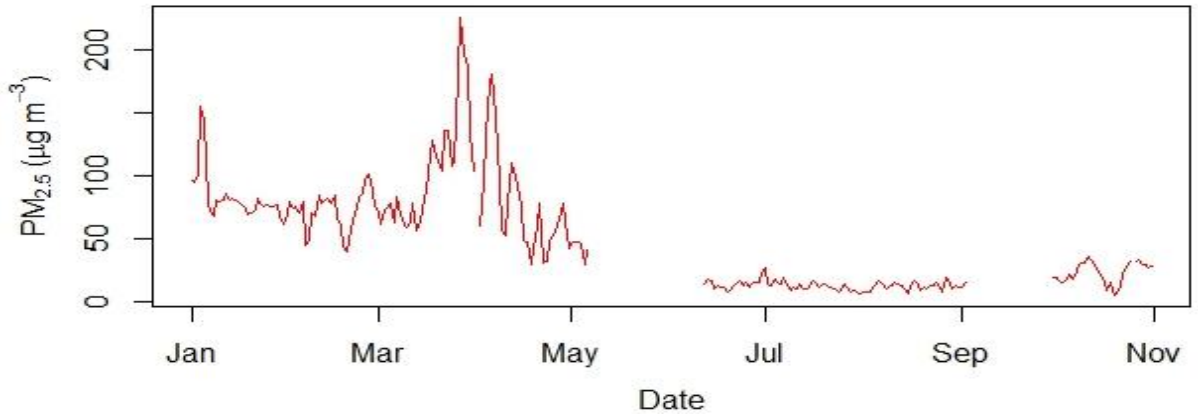


Figure 2.9.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

The monthly average value was found in between 11.76 µg m^{-3} to 103.15 µg m^{-3} with highest in March (103.15 µg m^{-3}) and lowest in August (11.76 µg m^{-3}). It was not calculated for November and December due to insufficient data (figure 2.9.5).

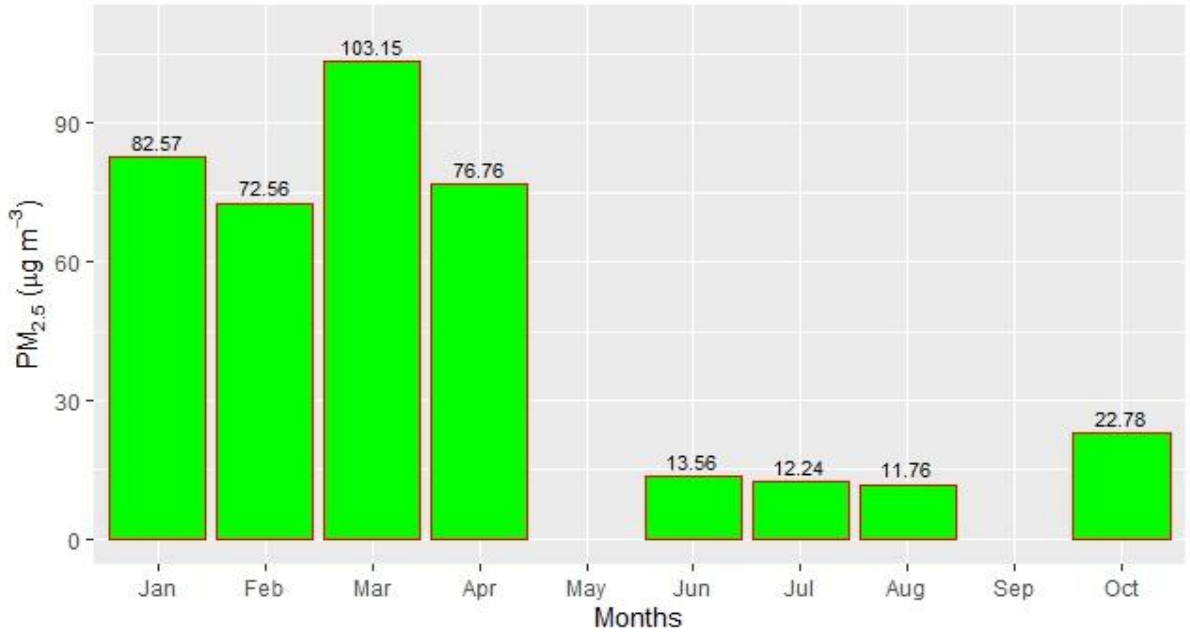


Figure 2.9.5: Monthly average $PM_{2.5}$

In the box plot, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. The box plot below shows high variation in $PM_{2.5}$ values in between January to April. The mean value was found more than median especially in March and April (figure 2.9.6).

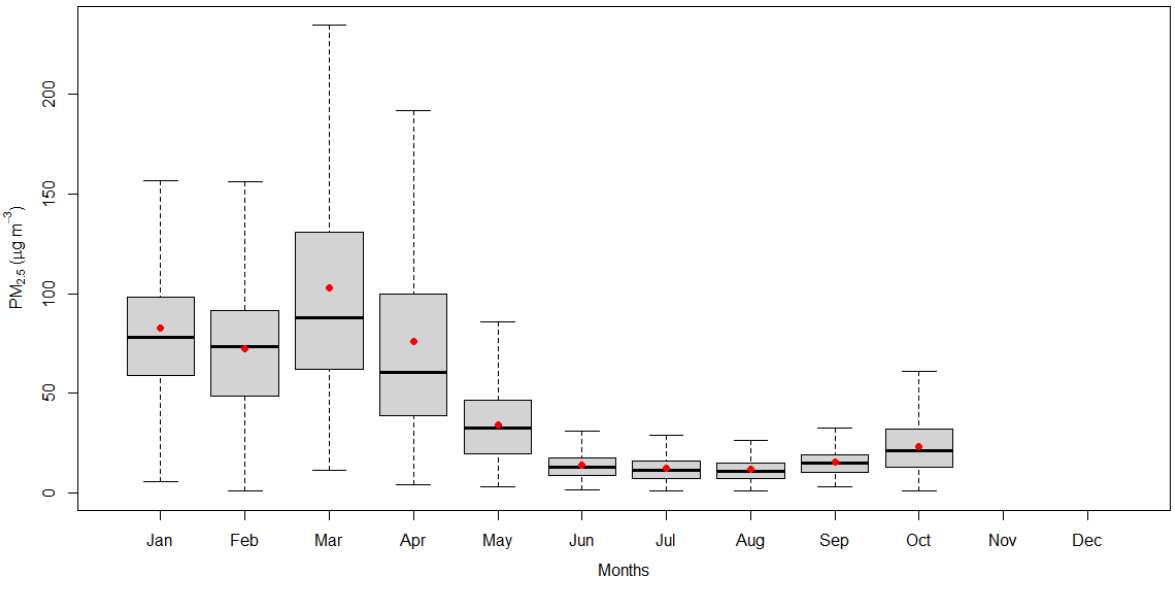


Figure 2.9.6: Monthly variation of $PM_{2.5}$

Seasonal Average

The seasonal average $PM_{2.5}$ value was found maximum in pre-monsoon (89.95 µg m^{-3}) and minimum in monsoon season (12.52 µg m^{-3}).

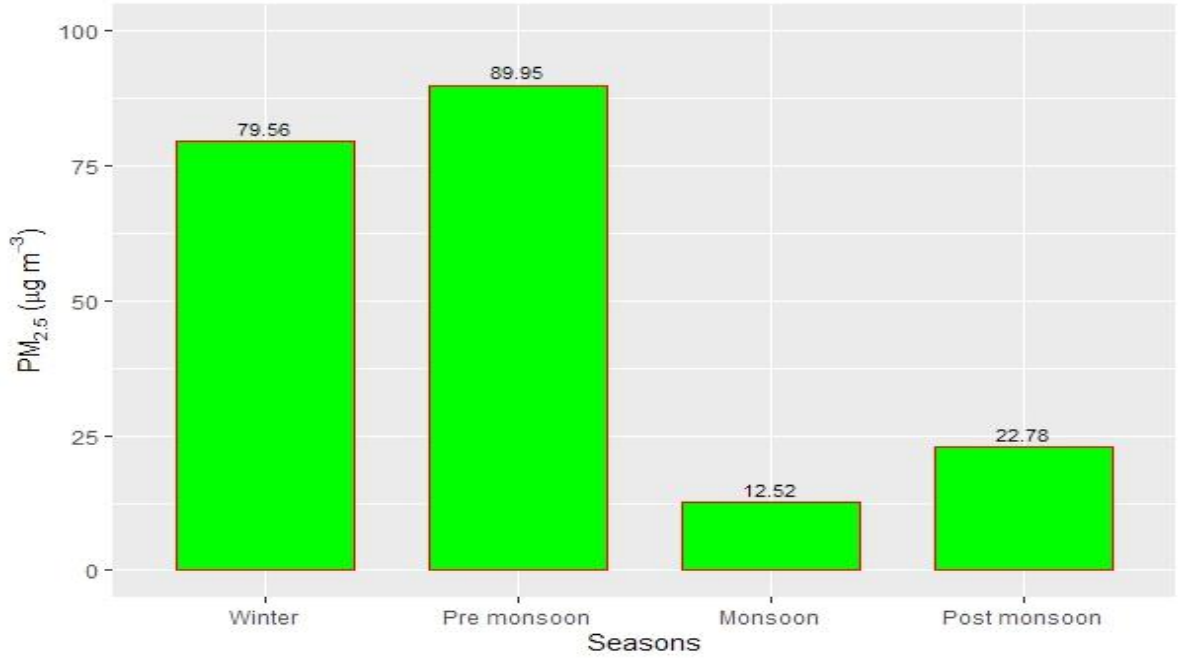


Figure 2.9.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 239 days of measurement, 121 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$. From June to October none of the days exceeded NAAQS of 40 µg m^{-3} (figure 2.9.8).

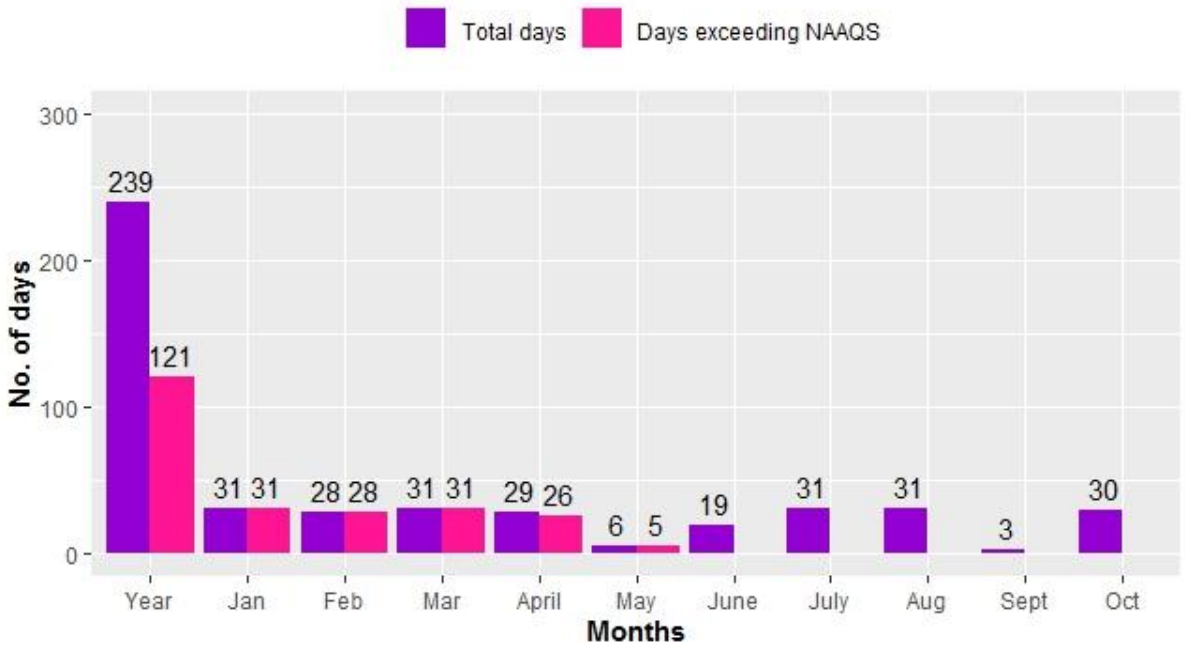


Figure 2.9.8: Compliance status of $PM_{2.5}$

2.9.3 PM_{10}

Histogram

The PM_{10} value ranged in between 0.80 to 2988.50 µg m^{-3}. The annual average PM_{10} was found to be 90.37 µg m^{-3} (Figure 2.9.9).

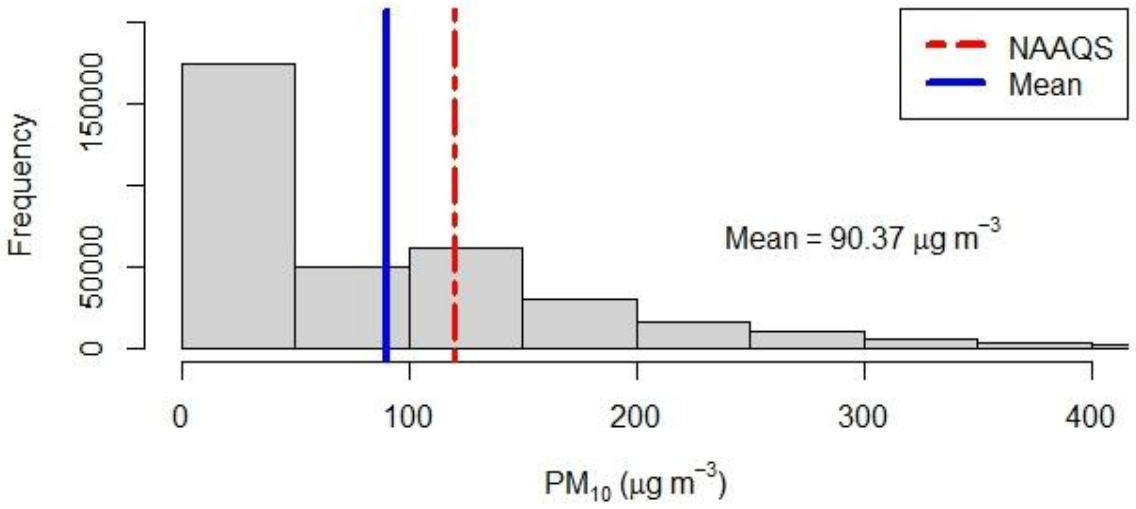


Figure 2.9.9: Histogram of PM_{10}

Diurnal Variation

The PM_{10} value was found maximum in between 7 AM to 10 AM, decreased in the day time and then increases after 4 PM till 9 PM. The box plot below shows that mean value was found to be more than the median throughout the day (figure 2.9.11).

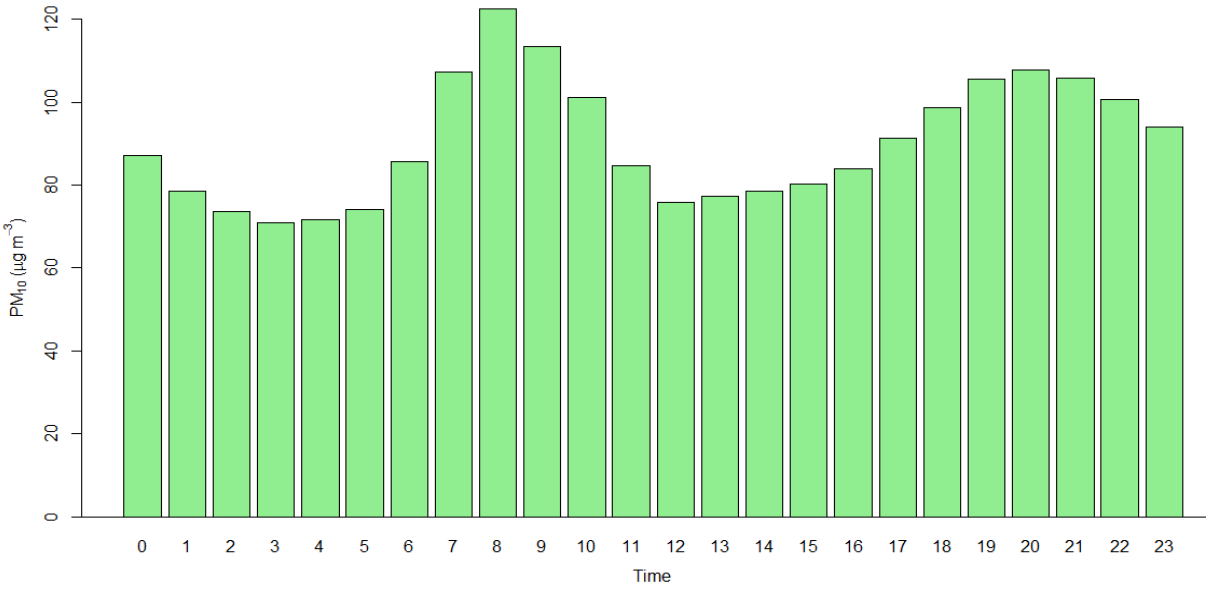


Figure 2.9.10: Hourly average of PM_{10}

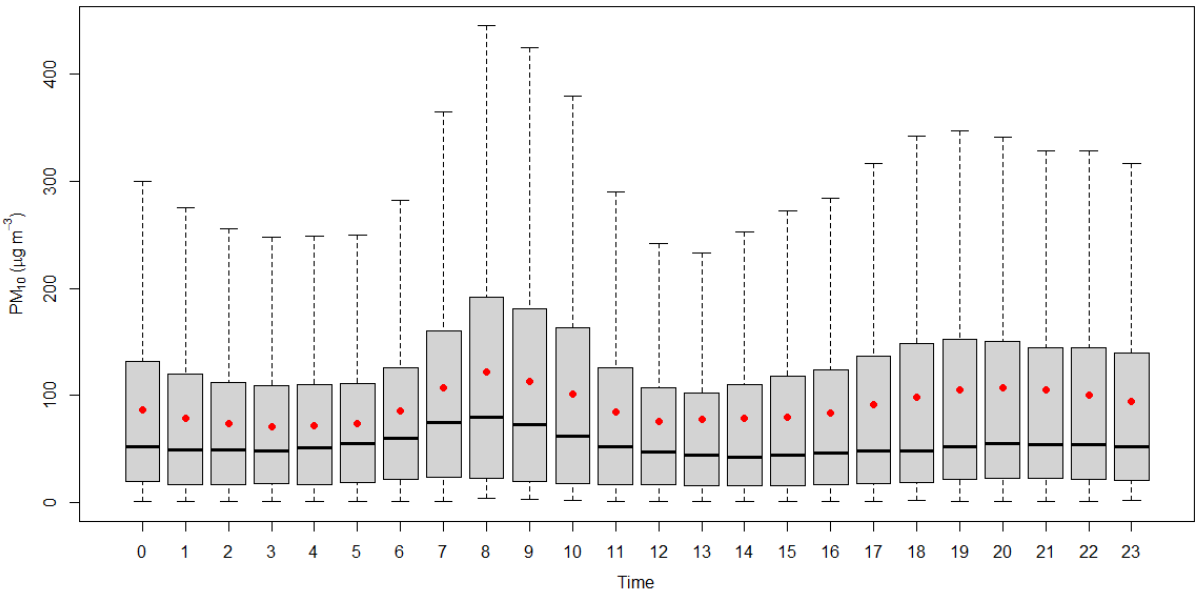


Figure 2.9.11: Box-plot showing diurnal variation of PM_{10}

Daily average

The daily average PM_{10} values were found higher in between January to May and found maximum in the month of April. The values were found low in between June to October. (figure 2.9.12).

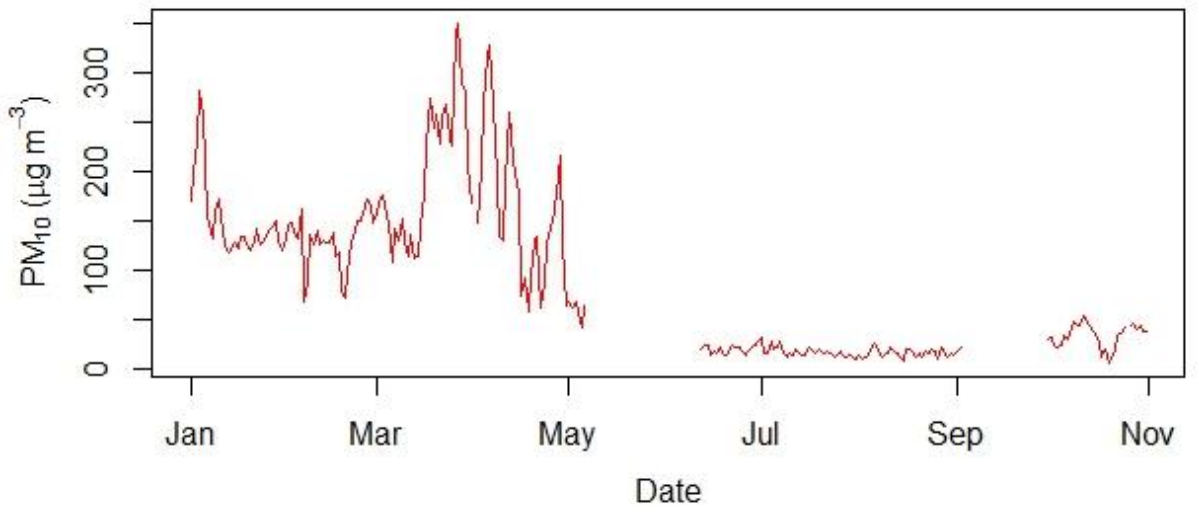


Figure 2.9.12: Daily mean concentration of PM_{10}

Monthly Variation

The monthly average value was found in between 15.77 µg m^{-3} to 197.06 µg m^{-3} with highest in March (197.06 µg m^{-3}) and lowest in August (15.77 µg m^{-3}). It was not calculated for May, September, November and December due to insufficient data. (figure 2.9.13).

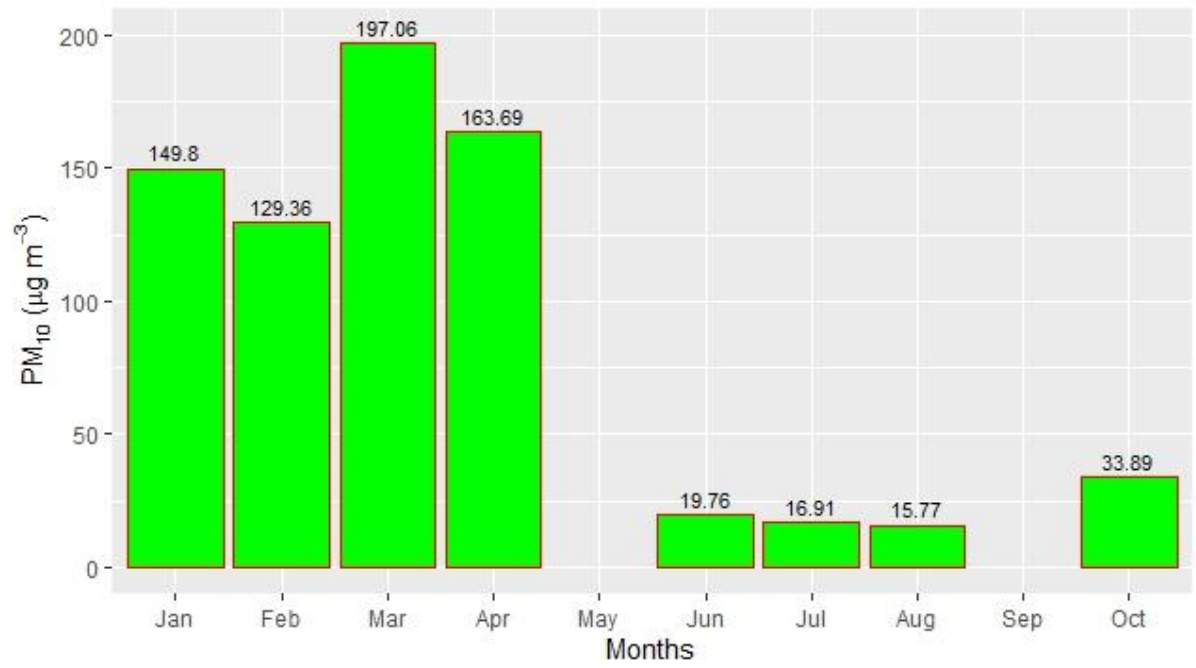


Figure 2.9.13: Monthly average of PM_{10}

The box plot below shows high variation in PM_{10} values in between January to April. The mean value was found more than median especially in March and April (figure 2.9.14).

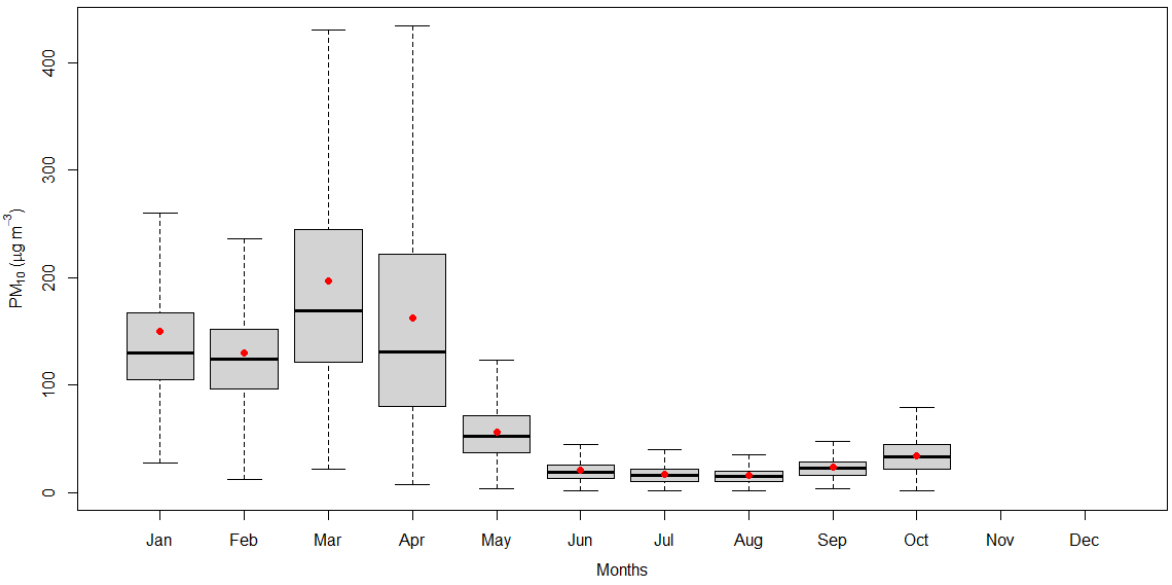


Figure 2.9.14: Monthly variation of PM_{10}

Seasonal Average

The seasonal average PM_{10} value was found maximum in pre-monsoon (180.37 µg m^{-3}) and minimum in monsoon season (17.48 µg m^{-3}) as shown in figure 2.9.15.

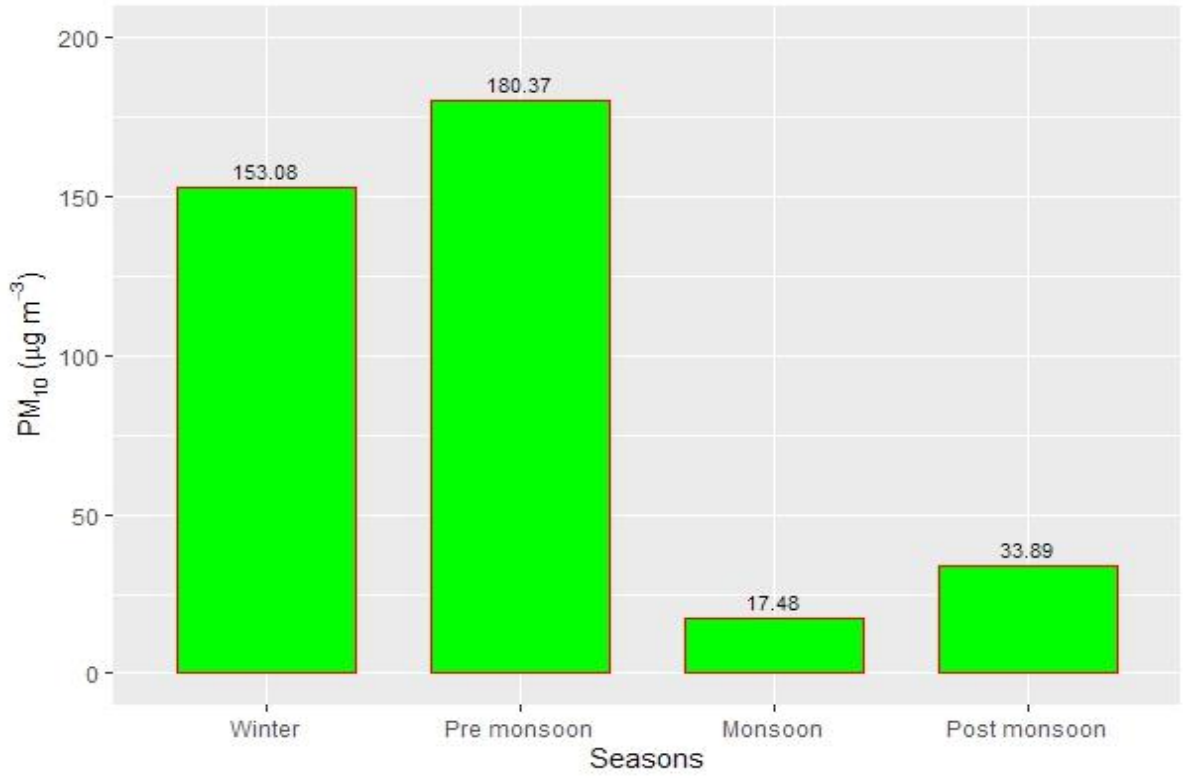


Figure 2.9.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 239 days of measurement, 100 days exceeded the National Ambient Air Quality Standard for PM_{10}. From May to October none of the days exceeded NAAQS of 120 µg m^{-3} (figure 2.9.16).

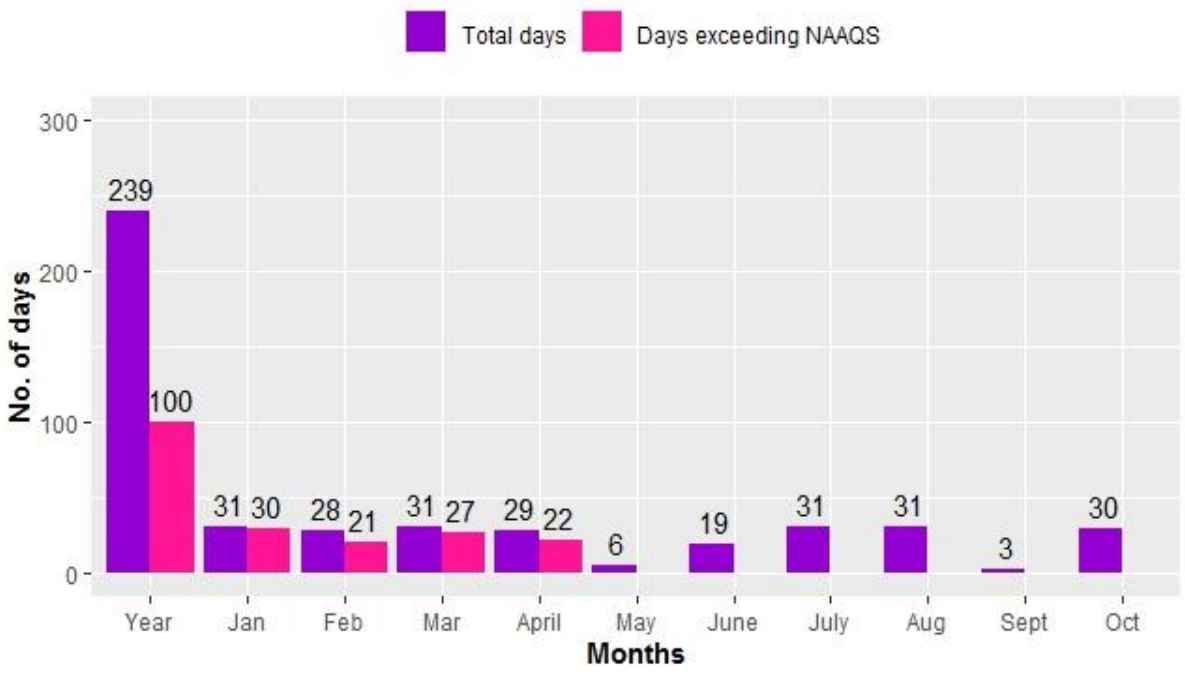


Figure 2.9.16: The compliance status of PM_{10}

2.9.4 TSP

Histogram

The TSP value ranged in between 0.80 to 4992.8 µg m^{-3}. The annual average TSP value was found to be 177.1 µg m^{-3} (Figure 2.9.17).

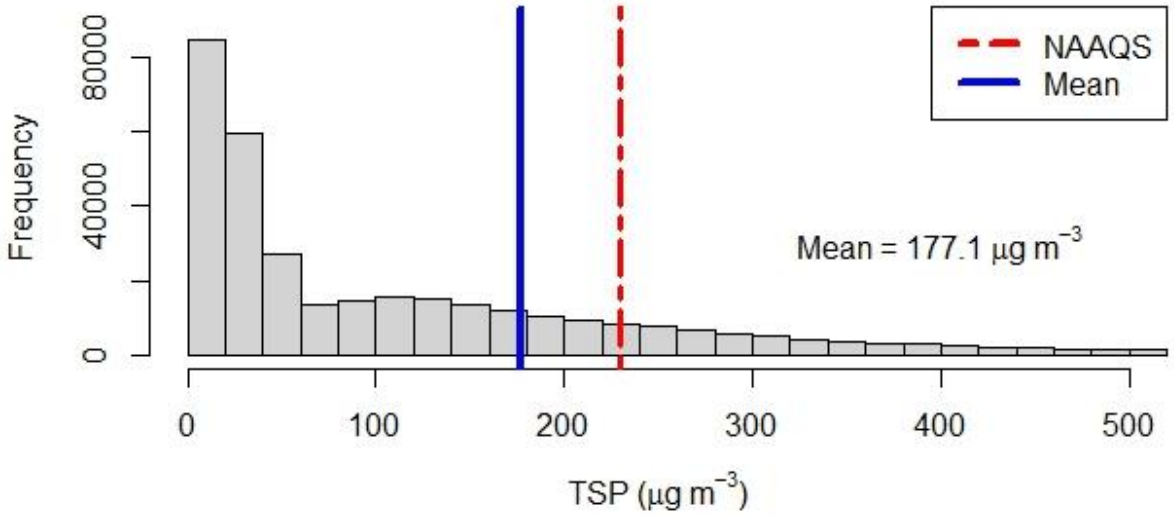


Figure 2.9.17: Histogram of TSP

Diurnal Variation

In contrast to the trend of $PM_{2.5}$, PM_{10}, the TSP value slowly increased in the morning and found maximum in day time especially in between 1 to 3 PM which gradually started to decrease then after. The box plot below shows that mean value was found to be more than the median throughout the day (figure 2.9.19).

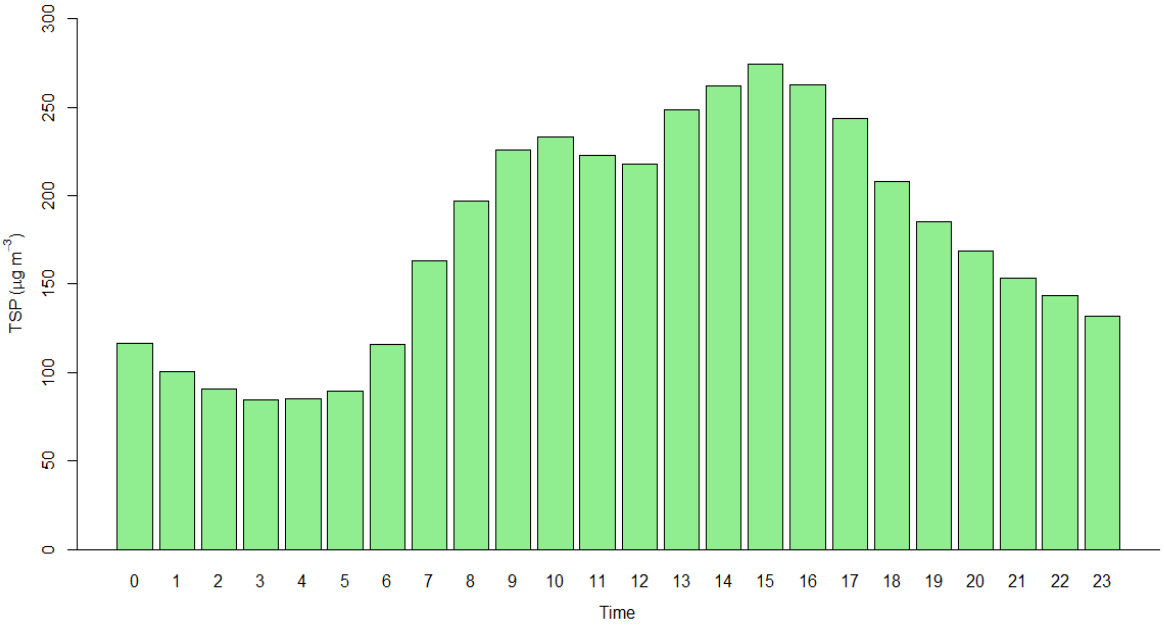


Figure 2.9.18: Hourly average of TSP

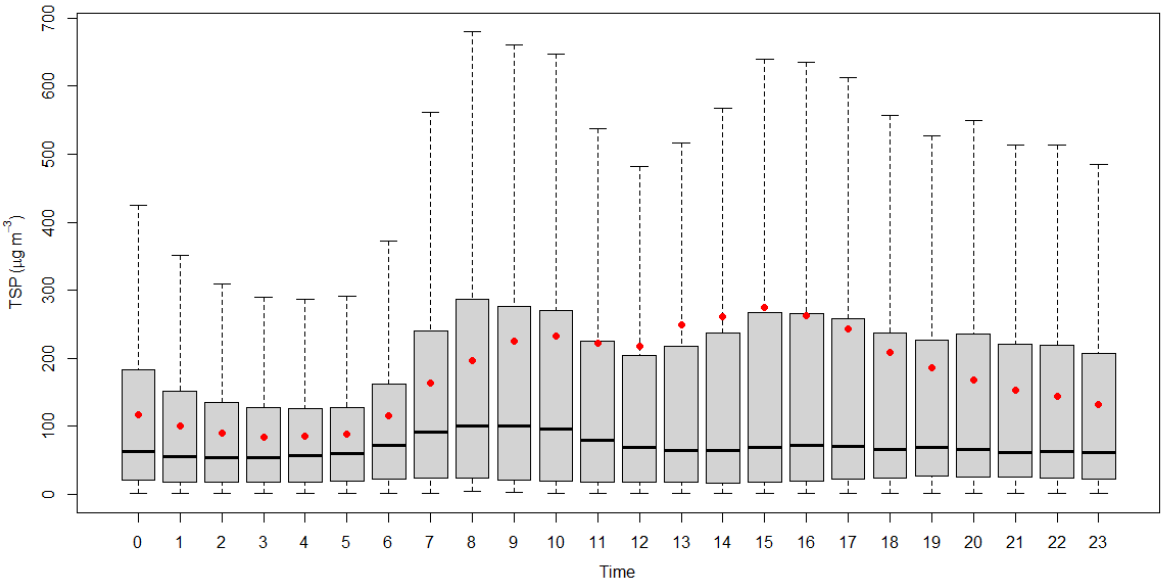


Figure 2.9.19: Diurnal variation of TSP

Daily average

The daily average TSP values were found higher in between January to May and found maximum in the month of April. The values were found low in between June to October as in figure 2.9.20.

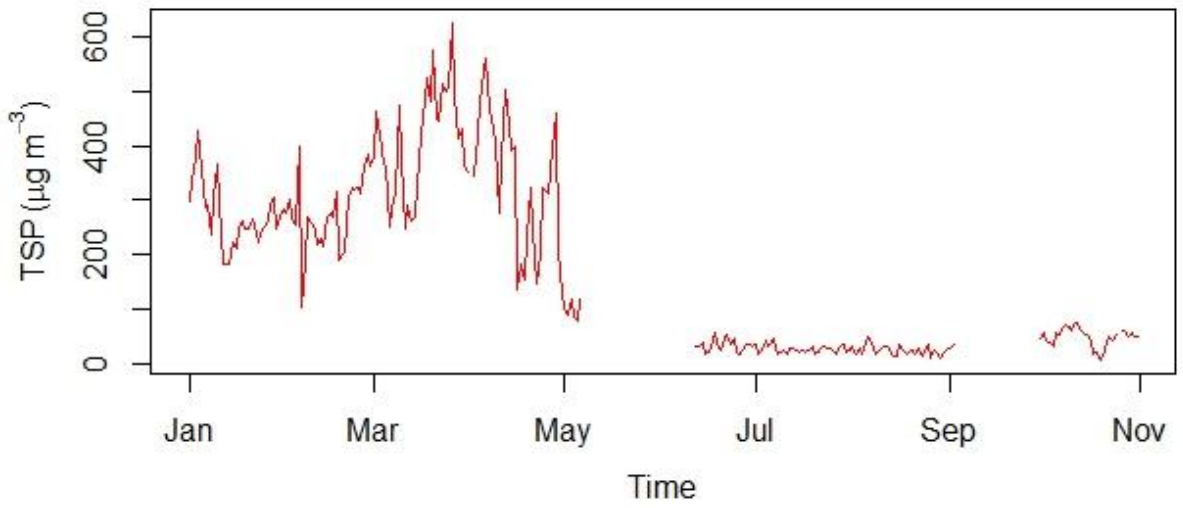


Figure 2.9.20: Daily average value of TSP

Monthly Variation

The monthly average value for March was found to be the highest (421.86 µg m^{-3}) and that of August was found to be the lowest (26.59 µg m^{-3}) while comparing with other months as shown in figure 2.9.21.

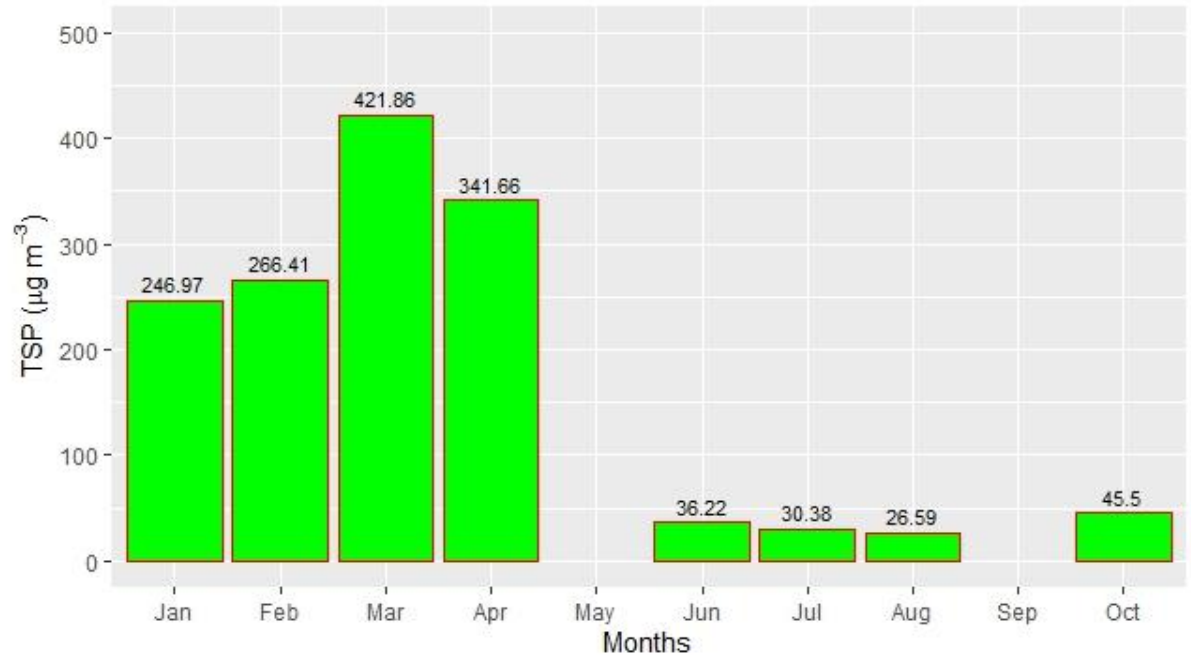


Figure 2.9.21: Monthly average of TSP

The box plot below shows high variation in between January to April and less variation during May to October. The mean value was found more than median in every month.

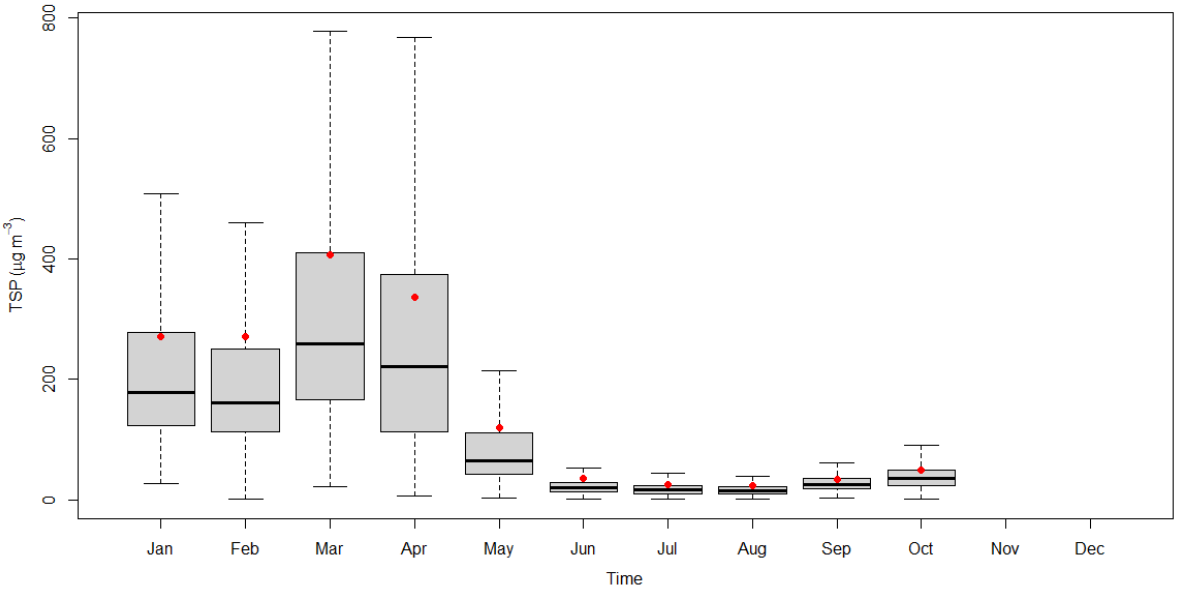


Figure 2.9.22: Monthly variation of TSP

Seasonal Average

The seasonal average TSP value was found maximum in pre-monsoon (381.72 µg m^{-3}) and minimum in monsoon season (31.067 µg m^{-3}) as shown in figure 2.9.23. Seasonal average was not calculated for post monsoon season due to insufficient data.

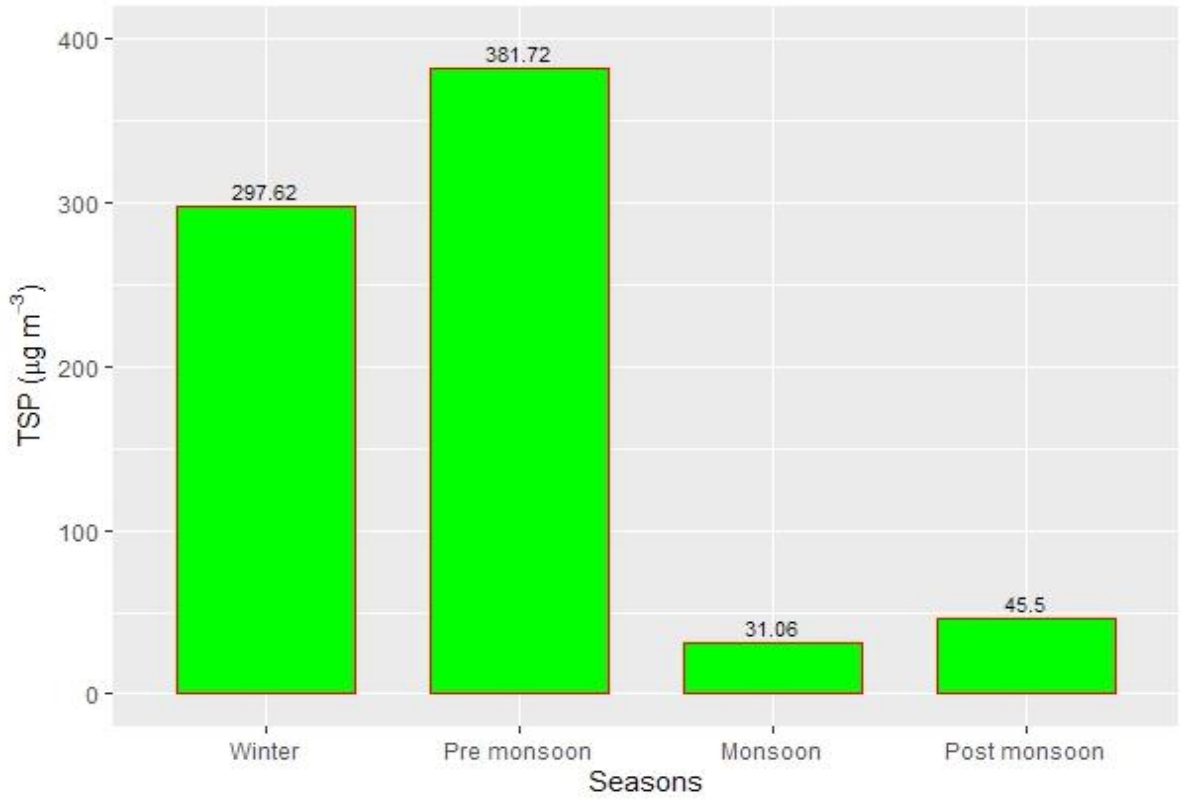


Figure 2.9.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 239 days of measurement, 98 days exceeded the National Ambient Air Quality Standard for TSP. From May to October none of the days exceeded NAAQS of 230 µg m^{-3} (figure 2.9.24).

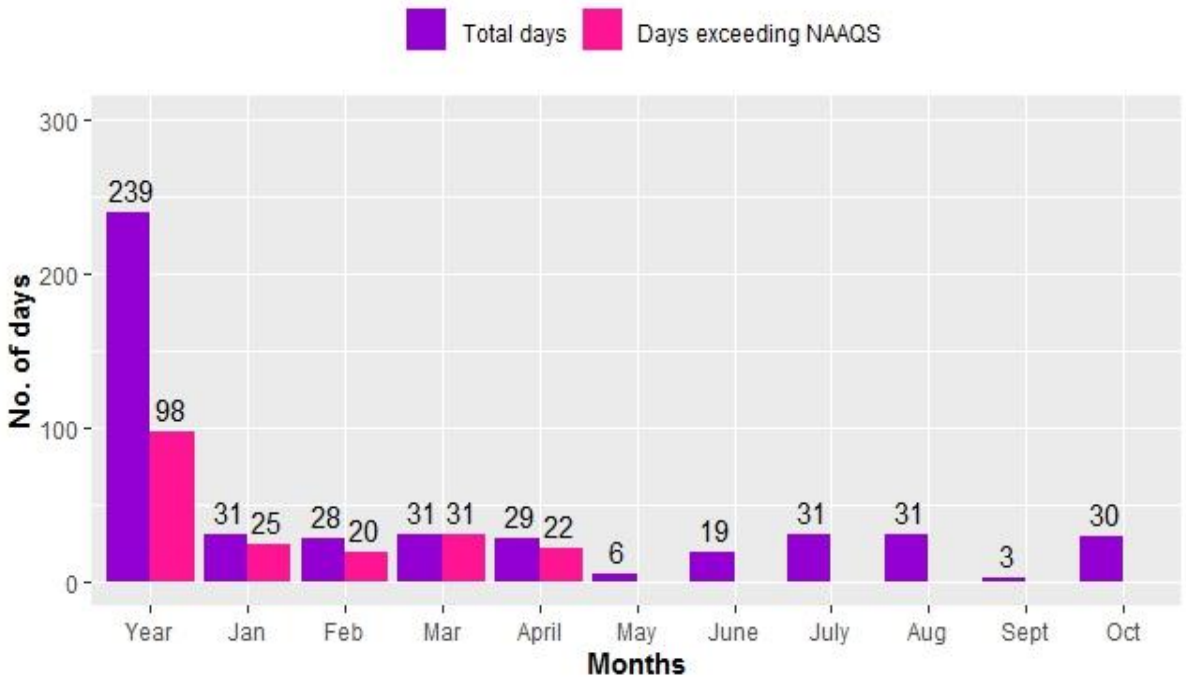


Figure 2.9.24: Compliance status of TSP

Calendar Plot

The following figure shows the calendar plot for $PM_{2.5}$ based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to very unhealthy level in 26-29 of March and 5th and 6th of April and was unhealthy during January, February, March and few days in April.

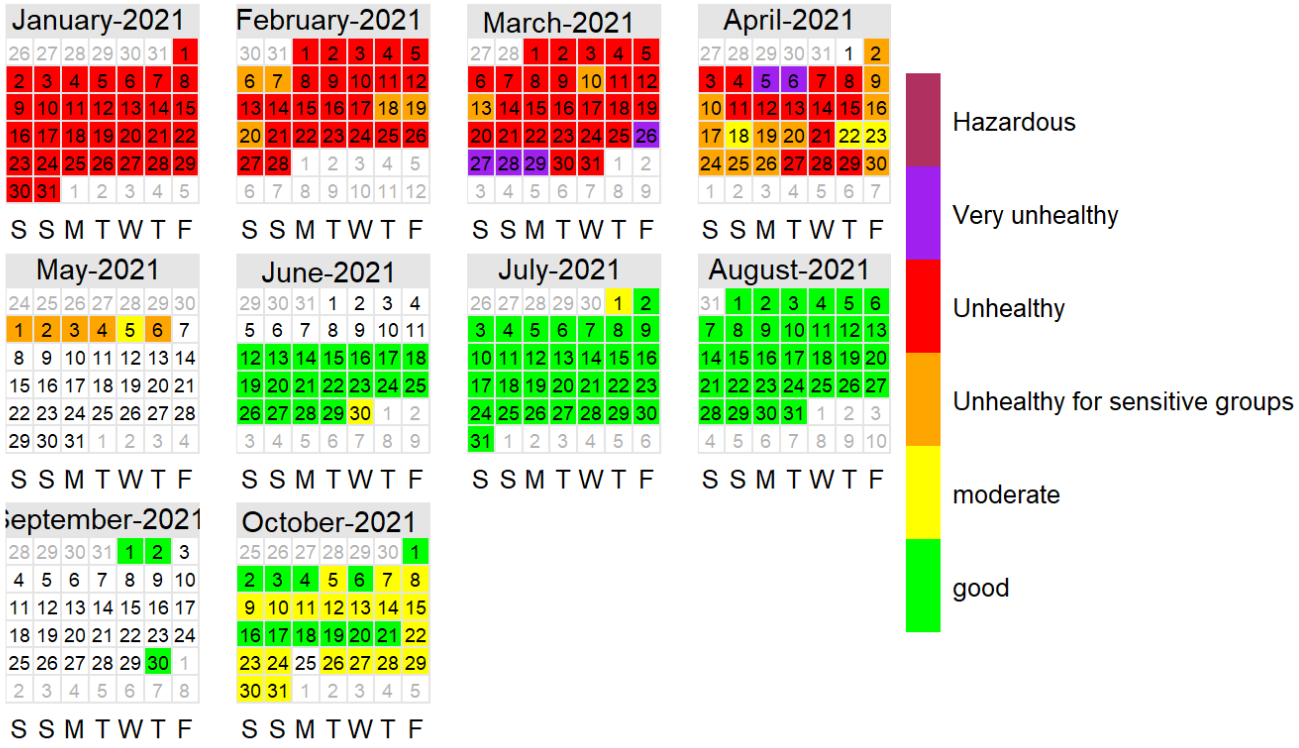


Figure 2.9.25: Calendar plot for $PM_{2.5}$ for the year 2021

2.10 Air quality status – Ratnapark

2.10.1 Introduction

Ratnapark Air Quality Monitoring Station was established in the year 2016. It lies in inside Shankhadhar park near Rani Pokhari. This station lies on the heart of the Kathmandu. So, it represents the urban area. Hence the major source of air pollution in this area is vehicles and commercial activities.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Nos of instruments
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

Besides particulate matter this station has equipment's for measuring gases pollutant and black carbon also. However, in this report we have analysed data of Particulate matter only.

2.10.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Ratnapark Station was observed to range from 1 to 1475.8 µg m^{-3} (Figure 2.10.1). The mean of the $PM_{2.5}$ point data was observed to be 47.43 µg m^{-3}.

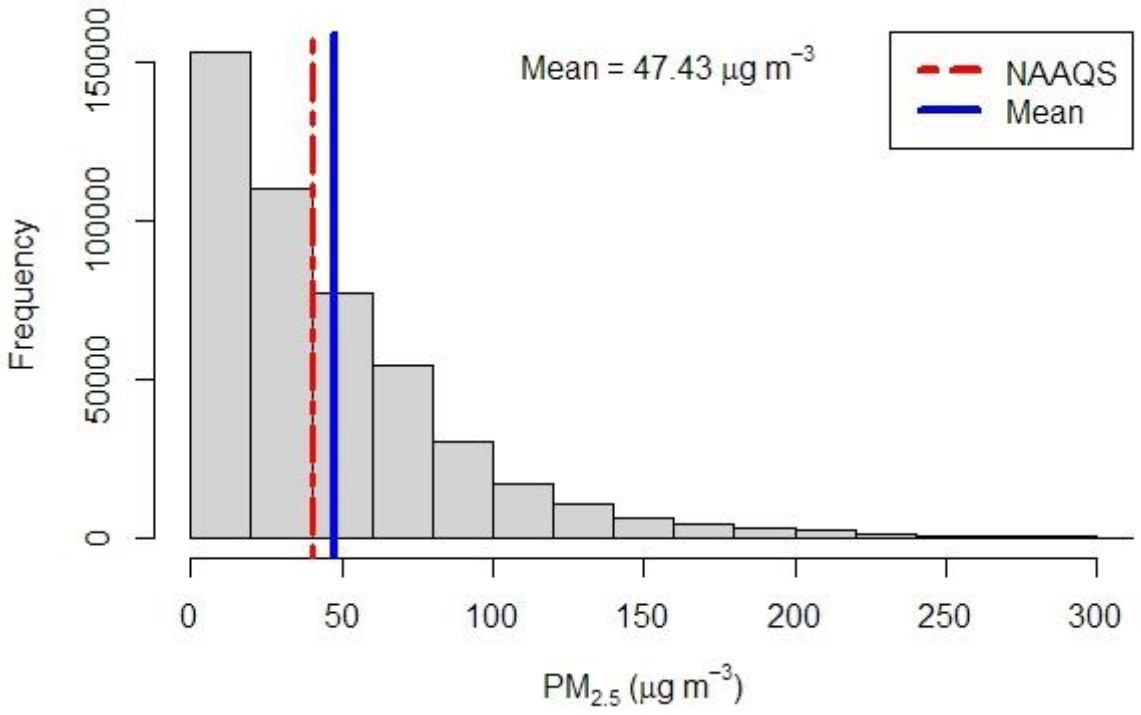


Figure 2.10.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.10.2 shows $PM_{2.5}$ peaks at 7 AM to 8 AM and at 8 PM to 11 PM. The mean value is found to be more than the median throughout the day.

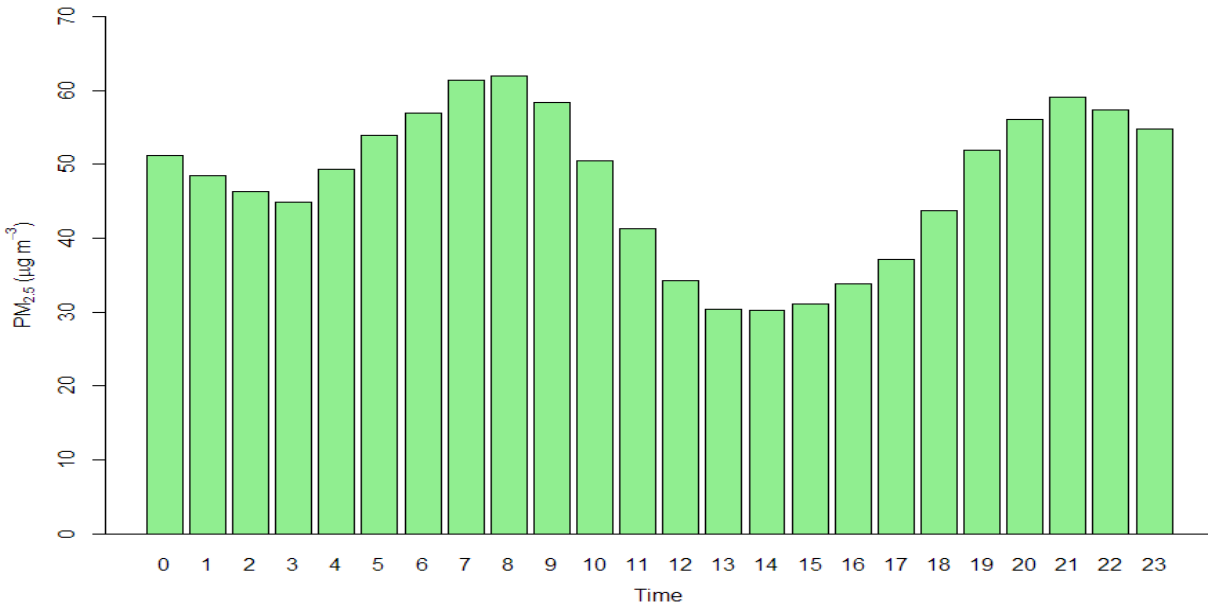


Figure 2.10.2: Hourly average of $PM_{2.5}$

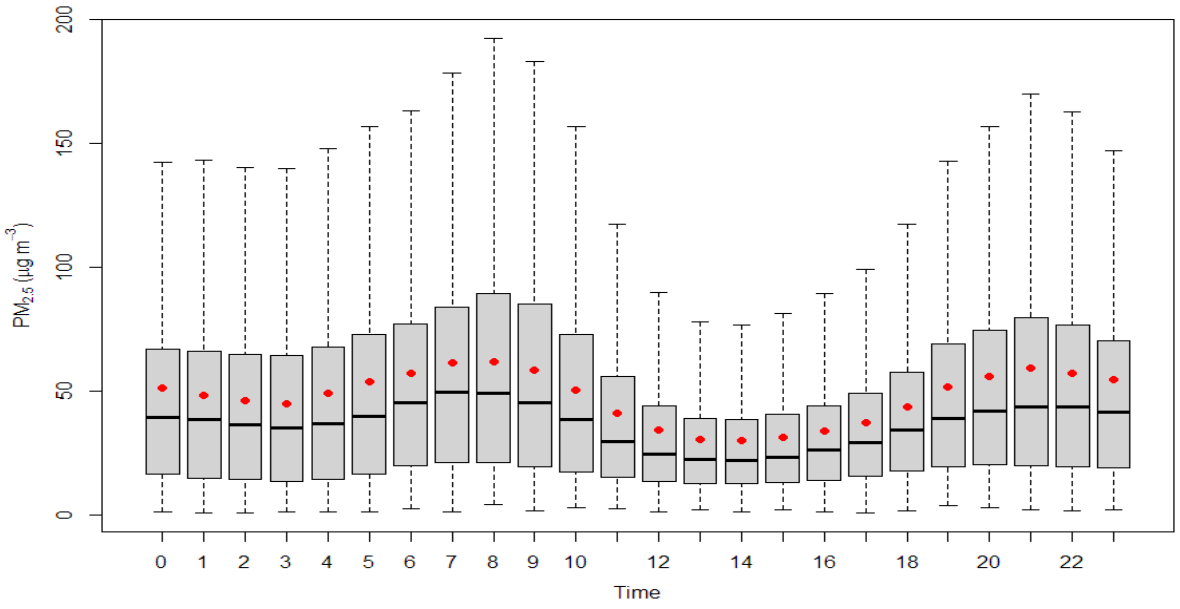


Figure 2.10.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variations of $PM_{2.5}$ is shown in figure 2.10.4. Higher concentration can be seen during January and April whereas lower concentration was observed during monsoon and post-monsoon season.

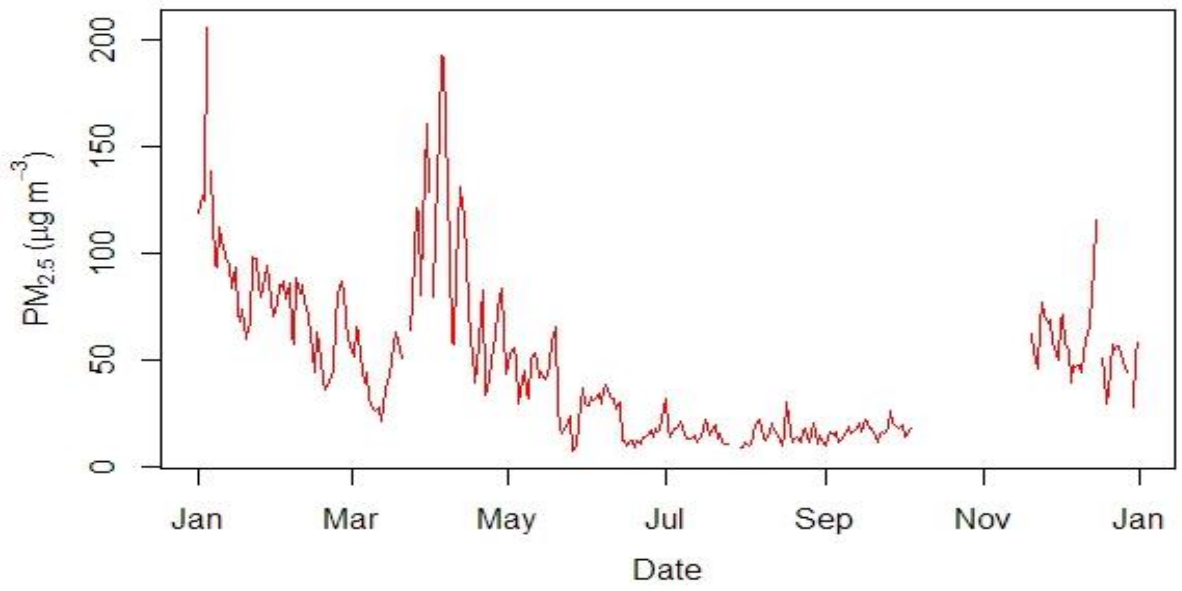


Figure 2.10.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during January and April whereas less during June to October. The mean value was found more than median during January, February, March, April and December.

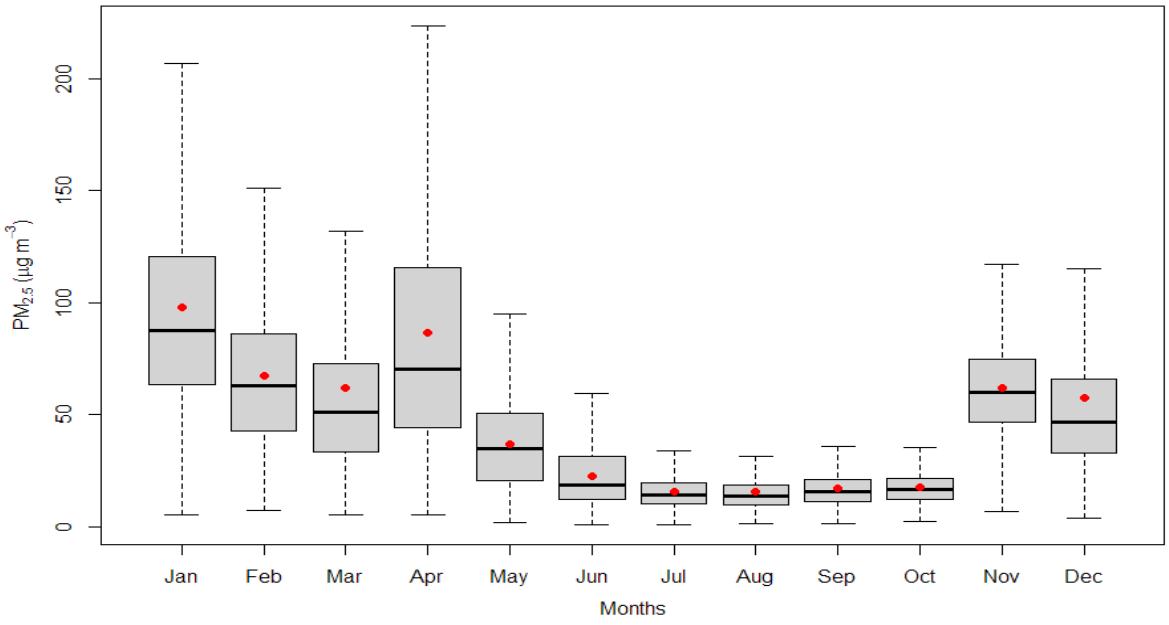


Figure 2.10.5: Monthly variation of $PM_{2.5}$

The monthly average of January was found to be highest (95.09 µg m^{-3}) and that of July and August was found to be lowest (15.49 µg m^{-3}) while comparing with other months as shown in figure 2.10.6 below. Monthly average was not calculated for October and November due to insufficient data.

