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

Status of Air Quality in Nepal
Annual Report, 2022

October, 2023

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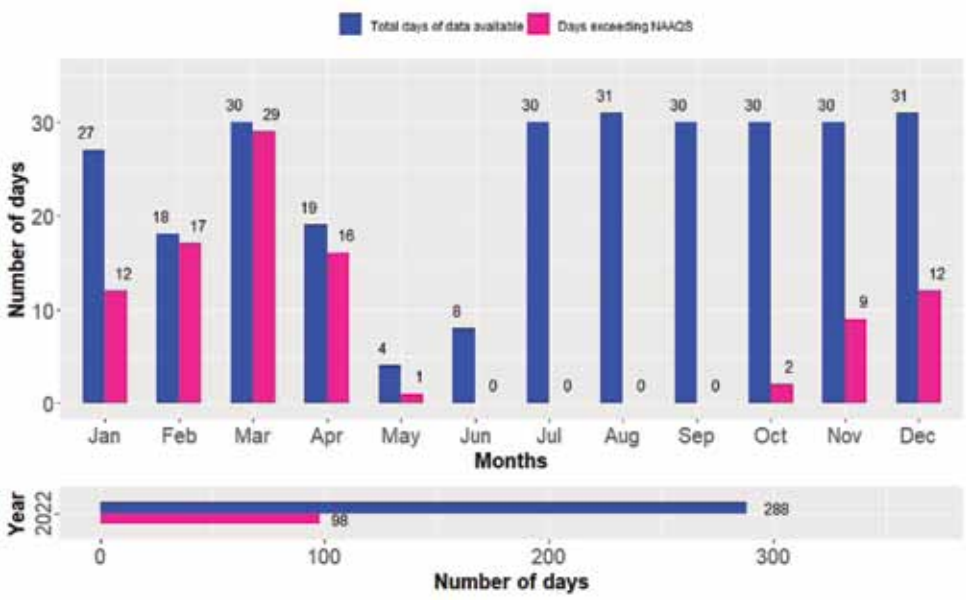

October, 2023

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Publisher: Government of Nepal,
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Published year: 2023

Citation: Lamichhane, G.P., Maharjan, N. Pandey, B., K.C., P., Paudel, R. & Paudel, S.P, (2023), Status of Air Quality in Nepal Annual Report, 2022, Department of Environment, Kathmandu, Nepal.

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Ref. No: Date:

Message

The Ministry of Health and Population has declared air pollution to cause yearly 42,100 deaths in Nepal. The affected population data shows that about 19% of these are kids under five years old, and around 27% are adults over 70. As per the Ministry of Health and Population, breathing polluted air in Nepal can reduce life expectancy by 4.1 years. Numerous studies from the government and others have indicated the quality status of air and have recommended several urgent actions to improve it.

The constitution of Nepal, the Environmental protection act 2076, the environmental protection regulation 2077, and the state's allegiance to national and international commitments, and treaties guides the Department of Environment under to work for clean and healthy environment.

As a step towards a healthy environment, the Department of the Environment with support from various governmental, intergovernmental, and non-governmental partners has established 27 air quality monitoring stations throughout the country till 2023. These monitoring stations measure the air and save real-time data every minute.

To tell everyone about the air we breathe, the Department started analyzing data from these stations and making yearly reports since FY 077/78. This is the third air quality report of Department of Environment, where data of particulate matter of eleven (11) stations from January 2022 to December 2022 were analyzed. It is our hope that this report will serve as a valuable resource for policymakers, scientists, environmental advocates, and concerned citizens alike. It is a testament to our commitment to transparency, accountability, and the pursuit of a cleaner, healthier future.

We would like to thank Honorable Minister Dr. Birendra Prasad Mahato and Secretary Dr. Deepak Kumar Kharal, Ministry of Forests and Environment for their inspiration and guidance to prepare this report. We extend our sincere gratitude towards the expert committee members- Dr. Ramesh Prasad Sapkota, Assistant Professor, Tribhuvan University; Mr. Keshab Raj Joshi, Environment Inspector, Ministry of Forests and Environment, Mr. Govinda Kumar Jha, Meteorologist, Department of Hydrology and Meteorology and Mr. Suresh Pokhrel, Aerosol Measurement Research Associate, ICIMOD for their comments and suggestions to prepare this report. Special gratitude to Dr. Bhupesh Adhikary, Interim Action Area Coordinator, ICIMOD; Mr. Sagar Adhikari, Air Pollution Analyst - Mitigation, ICIMOD; for their constructive comments and suggestions to shape this report.

Similarly, we acknowledge Mr. Shankar Prasad Paudel, Section Head of Pollution Monitoring and Regulation, and all other section heads for their constructive inputs 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. Rajeshor Paudel, Mr. Bishnu Pandey, and Mr. Pakash KC for their continuous and rigorous 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 for its finalization.

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

Mr Shiva Lal Tiwari
Director General
2023/11/02

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Foreword

In an era where environmental concerns have reached critical levels, understanding and addressing air pollution is very essential for the well-being of our communities, ecosystems, and the generations that will follow. Air pollution, in its various forms, poses a significant threat to public health, exacerbates climate change, and impacts the overall quality of life for millions around the world.

Department of Environment, under the Ministry of Forests and Environment, Government of Nepal is publishing "Status of Air Quality in Nepal, Annual Report 2022", which is expected to have great contribution to the concerned agencies, government sectors, public, international communities, environmental actors etc about the status of air quality of Nepal, throughout the year. This will in future help to make policies, plan and guidelines regarding healthy and clean air for the survival of all living beings.

Department of Environment has been publishing Air Quality Report every year since FY 077/78, based on the air quality data recorded from different stations distributed throughout the country. In this report, we have analyzed data of particulate matter from eleven (11) monitoring stations form January 2022 to December 2022. Though some of those stations are not well functioning, Department of Environment is continuously working on the maintenance of monitoring stations so that all these 26 stations work properly and provide data regularly. Besides this, Department of Environment is going to establish three new air quality monitoring stations in the fiscal year 2080/81 at three different locations across the country. These three new monitoring stations will contribute in reports that are to be published in upcoming days.

Eventually, I would like to appreciate the contribution and effort of each and every individual who's been directly involved in preparing and publishing this report. Similarly, I would like to thank "Pollution Control and Regulation" section as well as other relevant sections and staffs of DoEnv for their contribution and regular support during the publication of this report.

Mr. Tara Datt Bhatt
Deputy Director General
2023/11/02

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Acknowledgements

The accomplishment of this report was possible with the support, contributions and guidance of many individuals and entities. We are very grateful to every individual who directly and indirectly contributed to shaping the report.

We acknowledge Dr. Deepak Kumar Kharal, Secretary, Ministry of Forests and Environment; Mr. Shiva Lal Tiwari, Director General; Mr. Tara Datt Bhatt, Deputy Director General; and all section heads of the Department of Environment for their inspiration and guidance in preparing this report.

We extend our special gratitude to the expert committee members for their constructive comments and recommendations, including Dr. Ramesh Prasad Sapkota, Assistant Professor, Central Department of Environment Science, Tribhuvan University; Mr. Keshab Raj Joshi, Environment Inspector, Ministry of Forests and Environment; Mr. Govinda Kumar Jha, Meteorologist, Department of Hydrology and Meteorology; and Mr. Suresh Pokhrel, Aerosol Measurement Research Associate, ICIMOD. Without support from Dr. Ramesh Prasad Sapkota in R coding and Mr. Suresh Pokhrel, in Python and R coding, downloading and analyzing data would not be this simple.

We are especially grateful to Dr. Bhupesh Adhikary, Interim Action Area Coordinator and Mr. Sagar Adhikari, Air Pollution Analyst for Mitigation of ICIMOD, for their critical and factual feedback that helped to build this study. Sincere gratitude is extended to Environment Inspectors Ms. Swasti Shrestha, Ms. Bina Ghimire and Ms. Arati Shrestha, for their insightful comments.

Lastly, we are thankful to the Department of Environment Family for their support during the report preparation.

EXECUTIVE SUMMARY

Air quality measurement is the foundation of air pollution management. Progressing for better air quality, the Government of Nepal has set the National Ambient Air Quality Standard 2012 for nine air quality parameters. Since 2016, the Department of Environment has installed 27 real-time-air quality monitoring stations throughout the country, all of which are equipped with EDM Grimm 180+ that measures PM_1, $PM_{2.5}$, PM_{10} and TSP. Some of these stations are also equipped with instruments that measures gaseous parameters.

In this report "Status of Air Quality in Nepal: Annual Report 2022", data from 1st Jan to 31st Dec 2022 of $PM_{2.5}$, PM_{10} and TSP were analyzed for 11 different stations. These 11 stations represent four out of seven provinces of Nepal namely Koshi, Bagmati, Lumbini and Karnali Province. The CSV formatted data were downloaded using Python and analyzed by basic R and various R packages (like Open Air and others). The raw (per minute) data was processed to calculate time average data (hourly average, daily average, monthly average and seasonal average). Data availability threshold of 80% was set for calculating hourly form minute data and daily average from hourly average. The monthly average was calculated from the daily average only where daily data availability was equal to or greater than 50%. The seasonal average was calculated from the daily average for winter, pre-monsoon and monsoon seasons only if the monthly average of at least two months of that season was available. For post-monsoon season seasonal average was calculated only if monthly average of at least one month for the season is available.

The Dhankuta air quality monitoring station of Koshi province has 288 days of valid measurement where the mean of daily average of $PM_{2.5}$, PM_{10} and TSP were calculated to be 31.9 μg m^{-3}, 41.8 μg m^{-3} and 75.4 μg m^{-3} respectively. Out of 10 months (except May and June) with data, March was found to be the most polluted month and similar was the condition for pre-monsoon season. The number of days exceeding the NAAQS was calculated to be 98, 3 and 10 for $PM_{2.5}$, PM_{10} and TSP, respectively.

This report analyzes data form six AQMS of Bagmati province namely-Bharatpur, Hetauda, Khumaltar, Ratnapark, Shankhapark and TU Kirtipur. The Bharatpur AQMS has 96 days of valid measurement where the mean of daily average of $PM_{2.5}$, PM_{10} and TSP were calculated to be 63.2 μg m^{-3}, 113.4 μg m^{-3} and 212.2 μg m^{-3} respectively. The monthly average of only three Months-February, March and April and a seasonal average of only pre-monsoon season were calculated. The number of days exceeding the NAAQS was found to be 76, 41 and 38 for $PM_{2.5}$, PM_{10} and TSP, respectively.

The Hetauda AQMS has 313 days of valid measurement where the mean of daily average of $PM_{2.5}$, PM_{10} and TSP were calculated to be 13.8 μg m^{-3}, 15.7 μg m^{-3} and 18.5 μg m^{-3} respectively. December was determined to be the most polluted month out of the ten months with data (excluding July and August) and the winter season's conditions were comparable. Nine days were assessed to have exceeded the NAAQS for $PM_{2.5}$, while no days had exceeded the NAAQS for PM_{10} or TSP.

The Khumaltar AQMS has 243 and 254 days of valid measurement for $PM_{2.5}$ and PM_{10} where the mean of daily average of $PM_{2.5}$ and PM_{10} was found to be 38.1 μg m^{-3} and, 76.6 μg m^{-3} respectively. A monthly average of only eight months was calculated for this station. Out of the three seasons-pre-monsoon, monsoon and post-monsoon, the pre-monsoon season was the most polluted. In comparison to 42 days for PM_{10}, 112 days were determined to have exceeded the NAAQS for $PM_{2.5}$.

The Ratnapark AQMS has 250 days of valid measurement where the mean of daily average of $PM_{2.5,}$ PM_{10} and TSP were calculated to be 33.3 μg m^{-3}, 48.9 μg m^{-3} and 80.7 μg m^{-3} respectively. For this station, a monthly average of just nine months and seasonal average of only three seasons was determined. Out of three season's winter, monsoon and post-monsoon, the winter season was the most polluted. The number of days exceeding the NAAQS was found to be 101, 5 and 5 days for $PM_{2.5}$, PM_{10} and TSP, respectively.

The Shankhapark AQMS has 102 days of valid measurement where the mean of daily average of $PM_{2.5}$, PM_{10} and TSP were calculated to be 43.9 μg m^{-3}, 61.6 μg m^{-3} and 112.2 μg m^{-3} respectively. For this station, a monthly average of just four months (September to December) and a seasonal average of only one season (post-monsoon) was determined. The number of days exceeding the NAAQS was found to be 55, 4 and 2 days for $PM_{2.5}$, PM_{10} and TSP, respectively.

The TU Kirtipur AQMS has 275 days of valid measurement where the mean of daily average of $PM_{2.5}$, PM_{10} and TSP were calculated to be 44.8 μg m^{-3}, 80.4 μg m^{-3} and 151.0 μg m^{-3} respectively. For this station, a monthly average of ten months (except August and December) was determined. Out of the four seasonal average calculated for this station, $PM_{2.5}$ has the highest value for the winter season and PM_{10} and TSP have the highest value for pre-monsoon season. The number of days exceeding the NAAQS was found to be 149, 61 and 60 days for $PM_{2.5,}$ PM_{10} and TSP, respectively.

This report analyzes data from two AQMS of Lumbini province namely -Dang and Nepalgunj. The Dang AQMS has 98 days of valid measurement where the mean of daily average of $PM_{2.5}$, PM_{10} and TSP were calculated to be 25.1 μg m^{-3}, 30.4 μg m^{-3} and 40.1 μg m^{-3} respectively. The monthly average of only three months: January, May and September and a seasonal average of only winter season was calculated. The number of days exceeding the NAAQS was found to be 21 days for $PM_{2.5}$. None of the days exceeded NAAQS for PM_{10} and TSP.

Nepalgunj AQMS has 149 days of valid measurement where the mean of daily average of $PM_{2.5}$, PM_{10} and TSP were calculated to be 39.4 μg m^{-3}, 52.9 μg m^{-3} and 76.1 μg m^{-3} respectively. The monthly average of only five months and a seasonal average of only winter and pre-monsoon seasons was calculated. The number of days exceeding the NAAQS was found to be 70 days for $PM_{2.5}$. None of the days exceeded NAAQS for PM_{10} and TSP.

For Karnali province, this report analyzes data from two AQMS namely- Rara and Surkhet. Rara AQMS has 284, 291 and 295 days of valid measurement for $PM_{2.5}$, PM_{10} and TSP respectively. The mean of daily average of $PM_{2.5}$, PM_{10} and, TSP was found to be 13.9 μg m^{-3}, 19.8 μg m^{-3} and 76.1 μg m^{-3} respectively. A monthly average of 10 months and a seasonal average of three seasons was calculated for this station. The pre-monsoon season was the most polluted of the three seasons-winter, pre-monsoon and post-monsoon. The number of days exceeding the NAAQS was found to be 19 and a day for $PM_{2.5}$ and PM_{10} and none of the days exceeded NAAQS for TSP.

Surkhet AQMS has 130 days of valid measurement where the mean of daily average of $PM_{2.5}$, PM_{10} and TSP were calculated to be 30.9 μg m^{-3}, 35.7 μg m^{-3} and 37.3 μg m^{-3} respectively. The monthly average of only four months and a seasonal average of only winter and pre-monsoon seasons were calculated. The number of days exceeding the NAAQS was found to be 24 days for $PM_{2.5}$. None of the days exceeded NAAQS for PM_{10} and TSP.

In all 11 stations analyzed in this report, sources of pollution vary from construction-related activities to industrial activities, forest fires, transboundary movement of air and many more. For each monitored station, the compliance level for $PM_{2.5}$ concentration is never cent percent, pointing towards the seriousness of the issue, as $PM_{2.5}$ is so minute that it can enter lungs and cause various respiratory-related diseases. The concentration of $PM_{2.5}$ and PM_{10} seems to be high during the early morning and evening, as scenarios are different for TSP, which is higher during afternoon. Sources of pollution differs as per geographical location and development activities that are happening, but the issue of air pollution is common everywhere and control of pollution is today's urgent need.

कार्यकारी सारांश

वायु गुणस्तर अनुगमन वायु प्रदूषण व्यवस्थापनको मुख्य आधार हो । नेपाल सरकारले वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड, २०६९ मा विभिन्न नौ वटा पारामिटर (Parameter) हरूका लागि मापदण्ड तोकिएको छ। सन् २०१६ देखि वातावरण विभागले वास्तविक समयमा तथ्याङ्क दिने वायु गुणस्तर मापन केन्द्रहरू स्थापना गर्न शुरु गरेकोमा हालसम्म यस्ता मापन केन्द्रहरूको संख्या २७ पुगेको छ। उक्त वायु गुणस्तर मापन केन्द्रमा रहेको उपकरण Grimm EDM 180+ ले हावामा रहेका धुलोका कणहरू PM_1, $PM_{2.5}$, PM_{10} र TSP मापन गर्दछ। उक्त मापन केन्द्रहरूमध्ये केही स्टेशनहरूमा कार्बन मनोक्साइड (CO) , ओजन (O_3) जस्ता ग्याँस पारामिटरहरू मापन गर्ने उपकरणहरू समेत रहेका छन् ।

"Status of Air Quality in Nepal: Annual Report 2022" प्रतिवेदनमा विभिन्न एघार (११) वटा स्टेशनहरूबाट जनवरी १ देखि ३१ डिसेम्बर, २०२२ सम्म प्राप्त $PM_{2.5}$, PM_{10} र TSP को तथ्यांक विश्लेषण गरिएको छ । यी ११ वटा स्टेसनहरूले नेपालको सातमध्ये चार प्रदेश: कोशी, वाग्मती, लुम्बिनी र कर्णाली प्रदेशलाई प्रतिनिधित्व गर्दछन् । तथ्याङ्क बिश्लेषणका लागि पाइथन प्रोग्राम (Python Program) को प्रयोग गरेर सर्भरबाट प्रति मिनेटको तथ्याङ्क डाउनलोड गरिएको थियो भने R प्रोग्राम र यसका विभिन्न प्याकेजहरू (जस्तै Open air) द्वारा तथ्याङ्क विश्लेषण गरिएको थियो । प्रति मिनेट तथ्याङ्कबाट प्रति घण्टाको औसत गणना गरिएको थियो भने प्रति घण्टाको औसतबाट दैनिक औसत र दैनिक औसतबाट मासिक औसतको गणना गरिएको थियो । त्यसैगरी सिजनल औसत दैनिक औसतका आधारमा गणना गरिएको थियो । प्रति घण्टा औसत तथा दैनिक औसत गणनाका लागि तथ्याङ्क उपलब्धताको थ्रेसहोल्ड ८०% तय गरिएको थियो । अर्थात् प्रति घण्टा औसत गणनाका लागि कम्तिमा ८०% प्रति मिनेटको तथ्याङ्क उपलब्ध हुनुपर्दछ। त्यसैगरी दैनिक औसत गणनाका लागि कम्तिमा ८०% प्रति घण्टा औसत तथ्याङ्क उपलब्ध हुनुपर्दछ । मासिक औसत गणनाका लागि दैनिक औसत तथ्याङ्क उपलब्धताको थ्रेसहोल्ड ५०% तय गरिएको थियो । हिउँद, प्रि-मनसुन र मनसुन सिजनको लागि कम्तिमा दुई महिनाको मासिक औसत उपलब्ध भएको खण्डमा उक्त सिजनको सिजनल औसतको गणनाका दैनिक औसतबाट गरिएको थियो भने पोष्ट मनसुन सिजनको हकमा उक्त सिजनको कम्तिमा एउटा महिनाको मासिक औसत उपलब्ध भएमा सिजनल औसत गणना गरिएको थियो ।

कोशी प्रदेशको धनकुटा वायु गुणस्तर अनुगमन केन्द्रमा २८८ दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः ३१.८ $\mu g\ m^{-3}$, ४१.७ $\mu g\ m^{-3}$ र ७५.६ $\mu g\ m^{-3}$ मापन गरिएको थियो । मासिक तथ्याङ्क उपलब्ध भएका १० महिनाहरू (मे र जुन बाहेक) मध्ये मार्च सबैभन्दा प्रदूषित रहेको पाइयो साथै सिजनहरूमा प्रि-मनसुन सिजन बढी प्रदुषित रहेको पाइयो। $PM_{2.5}$, PM_{10} र TSP को दैनिक औसत, वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड (NAAQS) भन्दा बढी भएको दिनहरूको संख्या क्रमशः ९८, ३ र १० रहेको छ ।

यस प्रतिवेदनमा वाग्मती प्रदेशका छ (६) वटा वायु गुणस्तर मापन केन्द्रहरू-भरतपुर, हेटौंडा, खुमलटार, रत्नपार्क, शंखपार्क र त्रिवि कीर्तिपुरको तथ्यांक विश्लेषण गरिएको छ । भरतपुर वायु गुणस्तर मापन केन्द्रमा ९६ दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः ६३.३ $\mu g\ m^{-3}$, ११३.३ $\mu g\ m^{-3}$ र २१२.५ $\mu g\ m^{-3}$ मापन गरिएको थियो । फेब्रुअरी, मार्च र अप्रिल गरी जम्मा तीन महिनाको मात्रै मासिक औसत गणना गर्न सकिएको थियो भने प्रि-मनसुन सिजनको मात्रै सिजनल औसत उपलब्ध छ। $PM_{2.5}$, PM_{10} र TSP को दैनिक औसत, वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड (NAAQS) भन्दा बढी भएको दिनहरूको संख्या क्रमशः ७६, ४१ र ३८ पाइयो ।

हेटौंडा वायु गुणस्तर अनुगमन केन्द्रमा ३१३ दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः १४.५ $\mu g\ m^{-3}$, १६.४ $\mu g\ m^{-3}$ र १९.५ $\mu g\ m^{-3}$ मापन गरिएको थियो । मासिक तथ्याङ्क उपलब्ध भएका १० महिनाहरूमा (जुलाई र अगस्ट बाहेकका महिना) डिसेम्बर सबैभन्दा प्रदूषित रहेको पाइयो भने हिउँद सिजन तुलनात्मक रुपमा बढी प्रदूषित रहेको पाइयो । $PM_{2.5}$ को दैनिक औसत NAAQS भन्दा बढी भएको दिनहरूको संख्या नौ (९) रहेको छ भने कुनै पनि दिनमा PM_{10} र TSP को दैनिक औसत वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड (NAAQS) भन्दा बढी रहेको पाइएन ।