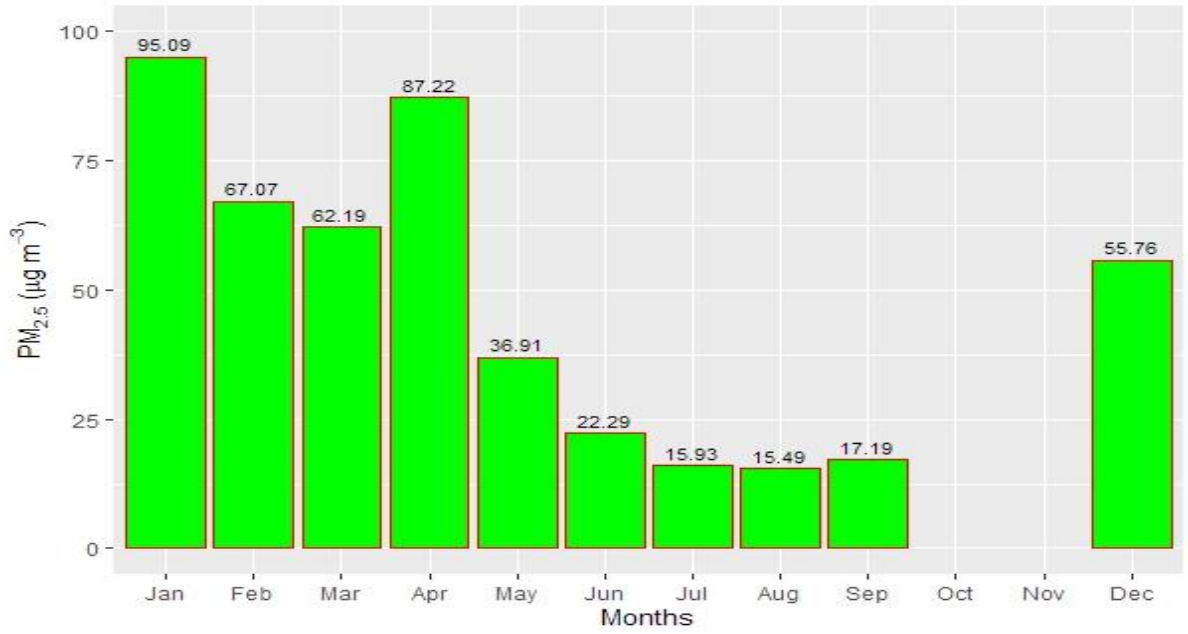


Figure 2.10.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during the winter season (85.2 µg m^{-3}) and the lowest during the monsoon season (17.75 µg m^{-3}) as in figure 2.10.7. Seasonal average was not calculated for post monsoon season due to insufficient data.

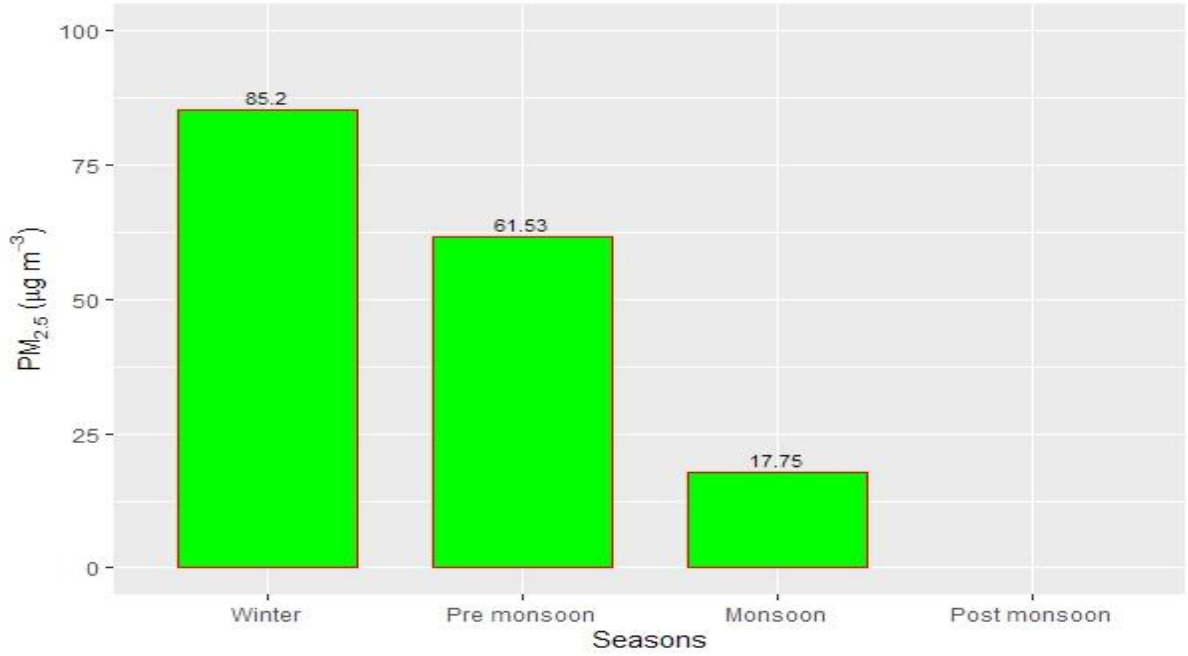


Figure 2.10.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 309 days of measurement, 153 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$. From June to October none of the days exceed NAAQS of 40 µg m^{-3} as shown in figure 2.10.8.

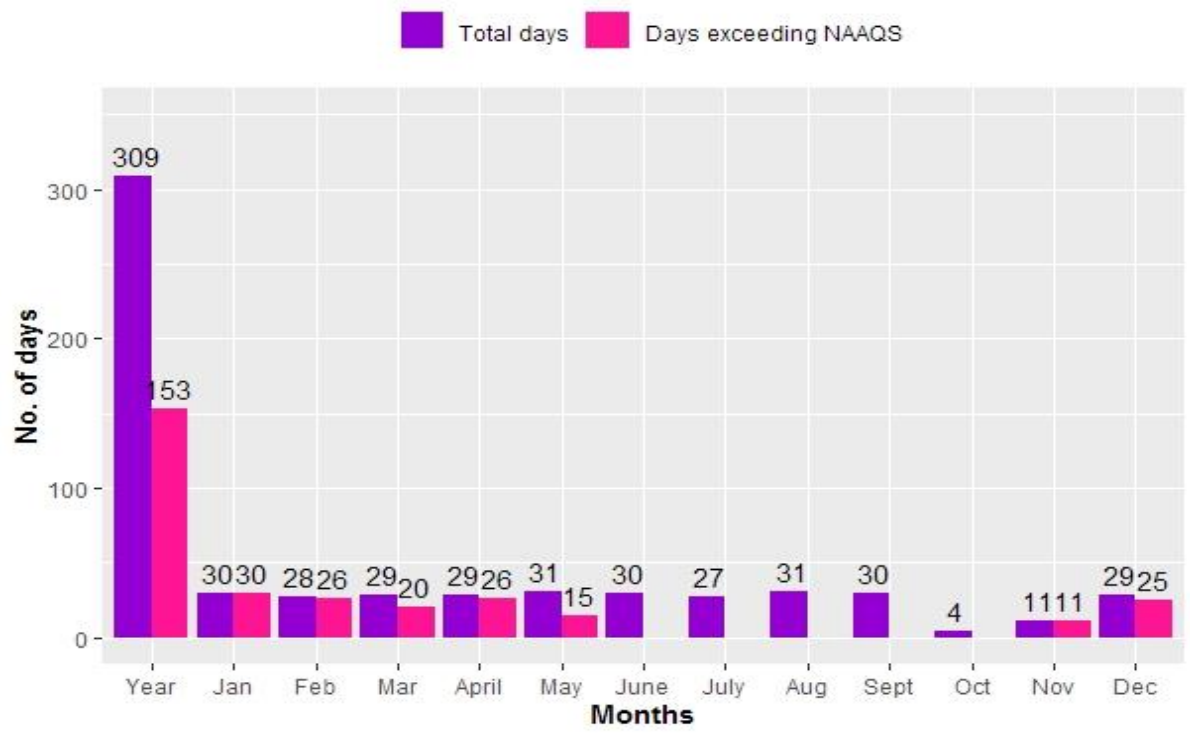


Figure 2.10.8: Compliance status of $PM_{2.5}$

2.10.3 PM_{10}

Histogram

PM_{10} in Ratnapark Station was observed to range from 1 to 2945.2 µg m^{-3} (Figure 2.10.9). The mean of the PM_{10} point data was observed to be 78.36 µg m^{-3}.

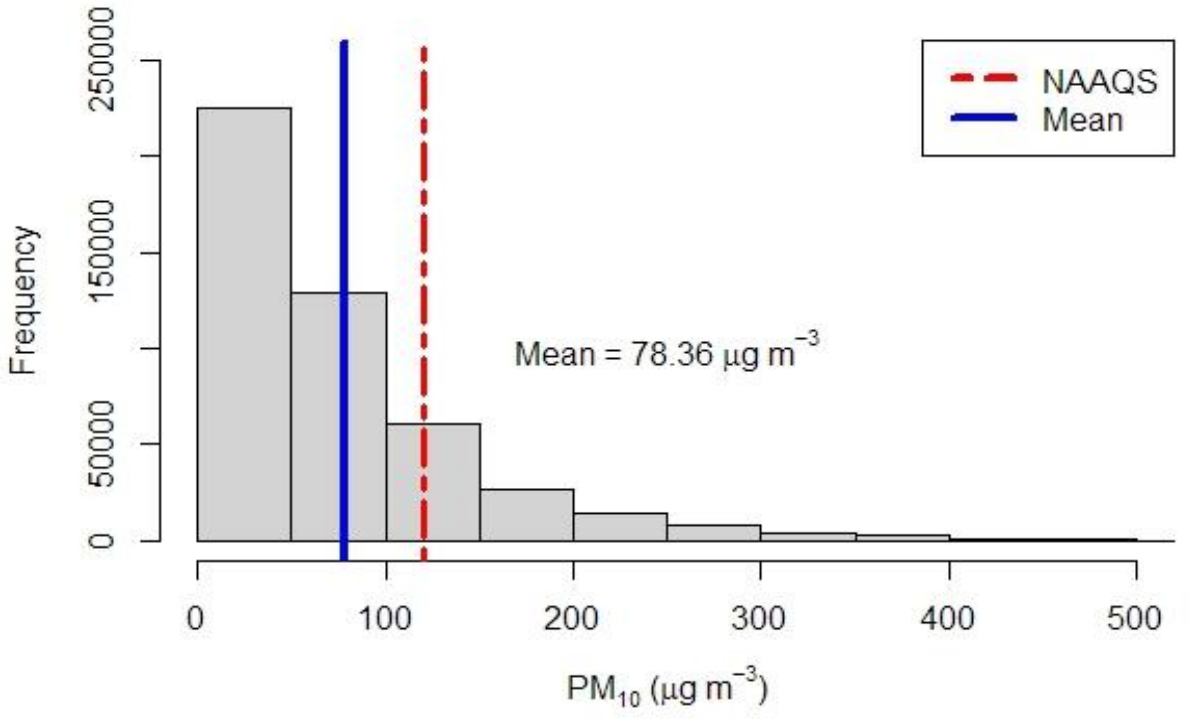


Figure 2.10.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.10.10 shows PM_{10} starts falling from 12 AM then reaches lowest at 3 AM then starts rising and peaks at 9 PM then starts falling slowly till 5 PM and starts again rising peaks at 9 PM then again starts falling.

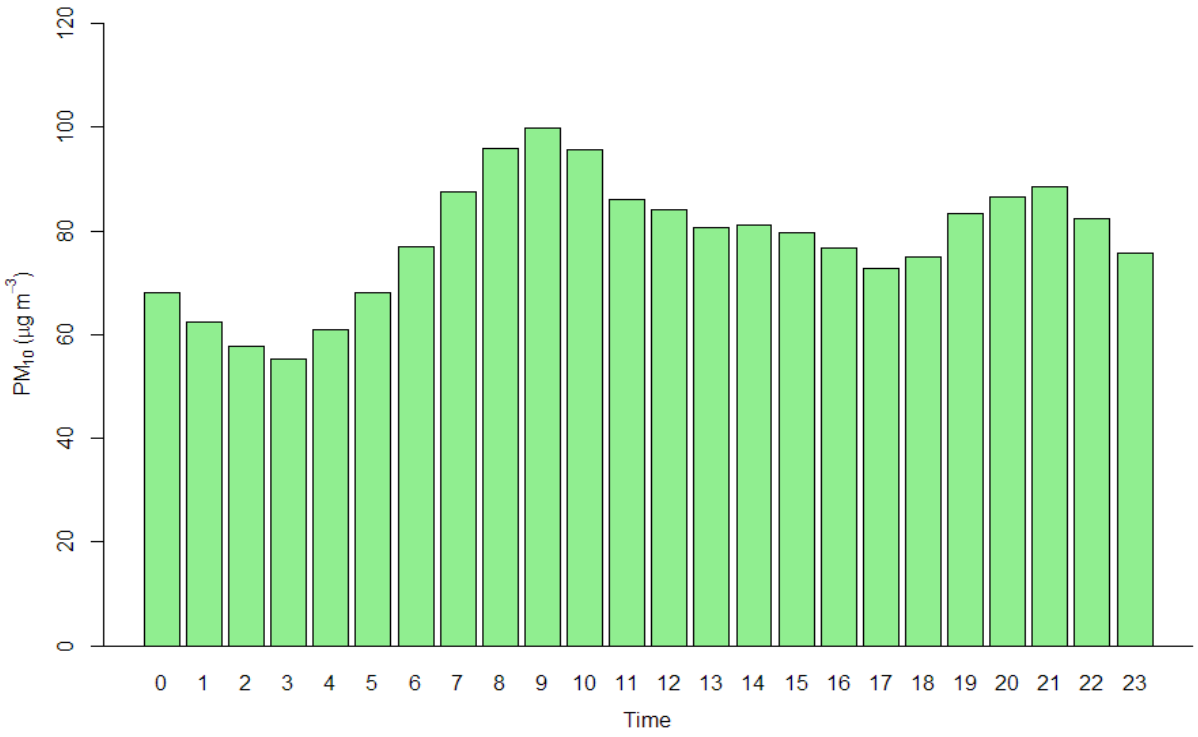


Figure 2.10.10: Hourly average of PM_{10}

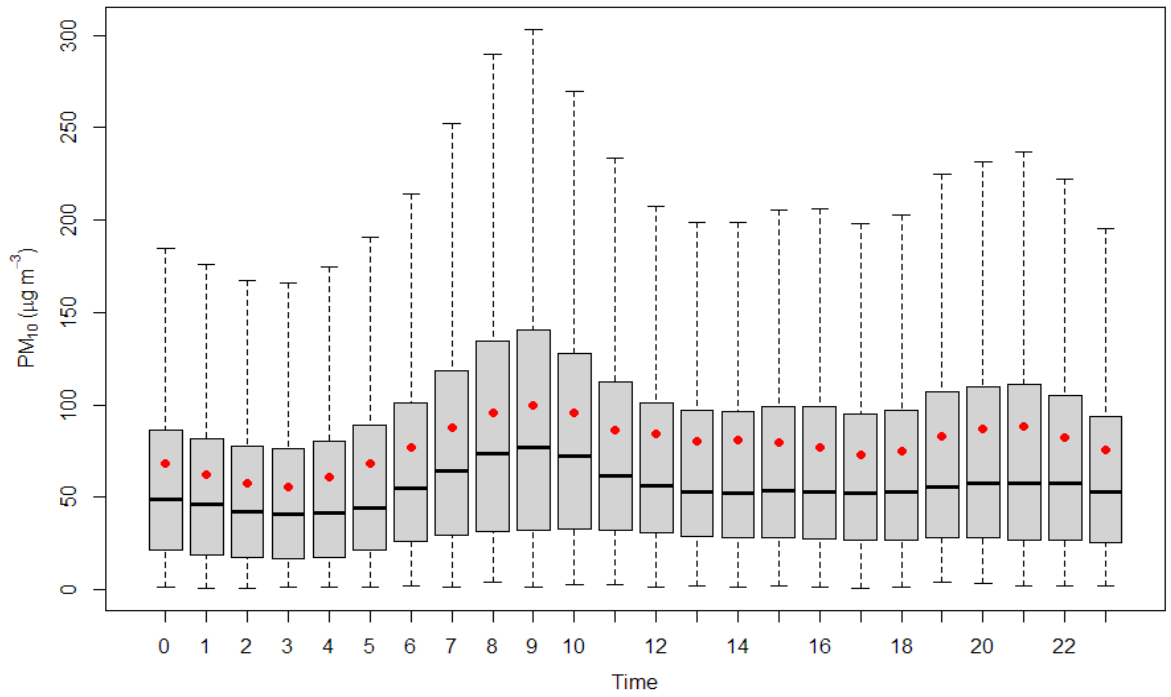


Figure 2.10.11: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.10.12. Higher concentration can be seen during January and April whereas lower concentration was observed during monsoon and post monsoon season.

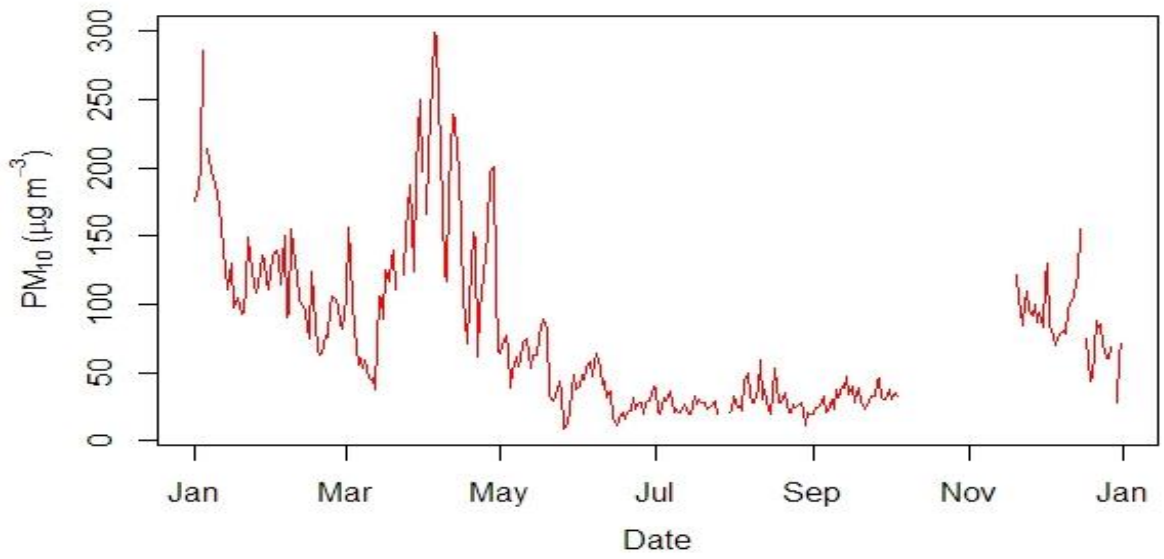


Figure 2.10.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly $PM_{10,}$ the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during January and April whereas less during May to October. The mean value was found more than the median during January, February, March, April, November and December.

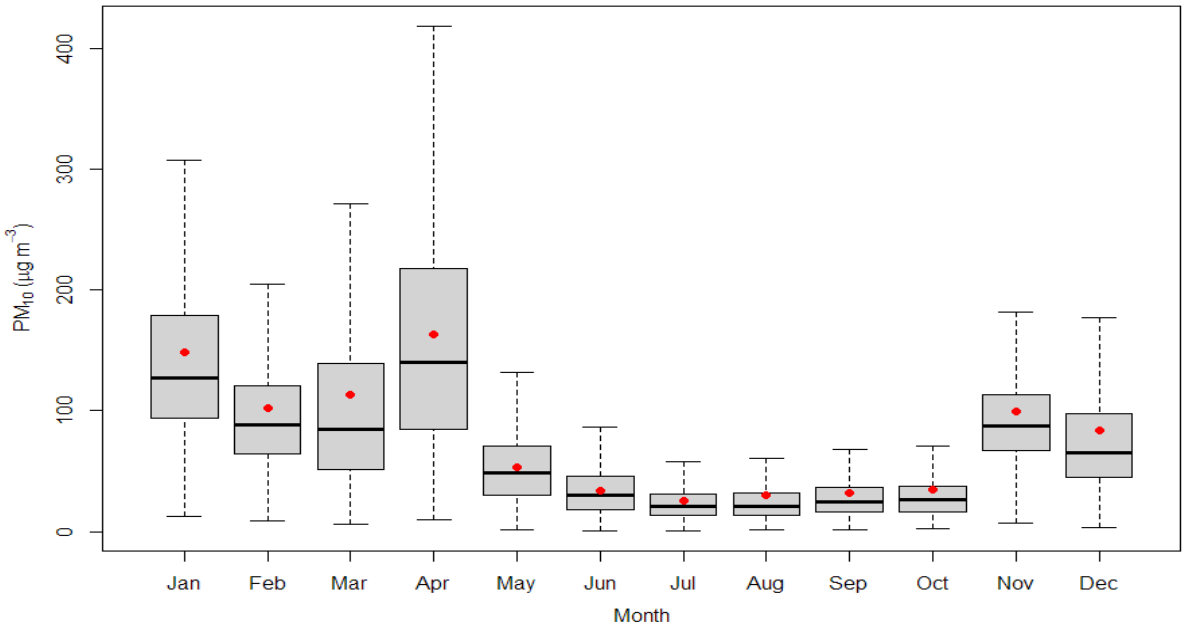


Figure 2.10.13: Monthly variation of PM_{10}

The monthly average for April was found the highest (165.08 µg m^{-3}) and that of July was found lowest (25.78 µg m^{-3}) while comparing with other months as shown in figure 2.10.14. The monthly average was not calculated for October and November due to insufficient data.

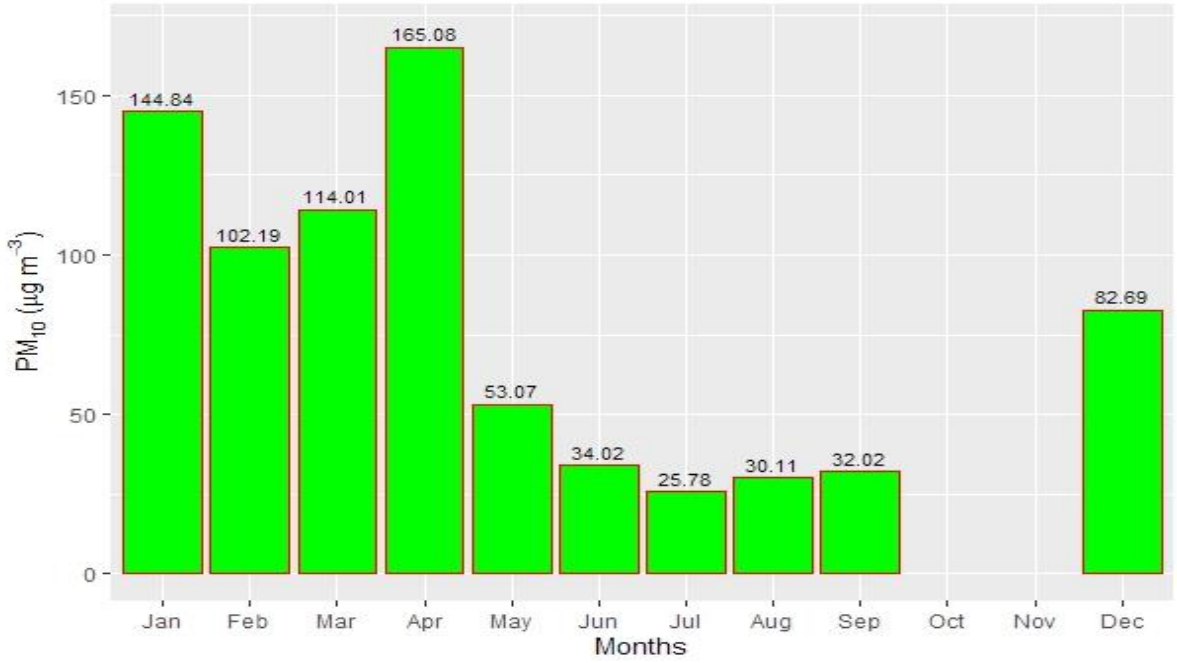


Figure 2.10.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during winter season (130.16 µg m^{-3}) and the lowest during monsoon season (30.59 µg m^{-3}) as in figure 2.10.15. Seasonal average was not calculated for post monsoon season due to insufficient data.

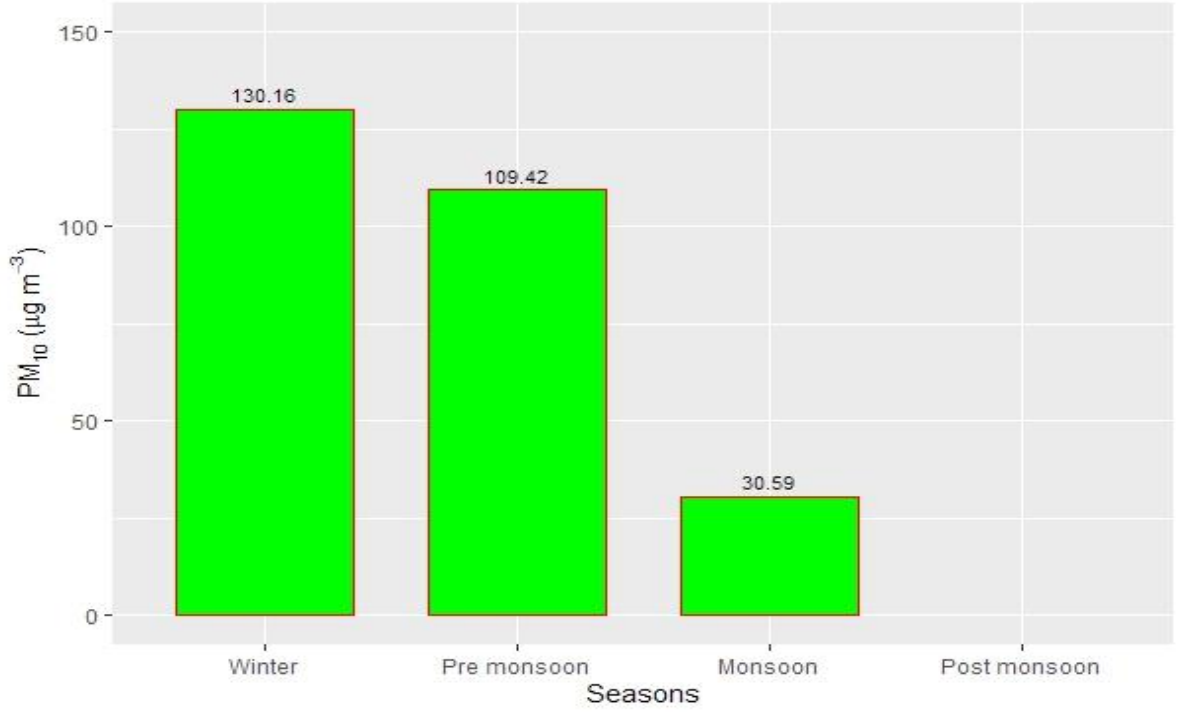


Figure 2.10.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 309 days of measurement, 62 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. From May to October none of the days exceed NAAQS as shown in figure 2.10.16.

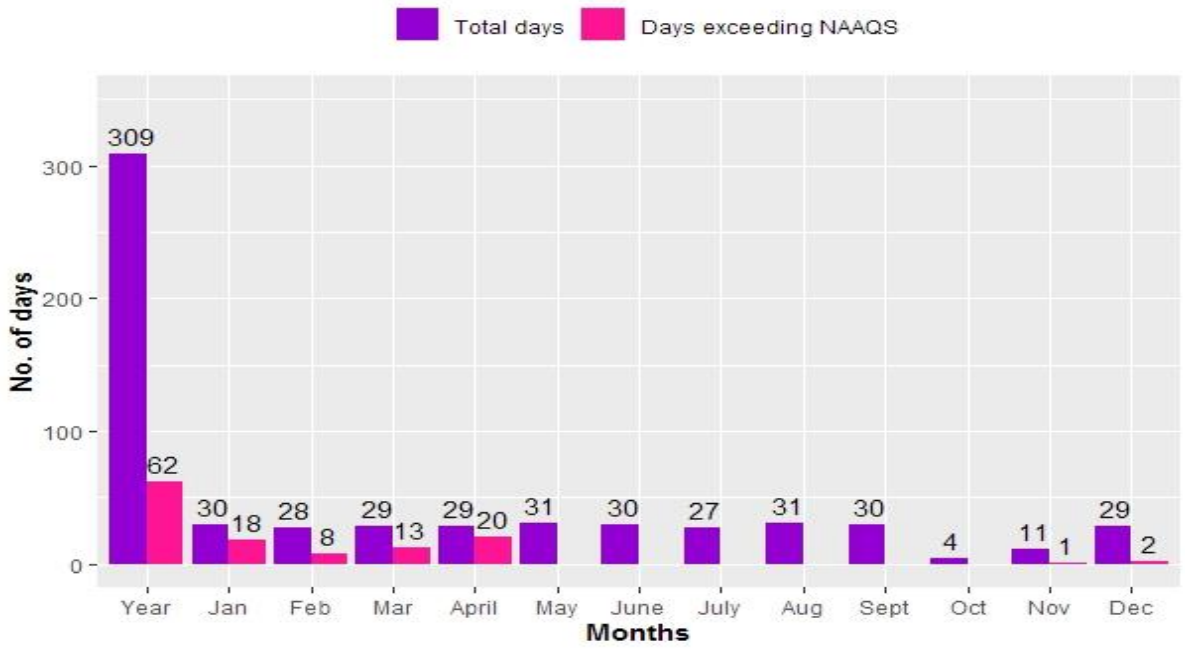


Figure 2.10.16: The compliance status of PM_{10}

2.10.4 TSP

Histogram

TSP in Ratnapark Station was observed to range from 1 to 4997.2 µg m^{-3} (Figure 2.10.17). The mean of the TSP point data was observed to be 159.15 µg m^{-3}.

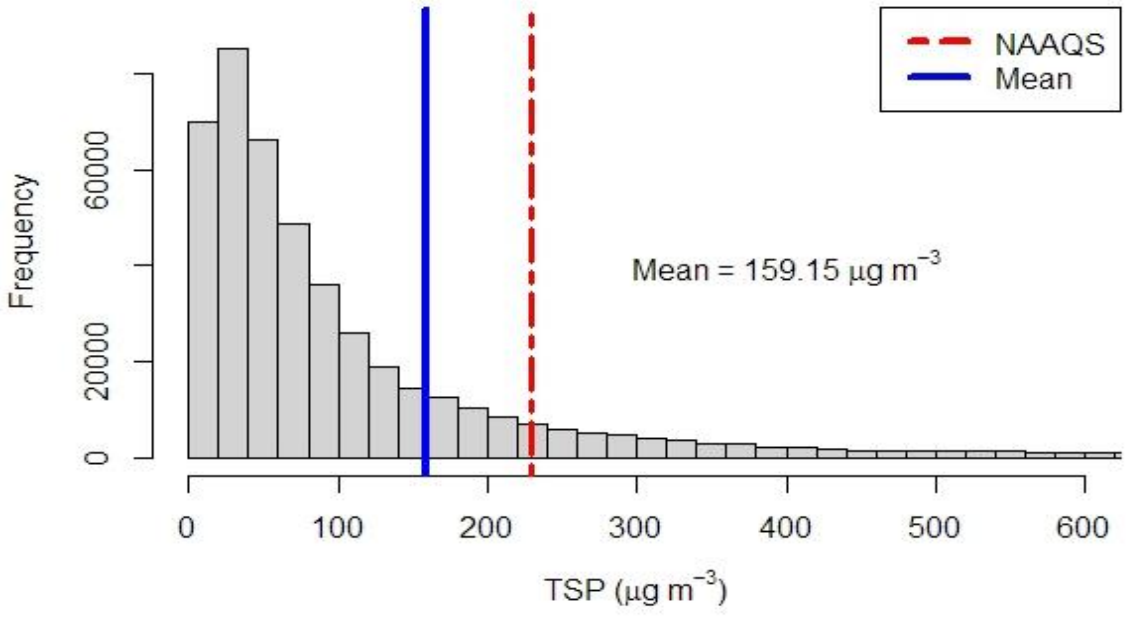


Figure 2.10.17: Histogram of TSP

Diurnal Variation

The Figure 2.10.18 shows TSP peaks at 1 PM and 2 PM. During day time the mean is much higher compared to the median value.

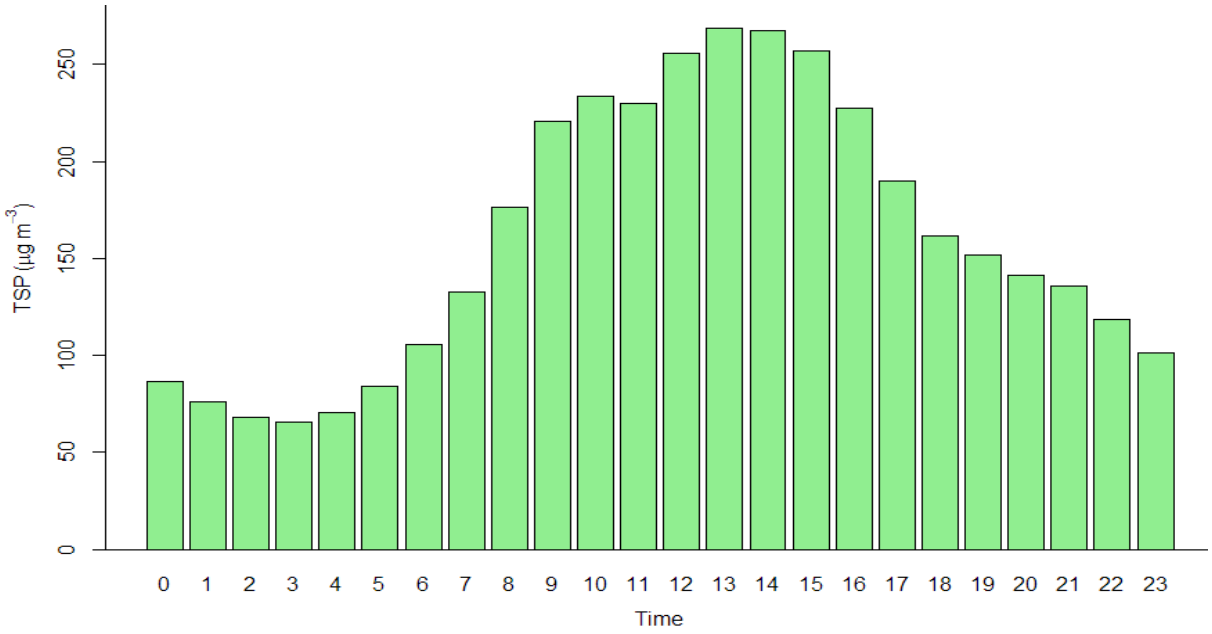


Figure 2.10.18: Hourly average of TSP

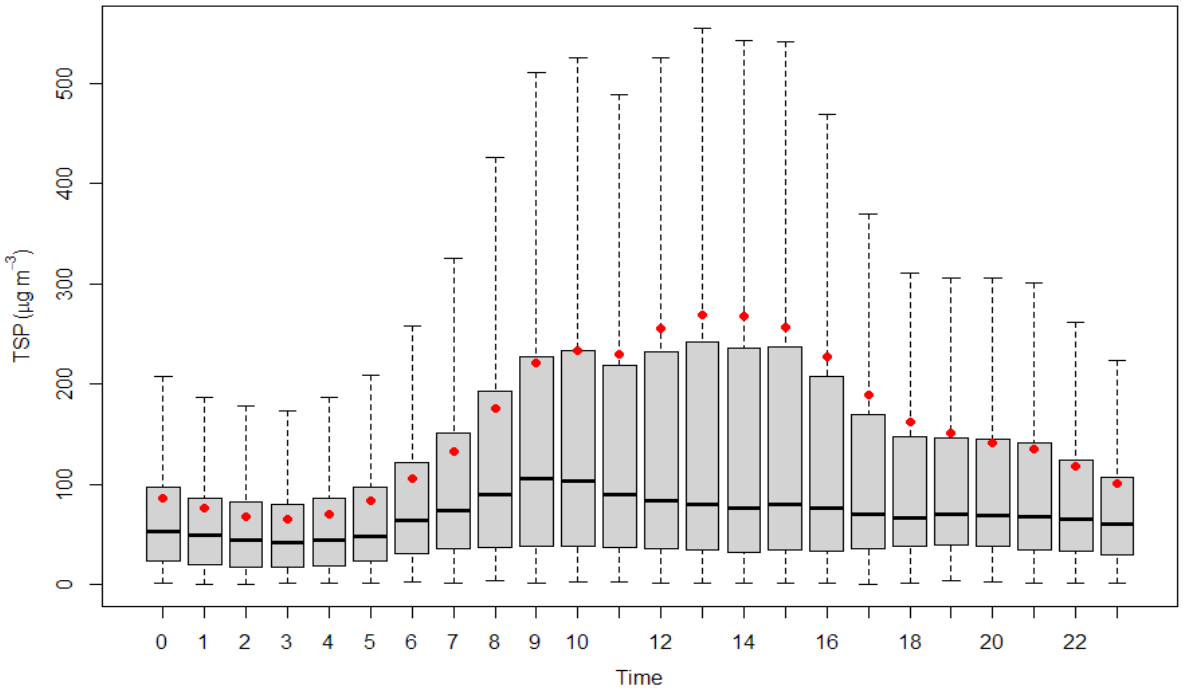


Figure 2.10.19: Diurnal variation of TSP

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.10.20. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post monsoon season.

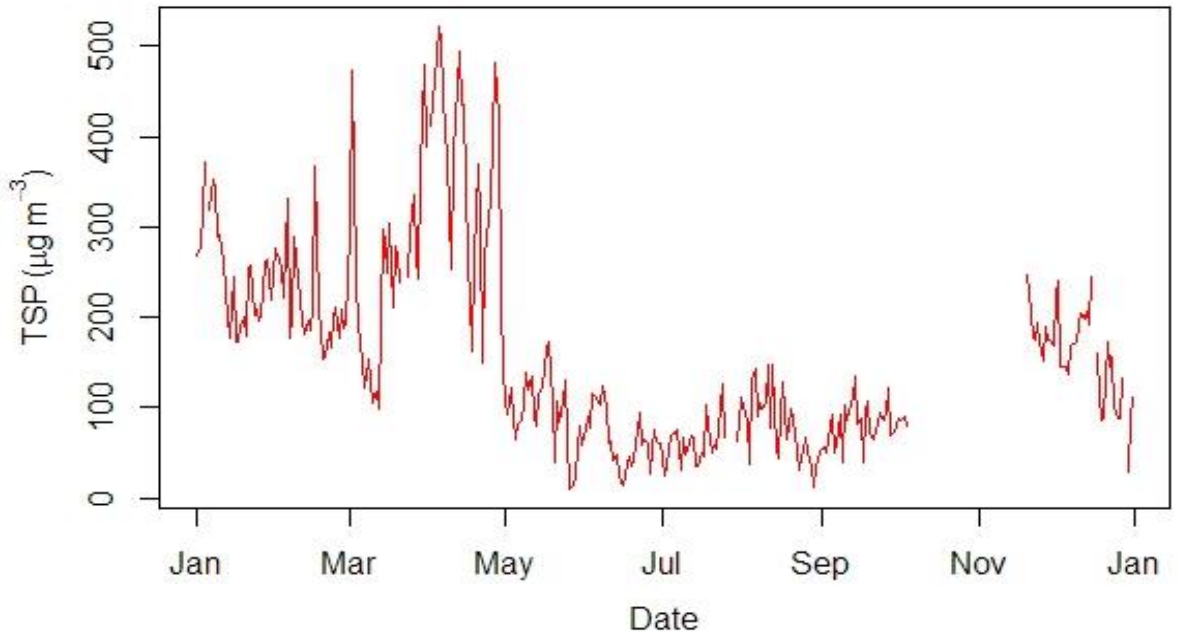


Figure 2.10.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during April whereas less during May to October. The mean value was found more than median in every month.

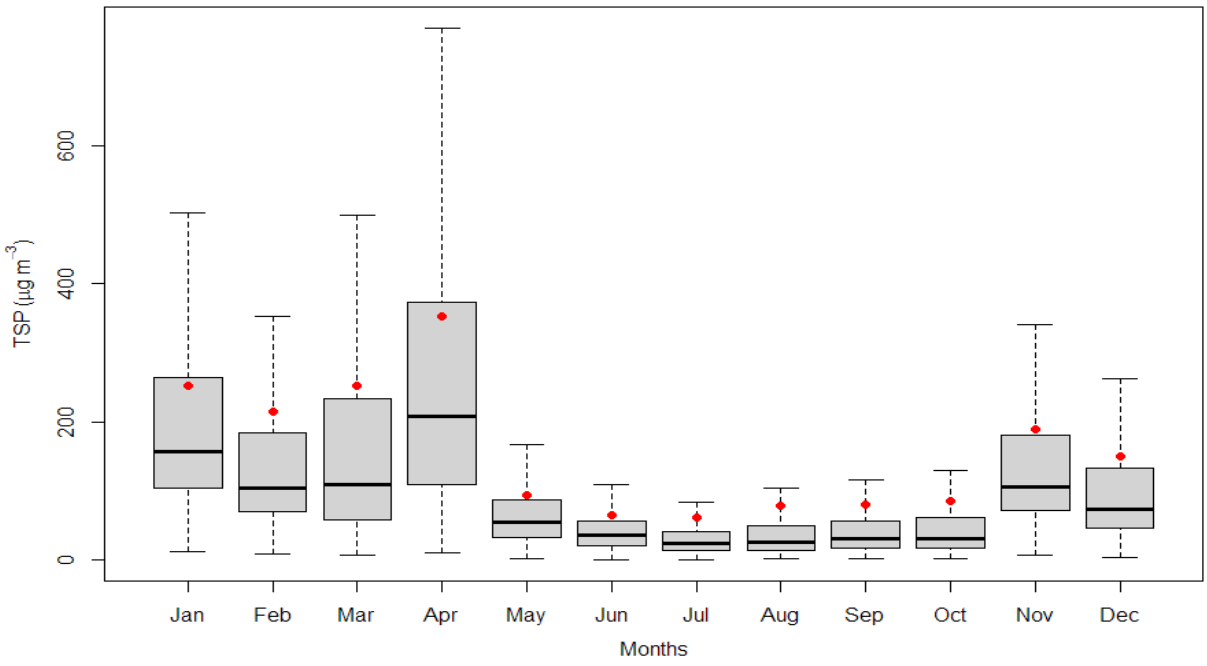


Figure 2.10.21: Monthly Box plot of TSP

The monthly average for April was found to be the highest (354 µg m^{-3}) and that of July was found to be the lowest (61.39 µg m^{-3}) while comparing with other months as shown in figure 2.10.22.

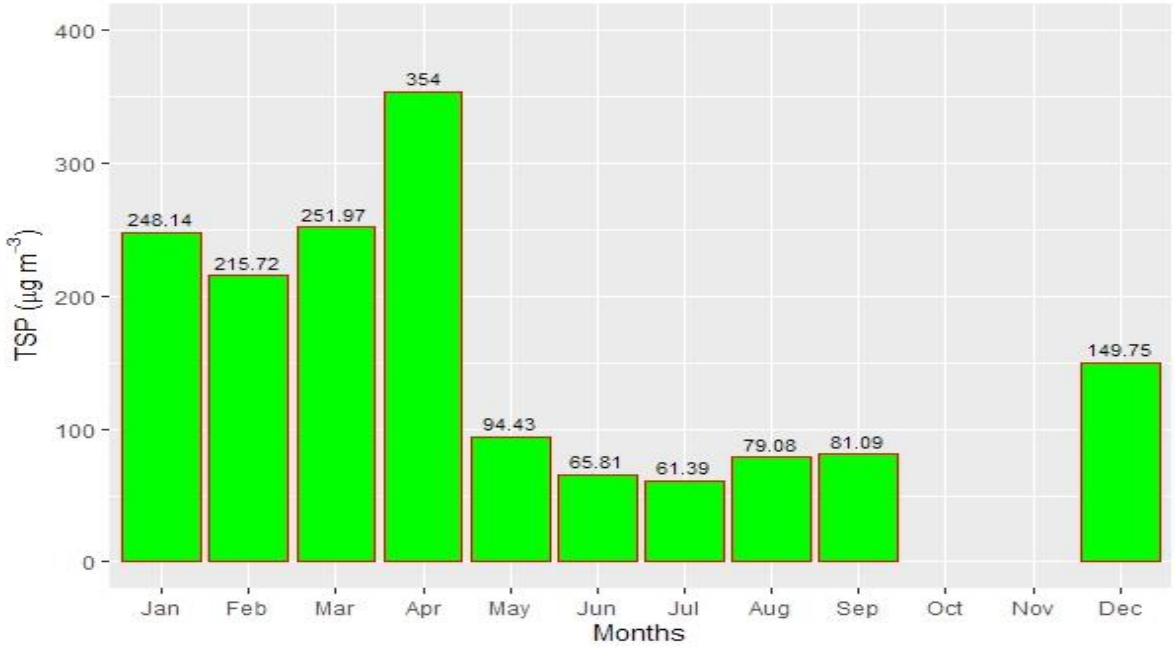


Figure 2.10.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during the winter season (236.62 µg m^{-3}) and the lowest during the monsoon season (72.16 µg m^{-3}) as in figure 2.10.23. Seasonal average for post monsoon season was not calculated due to insufficient data.

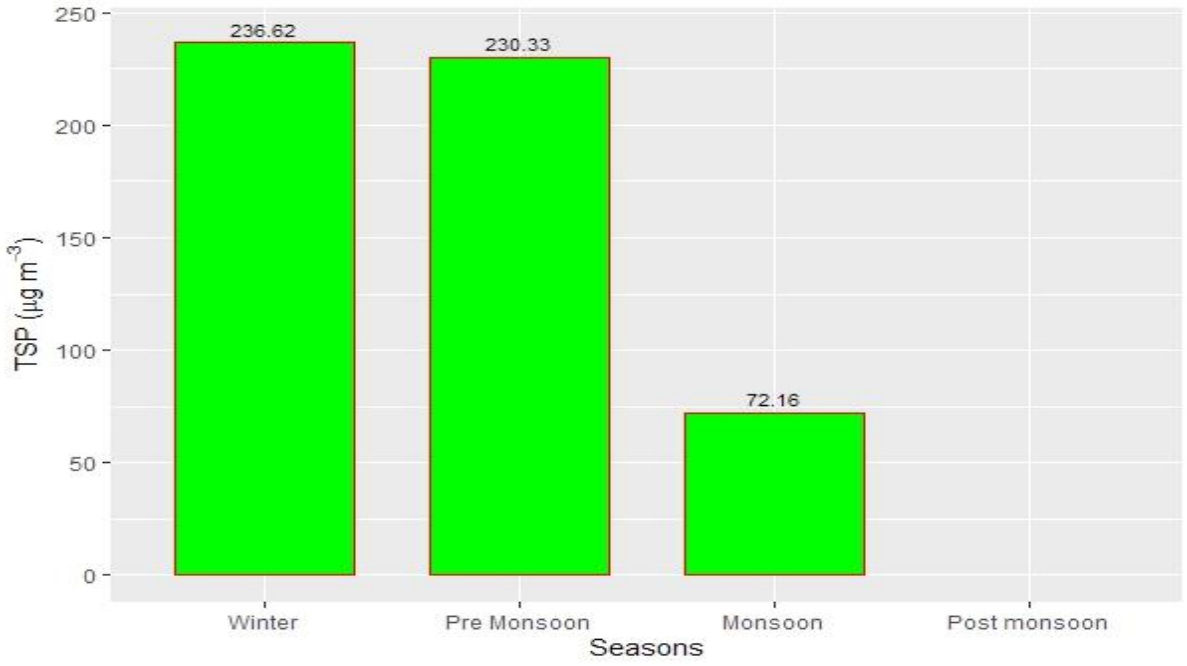


Figure 2.10.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 309 days of measurement, 70 days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}. From May to October none of the days exceed NAAQS as shown in figure 2.10.24.

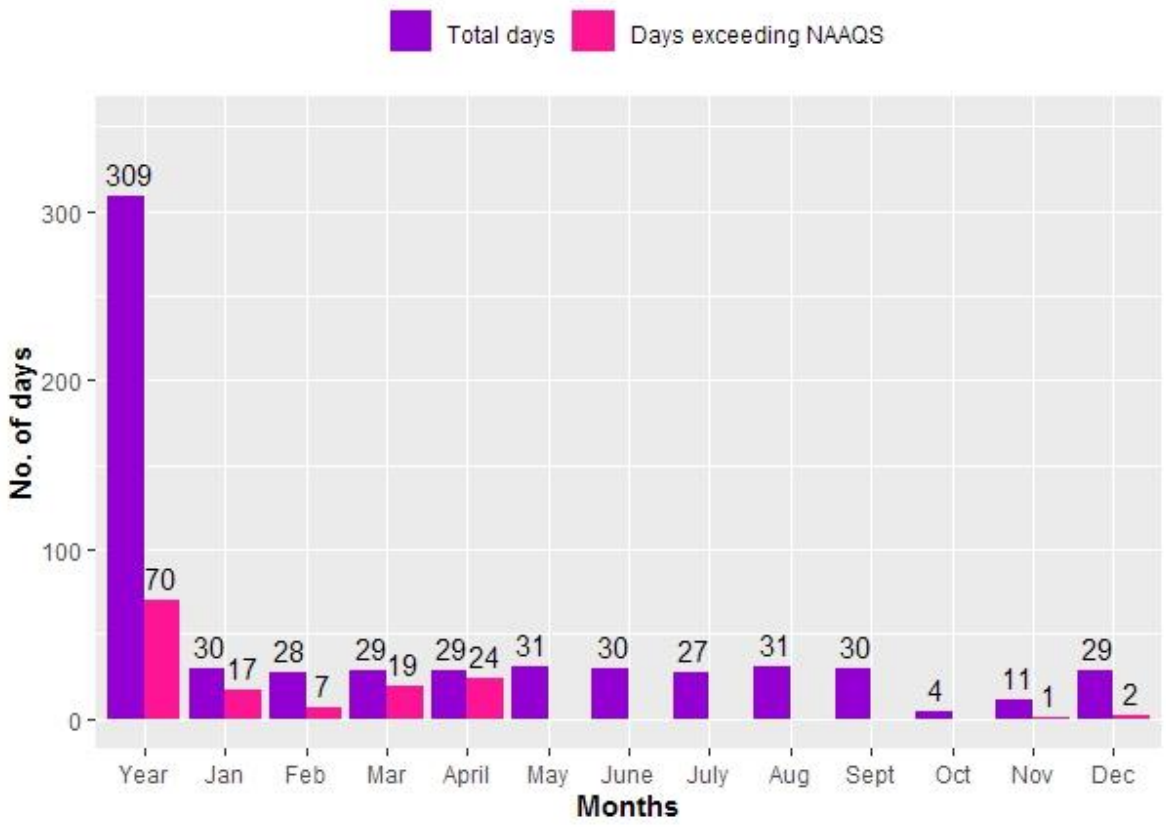


Figure 2.10.24: Compliance status of TSP

Annual Average

The annual average of $PM_{2.5}$, PM_{10} and TSP is shown in figure 2.10.25.

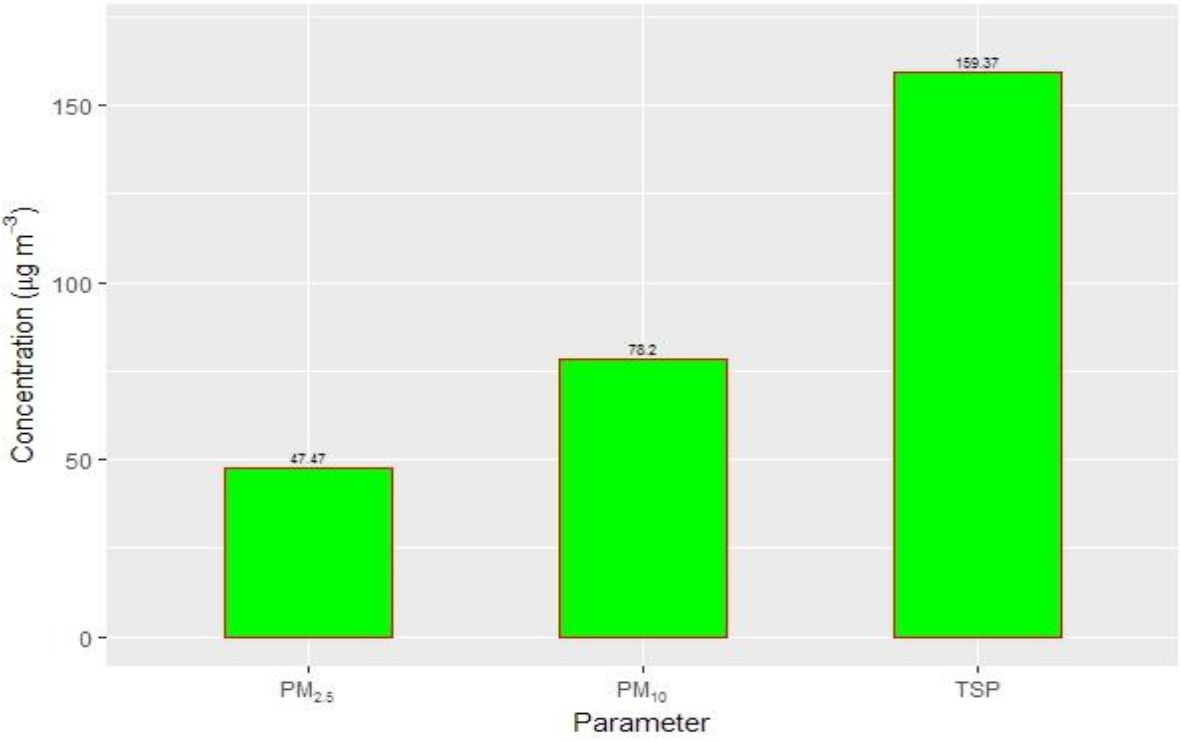


Figure 2.10.25: Annual average of $PM_{2.5}$, PM_{10} and TSP

Calendar Plot

Calendar plot is prepared for PM $_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to very unhealthy level in 4th of January, 30th of March and 5th to 7th of April and was unhealthy during January, February, and few days in March, April, November and December.

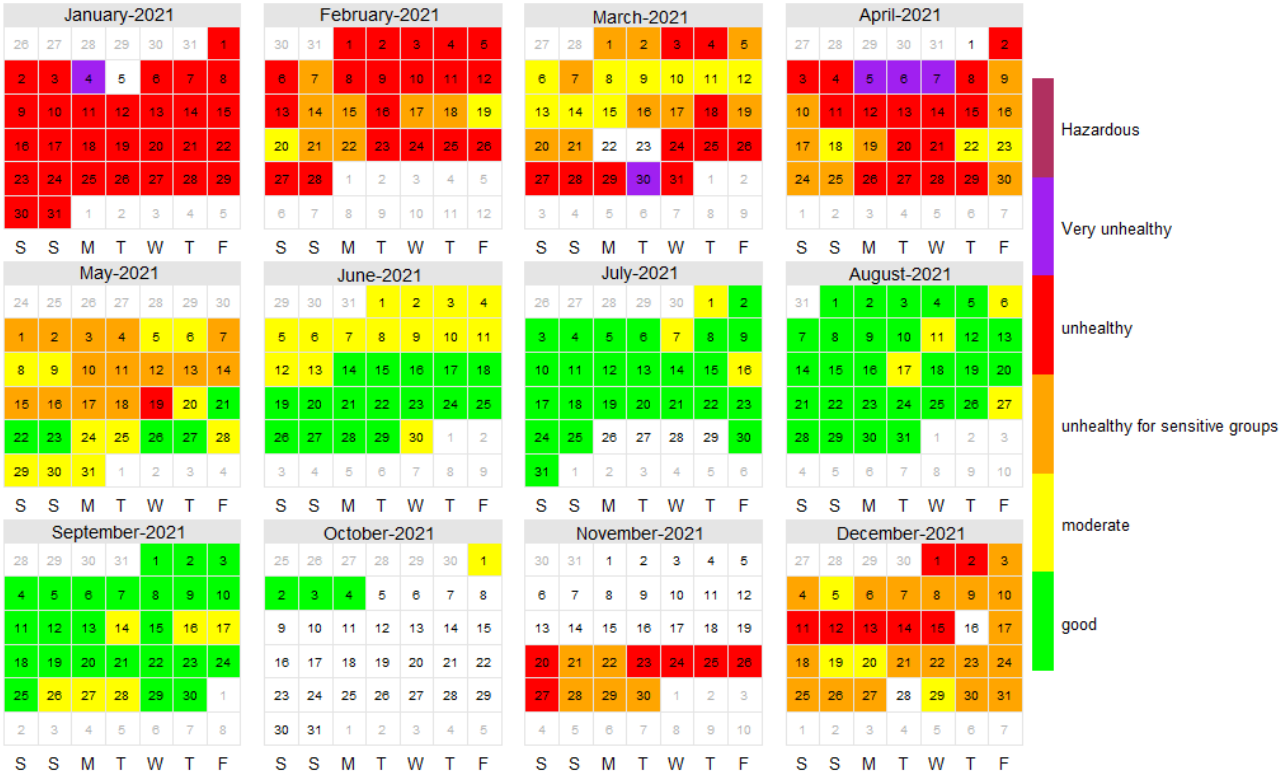


Figure 2.10.26: Calendar plot for $PM_{2.5}$ for the year 2021

2.11 Air quality status –Tribhuvan University

2.11.1 Introduction

TU Air Quality Monitoring Station was established in the year 2016. It lies in inside the premises of Tribhuvan university (TU) near DHM weather station. It represents the background area. The major source of air pollution in this area is vegetation burning.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.11.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in TU Station was observed to range from 1 to 1376.8 µg m^{-3} (Figure 2.11.1). The mean of the $PM_{2.5}$ point data was observed to be 44.57 µg m^{-3}.

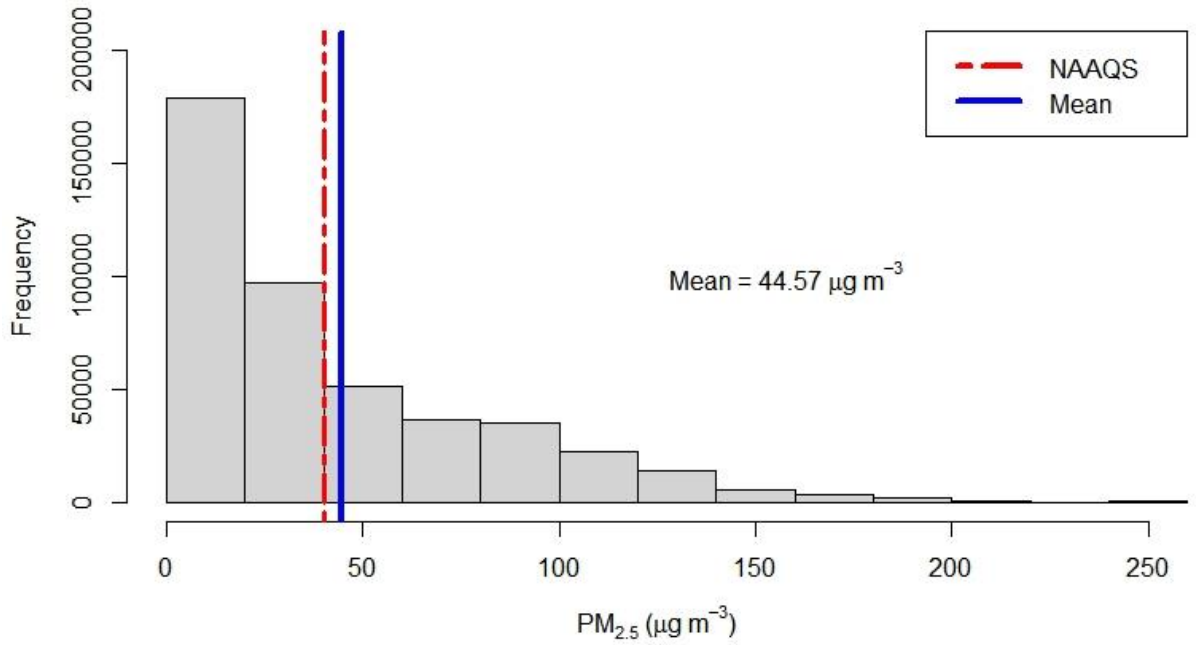


Figure 2.11.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.11.2 shows $PM_{2.5}$ peaks at 7 AM to 8 AM and at 8 PM to 10 PM. The mean value is found to be more than the median throughout the day.

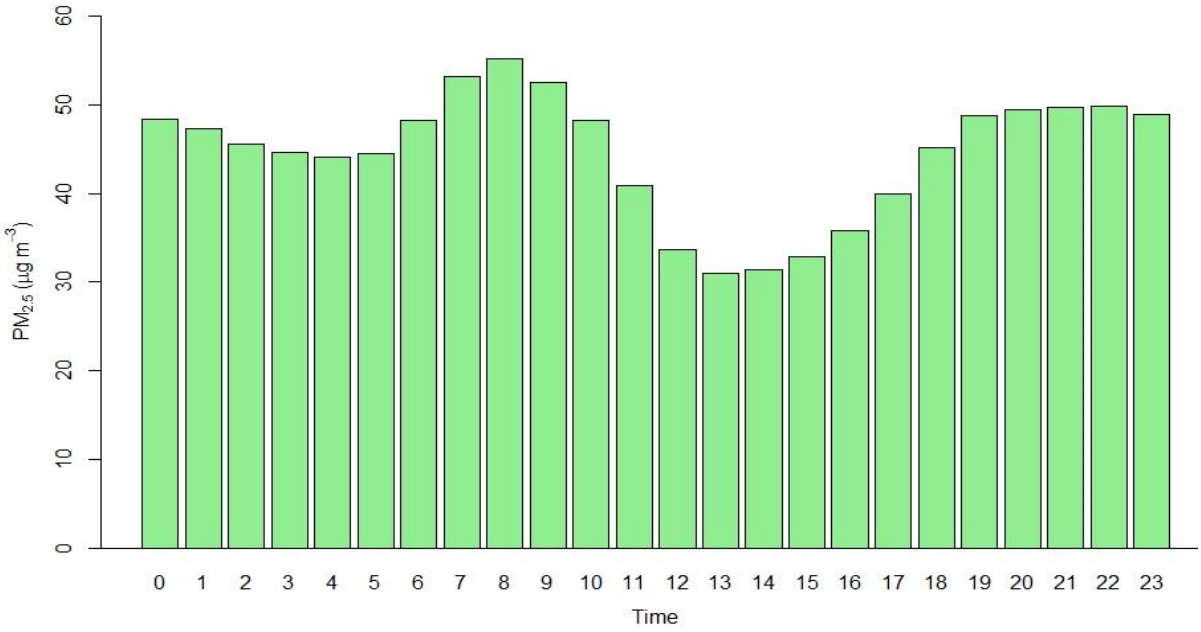


Figure 2.11.2: Hourly average of $PM_{2.5}$

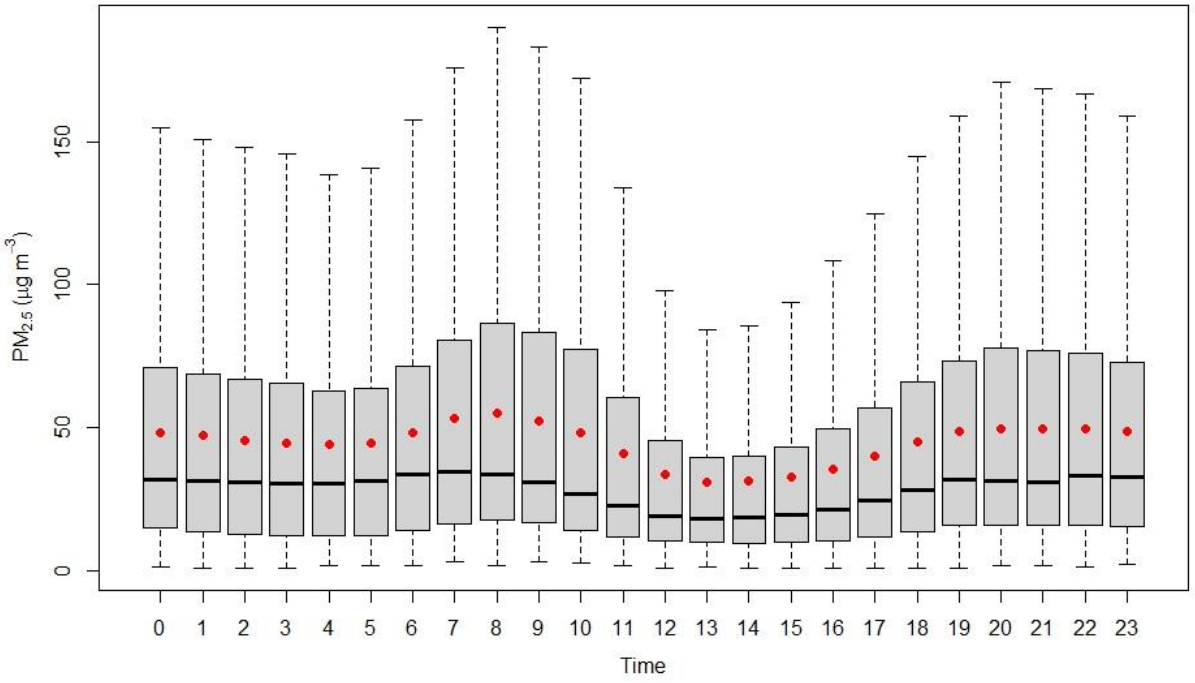


Figure 2.11.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variations of $PM_{2.5}$ is shown in figure 2.11.4. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post-monsoon season.

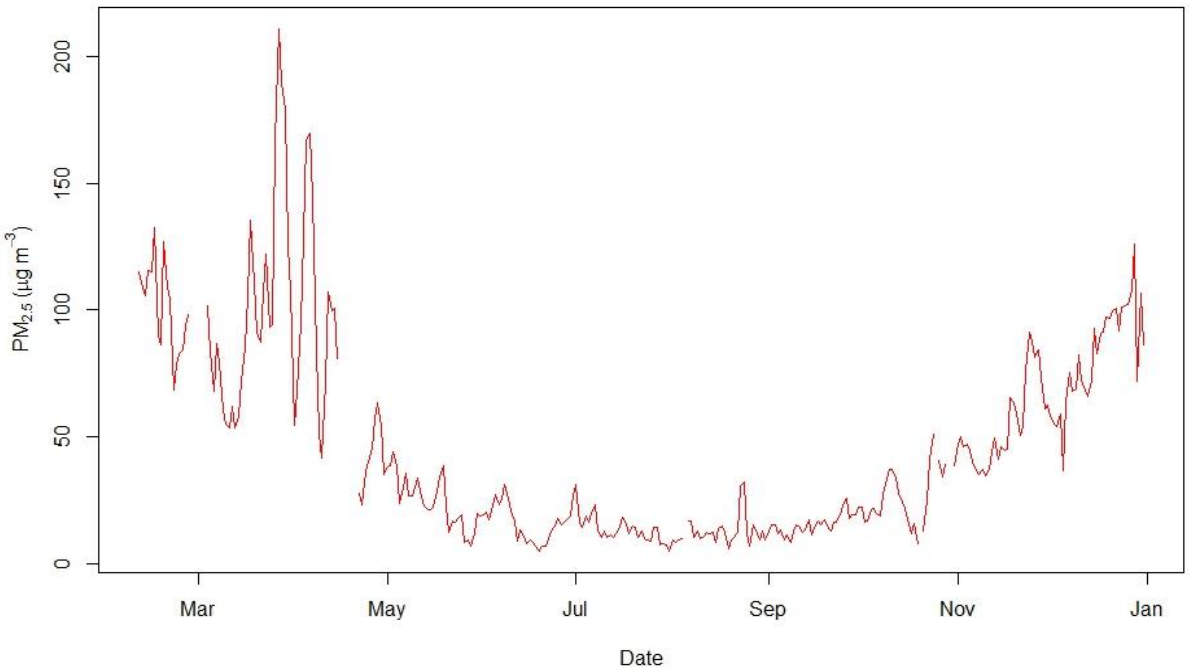


Figure 2.11.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during March and April whereas less during July and August. The mean value was found more than median during March and April.

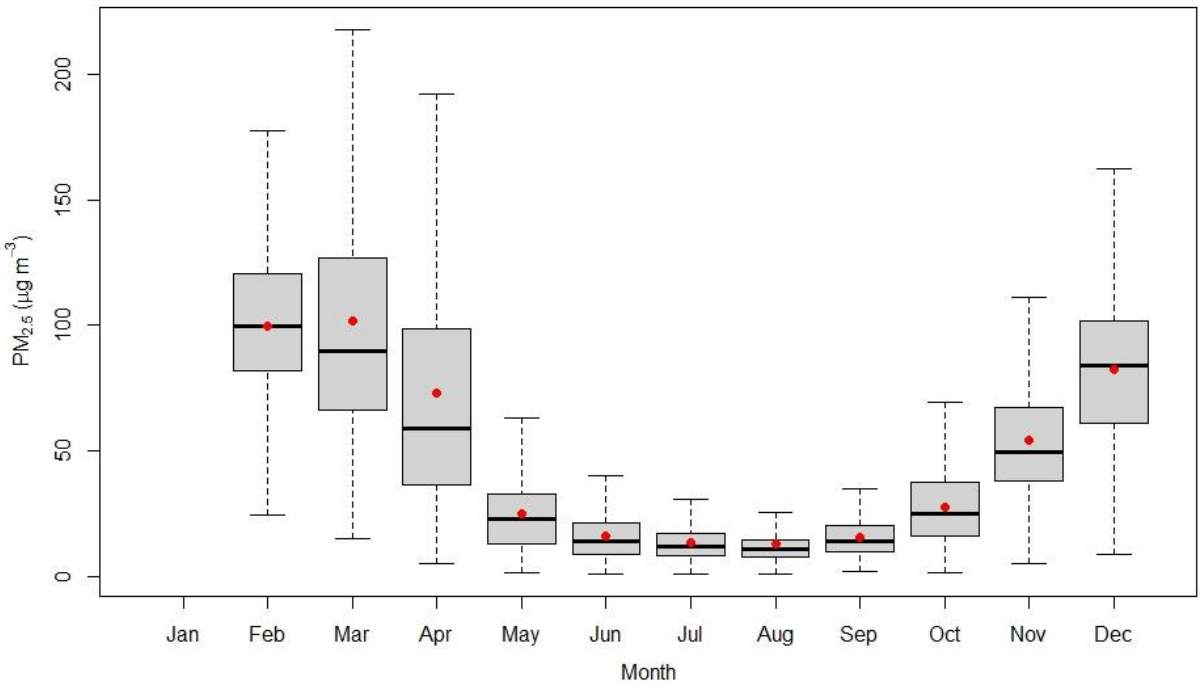


Figure 2.11.5: Monthly variation of $PM_{2.5}$

The monthly average of March was found to be highest (101.66 µg m^{-3}) and that of August was found to be lowest (12.85 µg m^{-3}) while comparing with other months as shown in figure 2.11.6 below. Monthly average was not calculated for January due to insufficient data.

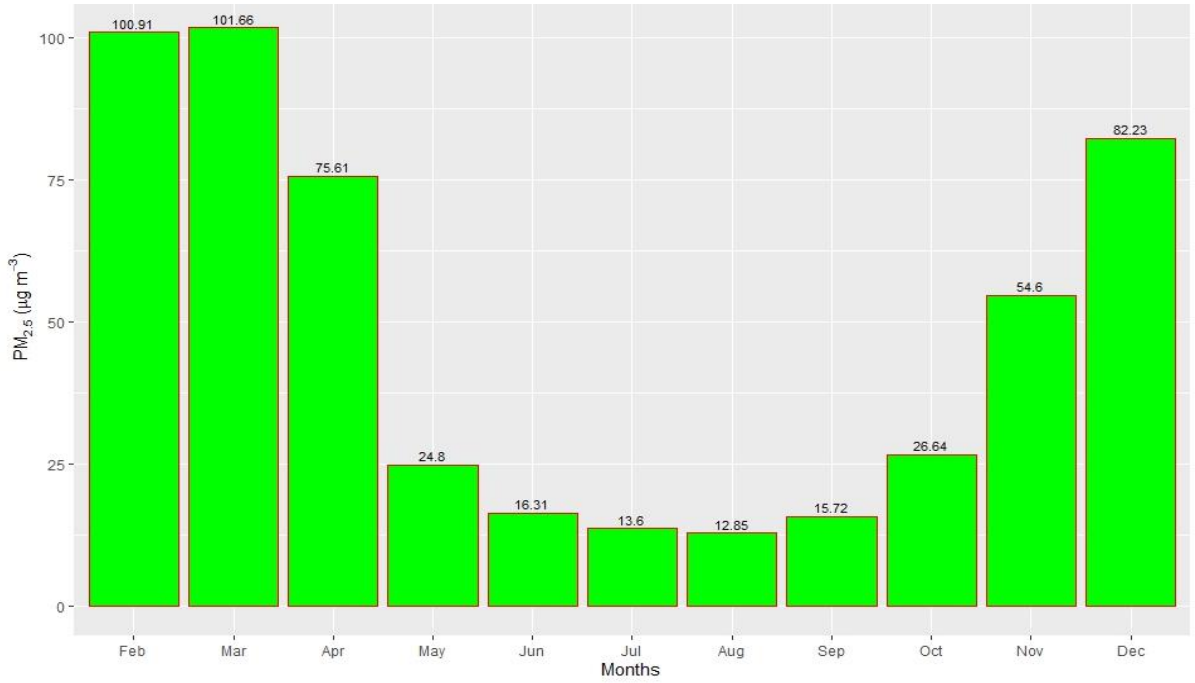


Figure 2.11.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during the pre-monsoon season (65.54 µg m^{-3}) and the lowest during the monsoon season (14.61 µg m^{-3}) as in figure 2.11.7. Seasonal average was not calculated for post monsoon season due to insufficient data.

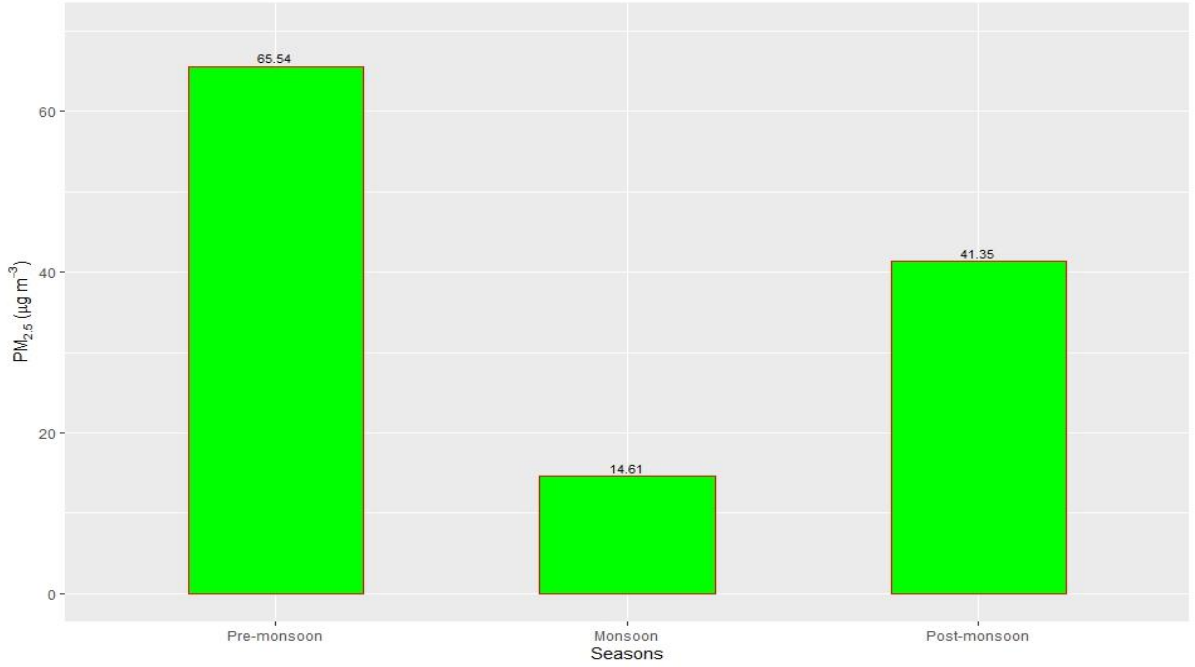


Figure 2.11.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 310 days of measurement, 124 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$. From June to September none of the days exceed NAAQS of 40 µg m^{-3} as shown in figure 2.11.8.

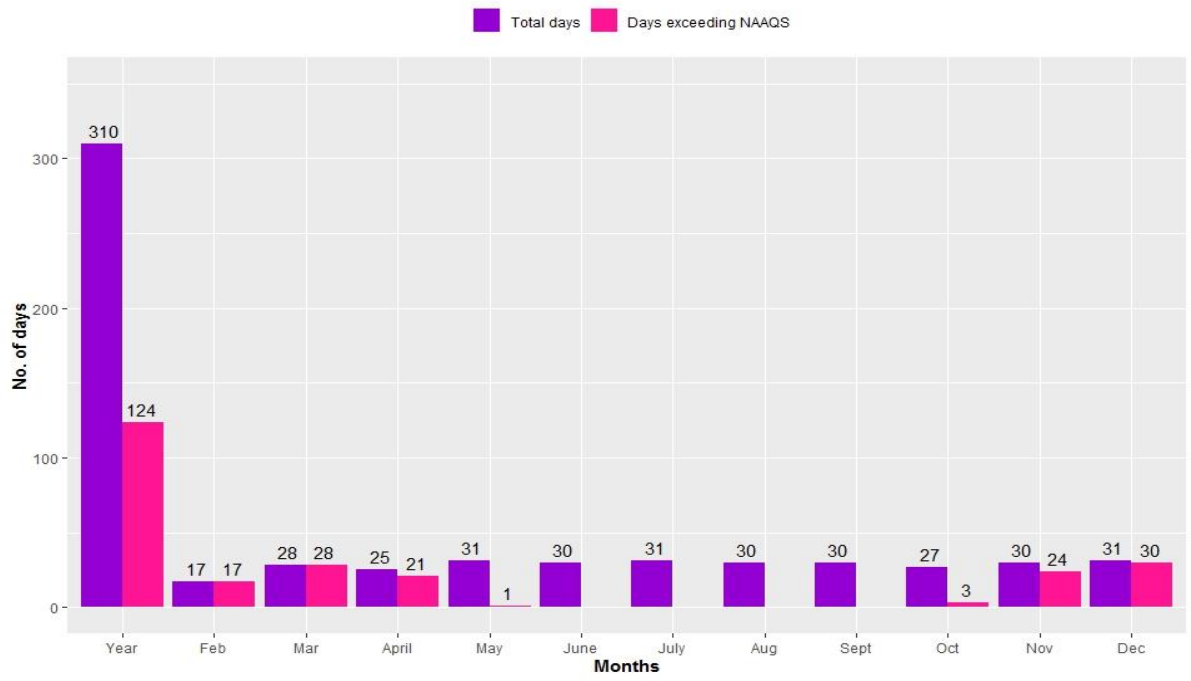


Figure 2.11.8: Compliance status of $PM_{2.5}$

2.11.3 PM_{10}

Histogram

PM_{10} in TU Station was observed to range from 1 to 2943.8 µg m^{-3} (Figure 2.11.9). The mean of the PM_{10} point data was observed to be 72.21 µg m^{-3}.

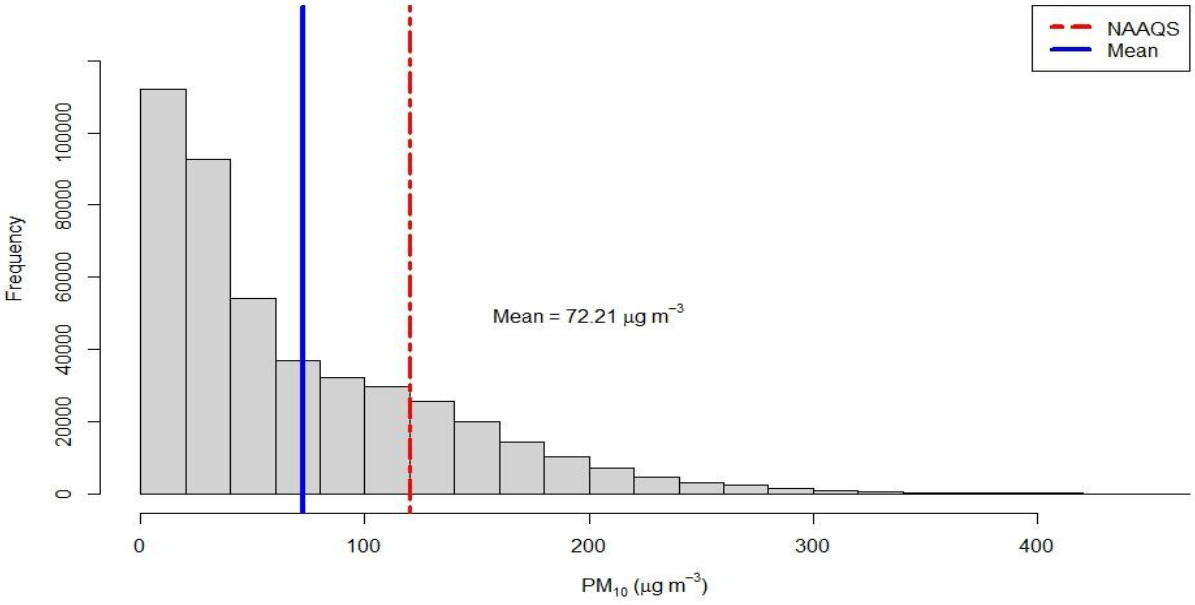


Figure 2.11.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.11.10 shows PM_{10} starts falling from 12 AM then reaches lowest at 5 AM then starts rising and peaks at 9 PM then starts falling slowly till 2 PM and starts again rising peaks at 7 PM then again starts falling.

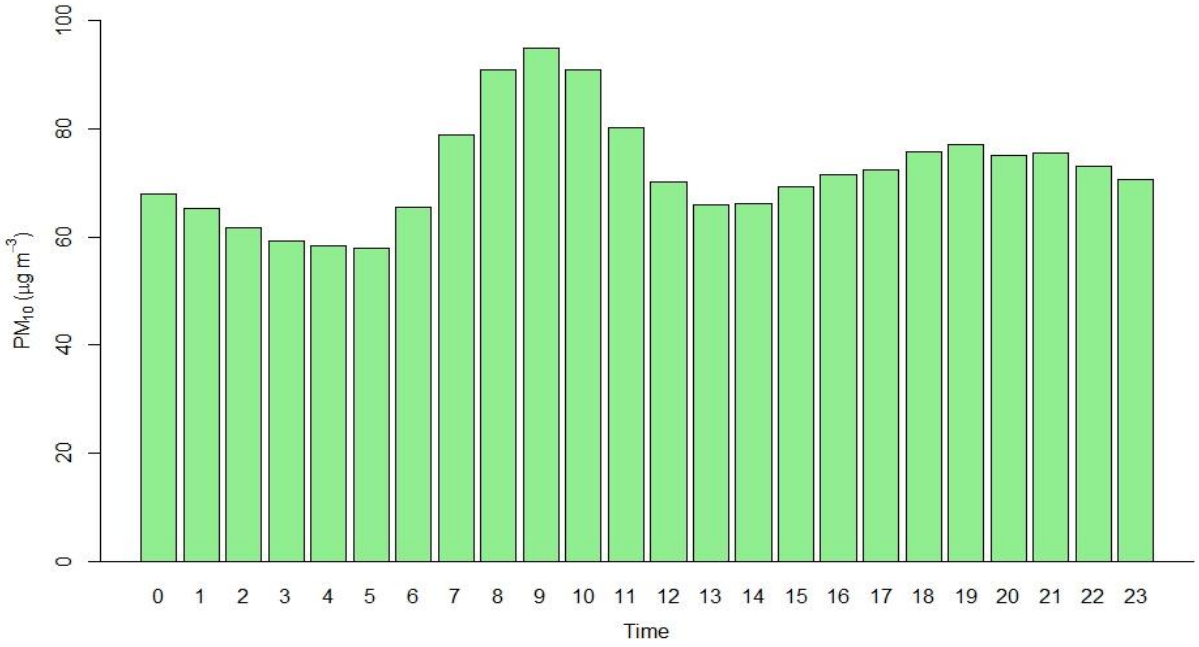


Figure 2.11.10: Hourly average of PM_{10}

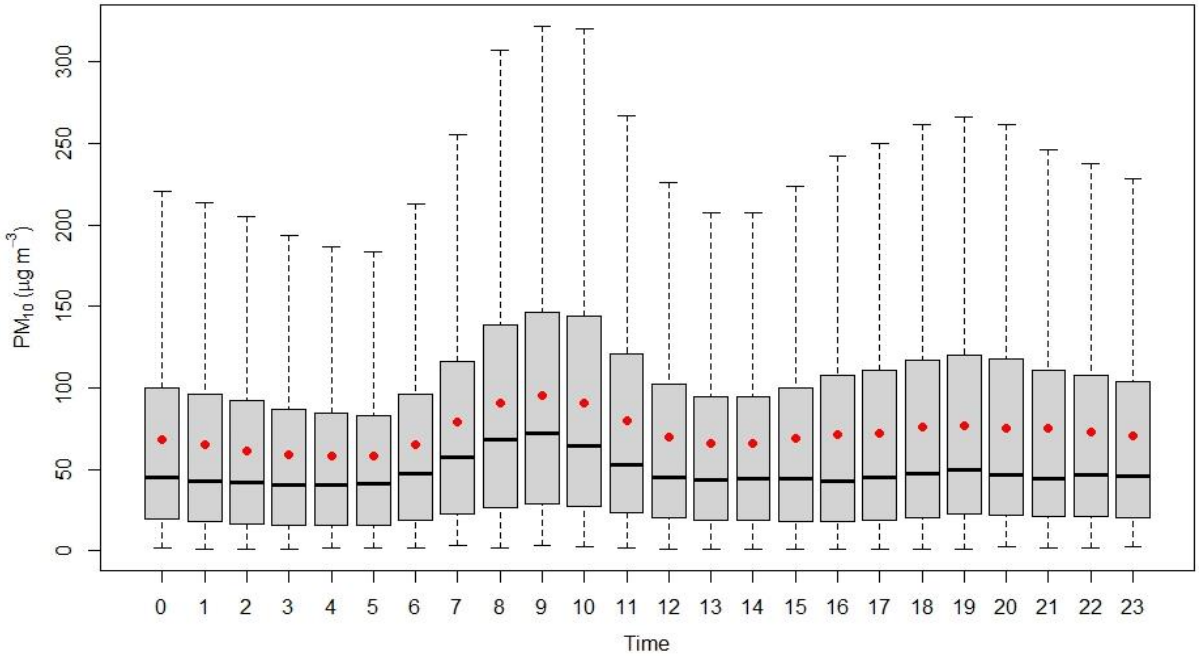


Figure 2.11.11: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.11.12. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post monsoon season.

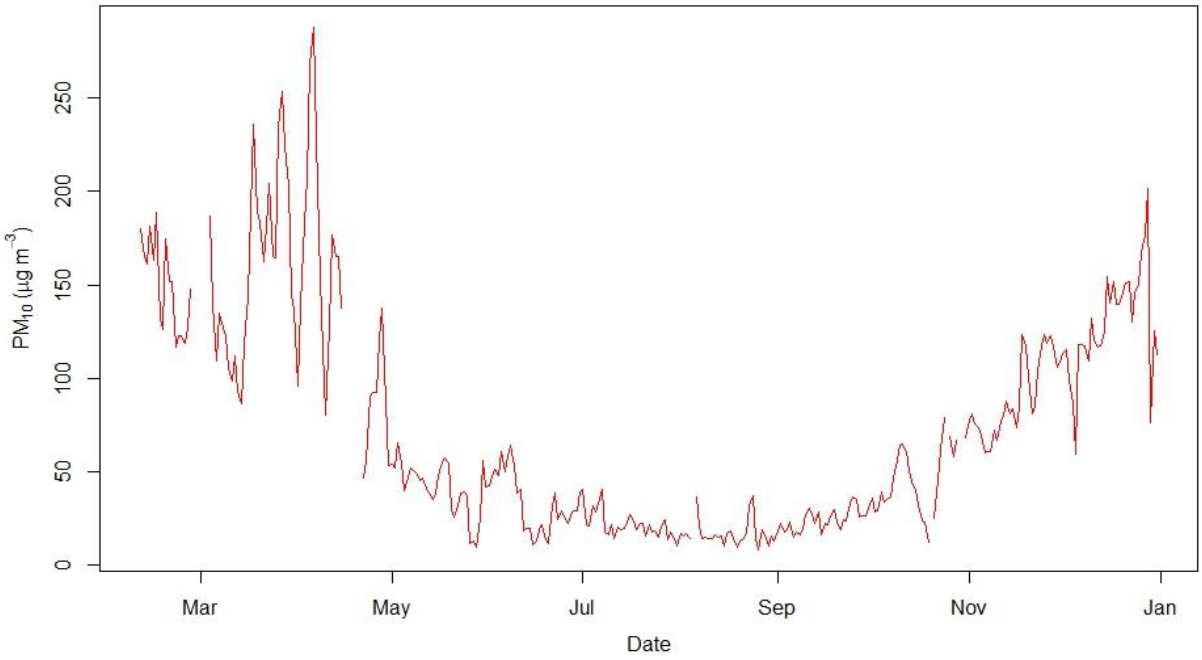


Figure 2.11.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during March and April whereas less during August. The mean value was found more than the median for all available months.

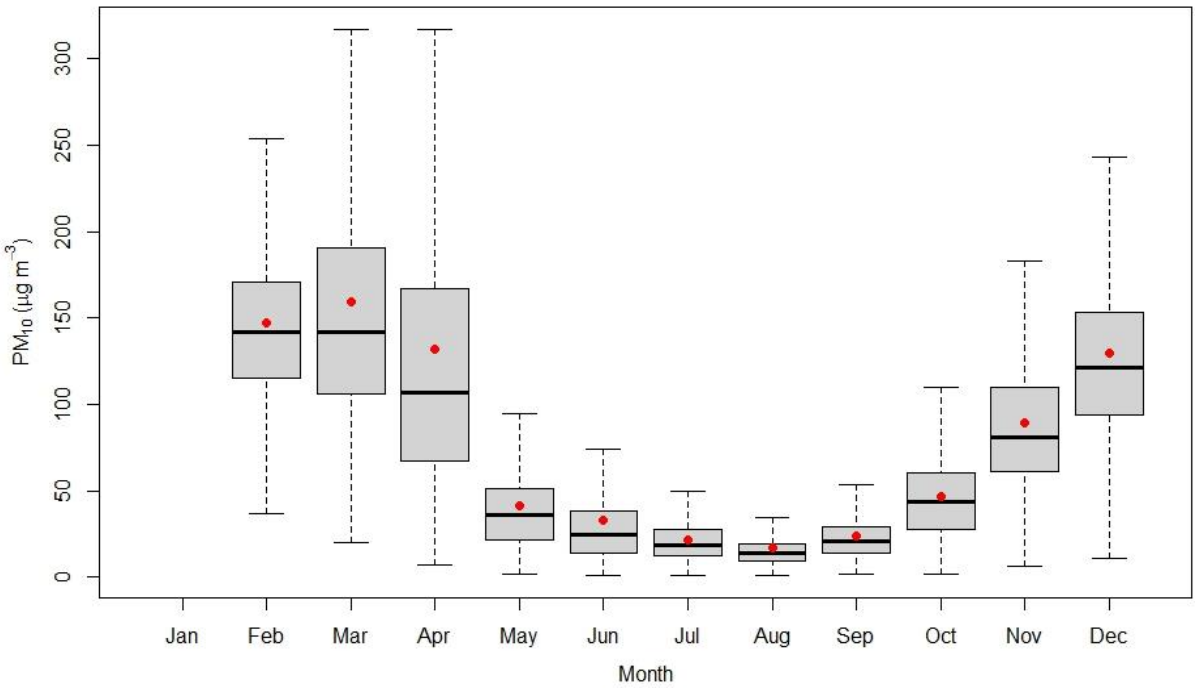


Figure 2.11.13: Monthly variation of PM_{10}

The monthly average for March was found the highest (159.06 µg m^{-3}) and that of August was found lowest (16.78 µg m^{-3}) while comparing with other months as shown in figure 2.11.14. The monthly average was not calculated for January due to insufficient data.

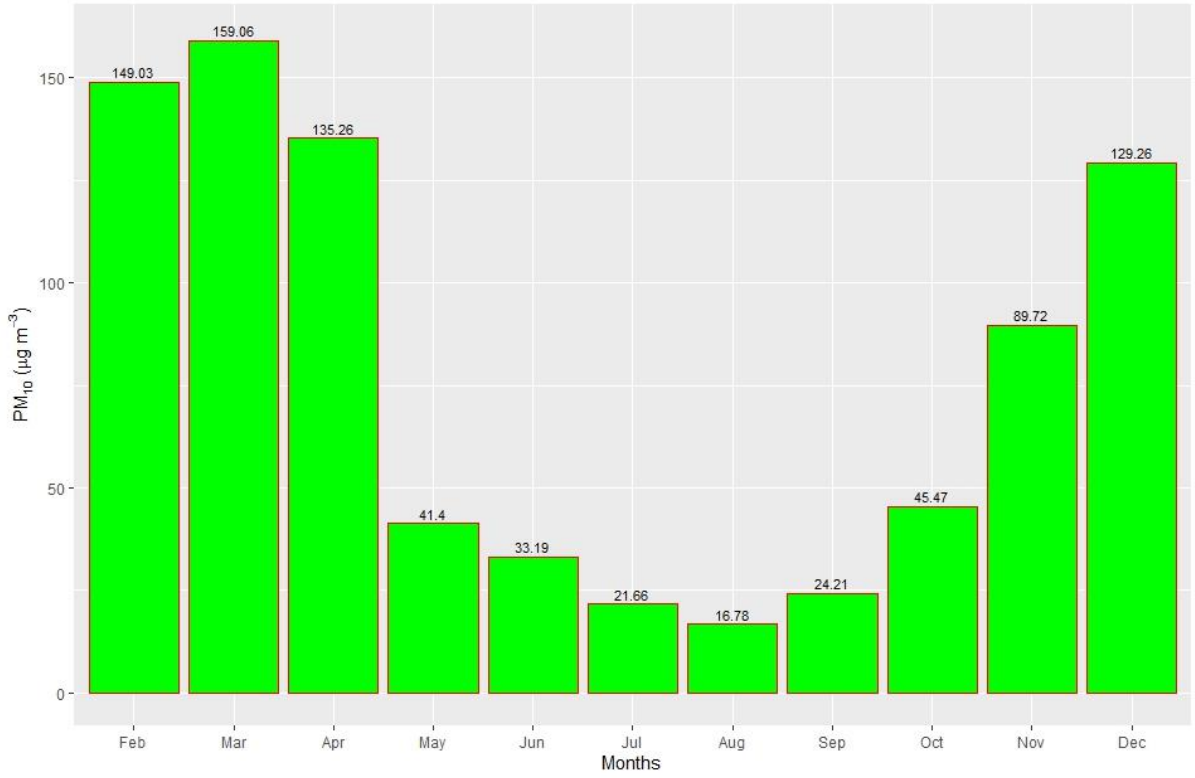


Figure 2.11.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during winter season (108.55 µg m^{-3}) and the lowest during monsoon season (23.94 µg m^{-3}) as in figure 2.11.15. Seasonal average was not calculated for winter season due to insufficient data.

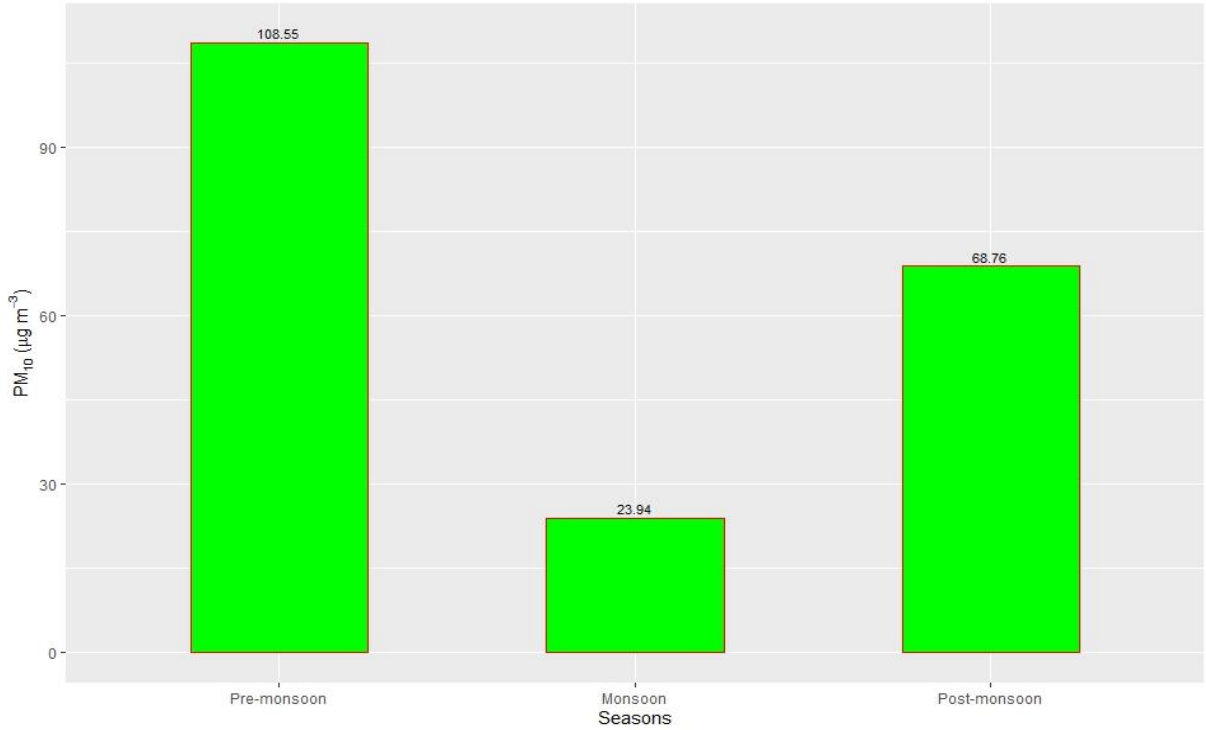


Figure 2.11.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 310 days of measurement, 71 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. From May to October none of the days exceed NAAQS as shown in figure 2.11.16.

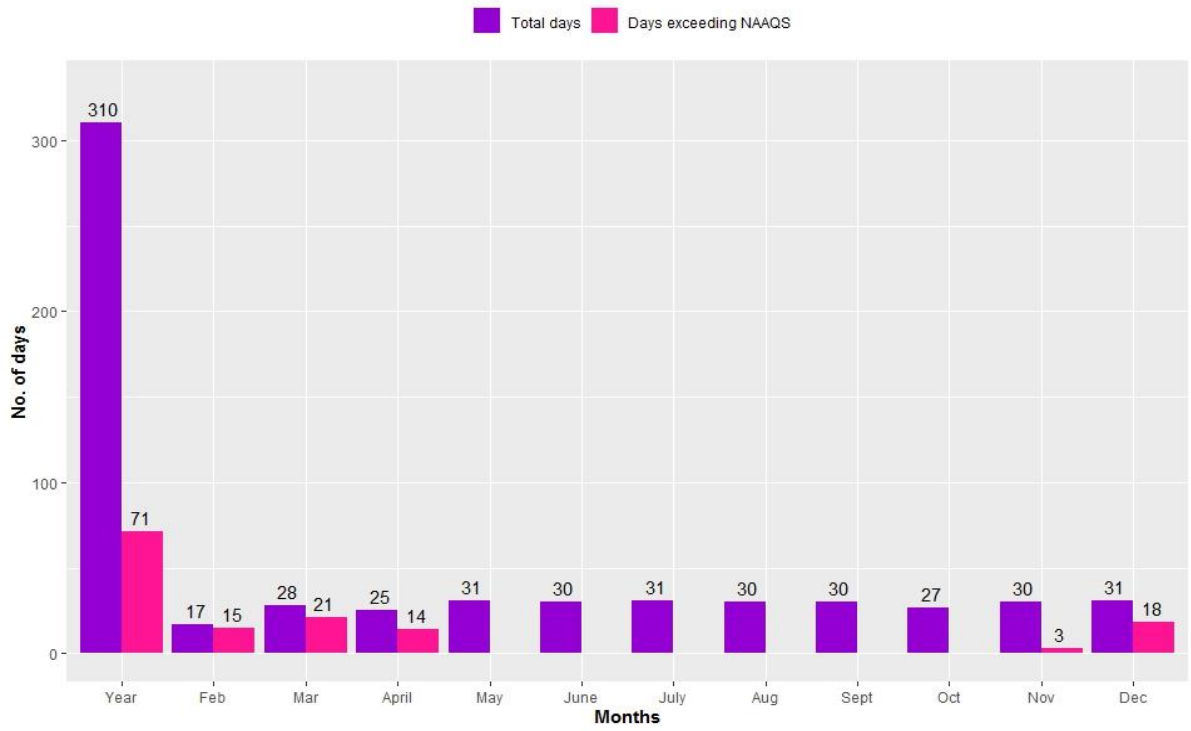


Figure 2.11.16: The compliance status of PM_{10}

2.11.4 TSP

Histogram

TSP in TU Station was observed to range from 1 to 4998.8 µg m^{-3} (Figure 2.11.17). The mean of the TSP point data was observed to be 125 µg m^{-3}.

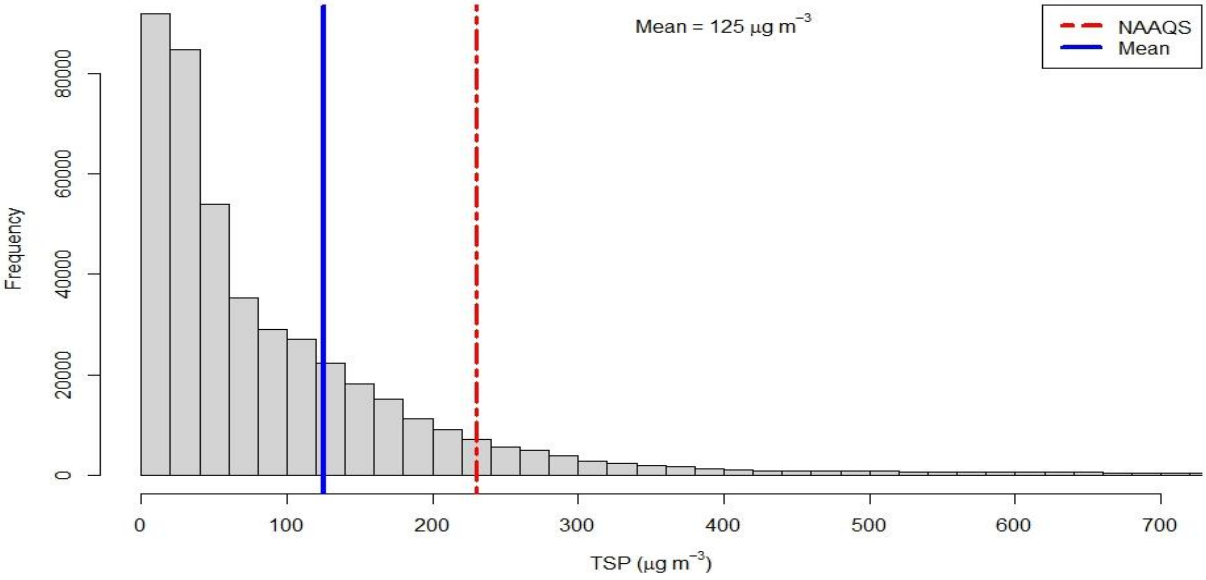


Figure 2.11.17: Histogram of TSP

Diurnal Variation

The Figure 2.11.18 shows TSP peaks at 3 PM. During day time the mean is much higher compared to the median value.

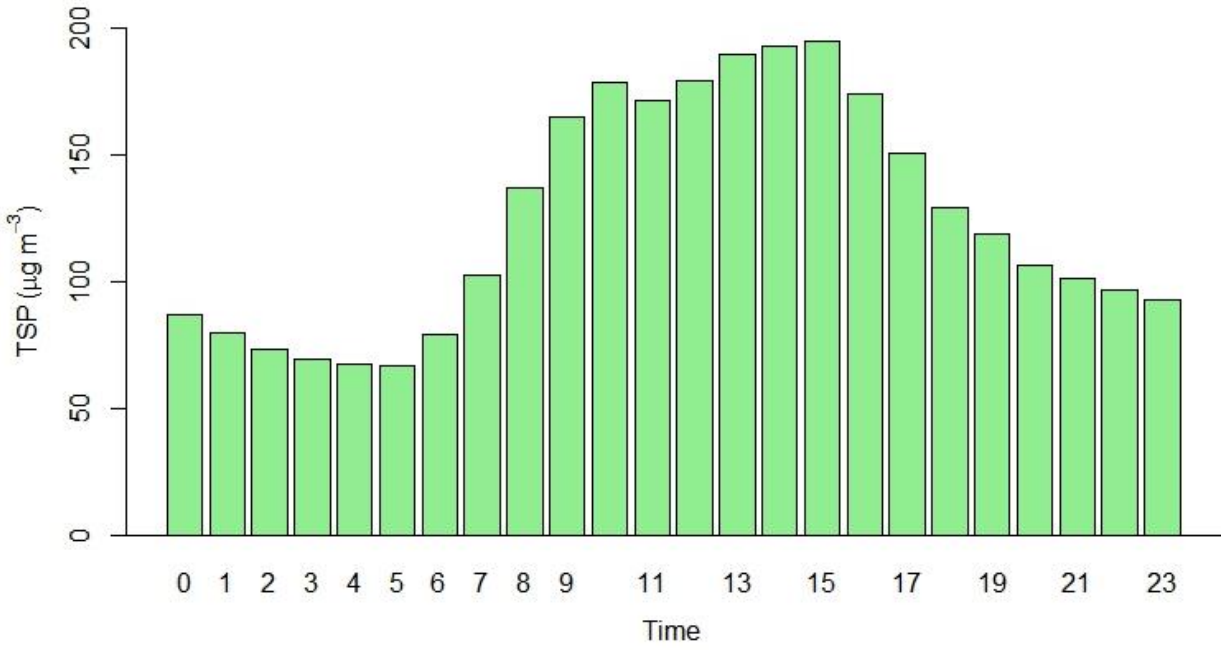


Figure 2.11.18: Hourly average of TSP

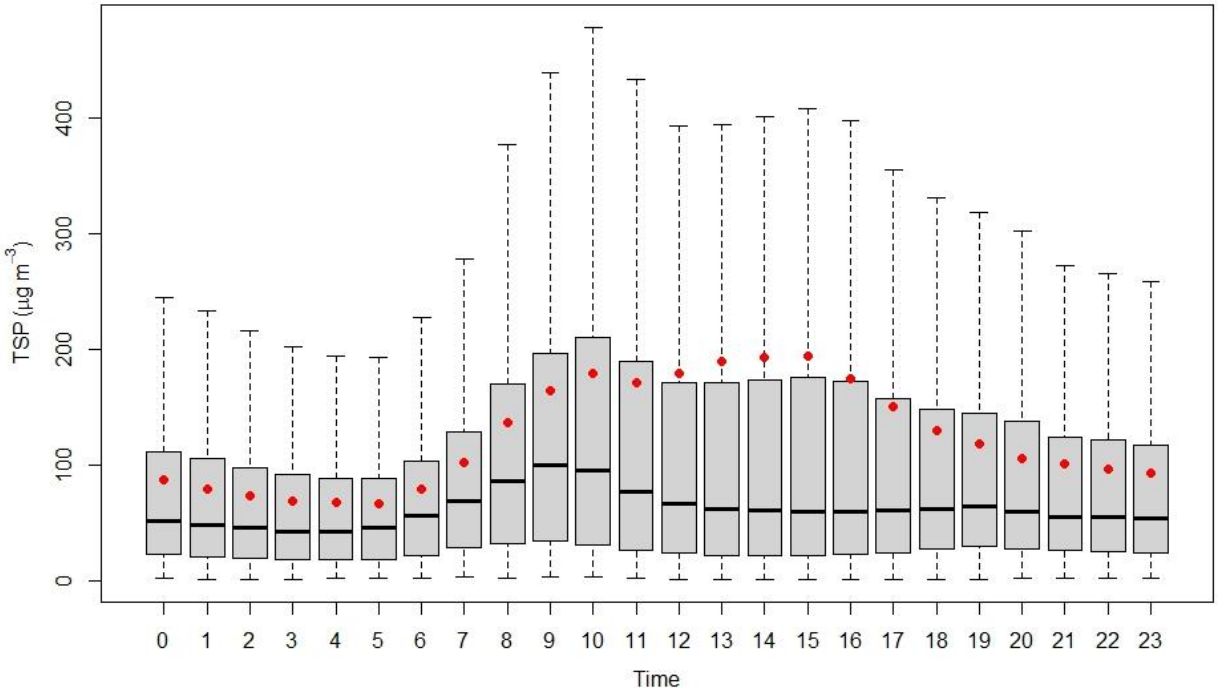


Figure 2.11.19: Diurnal variation of TSP.

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.11.20. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post monsoon season.

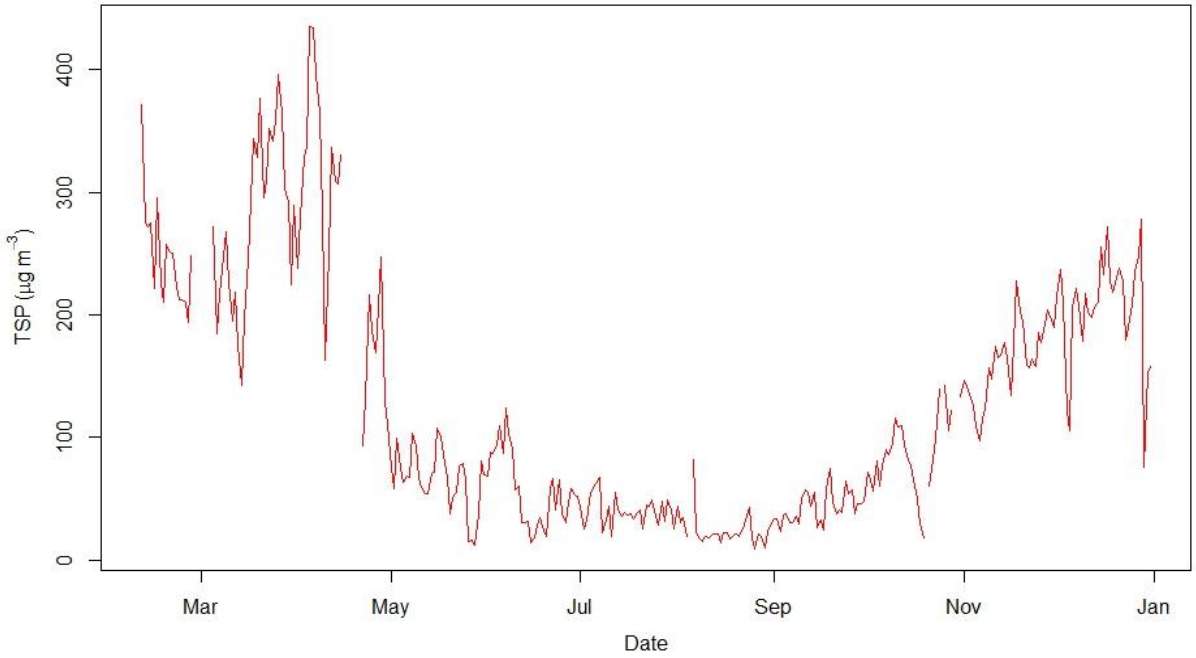


Figure 2.11.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during April whereas less during August. The mean value was found more than median in every month.

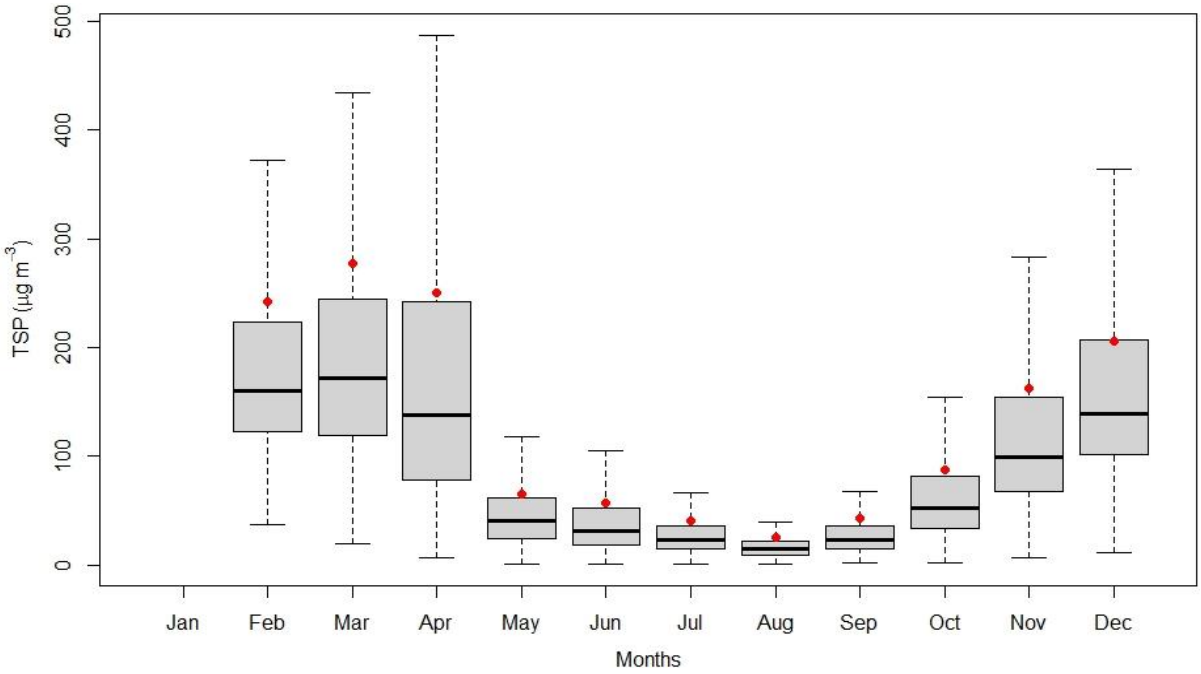


Figure 2.11.21: Monthly variation of TSP

The monthly average for March was found to be the highest (275.81 µg m^{-3}) and that of August was found to be the lowest (24.58 µg m^{-3}) while comparing with other months as shown in figure 2.11.22.

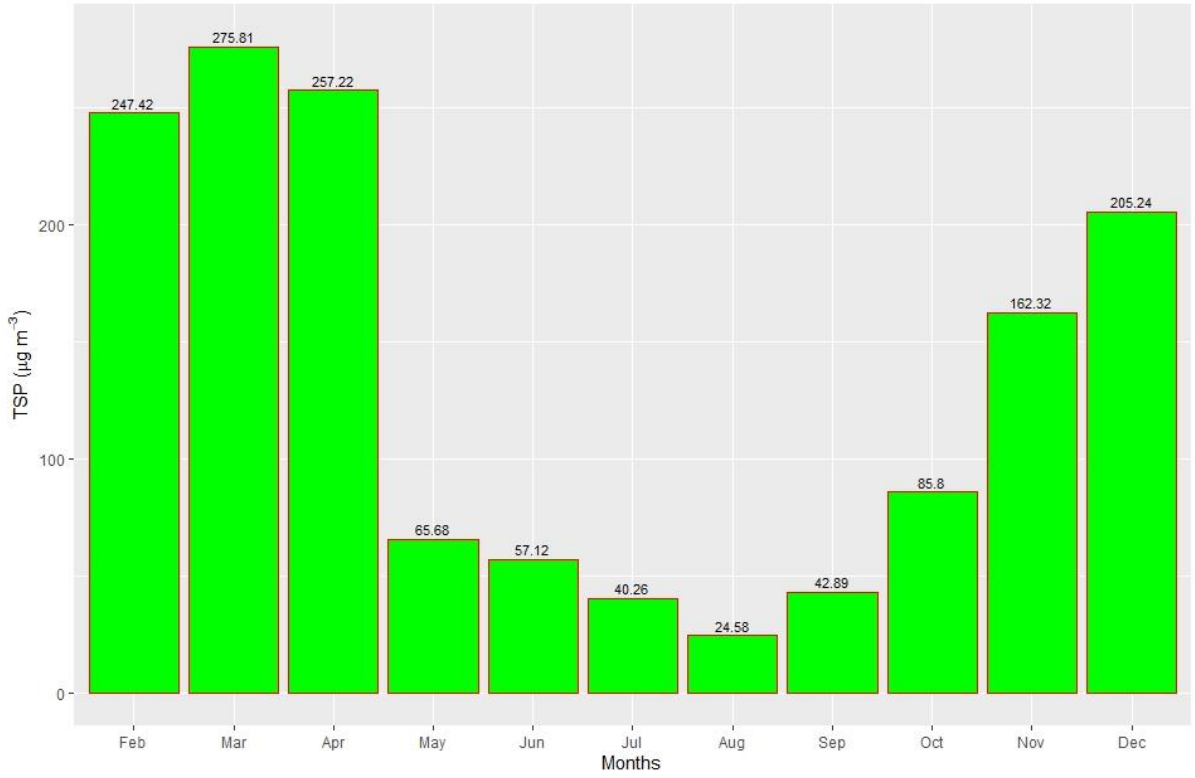


Figure 2.11.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during the pre-monsoon season (191.73 µg m^{-3}) and the lowest during the monsoon season (41.21 µg m^{-3}) as in figure 2.11.23. Seasonal average for winter season was not calculated due to insufficient data.

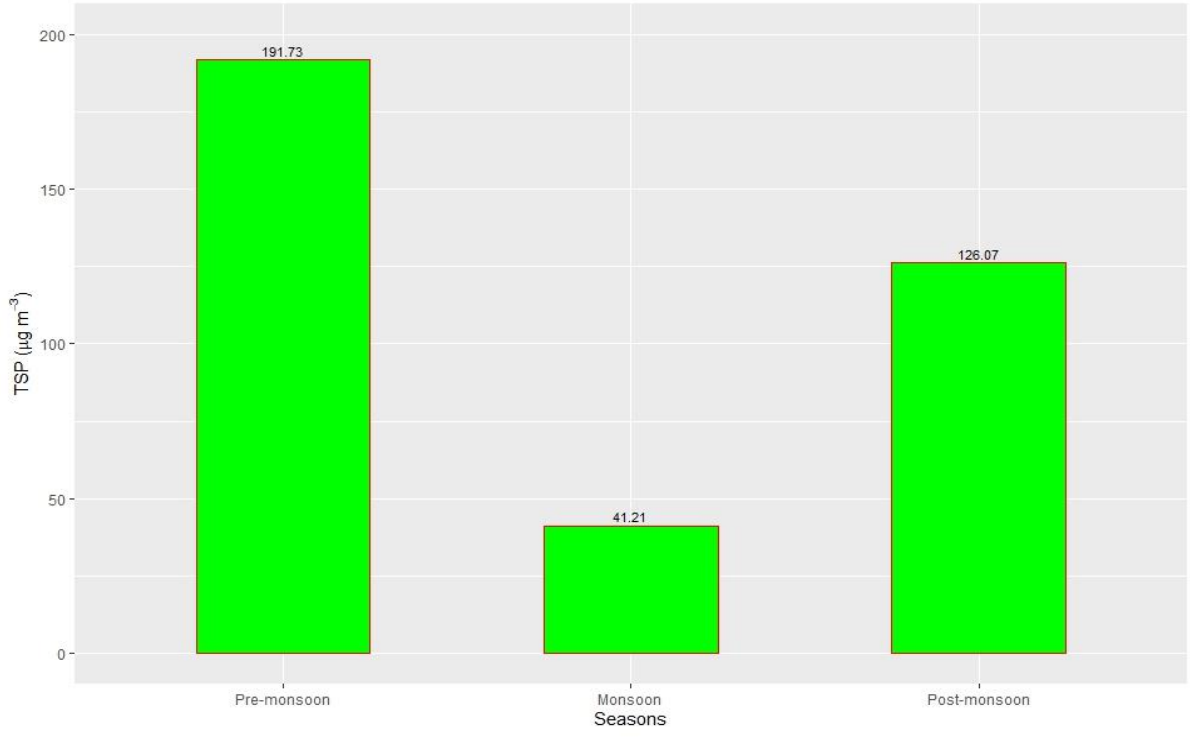


Figure 2.11.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 309 days of measurement, 54 days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}. From May to November none of the days exceed NAAQS as shown in figure 2.11.24.

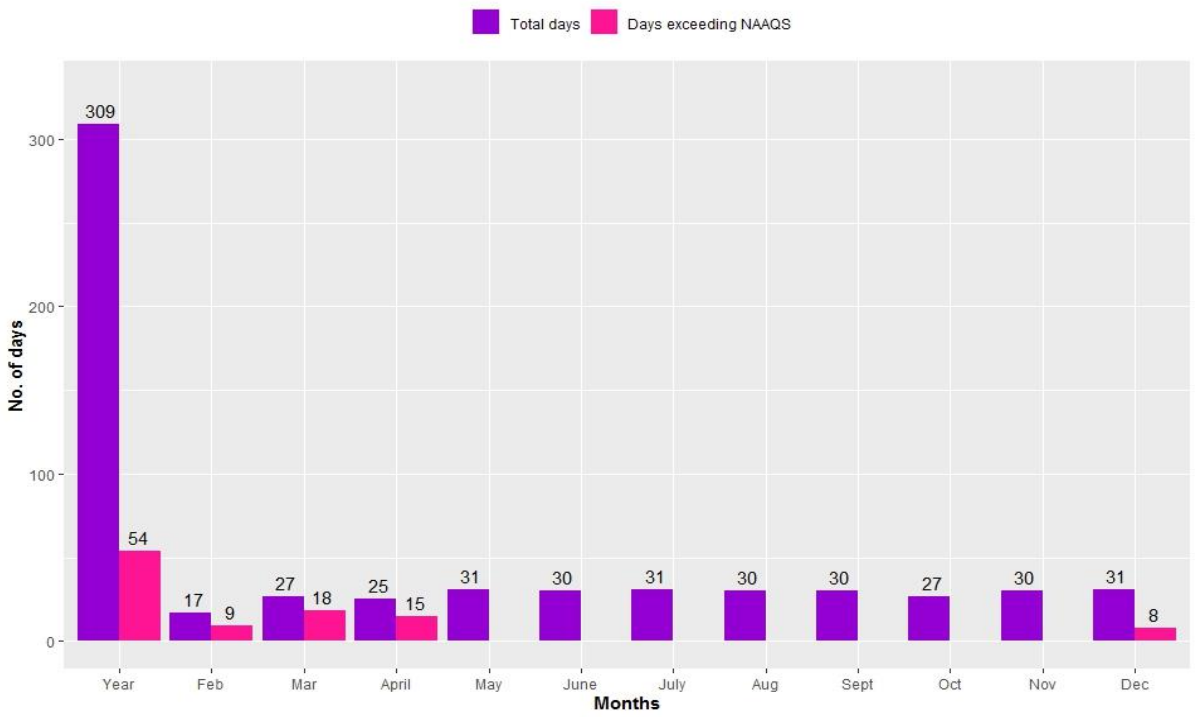


Figure 2.11.24: Compliance status of TSP

Annual Average

The annual average of $PM_{2.5}$, PM_{10} and TSP is shown in figure 2.11.25.

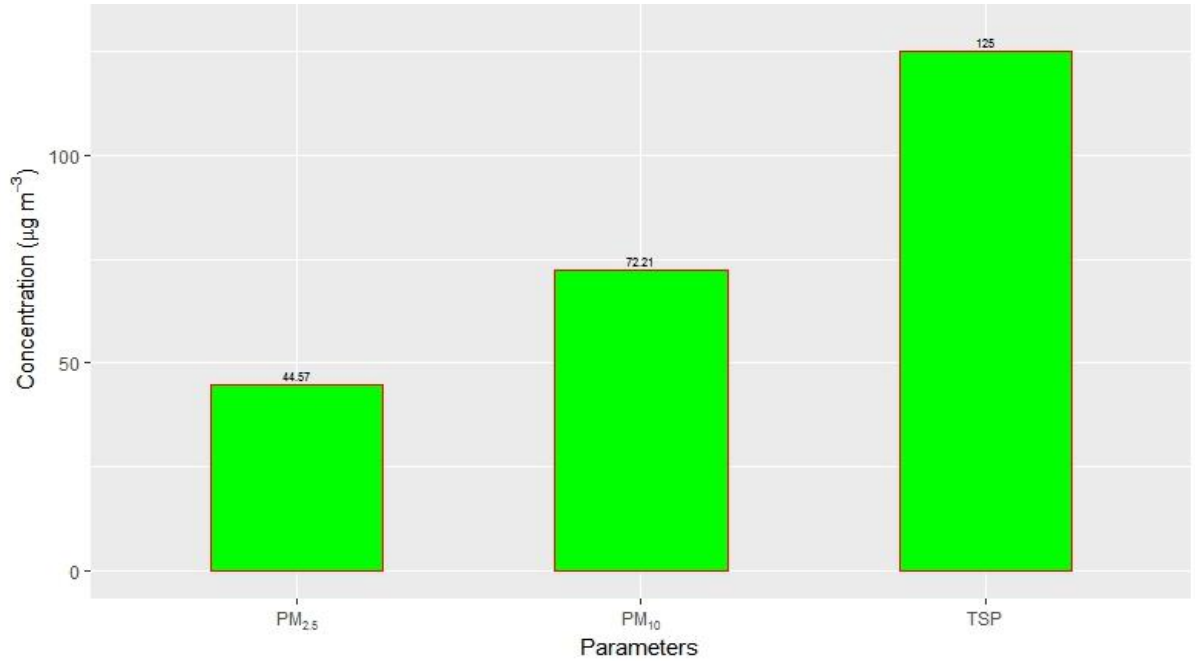


Figure 2.11.25: Annual average of $PM_{2.5}$, PM_{10} and TSP

Calendar Plot

Calendar plot is prepared for $PM_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The calendar plot shows AQI for $PM_{2.5}$ reached to very unhealthy level in 36th to 29th of March and 5th to 7th of April and was unhealthy during February, March, December and few days in November.

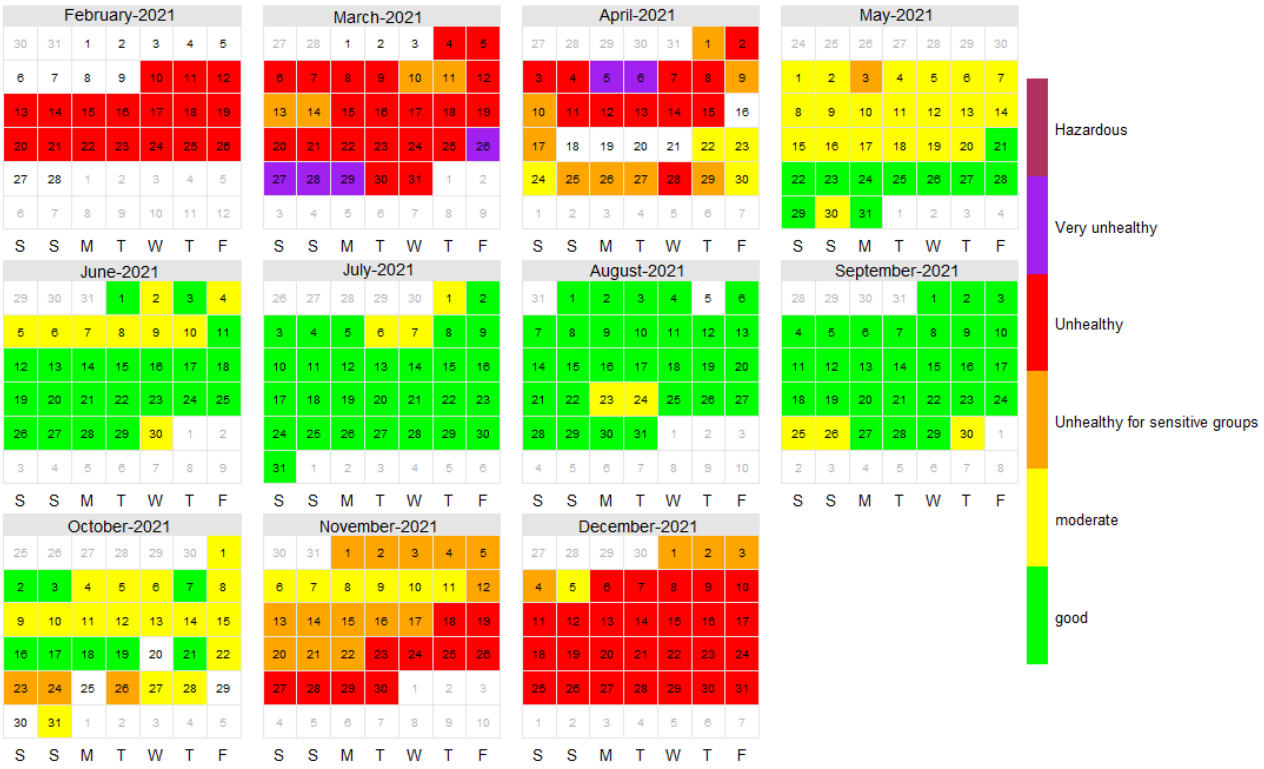


Figure 2.11.26: Calendar plot for $PM_{2.5}$ for the year 2021

2.12 Air quality status – Simara

2.12.1 Introduction

Simara Air Quality Monitoring Station was established in the year 2018. It lies in inside Armed police force. It represents the semi urban area. Near to the station lies Bara-Parsa industrial corridor. So, the major sources of pollution are industries. It lies in the southern part of Nepal so trans boundary pollution is also the major source.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

Besides particulate matter this station has equipment for measuring gases pollutant and black carbon also. However, in this report we have analysed data of Particulate matter only.

2.12.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Simara station was observed to range from 1 to 1475.8 µg m^{-3} (Figure 2.12.1). The mean of the $PM_{2.5}$ point data was observed to be 78.39 µg m^{-3}

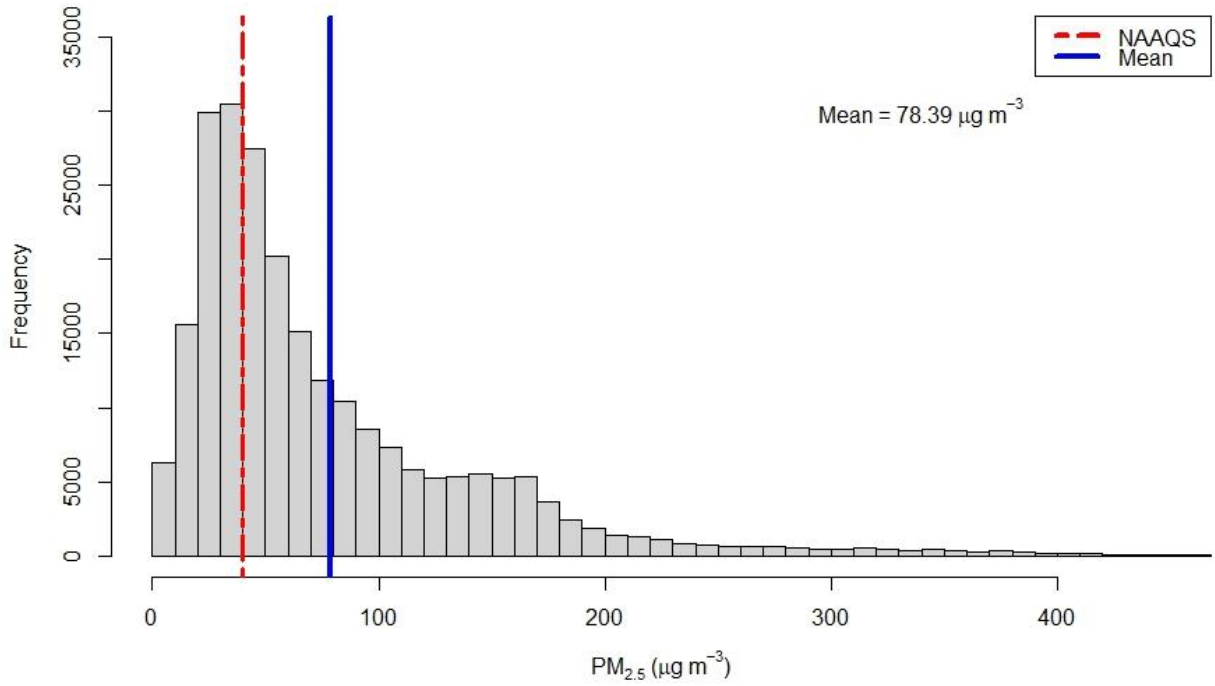


Figure 2.12.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.12.2 shows $PM_{2.5}$ peaks at 7 AM and at 8 PM to 11 PM. The mean value is found to be more than the median throughout the day.

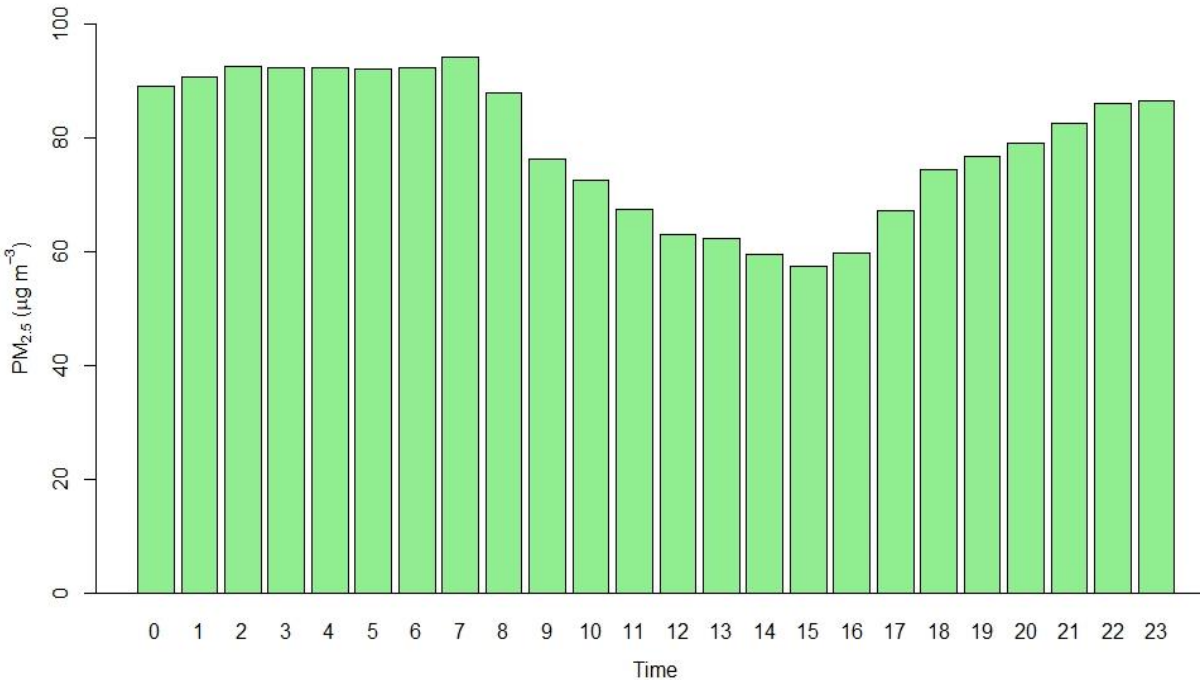


Figure 2.12.2: Hourly average of $PM_{2.5}$

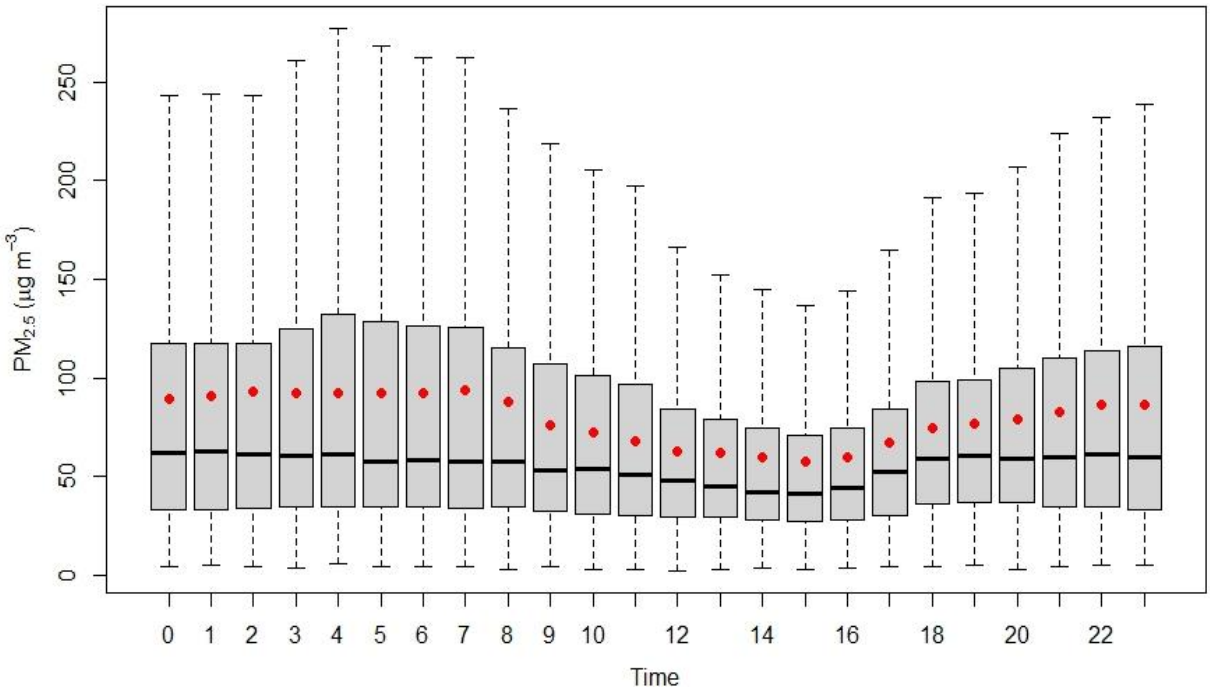


Figure 2.12.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variations of $PM_{2.5}$ is shown in figure 2.12.4. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post-monsoon season.