खुमलटार वायु गुणस्तर अनुगमन केन्द्रमा २४३ दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$ र PM_{10} दैनिक औसतको मध्यक (mean) क्रमशः ३८.५ $\mu g\ m^{-3}$ र ७७.३ $\mu g\ m^{-3}$ मापन गरिएको थियो । यस स्टेशनको लागि आठ महिनाको मात्र मासिक औसत गणना गरिएको थियो । सिजनल औसत उपलब्ध भएका तीनवटा सिजनः प्रि-मनसुन, मनसुन र पोस्ट-मनसुन मध्ये प्रि-मनसुन सबैभन्दा बढी प्रदूषित रहेको पाइयो । PM_{10} को लागि ४२ दिनको तुलनामा, $PM_{2.5}$ को लागि ११२ दिनको दैनिक औसत वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड (NAAQS) भन्दा बढी रहेको पाइयो ।

रत्नपार्क वायु गुणस्तर अनुगमन केन्द्रमा २५० दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः ३३.३ $\mu g\ m^{-3}$, ४८.९ $\mu g\ m^{-3}$ र ८०.७ $\mu g\ m^{-3}$ मापन गरिएको थियो । यस स्टेशनको लागि नौ महिनाको मात्र मासिक औसत र तीनवटा सिजनको मात्र सिजनल औसत गणना गरिएको थियो । सिजनल औसत उपलब्ध भएका हिउँद, मनसुन र पोष्ट मनसुन सिजनमध्ये हिउँद सिजन सबैभन्दा बढी प्रदूषित रहेको पाइयो । $PM_{2.5}$, PM_{10} र TSP को दैनिक औसत, वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड (NAAQS) भन्दा बढी भएको दिनहरूको संख्या क्रमशः १०१, ५ र ५ पाइयो ।

शंखपार्क वायु गुणस्तर अनुगमन केन्द्रमा १०२ दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः ४३.९ $\mu g\ m^{-3}$, ६१.६ $\mu g\ m^{-3}$ र ११२.२ $\mu g\ m^{-3}$ मापन गरिएको थियो । यस स्टेशनका लागि मात्र चार महिना (सेप्टेम्बरदेखि डिसेम्बर) को मासिक औसत र केवल एक सिजन (पोष्ट मनसुन सिजन) को सिजनल औसत गणना गरिएको थियो । $PM_{2.5}$, PM_{10} र TSP को दैनिक औसत, वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड (NAAQS) भन्दा बढी भएको दिनहरूको संख्या क्रमशः ५५, ४ र २ दिन रहेको छ ।

त्रि.वि. कीर्तिपुर वायु गुणस्तर अनुगमन केन्द्रमा २७५ दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः ४४.८ $\mu g\ m^{-3}$, ८०.४ $\mu g\ m^{-3}$ र १५१.० $\mu g\ m^{-3}$ मापन गरिएको थियो । यस स्टेशनको लागि दस महिनाको मासिक औसत (अगस्ट र डिसेम्बर बाहेकका अन्य महिनाहरू) गणना गरिएको थियो । चारवटा सिजनहरूको सिजनल औसतहरू मध्ये, हिँउद सिजनमा $PM_{2.5}$ को मान उच्च रहेको छ । त्यस्तै PM_{10} र TSP को मान प्रि-मनसुन सिजनमा उच्चतम रहेको छ । $PM_{2.5}$, PM_{10} र TSP को दैनिक औसत, वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड (NAAQS) भन्दा बढी भएको दिनहरूको संख्या क्रमशः १४९, ६१ र ६० दिन रहेको छ ।

यस प्रतिवेदनमा लुम्बिनी प्रदेशका दुई (२) वायु गुणस्तर अनुगमन केन्द्रहरू- दाङ र नेपालगन्जको तथ्यांक विश्लेषण गरिएको छ । दाङ वायु गुणस्तर अनुगमन केन्द्रमा ९८ दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः २५.१ $\mu g\ m^{-3}$, ३०.४ $\mu g\ m^{-3}$ र ४०.१ $\mu g\ m^{-3}$ मापन गरिएको थियो । केवल तीन महिना- जनवरी, मे र सेप्टेम्बरको मासिक औसत र केवल हिउँद सिजनको सिजनल औसत गणना गरिएको थियो । $PM_{2.5}$ को दैनिक औसत NAAQS भन्दा बढी भएको दिनहरूको संख्या २१ रहेको छ भने कुनै पनि दिनमा PM_{10} र TSP को दैनिक औसत NAAQS भन्दा बढी रहेको पाइएन ।

नेपालगन्ज वायु गुणस्तर अनुगमन केन्द्रमा १४९ दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः ३९.४ $\mu g\ m^{-3}$, ५२.९ $\mu g\ m^{-3}$ र ७६.१ $\mu g\ m^{-3}$ मापन गरिएको थियो । पाँच महिनाको मात्रै मासिक औसत तथा हिउँद र प्रि-मनसुन सिजनको मात्रै सिजनल औसत गणना गरिएको थियो । $PM_{2.5}$ को दैनिक औसत वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड (NAAQS) भन्दा बढी भएको दिनहरूको संख्या ७० रहेको छ भने कुनै पनि दिनमा PM_{10} र TSP को दैनिक औसत NAAQS भन्दा बढी रहेको पाइएन ।

कर्णाली प्रदेशका रारा र सुर्खेत वायु गुणस्तर अनुगमन केन्द्रबाट प्राप्त तथ्याङ्क विश्लेषण गरिएको छ । रारा वायु गुणस्तर अनुगमन केन्द्रमा $PM_{2.5}$, PM_{10} र TSP को क्रमशः २८४, २९१ र २९५ दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः १३.९ $\mu g\ m^{-3}$, १९.८ $\mu g\ m^{-3}$ र ७६.१ $\mu g\ m^{-3}$ रहेको पाइयो । यस स्टेशनको लागि १० महिनाको मासिक औसत र तीन सिजनको सिजनल औसत गणना गरिएको थियो । मासिक औसत उपलब्ध भएका तीन सिजनहरूः हिउँद, प्रि-मनसुन र पोष्ट मनसुन सिजनहरूमध्ये प्रि-मनसुन सिजन सबैभन्दा बढी प्रदूषित पाइएको थियो । $PM_{2.5}$

र PM_{10} को दैनिक औसत, NAAQS भन्दा बढी भएको दिनहरूको संख्या क्रमशः १९ र १ रहेको छ भने कुनै पनि दिनमा TSP को दैनिक औसत NAAQS भन्दा बढी रहेको पाइएन ।

सुर्खेत वायु गुणस्तर अनुगमन केन्द्रसँग १३० दिनको मान्य तथ्याङ्क उपलब्ध भएकोमा $PM_{2.5}$, PM_{10} र TSP को दैनिक औसतको मध्यक (mean) क्रमशः ३०.९ $\mu g\ m^{-3}$, ३५.७ $\mu g\ m^{-3}$ र ३७.३ $\mu g\ m^{-3}$ रहेको पाइयो । यस स्टेशनका लागि चार महिनाको मात्रै मासिक औसत तथा हिउँद र प्रि-मनसुन सिजनको मात्रै सिजनल औसत गणना गरिएको थियो । $PM_{2.5}$ को दैनिक औसत NAAQS भन्दा बढी भएको दिनहरूको संख्या २४ दिन छ भने कुनै पनि दिन PM_{10} र TSP को दैनिक औसत NAAQS भन्दा बढी रहेको पाइएन ।

यस प्रतिवेदनमा समावेश भएका ११ वटा स्टेशनहरूमा प्रदुषणका मुख्य स्रोतहरूमा भिन्नता रहेको पाइन्छ । प्रदूषणका मुख्य स्रोतहरूमा निर्माण सम्बन्धी गतिविधिहरू, औद्योगिक गतिविधिहरू, वन डडेलो, सीमापारबाट आउने प्रदूषण र अन्य स्रोतहरू रहेको पाइन्छ । यस अध्ययनमा समावेश भएका स्टेशनहरूमा त्यस्तो कुनै स्टेशन रहेको छैन जसमा सबै दिनहरूमा $PM_{2.5}$ को मान वायु गुणस्तर सम्बन्धी राष्ट्रिय मापदण्ड भित्र नै रहेको छ । $PM_{2.5}$ मा मसिना धुलोका कणहरू पर्दछन जो सजिलै हाम्रो फोक्सोमा प्रवेश गर्न सक्छन् र श्वासप्रश्वास सम्बन्धी विभिन्न रोगहरू निम्त्याउन सक्छ । यसले प्रदूषणको तहको गम्भिरतालाई इंगित गर्दछ । $PM_{2.5}$ र PM_{10} को प्रदूषण बिहान र साँझको समयमा उच्च देखिन्छ भने TSP को लागि भने फरक परिदृश्यहरू देखिन्छ । प्रायजसो दिउँसोको समयमा TSP को मान उच्च देखिन्छ । भौगोलिक अवस्थिति र विकासका गतिविधिका कारण विभिन्न स्थनमा प्रदूषणको कारक फरक-फरक हुन सक्छन् तर वायु प्रदूषणको समस्या जतातै छ र प्रदूषणको नियन्त्रण आजको अत्यावश्यकता हो ।

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ACRONYMS AND ABBREVIATION

AQMS	:	Air Quality Monitoring Station
μg m^{-3}	:	Microgram per cubic meter
μm	:	Micro meter
m	:	Meter
masl	:	Meter above sea level
AQI	:	Air Quality Index
CSV	:	Comma-separated values
DoEnv	:	Department of Environment
EDM	:	Environmental Dust Monitor
EPA	:	Environmental Protection Act
EPR	:	Environmental Protection Regulation
GoN	:	Government of Nepal
ICIMOD	:	International Centre for Integrated Mountain Development
L/min	:	Liter per minute
NAAQS	:	National Ambient Air Quality Standards
NITC	:	National Information Technology Centre
PM_1	:	Particulate matter having aerodynamic diameter less than 1 micron
$PM_{2.5}$	:	Particulate matter having aerodynamic diameter less than 2.5 micron
PM_{10}	:	Particulate matter having aerodynamic diameter less than 10 micron
TSP	:	Total Suspended Particulate
TU	:	Tribhuvan University
SD	:	Standard Deviation
WHO	:	World Health Organization

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Air pollution is the single largest environmental health risk in the world. According to World Health Organization (WHO), seven million people die prematurely every year globally and thirty-eight thousand people die prematurely every year in Nepal due to exposure to air pollution. According to WHO estimates, 90% of the global population is breathing polluted air and the situation is even more severe in developing countries like Nepal.

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) in 2019 and Environment Protection Regulation (EPR) in 2020, focusing on prevention and control of pollution and maintaining balance between environment and development. National Environment Policy 2019 and 15th Periodic development plan also emphasize the reduction pollution from different sectors. To ensure good air quality, Nepal Government has endorsed National Ambient Air Quality Standards (NAAQS), 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 means the systematic measurement of ambient air pollutants in order to be able to assess the exposure of vulnerable receptors (e.g., people, animals, plants and art works) on the basis of standards and guidelines derived from observed effects and/or to establish the source of the air pollution (causal analysis).

Ambient air pollutant concentration is influenced by the spatial or time variance of emissions of pollutants and the dynamics of their dispersion in the air. As a consequence, marked daily and annual variations of concentration occur. It is practically impossible to determine in a unified way all these different variations of air quality (in statistical language, the population of air quality states). Thus, ambient air pollutant concentration measurements always have the character of random spatial or time samples.

Air quality monitoring is a basic foundation of air quality management. Based on the report prepared by Department of Environment (DoEnv) and International Centre for Integrated Mountain Development (ICIMOD) in 2015 titled "'A Plan for Nepal's Air Pollution Monitoring Network", Department of Environment under Ministry of Forests and Environment with various government as well as intergovernmental partners, established 27 Real Time Air Quality Monitoring Stations (AQMS) throughout seven provinces of the country. These stations provide an idea about the status of air quality of a place/region.

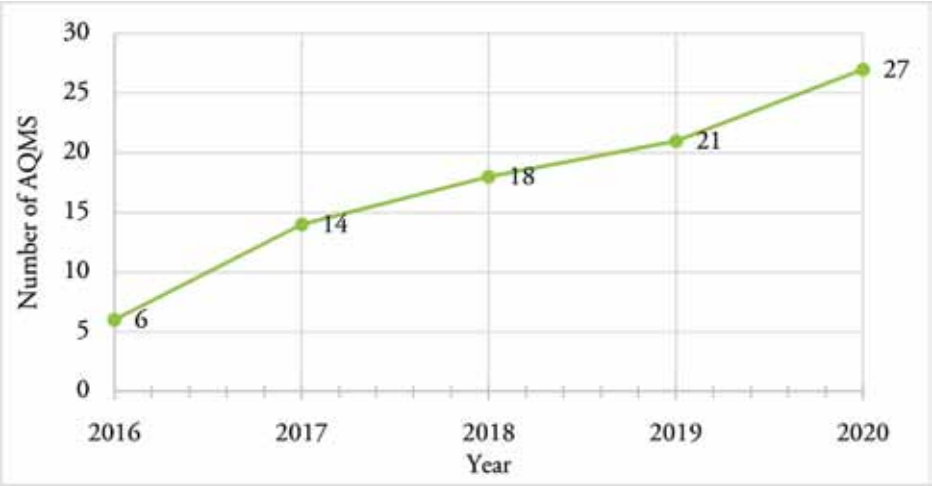

Figure 1: Trend of Real Time Air Quality Monitoring Stations

These 27 AQMS are distributed throughout the country (figure 1), with the highest number located in Bagmati province. The installation of AQMS is done to represent air quality in both urban and pristine environment. All 27 stations measure PM_1, $PM_{2.5}$, PM_{10} and TSP. AQMS at Ratnapark, Dhulikhel and Lumbini measure CO, SO_2, NOx and O_3 and AQMS at Sauraha and Pulchowk measure O_3 in addition to particulate matter.

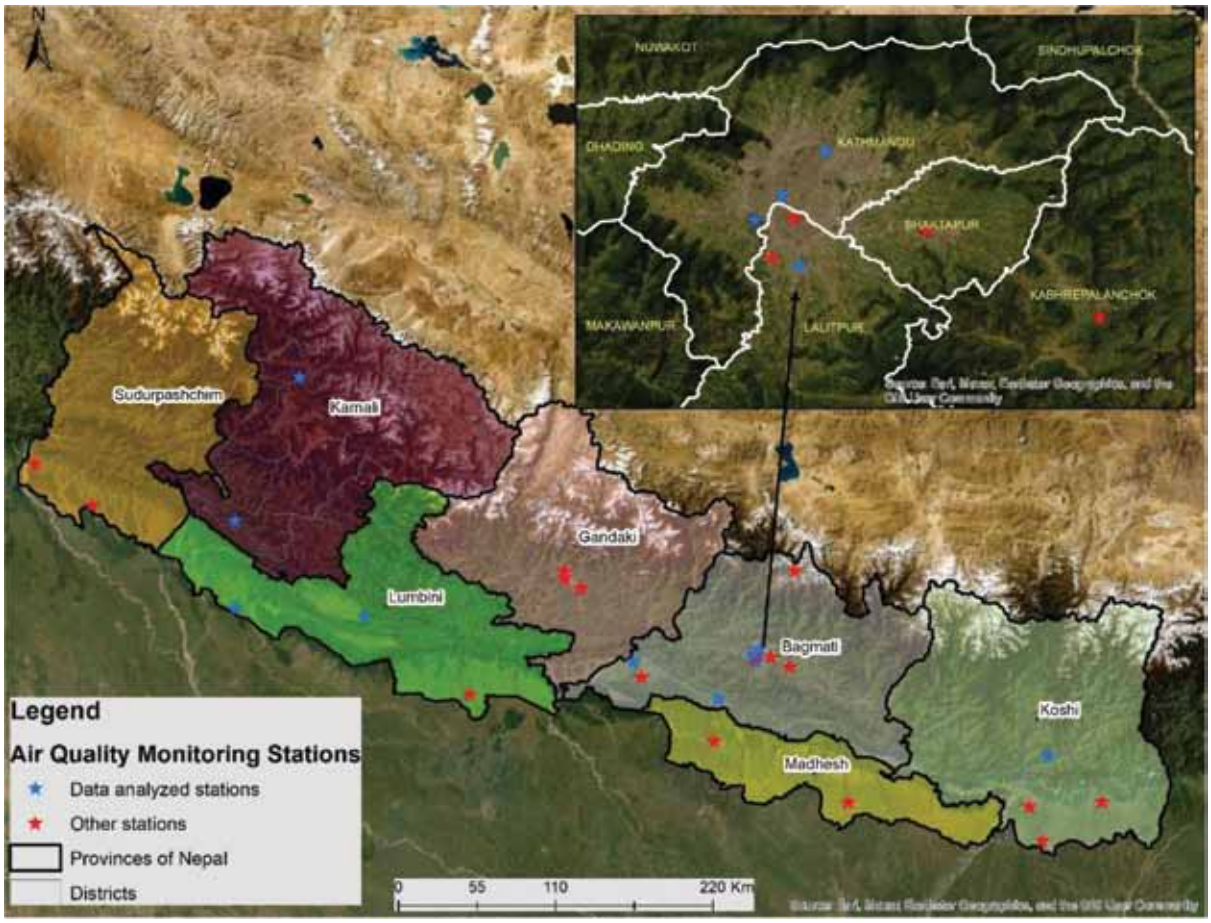

Figure 2: Distribution of AQMS in Nepal

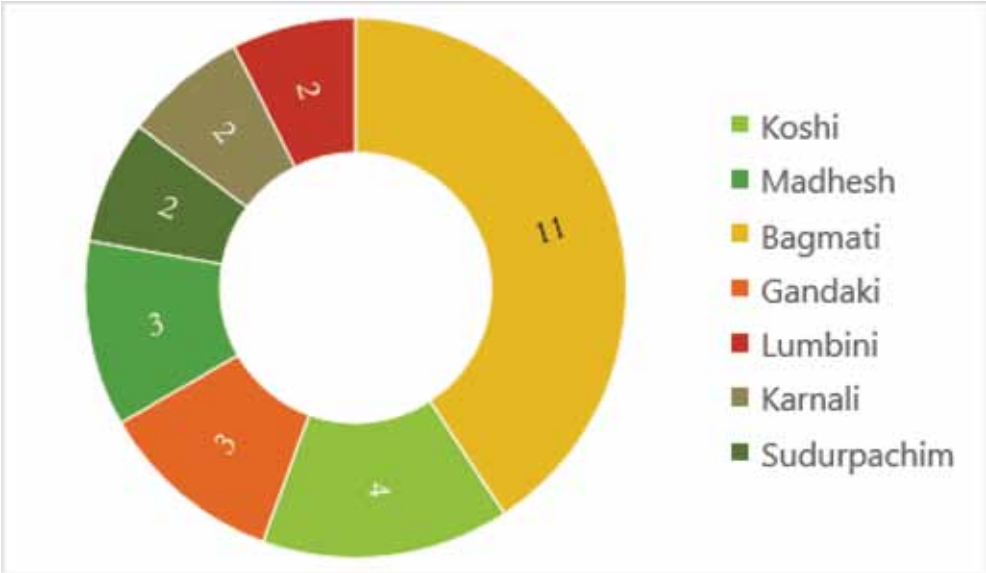

Figure 3: Provincial distribution of Air Quality Monitoring Stations

In this report- "Status of Air Quality in Nepal; Annual Report 2022", air quality data from only eleven (11) AQMS (table 1) are analyzed. Data from the remaining AQMS are excluded due to data unavailability. Furthermore, even though the instrument provides data for PM_1, an analysis for this parameter is not been conducted, primarily because the Government of Nepal has yet to formulate a standard for it.

Table 1: List of analyzed AQMS

SN	Name of Air Quality Monitoring Station	Province Name
1	Dhankuta	Koshi
2	Bharatpur	Bagmati
3	Hetauda	Bagmati
4	Khumaltar	Bagmati
5	Ratnapark	Bagmati
6	Shankapark	Bagmati
7	Tribhuvan University, Kritipur	Bagmati
8	Rara	Karnali
9	Surkhet	Karnali
10	Dang	Lumbini
11	Nepalgunj	Lumbini

1.2 OBJECTIVES

The overall objective of this report is to present the air quality status based on the data collected from the 11 Air Quality Monitoring Stations for the year 2022.

The specific objectives are:

- To analyze $PM_{2.5}$, PM_{10} and the Total Suspended Particulate (TSP) data that are generated from the stations listed on table 1,
- To analyze the compliance status of $PM_{2.5}$, PM_{10} and TSP data that are generated from the stations listed on table 1.

1.3 AIR QUALITY PARAMETERS MONITORED

The following parameters were monitored in the stations.

- $PM_{2.5}$: Includes particulate matter with an aerodynamic diameter less than or equal to 2.5 μm diameter and is important in terms of health impacts.
- PM_{10}: Includes particulate matter with an aerodynamic diameter less than or equal to 10 μm.
- TSP: Includes all solid and liquid droplet particulate present in the air, aerodynamic diameter of which ranges from 0.25 μm to 100 μm.

1.4 METHODS OF AIR QUALITY MONITORING AND DATA ANALYSIS

The Environmental Dust Monitor (Grimm EDM 180+) is used for air quality monitoring that measures ambient dust. 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 solid 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/min.

1.4.1 DATA ACQUISITION

This EDM instrument has the highest measurement resolution of six second but we are taking measurements every minute and get logged one-minute averaged data into the data logger installed at each AQMS. The data stored in the data logger is in CSV format. This data logger system then transmits 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. For this report data from 1st January to 31st December, 2022 were downloaded.

1.4.2 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.

1.4.3 DATA AVERAGING

Daily data is calculated by averaging the minute data, which is done only when availability of minute data is equal to or more than 80%. Similarly, monthly average is calculated from daily average only for those months where daily data availability is equal to or more than 50%. The seasonal average was calculated from the daily average only if the monthly average of at least two months of that season was available for winter, pre-monsoon and monsoon seasons which was at least one month for the post-monsoon season.

Following months are 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

1.4.4 DATA ANALYSIS METHOD AND PLOTS/GRAPHS USED IN THE REPORT

The **histogram,** monthly **box-plot** and hourly box-plot are made from the hourly data. The daily average was the average of point data of a day. The monthly average was calculated from the daily average. The seasonal average was the average of daily averaged data of all days for that season. For the winter season, daily average data from December of the preceding year (in this case, 2021) along with January and February of this year (2022) are used for winter season. Similarly, for the pre- monsoon, data from March to May, for monsoon, data from June to September and for post-monsoon data from October and November were used.

Python programming was used to automate the download of large datasets from the central server while R programming was used for data analysis.

In **calendar plot** daily $PM_{2.5}$ data were visualized according to their Air quality index (AQI) group in calendar format. The AQI was calculated from daily averaged data. The break point used by the government of Nepal was used for the calculation. The AQI group and their respective colour code is as follows.

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 ranges, 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.

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	Oranges
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 400	Hazardous	Maroon
401 to 500	Very Hazardous	Maroon

1.4.5 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 2: National Ambient Air Quality Standards, 2012

SN	Parameters	Units	Averaging time	Maximum concentration
1	$PM_{2.5}$	$\mu g\ m^{-3}$	24-hr	40
2	PM_{10}	$\mu g\ m^{-3}$	24-hr	120
3	TSP	$\mu g\ m^{-3}$	24-hr	230
4	Ozone	$\mu g\ m^{-3}$	8-hr	157
5	Sulfur 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 KOSHI PROVINCE

2.1.1 DHANKUTA AIR QUALITY MONITORING STATION

Dhankuta air quality monitoring station was established in 2019 at Dhankuta Municipality in Dhankuta district, Koshi Province. The station situated adjacent to the Dhankuta municipality office on the road -side represents the urban area.

Emission from the vehicles, forest fires in nearby regions and pollutants transported from surrounding regions are the major sources of air pollution in this area.

2.1.1.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 1.5 µg m^{-3} to 223.2 µg m^{-3}. The lowest and the highest concentration of $PM_{2.5}$ was observed on 5th October at 15:00 and 5th December at 17:00. The statistical summary of the hourly average is presented in the table below:

Table 3: Summary of hourly average of $PM_{2.5}$ for Dhankuta Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.5 µg m^{-3}	14.3 µg m^{-3}	26.2 µg m^{-3}	31.9 ± 21.6 µg m^{-3}	47.1 µg m^{-3}	223.2 µg m^{-3}

Histogram:

The dataset is clustered towards the lower end of values (5-20) and as values increase, the frequency of observations decreases rapidly.

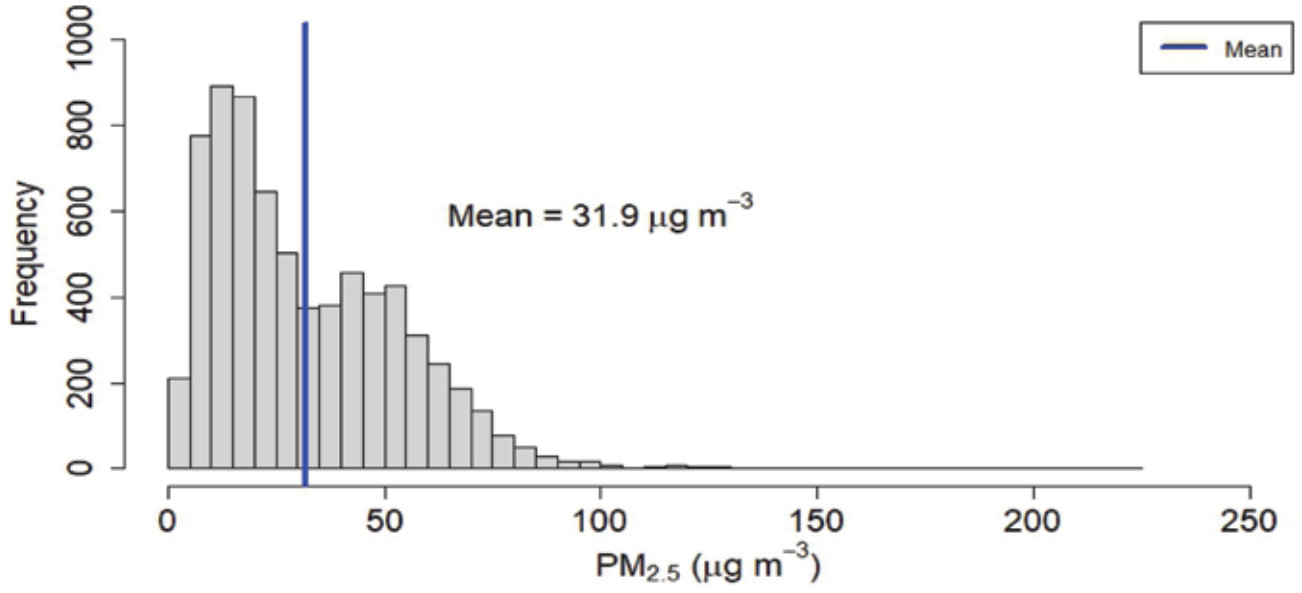

Figure 4: Histogram of $PM_{2.5}$ for Dhankuta Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ remains consistent throughout the day. It gains peak at 7:00 and 18:00. The mean value was found to be more than median throughout the day.

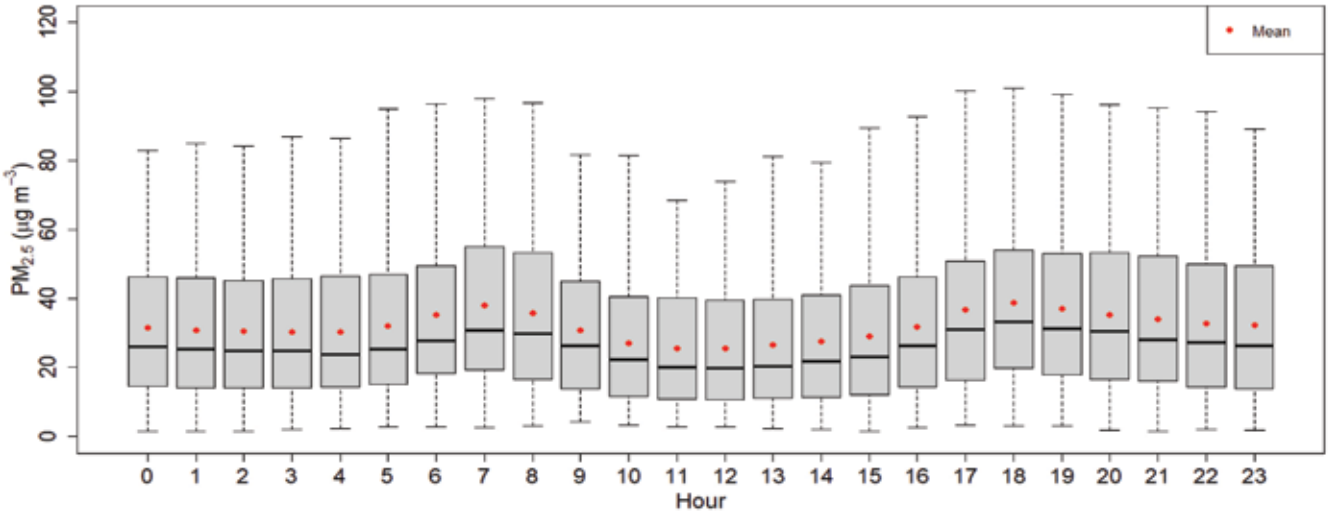

Figure 5: Diurnal variation of $PM_{2.5}$ for Dhankuta Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during December, whereas less during July and August.

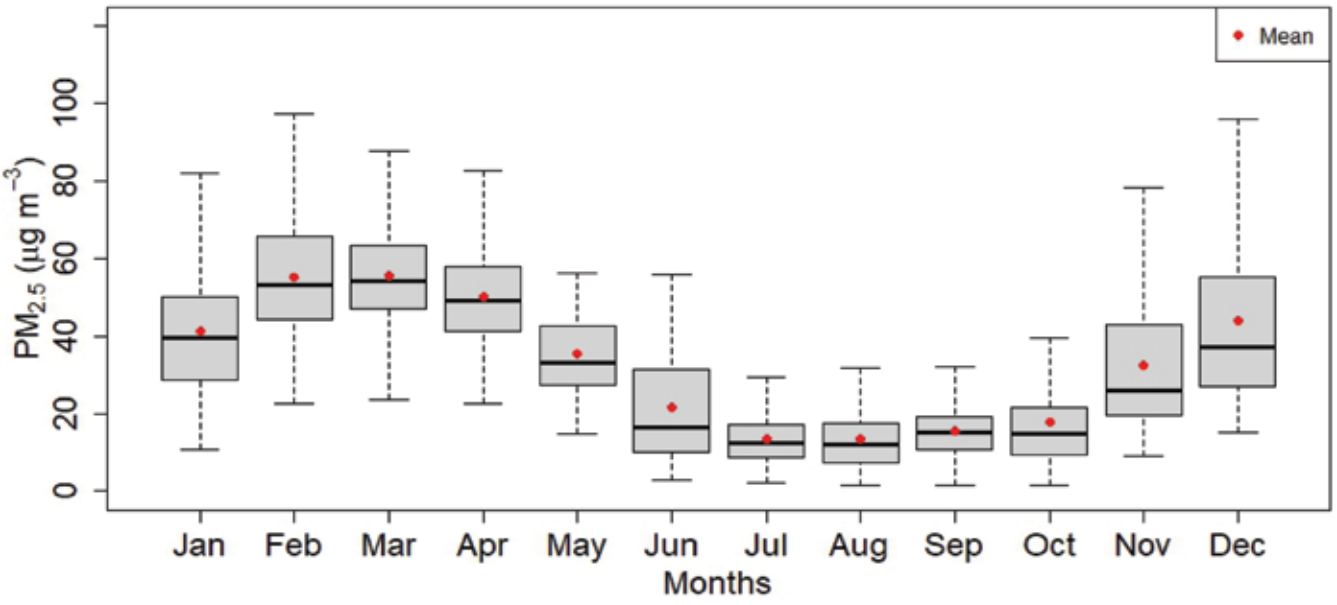

Figure 6: Monthly variation of $PM_{2.5}$ for Dhankuta Station

Daily average:

Figure 7 explains the daily trend of $PM_{2.5}$ throughout the year.

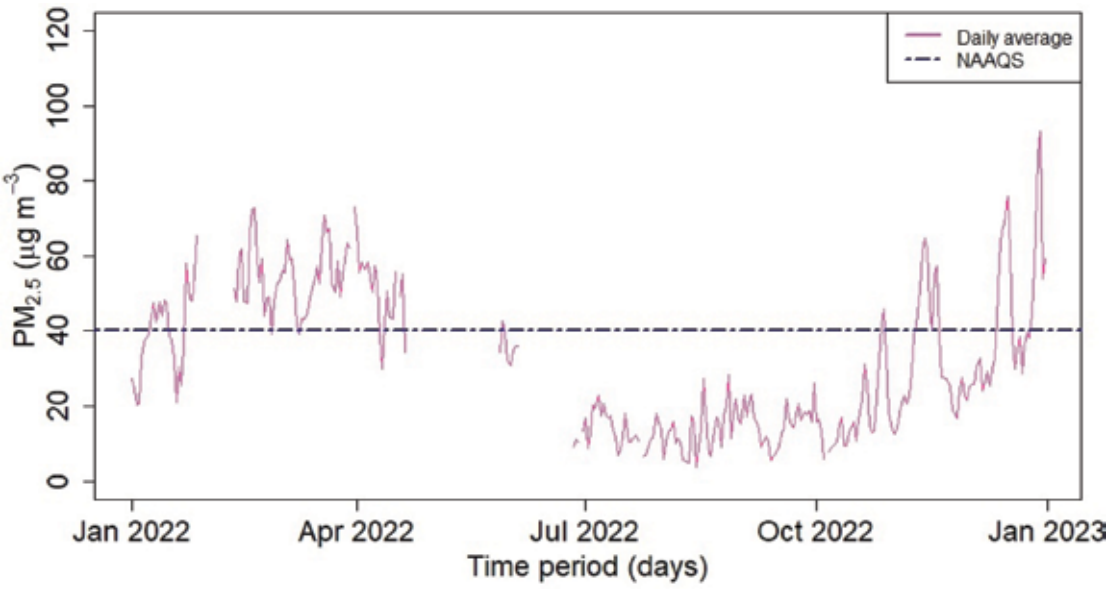

Figure 7: Daily average of $PM_{2.5}$ for Dhankuta Station

Table 4: Summary of daily average of $PM_{2.5}$ for Dhankuta Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
3.6 µg m^{-3}	15.5 µg m^{-3}	27.4 µg m^{-3}	31.8 ± 19.3 µg m^{-3}	47.9 µg m^{-3}	93.4 µg m^{-3}

Within the available data, the lowest and highest concentration of $PM_{2.5}$ was observed to be 3.6 µg m^{-3} and 93.4 µg m^{-3} on 14th August and 29th December respectively. During the majority of days, $PM_{2.5}$ concentration was found below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. The average concentration of $PM_{2.5}$ ranges from 13.4 µg m^{-3} in August to 55.6 µg m^{-3} in March.

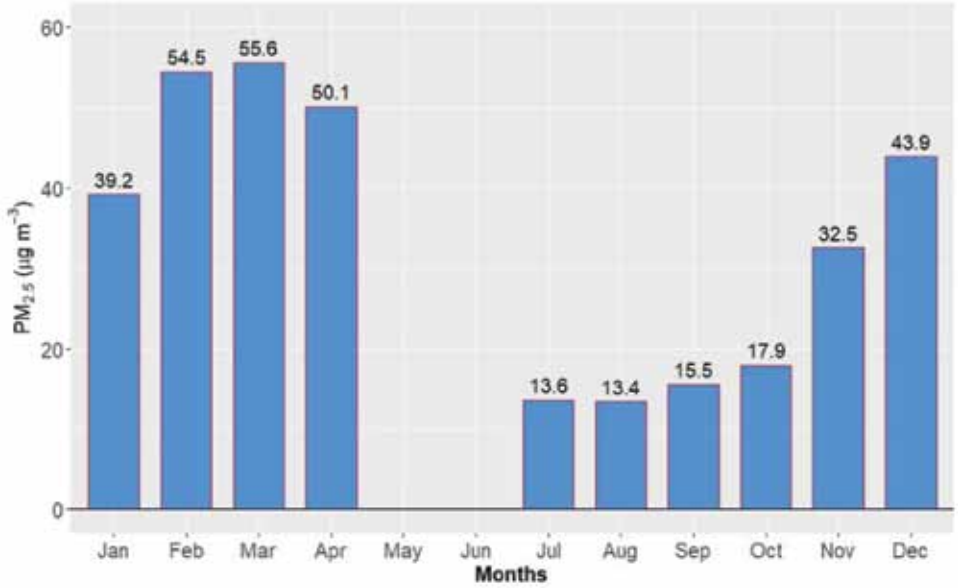

Figure 8: Monthly average of $PM_{2.5}$ for Dhankuta Station

Seasonal average:

This bar chart illustrates the seasonal distribution of $PM_{2.5}$ concentration. The seasonal average of $PM_{2.5}$ for pre-monsoon was found to be the highest (52.3 µg m^{-3}) and that of monsoon season to be the lowest (14.9 µg m^{-3}).

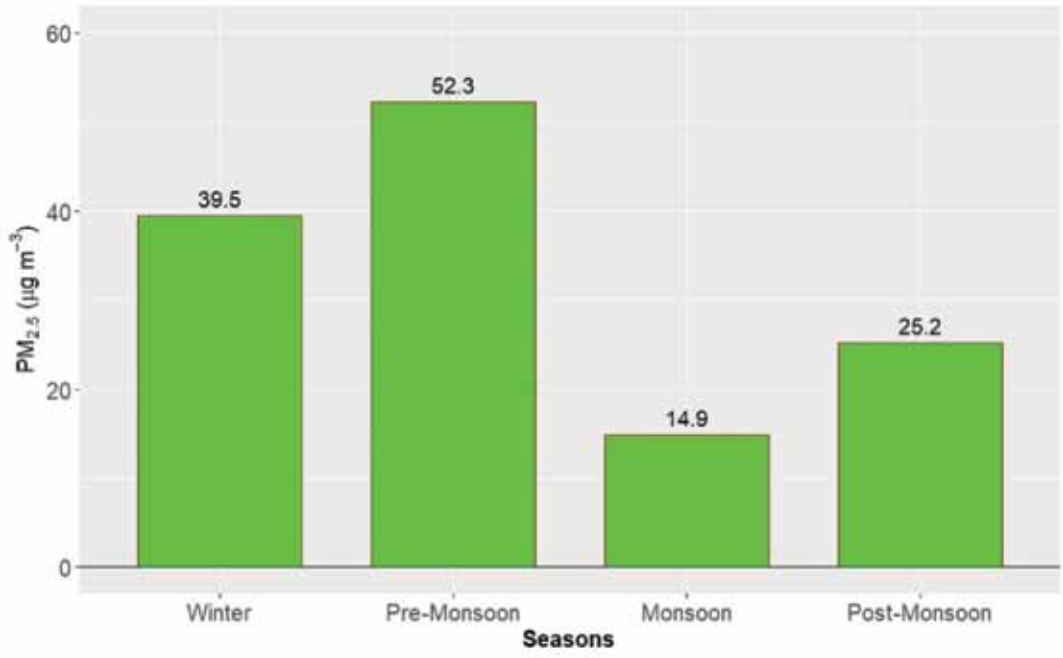

Figure 9: Seasonal average of $PM_{2.5}$ for Dhankuta Station

Compliance status:

Out of the total 288 days of valid measurement, 98 days exceeded the NAAQS. Most of the non-compliance days were included in February and March as shown in figure 10.

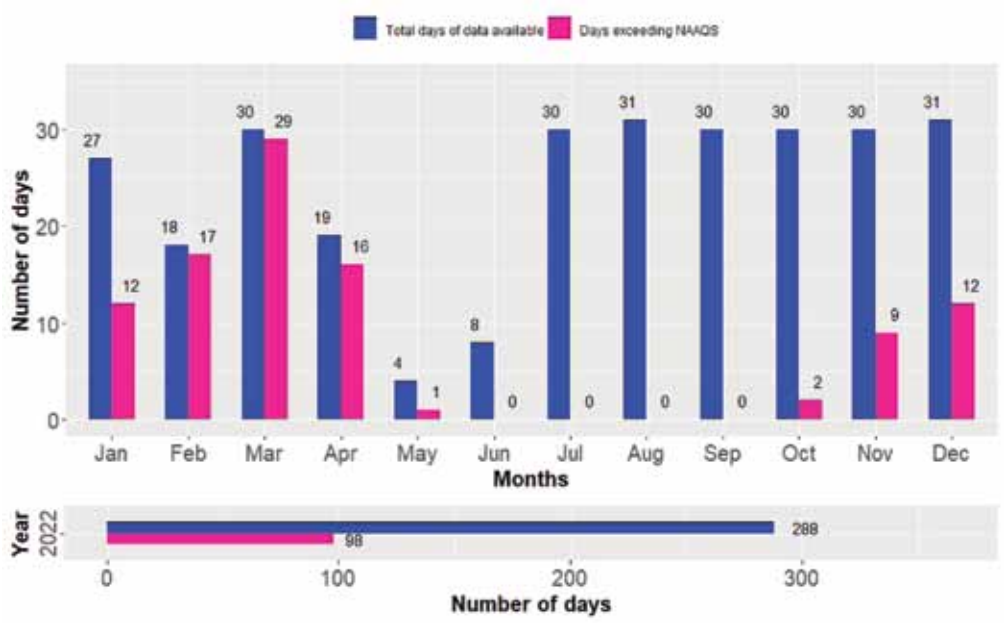

Figure 10: Compliance status of $PM_{2.5}$ for Dhankuta Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 11), out of the total 288 valid days, the majority of days showed an AQI of good to moderate. Few days in January to April and November and December reached an unhealthy state.

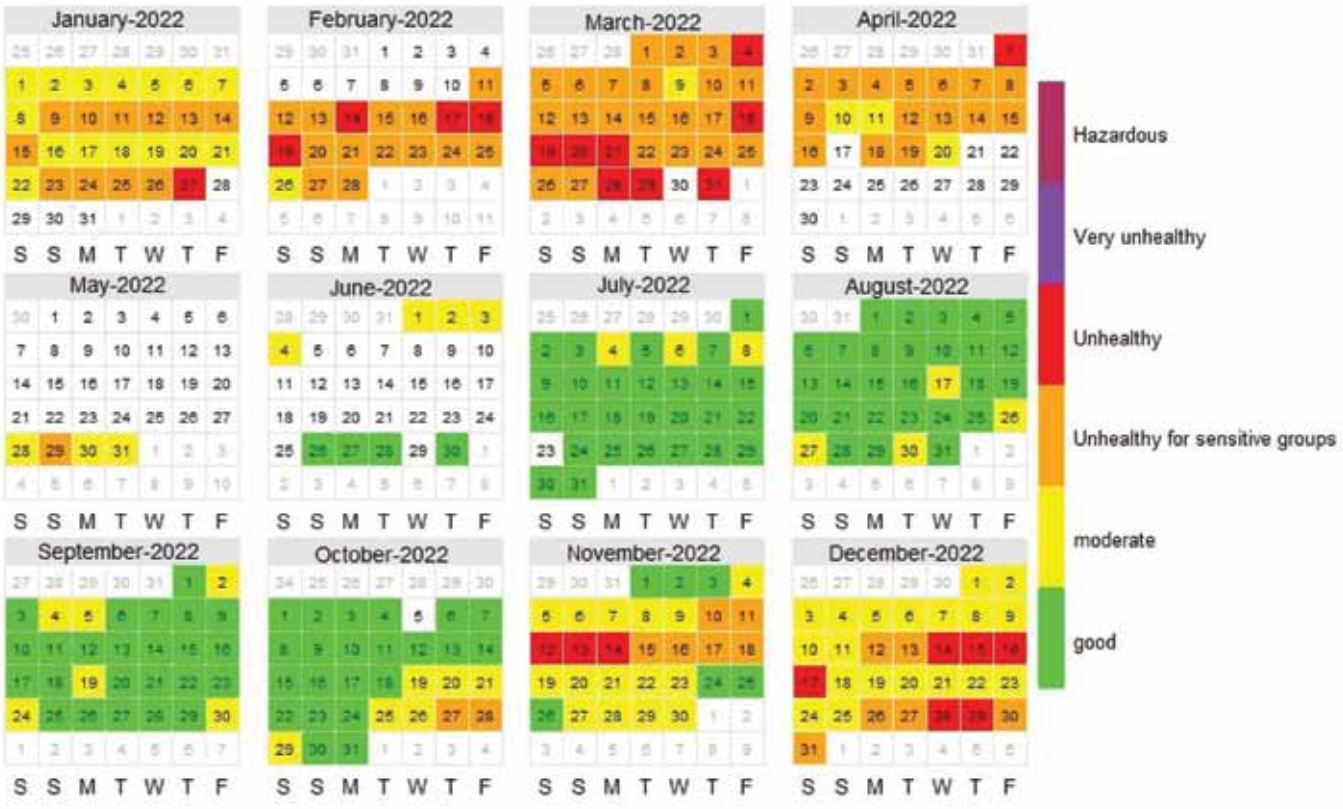

Figure 11: Calendar plot of $PM_{2.5}$ for Dhankuta Station

2.1.1.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 1.5 μg m^{-3} to 238.8 μg m^{-3}. The lowest and highest concentration of PM_{10} were observed on 14th August at 23:00 and 5th December at 17:00. The statistical summary of the hourly average is presented in the table below:

Table 5: Summary of hourly average of PM_{10} for Dhankuta station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.5 μg m^{-3}	17.5 μg m^{-3}	32.9 μg m^{-3}	41.8 ± 30.1 μg m^{-3}	61.1 μg m^{-3}	238.8 μg m^{-3}

Histogram:

The point data are aggregated in the mean region.