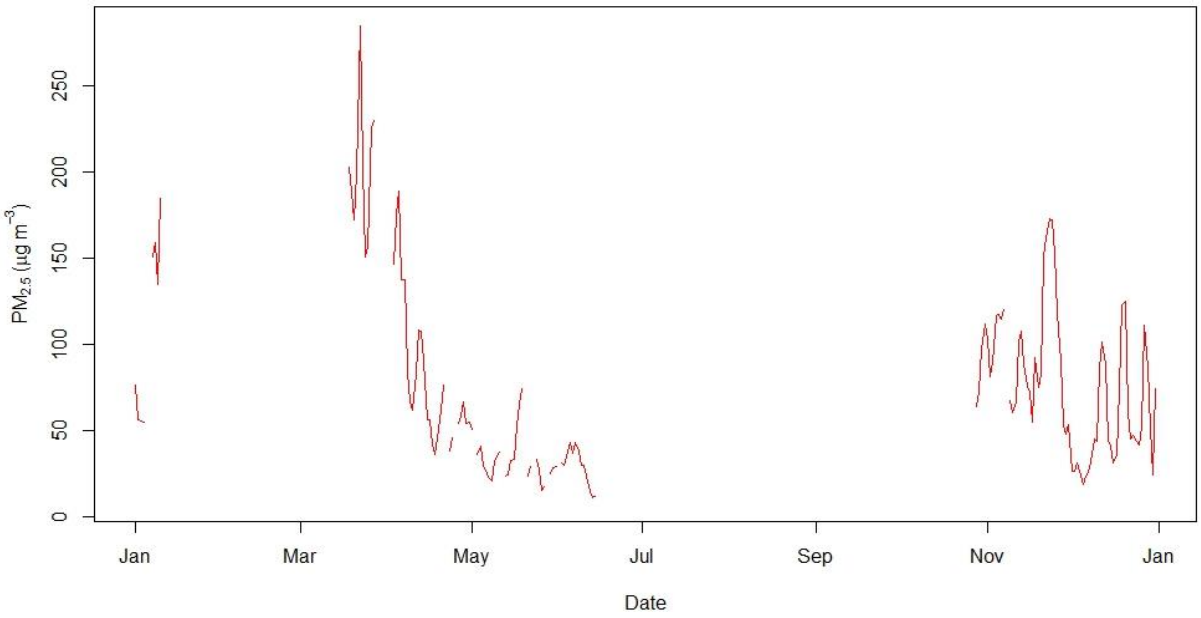


Figure 2.12.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5}$, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during March whereas less during May and June. The mean value was found more than median during March and December.

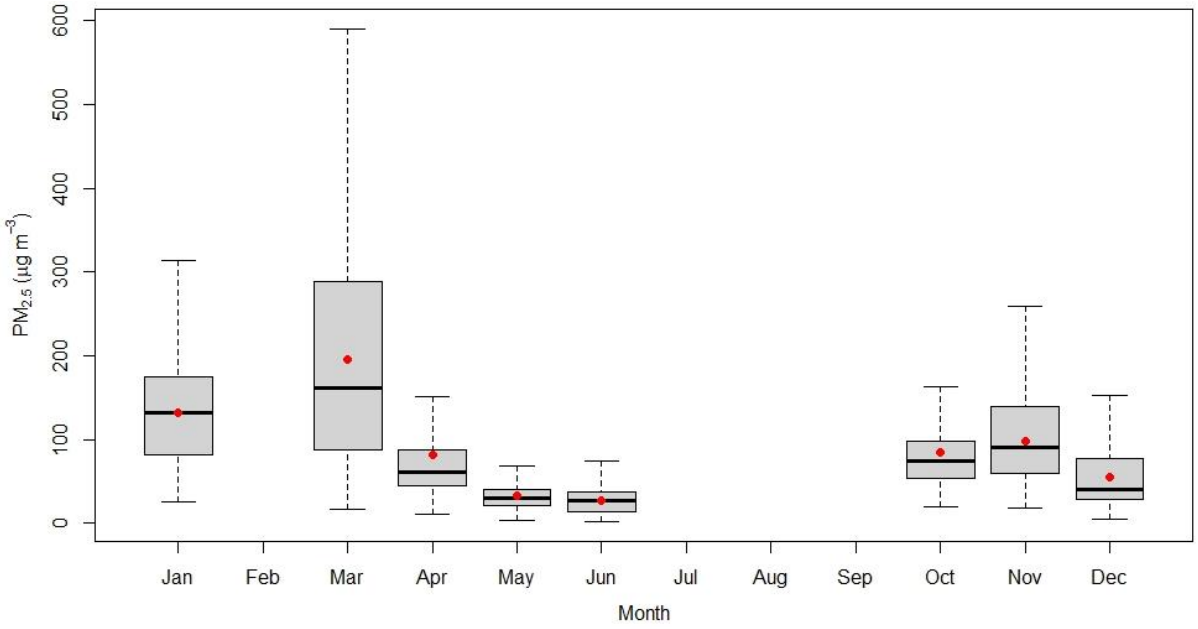


Figure 2.12.5: Monthly variation of $PM_{2.5}$

The monthly average of November was found to be highest (113.36 µg m^{-3}) and that of May was found to be lowest (52.29 µg m^{-3}) while comparing with other months as shown in figure 2.12.6 below.

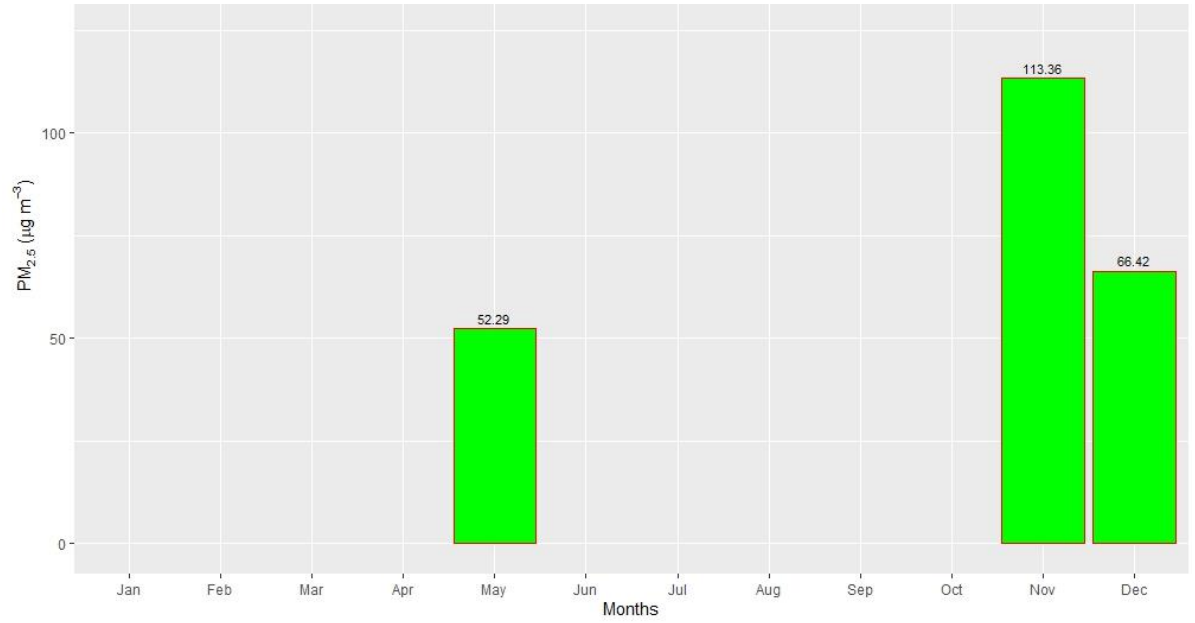


Figure 2.12.6: Monthly average $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 148 days of measurement, 102 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$ as shown in figure 2.12.7.

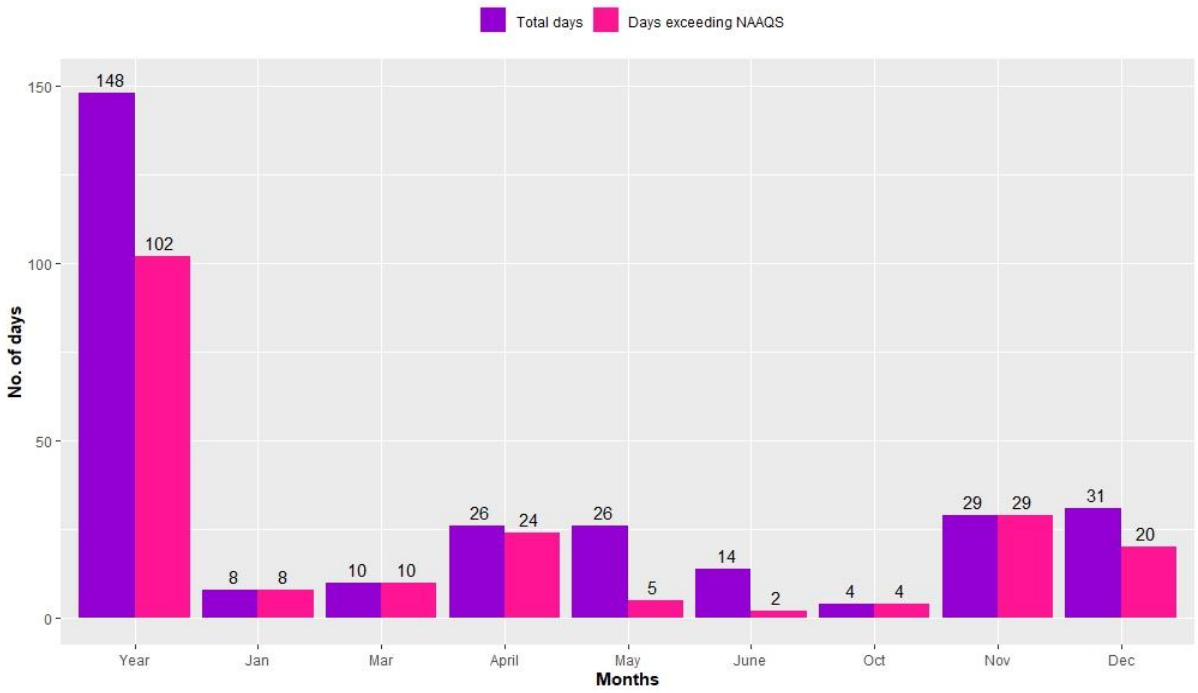


Figure 2.12.7: Compliance status of $PM_{2.5}$

2.12.3 PM_{10}

Histogram

PM_{10} in Simara station was observed to range from 1 to 2945.2 µg m^{-3} (Figure 2.12.8). The mean of the PM_{10} point data was observed to be 114 µg m^{-3}.

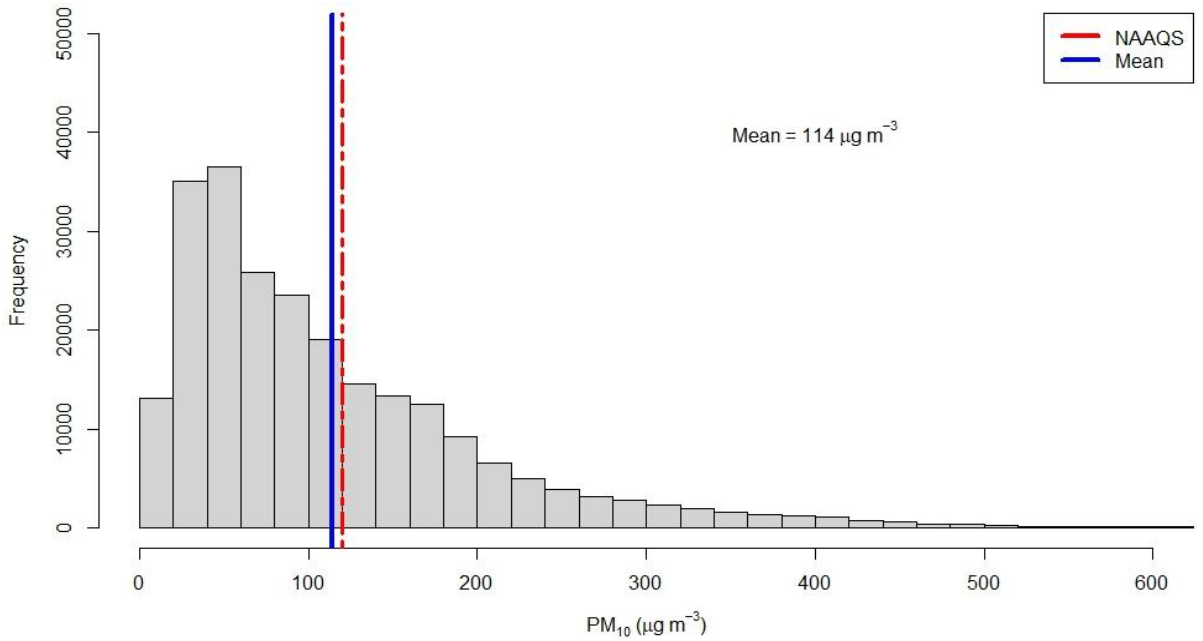


Figure 2.12.8: Histogram of PM_{10}

Diurnal Variation

Figure 2.12.9 shows diurnal variation of PM_{10} which peaks at 5-6 PM.

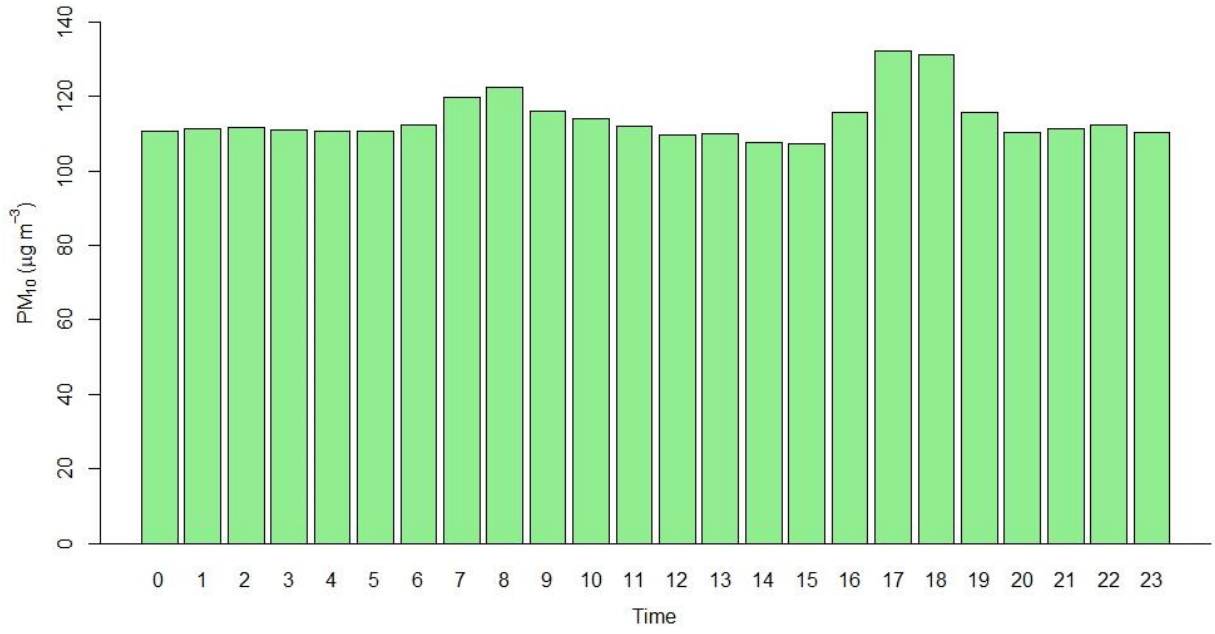


Figure 2.12.9: Hourly average of PM_{10}

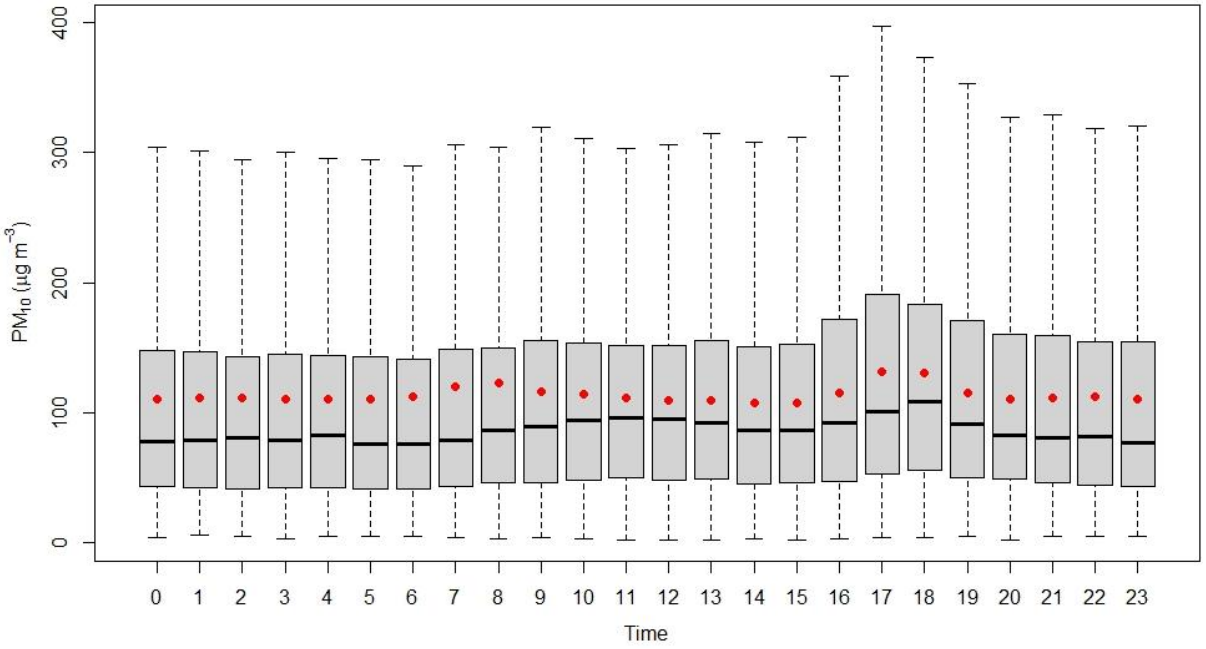


Figure 2.12.10: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.12.11. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post monsoon season.

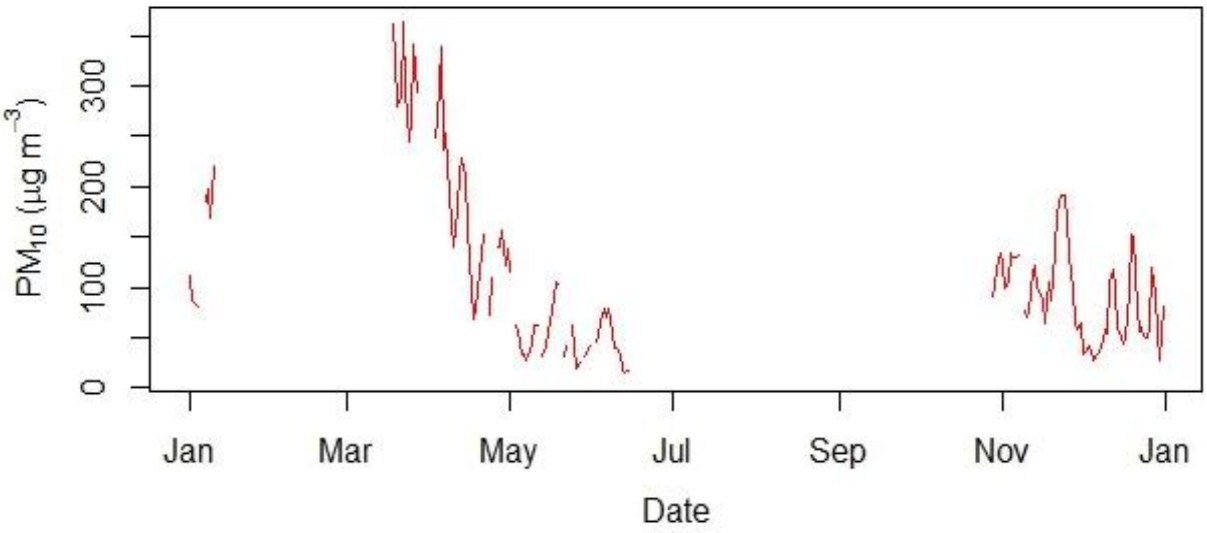


Figure 2.12.11: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during March whereas less during May.

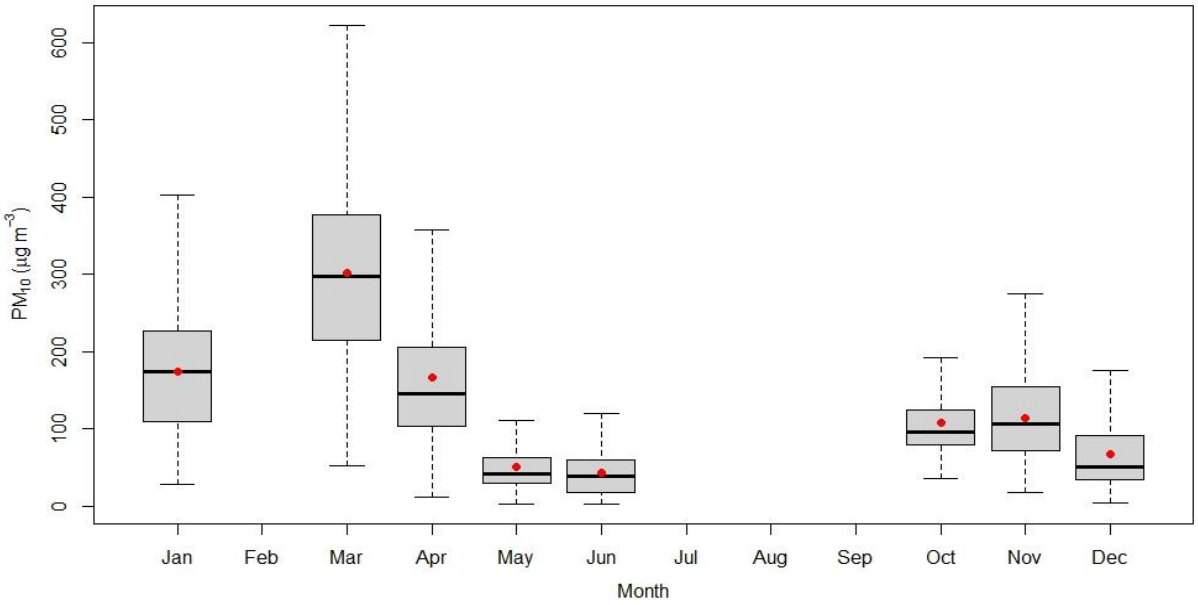


Figure 2.12.12: Monthly variation of PM_{10}

The monthly average for April was found the highest (168 µg m^{-3}) and that of May was found lowest (52.29 µg m^{-3}) while comparing with other months as shown in figure 2.12.13.

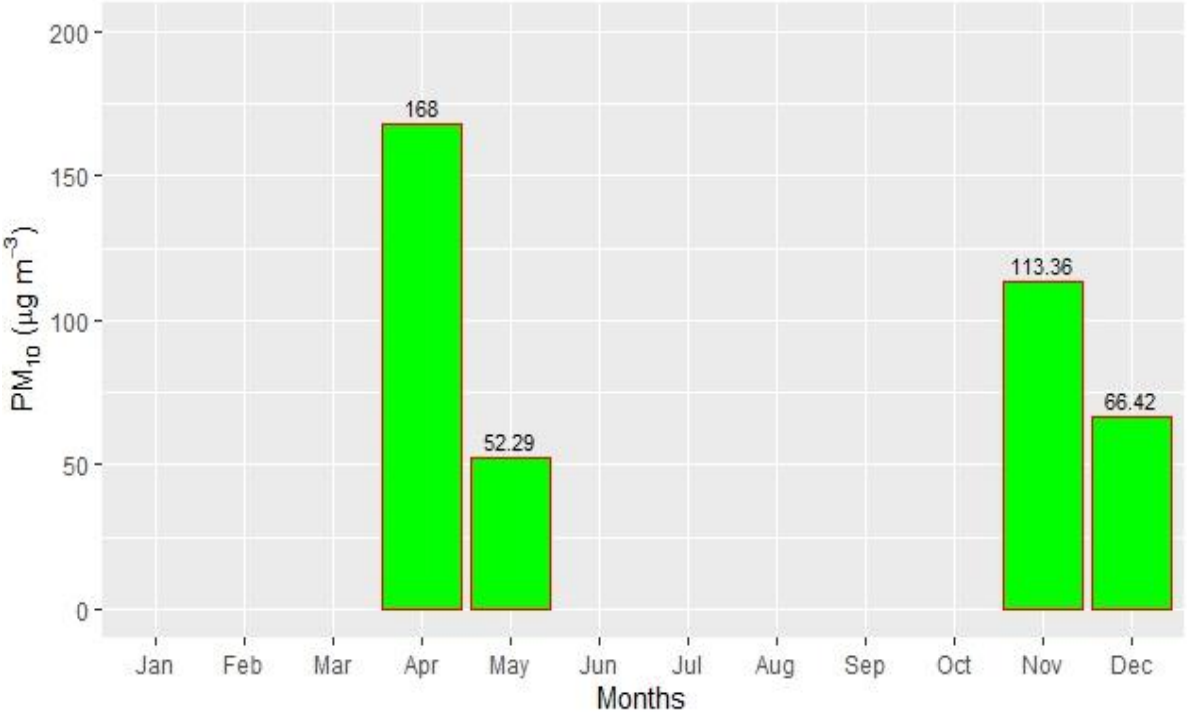


Figure 2.12.13: Monthly average of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 148 days of measurement, 51 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10} as shown in figure 2.12.14.

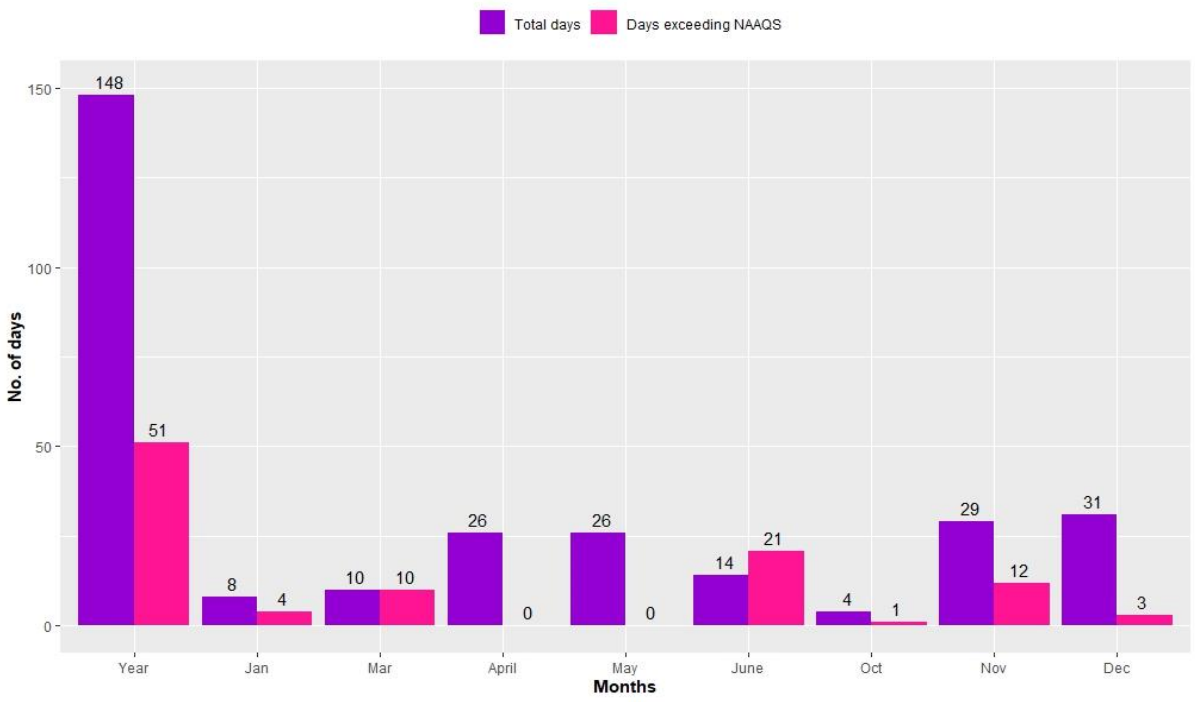


Figure 2.12.14: Compliance status of PM_{10}

2.12.4 TSP

Histogram

TSP in Simara Station was observed to range from 1 to 4997.2 µg m^{-3} (Figure 2.12.15). The mean of the TSP point data was observed to be 167.7 µg m^{-3}.

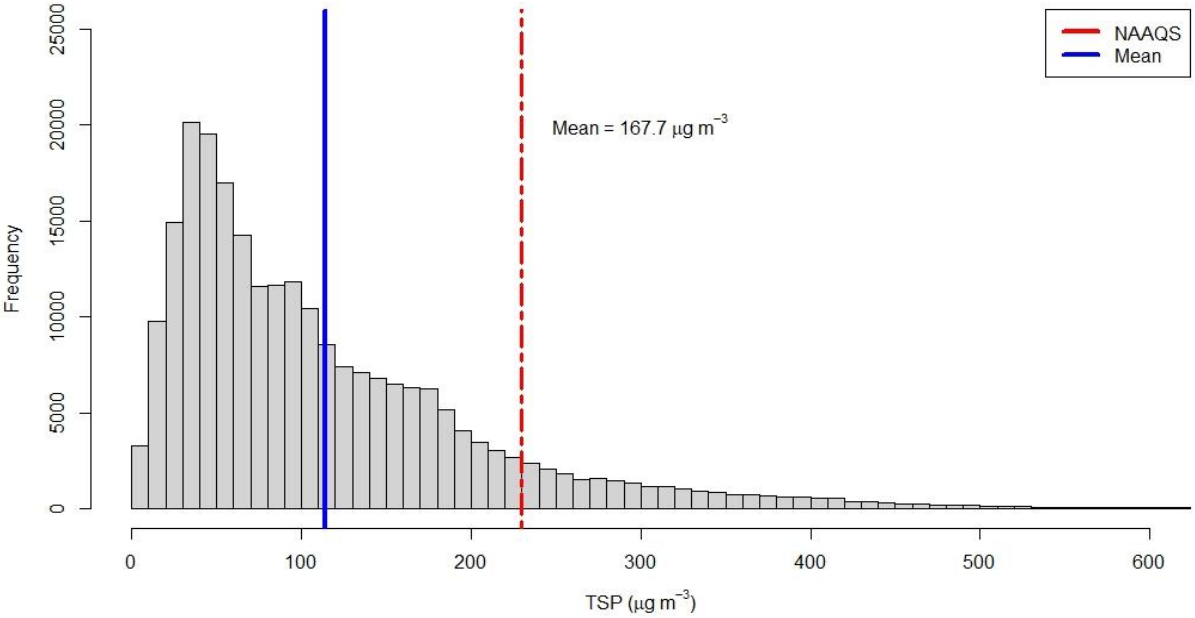


Figure 2.12.15: Histogram of TSP

Diurnal Variation

The Figure 2.12.16 shows TSP peaks at 5 PM to 6 PM. During day time the mean is much higher compared to the median value.

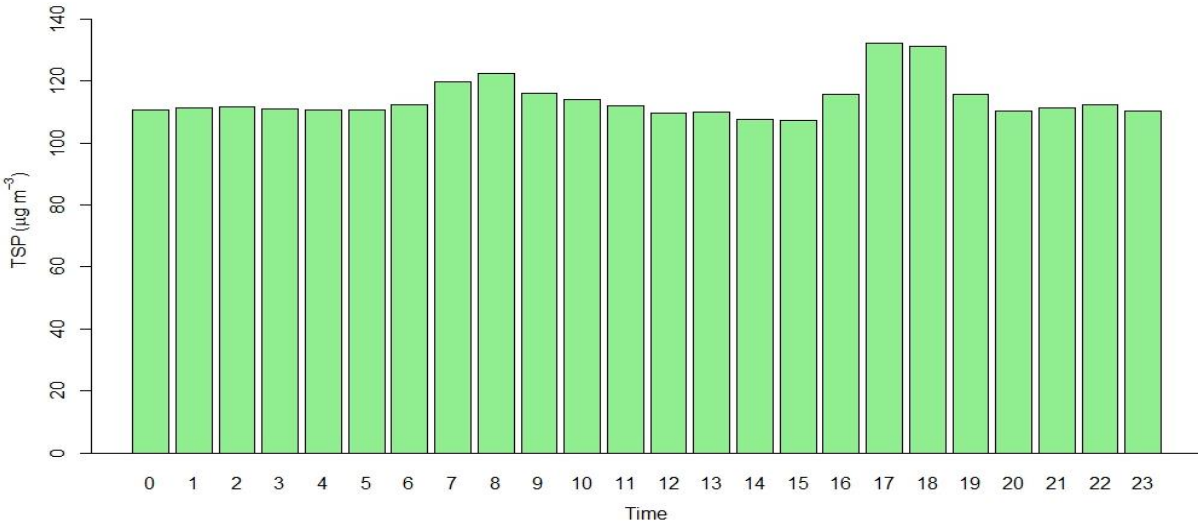


Figure 2.12.16: Hourly average of TSP

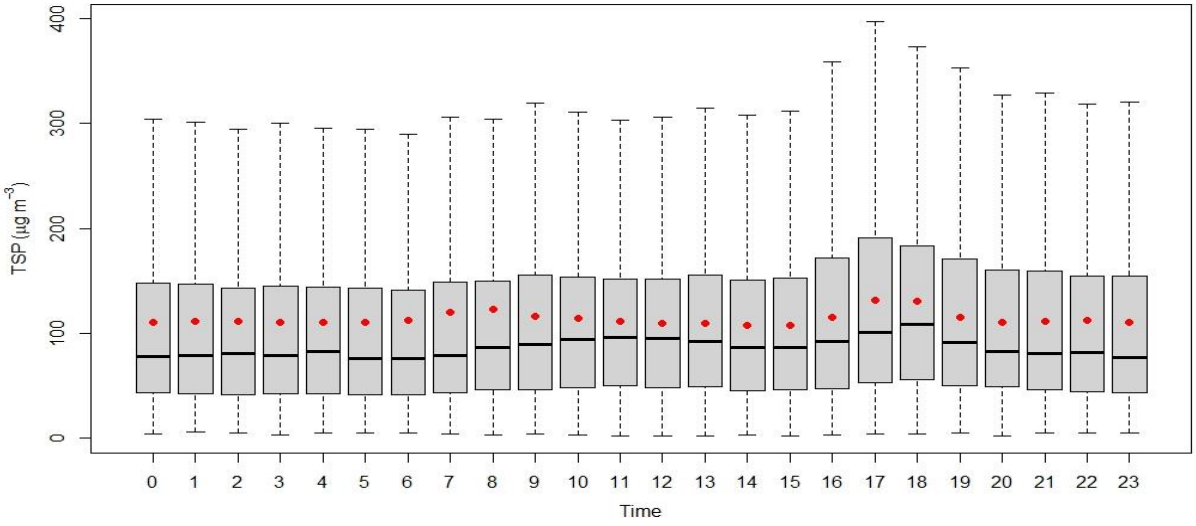


Figure 2.12.17: Diurnal variation of TSP

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.12.18. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post monsoon season.

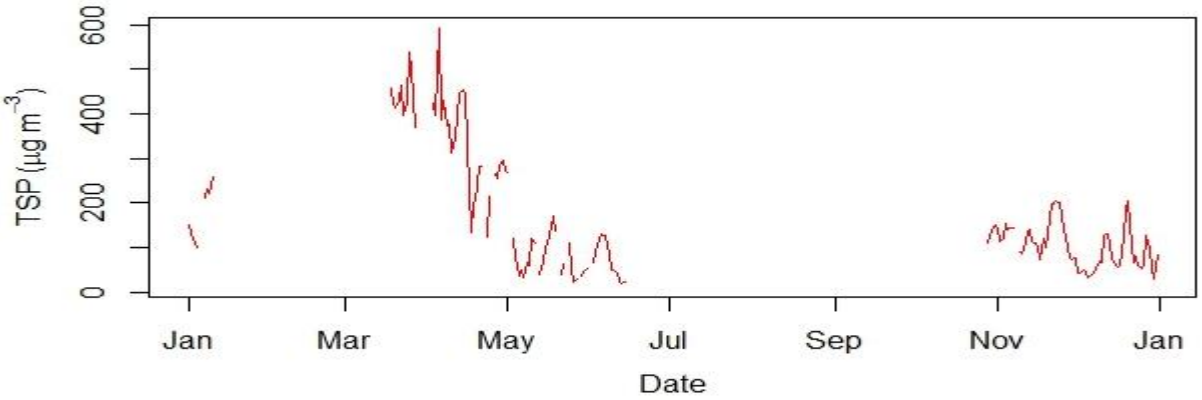


Figure 2.12.18: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during March whereas less during May.

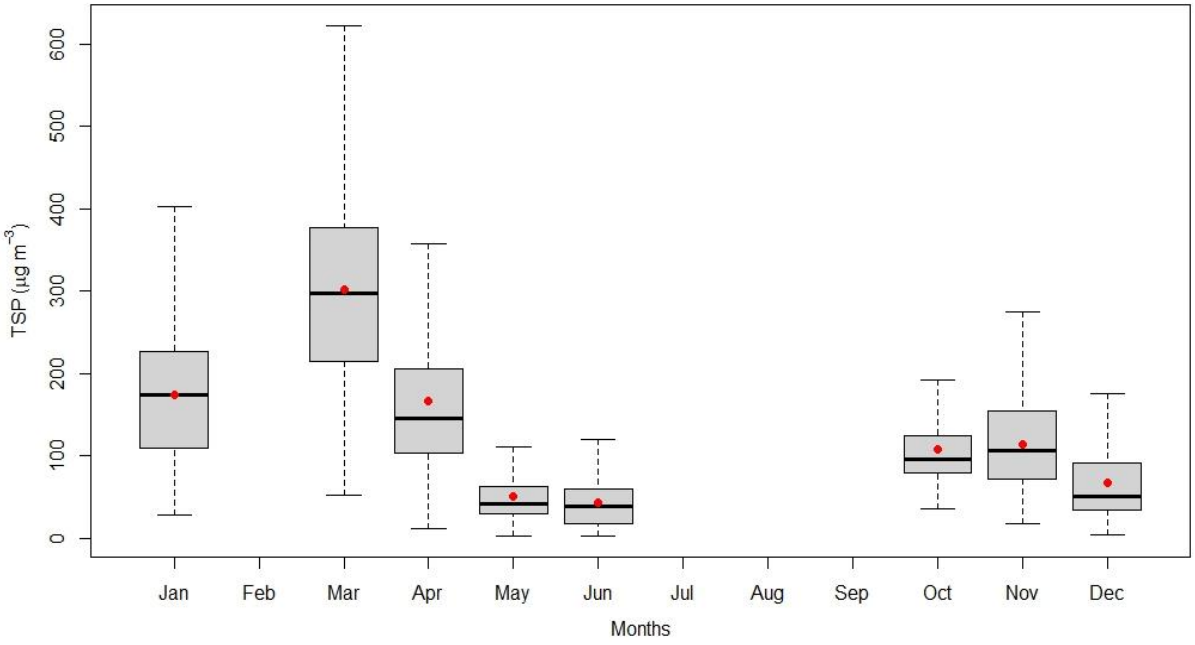


Figure 2.12.19: Monthly variation of TSP

The monthly average for April was found to be the highest (328.54 µg m^{-3}) and that of December was found to be the lowest (79.23 µg m^{-3}) while comparing with other months as shown in figure 2.12.20.

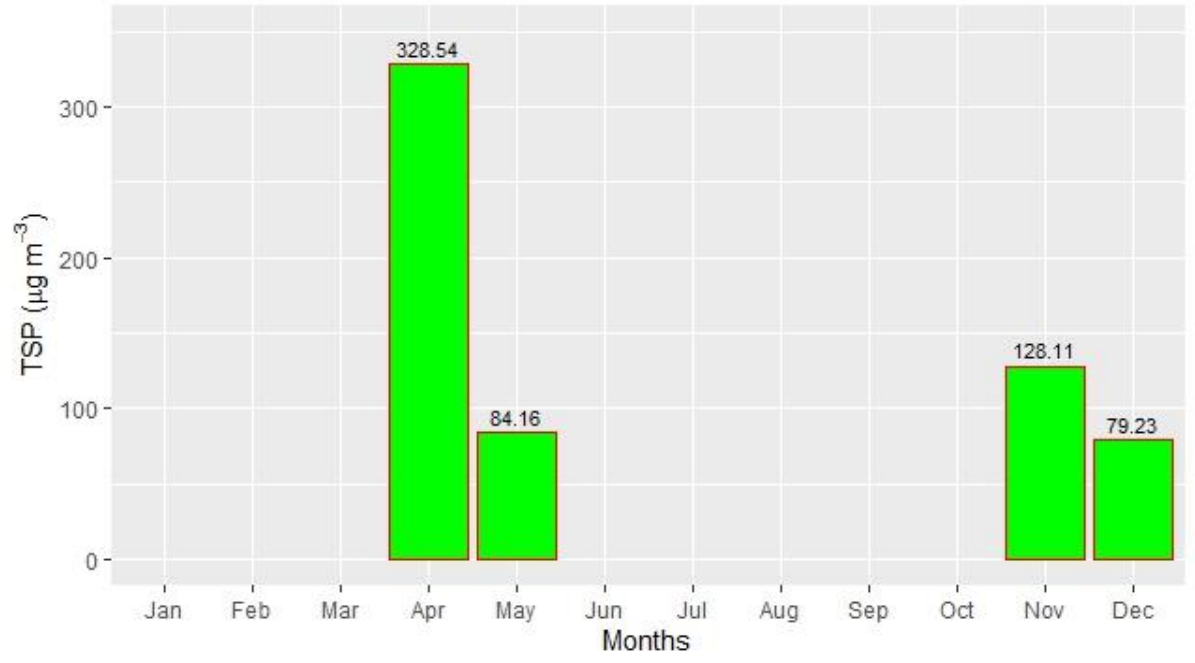


Figure 2.12.20: Monthly average of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 148 days of measurement, 51 days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3} as shown in figure 2.12.21.

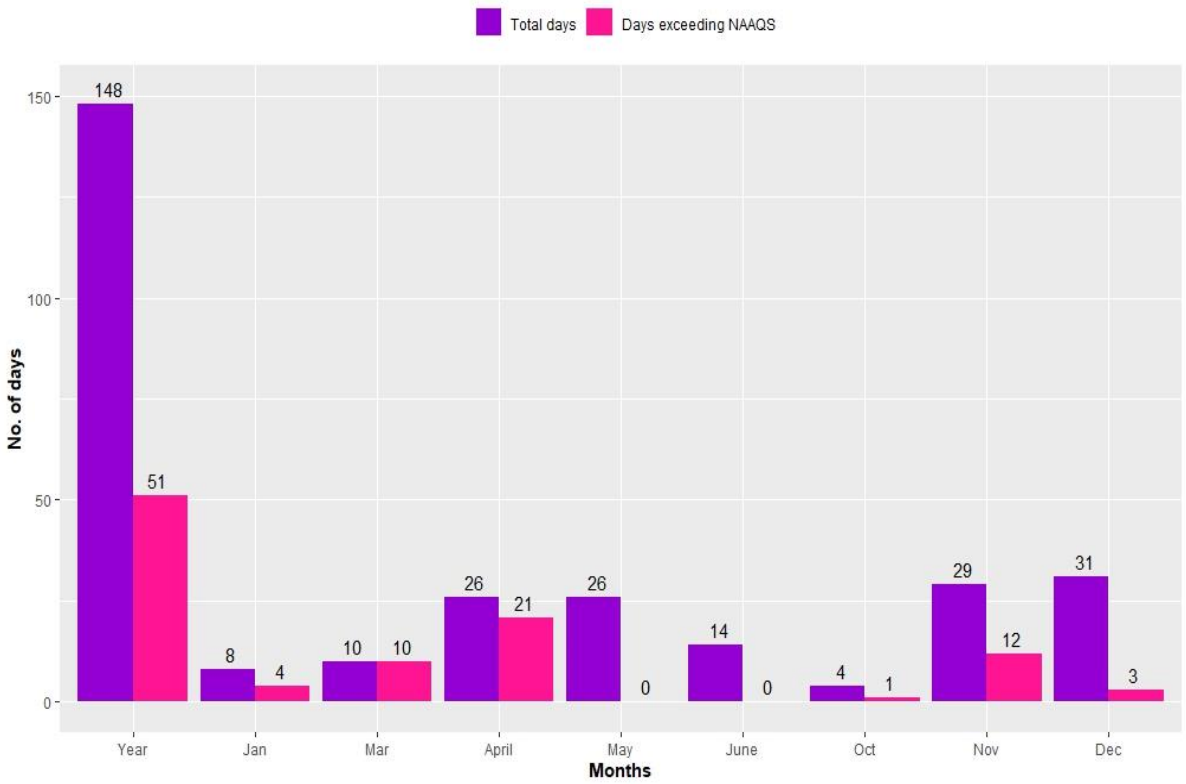


Figure 2.12.21: Compliance status of TSP

Calendar Plot

Calendar plot is prepared for PM $_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The Calendar plot shows AQI for $PM_{2.5}$ reached to Hazardous level in March 22. Similarly, it reached to very unhealthy level in January 10, in March 18,19, 20,21, 23 26 and 27, in April 4 and 5, in November 22, 23 and 24.

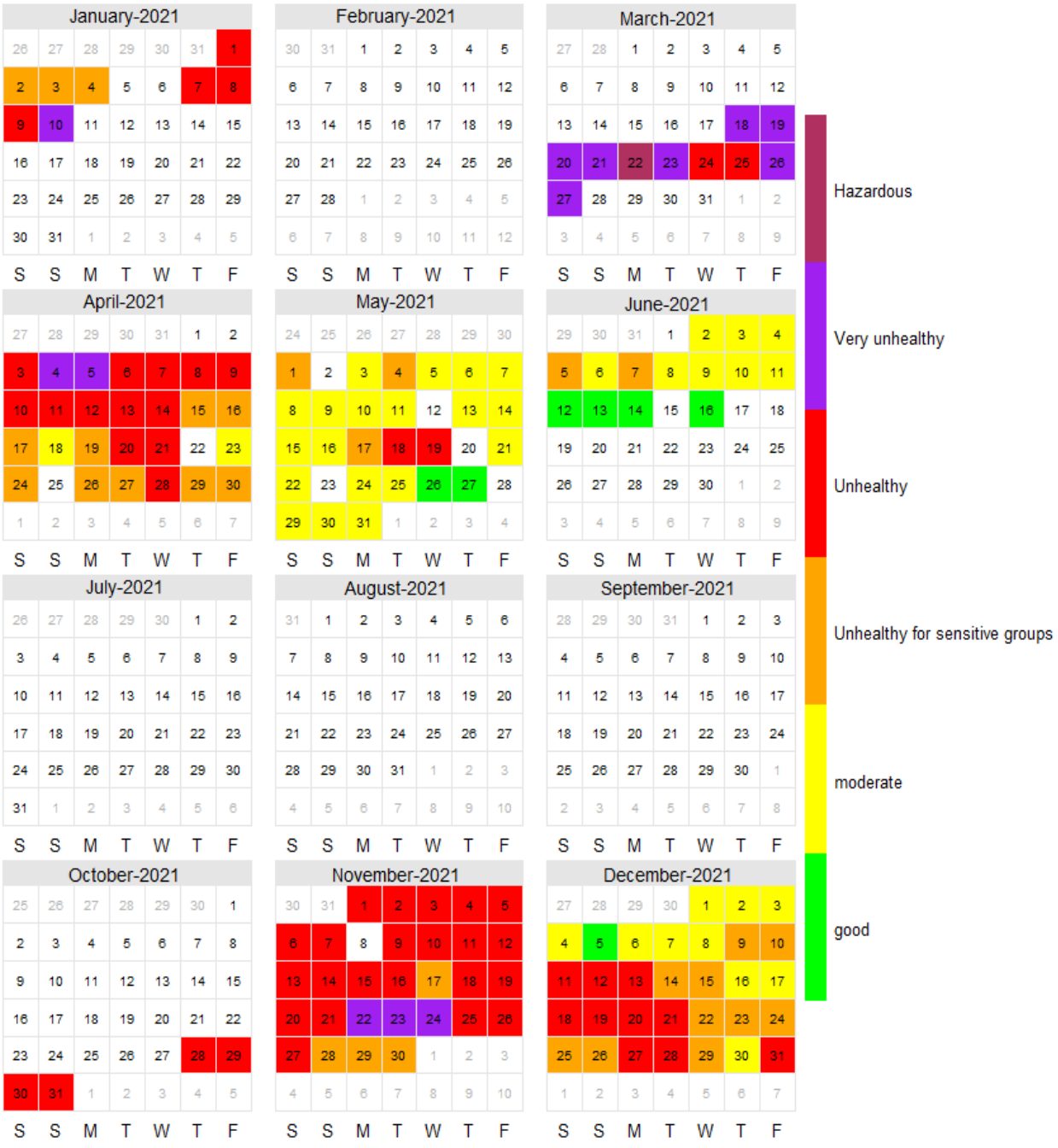


Figure 2.12.22: Calendar plot for $PM_{2.5}$ for the year 2021

2.13 Air quality status – Janakpur

2.13.1 Introduction

Inside the premises of office of chief minister and council of ministers, of Madhes Province the Janakpur Air Quality Monitoring Station was established in the year 2020. The station lies in the center of Janakpur city. So, it represents the urban area. The main sources of pollution are vehicles and industries. In this area lot of agricultural residues burning is found in Pre monsoon season. Since this is near to border trans boundary air pollution is also an issue.

The Station is installed with following instruments:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.13.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Janakpur Station was observed to range from 1 to 579.4 µg m^{-3} (Figure 2.13.1). The mean of the $PM_{2.5}$ point data was observed to be 29.67 µg m^{-3}.

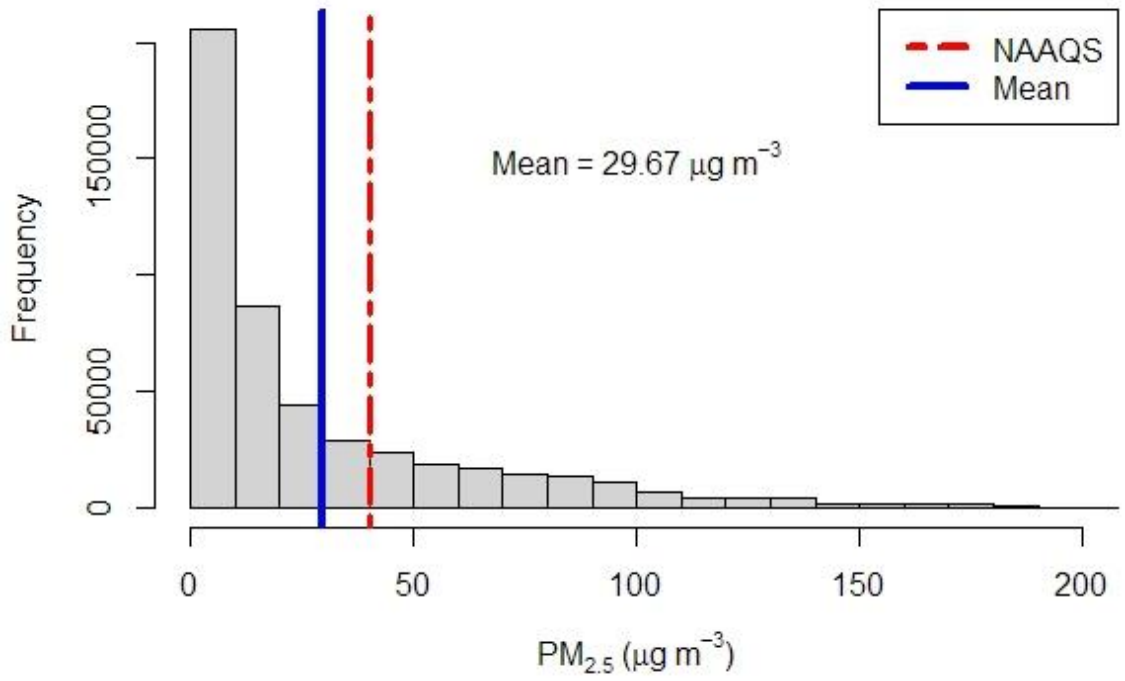


Figure 2.13.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.13.2 shows $PM_{2.5}$ starts falling from 12 AM to 2 PM then after 5 PM it again starts rising and peaks at 11 PM. The Box-plot shows mean is greater than median at each hour. And $PM_{2.5}$ is less variable during day time.

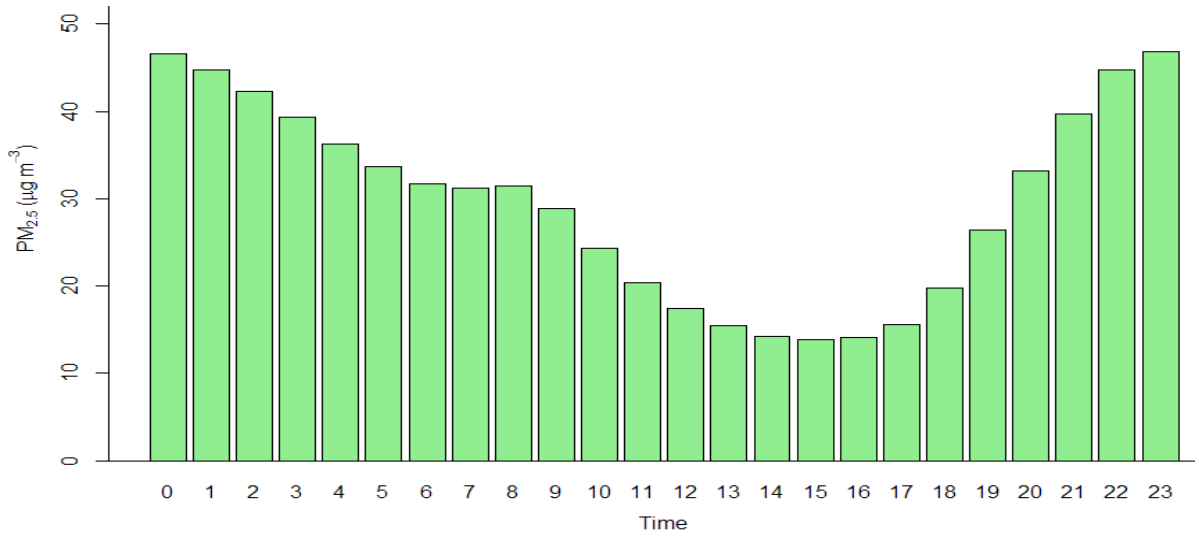


Figure 2.13.2: Hourly average of $PM_{2.5}$

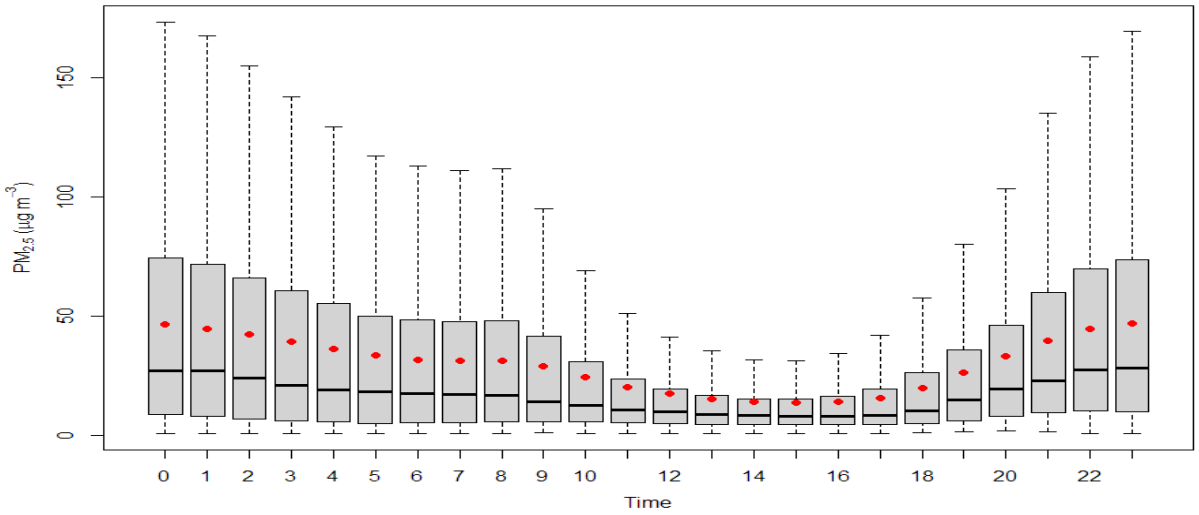


Figure 2.13.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variations of $PM_{2.5}$ is shown in figure 2.13.4. Higher concentration can be seen that higher concentration is during winter pre-monsoon and post-monsoon season.

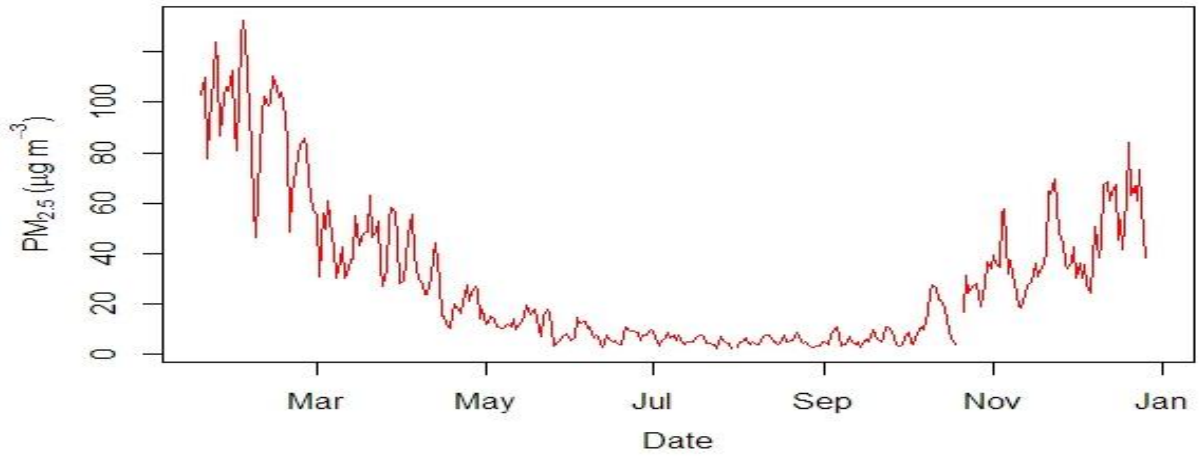


Figure 2.13.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5,}$ the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during January, February. November and December.

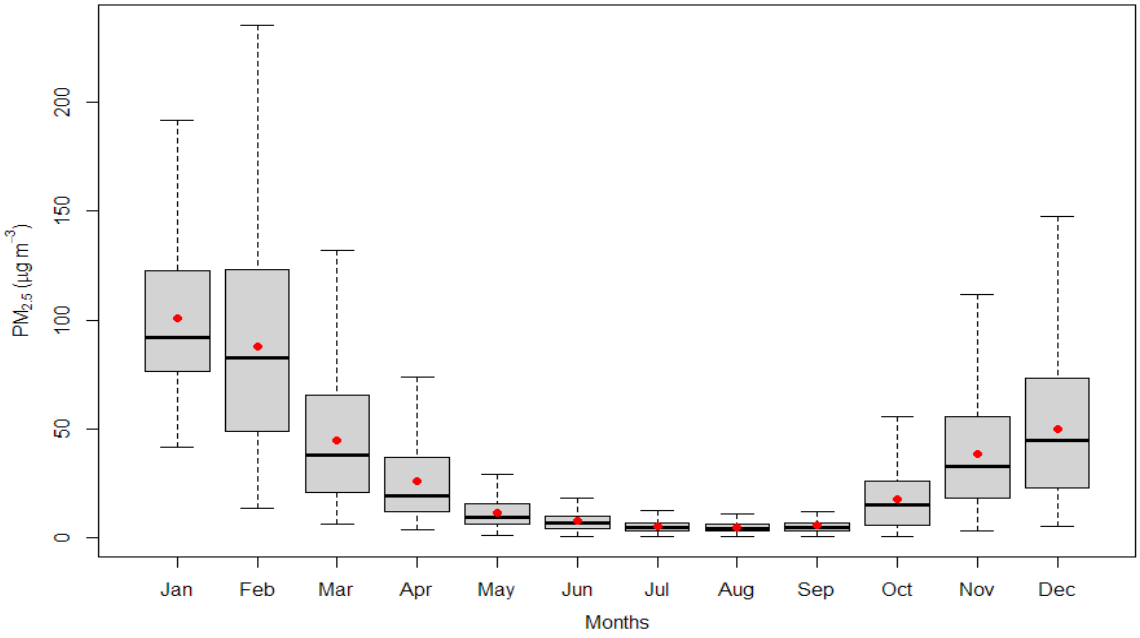


Figure 2.13.5: Monthly variation of $PM_{2.5}$

The monthly average of February was found to be highest (87.99 µg m^{-3}) and that of August was found to be lowest (5.09 µg m^{-3}) while comparing with other months as shown in figure 2.13.6 below.

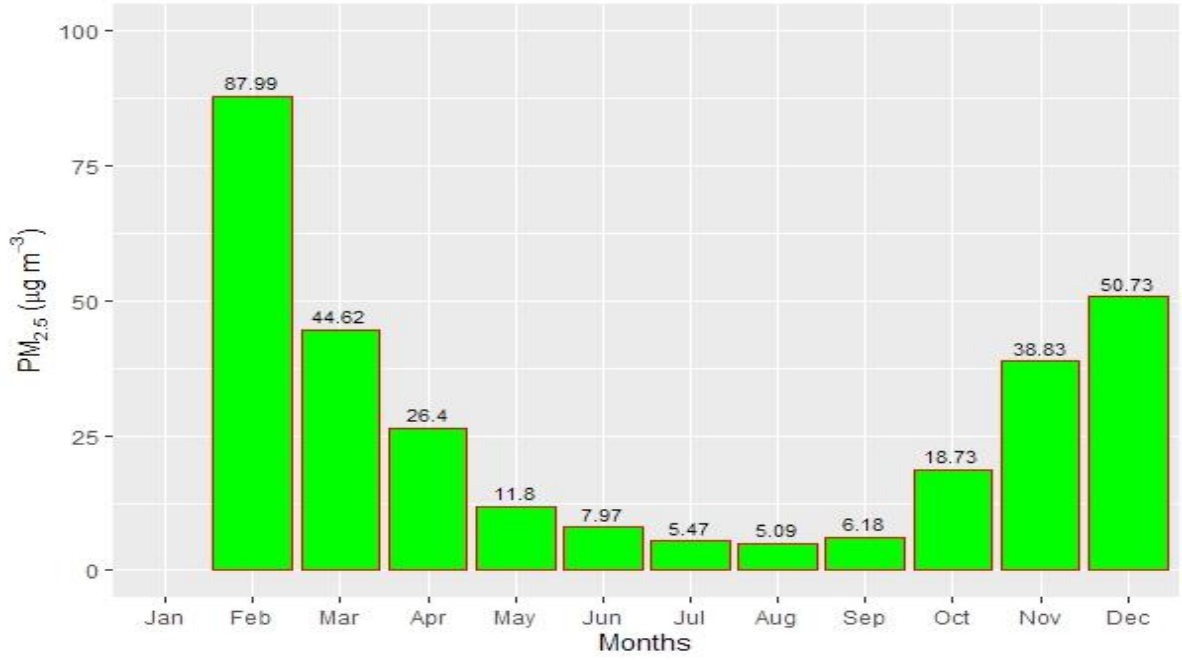


Figure 2.13.6: Monthly average of $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be similar in pre-monsoon season (27.62 µg m^{-3}) and Post–monsoon season (28.94 µg m^{-3}) while it was much lower in Monsoon season (6.16 µg m^{-3}). Seasonal average was not calculated for winter season due to insufficient data.

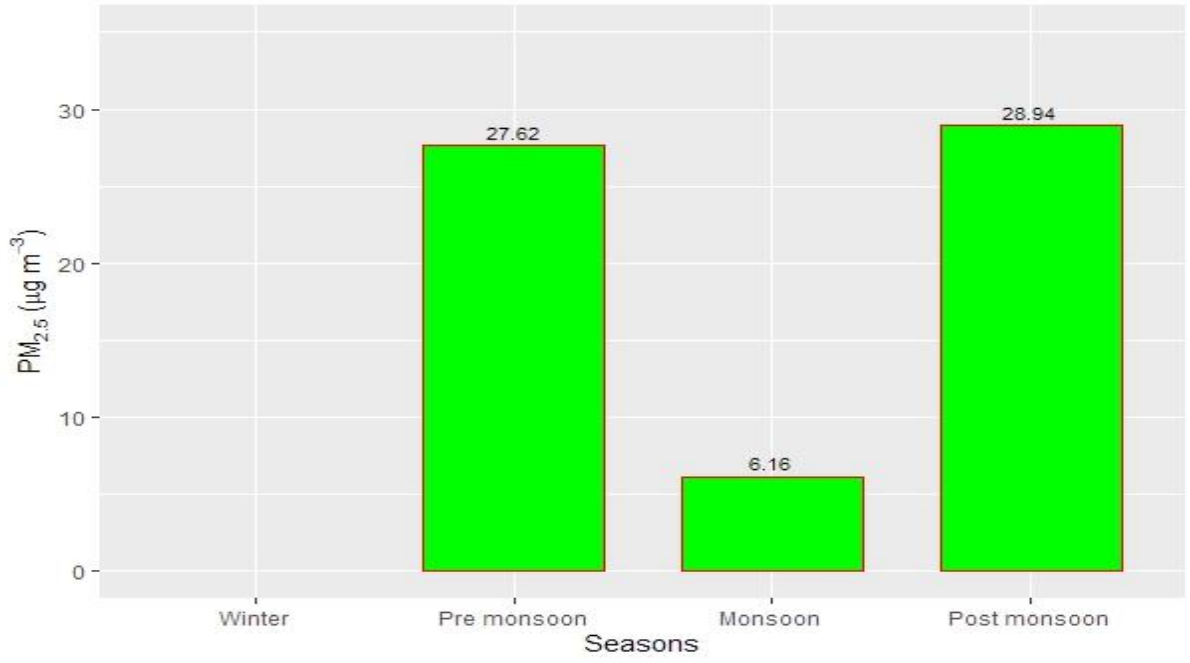


Figure 2.13.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 340 days of measurement, 92 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$. From May to October none of the days exceed NAAQS of 40 µg m^{-3} as shown in figure 2.13.8.

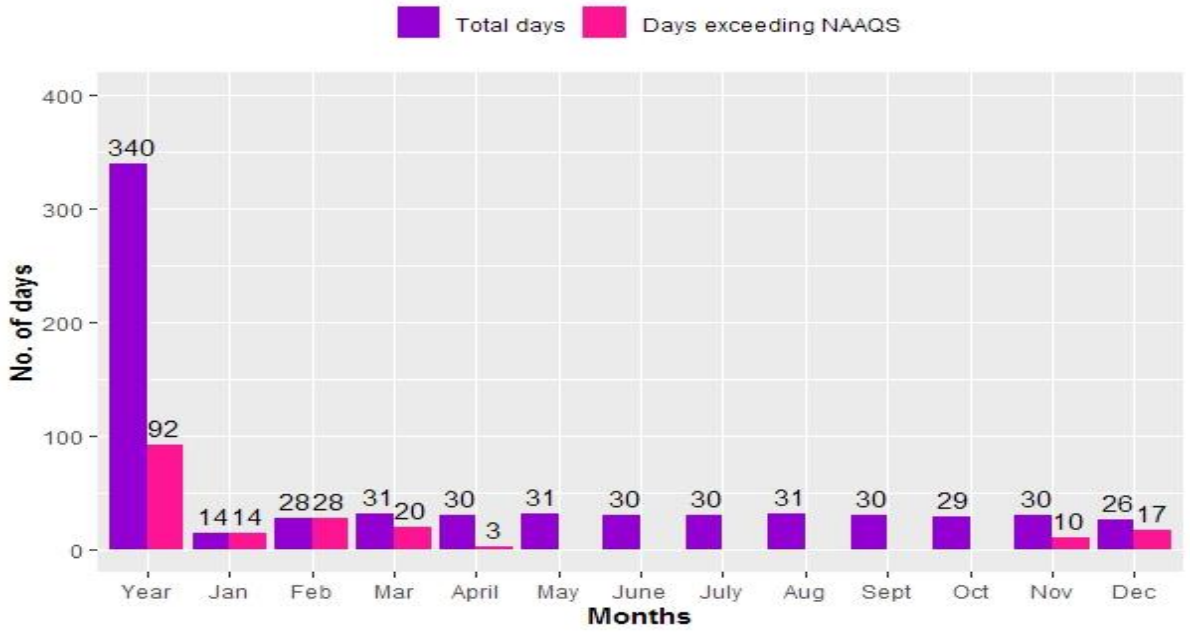


Figure 2.13.8: Compliance status of $PM_{2.5}$

Annual Average

The annual average of $PM_{2.5}$ for Janakpur station was calculated to be 29.97 µg m^{-3}.

Calendar Plot

Calendar plot is prepared for PM $_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The Calender plot shows AQI for $PM_{2.5}$ reached to very unhealthy level in January, February and few days in November and December.