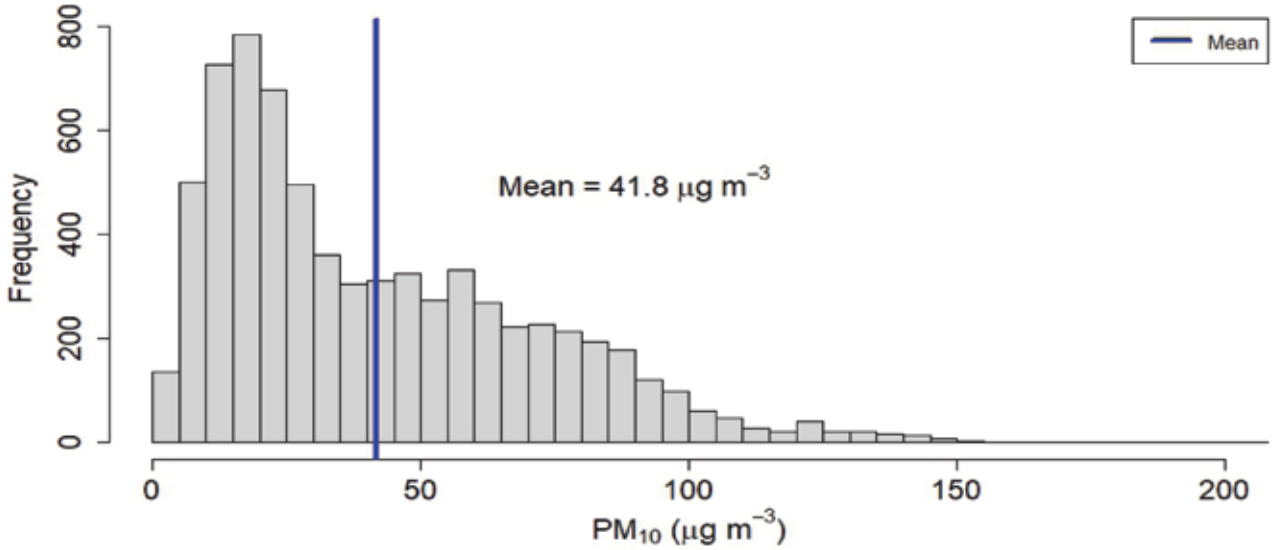

Figure 12: Histogram of PM_{10} for Dhankuta Station

Diurnal variation:

The hourly mean of PM_{10} remains consistent throughout the day. It gains peak at 8:00 and 13:00. The mean value was found more than median throughout the day.

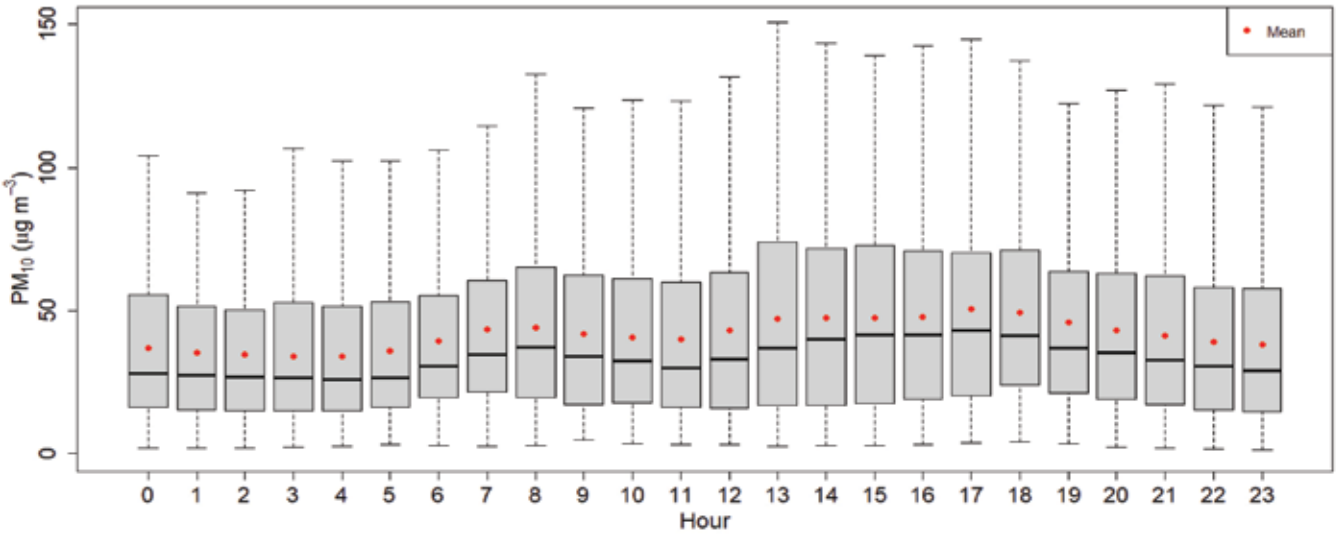

Figure 13: Diurnal variation of PM_{10} for Dhankuta Station

Monthly variation:

A high variation of PM_{10} concentration was seen during June, whereas less during July, August and September.

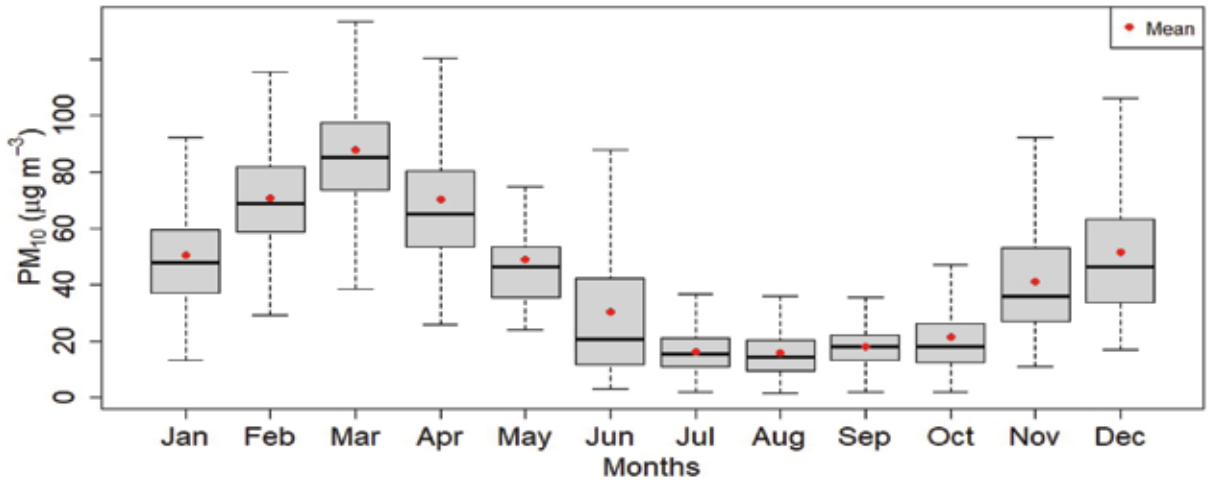

Figure 14: Monthly variation of PM_{10} for Dhankuta Station

Daily average:

Figure 15 explains the daily trend of PM_{10} throughout the year.

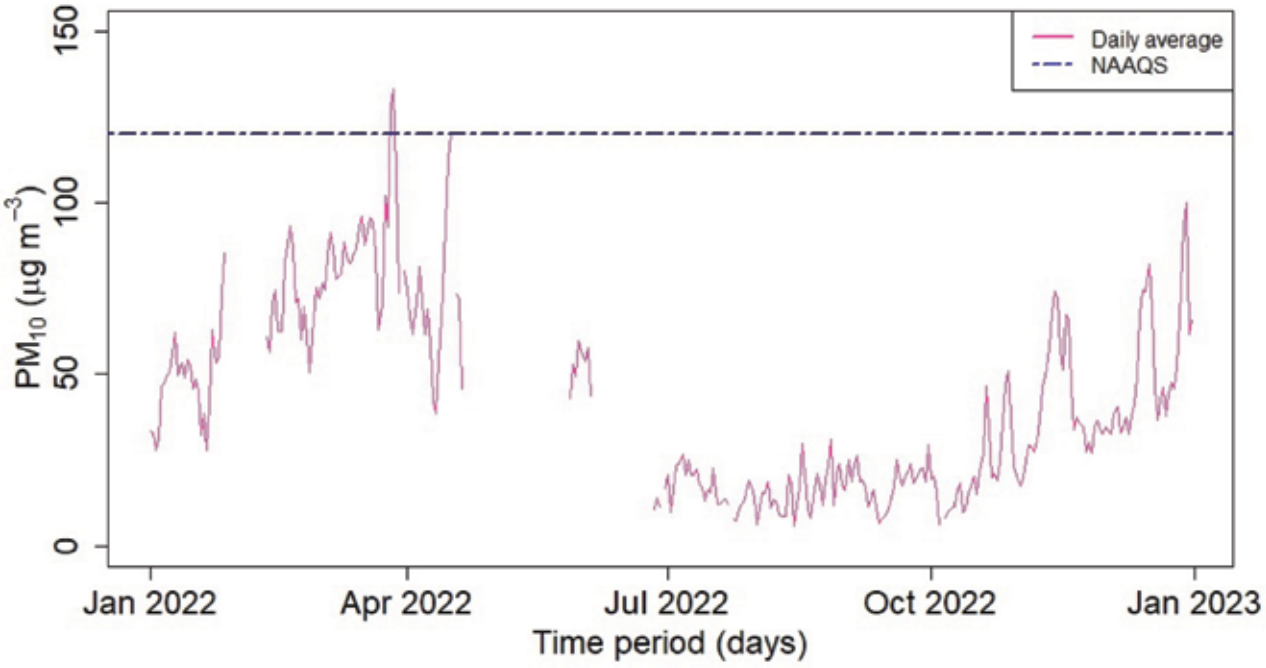

Figure 15: Daily average of PM_{10} for Dhankuta Station

Table 6: Summary of daily average of PM_{10} for Dhankuta Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
5.6 µg m^{-3}	18.5 µg m^{-3}	34.3 µg m^{-3}	41.7 ± 27.6 µg m^{-3}	61.9 µg m^{-3}	133.2 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 5.6 µg m^{-3} to 133.2µg m^{-3} on 14th August and 27th March respectively. The majority of available PM_{10} concentration were found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of PM_{10}. The average concentration of PM_{10} ranges from 15.7 µg m^{-3} in August to 88.2 µg m^{-3} in March.

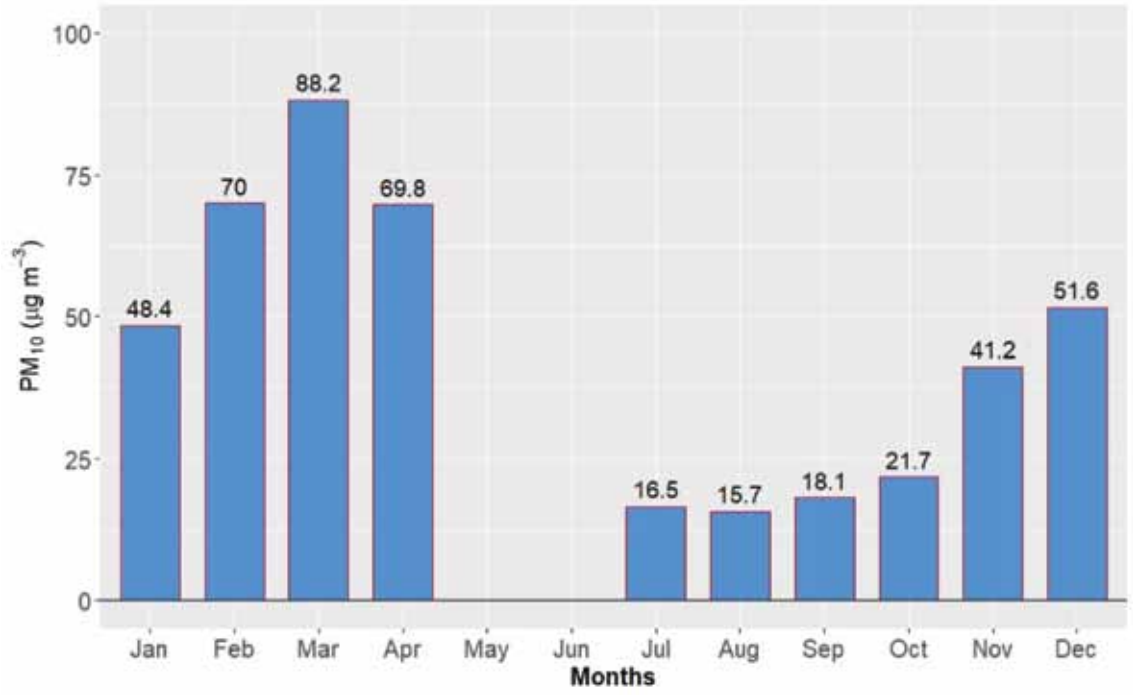

Figure 16: Monthly average of PM_{10} for Dhankuta Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}. The seasonal average of PM_{10} for pre-monsoon was found to be the highest (78.8 µg m^{-3}) and that of monsoon season to be the lowest (18.1 µg m^{-3}).

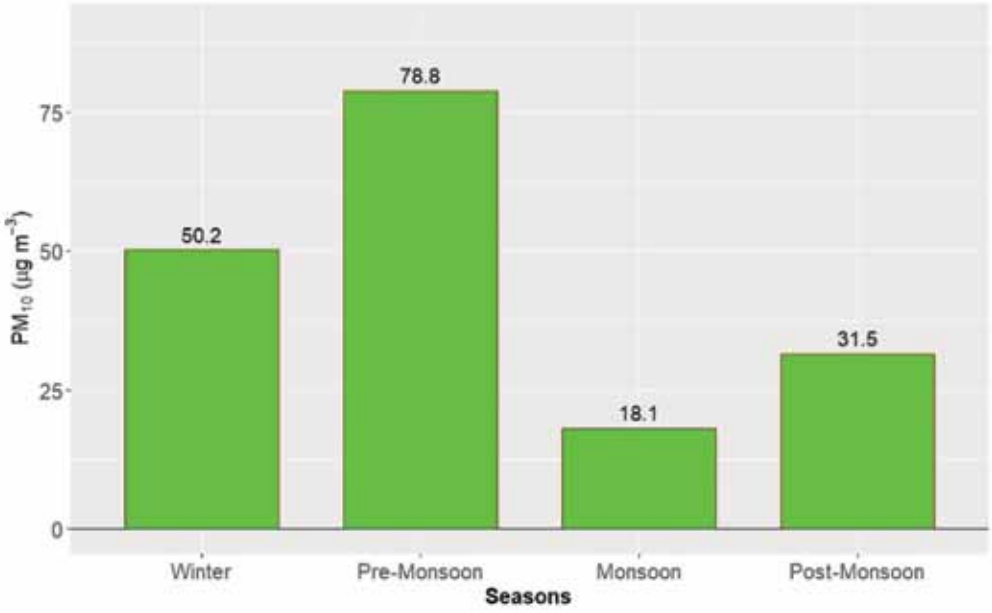

Figure 17: Seasonal average of PM_{10} for Dhankuta Station

Compliance status:

Out of the total 288 days of measurement, only three days exceeded the NAAQS as shown in figure 18.

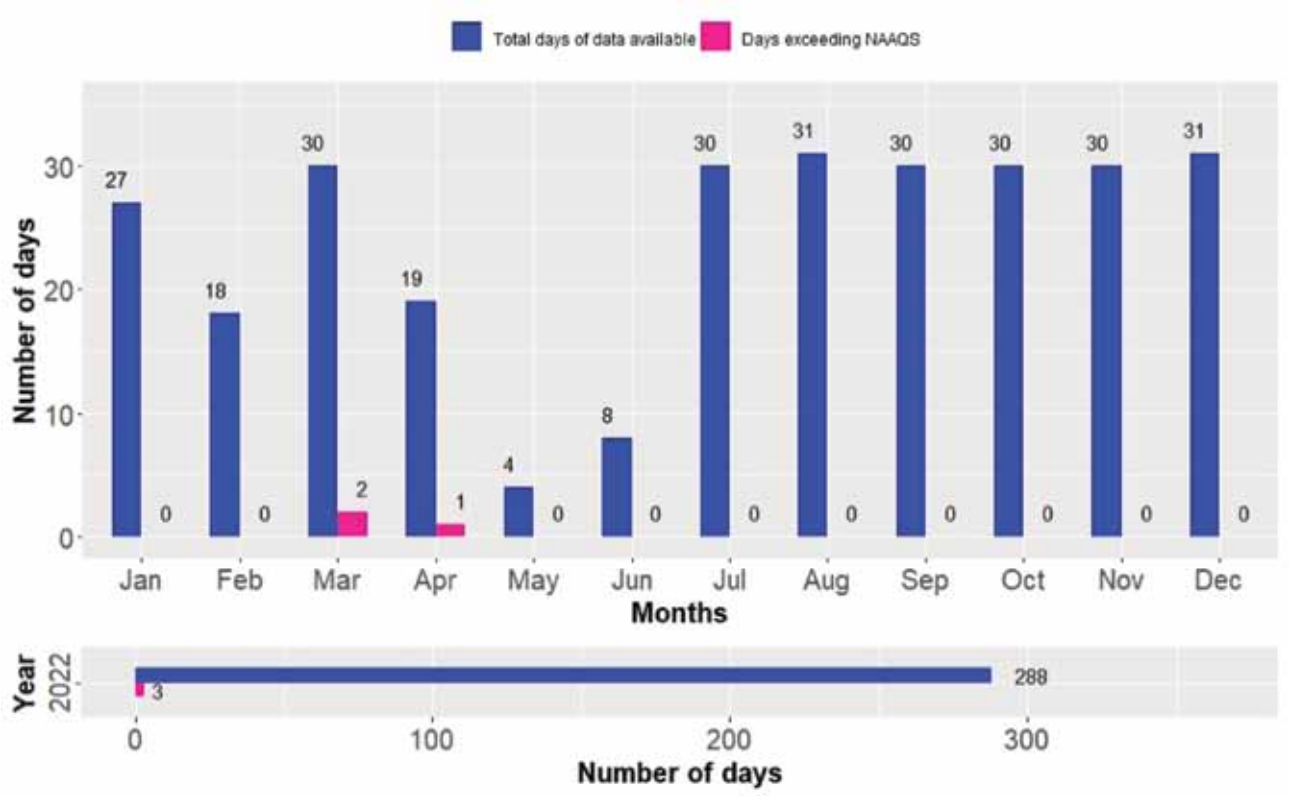

Figure 18: Compliance status of PM_{10} for Dhankuta Station

2.1.1.3 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 1.6 µg m^{-3} to 1446.8 µg m^{-3}. The lowest and the highest concentration of TSP were observed on 14th August at 23:00 and 31th May at 13:00. The statistical summary of the hourly average is presented in the table below:

Table 7: Summary of hourly average TSP for Dhankuta Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.6 µg m^{-3}	21.1 µg m^{-3}	44.7 µg m^{-3}	75.4 ± 94.6 µg m^{-3}	89.2 µg m^{-3}	1446.8 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-50) and as values increase, the frequency of observations decreases rapidly.

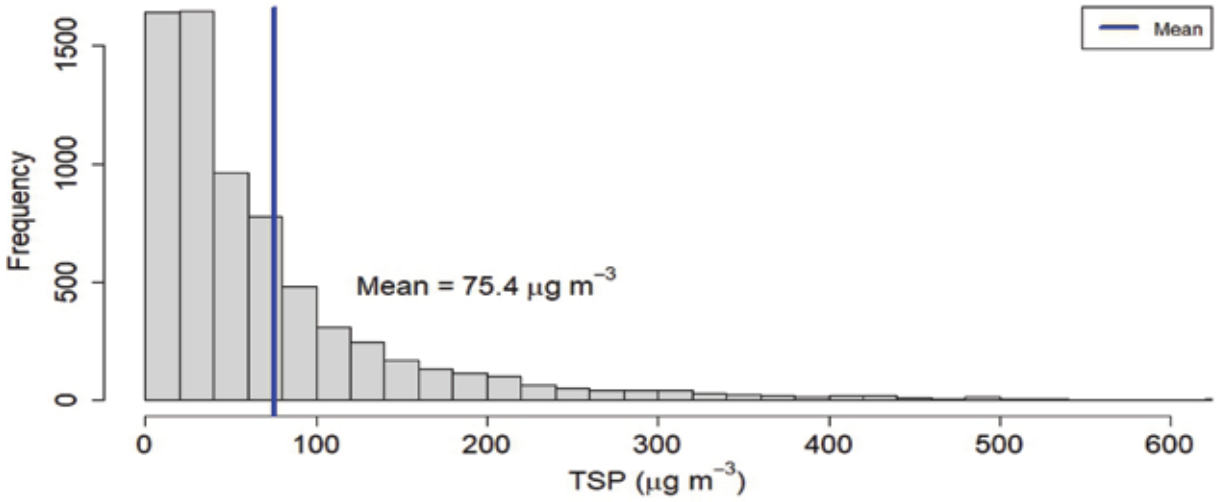

Figure 19: Histogram of TSP for Dhankuta Station

Diurnal variation:

The hourly mean of TSP progressively increased with time and reached to its peaks at 13:00-14:00 which then decreases with time.

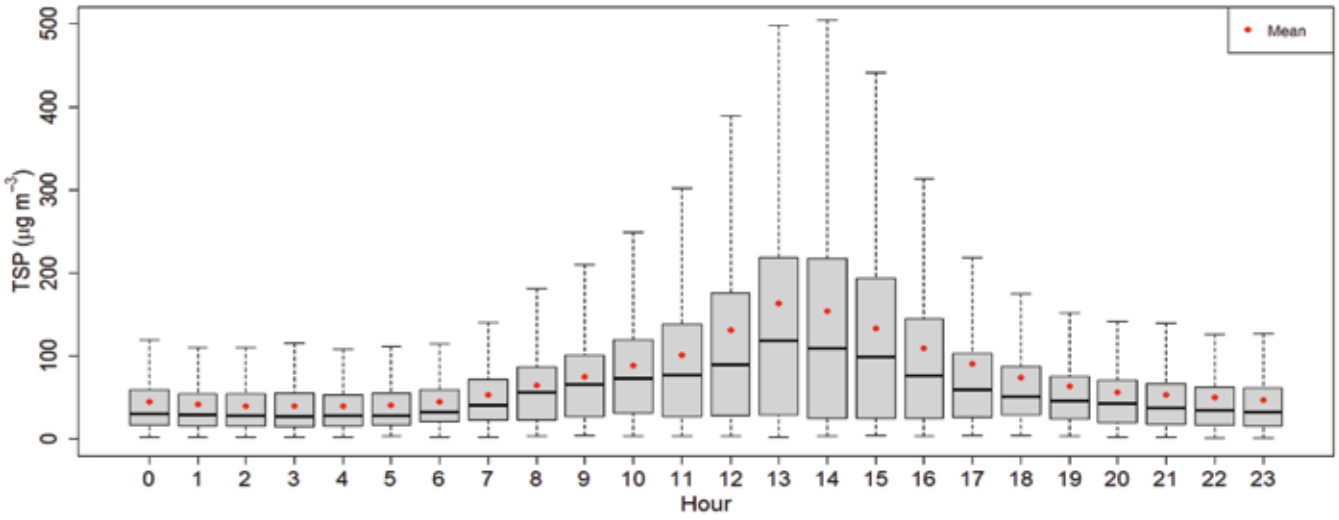

Figure 20: Diurnal variation of TSP for Dhankuta Station

Monthly variation:

A high variation of TSP concentration was seen during March, whereas less occurs during July to September.

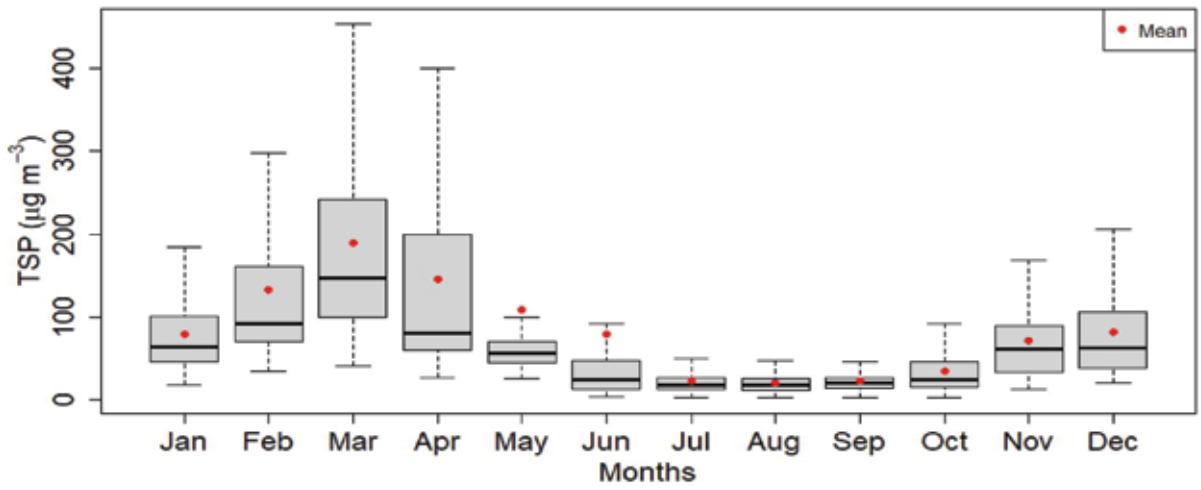

Figure 21: Monthly variation of TSP for Dhankuta Station

Daily average:

The daily average data was available only from 1st January to 31st December. Figure 22 explains the daily trend of TSP throughout the year.

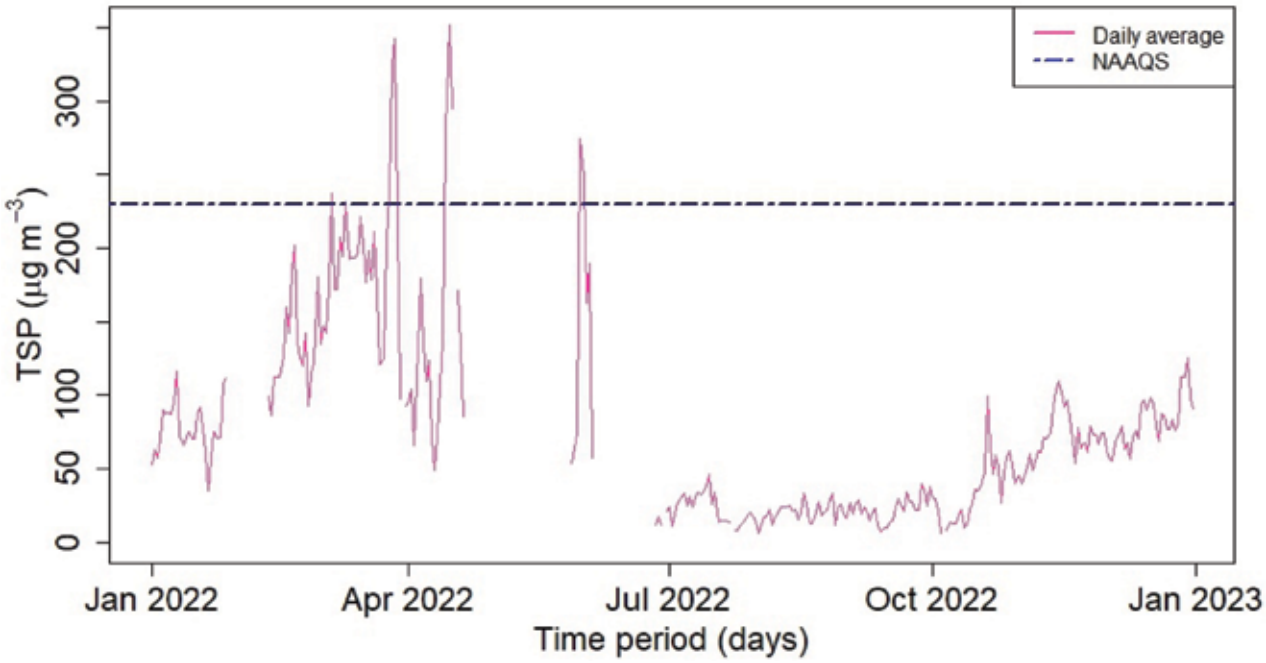

Figure 22: Daily average of TSP for Dhankuta Station

Table 8: Summary of daily average TSP for Dhankuta Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
6.2 µg m^{-3}	24.3 µg m^{-3}	62.3 µg m^{-3}	75.6 ± 65.4 µg m^{-3}	98.1 µg m^{-3}	352.5 µg m^{-3}

Within the available data, the lowest and highest concentration of TSP was found to be 6.2 µg m^{-3} to 352.5 µg m^{-3} on 1st August and 15th April respectively (table 11). The total available TSP concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. The average concentration of TSP ranges from 20.4 µg m^{-3} in August to 190.4 µg m^{-3} in March.

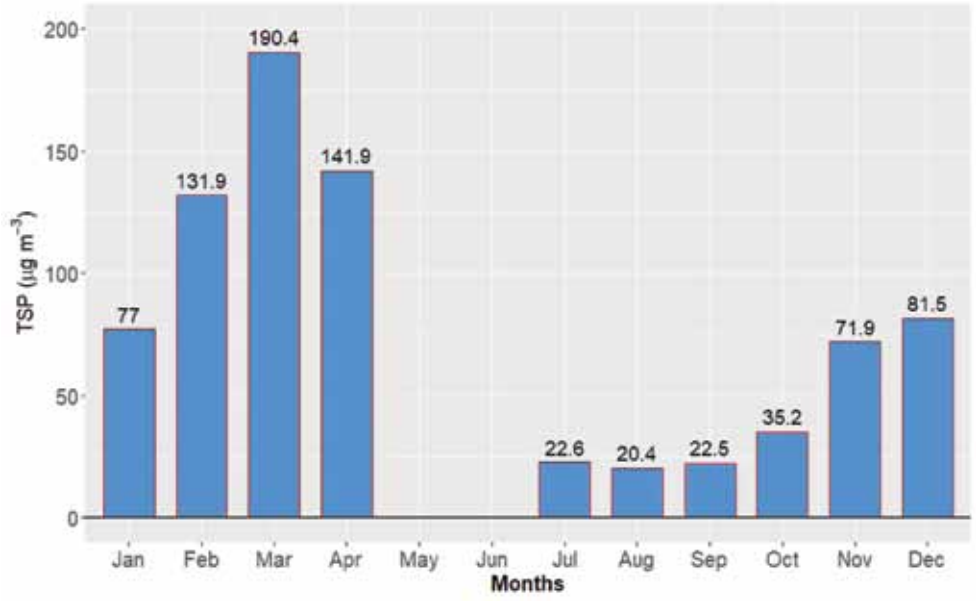

Figure 23: Monthly average of TSP for Dhankuta Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP. The seasonal average of TSP for pre-monsoon was found to be the highest (167.4 µg m^{-3}) and that of monsoon season to be the lowest (27.4 µg m^{-3}).

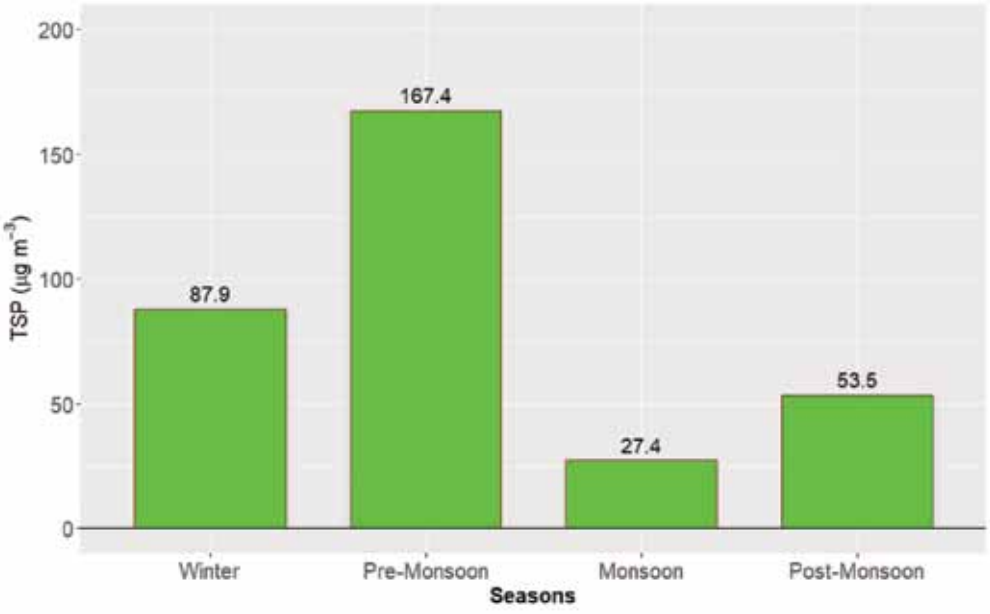

Figure 24: Seasonal average of TSP for Dhankuta Station

Compliance status:

Out of the total 288 days of measurement, only 10 day exceeded the NAAQS.

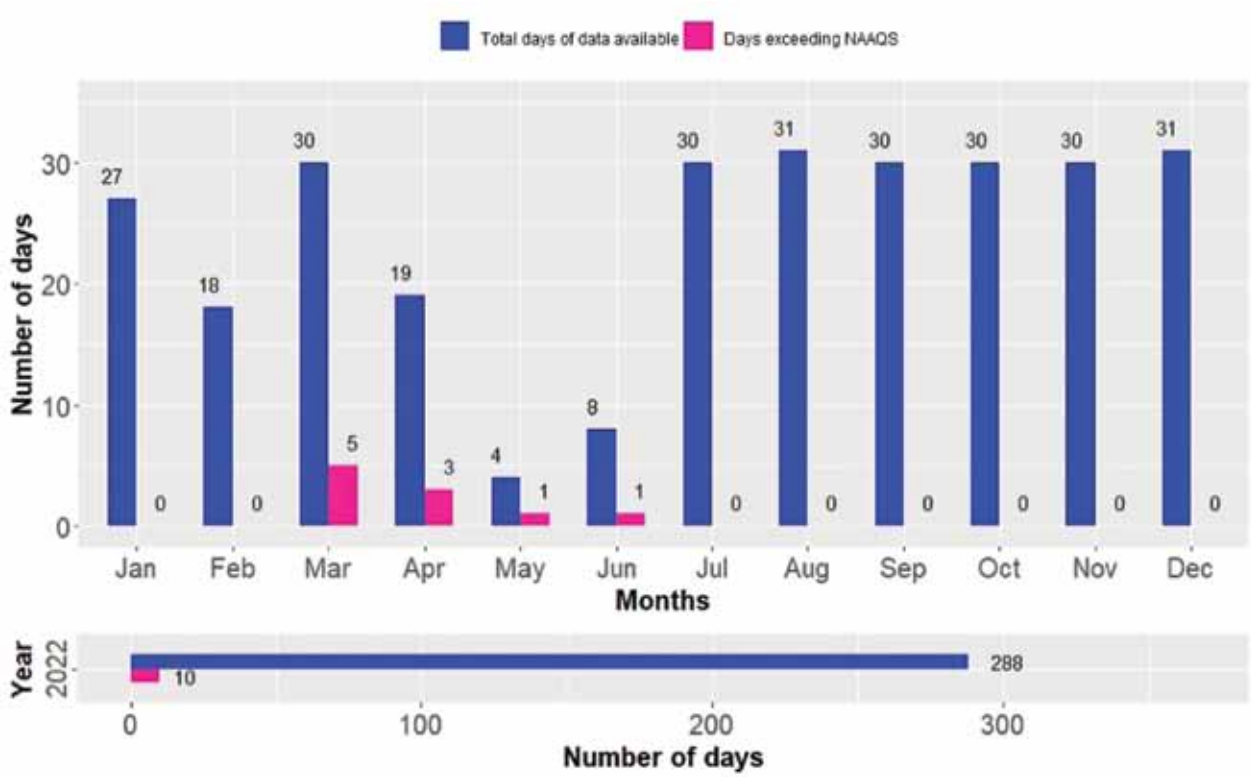

Figure 25: Compliance status of TSP for Dhankuta Station

2.2 BAGMATI PROVINCE

2.2.1 BHARATPUR AIR QUALITY MONITORING STATION

Bharatpur air quality monitoring station was established in 2020 at Bharatpur metropolitan city in Chitwan district, Bagmati Province. This station is located in the compound of District administration office of Chitwan, by the side of the road. Many government offices are located near the station. This station represents the urban area.

Emission from the vehicles and industries are the main sources of pollution in the area around the station. Another likely source of air pollution in this region is the extensive burning of agricultural residue during the pre-monsoon season.

2.2.1.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 1.6 µg m^{-3} to 267.5 µg m^{-3}. The lowest and the highest concentration of $PM_{2.5}$ was observed on 17th September at 17:00 and 22nd March at 17:00. The statistical summary of the hourly average is presented in the table 13 below:

Table 9: Summary of hourly average of $PM_{2.5}$ for Bharatpur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.6 µg m^{-3}	39.6 µg m^{-3}	58.1 µg m^{-3}	63.2 ± 33.6 µg m^{-3}	80.6 µg m^{-3}	267.5 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (20-80) and as values increase, the frequency of observations decreases rapidly.

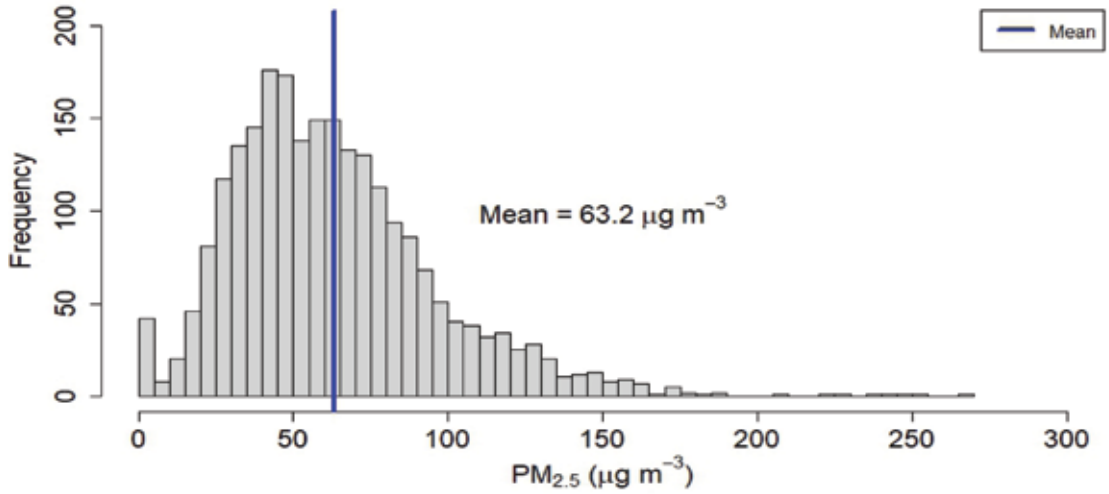

Figure 26: Histogram of $PM_{2.5}$ for Bharatpur Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ progressively increases with time and reaches to its peak at 7:00 which again decreases till 15:00 and again starts to increase around 17:00 and gains height around 19:00.

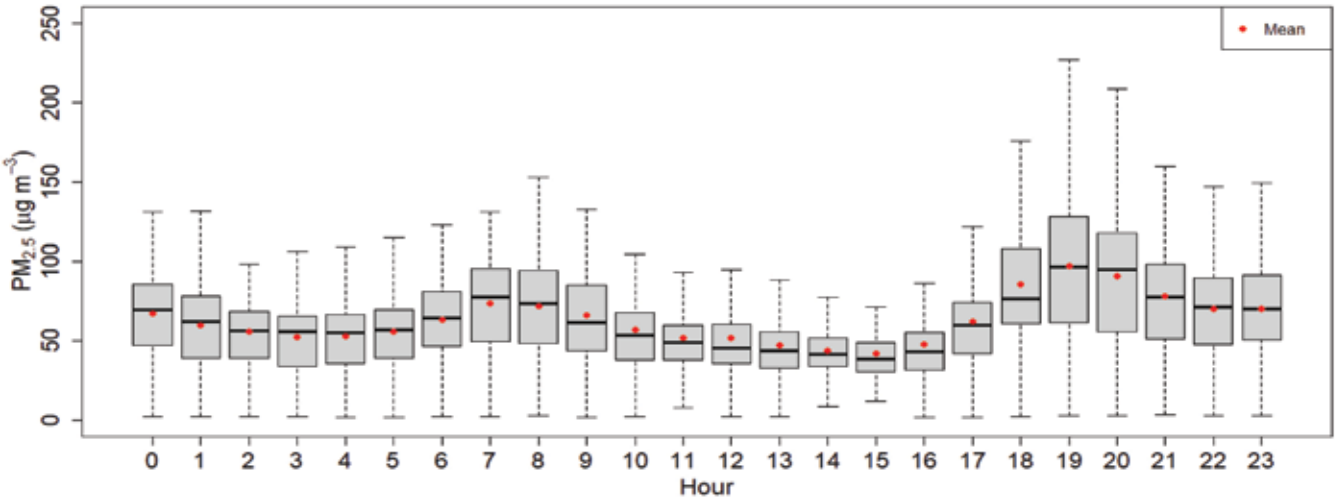

Figure 27: Diurnal variation of $PM_{2.5}$ for Bharatpur Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during February whereas less during September.