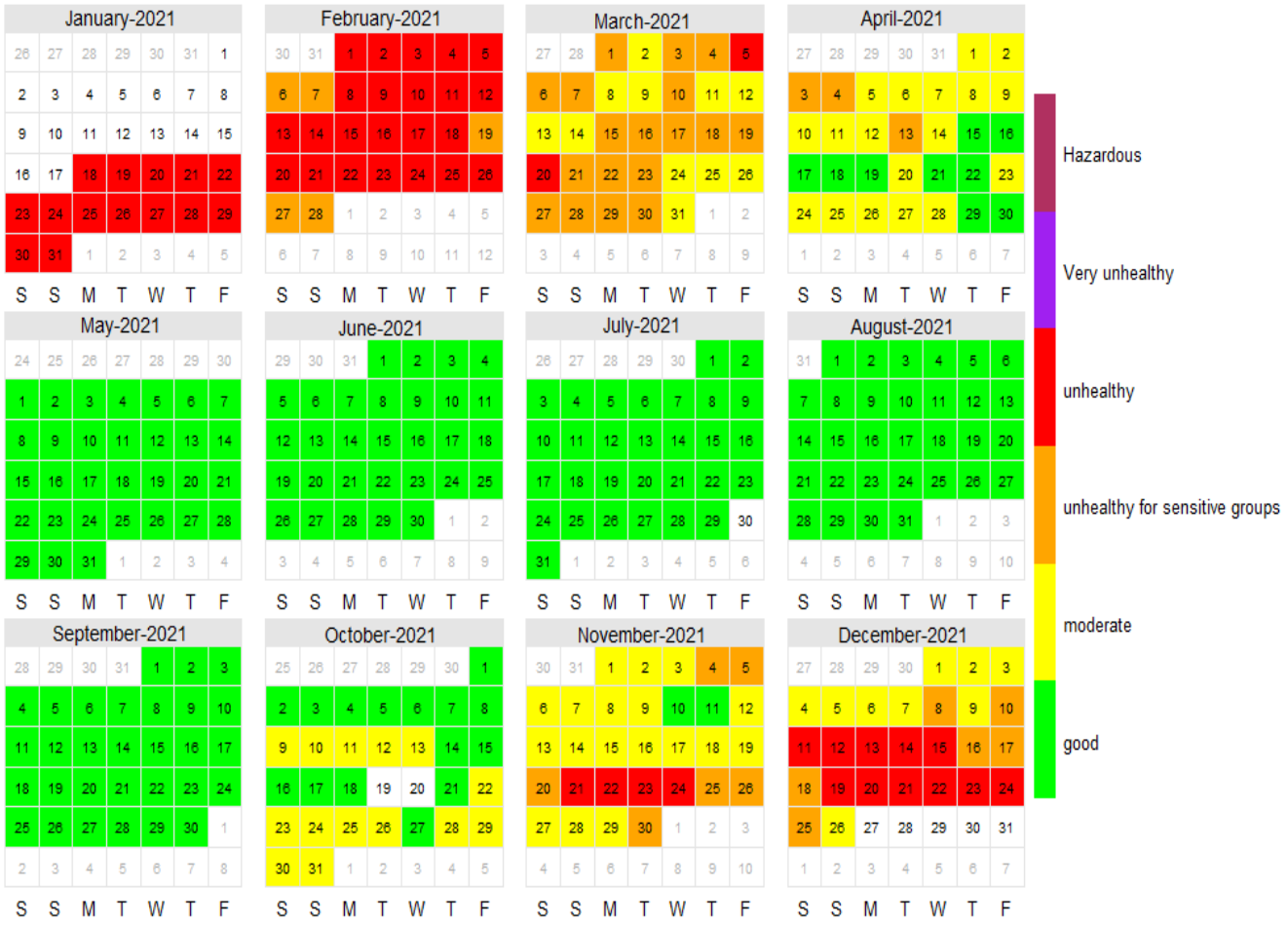


Figure 2.13.9: Calendar plot for $PM_{2.5}$ for the year 2021

2.14 Air quality status – Biratnagar

2.14.1 Introduction

Biratnagar Air Quality Monitoring Station was established in the year 2020. It lies inside the premise of Mahendra Morang Campus, Biratnagar, Morang at western corner of the campus premises. This station lies in the eastern part of Nepal and represents the urban area. The major source of air pollution in this area are vehicles and commercial activities.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180+	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.14.2 $PM_{2.5}$

Histogram

The $PM_{2.5}$ value ranged in between 1 to 1028 µg m^{-3}. The annual average $PM_{2.5}$ value was found to be 60.72 µg m^{-3} exceeding the national standard of 40 µg m^{-3} (Figure 2.14.1).

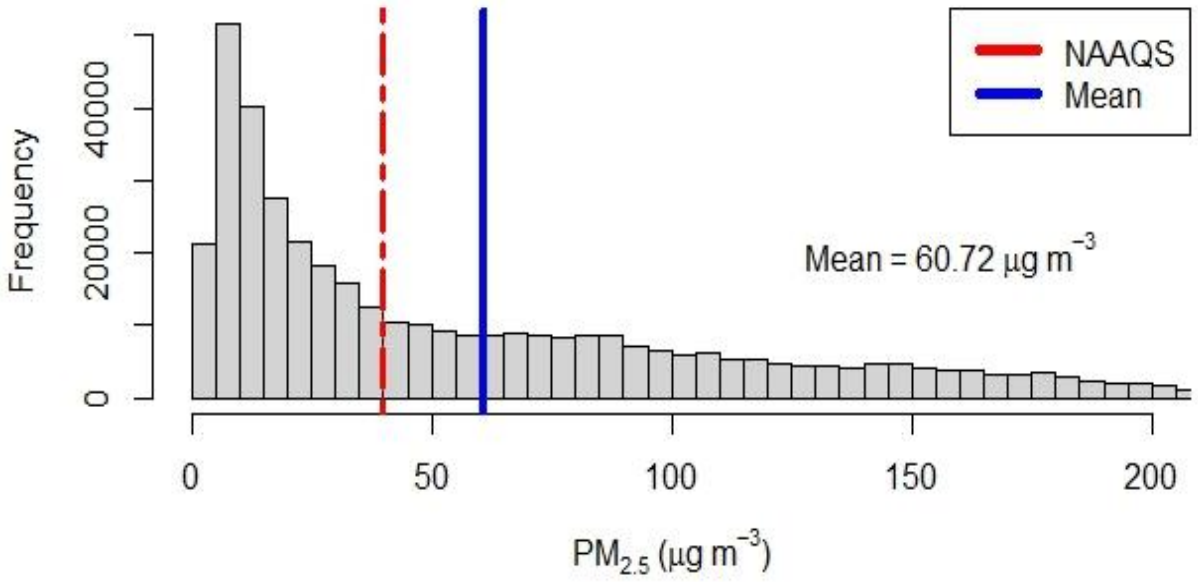


Figure 2.14.1: Histogram of $PM_{2.5}$

Diurnal Variation

The $PM_{2.5}$ value was found more in between 12 AM to 8 AM and in between 6 PM to 11 PM (figure 2.14.2). The box plot shows that mean value was found to be more than the median throughout the day (figure 2.14.3).

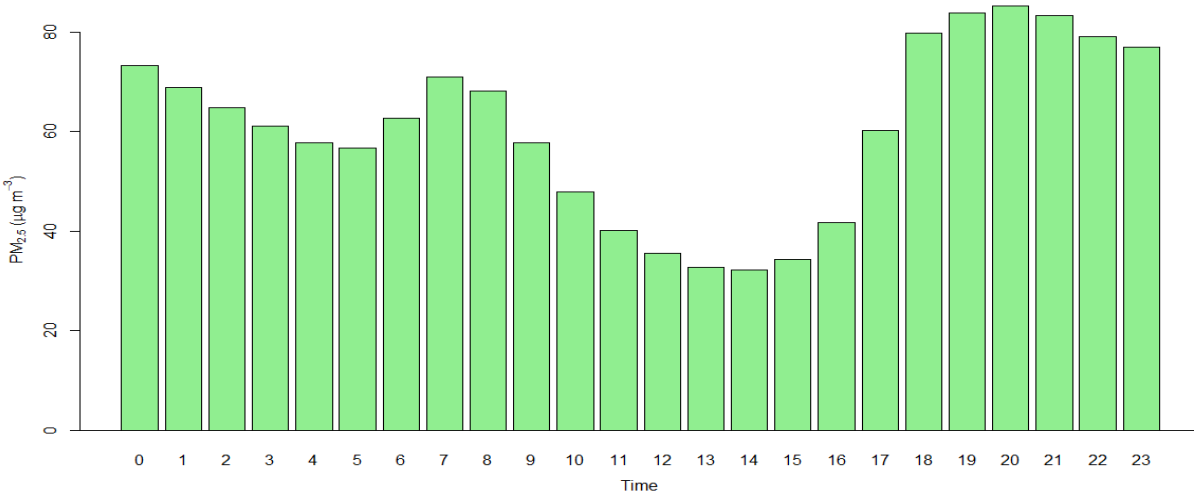


Figure 2.14.2: Diurnal variation of $PM_{2.5}$

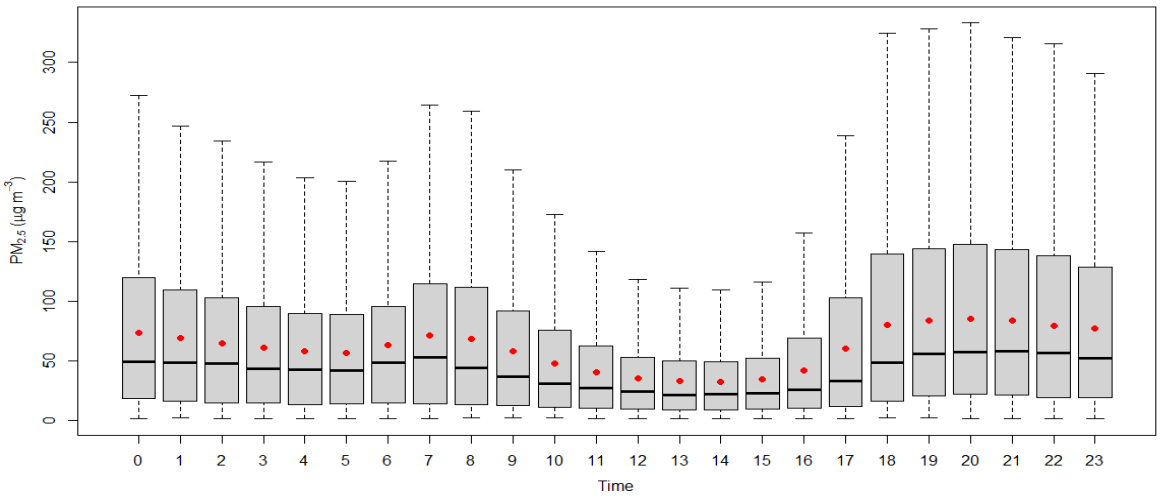


Figure 2.14.3: Diurnal variation of $PM_{2.5}$

Daily average

The daily average $PM_{2.5}$ values were found higher in between January to May and found maximum in the month of November. The values were found low in between May to October. (figure 2.14.4).

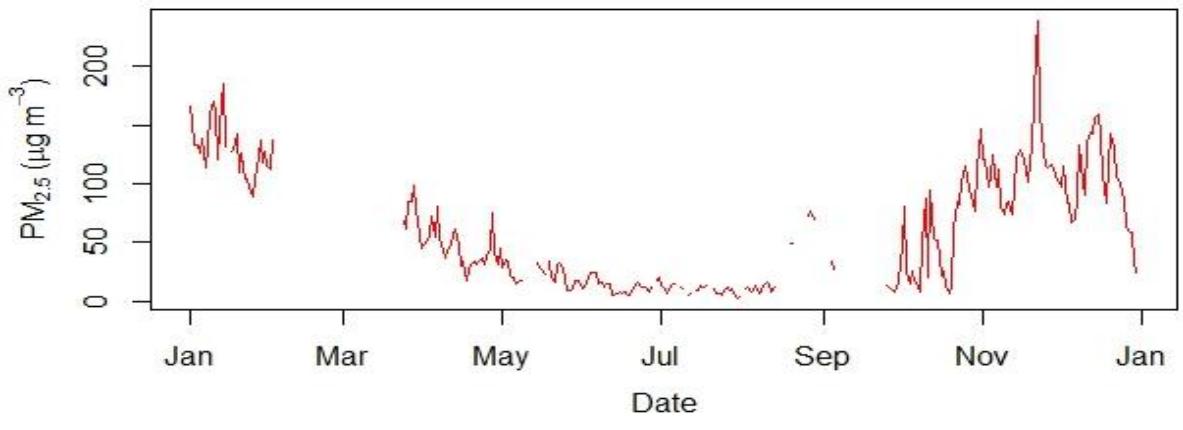


Figure 2.14.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

The monthly average value was found in between 9.62 µg m^{-3} to 131.32 µg m^{-3} with highest in January (131.32 µg m^{-3}) and lowest in July (9.62 µg m^{-3}). It was not calculated for February, March and September due to insufficient data. (figure 2.14.5)

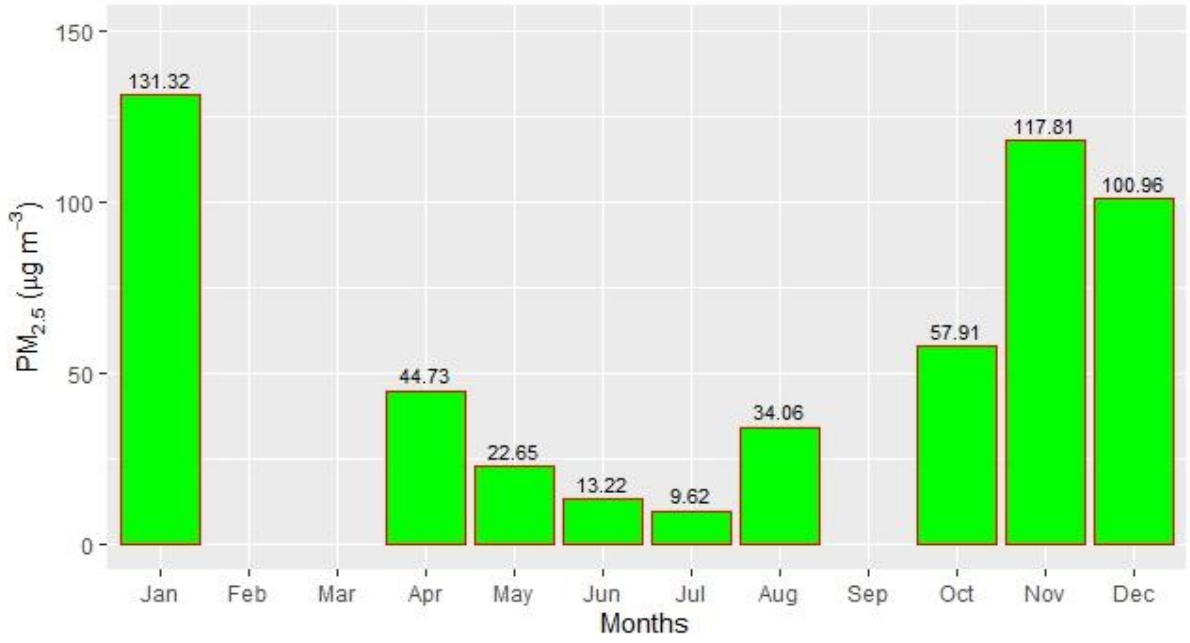


Figure 2.14.5: Monthly average $PM_{2.5}$

In the box plot, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. The box plot below shows low variation in $PM_{2.5}$ values in between June to July. The mean value was found more than median especially in August and October (figure 2.14.6).

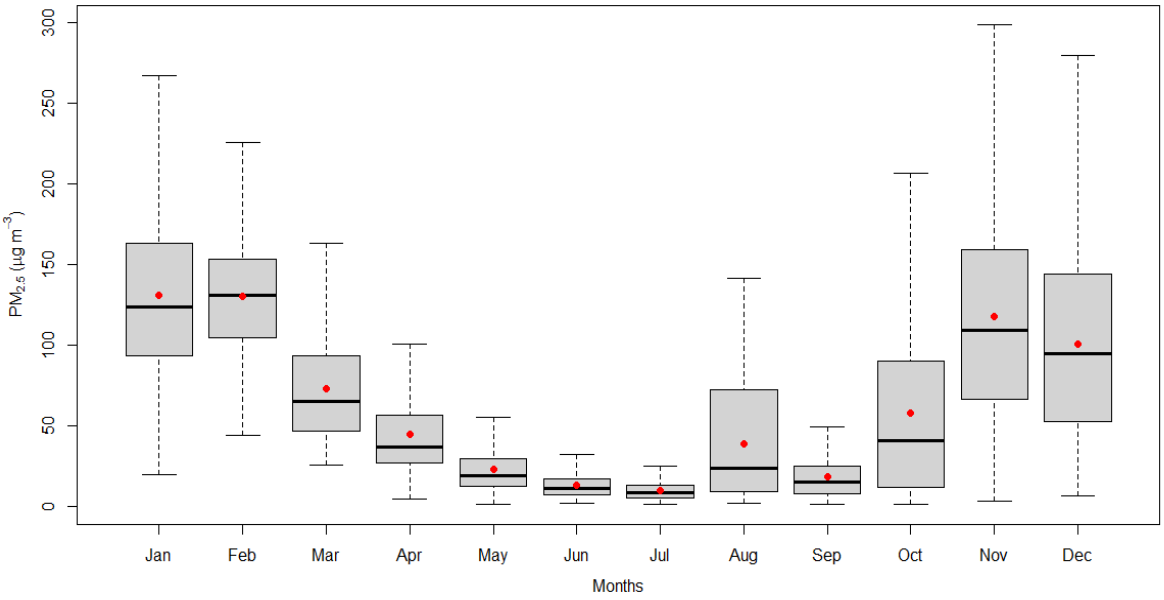


Figure 2.14.6: Monthly variation of $PM_{2.5}$

Seasonal Average

The seasonal average $PM_{2.5}$ value was found maximum in winter (143 µg m^{-3}) and minimum in monsoon season (17.47 µg m^{-3}). (figure 2.14.7)

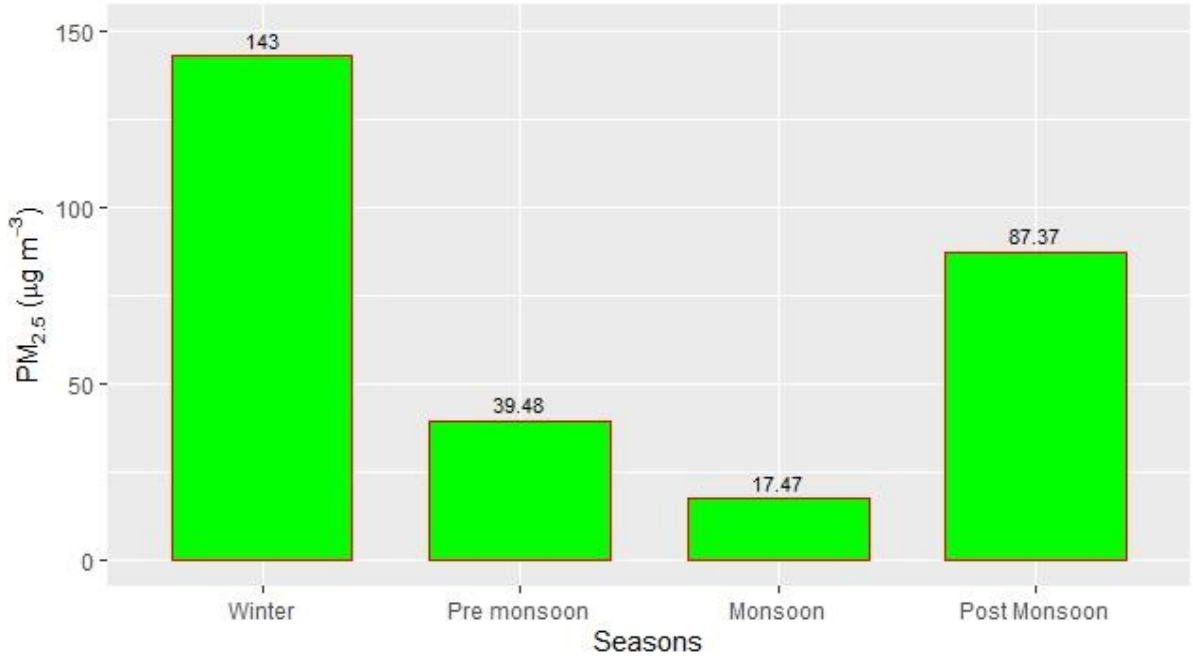


Figure 2.14.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 269 days of measurement, 142 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$. From May to July none of the days exceeded NAAQS of 40 µg m^{-3} (figure 2.14.8).

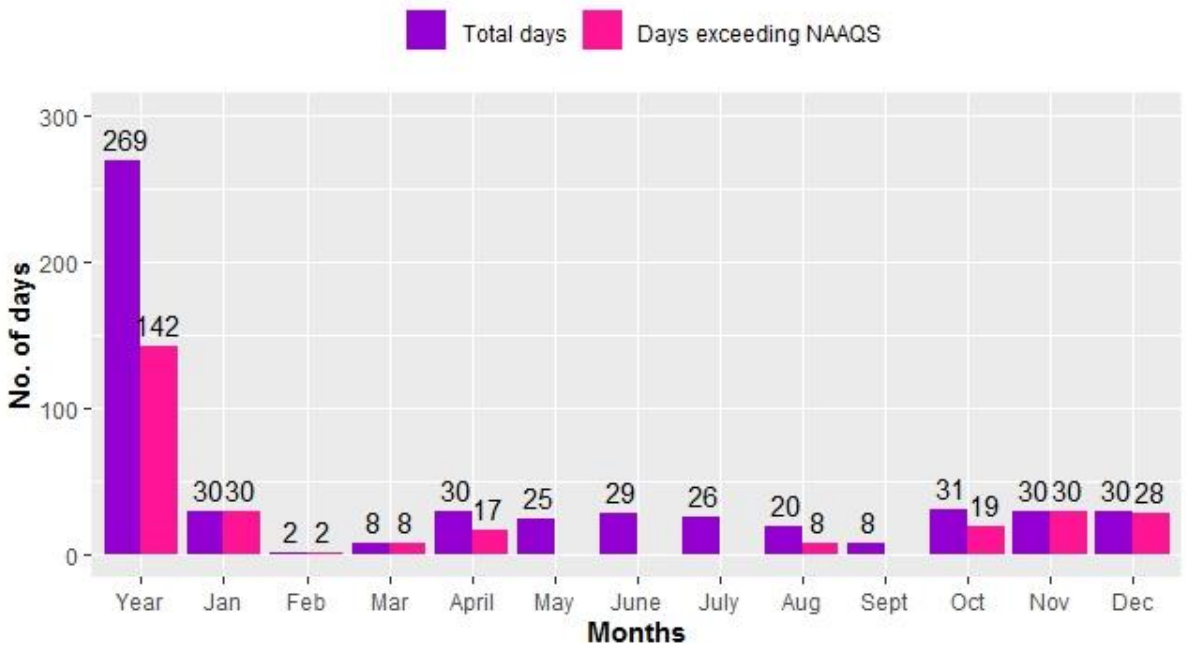


Figure 2.14.8: Compliance status of $PM_{2.5}$

2.14.3 PM_{10}

Histogram

The PM_{10} value ranged in between 1 to 2562 µg m^{-3}. The annual average PM_{10} was found to be 75.51 µg m^{-3} (Figure 2.14.9).

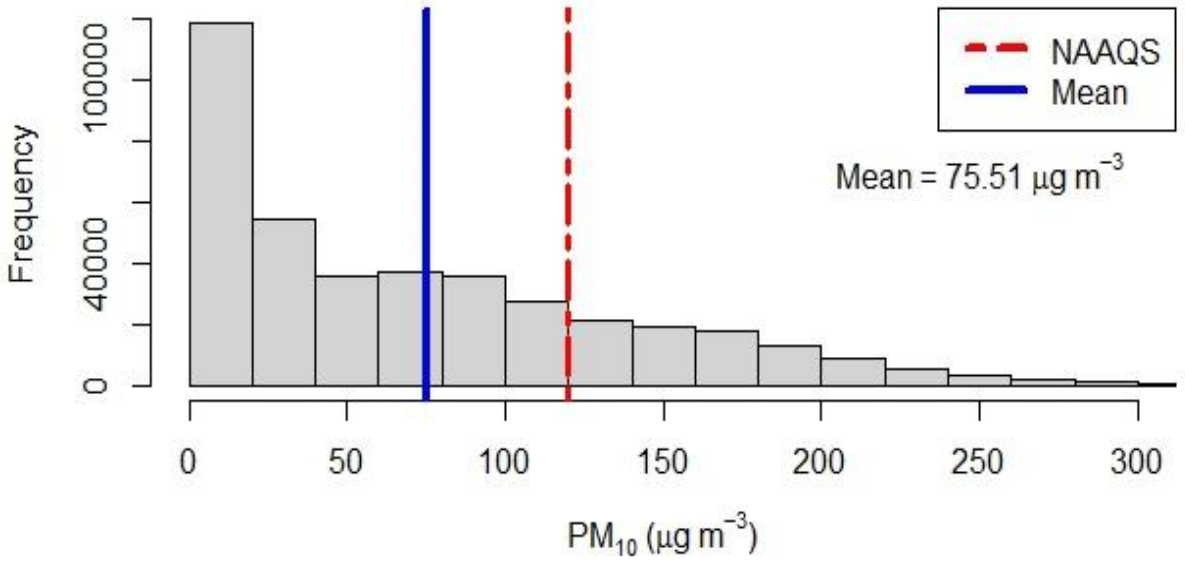


Figure 2.14.9: Histogram of PM_{10}

Diurnal Variation

The PM_{10} value was found maximum in between 7am to 10AM, decreased in the day time and then increases after 6 PM till 11 PM (figure 2.14.10). The box plot below shows that mean value was found to be more than the median throughout the day (figure 2.14.11).

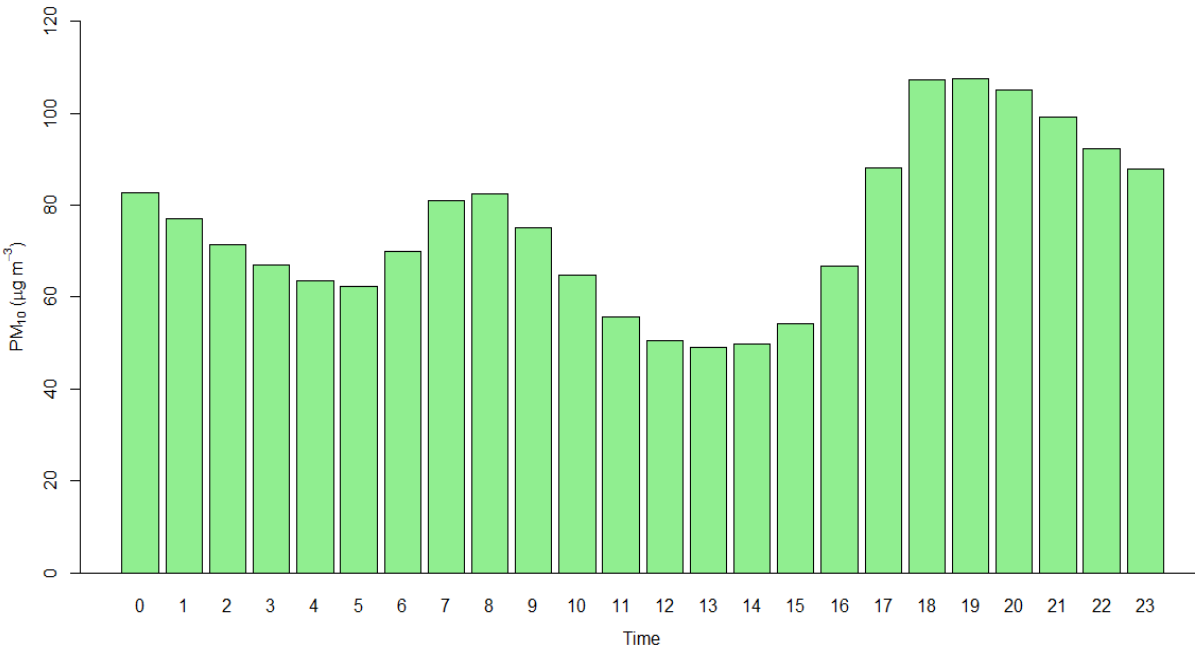


Figure 2.14.10: Hourly average of PM_{10}

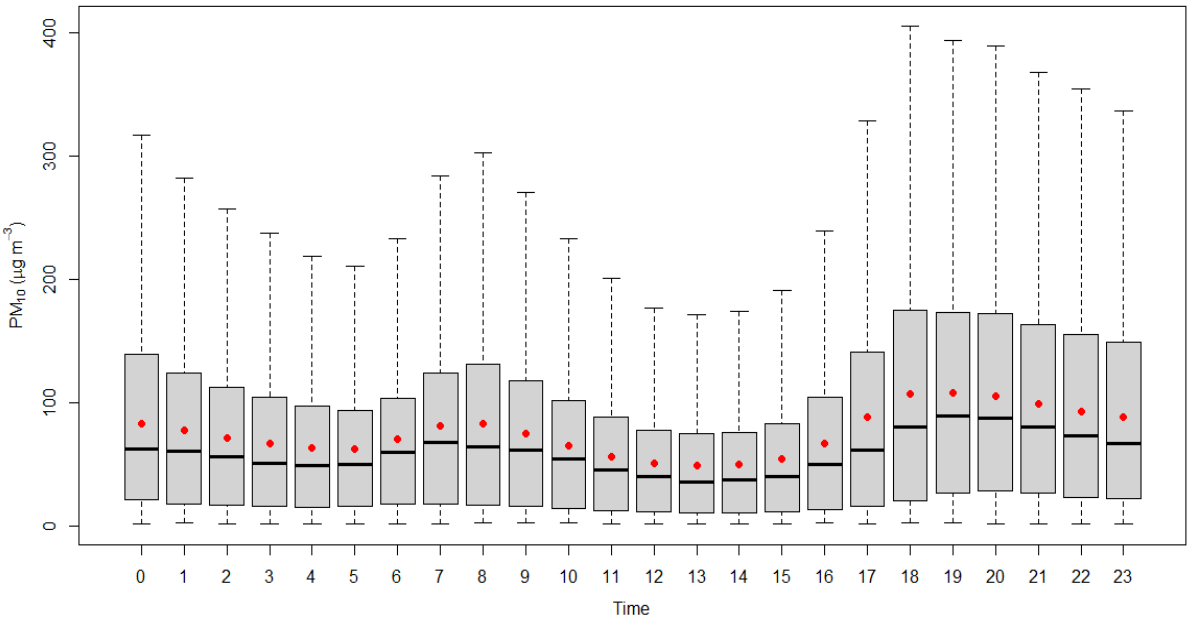


Figure 2.14.11: Diurnal variation of PM_{10}

Daily average

The daily average PM_{10} values were found higher in between November to May and found maximum in the month of December. The values were found low in between June to October. (figure 2.14.12).

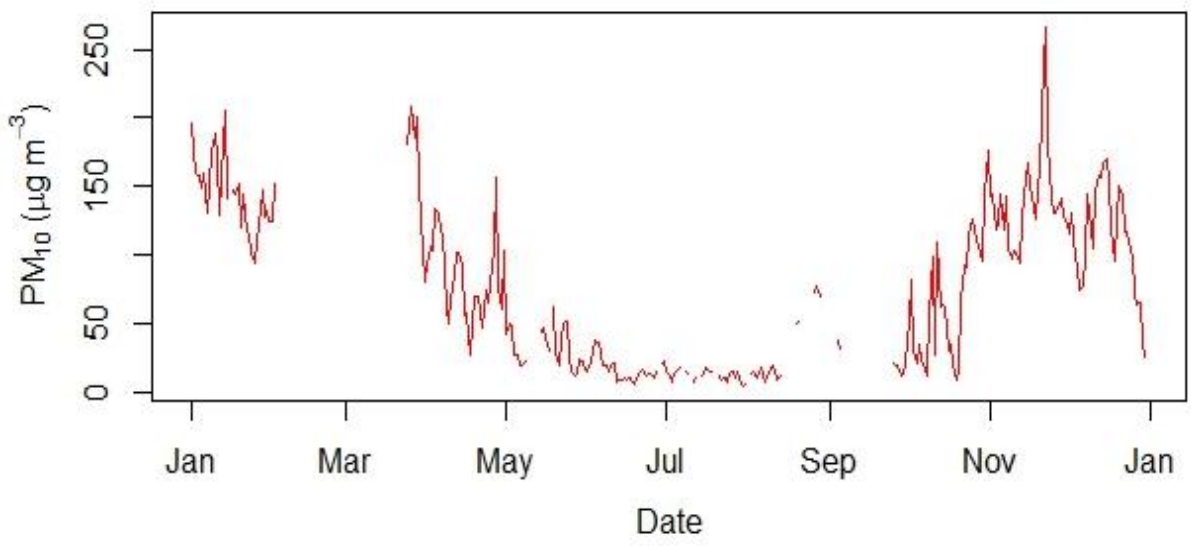


Figure 2.14.12: Daily mean concentration of PM_{10}

Monthly Variation

The monthly average value was found in between 11.53 µg m^{-3} to 145.65 µg m^{-3} in January and July respectively. It was not calculated for February, March and September due to insufficient data (figure 2.14.13).

The box plot below shows high variation in $PM_{2.5}$ values in between March, October, November and December. The mean value was found more than median especially in August and November (figure 2.14.14).

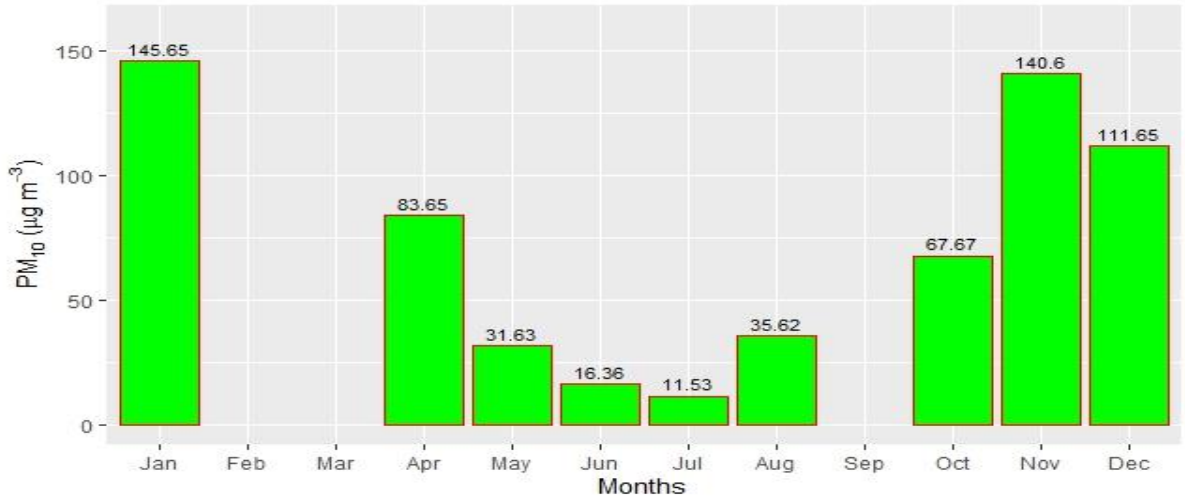


Figure 2.14.13: Monthly average of PM_{10}

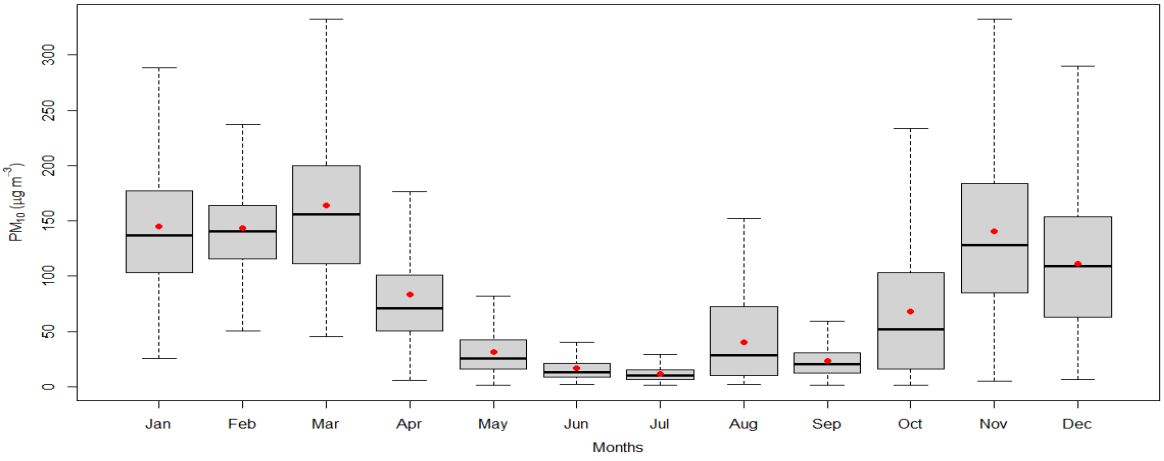


Figure 2.14.14: Monthly variation of PM_{10}

Seasonal Average

The seasonal average PM_{10} value was found maximum in winter (168.29 µg m^{-3}) and minimum in monsoon season (20.04 µg m^{-3}) (figure 2.14.15).

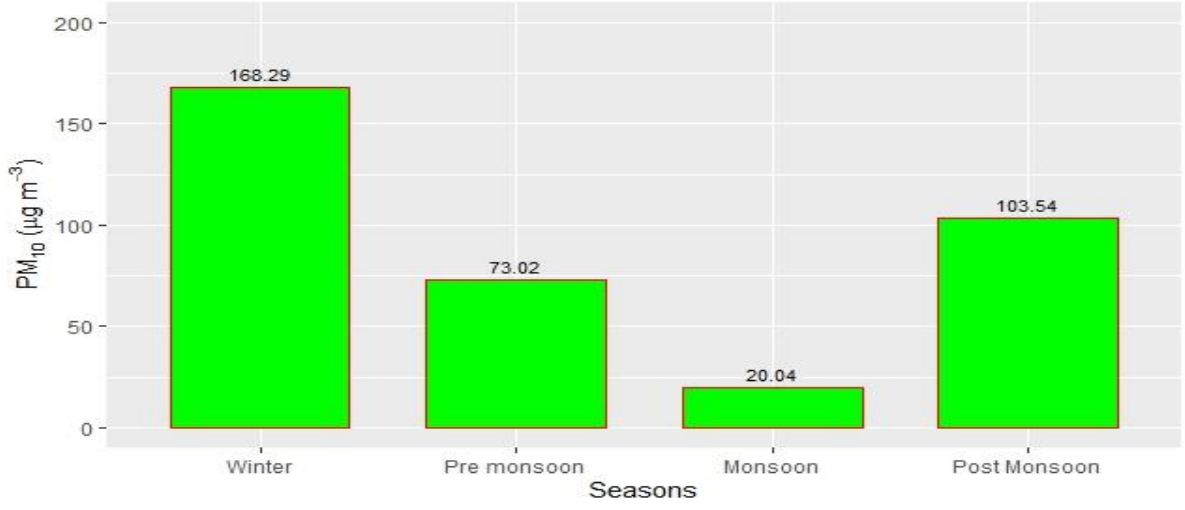


Figure 2.14.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 269 days of measurement, 72 days exceeded the National Ambient Air Quality Standard for PM_{10}. From May to September none of the days exceeded NAAQS of 120 µg m^{-3} (figure 2.14.16).

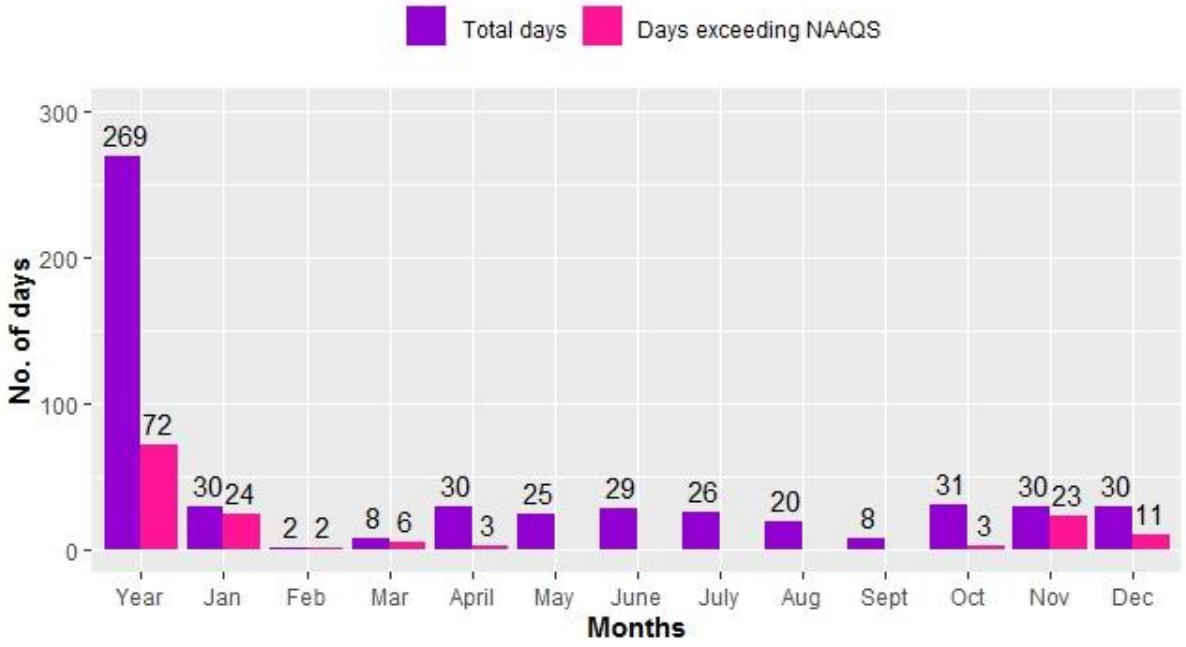


Figure 2.14.16: Compliance status of PM_{10}

2.14.4 TSP

Histogram

The TSP value ranged in between 1 to 4975.1 µg m^{-3}. The annual average TSP value was found to be 102.41 µg m^{-3} (Figure 2.14.17).

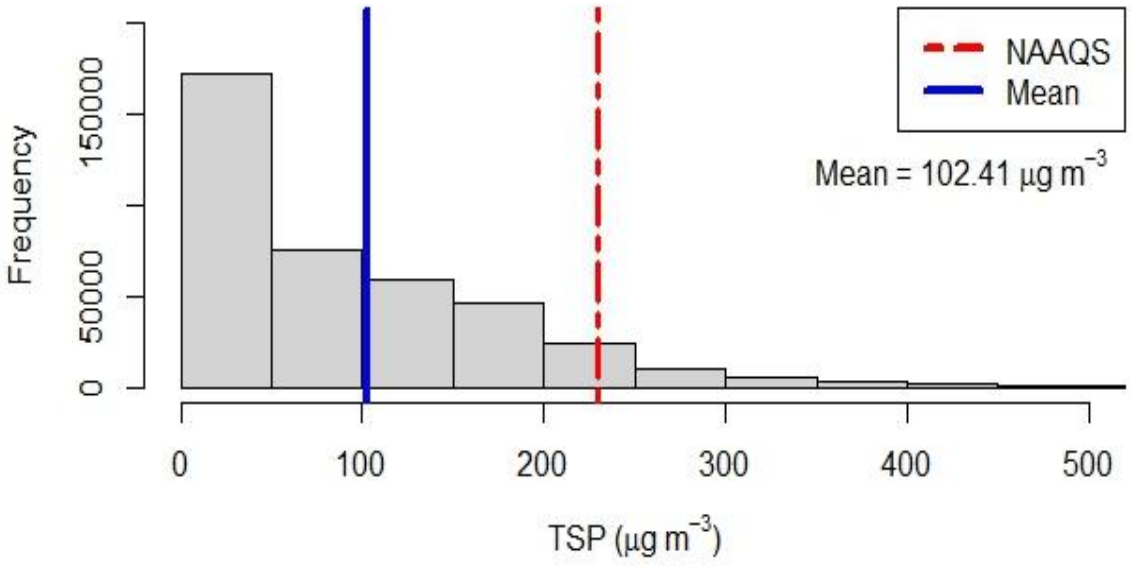


Figure 2.14.17: Histogram of TSP

Diurnal Variation

In contrast to the trend of $PM_{2.5,}$ $PM_{10,}$ the TSP value slowly increased in the morning and found maximum in evening time especially in between 5 to 7 PM which gradually started to decrease then after (figure 2.14.18). The box plot below shows that mean value was found to be more than the median throughout the day (figure 2.14.19).

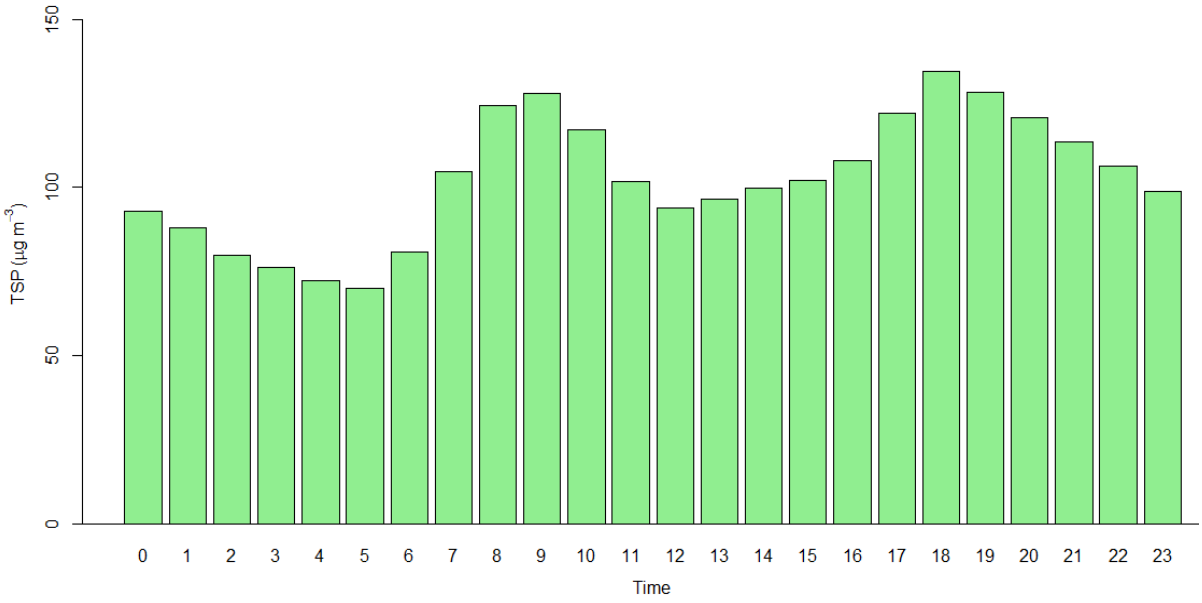


Figure 2.14.18: Hourly average of TSP

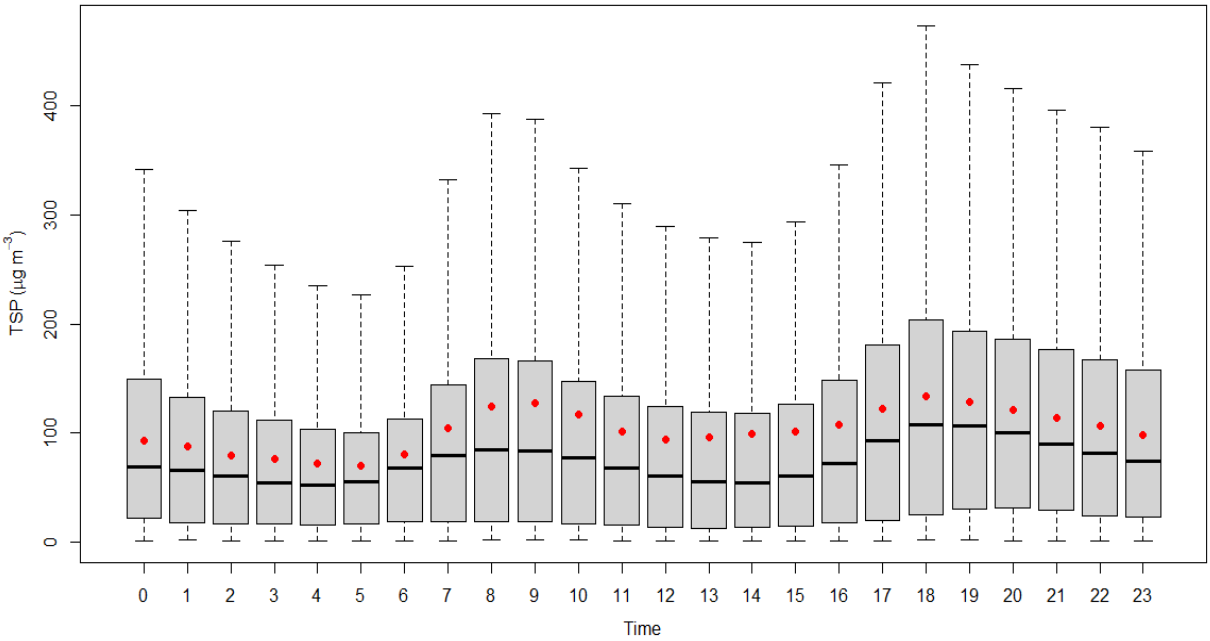


Figure 2.14.19: Diurnal variation of TSP

Daily average

The daily average TSP values were found maximum in the month of April. The values were found low in between May to October (figure 2.14.20).

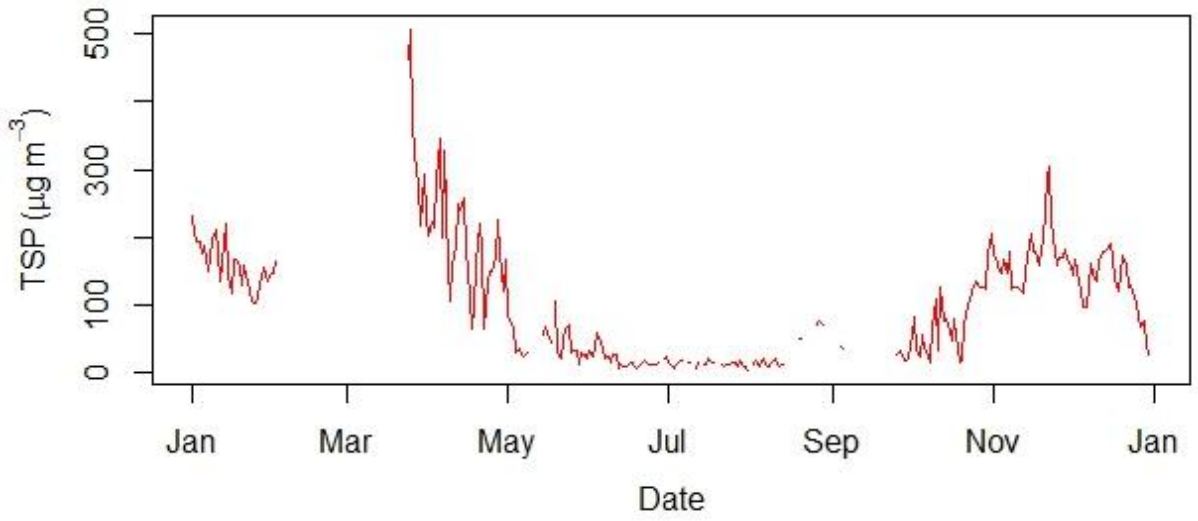


Figure 2.14.20: Daily average value of TSP

Monthly Variation

The monthly average value for April was found to be the highest (185.76 µg m^{-3}) and that of July was found to be the lowest (13.74 µg m^{-3}) while comparing with other months. It was not calculated for February, March and September due to insufficient data.as shown in figure 2.14.21.

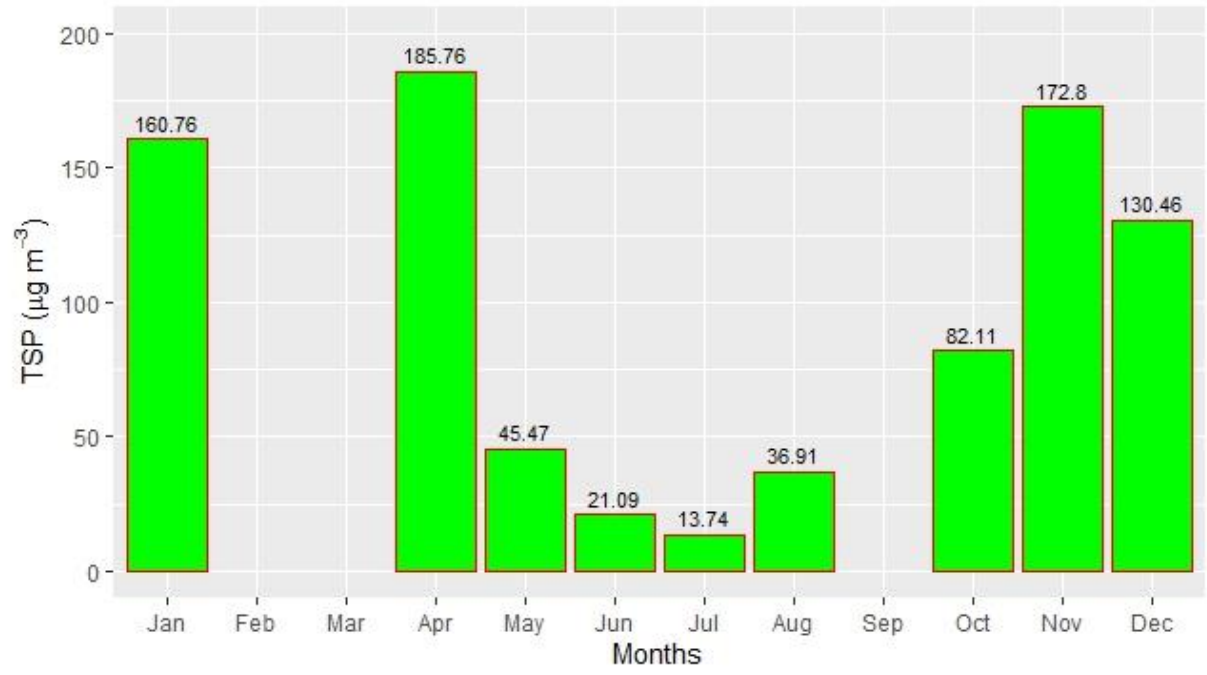


Figure 2.14.21: Monthly average of TSP

The box plot below shows high variation in between March and April and less variation during May to September. The mean value was found more than median in every month while mean value is significantly higher than median in March as shown in figure 2.14.22.

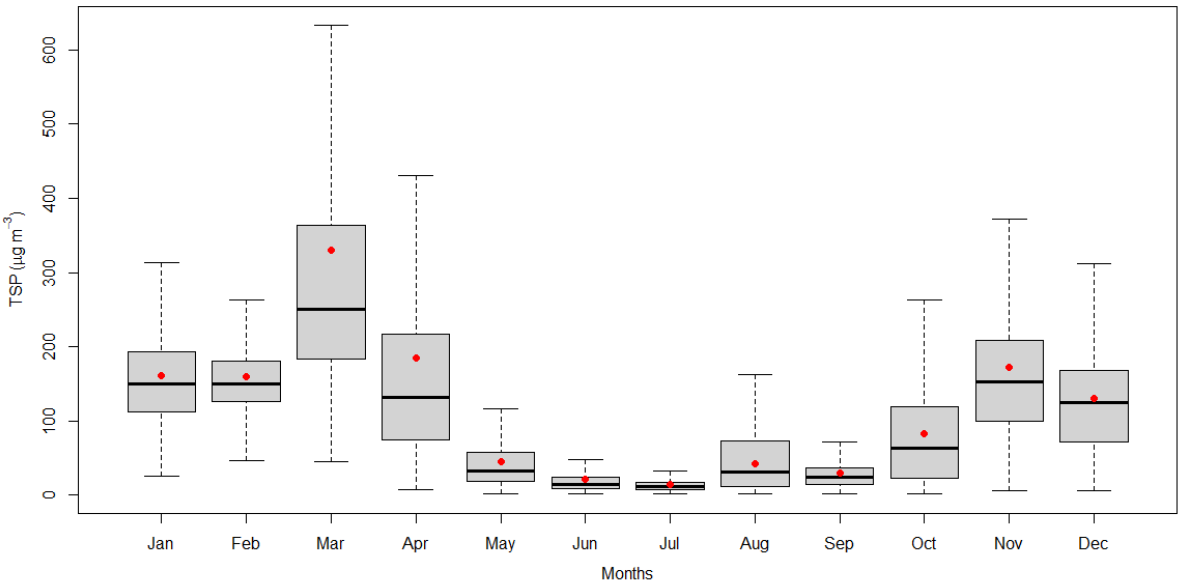


Figure 2.14.22: Monthly variation of TSP

Seasonal Average

The seasonal average TSP value was found maximum in winter (195.67 µg m^{-3}) and minimum in monsoon season (23.28 µg m^{-3}).

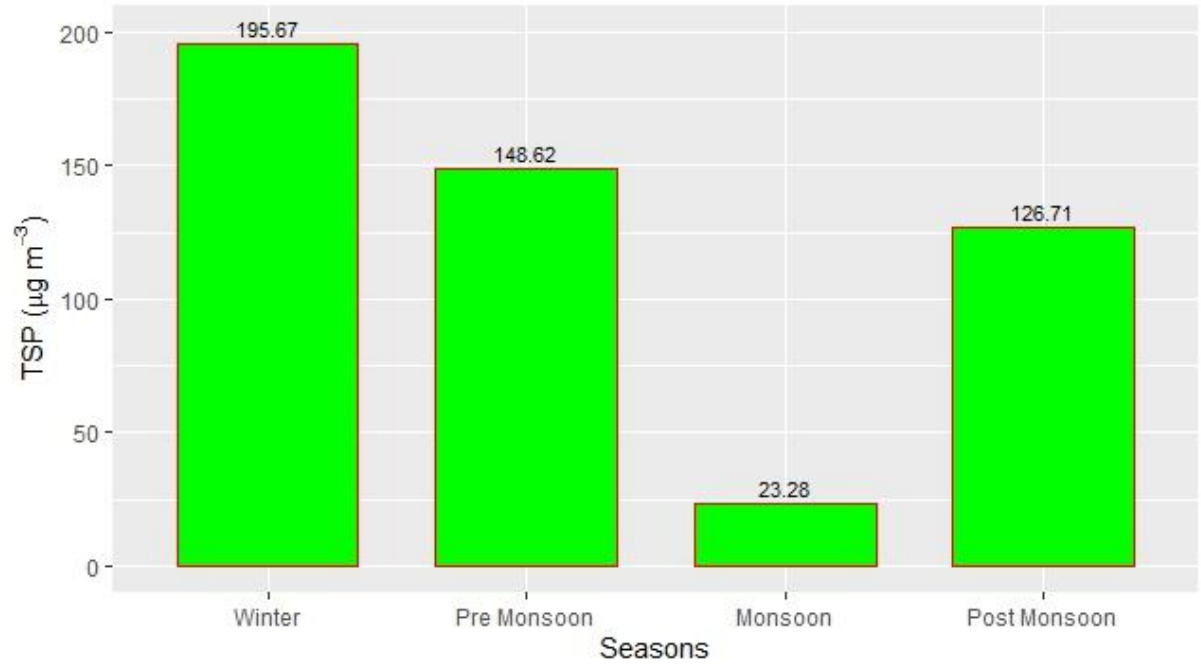


Figure 2.14.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 270 days of measurement, 16 days exceeded the National Ambient Air Quality Standard for TSP. From May to October, December and February none of the days exceeded NAAQS of 230 µg m^{-3} (figure 2.14.24).

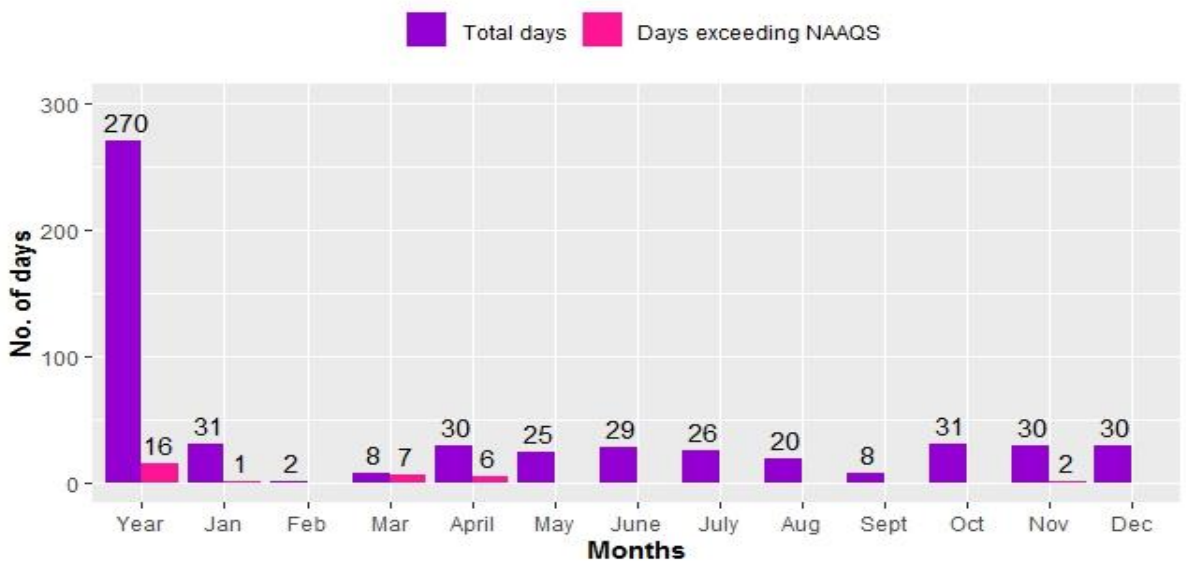


Figure 2.14.24: Compliance status of TSP

Calendar Plot

The following figure shows the calendar plot for PM $_{2.5}$ based on the Air Quality Index (AQI) developed by Government of Nepal. The Calender plot shows AQI for $PM_{2.5}$ reached to very unhealthy level in 1^{st,} 10 to 11th and 13 to 14th January and reached to very unhealthy level in January, November and December and few days in March, April and August.

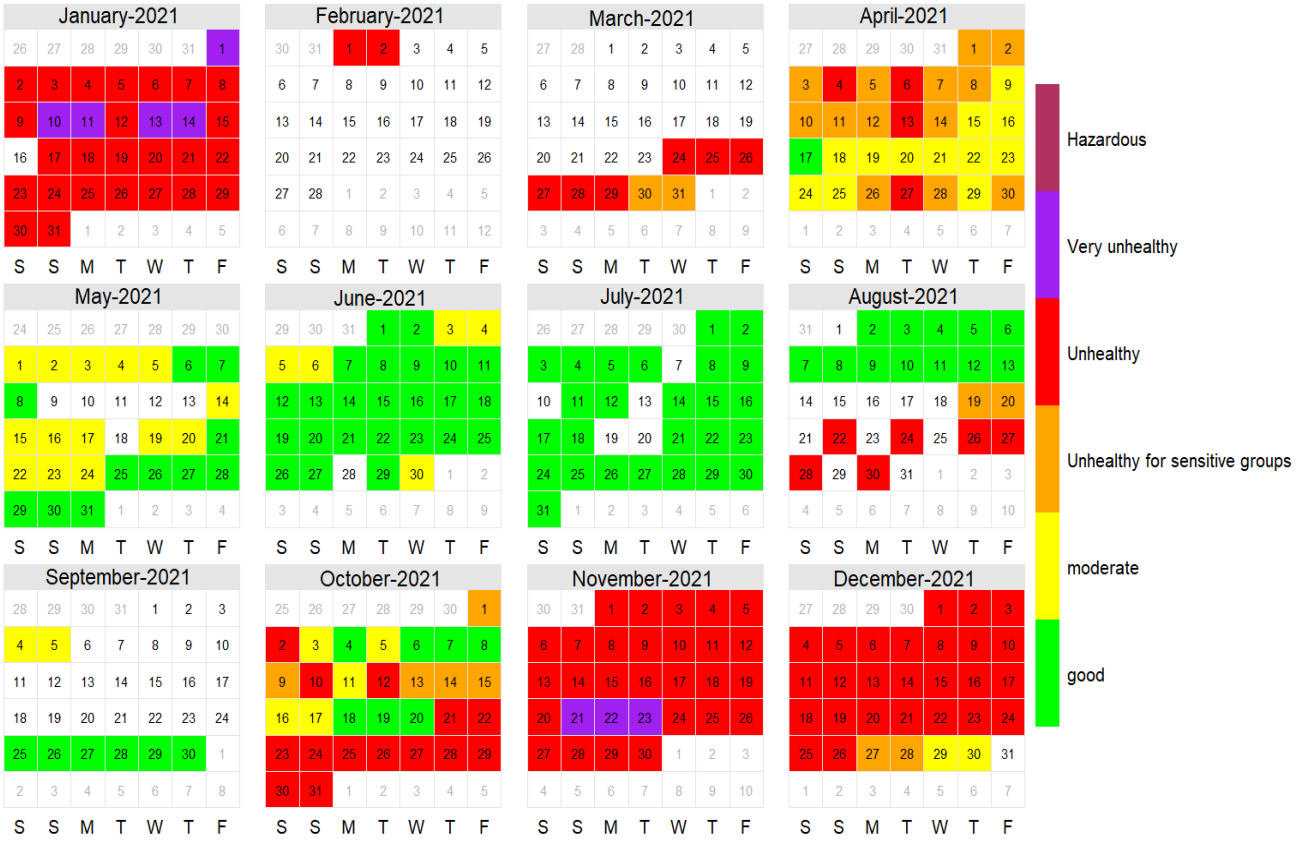


Figure 2.14.25: Calendar plot for $PM_{2.5}$ for the year 2021

2.15 Air quality status – Jhumka

2.15.1 Introduction

Jhumka Air Quality Monitoring Station was established in the year 2016. It lies in inside Ramdhuni, Jhumka, Sunsari, Regional Agriculture Training Centre. It represents the urban area. Major source of air pollution in this area is vehicles and commercial activities.

For the measurement of particulate matter this station is equipped with following equipment:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.15.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Jhumka Station was observed to range from 1 to 1343.8 µg m^{-3} (Figure 2.15.1). The mean of the $PM_{2.5}$ point data was observed to be 47.3 µg m^{-3}.

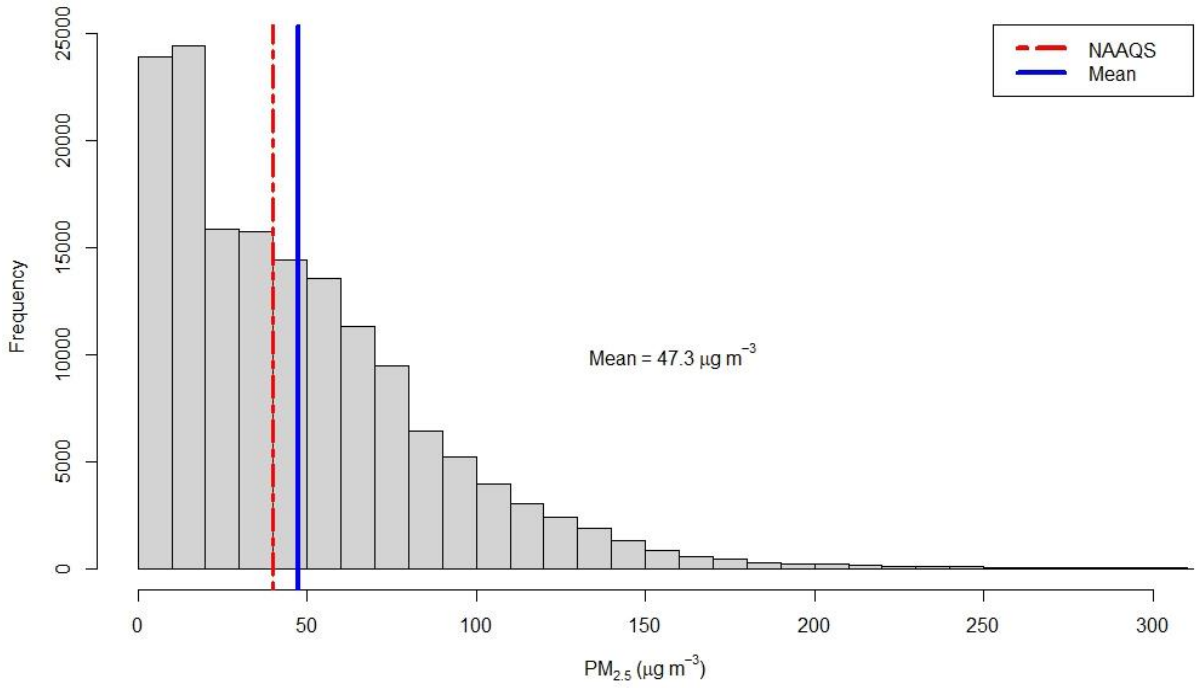


Figure 2.15.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.15.2 shows $PM_{2.5}$ peaks at 7 AM and at 7 PM. The mean value is found to be same to the median throughout the day.