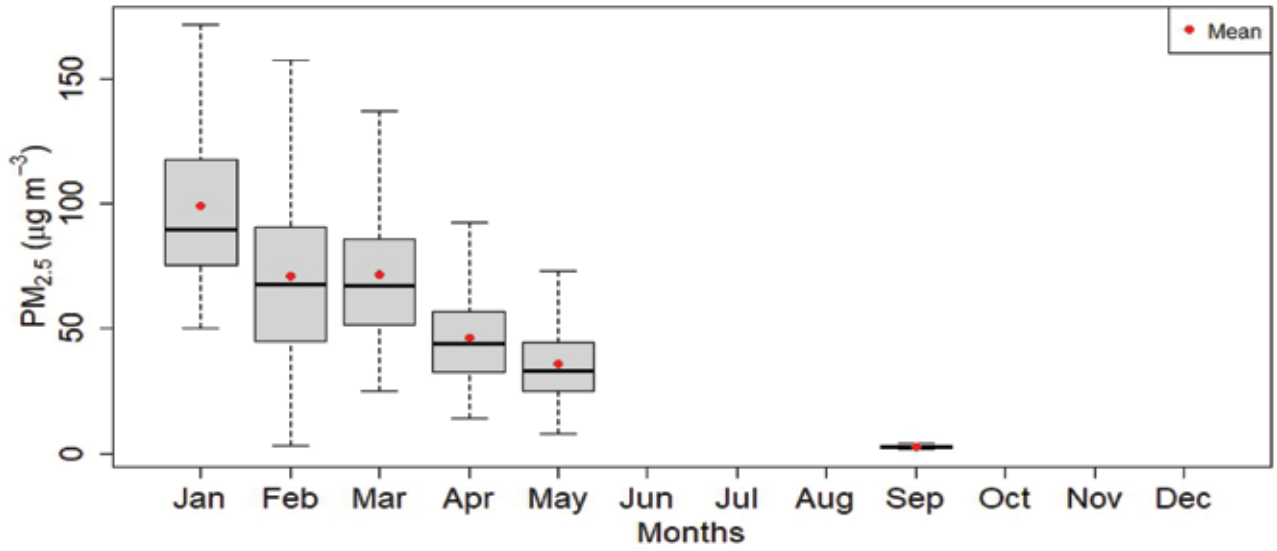

Figure 28: Monthly variation of $PM_{2.5}$ for Bharatpur Station

Daily average:

The daily average data was available only for 96 days.

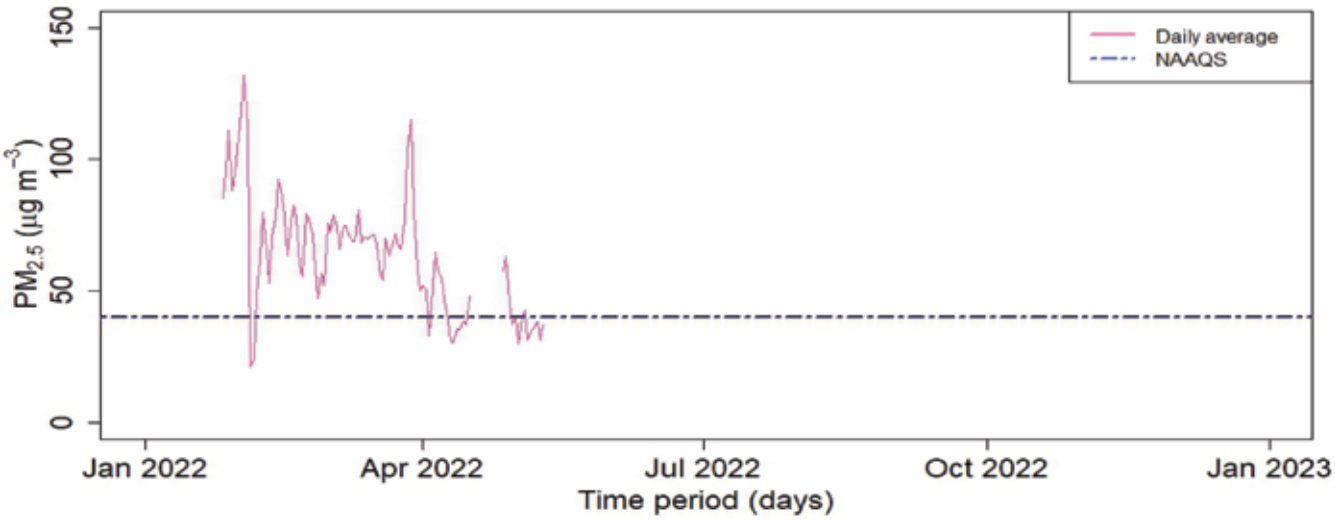

Figure 29: Daily average of $PM_{2.5}$ for Bharatpur Station

Table 10: Summary of daily average of $PM_{2.5}$ for Bharatpur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.5 µg m^{-3}	47.0 µg m^{-3}	65.3 µg m^{-3}	63.3 ± 23.3 µg m^{-3}	76.6 µg m^{-3}	131.9 µg m^{-3}

Within the available data, the lowest and highest concentration of $PM_{2.5}$ was found to be 2.5 µg m^{-3} to 131.9 µg m^{-3} on 18th September and 2nd February respectively (table 14). In majority of days, $PM_{2.5}$ concentration was found to be above NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. The average concentration of $PM_{2.5}$ ranges from 45.6 µg m^{-3} in April to 71.8 µg m^{-3} in March.

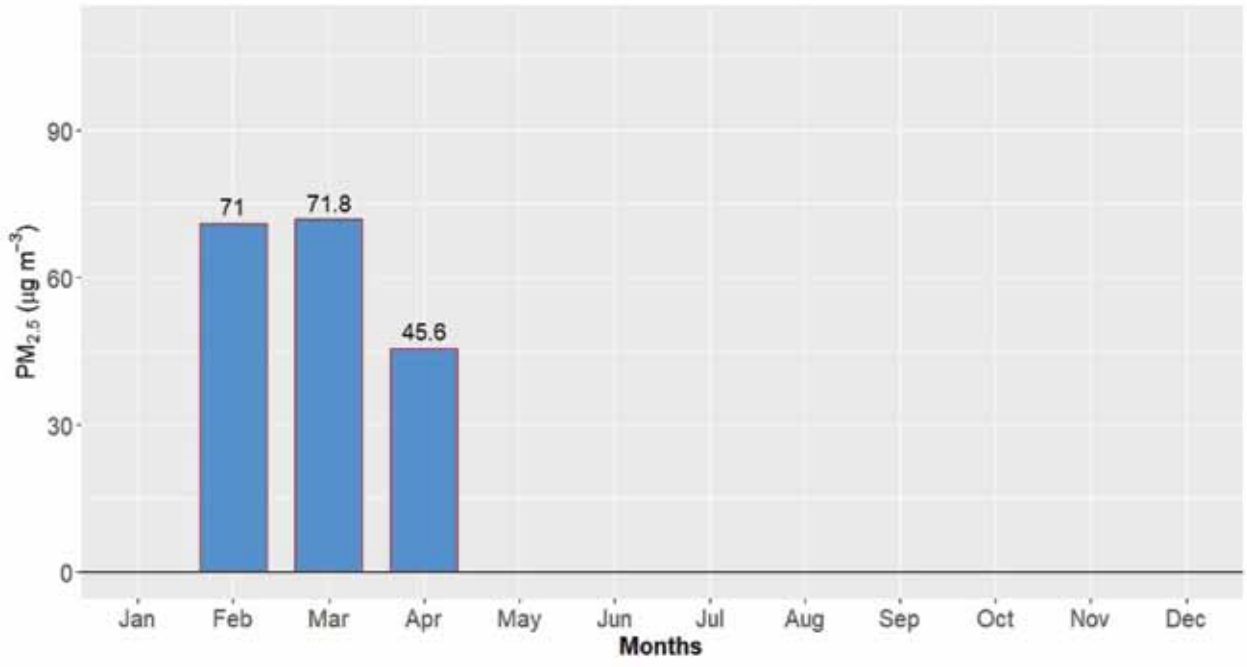

Figure 30: Monthly average of $PM_{2.5}$ for Bharatpur Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Because of limited data, the averages of only one season- pre-monsoon (57.4 μg m^{-3}), is presented in the figure 31.

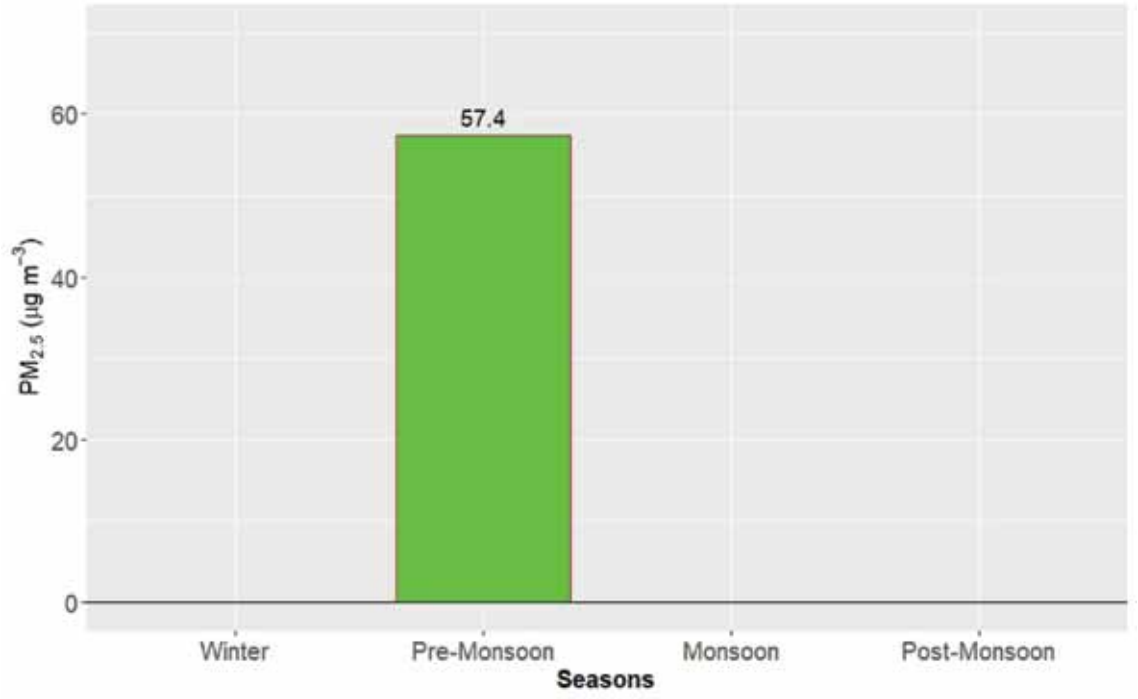

Figure 31: Seasonal average of $PM_{2.5}$ for Bharatpur Station

Compliance status:

Out of the total 96 days of valid measurement, 76 days exceeded the NAAQS. Those noncompliance days were distributing in all four months as shown in figure 32.

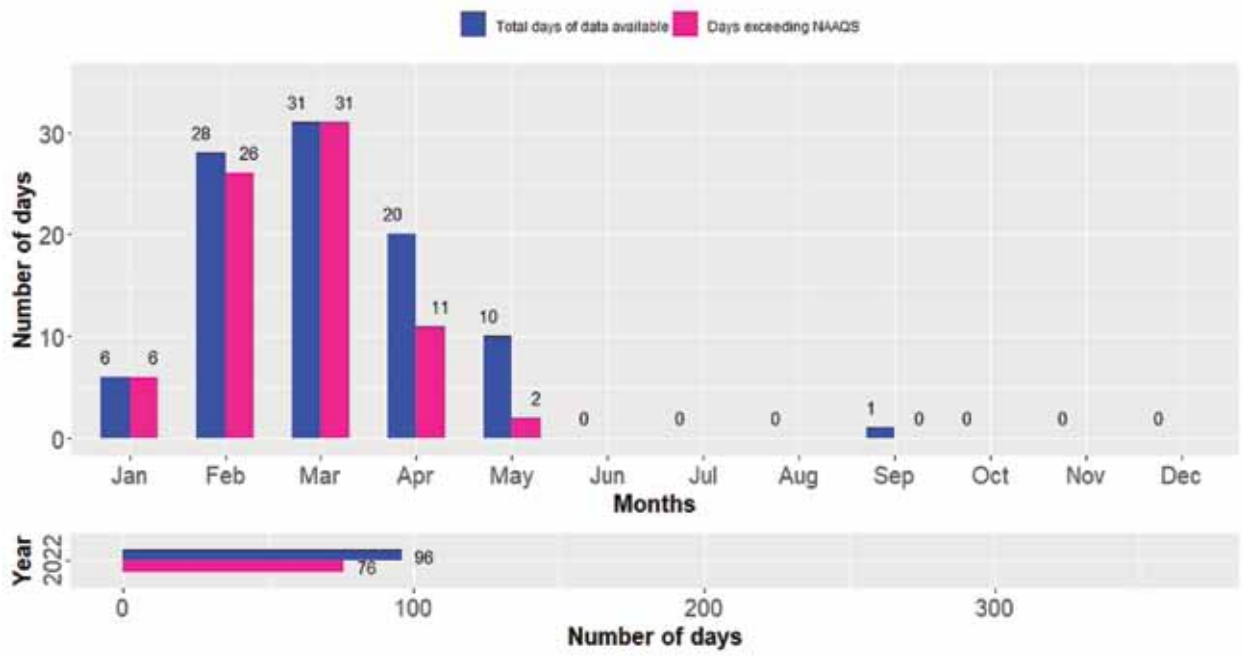

Figure 32: Compliance status of $PM_{2.5}$ for Bharatpur Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 33), out of the total 96 valid measurement days, the majority of days showed unhealthy AQI. Only one days (September 17) is in good condition.

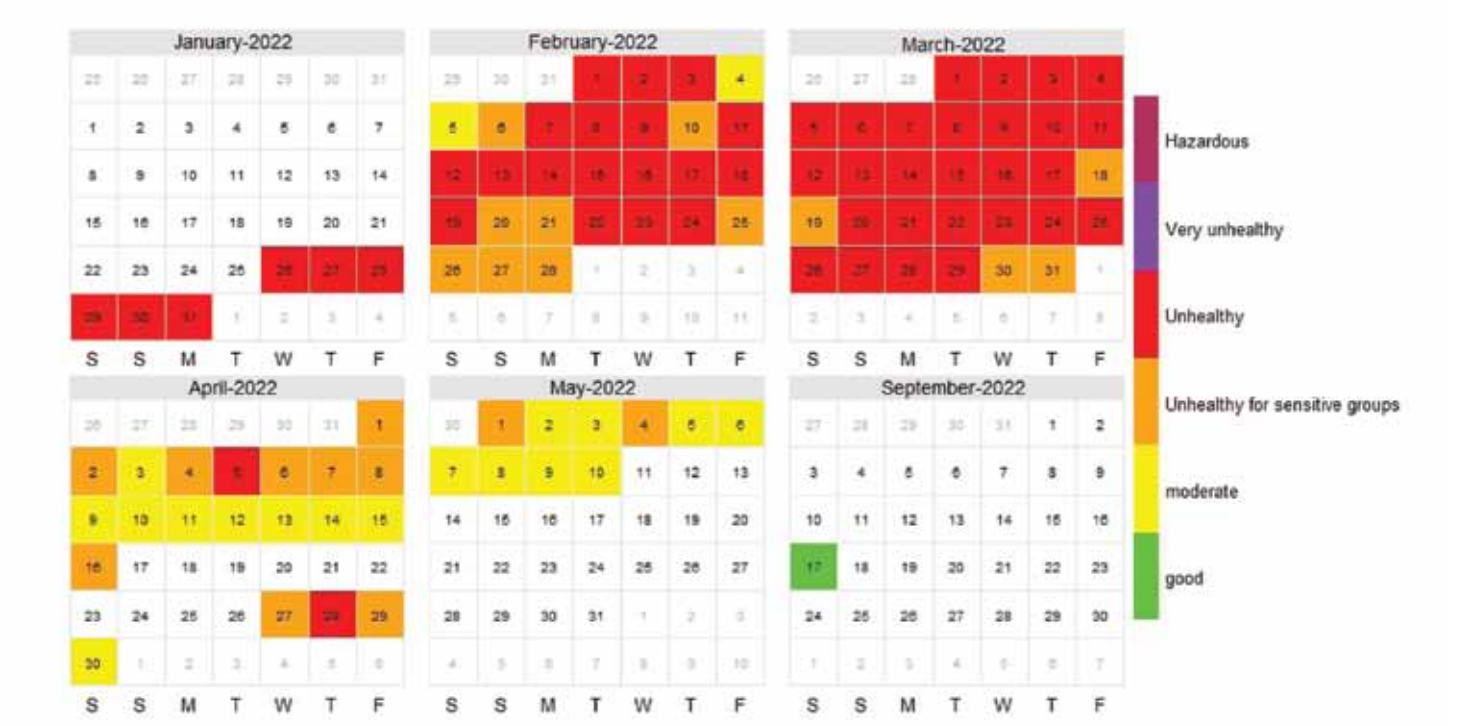

Figure 33: Calendar plot of $PM_{2.5}$ for Bharatpur Station

2.2.1.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 1.9 µg m^{-3} to 860.9 µg m^{-3}. The lowest and highest concentration of PM_{10} were observed on 17th September at 17:00 and 22nd February at 17:00. The statistical summary of the hourly average is presented in the table below:

Table 11: Summary of hourly average of PM_{10} for Bharatpur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.9 µg m^{-3}	68.6 µg m^{-3}	101.8 µg m^{-3}	113.4 ± 67.9 µg m^{-3}	144.5 µg m^{-3}	860.9 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-170) and as values increase, the frequency of observations decreases rapidly.

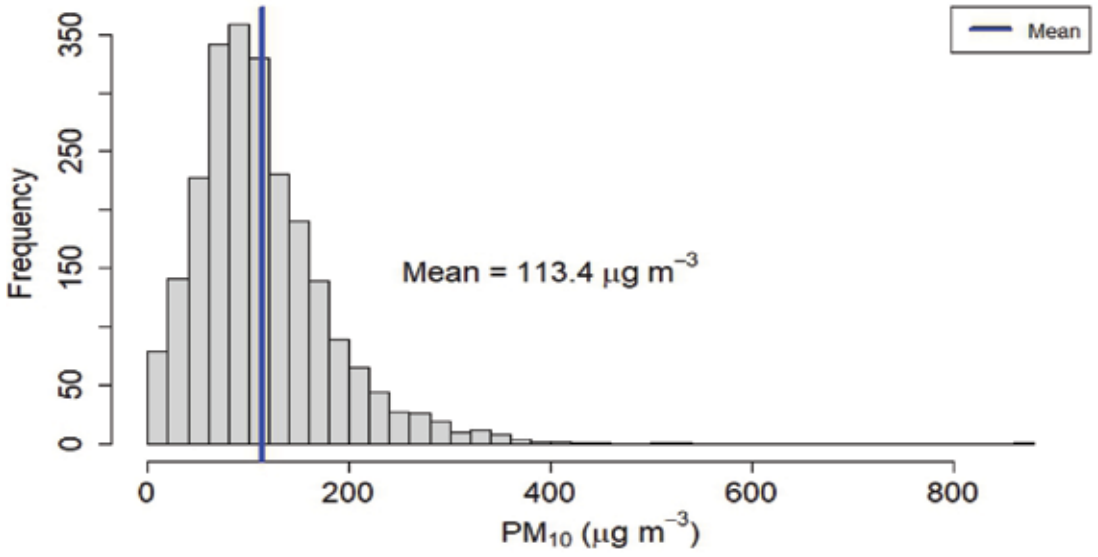

Figure 34: Histogram of PM_{10} for Bharatpur Station

Diurnal variation:

The hourly mean of PM_{10} progressively increases with time and reached its peaks at 19:00.

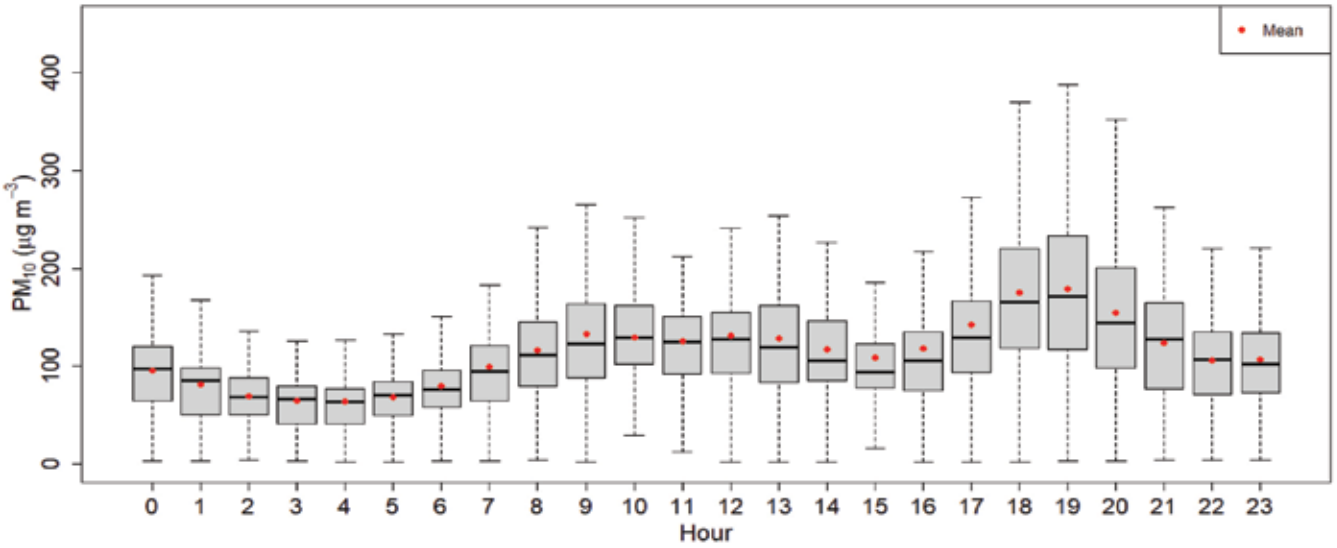

Figure 35: Diurnal variation of PM_{10} for Bharatpur Station

Monthly variation:

A high variation of PM_{10} concentration was seen during March, whereas less during September.

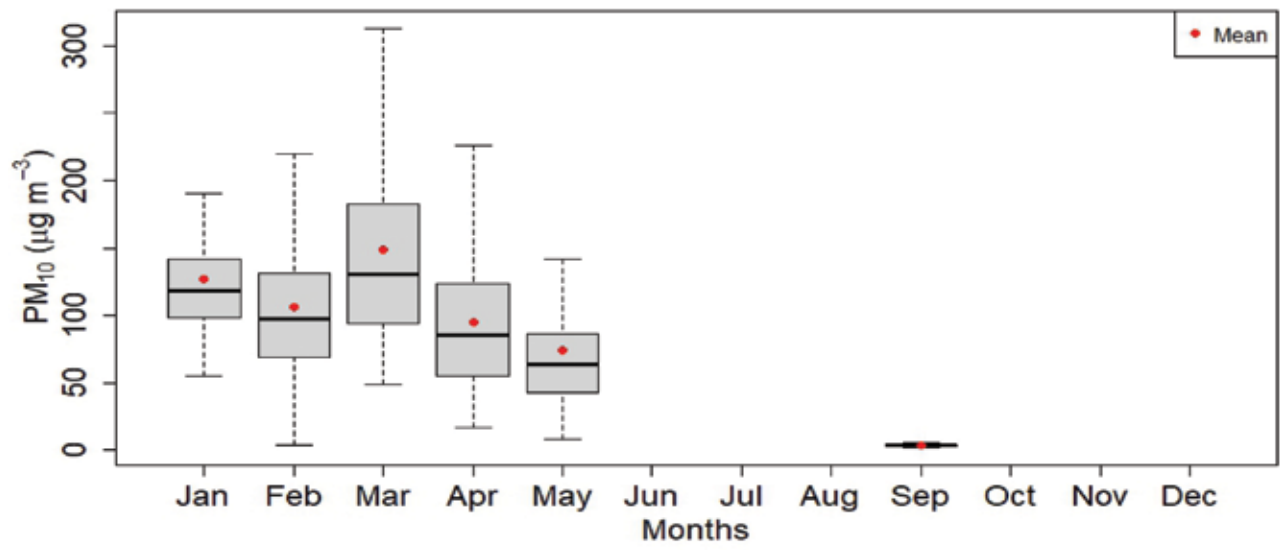

Figure 36: Monthly variation of PM_{10} for Bharatpur Station

Daily average:

The daily average data was available only for 96 days.

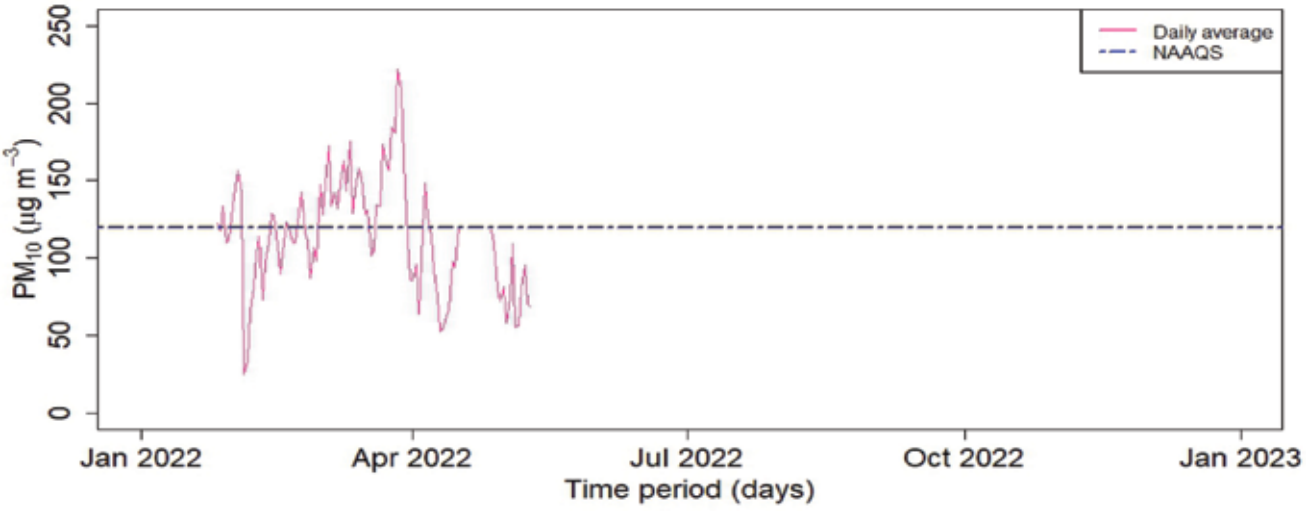

Figure 37: Daily average of PM_{10} for Bharatpur Station

Table 12: Summary of daily average of PM_{10} for Bharatpur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
3.4 µg m^{-3}	86.4 µg m^{-3}	113.2 µg m^{-3}	113.3 ± 38.7 µg m^{-3}	136.0 µg m^{-3}	222.2 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 3.4 µg m^{-3} to 222.2 µg m^{-3} on 18th September and127th March respectively (table 17). The majority of available PM_{10} concentration were found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of PM_{10}. The average concentration of $PM_{2.5}$ ranges from 92.6 µg m^{-3} in April to 148.5 µg m^{-3} in March.

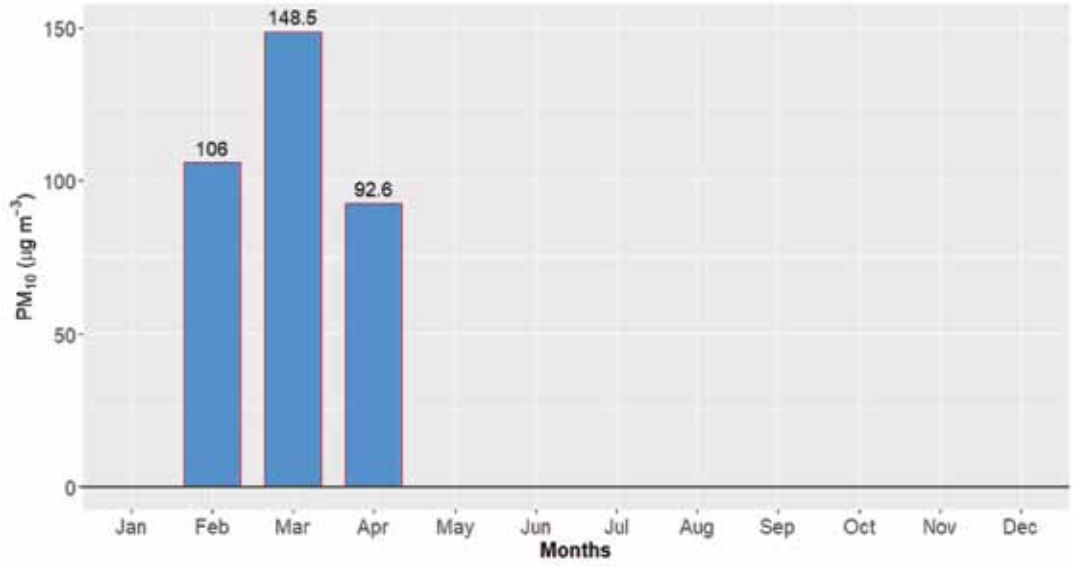

Figure 38: Monthly average of PM_{10} for Bharatpur Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}. Because of limited data, the averages of only one season- pre-monsoon (118.2 µg m^{-3}), is presented in the figure 39.

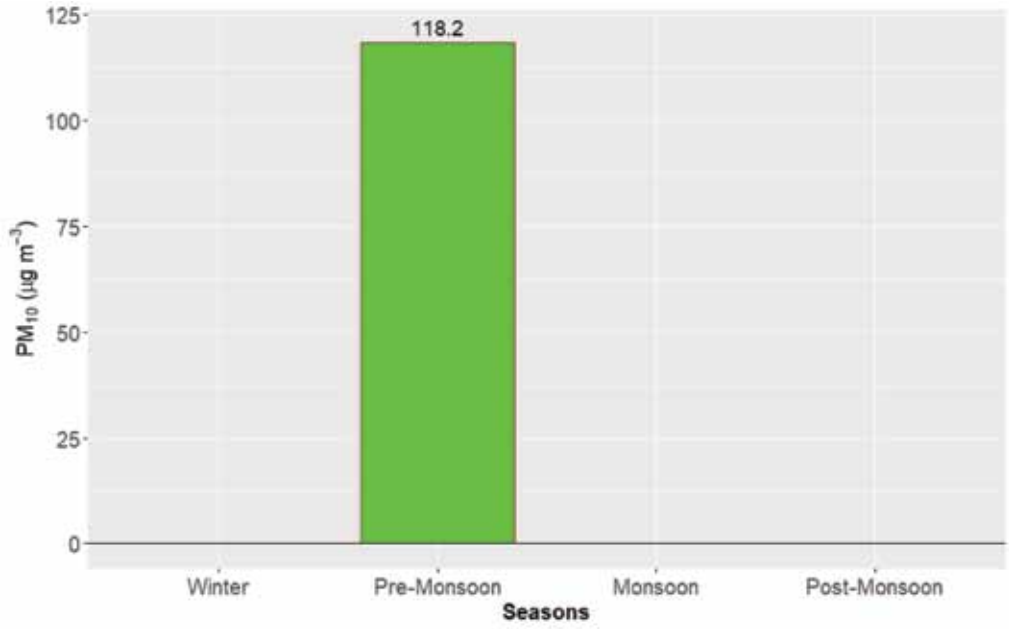

Figure 39: Seasonal average of PM_{10} for Bharatpur Station

Compliance status:

Out of the total 96 days of valid measurement, 41 days exceeded the NAAQS. Those noncompliance days were distributing in all four months (January to April) as shown in figure 40.

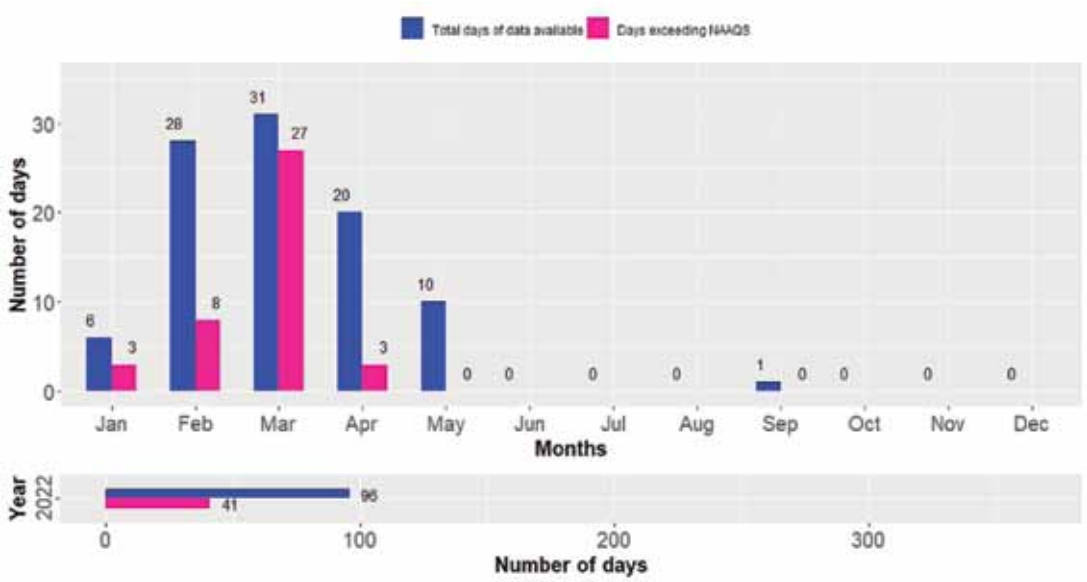

Figure 40: Compliance status of PM_{10} for Bharatpur Station

2.2.1.3 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 1.9 µg m^{-3} to 1307.7 µg m^{-3}. The lowest and the highest concentration of TSP was observed on 17th September at 17:00 and 4th March at 16:00. The statistical summary of the hourly average is presented in the table below:

Table 13: Summary of hourly average of TSP for Bharatpur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.9 µg m^{-3}	94.1 µg m^{-3}	175.1 µg m^{-3}	212.2 ± 157.8 µg m^{-3}	289.1 µg m^{-3}	1307.7 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-300) and as values increase, the frequency of observations decreases rapidly.

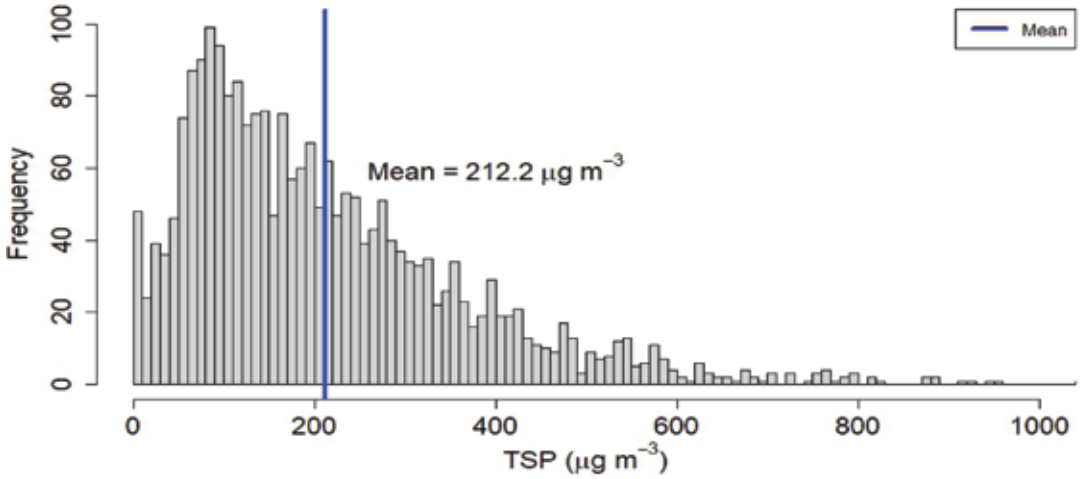

Figure 41: Histogram of TSP for Bharatpur Station

Diurnal variation:

The hourly mean of TSP progressively increases with time and reached to its peaks at 12:00 which again decreases slightly and gains height around 18:00.

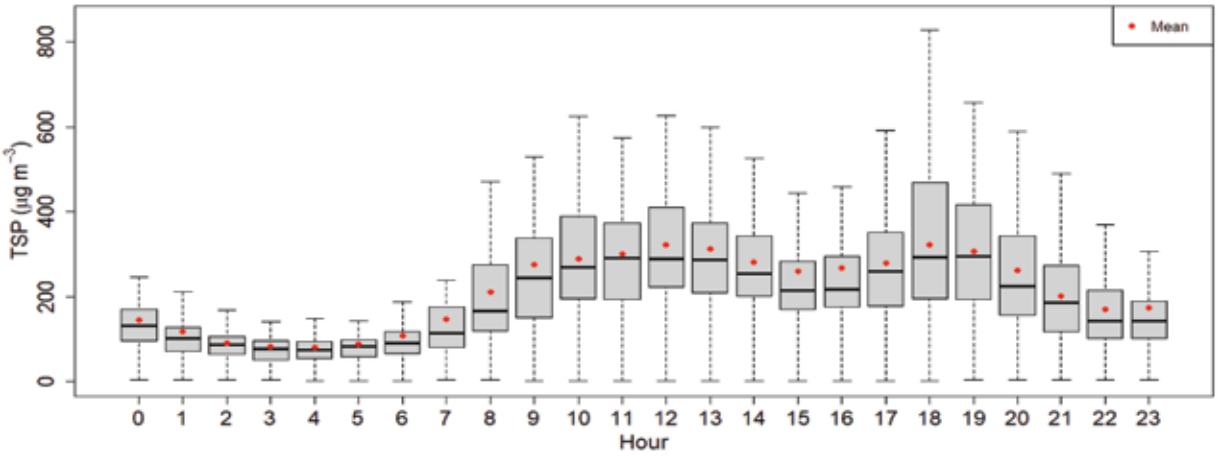

Figure 42: Diurnal variation of TSP for Bharatpur Station

Monthly variation:

A high variation of TSP concentration was seen during March, whereas less during September.

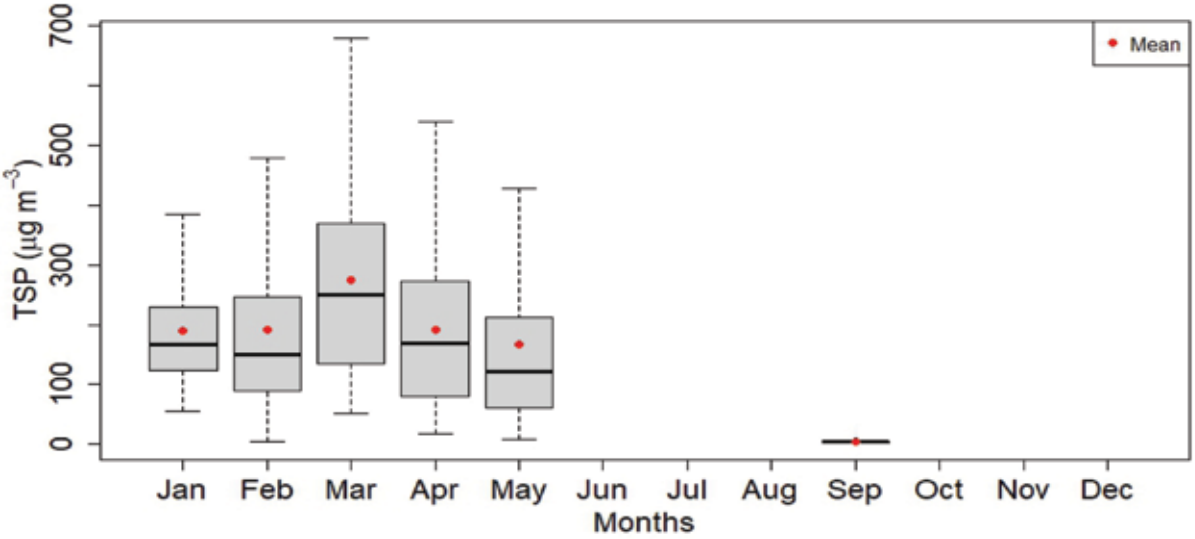

Figure 43: Monthly variation of TSP for Bharatpur Station

2.2.1.4 TIME AVERAGED DATA ANALYSIS FOR TSP

Daily average:

The daily average data was available only for 96 days.

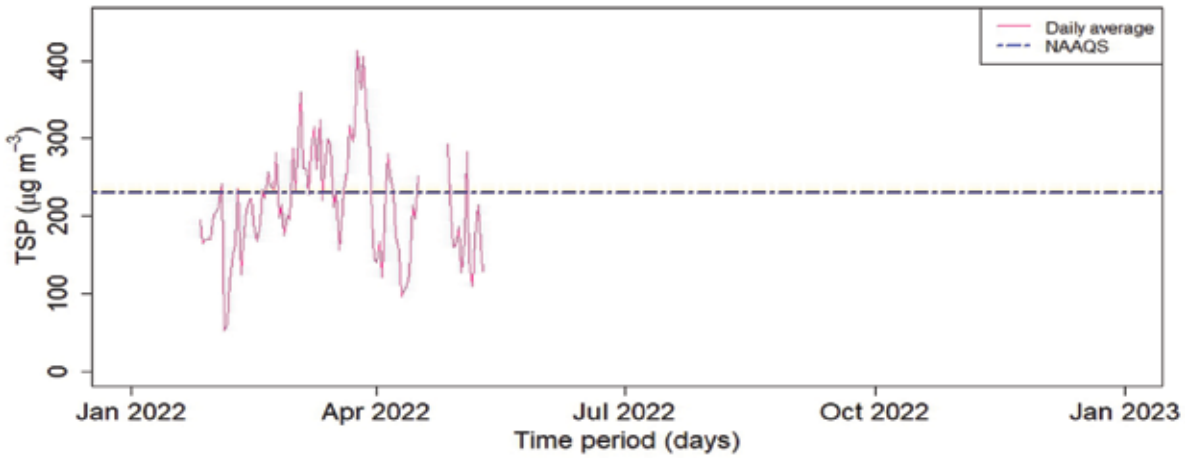

Figure 44: Daily average of TSP for Bharatpur Station

Table 14: Summary of daily average of TSP for Bharatpur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
4.0 µg m^{-3}	165.4 µg m^{-3}	211.7 µg m^{-3}	212.5 ± 73.5 µg m^{-3}	259.4 µg m^{-3}	413.7 µg m^{-3}

Within the available data, the lowest and highest concentration of TSP was found to be 4.0 µg m^{-3} to 413.7 µg m^{-3} on 17th September and 25th March respectively (table 20). The majority of available TSP concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. The average concentration of $PM_{2.5}$ ranges from 184.9 µg m^{-3} in April to 275.8 µg m^{-3} in March.

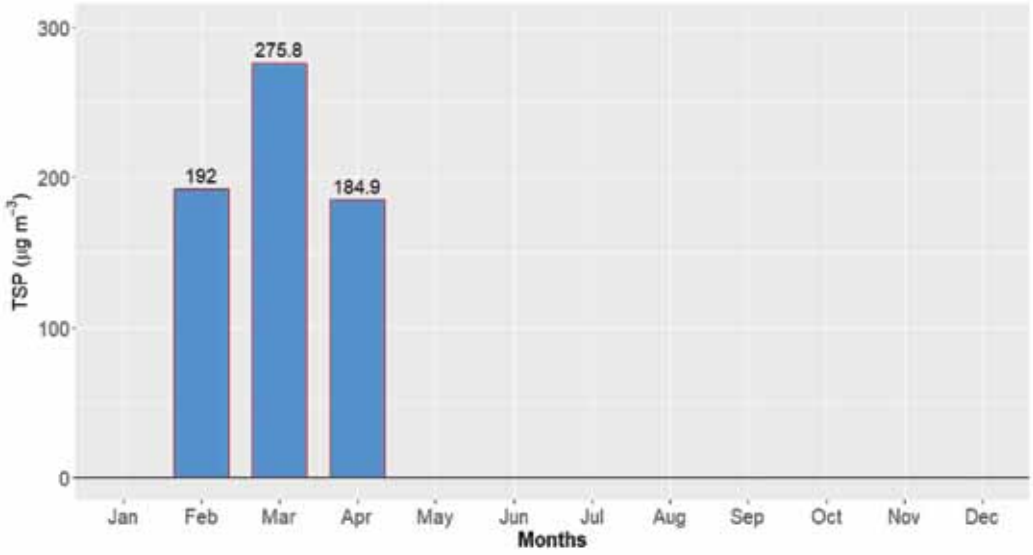

Figure 45: Monthly average of TSP for Bharatpur Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP. Because of limited data, the averages of only one season- pre-monsoon (228.7 µg m^{-3}), was presented in the figure 46.