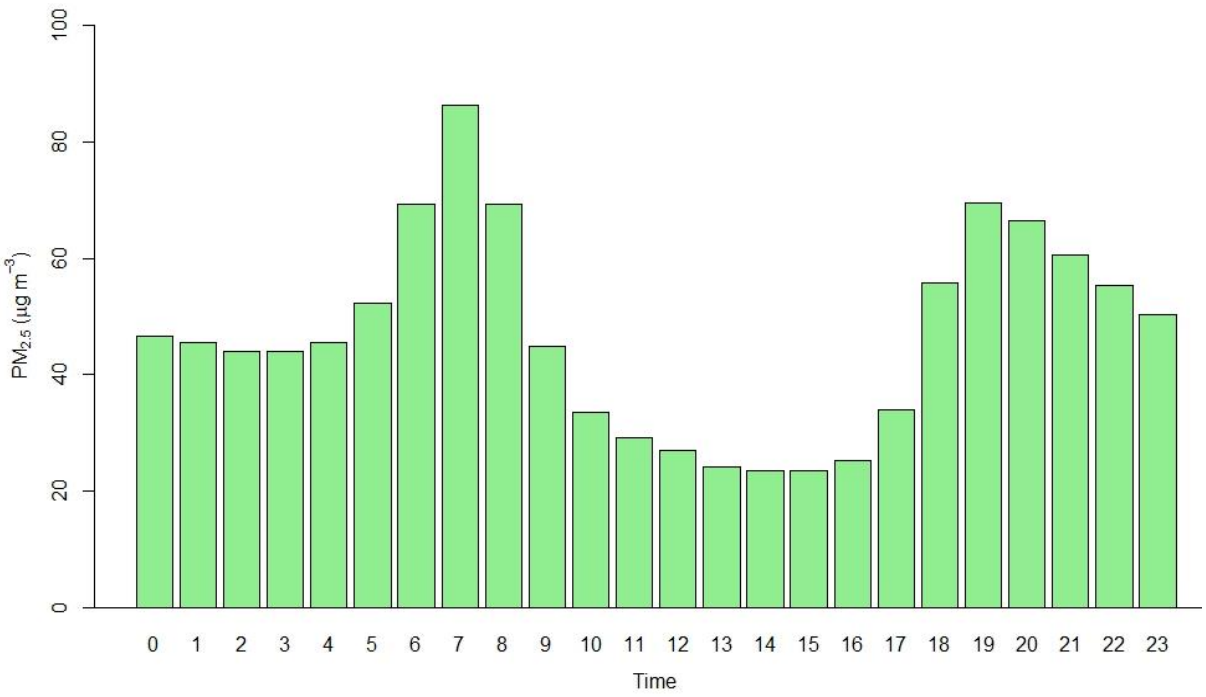


Figure 2.15.2: Hourly average of $PM_{2.5}$

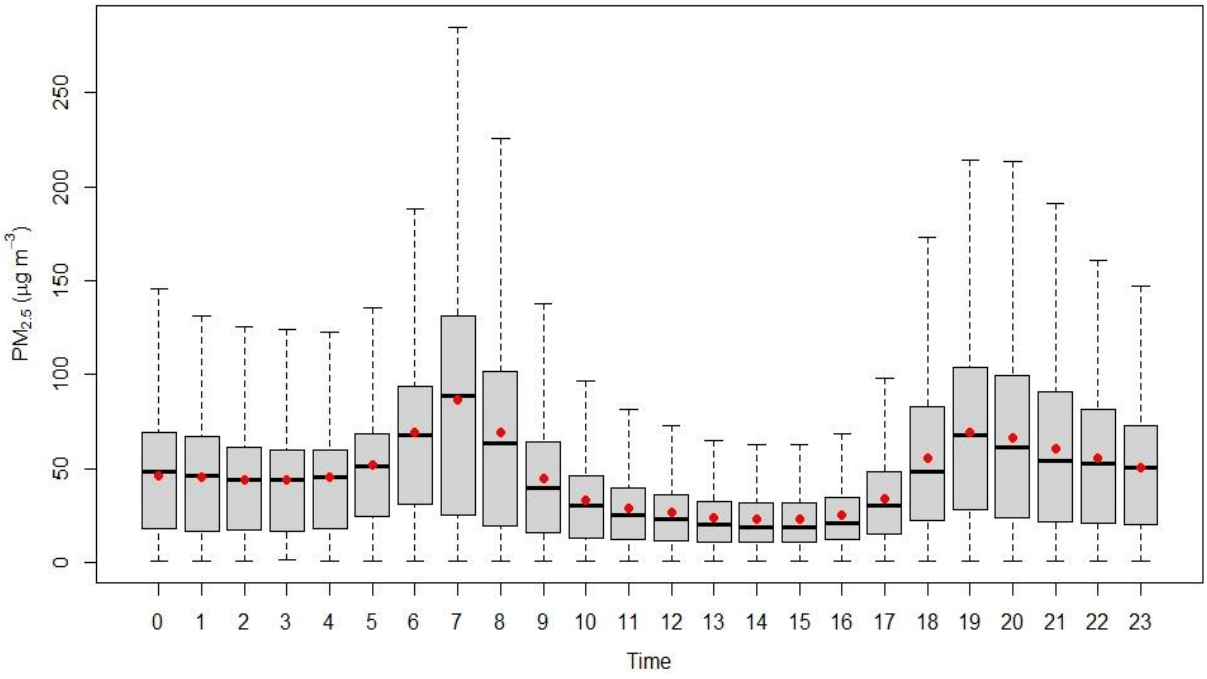


Figure 2.15.3: Diurnal variation of $PM_{2.5}$

Daily variation

The daily average variations of $PM_{2.5}$ is shown in figure 2.15.4. Higher concentration can be seen during January whereas lower concentration was observed during May.

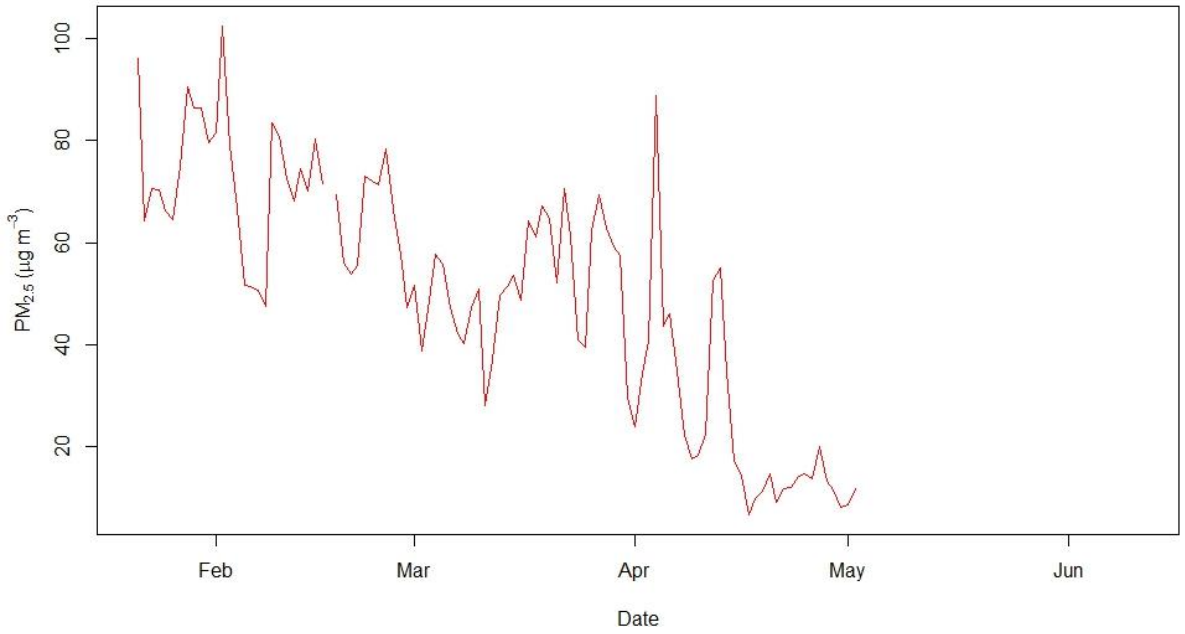


Figure 2.15.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5}$, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during February the mean value was found more than median during January, February, March and April.

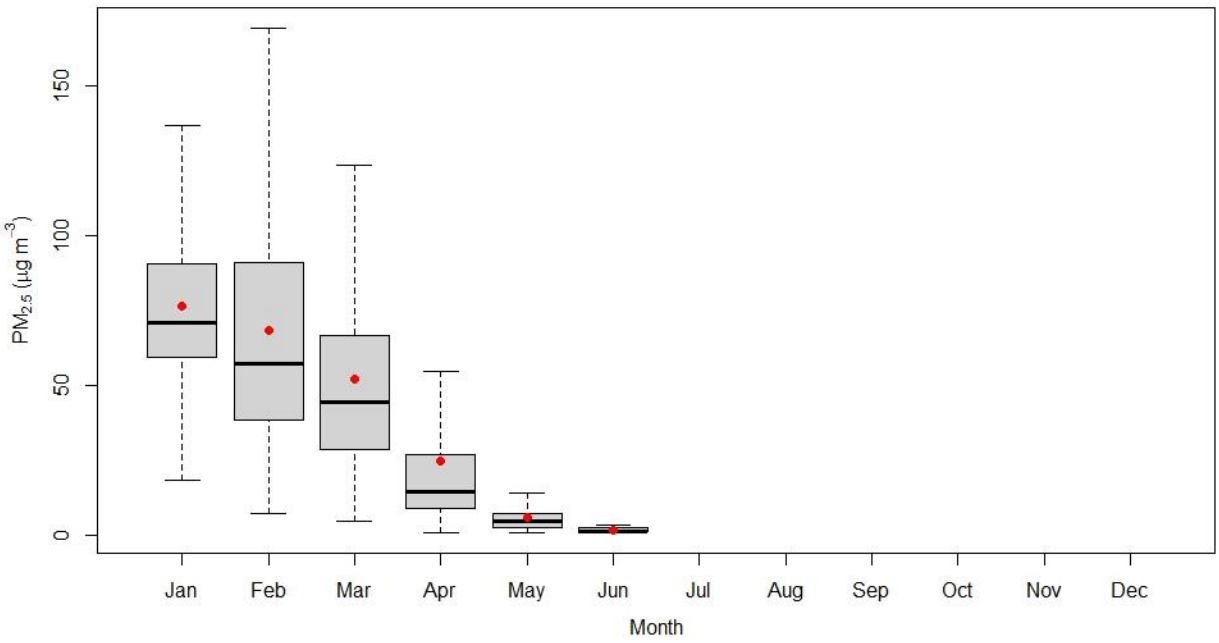


Figure 2.15.5: Monthly variation of $PM_{2.5}$

The monthly average of February was found to be highest (67.91 µg m^{-3}) and that of August was found to be lowest (24.67 µg m^{-3}). Monthly average was not calculated for other months due to insufficient data.

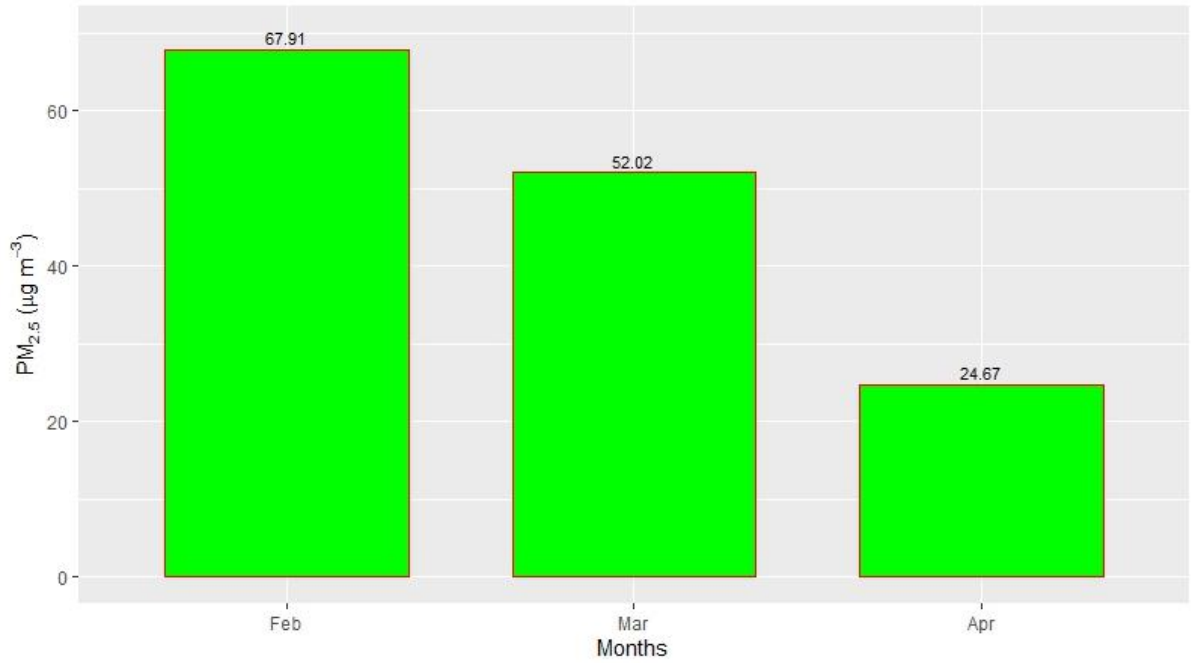


Figure 2.15.6: Monthly average $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 102 days of measurement, 70 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$ as shown in figure 2.15.7.

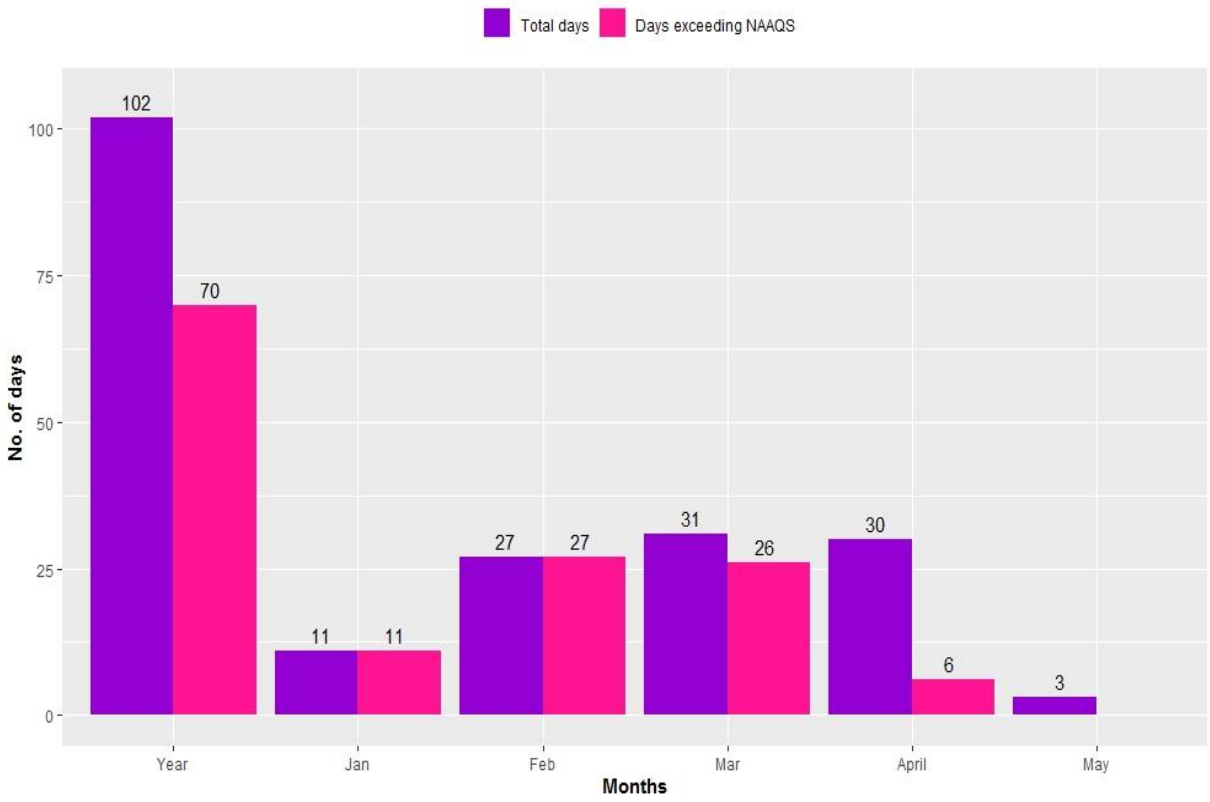


Figure 2.15.7: Compliance status of $PM_{2.5}$

2.15.3 PM_{10}

Histogram

PM_{10} in Jhumka Station was observed to range from 1 to 2932.6 µg m^{-3} (Figure 2.15.8). The mean of the PM_{10} point data was observed to be 59.34 µg m^{-3}.

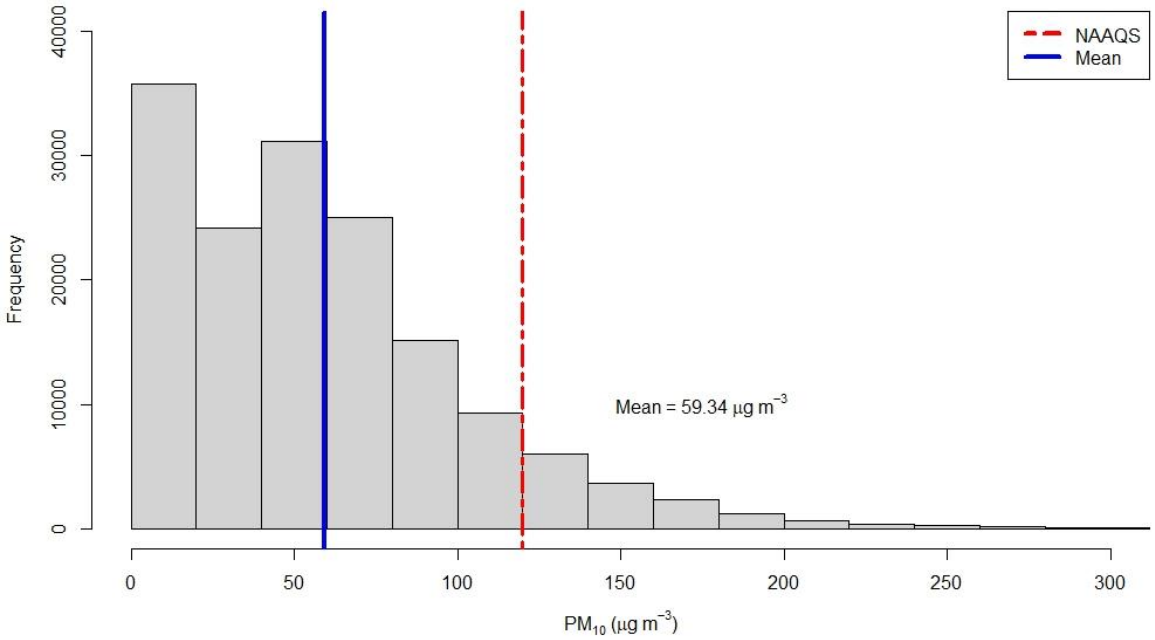


Figure 2.15.8: Histogram of PM_{10}

Diurnal Variation

Figure 2.15.9 shows PM_{10} starts falling from 12 AM then reaches lowest at 3 AM then starts rising and peaks at 7 PM then starts falling slowly till 1 PM and starts again rising peaks at 7 PM then again starts falling.

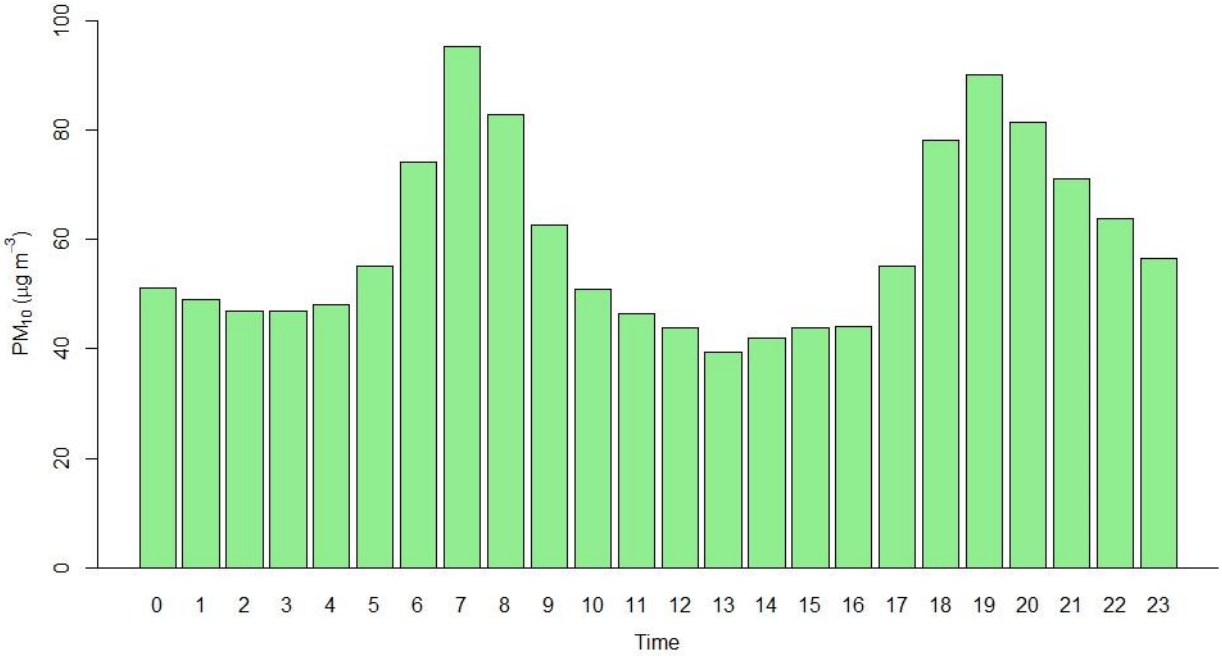


Figure 2.15.9: Hourly average of PM_{10}

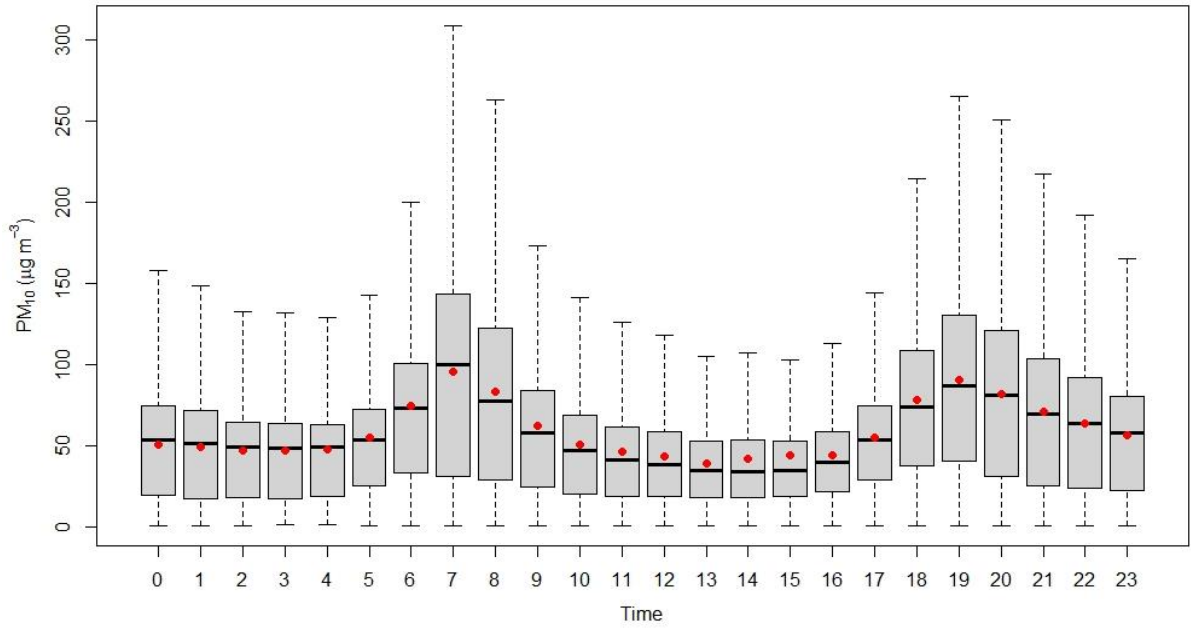


Figure 2.15.10: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.15.11. Higher concentration can be seen during February whereas lower concentration was observed during May.

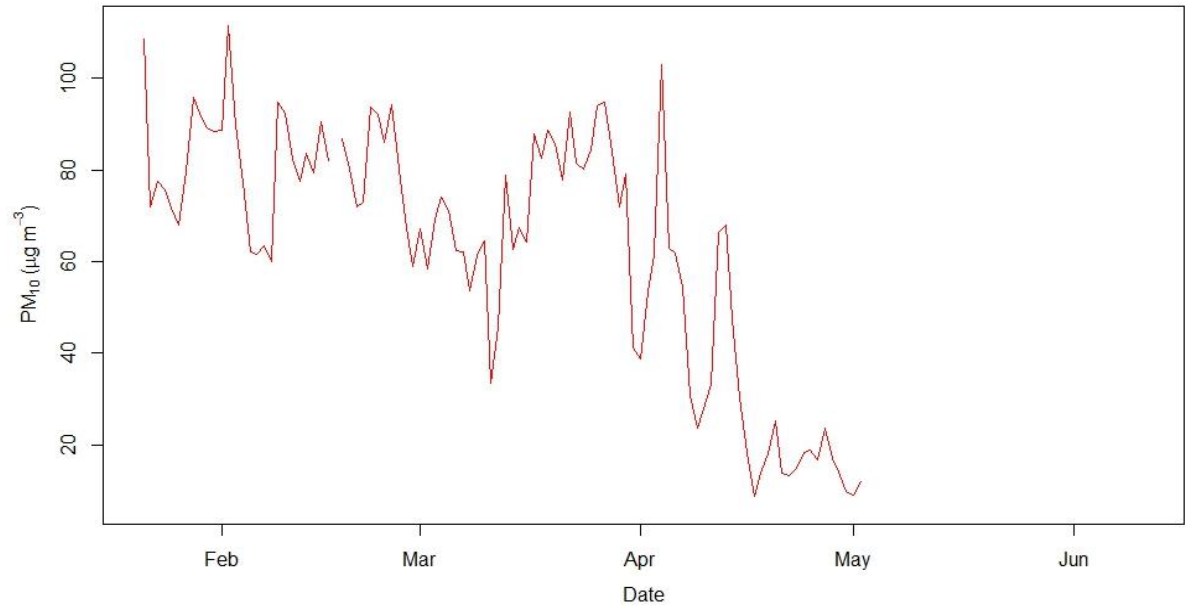


Figure 2.15.11: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly $PM_{10,}$ the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during February whereas less during May and June. The mean value was found more than the median during January, February, March and April.

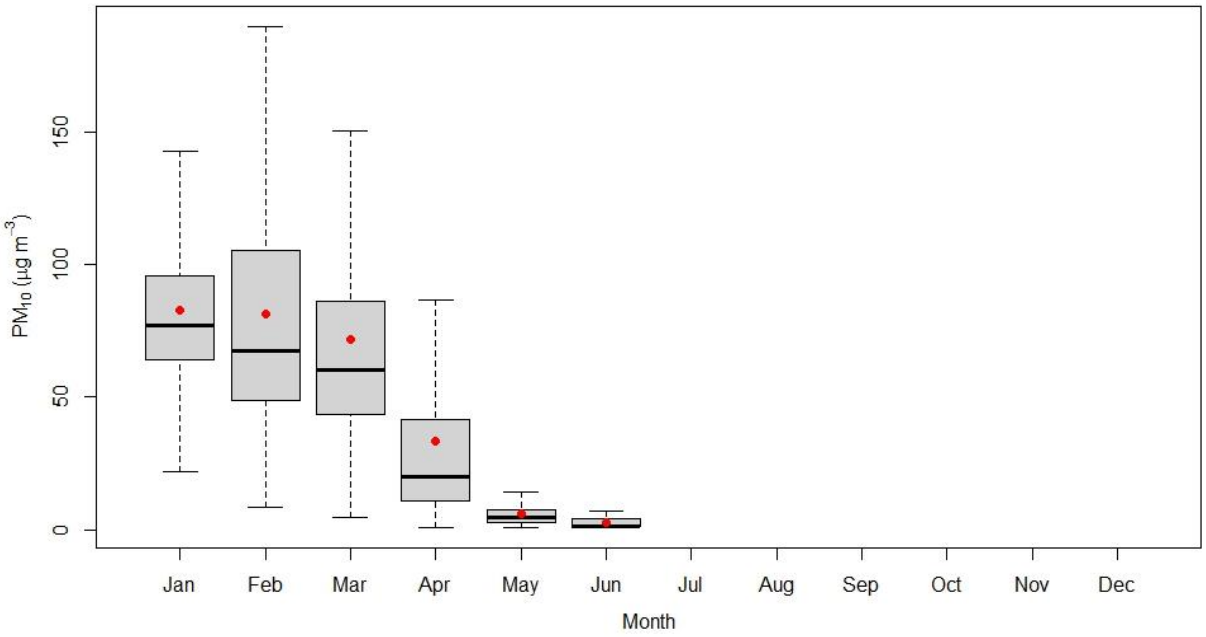


Figure 2.15.12: Monthly variation of PM_{10}

The monthly average for February was found the highest (80.78 µg m^{-3}) and that of April was found lowest (33.64 µg m^{-3}) while comparing with other months as shown in figure 2.15.13. The monthly average was not calculated for other months due to insufficient data.

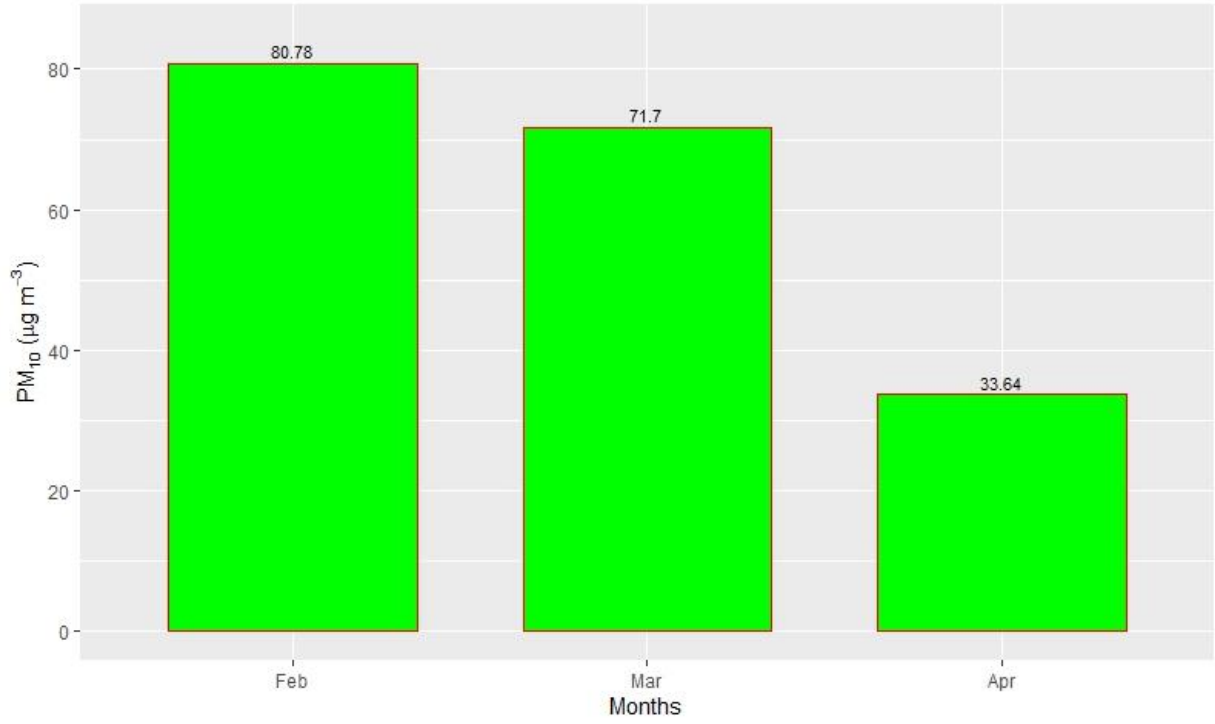


Figure 2.15.13: Seasonal variation of PM_{10}

Seasonal Average

The seasonal average TSP value was found maximum in pre-monsoon (95.55 µg m^{-3}) and minimum in post-monsoon season (61.15 µg m^{-3}).

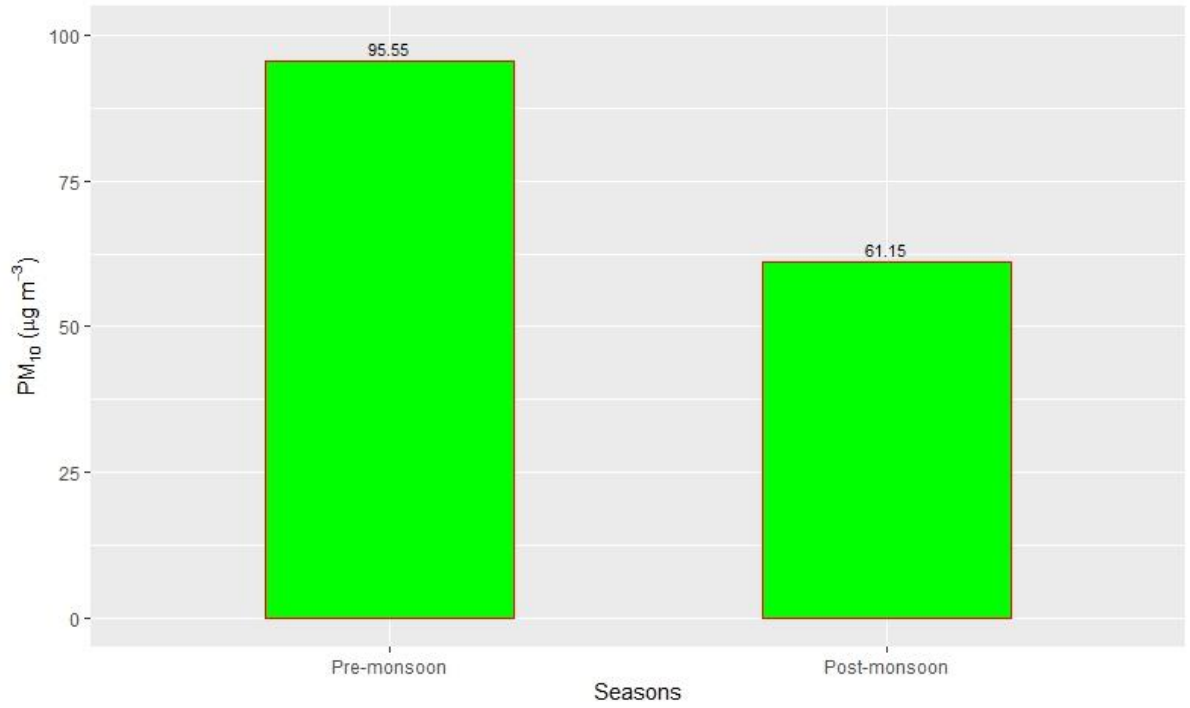


Figure 2.15.14: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 102 days of measurement, none of the days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}.

2.15.4 TSP

Histogram

TSP in Jhumka Station was observed to range from 1 to 4955.5 µg m^{-3} (Figure 2.15.15). The mean of the TSP point data was observed to be 80.44 µg m^{-3}.

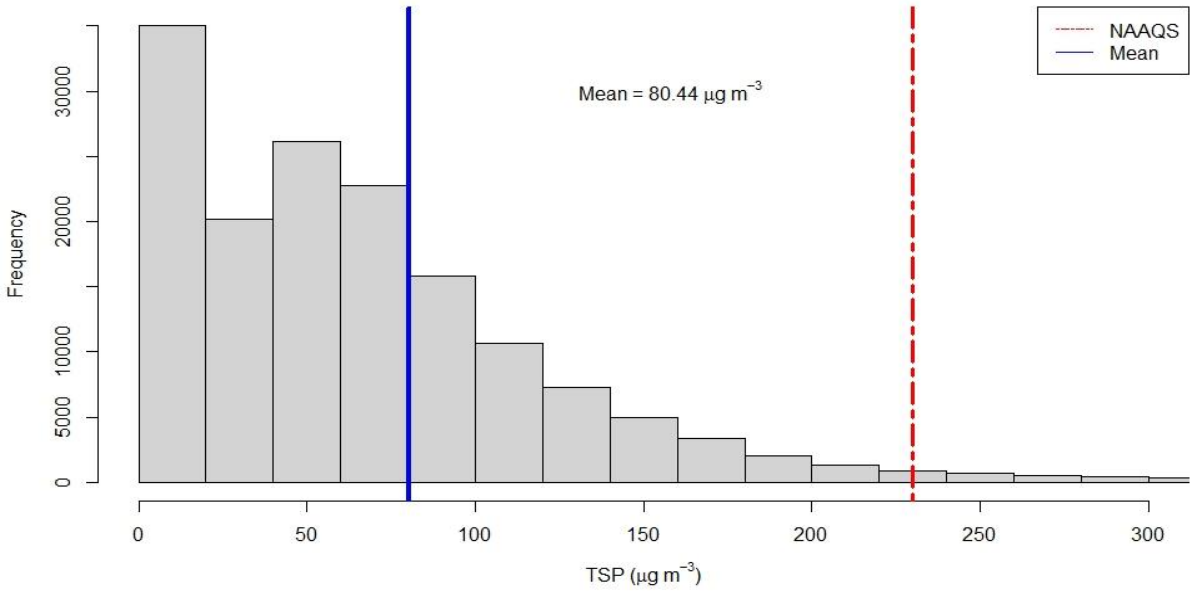


Figure 2.15.15: Histogram of TSP

Diurnal Variation

The Figure 2.15.16 shows TSP peaks at 7 AM and 7 PM. During day time the mean is much higher compared to the median value (Figure 2.15.17).

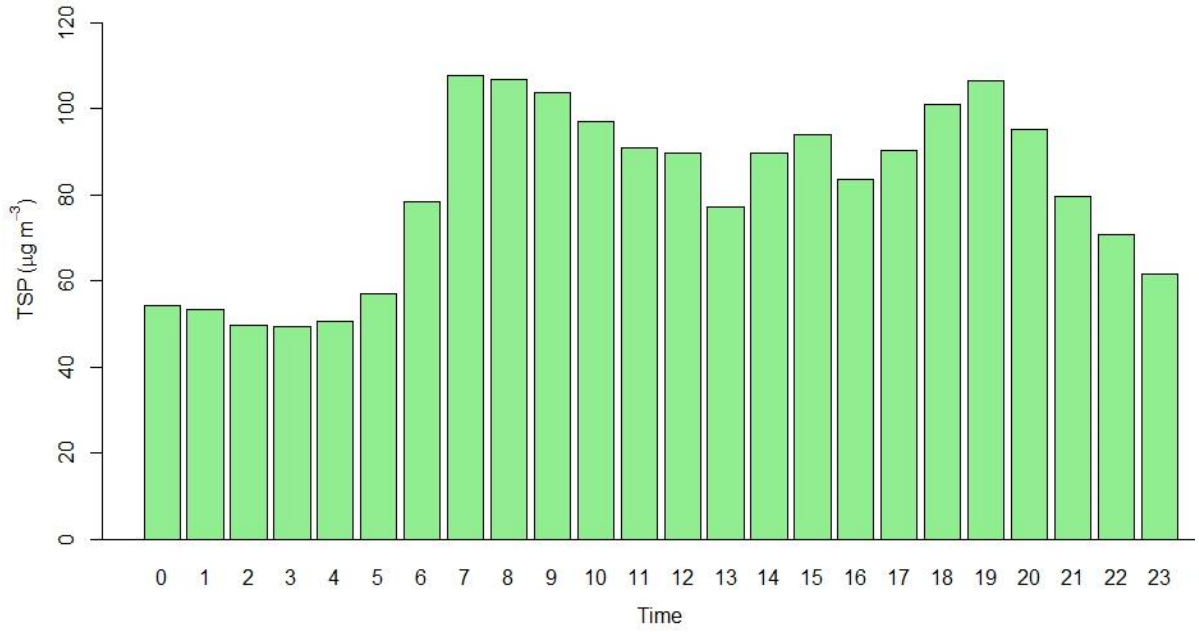


Figure 2.15.16: Hourly average of TSP

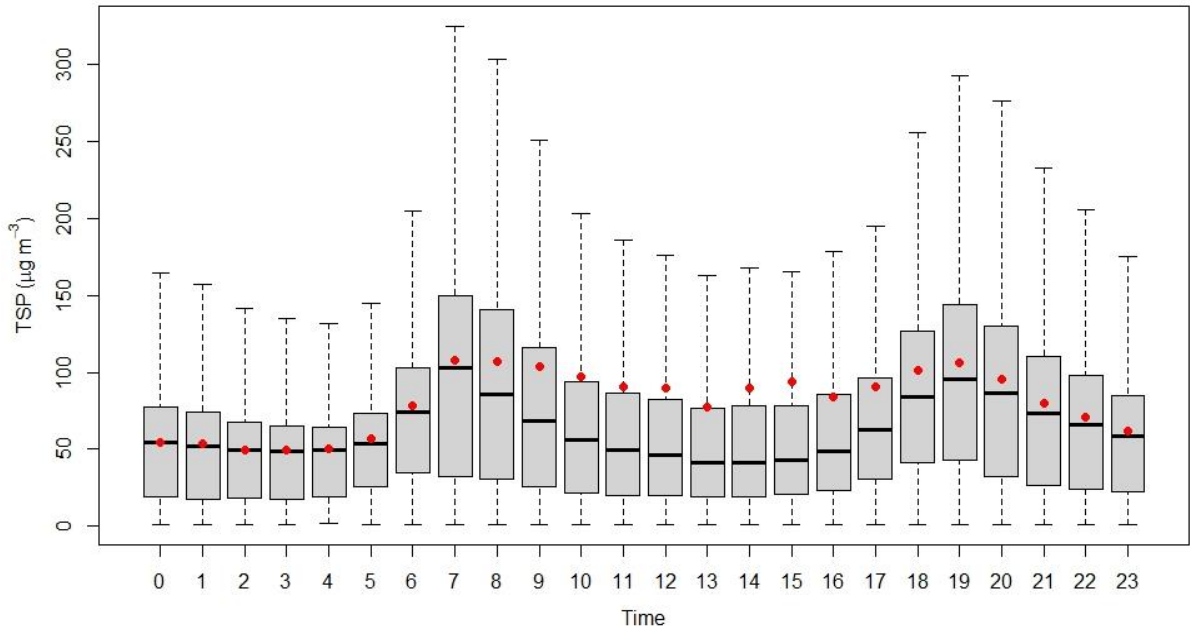


Figure 2.15.17: Diurnal variation of TSP

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.15.18. Higher concentration can be seen during April.

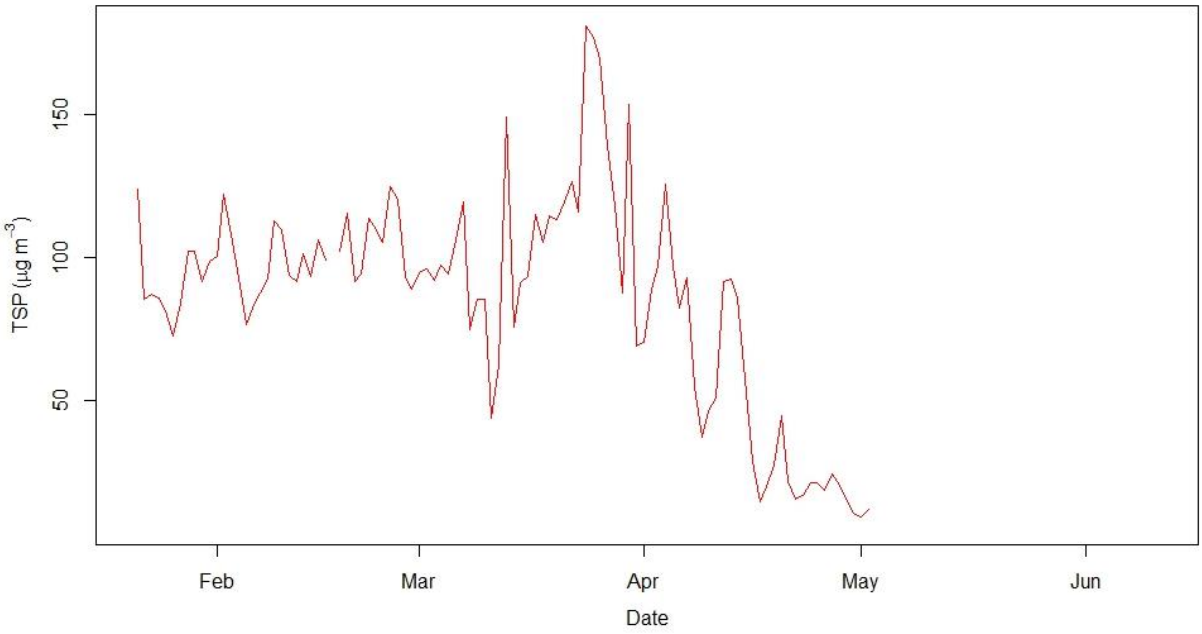


Figure 2.15.18: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during February whereas less during May and June. The mean value was found more than median from January to April.

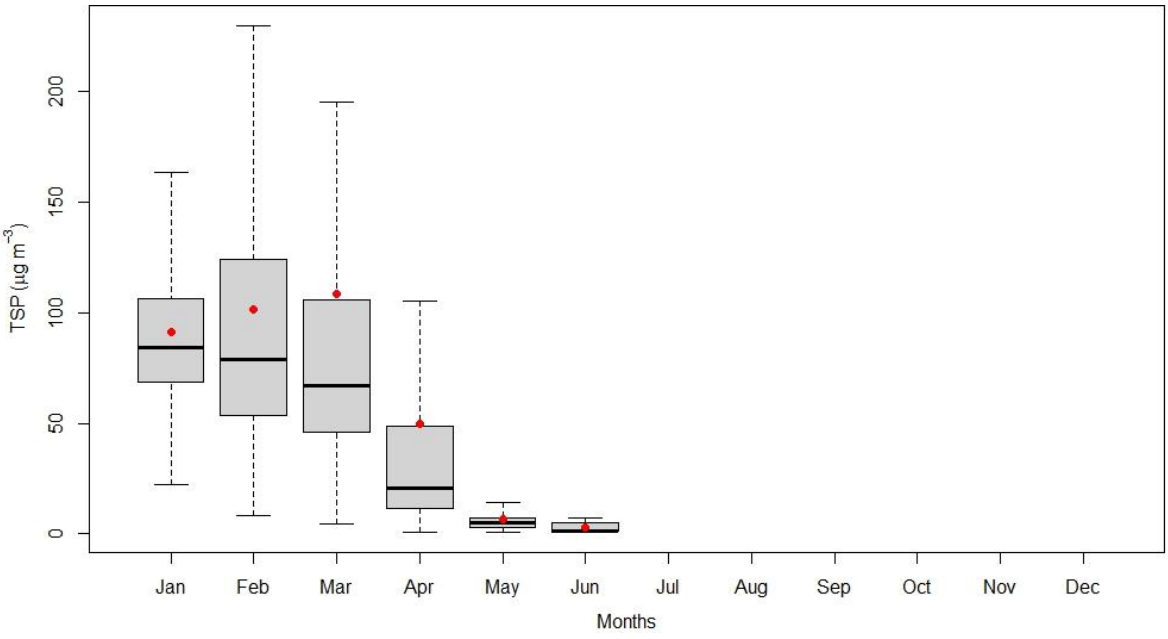


Figure 2.15.19: Monthly variation of TSP

The monthly average for March was found to be the highest (108.67 µg m^{-3}) as shown in figure 2.15.20.

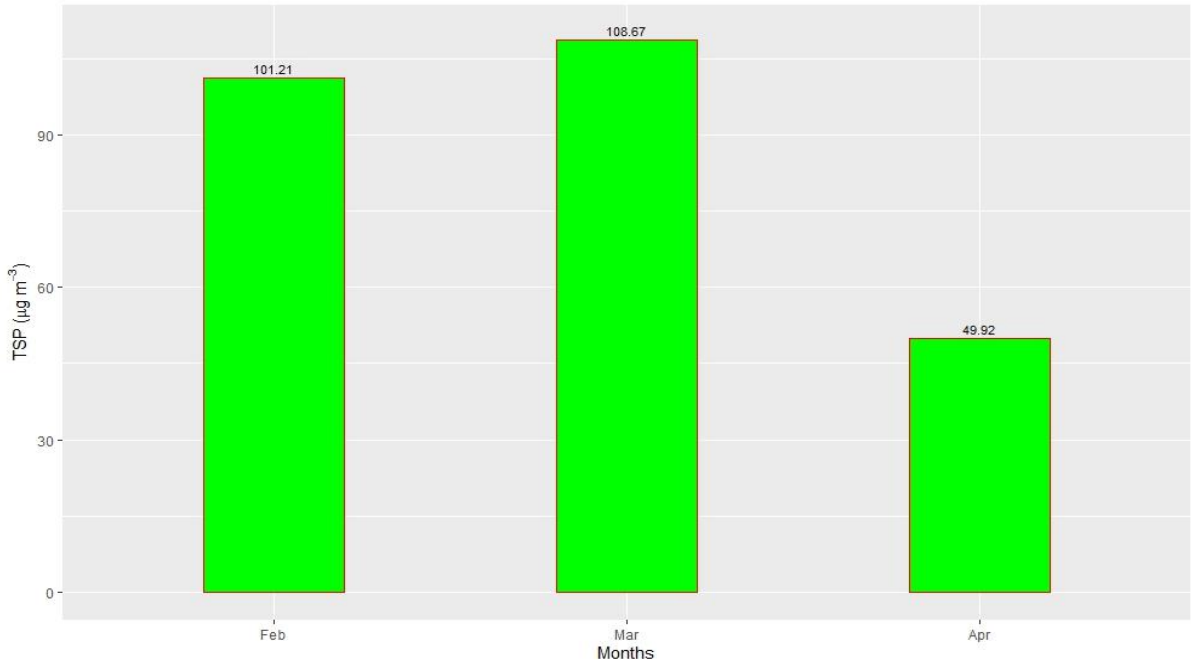


Figure 2.15.20: Monthly average of TSP

Seasonal Average

The seasonal average TSP value was found maximum in pre-monsoon (244.42 µg m^{-3}) and minimum in post-monsoon season (128.49 µg m^{-3}).

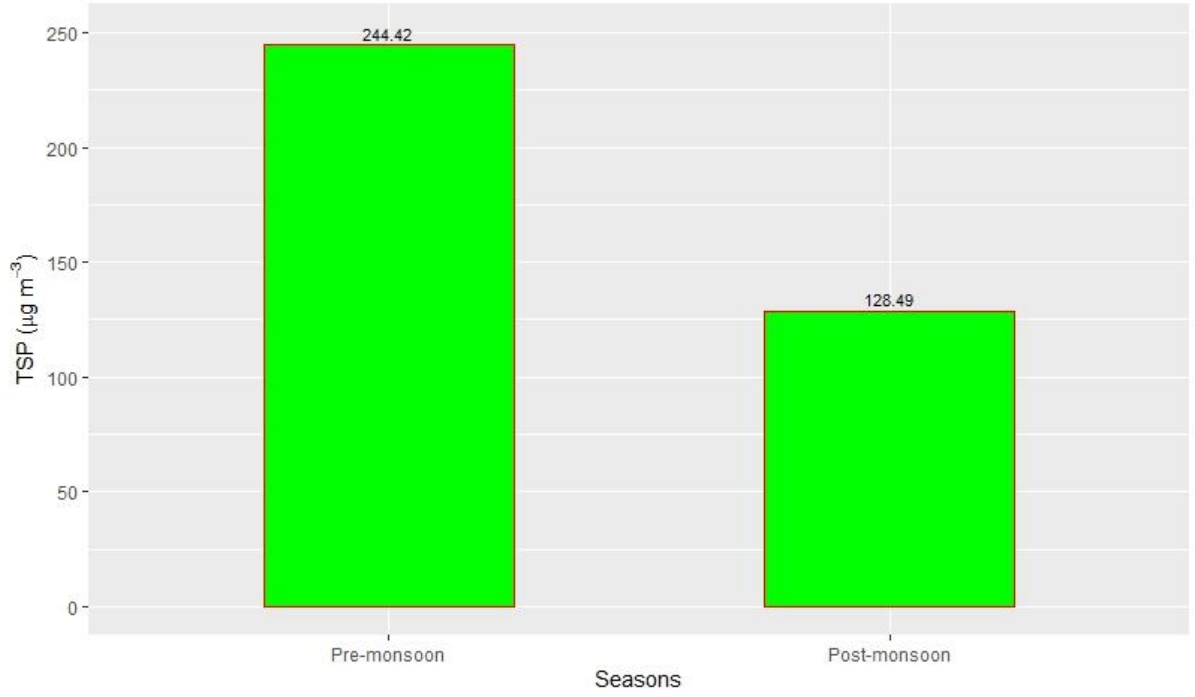


Figure 2.15.21: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 102 days of measurement, none of the days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}.

Calendar Plot

Calendar plot is prepared for $PM_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The Calender plot shows AQI for $PM_{2.5}$ reached to unhealthy level in January, February and few days in March.

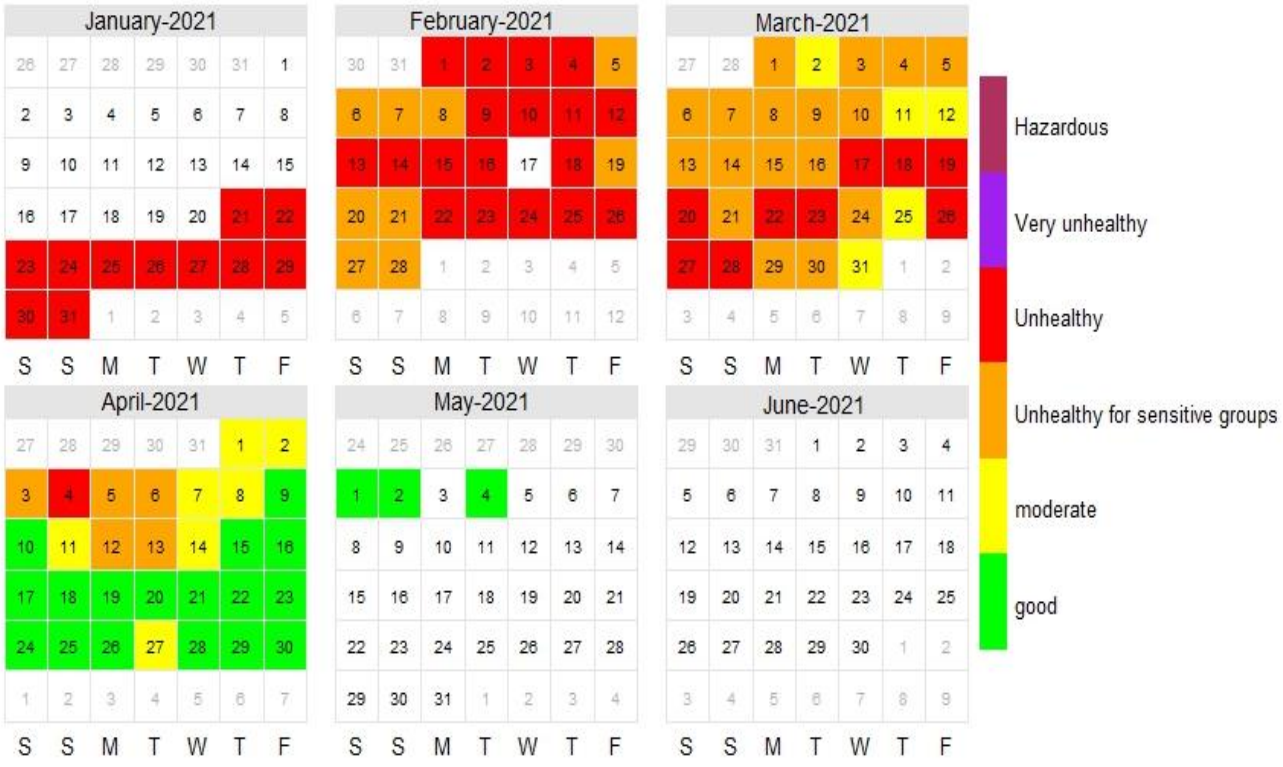


Figure 2.15.22: Calendar plot for $PM_{2.5}$ for the year 2021

2.16 Air quality status – Dhankuta

2.16.1 Introduction

Air Quality Monitoring Station was established in the premises of Dhankuta metropolitan city office in 2019 in Dhankuta district. Dhankuta is a small town in eastern hilly region of Nepal. The traffic in the city is not so much dense. Hence the major source of air pollution in this area is either forest fire, agriculture residue burning, vehicles or pollutants transported from other regions

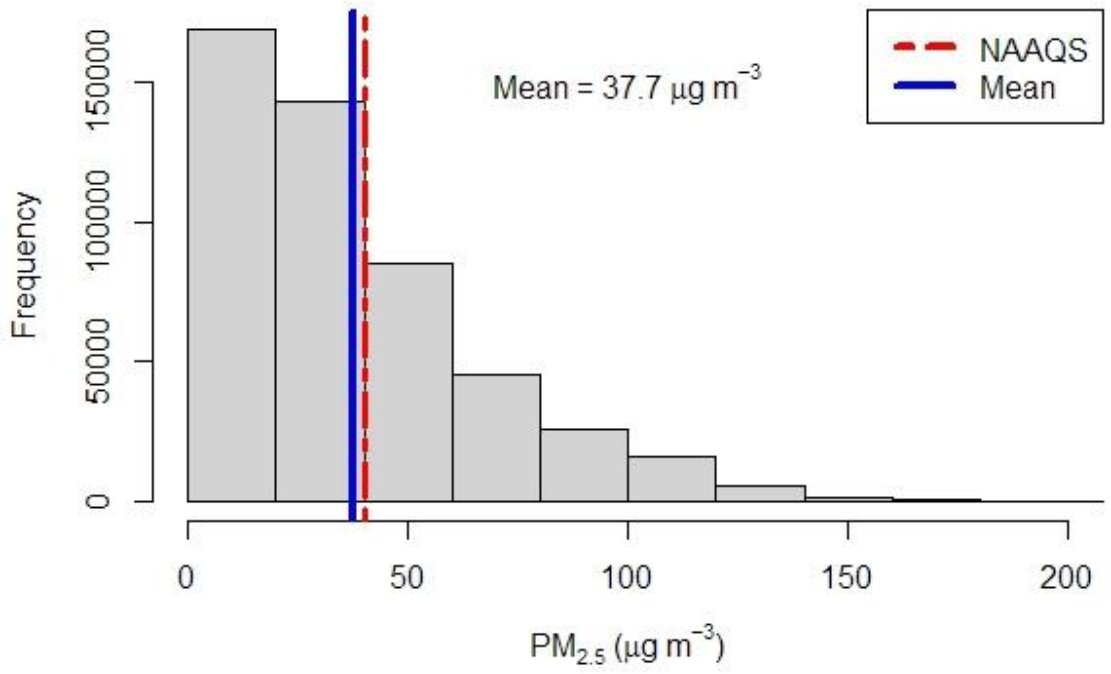
The Station is installed with following instruments:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.16.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Dhankuta Station was observed to range from 1 to 1015.2 µg m^{-3} (Figure 2.16.1). The mean of the $PM_{2.5}$ point data was observed to be 37.7 µg m^{-3}.



F

Figure 2.16.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.16.2 shows $PM_{2.5}$ peaks at 7 AM and at 6 PM. At 11 AM and 12 PM it is found to be least. The mean value is found to be more than the median throughout the day (Figure 2.16.3).

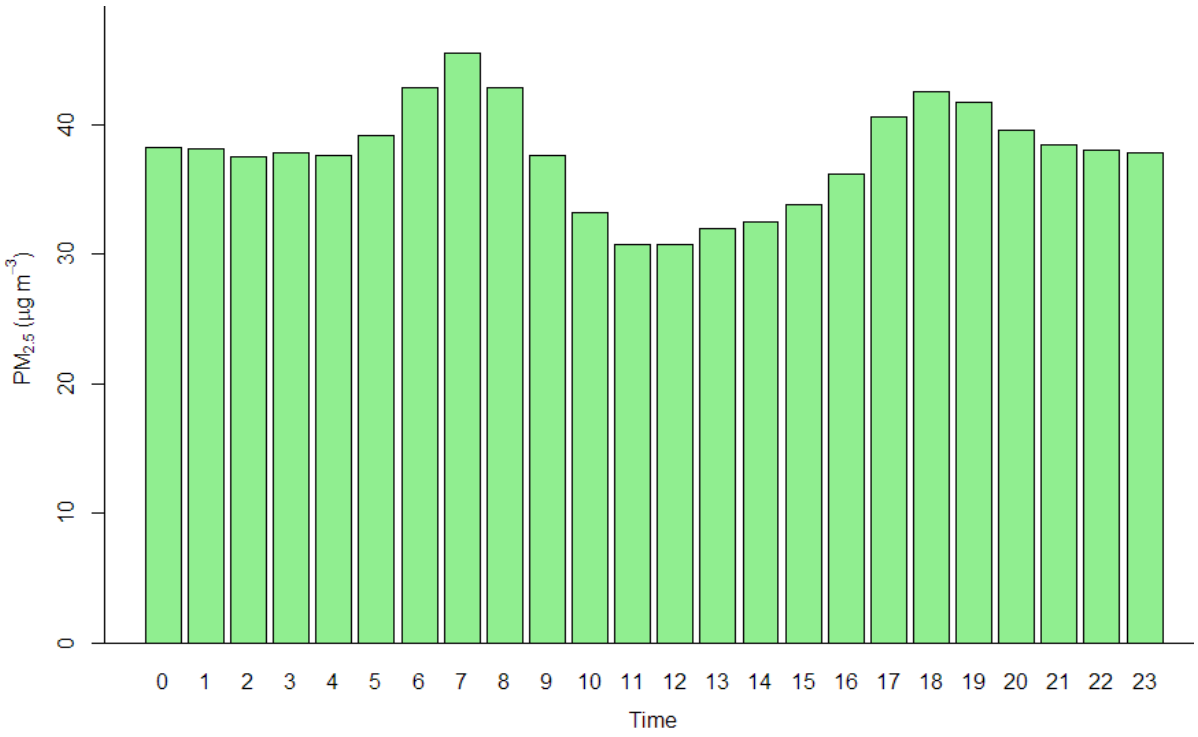


Figure 2.16.2: Hourly average of $PM_{2.5}$.

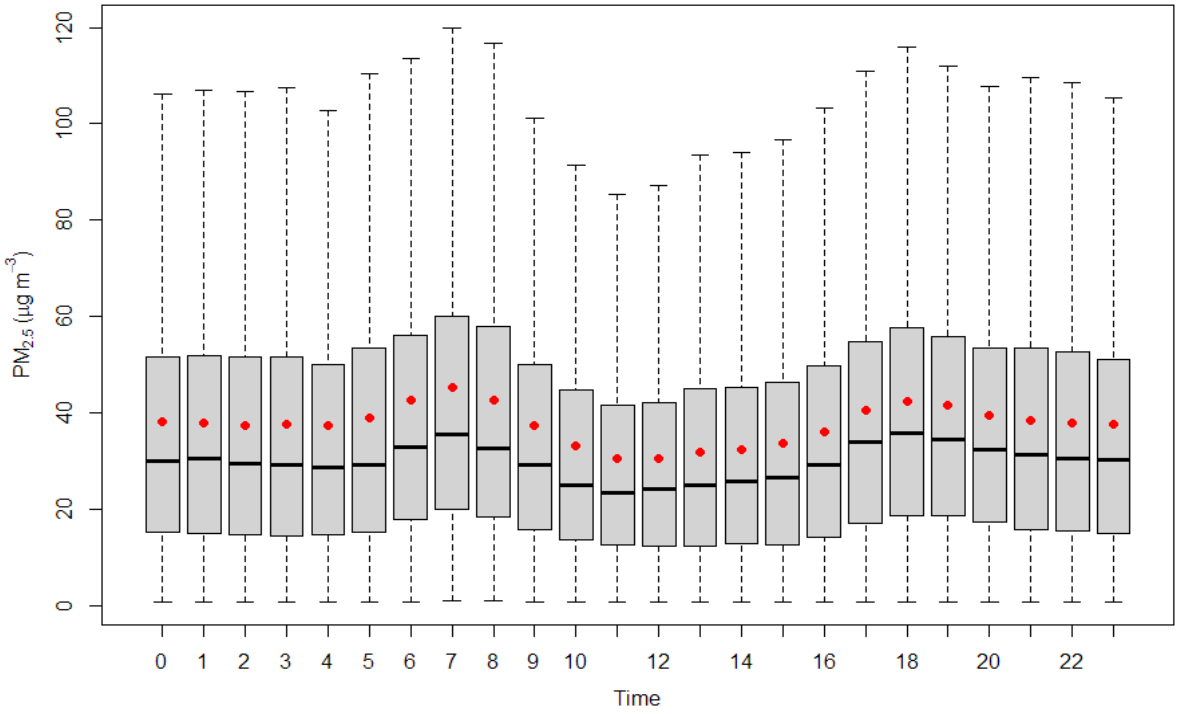


Figure 2.16.3: Diurnal variation of $PM_{2.5}$.

Daily variation

The daily average variations of $PM_{2.5}$ is shown in figure 2.16.4. Higher concentration can be seen during winter and pre-monsoon season whereas lower concentration was observed during monsoon season.

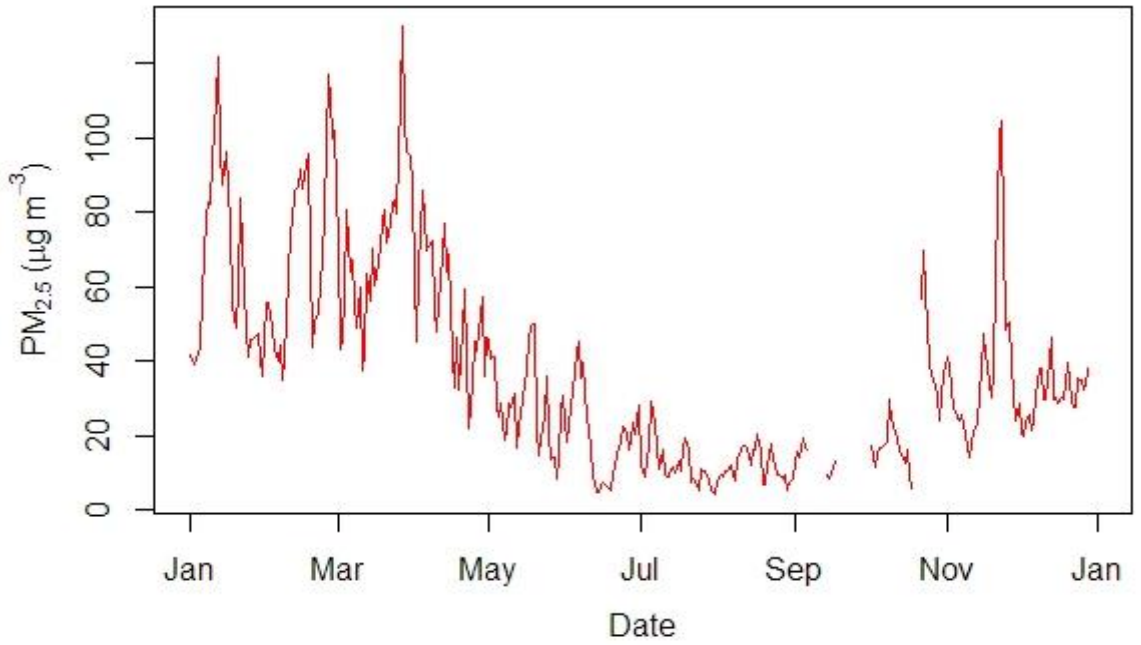


Figure 2.16.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation

In the box plot of the monthly $PM_{2.5}$, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during January, February and March. The mean value was found more than median during January, February, March, April June, October and November.

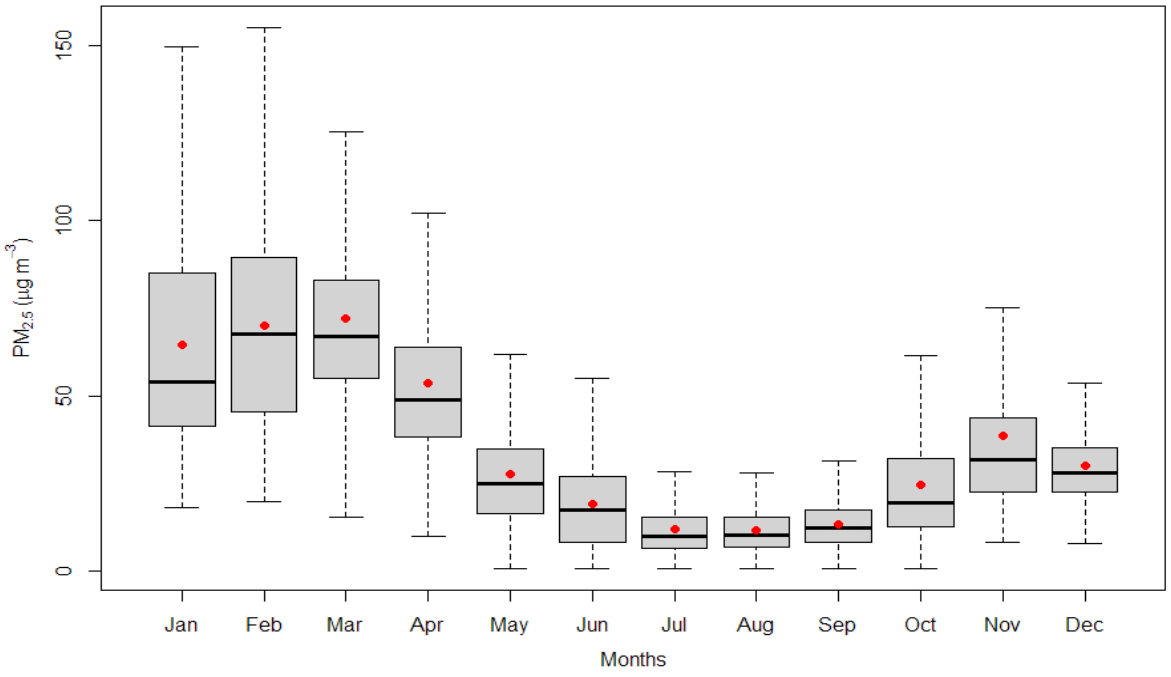


Figure 2.16.5: Monthly variation of $PM_{2.5}$

The monthly average of March was found to be highest (72.01 µg m^{-3}) and that of August was found to be lowest (11.68 µg m^{-3}) while comparing with other months as shown in figure 2.16.6 below. Monthly average was not calculated for September due to insufficient data.

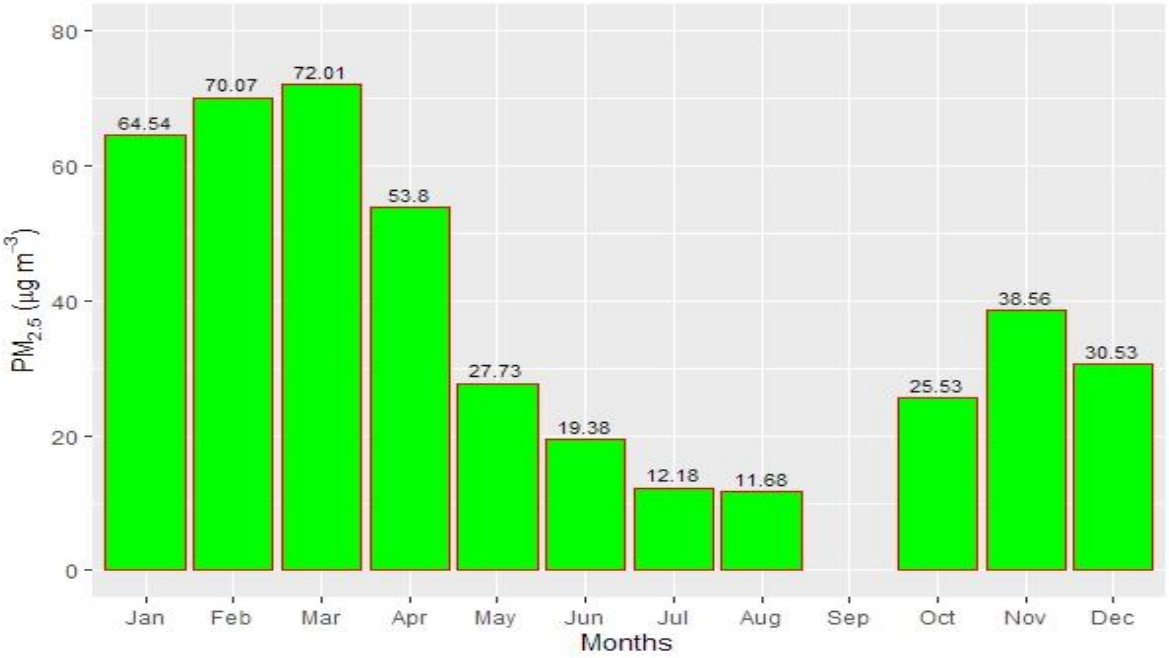


Figure 2.16.6: Monthly average $PM_{2.5}$

Seasonal Average

The average concentration of $PM_{2.5}$ was found to be the highest during the winter season (62.08 µg m^{-3}) and the lowest during the monsoon season (14.28 µg m^{-3}) as in figure 2.16.7.

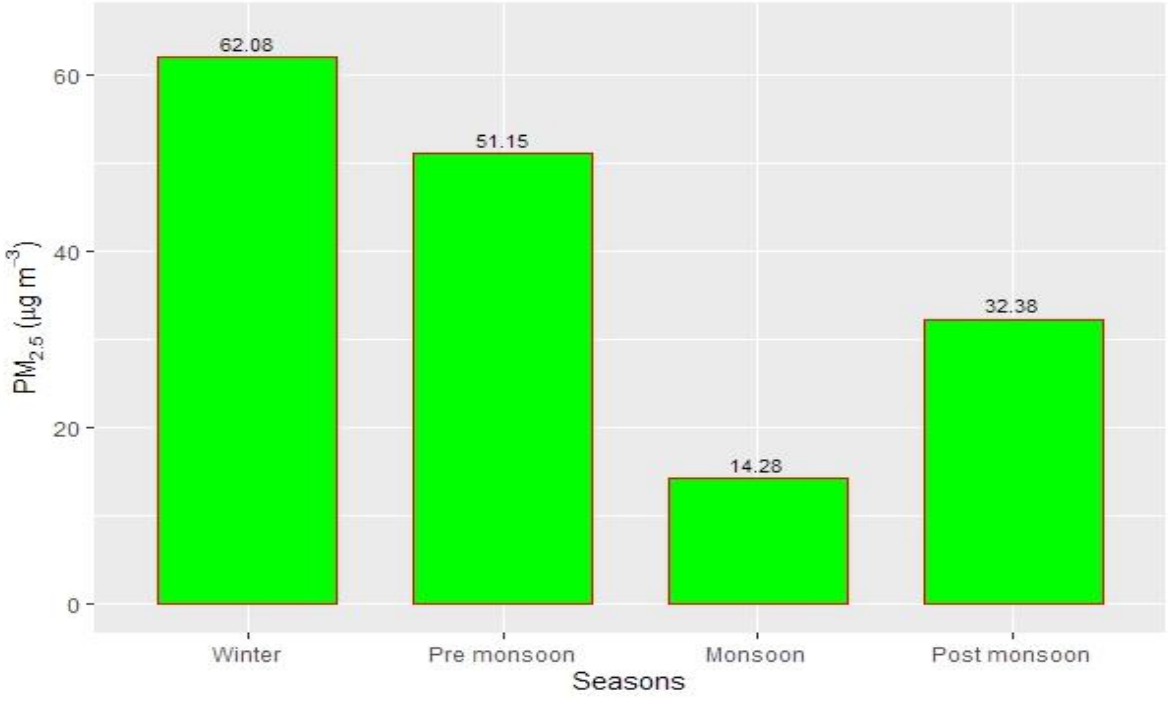


Figure 2.16.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 339 days of measurement, 134 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$. in July, August and September none of the days exceed NAAQS of 40 µg m^{-3} as shown in figure 2.16.8.

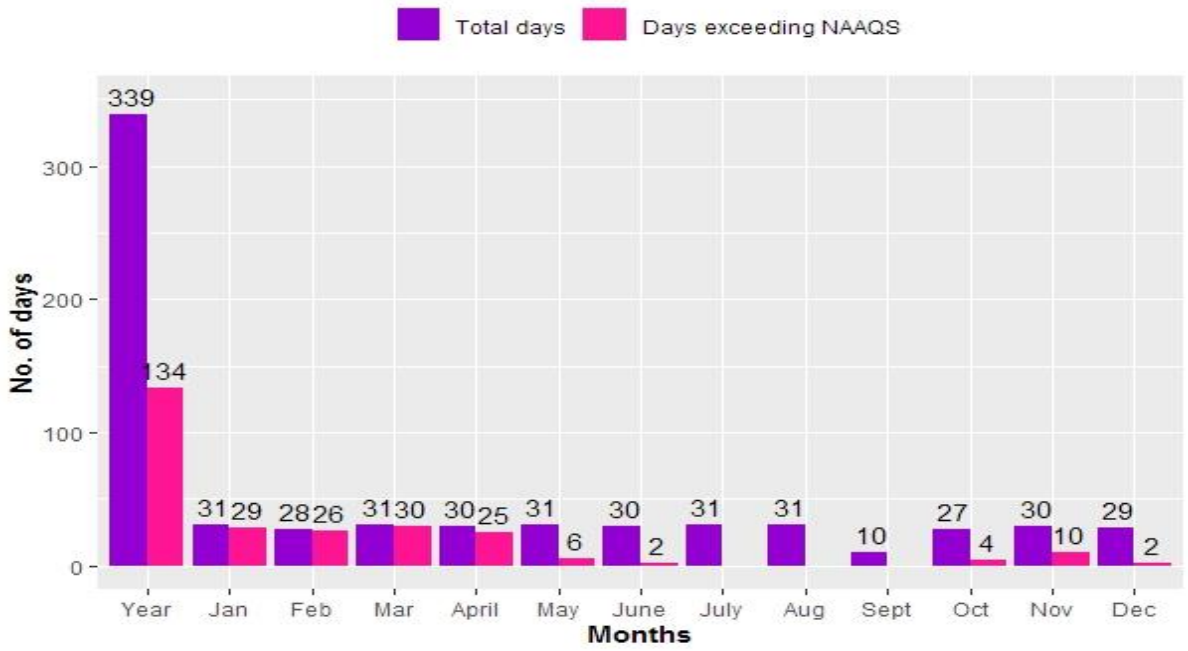


Figure 2.16.8: Compliance status of $PM_{2.5}$

2.16.3 PM_{10}

Histogram

PM_{10} in Dhankuta Station was observed to range from 1 to 2483.2 µg m^{-3} (Figure 2.16.9). The mean of the PM_{10} point data was observed to be 53.3 µg m^{-3}.

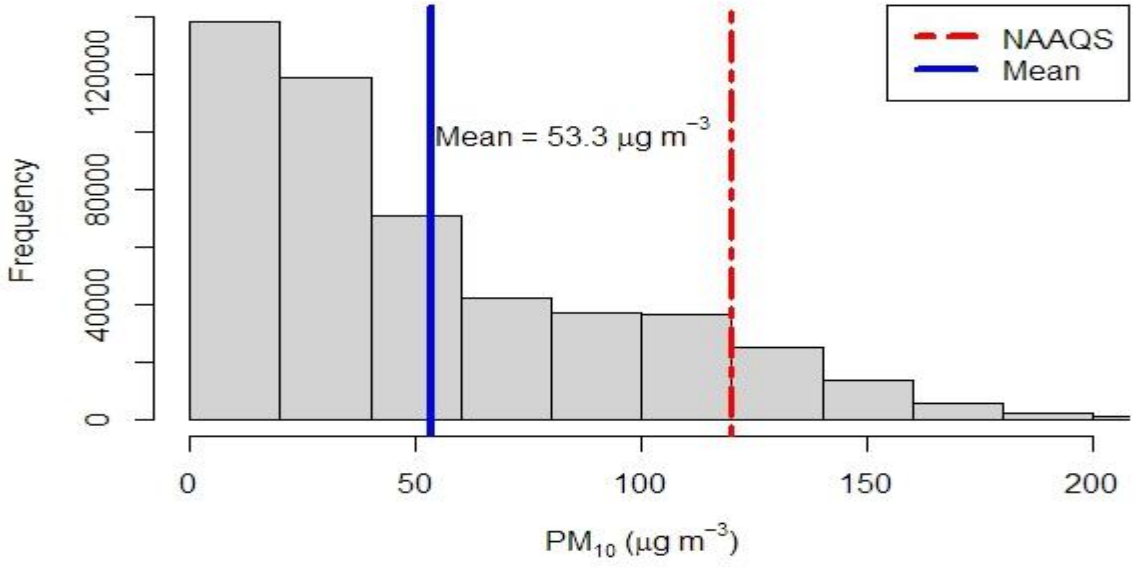


Figure 2.16.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.16.10 shows PM_{10} starts rising 4 AM then reaches peaks at 7 AM and 8 AM starts falling from 6 PM and reaches lowest at 11 PM. The diurnal variation is found high during 1 PM. The mean value is found to be more than median throughout the day.

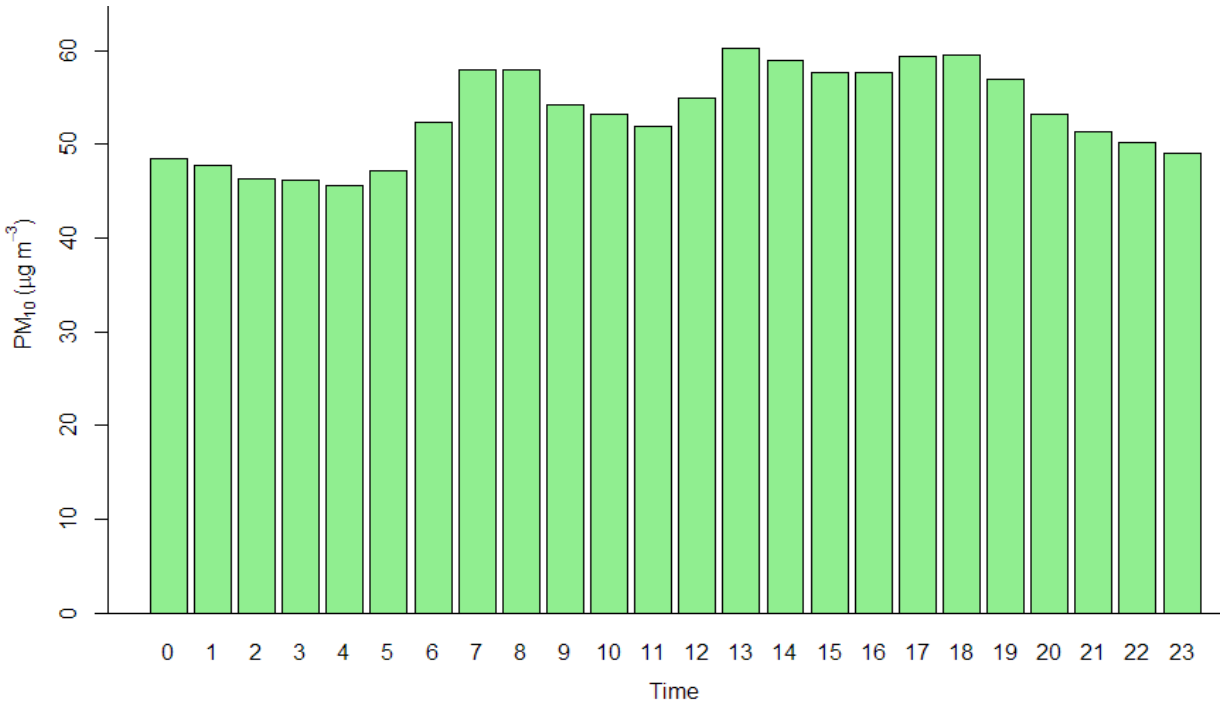


Figure 2.16.10: Hourly average of PM_{10}

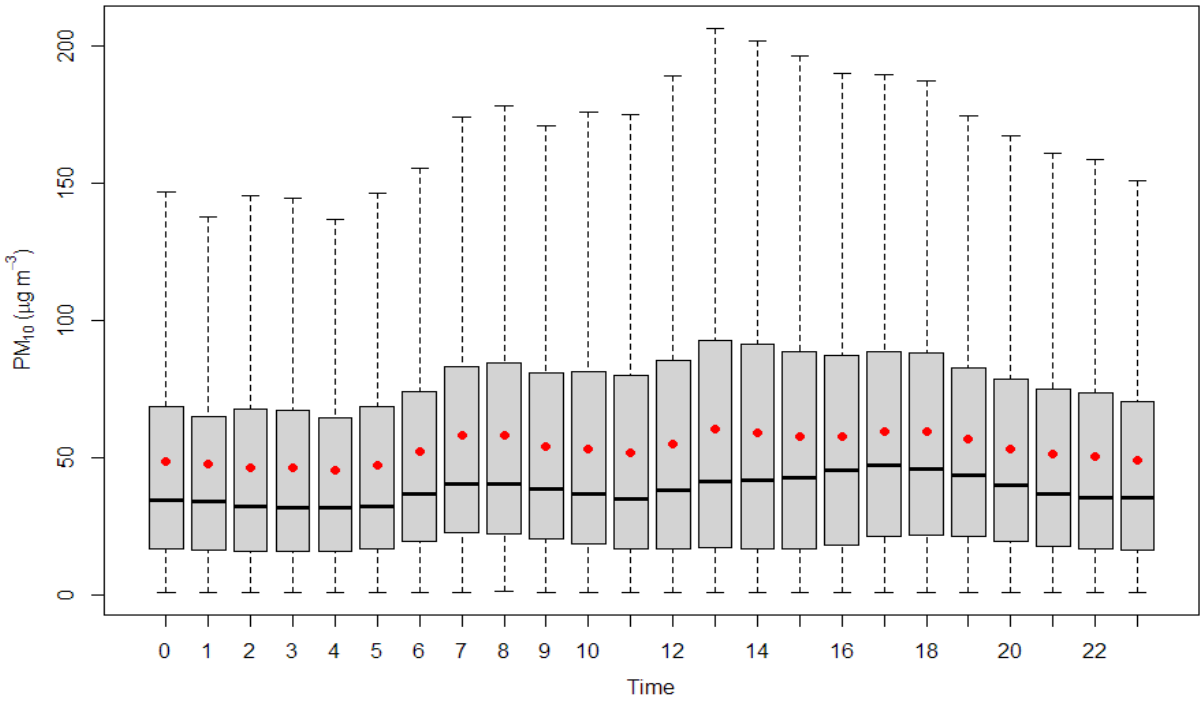


Figure 2.16.11: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.16.12. Higher concentration can be seen during winter and pre-monsoon season whereas lower concentration was observed during monsoon season.

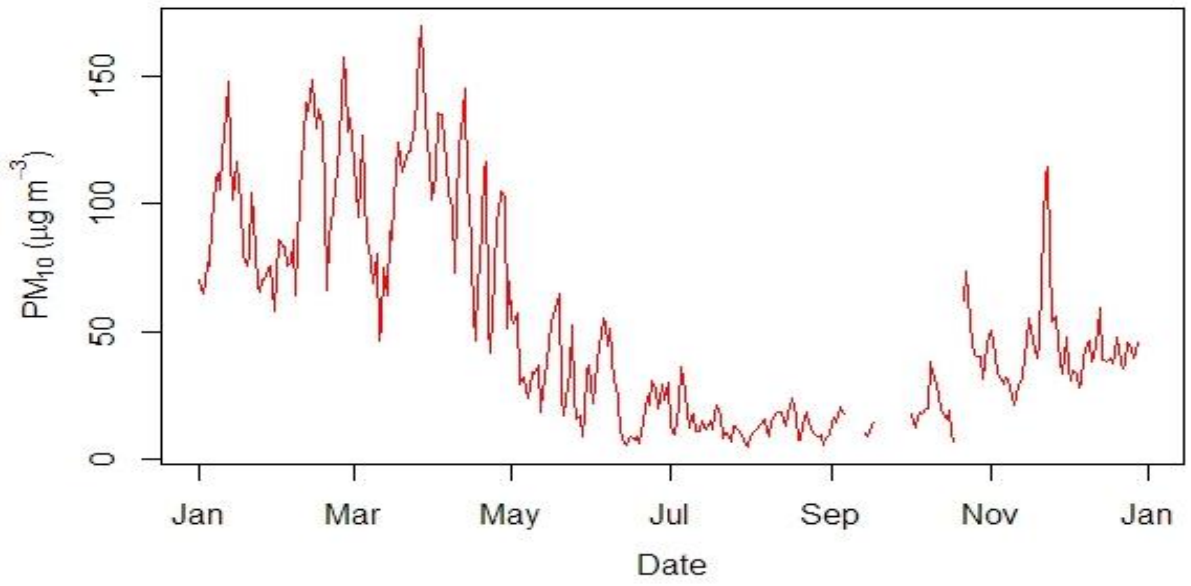


Figure 2.16.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during months of winter and pre-monsoon season while it is low during the month of monsoon season. The mean value and median values are almost similar in every month.

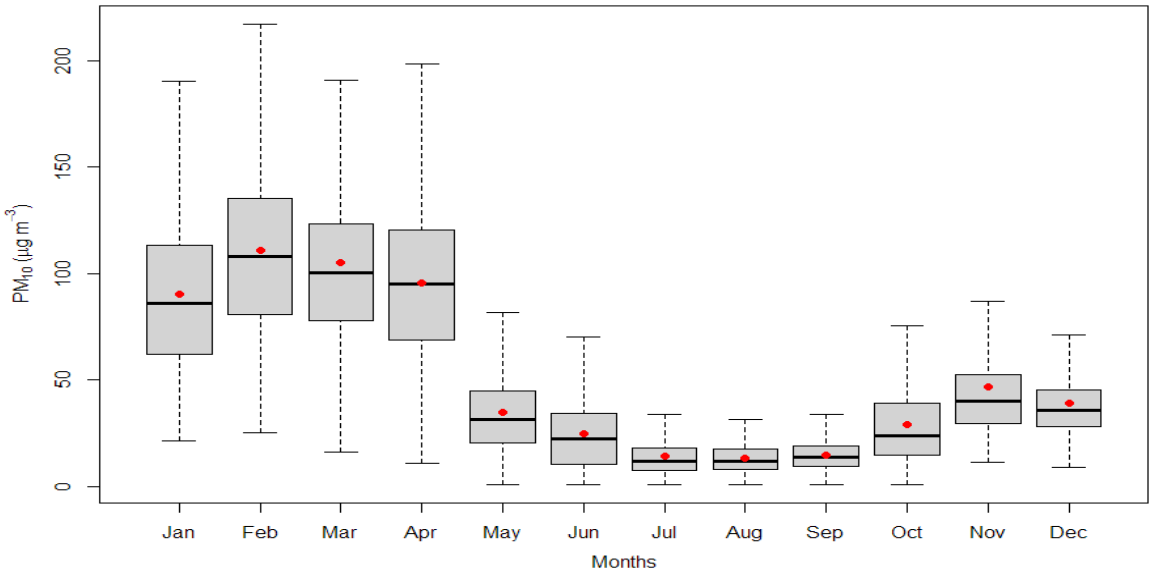


Figure 2.16.13: Monthly variation of PM_{10}

The monthly average for February was found highest (110.79 µg m^{-3}) and that of August was found lowest (13.25 µg m^{-3}) while comparing with other months as shown in figure 2.16.14. Monthly average was not calculated for September due to insufficient data.

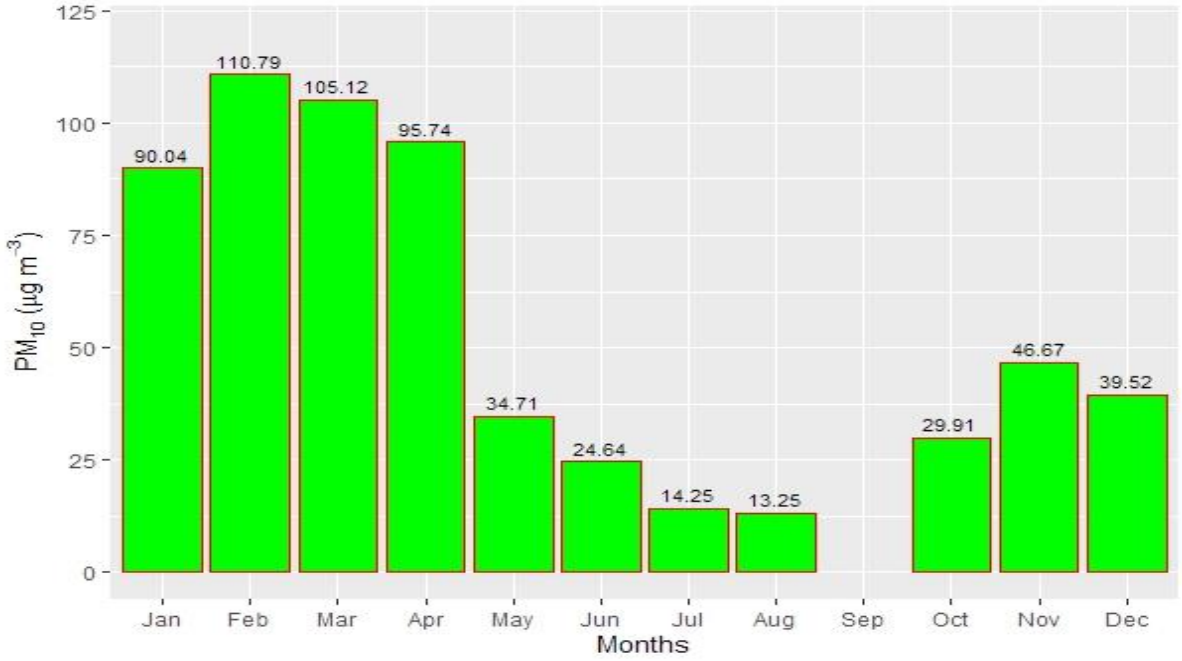


Figure 2.16.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during winter season (91.35 µg m^{-3}) and the lowest during monsoon season (17.05 µg m^{-3}) as in figure 2.16.15.

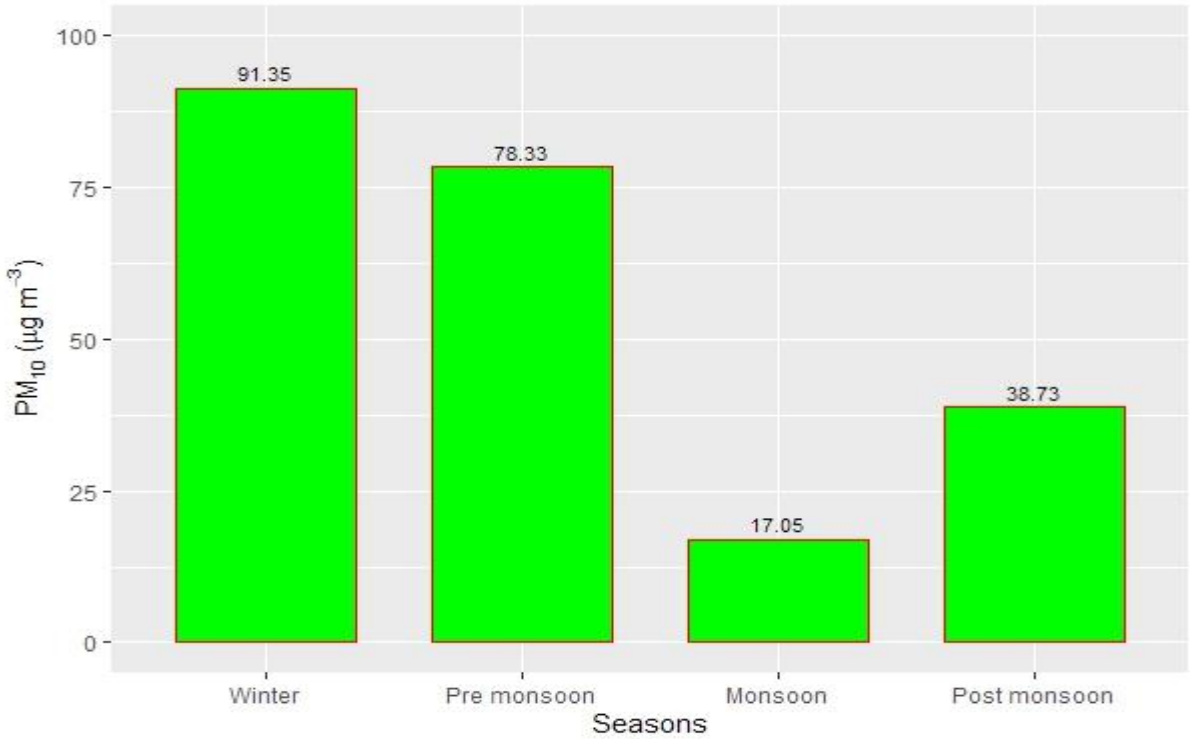


Figure 2.16.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 339 days of measurement, 32 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. From May to December none of the days exceed NAAQS as shown in figure 2.16.16.

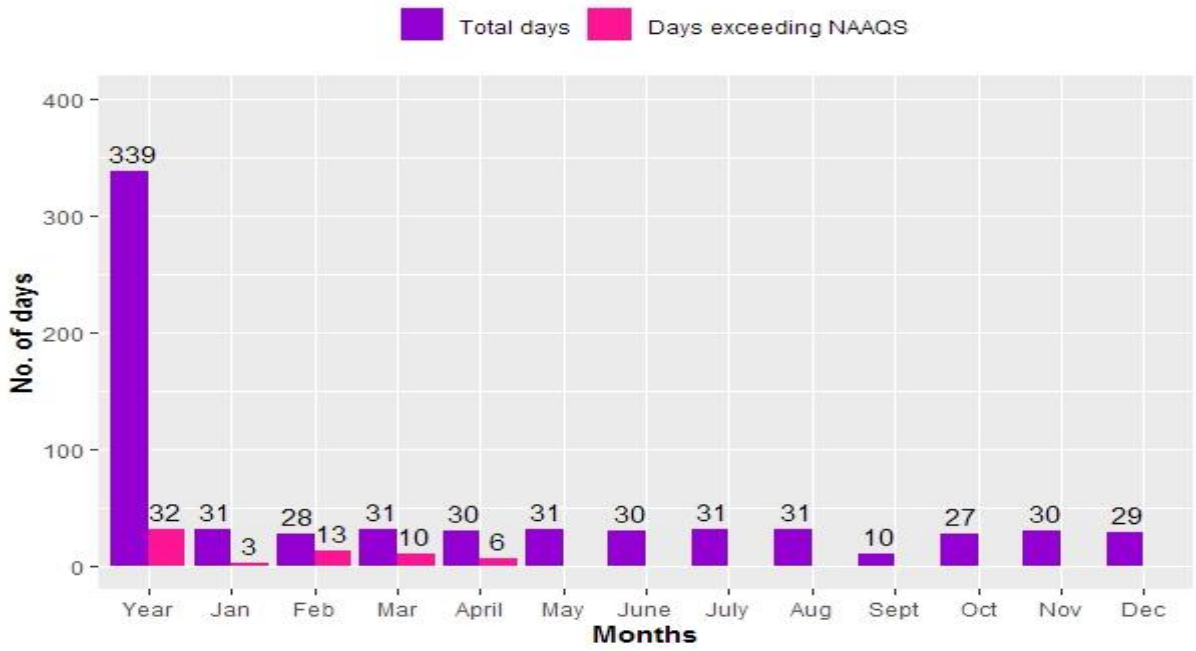


Figure 2.16.16: Compliance status of PM_{10}

2.16.4 TSP

Histogram

TSP in Dhankuta Station was observed to range from 1 to 4966.7 µg m^{-3} (Figure 2.16.17). The mean of the TSP point data was observed to be 102.1 µg m^{-3}.

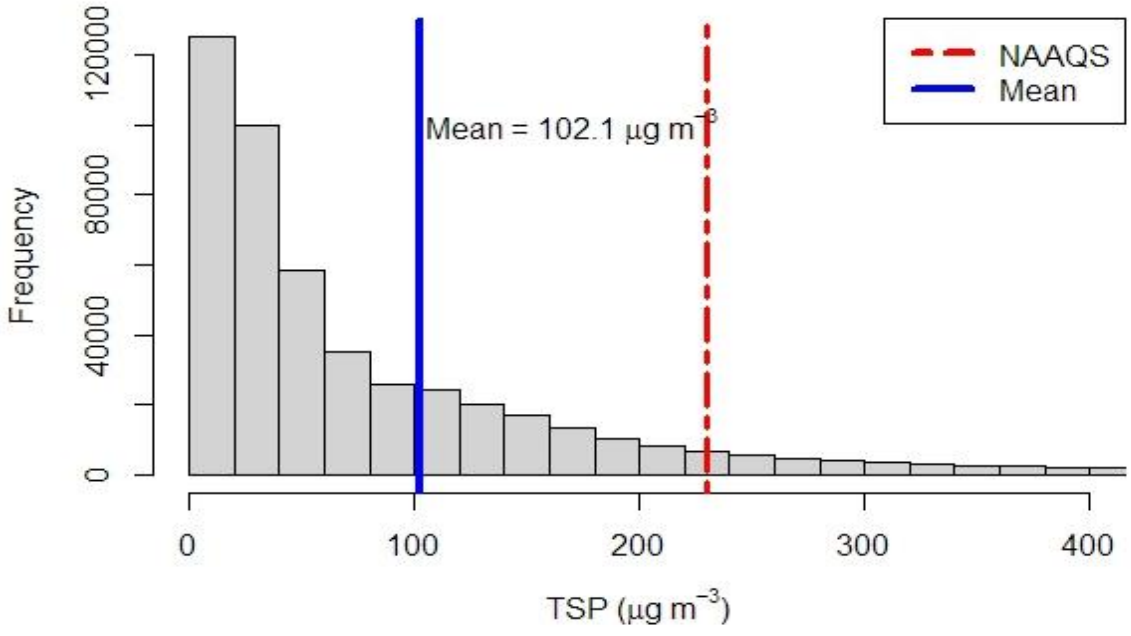


Figure 2.16.17: Histogram of TSP

Diurnal Variation

The Figure 2.16.18 shows TSP peaks at 1 AM. The diurnal variation is found high during 1 PM. The mean value is found to be more than median throughout the day. It is seen that higher the mean value higher is the difference between mean and median.

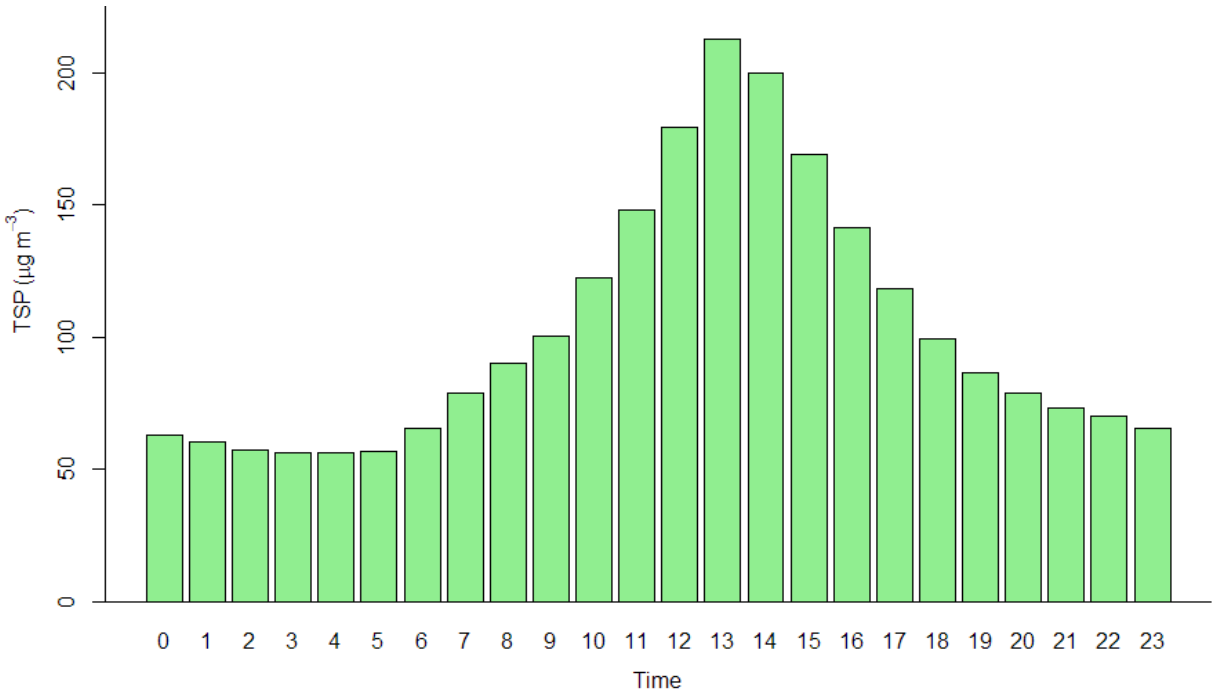


Figure 2.16.18: Hourly average of TSP

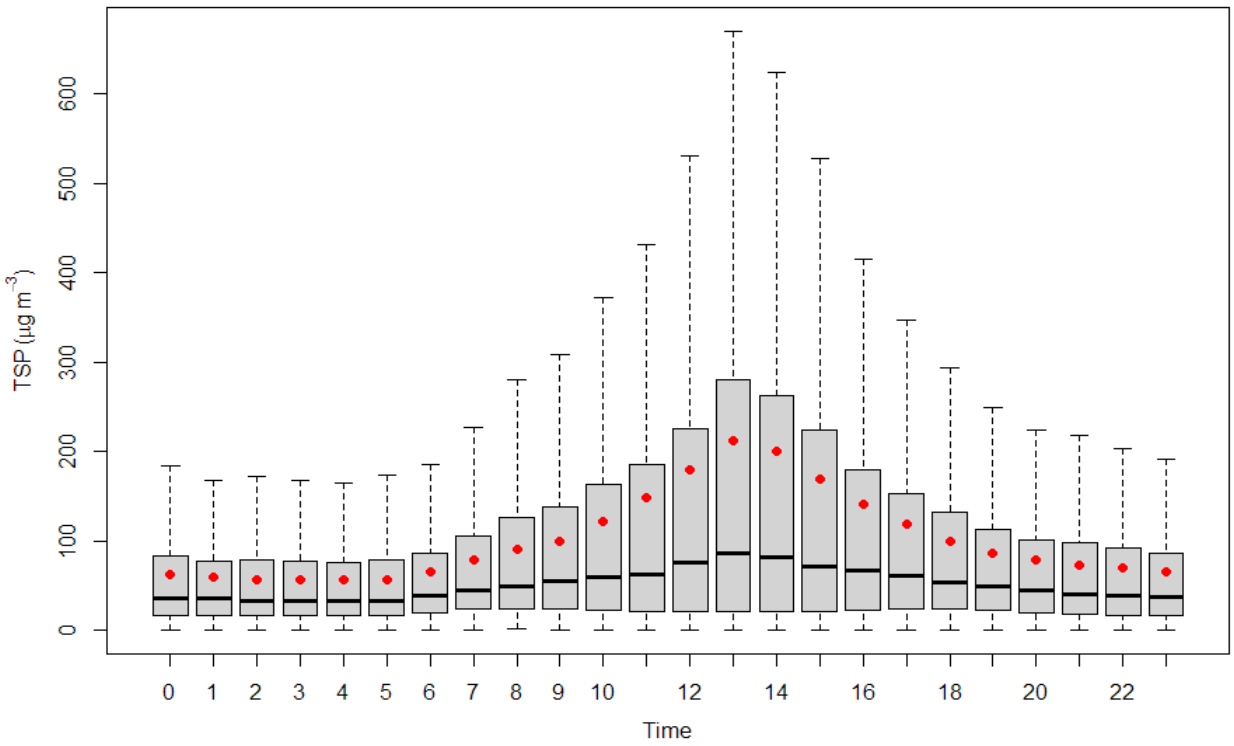


Figure 2.16.19: Diurnal variation of TSP

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.16.20. Higher concentration can be seen during winter and pre-monsoon season whereas lower concentration was observed during monsoon season.

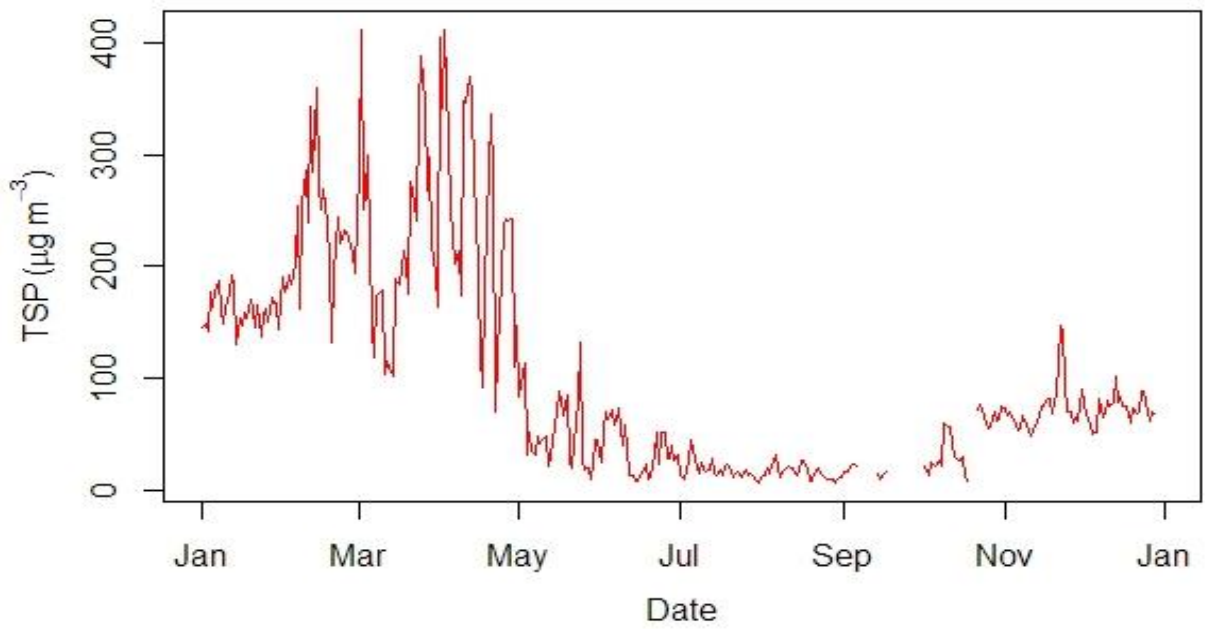


Figure 2.16.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during April whereas less during monsoon and post monsoon. The mean value was found more than median during January to April and November and December.

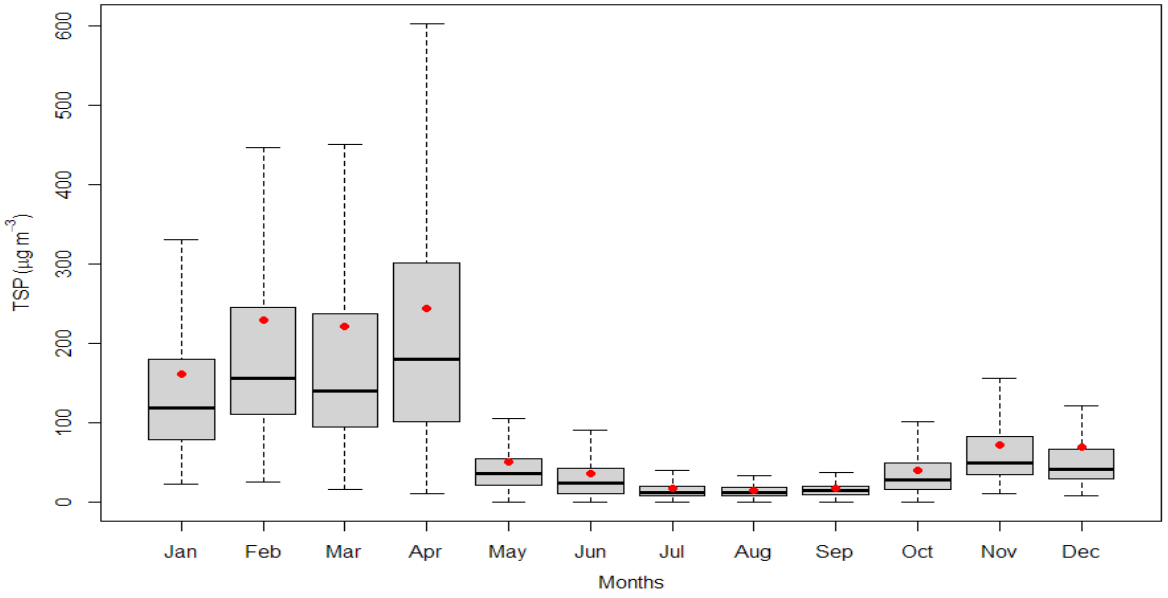


Figure 2.16.21: Monthly variation of TSP

The monthly average for April was found to be the highest (244.81 µg m^{-3}) and that of August was found to be the lowest (15.49 µg m^{-3}) while comparing with other months as shown in figure 2.16.22.

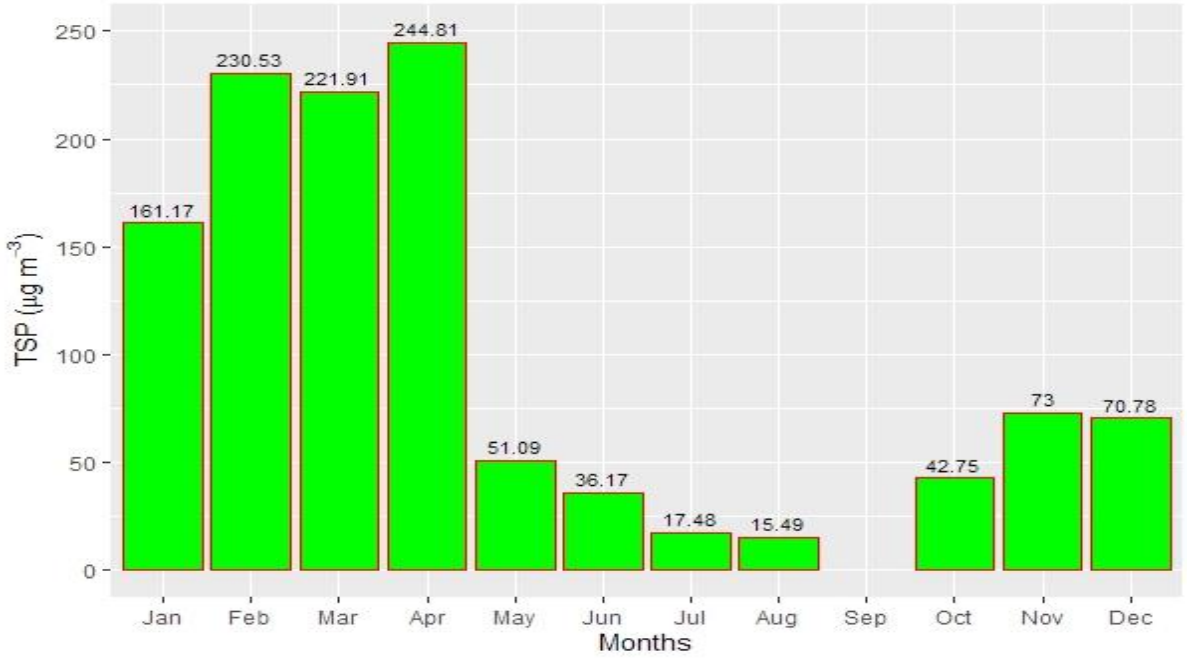


Figure 2.16.22: Monthly average of TSP

Seasonal Average

The average concentration of TSP was found to be the highest during the winter and pre-monsoon season (172.66 and 171.81 µg m^{-3}) and the lowest during the monsoon season (22.28 µg m^{-3}) as in figure 2.16.23.

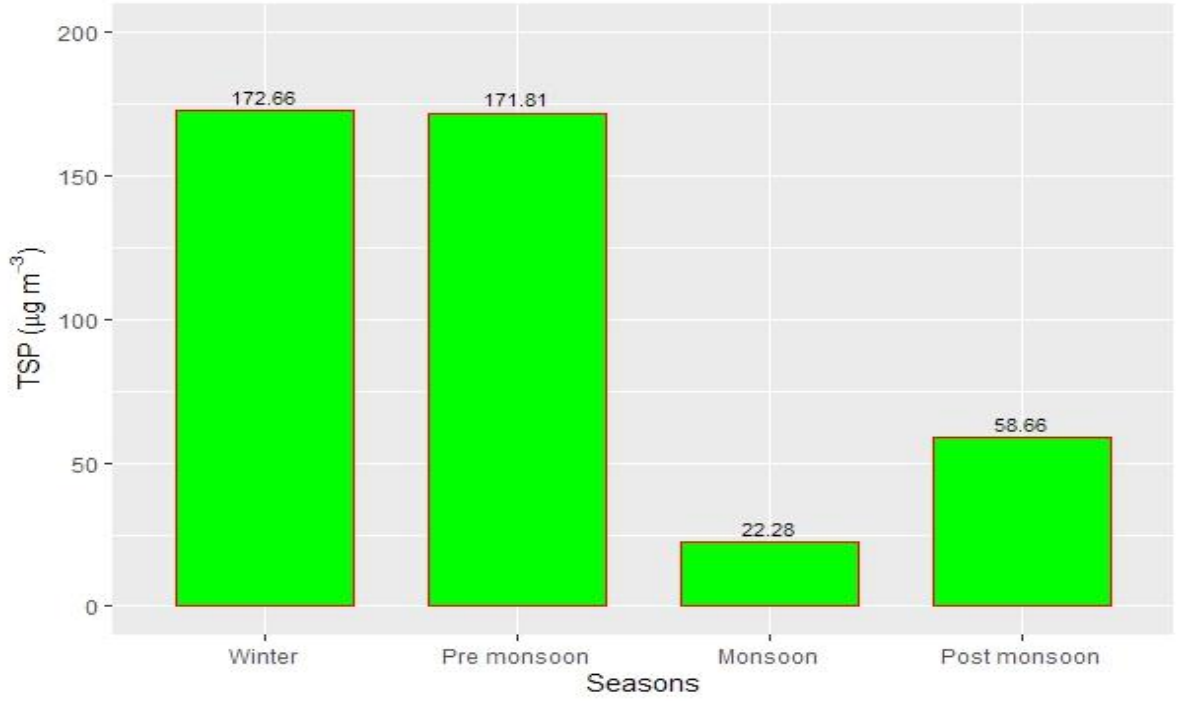


Figure 2.16.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 339 days of measurement, 44 days exceeded the National Ambient Air Quality Standard for TSP of 230 µg m^{-3}. From May to December none of the days exceed NAAQS as shown in figure 2.16.24.

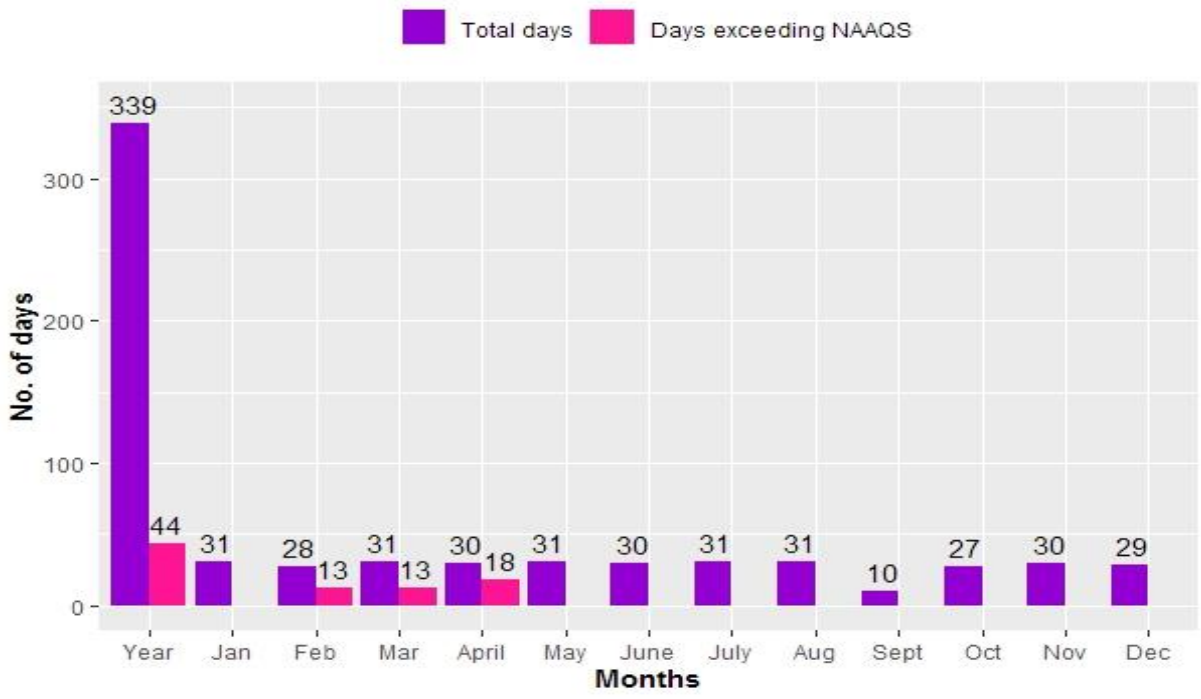


Figure 2.16.24: Compliance status of TSP

Annual Average

The annual average of $PM_{2.5}$, PM_{10} and TSP of Dhankuta station is shown in figure 2.16.25.

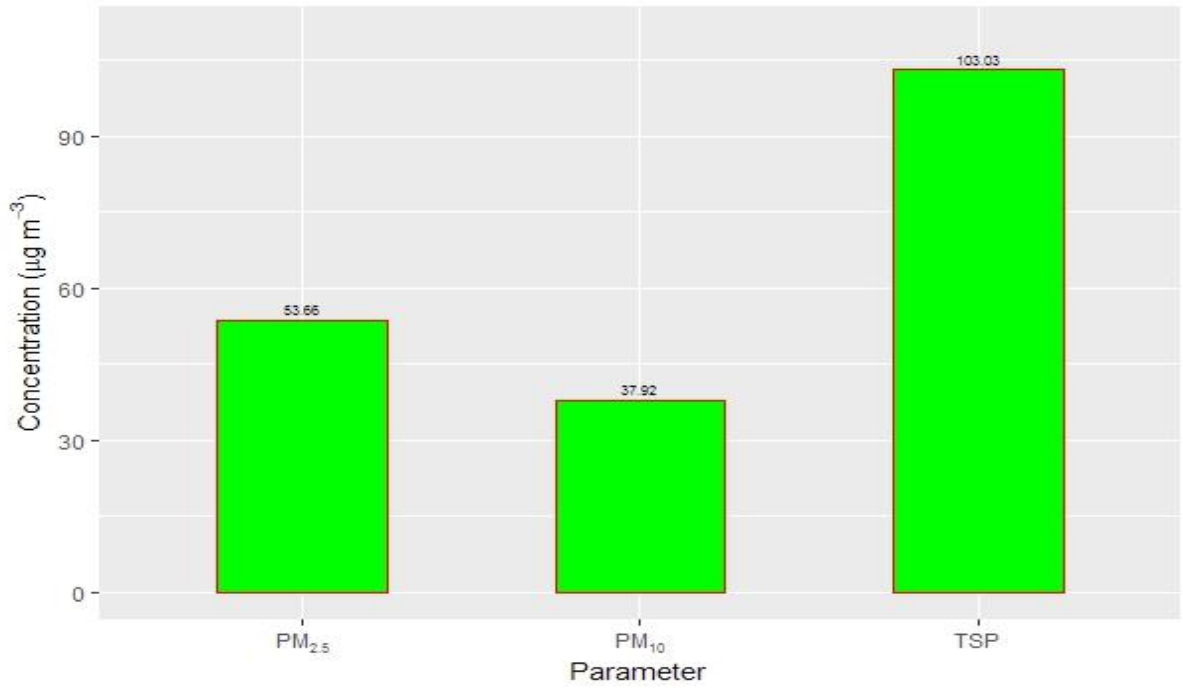


Figure 2.16.25: Annual average of $PM_{2.5}$, PM_{10} and TSP

Calendar Plot

Calendar plot is prepared for PM $_{2.5}$. It is based on the Air Quality Index (AQI) developed by Government of Nepal. The Calender plot shows AQI for $PM_{2.5}$ reached to unhealthy level in few days in January, February, March, April and November.

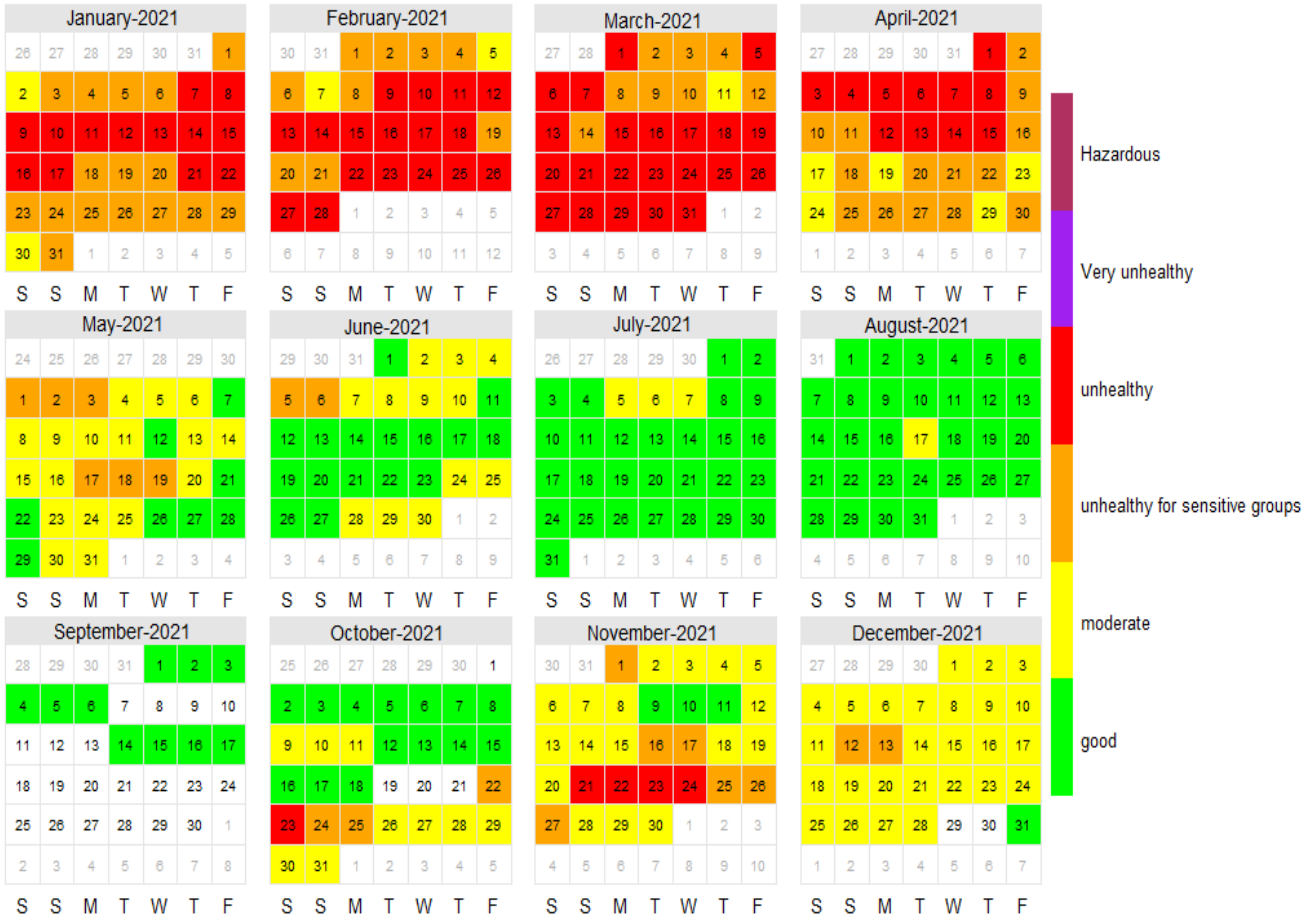


Figure 2.16.26: Calendar plot for $PM_{2.5}$ for the year 2021

2.17 Air quality status – Damak

2.17.1 Introduction

Inside the premises of Saraswati Madhyamik Bidyalaya, Damak, Jhapa district of Province 1, Air Quality Monitoring Station was established in the year 2019. This station represents air quality of urban flat land. Hence, the major source of air pollution in this area is either local or pollutants transported because of various meteorological processes.

The Station is installed with following instruments:

SN	Name of Instrument	Number of instruments
1	PM instrument- GRIMM EDM 180	1
2	Met sensor Lufft WS 700	1
3	Data logging and data transmission and power backup system	1

2.17.2 $PM_{2.5}$

Histogram

$PM_{2.5}$ in Damak Station was observed to range from 1 to 1493 µg m^{-3} (Figure 2.17.1). The mean of the $PM_{2.5}$ point data was observed to be 57.61 µg m^{-3}.

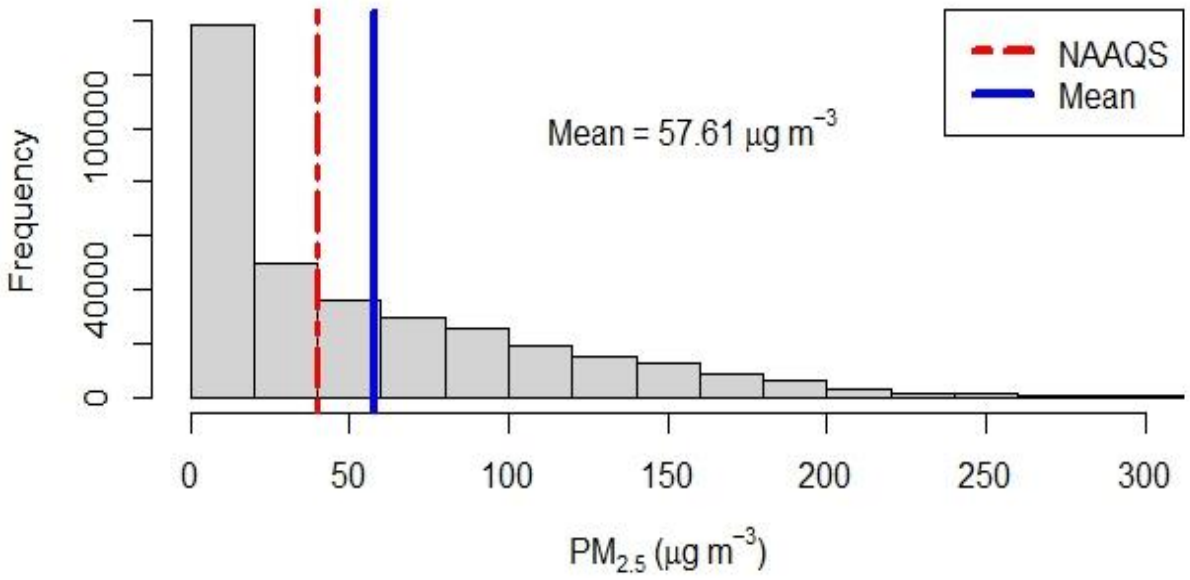


Figure 2.17.1: Histogram of $PM_{2.5}$

Diurnal Variation

Figure 2.17.2 shows $PM_{2.5}$ peaks at 6 AM to 8 AM and at 5 PM to 7 PM. The diurnal variation is found high during morning and evening. The mean value is found to be more than the median throughout the day as shown in figure 2.17.3.

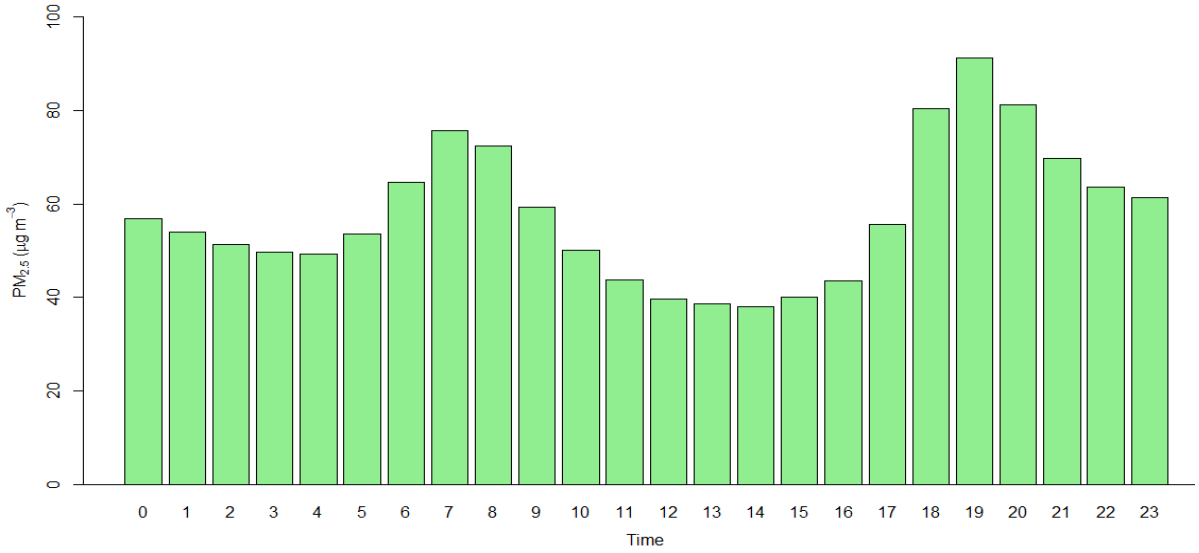


Figure 2.17.2: Hourly average of $PM_{2.5}$

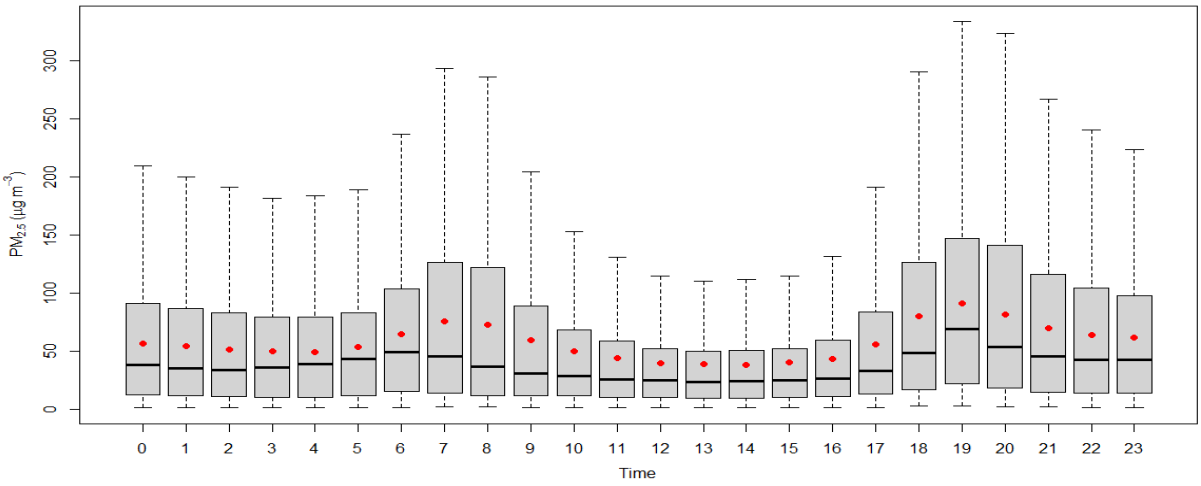


Figure 2.17.3: Diurnal variation of $PM_{2.5}$

Daily variation:

The daily average variations of $PM_{2.5}$ is shown in figure 2.17.4. Higher concentration can be seen during December February and April whereas lower concentration was observed during monsoon and post-monsoon season.

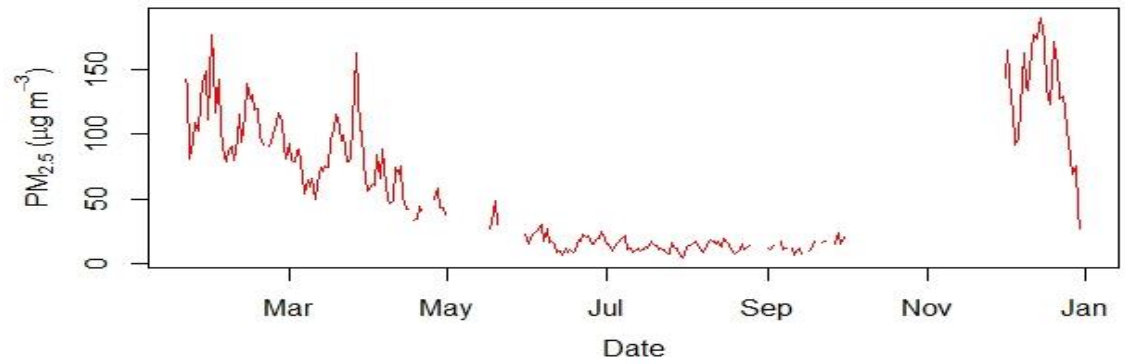


Figure 2.17.4: Daily mean concentration of $PM_{2.5}$

Monthly Variation:

In the box plot of the monthly $PM_{2.5}$, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dots indicate mean concentrations. High variation was seen during December whereas less during July to September.

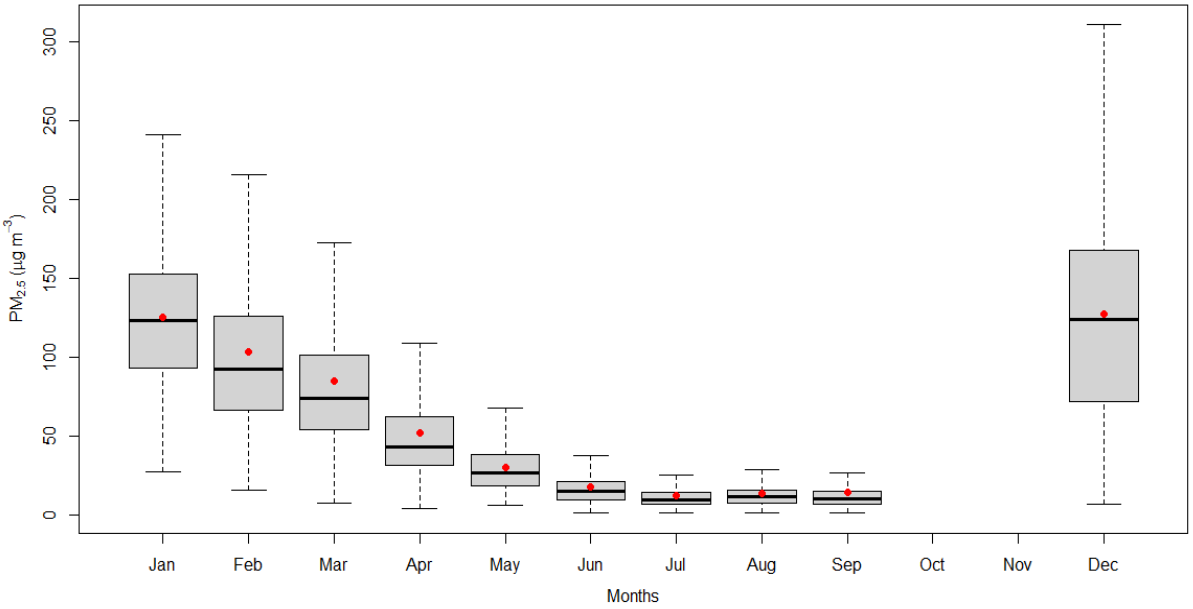


Figure 2.17.5: Monthly variation of $PM_{2.5}$

The monthly average of December was found to be highest (128.59 µg m^{-3}) and that of July was found to be lowest (12.67 µg m^{-3}) while comparing with other months as shown in figure 2.17.6 below.

Figure 2.17.6: Monthly average $PM_{2.5}$

Seasonal Average

Seasonal average was not calculated for winter and Post monsoon season. The average concentration of $PM_{2.5}$ was found to be the higher during the Pre monsoon season (68.29 µg m^{-3}) than during the monsoon season (14.64 µg m^{-3}) as in figure 2.17.7.

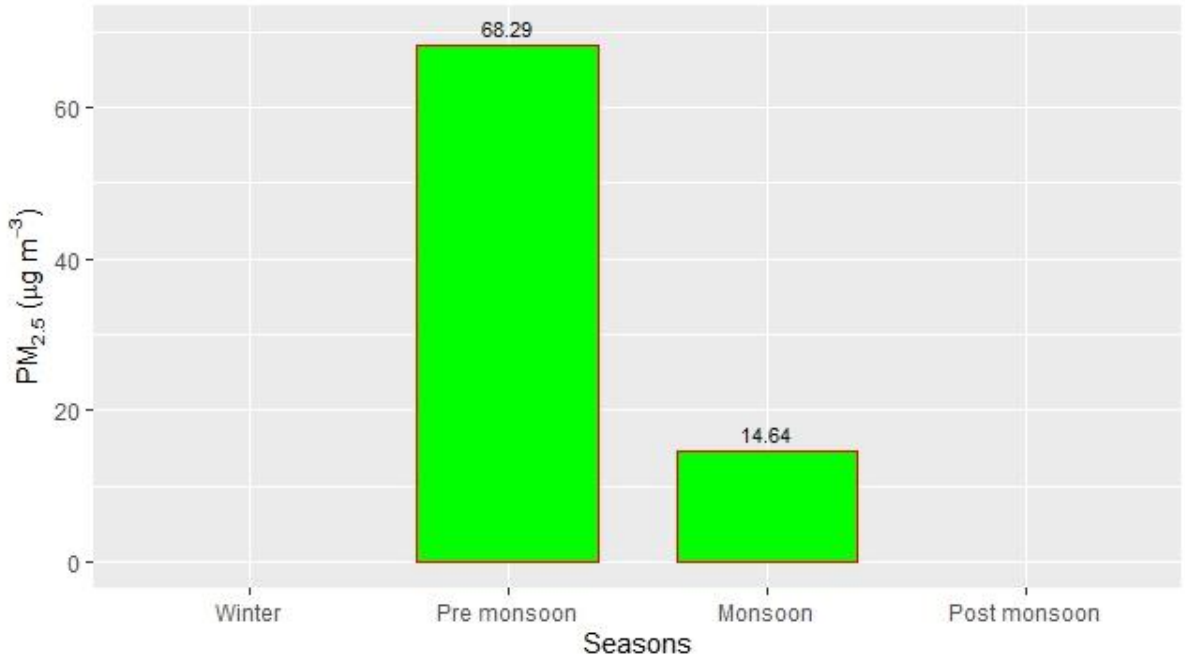


Figure 2.17.7: Seasonal variation of $PM_{2.5}$

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 236 days of measurement, only 122 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$ (40 µg m^{-3}) most of which belong to the months of winter and pre-monsoon as shown in figure 2.17.8.

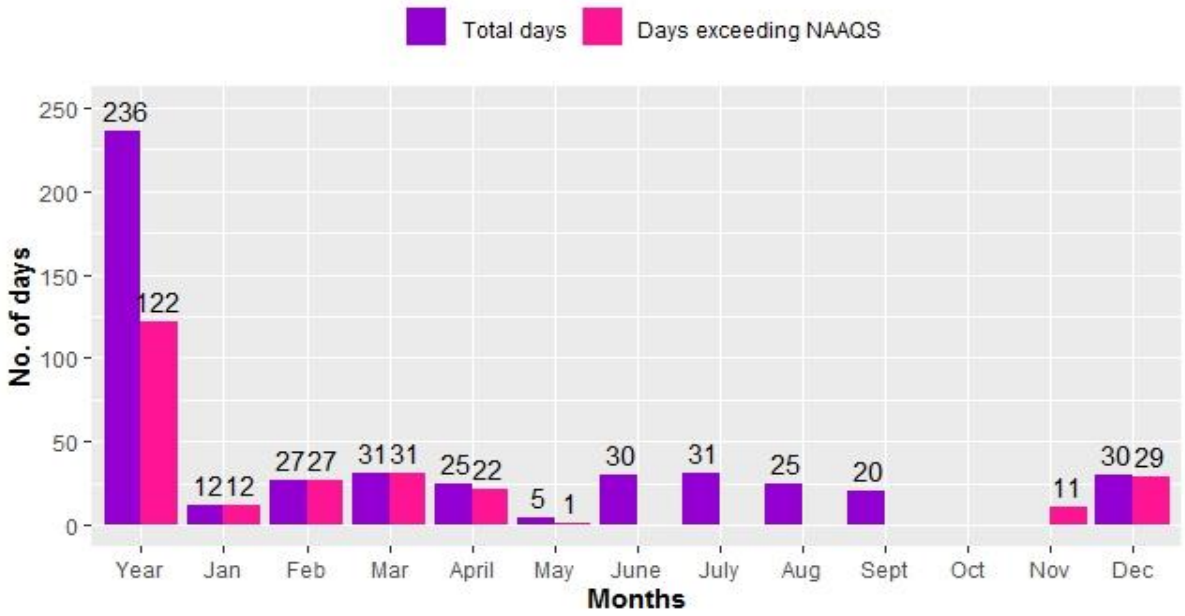


Figure 2.17.8: Compliance status of $PM_{2.5}$

2.17.3 PM_{10}

Histogram:

PM_{10} in Damak Station was observed to range from 1 to 2967 µg m^{-3} as in Figure 2.17.9. The mean of the PM_{10} point data was observed to be 73.17 µg m^{-3}.

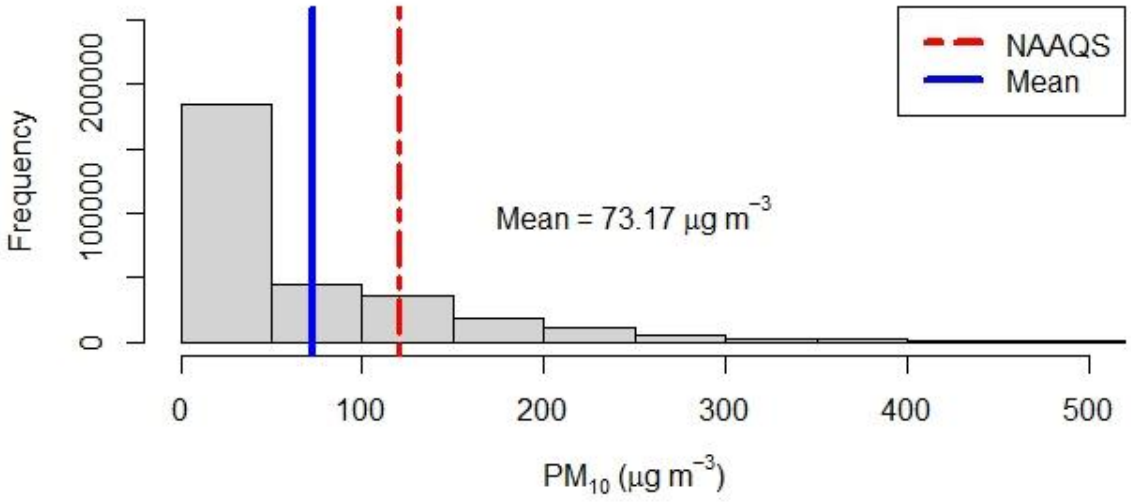


Figure 2.17.9: Histogram of PM_{10}

Diurnal Variation

Figure 2.17.10 shows PM_{10} peaks at 6 to 8 AM and at 5 to 8 PM. The diurnal variation is found high during 7 PM. The mean value is found to be more than median throughout the day.

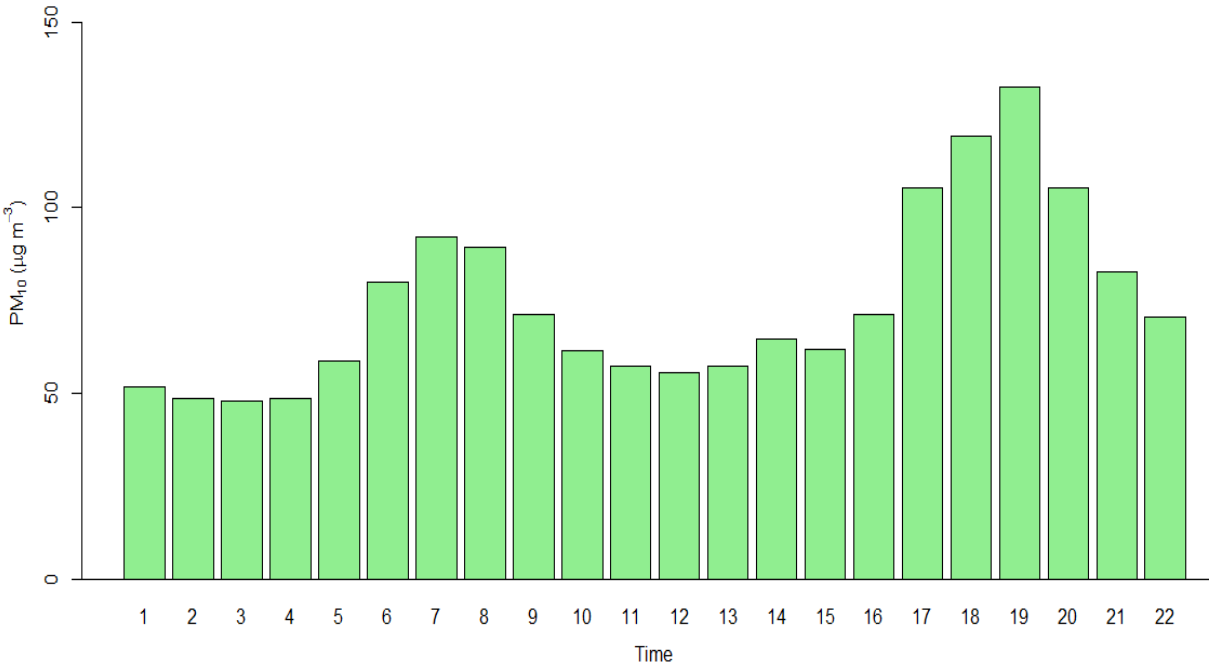


Figure 2.17.10: Hourly average of PM_{10}.

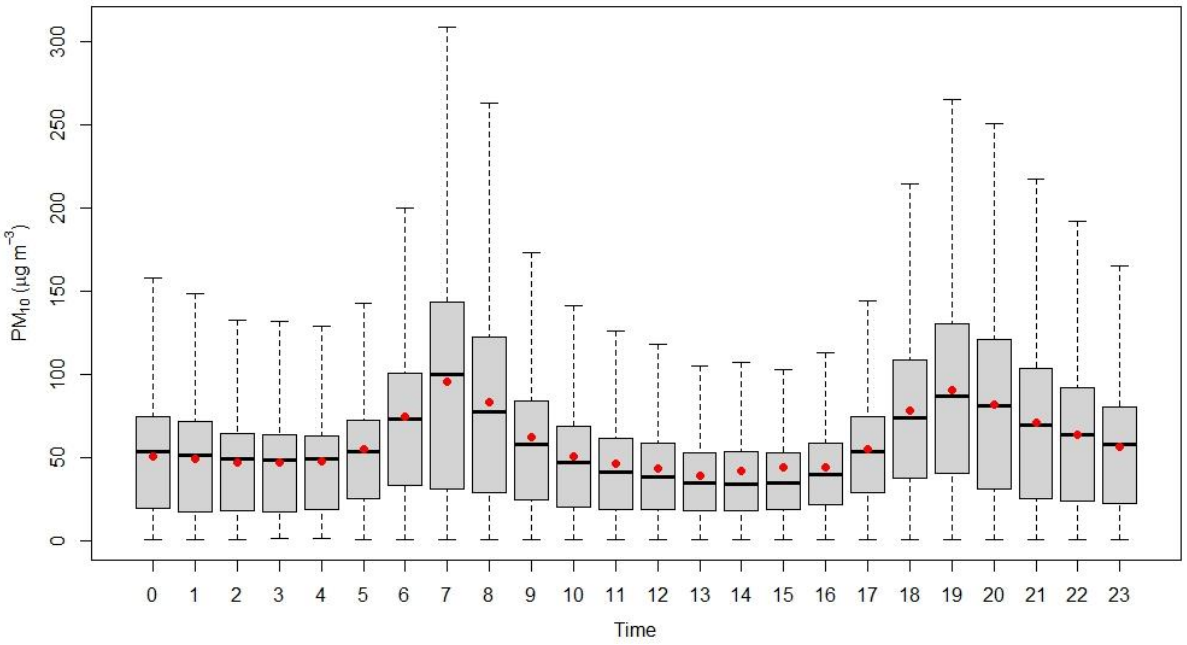


Figure 2.17.11: Diurnal variation of PM_{10}

Daily value

Similarly, the annual graph of daily average PM_{10} is shown in the figure 2.17.12. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post-monsoon season.

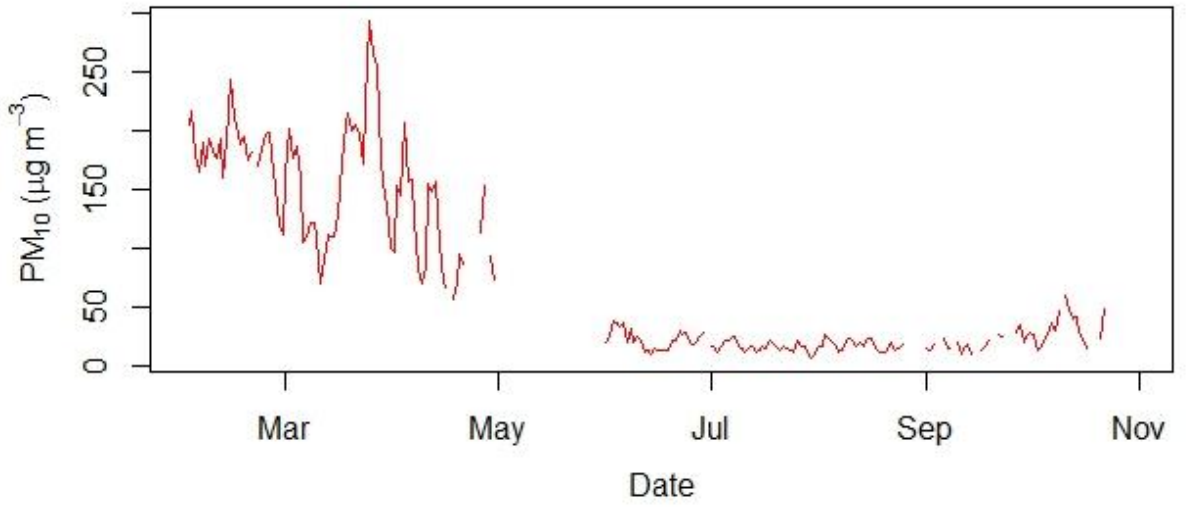


Figure 2.17.12: Daily mean concentration of PM_{10}

Monthly Variation

In the box plot of the monthly PM_{10}, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during February whereas less during July.

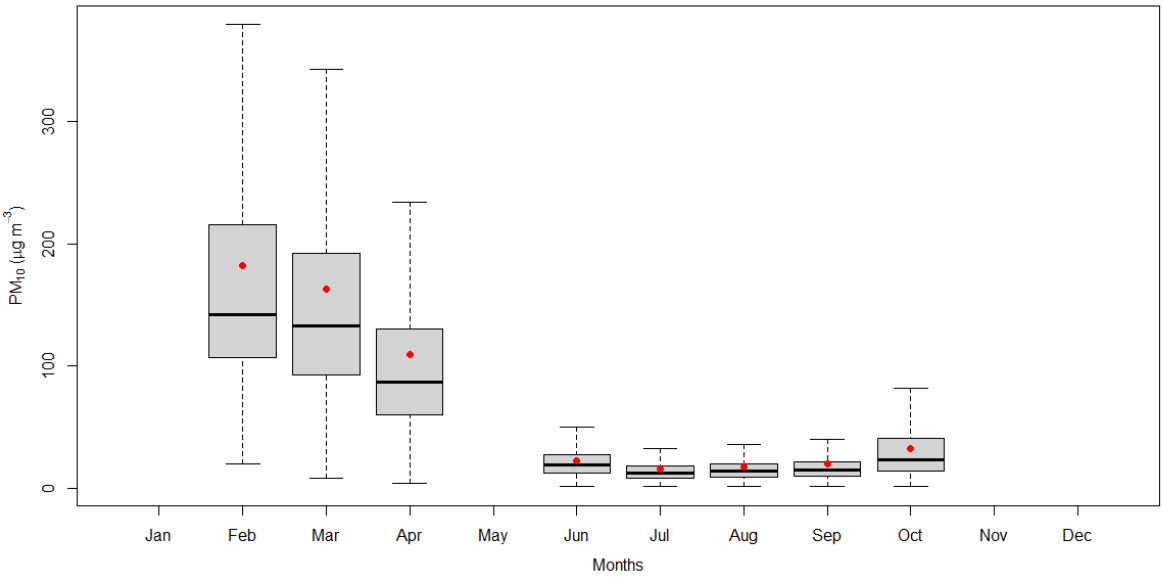


Figure 2.17.13: Monthly variation of PM_{10}

The monthly average for February was found the highest (182.94 µg m^{-3}) and that of July was found lowest (15.69 µg m^{-3}) while comparing with other months as shown in figure 2.17.14.

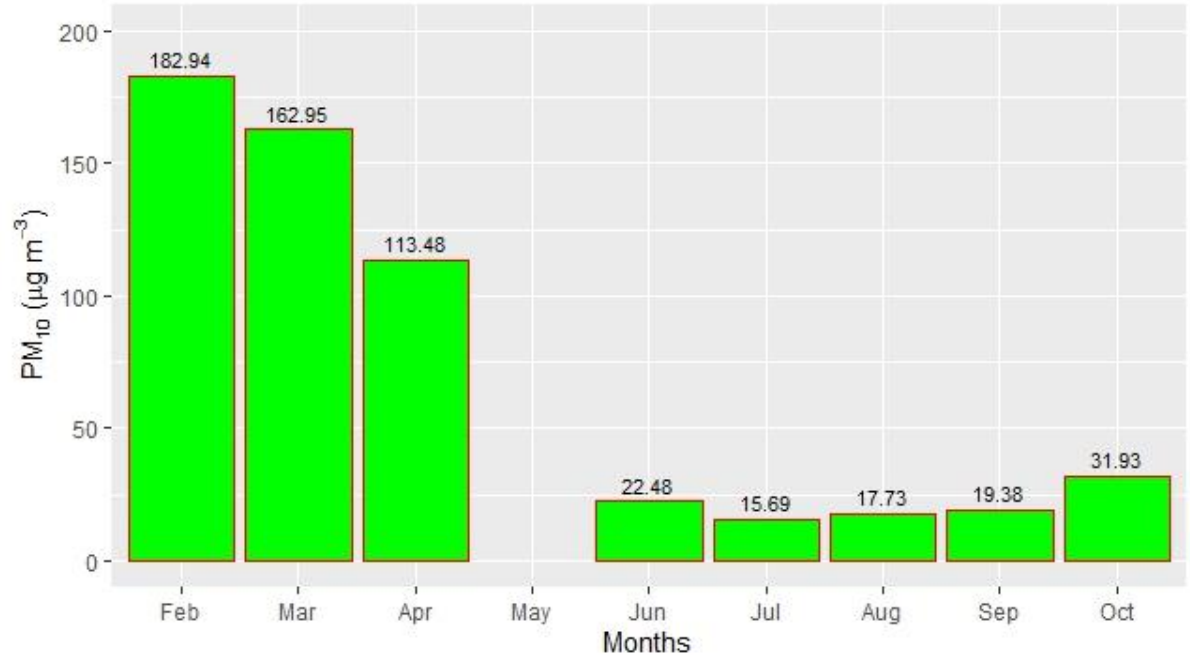


Figure 2.17.14: Monthly average of PM_{10}

Seasonal Average

The average concentration of PM_{10} was found to be the highest during Pre monsoon season (141.36 µg m^{-3}) and the lowest during monsoon season (18.75 µg m^{-3}) as in figure 2.17.15.

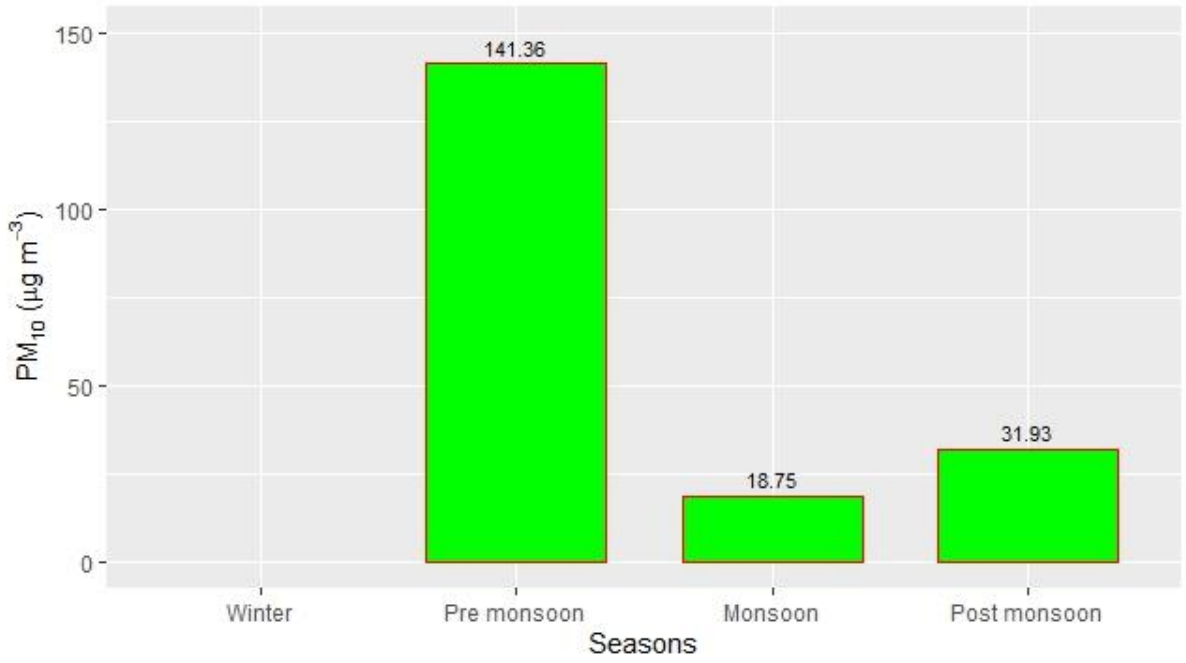


Figure 2.17.15: Seasonal variation of PM_{10}

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 207 days of measurement, only 58 days exceeded the National Ambient Air Quality Standard of 120 µg m^{-3} for PM_{10}. During monsoon season none of the days exceed NAAQS as shown in figure 2.17.16.

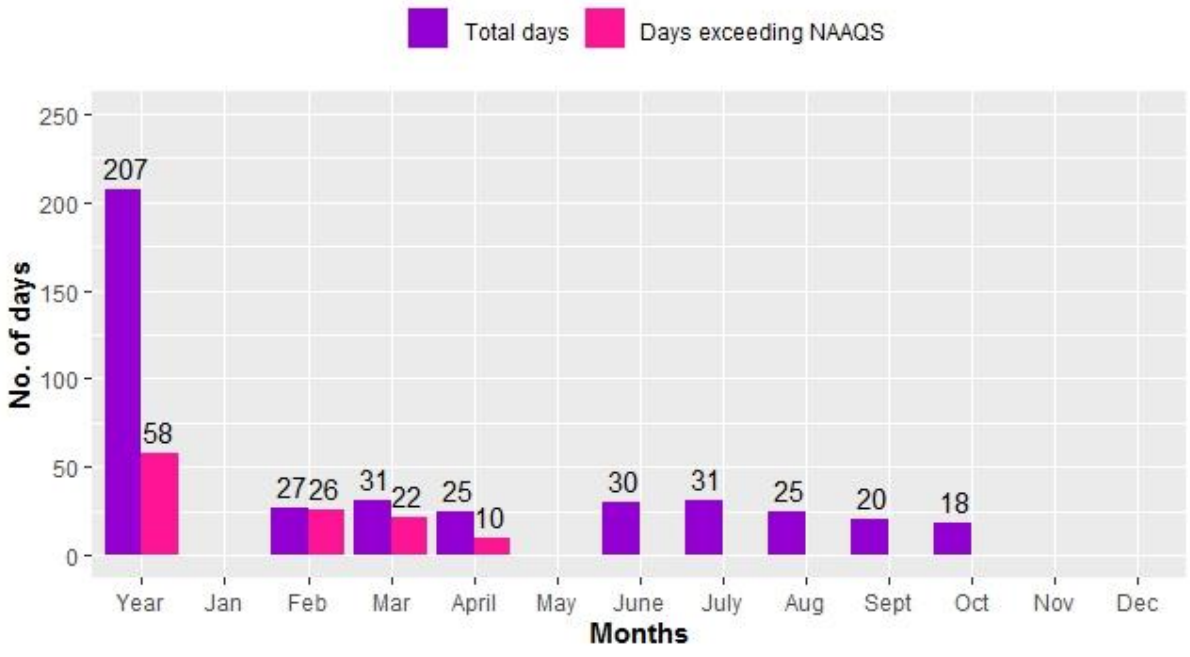


Figure 2.17.16: Compliance status of PM_{10}

2.17.4 TSP

Histogram

TSP in Damak Station was observed to range from 1 to 5000 µg m^{-3} as in Figure 2.17.17. The mean of the TSP point data was observed to be 109.4 µg m^{-3}.

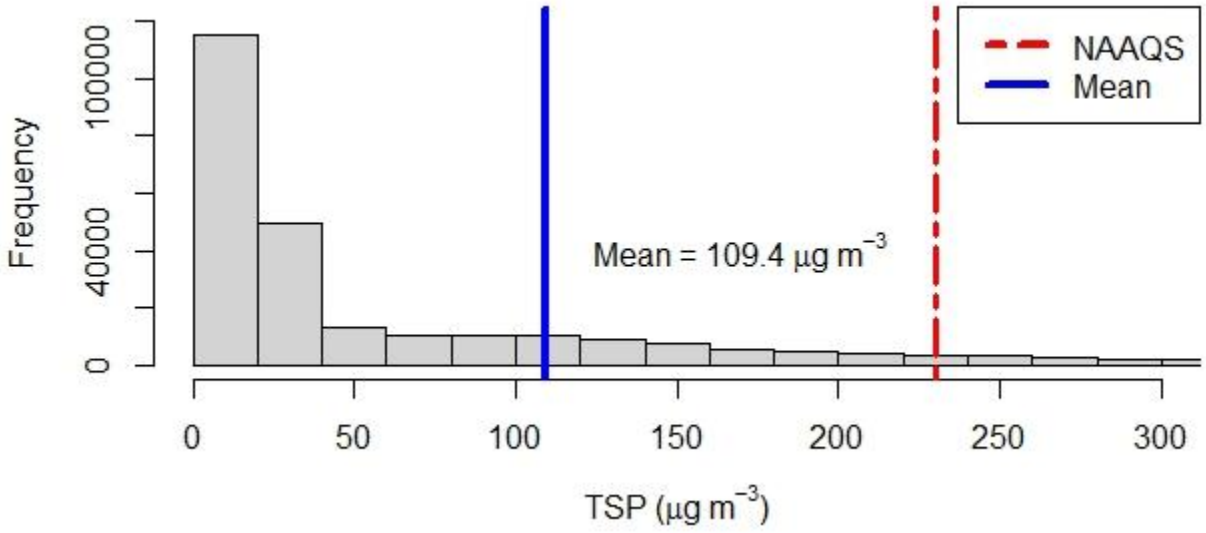


Figure 2.17.17: Histogram of TSP

Diurnal Variation

Figure 2.17.18 shows TSP peaks at 5 PM. The diurnal variation is found high during 7 AM. The mean value is found to be much higher than median form 8 AM to 8 PM.

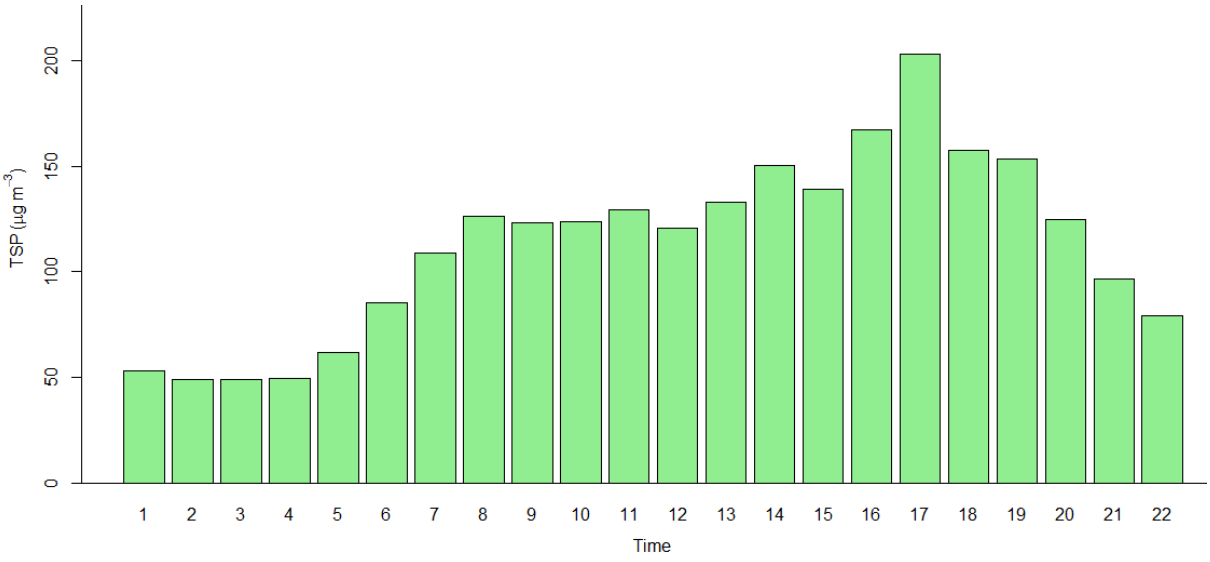


Figure 2.17.18: Hourly average of TSP

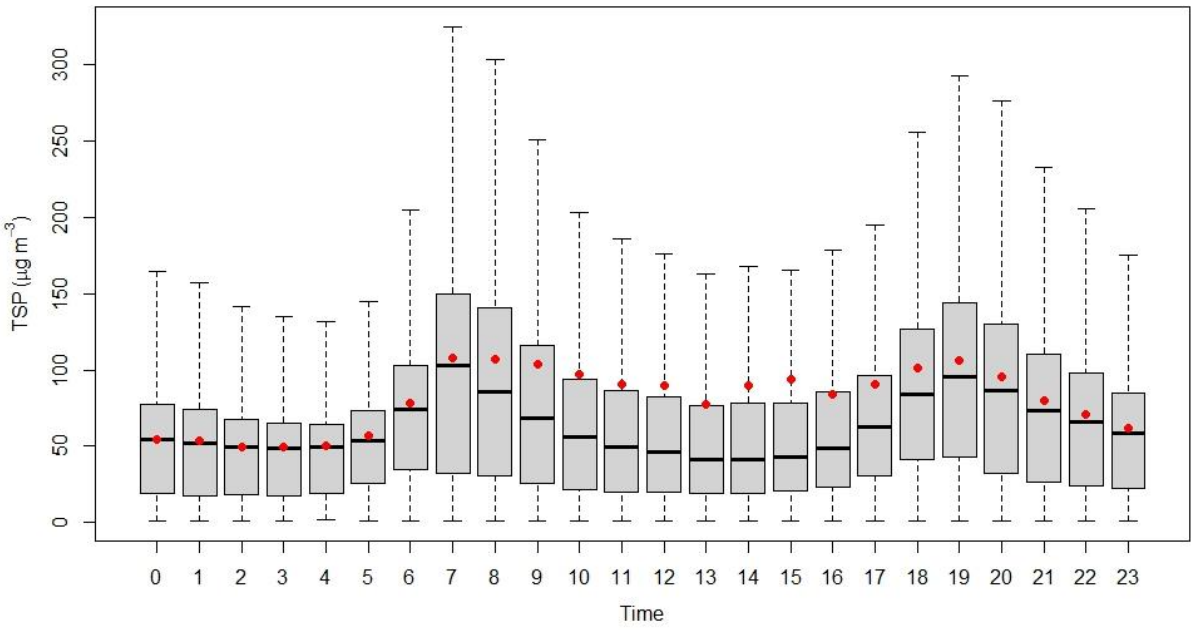


Figure 2.17.19: Diurnal variation of TSP

Daily value

Similarly, the annual graph of daily average TSP is shown in the figure 2.17.20. Higher concentration can be seen during April whereas lower concentration was observed during monsoon and post-monsoon season

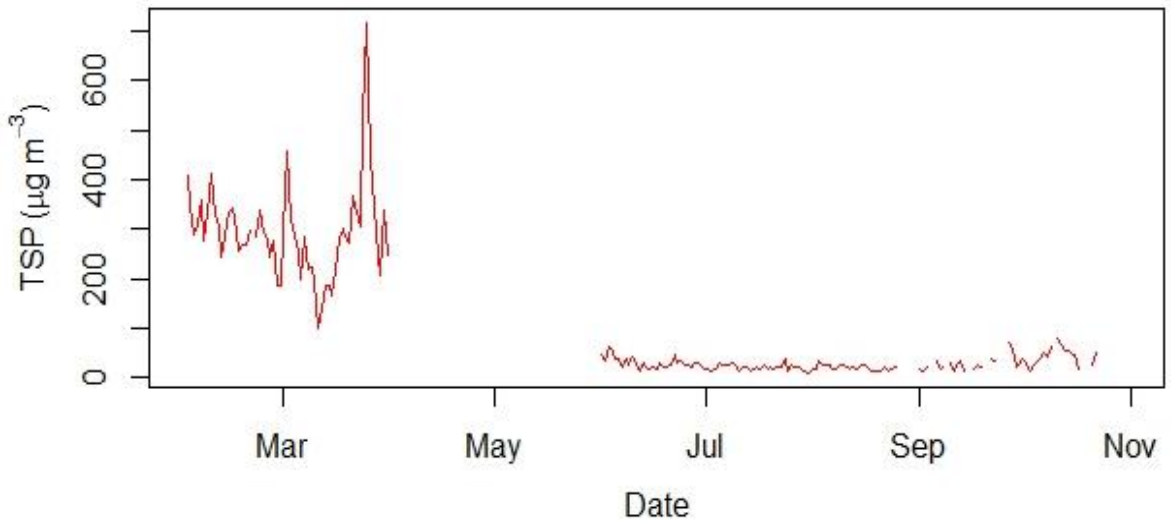


Figure 2.17.20: Daily mean concentration of TSP

Monthly Variation

In the box plot of the monthly TSP, the box edges indicate the interquartile range, whiskers indicate the maximum and minimum values, and the dashed lines inside the box are the medians and dot indicate mean concentrations. High variation was seen during February whereas less during monsoon.

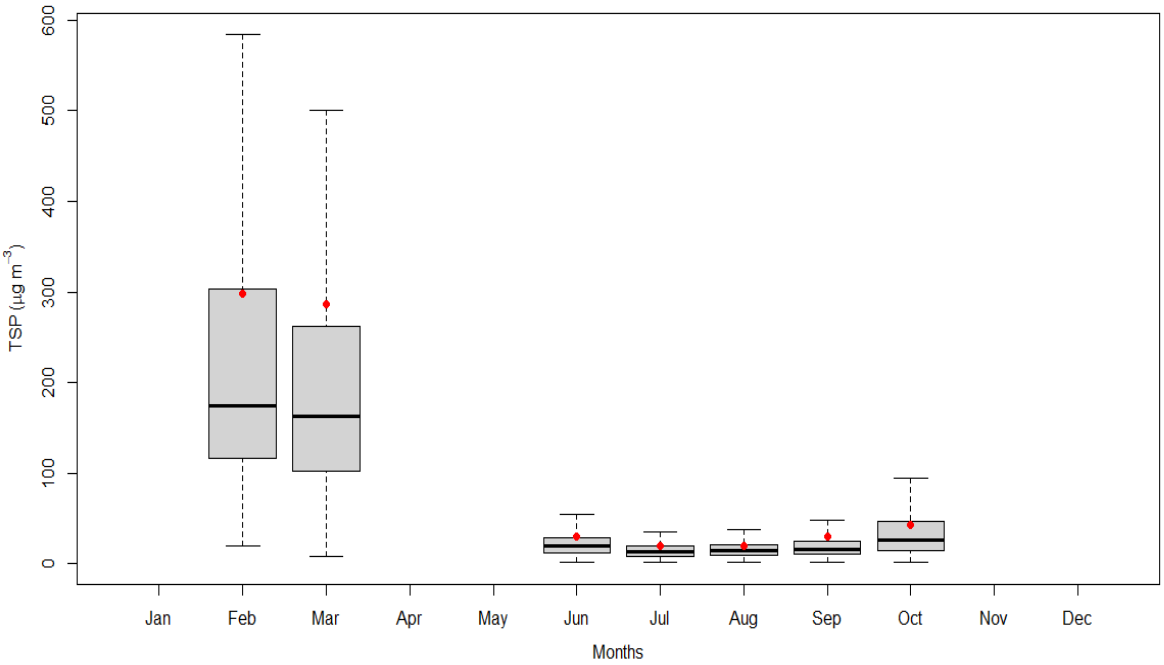


Figure 2.17.21: Monthly variation of TSP

The monthly average for February was found to be the highest (297.77 µg m^{-3}) and that of July was found to be the lowest (19.98 µg m^{-3}) while comparing with other months as shown in figure 2.17.22.

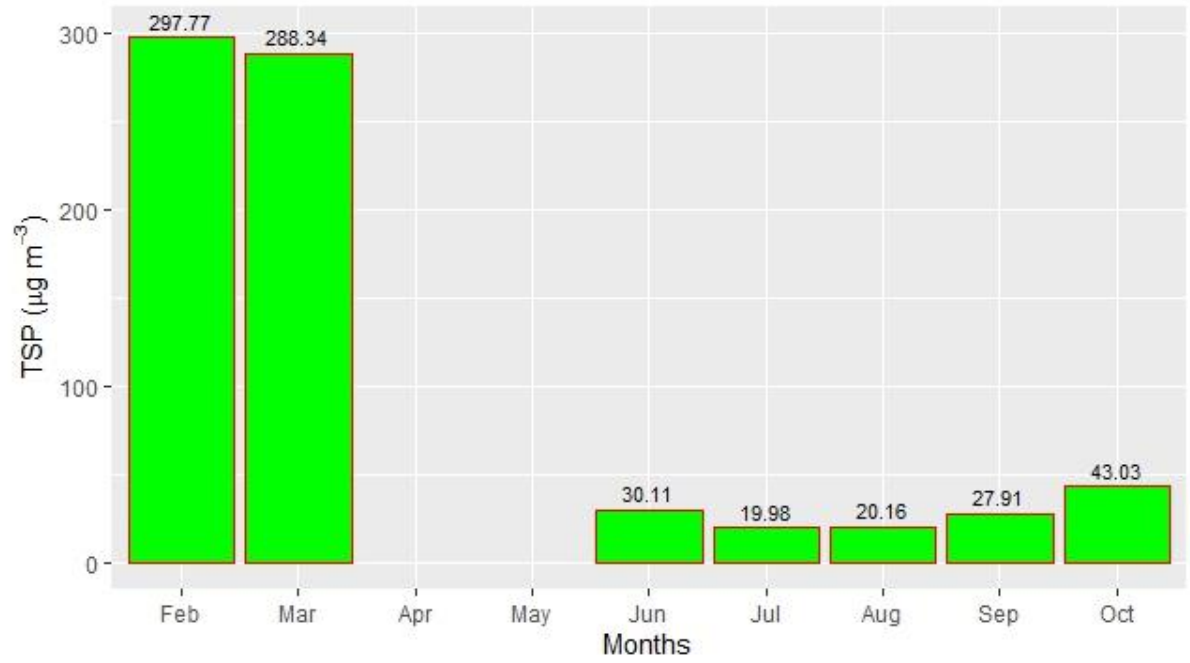


Figure 2.17.22: Monthly average of TSP

Seasonal Average

Seasonal average was not calculated for winter and Pre monsoon season. The average concentration of TSP was found to be higher during the Post monsoon season (43.03 µg m^{-3}) than monsoon season (24.38 µg m^{-3}) as in figure 2.17.23.

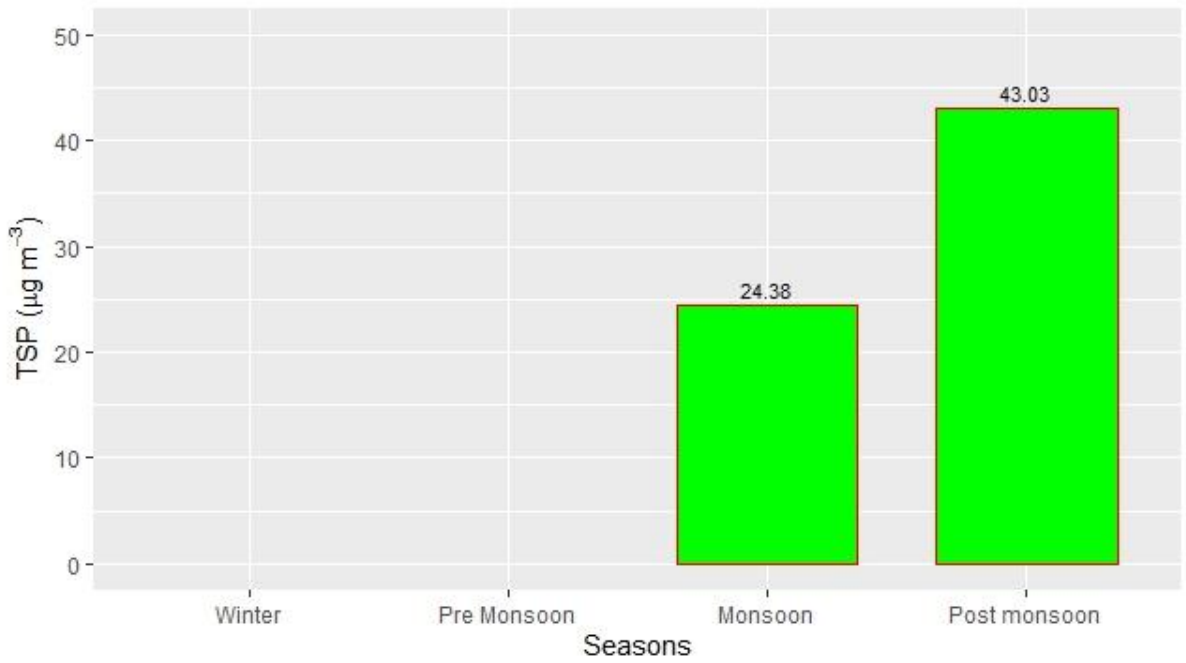


Figure 2.17.23: Seasonal variation of TSP

Compliance with National Ambient Air Quality Standards (NAAQS)

Out of 182 days of measurement, only 45 days exceeded the National Ambient Air Quality Standard for TSP of 230µg m^{-3}. Most the days exceeding the NAAQS lie in February and March month as shown in figure 2.17.24.

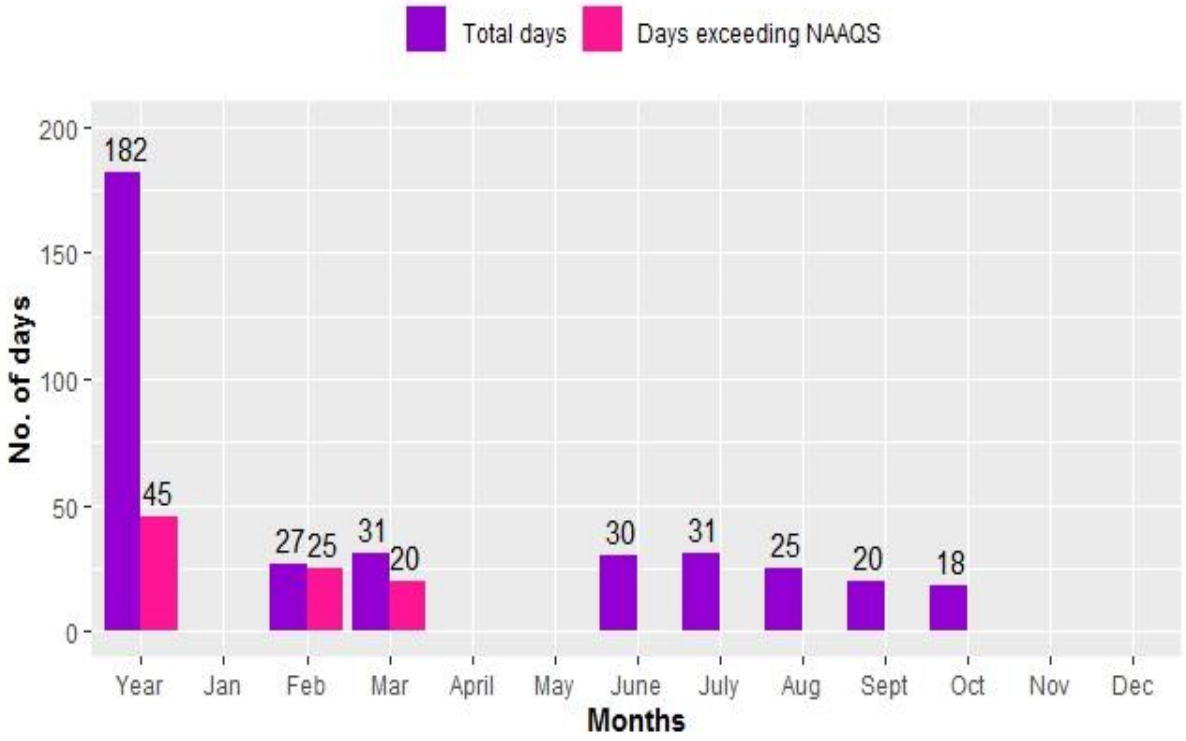


Figure 2.17.24: Compliance status of TSP

Calendar Plot:

Calendar Plot in figure 2.17.25 shows that most of the days in the months of December, January, February and March are unhealthy whereas most of the days in monsoon months i.e. June, July, August and September are good.

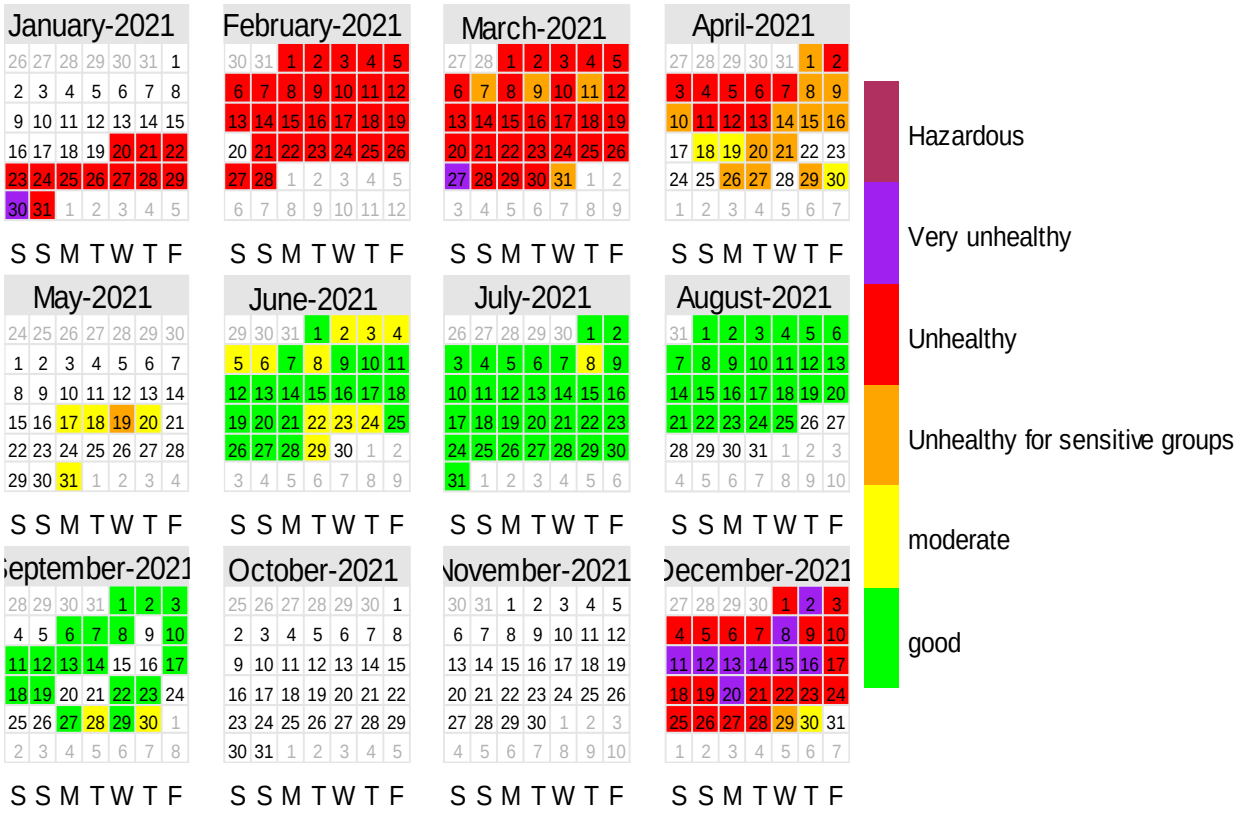
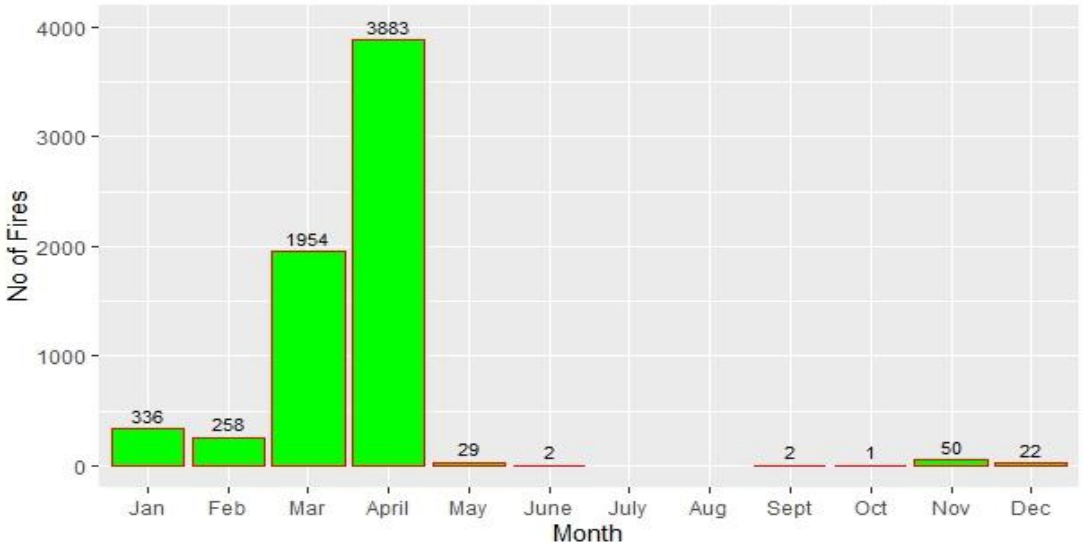


Figure 2.17.25: Calendar plot of $PM_{2.5}$ for the year 2021

2.18 Fire and Meteorological Parameters affecting Air quality

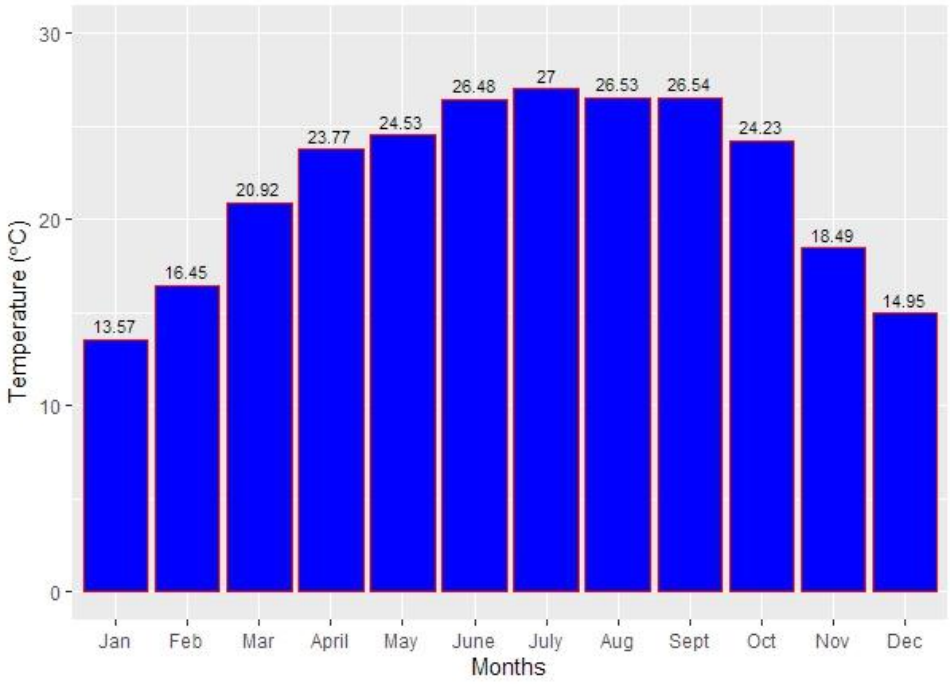
Various meteorological parameters such as rain fall, temperature, wind speed, wind direction and others affect level of air pollution. The report Among many, forest fire is one of the very important parameters that contributes in decreasing air quality in Nepal. The figure below shows number of forest fires in year 2021 in Nepal.



Source: Forest fire detection and monitoring system, DoFSC Nepal

Figure 2.18.1: Number of fires with months in year 2021

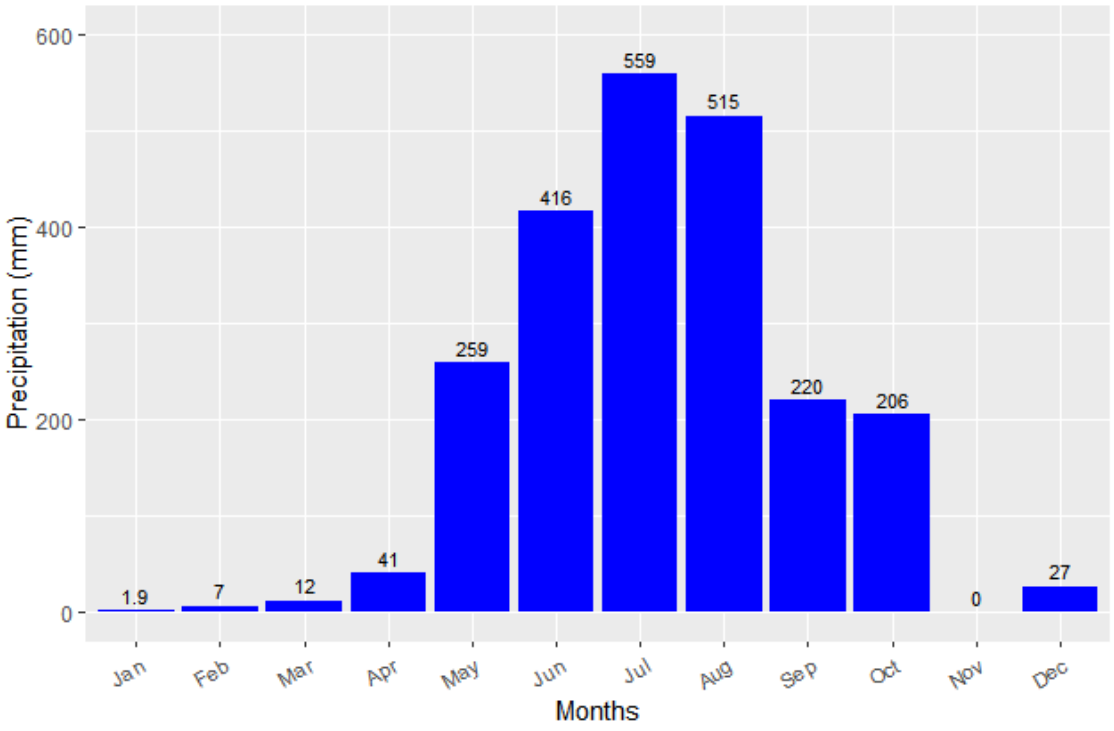
The monthly average temperature of 22 stations (annex 2) is shown in the figure 2.18.2 below. Maximum temperature was recorded during June to September.



Source: DHM Nepal

Figure 2.18.2: Monthly average temperature with months in year 2021

Similarly, the monthly average precipitation of 28 stations (annex 3) is shown in the figure 2.18.3 below. Rainfall is high during monsoon and low during other seasons.



Source: DHM Nepal

Figure 2.18.3: Monthly average precipitation with months in year 2021

Chapter 3. : Summary

Thus the air quality data of 17 stations were analyzed for the year 2021. For each stations hourly average, daily average, diurnal variation, monthly average, seasonal average, no of days exceeding the national standard were computed for $PM_{2.5}$, PM_{10} and TSP and respective graphs were plotted for those variables. The air quality status was found varied both temporally and spatially. The compliance status of NAAQS was found low in Kathmandu Valley and Terai regions especially during pre-monsoon and winter season. The analysis of diurnal variation shows that morning, evening and night time are more polluted than day time. The no of days exceeding the national standard was found more for $PM_{2.5}$ followed by PM_{10} and the TSP. The brief summary of air quality status of each stations is summarized as below.

3.1 Bhimdatta, Mahendranagar

According to the time series data for Bhimdatta station, out of 103 days of measurement, the number of days exceeding national standards for $PM_{2.5}$, PM_{10} and TSP were found to be 91, 45 and 58 days respectively. The monthly average was found to be maximum in February for $PM_{2.5}$ and PM_{10} and TSP. Nevertheless, due to the existing data gap, various year-round trend could not be reflected for this station.

3.2 Dhangadhi

All three parameter $PM_{2.5}$, PM_{10} and TSP were found to be high during winter and pre-monsoon season for the Dhangadi station. The reason for high concentration of particulate during this season is due to low level of precipitation and also due to inversion effect due to low temperature. Another reason for the high level of pollution in March and April could be also associated with huge number of forest fire incident that occurs throughout the country during these months. Out of 210 days of measurement, 142 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$.

3.3 Rara

All the parameter measured in this station were reported high during the month of March and April. The high concentration of particulate during these months might be associated with huge number of forest fire incident that occurs throughout the country during these months in addition to the local and transported pollutants. Out of 340 days of measurement, for $PM_{2.5}$ the number of days exceeding the national ambient air quality was 32 days that is 16 days in March and 14 days in April.

3.4 Nepalgunj

High concentration of particulate in all three parameter $PM_{2.5}$, PM_{10} and TSP during the winter season is due to low level of precipitation. Similarly, in the winter season due to inversion effect, the pollutants are not dispersed easily. Out of 95 days of measurement, the readings for 82 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$.

3.5 Dang

The high concentration of particulate in $PM_{2.5}$, PM_{10} and TSP parameters during the months of pre-monsoon and winter season could be associated to huge number of forest fire incident that occurs throughout the country during these months. In addition, local and transported pollutants also have a vital role in decreasing the air quality of the area. Out of the 272 days of measurement, 96 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$.

3.6 Gandaki Boarding school, Pokhara

All three parameter $PM_{2.5}$, PM_{10} and TSP were found high during the month of January, February, March, April and November resulted due to low precipitation and its effect for creating inversion effect. High pollution during March and April might be associated with huge number of forest fire incident along with local and transported pollutants. The high air pollution during November is unique to this station. This might be due to effect of some local pollution sources like burning of hay or agriculture remains in the post paddy harvest period. Out of 222 days of measurement in this station, 134 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$.

3.7 Pokhara University, Pokhara

Conclusively all the three parameter $PM_{2.5}$, PM_{10} and TSP were reported to be high during the Pre monsoon season and could be resulted for low level of precipitation during these seasons. Out of 208 days of measurement, 75 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$.

3.8 Bhaisipati, Lalitpur

Alike to other stations, all the three parameter were found to be high winter and Pre monsoon seasons due to low level of precipitation during these seasons. High level of pollution in March and April could be also associated with huge number of forest fire incident that occurs throughout the country during these months. Out of 302 days of measurement, 115 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$ in this station.

3.9 Bhaktapur

The time series data of $PM_{2.5}$, PM_{10} and TSP were analyzed for Bhaktapur station and the annual average values were found to be 49.36 µg m^{-3}, 90.37 µg m^{-3} and 177.1 µg m^{-3} respectively. These particulate matter concentrations were found to be high during pre-monsoon and winter season and the reason might be associated with meteorological condition and forest fire especially during pre-monsoon season. Out of 239 days of measurement, the number of days exceeding national standards for $PM_{2.5}$, PM_{10} and TSP were found to be 121, 100 and 98 respectively. Calculations showed that the monthly average was maximum in March, and seasonal average in pre- monsoon season.

3.10 Ratnapark, Kathmandu

Due to inversion effect in winter and pre-monsoon seasons, pollutants are not dispersed easily, and in absence of precipitations, all the three parameter $PM_{2.5}$, PM_{10} and TSP were found to be high during. High level of pollution in March and April has been also associated with huge number of forest fire incident that occurs throughout the country during these months. Out of 309 days of measurement, 153 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$.

3.11 Kirtipur, Kathmandu

Out of 310 days of measurement, data showed that 124 days exceeded the National Ambient Air Quality Standard for $PM_{2.5}$ in the station. In conclusion, all three parameter $PM_{2.5}$, PM_{10} and TSP were high winter and Pre monsoon season which could be seen as an effect of low level of precipitation and forest fire incidents during these seasons.

3.12 Simara

The data availability for this station is very limited. All three parameter $PM_{2.5}$, PM_{10} and TSP were high during winter months. Out of 148 days of measurement, 102 days exceeded the National Ambient Air Quality Standard for $PM_{2.5.}$

3.13 Janakpur

Due to some discrepancies in PM_{10} and TSP data of the station, they are not included in this report. Conclusion, $PM_{2.5}$ was high during winter, pre-monsoon and post-monsoon. High concentration of particulate during these months is due to low level of precipitation during these seasons. Besides in the winter season due to inversion effect pollutants are not dispersed easily. High level of pollution in March and April is also associated with huge number of forest fire incident that generally occurs throughout the country during these months. Out of 340 days of measurement, 92 days exceeded the National Ambient Air Quality Standard for $PM_{2.5.}$

3.14 Biratnagar

The time series data of $PM_{2.5}$, PM_{10} and TSP were analyzed for Biratnagar station, and as expected were found to be high during pre-monsoon and winter season. The reason could be associated with meteorological condition and forest fire especially during pre-monsoon season. Out of 269 days of measurement, the number of days exceeding national standards for $PM_{2.5}$, PM_{10} and TSP were found to be 142, 72 and 16 respectively. The monthly average was found maximum in January for $PM_{2.5}$ and PM_{10} and in April for TSP. Similarly, the seasonal average was found maximum in winter season.

3.15 Jhumka

In conclusion, all three parameter $PM_{2.5}$, PM_{10} and TSP were high during winter months. High concentration of particulate during these months is due to low level of precipitation along with temperature inversion. Local fire burning might be another reason for increasing level of pollutants during winter months. Out of 102 days of measurement, 70 days exceeded the National Ambient Air Quality Standard for $PM_{2.5.}$

3.16 Dhankuta

The entire parameters- $PM_{2.5}$, PM_{10} and TSP were found high during the winter and pre-monsoon season, and could be associated with huge number of forest fire incident that occurs throughout the country during these months along with local and transported pollutants. Out of 339 days of measurement, 134 days exceeded the National Ambient Air Quality Standard for $PM_{2.5.}$

3.17 Damak

In conclusion, all three parameter $PM_{2.5}$, PM_{10} and TSP were high during the month of February, March and April - which could be associated with huge number of forest fire incident that occurs throughout the country during these months. The local and transported pollutants also could be held accountable for the high figures. Out of 236 valid days of measurement, 122 days exceeded the National Ambient Air Quality Standard for $PM_{2.5.}$ Specifically, the months having highest violation in this station were during December to April.

Annex 1

GPS Locations of Air Quality Monitoring Stations

SN	Station Name	District	Longitude	Latitude
1	Bhaisipati	Kathmandu	85.3023	27.6531
2	Bhimdatta	Kanchanpur	80.1829	28.9651
3	Biratnagar	Morang	87.2751	26.4451
4	Birendra Sainik School	Bhaktapur	85.4175	27.6738
5	Damak	Jhapa	87.7033	26.6694
6	Dang	Dang	82.5346	27.9914
7	Dhangadhi	Kailali	80.5945	28.7041
8	Dhankuta	Dhankuta	87.3439	26.9807
9	DHM, Pokhara	Kaski	83.9737	28.2055
10	Dhulikhel,	Kavre	85.5478	27.6085
11	Gandaki Boarding School Pokhara	Kaski	83.969	28.2584
12	Hetauda	Makawanpur	85.0344	27.4227
13	Janakpur	Dhanusha	85.9285	26.7398
14	Jhumka	Sunsari	87.1952	26.6645
15	Khumaltar	Lalitpur	85.3234	27.6467
16	Kritipur, DHM station	Kathmandu	85.2893	27.6817
17	Lumbini,	Rupandehi	83.2791	27.4895
18	Nepalgunj	Banke	81.6222	28.0528
19	Bharatpur	Chitwan	84.4384	27.6725
20	Pokhara University	Kaski	84.0855	28.1434
21	Pulchwok	Lalitpur	85.3188	27.6826
22	Rara	Mugu	82.0938	29.5083
23	Ratnapark,	Kathmanfu	85.31	27.7
24	Sauraha	Chitwan	84.4986	27.5735
25	Shankapark	Kathmandu	85.3428	27.7328
26	Simara	Bara	84.9978	27.1567
27	Surkhet	Surkhet	81.621	28.6029
28	Yala	Rasuwa	85.6106	28.2136

Annex 2

Meteorological Stations for Temperature

SN	Name	District	Latitude	Longitude
1	Nepalgunj Airport	Banke	28.101755	81.667885
2	Simara Airport	Bara	27.16416667	84.98
3	Janakpur Airport	Dhanusha	26.709665	85.917228
4	Dhankuta	Dhankuta	26.98321944	87.34595556
5	Biratnagar Airport	Morang	26.483967	87.267006
6	Tarahara	Sunsari	26.698692	87.278648
7	Damak	Jhapa	26.662324	87.698824
8	Nepalgunj(Reg.Off.)	Banke	28.05199444	81.62283889
9	Ghorai (Dang)	Dang	28.03719889	82.484156
10	Lumbini	Rupandehi	27.47027778	83.27611111
11	Mahendra Nagar	Kanchanpur	28.95477194	80.23049
12	Dhangadhi(Attariya)	Kailali	28.81272889	80.55995111
13	Rara	Mugu	29.540125	82.081825
14	Surkhet Airport (Birendranagar)	Surkhet	28.58786944	81.63516111
15	Hetauda N.F.I.	Makwanpur	27.420213	85.025209
16	Dhulikhel	Kavre	27.61611667	85.56550278
17	Khumaltar	Lalitpur	27.651677	85.325693
18	Panipokhari (Kathmandu)	Kathmandu	27.72863611	85.32415
19	Bhaktapur	Bhaktapur	27.67668056	85.42396944
20	Khokana	Lalitpur	27.64377222	85.29671667
21	Pokhara Airport	Kaski	28.20018333	83.97952222
22	Kathmandu Airport	Kathmandu	27.703825	85.35624722

Annex 3
Meteorological Station for Precipitation

SN	Name	District	Latitude	Longitude
1	Ratamata	Dang	27.96667	82.61667
2	Nepalgunj Airport	Banke	28.10176	81.66789
3	Simara Airport	Bara	27.16417	84.98
4	Janakpur Airport	Dhanusha	26.70967	85.91723
5	Dhankuta	Dhankuta	26.98322	87.34596
6	Biratnagar Airport	Morang	26.48397	87.26701
7	Tarahara	Sunsari	26.69869	87.27865
8	Damak	Jhapa	26.66232	87.69882
9	Nepalgunj(Reg.Off.)	Banke	28.05199	81.62284
10	Ghorai (Dang)	Dang	28.0372	82.48416
11	Lumbini	Rupandehi	27.47028	83.27611
12	Itram (Surkhet Regional Office)	Surkhet	28.60224	81.62429
13	Mahendra Nagar	Kanchanpur	28.95477	80.23049
14	Dhangadhi (Attariya)	Kailali	28.81273	80.55995
15	Rara	Mugu	29.54013	82.08183
16	Surkhet Airport (Birendranagar)	Surkhet	28.58787	81.63516
17	Jhuwani	Chitwan	27.5909	84.5223
18	Hetauda N.F.I.	Makwanpur	27.42021	85.02521
19	Dhulikhel	Kavre	27.61612	85.5655
20	Khumaltar	Lalitpur	27.65168	85.32569
21	Panipokhari (Kathmandu)	Kathmandu	27.72864	85.32415
22	Bhaktapur	Bhaktapur	27.67668	85.42397
23	Khokana	Lalitpur	27.64377	85.29672
24	Pokhara Airport	Kaski	28.20018	83.97952
25	Lamachaur	Kaski	28.2613	83.96829
26	Begnas	Kaski	28.16603	84.08932
27	Syamgha	Tanahu	28.04078	84.22912
28	Kathmandu Airport	Kathmandu	27.70383	85.35625