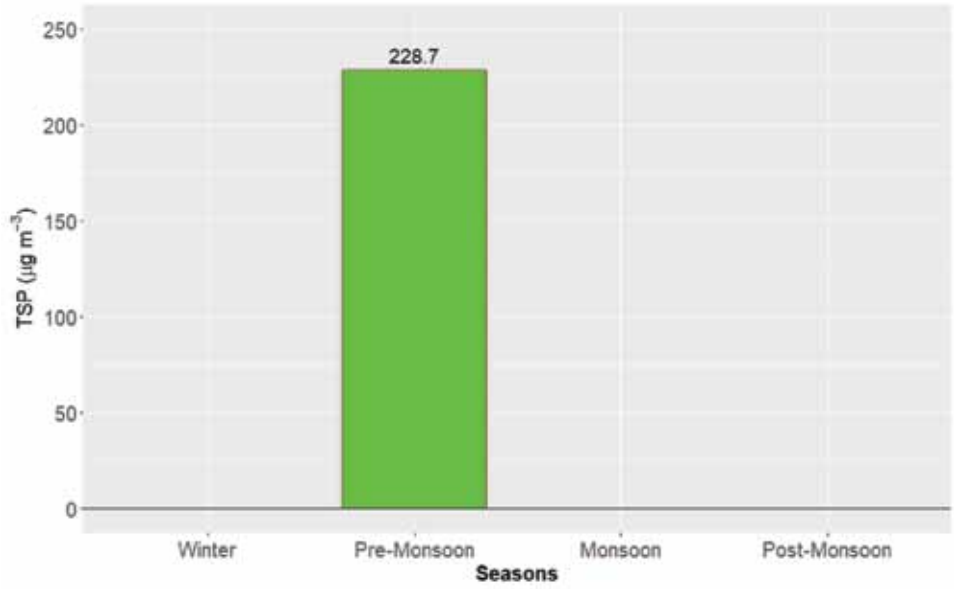

Figure 46: Seasonal average of TSP for Bharatpur Station

Compliance status:

Out of the total 96 days of valid measurement, 38 days exceeded the NAAQS. Those noncompliance days were distributed from January to May months as shown in figure 47.

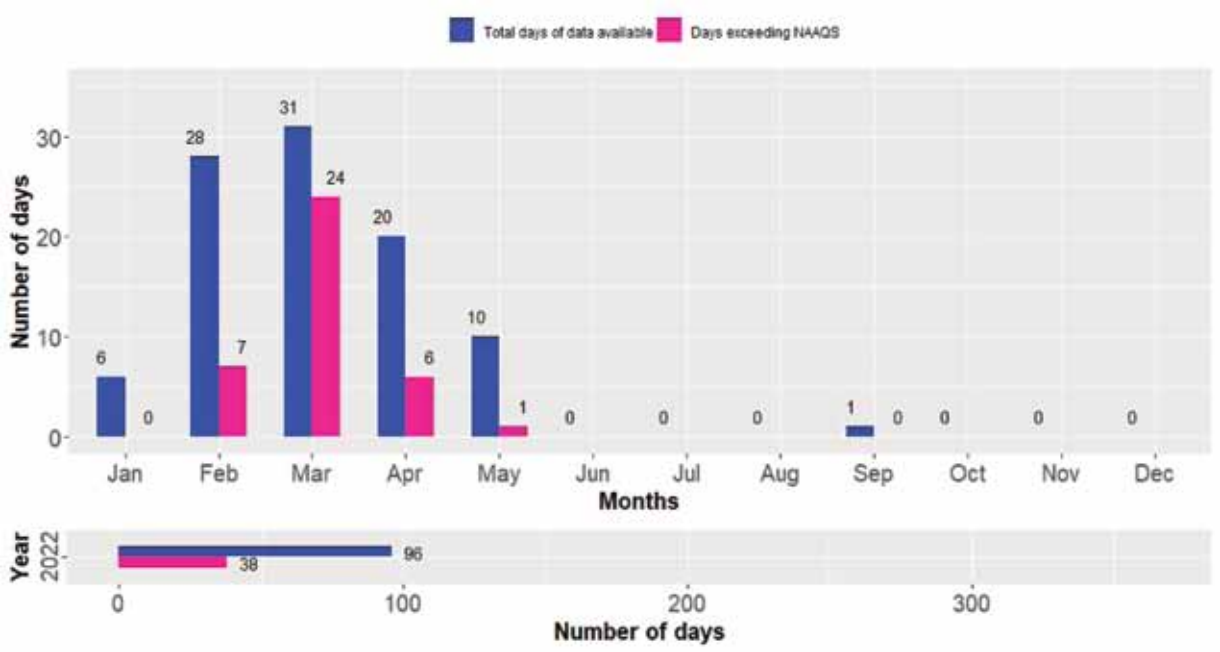

Figure 47: Compliance status of TSP for Bharatpur Station

2.2.2 HETAUDA AIR QUALITY MONITORING STATION

Hetauda air quality monitoring station was established in 2020 at Hetauda sub metropolitan city in Makawanpur district, Bagmati Province. This station is located adjacent to the office of ward number 4, on the football ground at Hupra chaur by the side of the road. This station represents the urban area.

Emission from the vehicles and industries are the main sources of pollution in the area around the station. Dust from the football ground might also contribute to the particulate measured by this station.

2.2.2.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 1.1 µg m^{-3} to 178.6 µg m^{-3}. The lowest and highest concentration of $PM_{2.5}$ was observed on 22nd July at 16:00 and 30th April at 4:00. The statistical summary of the hourly average is presented in the table below:

Table 15: Summary of hourly average of $PM_{2.5}$ for Hetauda Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 µg m^{-3}	5.5 µg m^{-3}	11.5 µg m^{-3}	13.8 ± 11.9 µg m^{-3}	18.7 µg m^{-3}	178.6 µg m^{-3}

Histogram

The dataset is clustered on the lower end of values (0-20) and as values increase, the frequency of observations decreases rapidly.

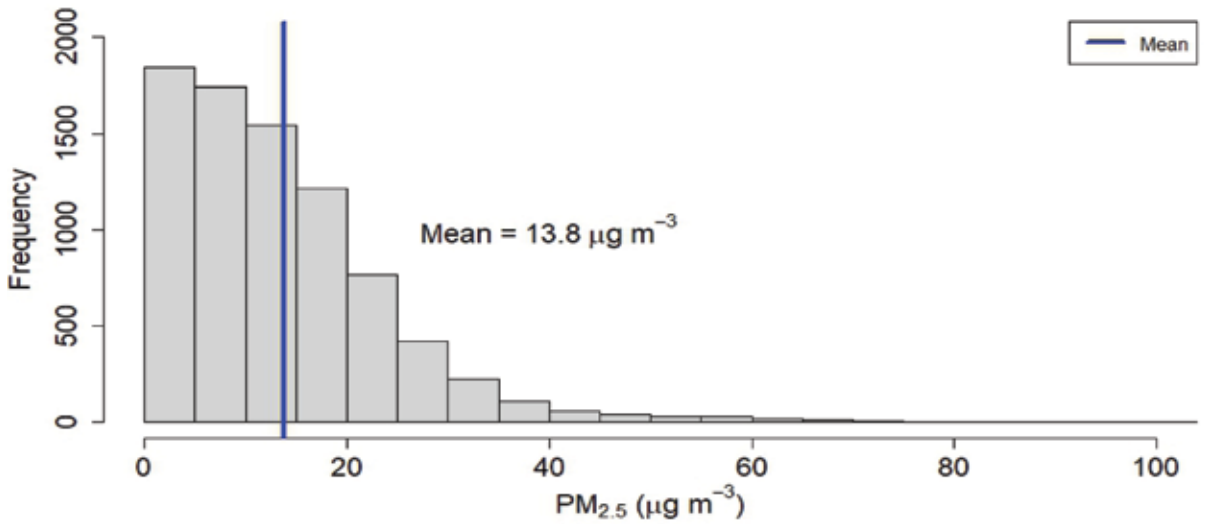

Figure 48: Histogram of $PM_{2.5}$ for Hetauda Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ reached to its peak at 7:00-8:00 which progressively decreases and gains height around 18:00-23:00 which remain almost consistent throughout the time. The mean value was more than the median throughout the day.

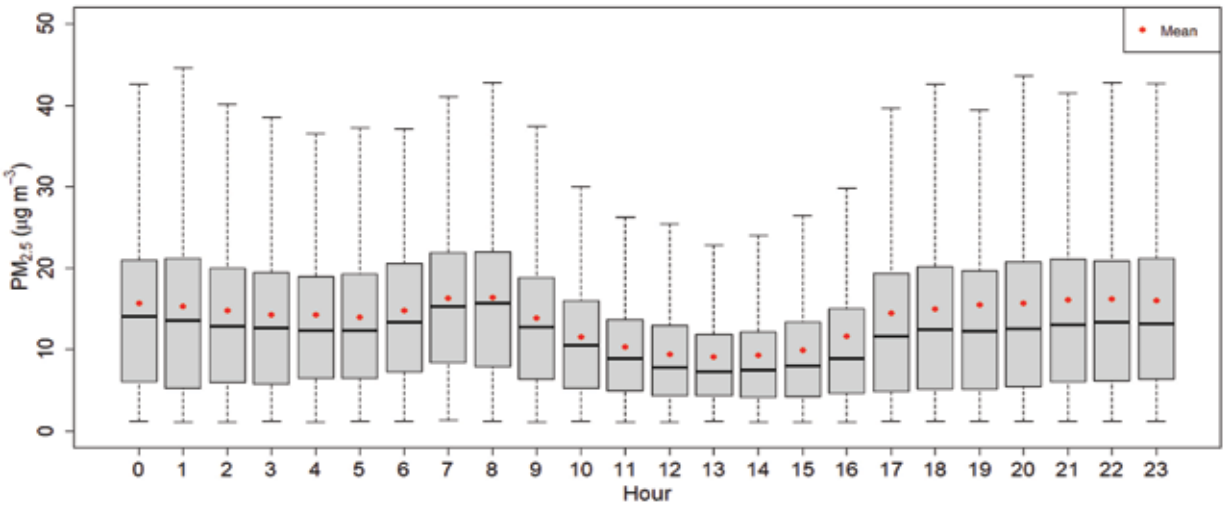

Figure 49: Diurnal variation of $PM_{2.5}$ for Hetauda Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during December, whereas less during September.

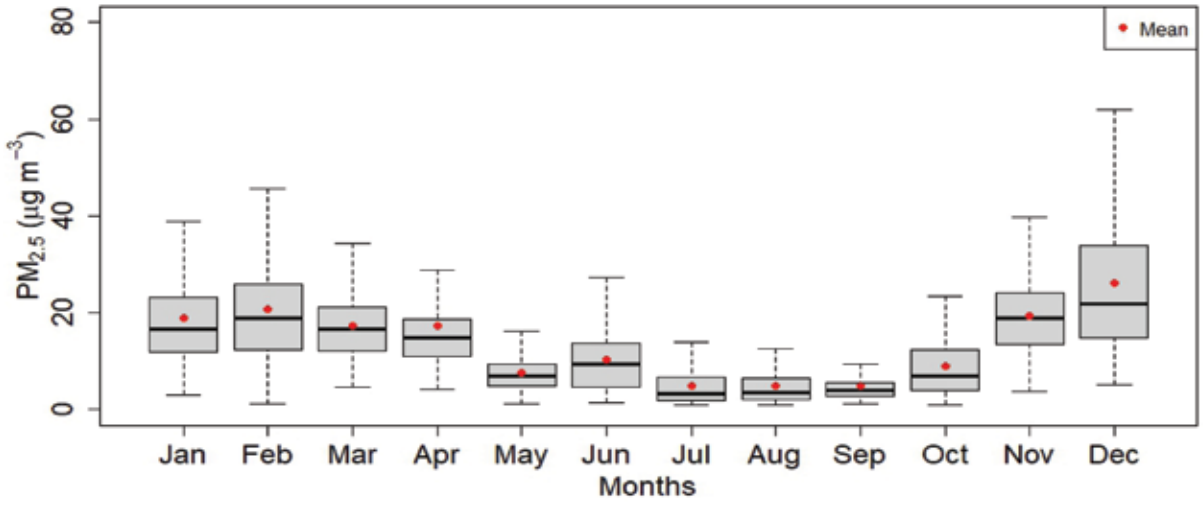

Figure 50: Monthly variation of $PM_{2.5}$ for Hetauda Station

Daily average:

The daily average data was available for 313 days. Figure 51 explains the daily trend of $PM_{2.5}$ throughout the year.

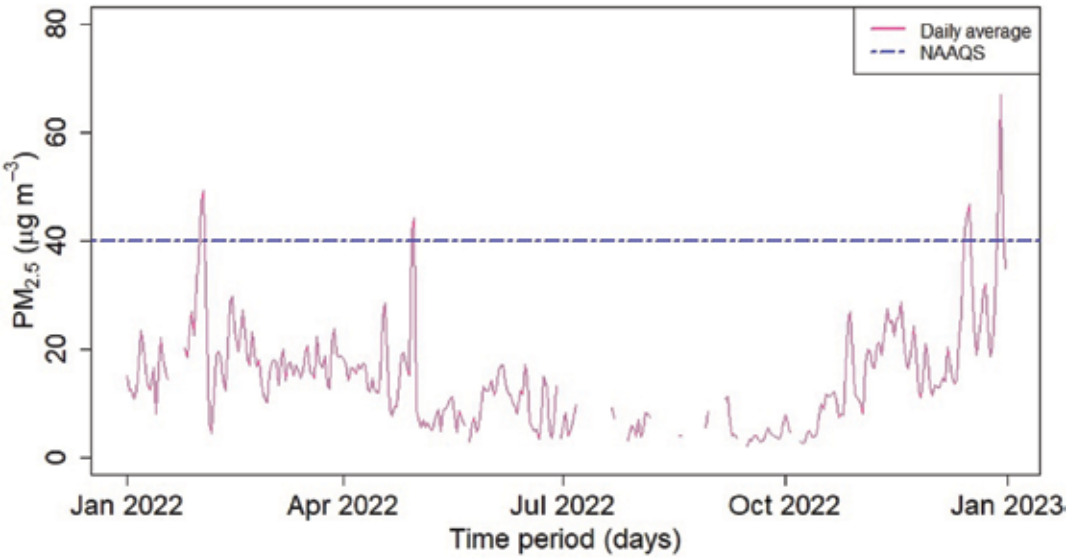

Figure 51: Daily average of $PM_{2.5}$ for Hetauda Station

Table 16: Summary of daily average of $PM_{2.5}$ for Hetauda Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.1 µg m^{-3}	7.2 µg m^{-3}	13.2 µg m^{-3}	14.5 ± 9.5 µg m^{-3}	18.7 µg m^{-3}	66.9 µg m^{-3}

Within the available data, the lowest and highest concentration of $PM_{2.5}$ was found to be 2.1 µg m^{-3} to 66.9 µg m^{-3} on 15th September and 29th December respectively (table 23). In majority of days, daily average $PM_{2.5}$ concentration was found within NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. The average concentration of $PM_{2.5}$ ranges from 4.7 µg m^{-3} to 26.2 µg m^{-3} in September and December respectively.

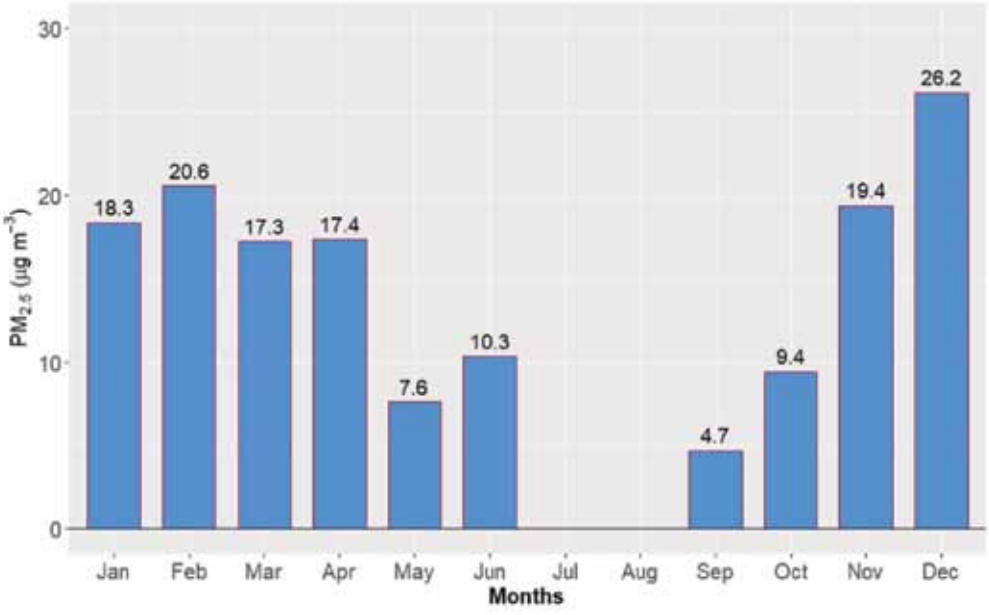

Figure 52: Monthly average of $PM_{2.5}$ for Hetauda Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. The highest concentration of $PM_{2.5}$ was found during winter season (19.5 µg m^{-3}) followed by pre-monsoon (14.6 µg m^{-3}). Concentration of $PM_{2.5}$ was found the least during monsoon season (7.1 µg m^{-3}) as presented in the figure 53.

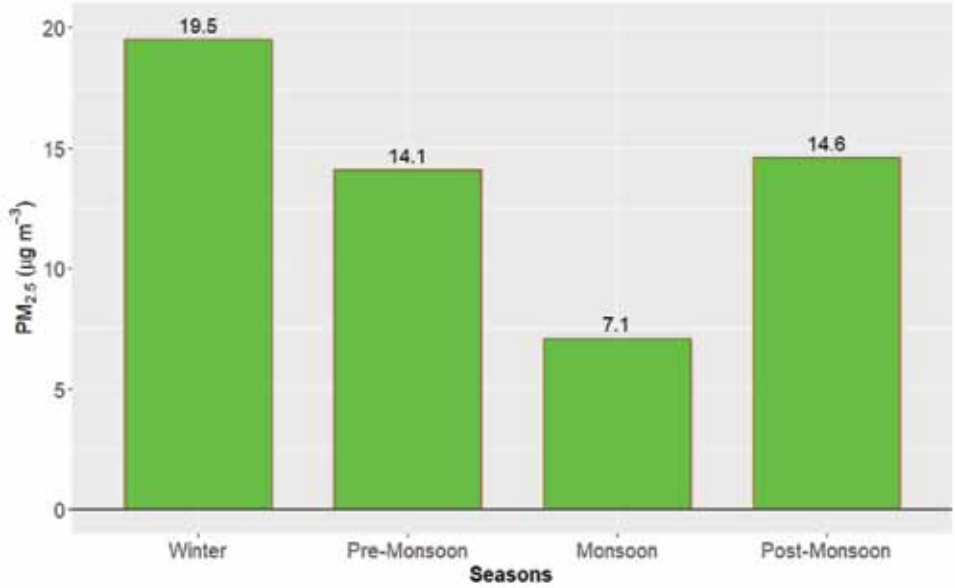

Figure 53: Seasonal average of $PM_{2.5}$ for Hetauda Station

Compliance status:

Out of the total 313 days of valid measurement, only 9 days exceeded the NAAQS. Those noncompliance days were included in February, April and December as shown in figure 54.

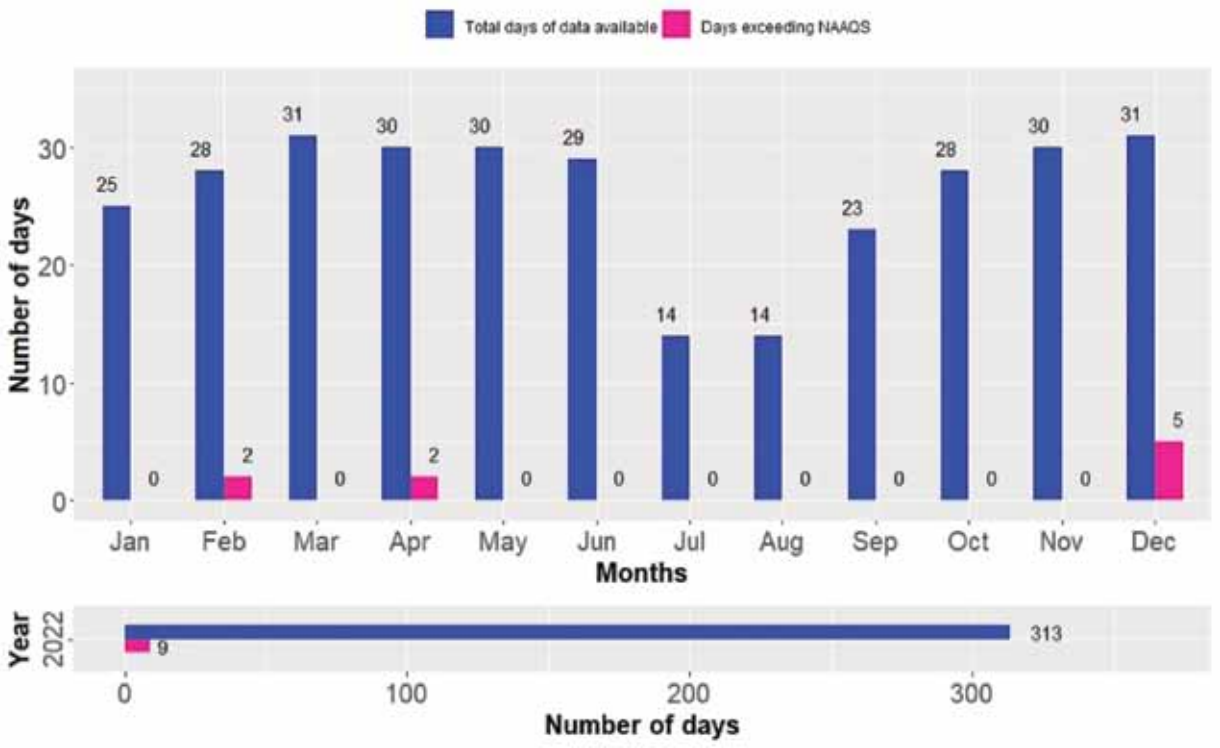

Figure 54: Compliance status of $PM_{2.5}$ for Hetauda Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 55), out of the total 313 valid measured days, the majority of days showed an AQI of good to moderate. Single day in December 29 reached an unhealthy state. Few days in February, April and December were also found to be unhealthy for the sensitive group.

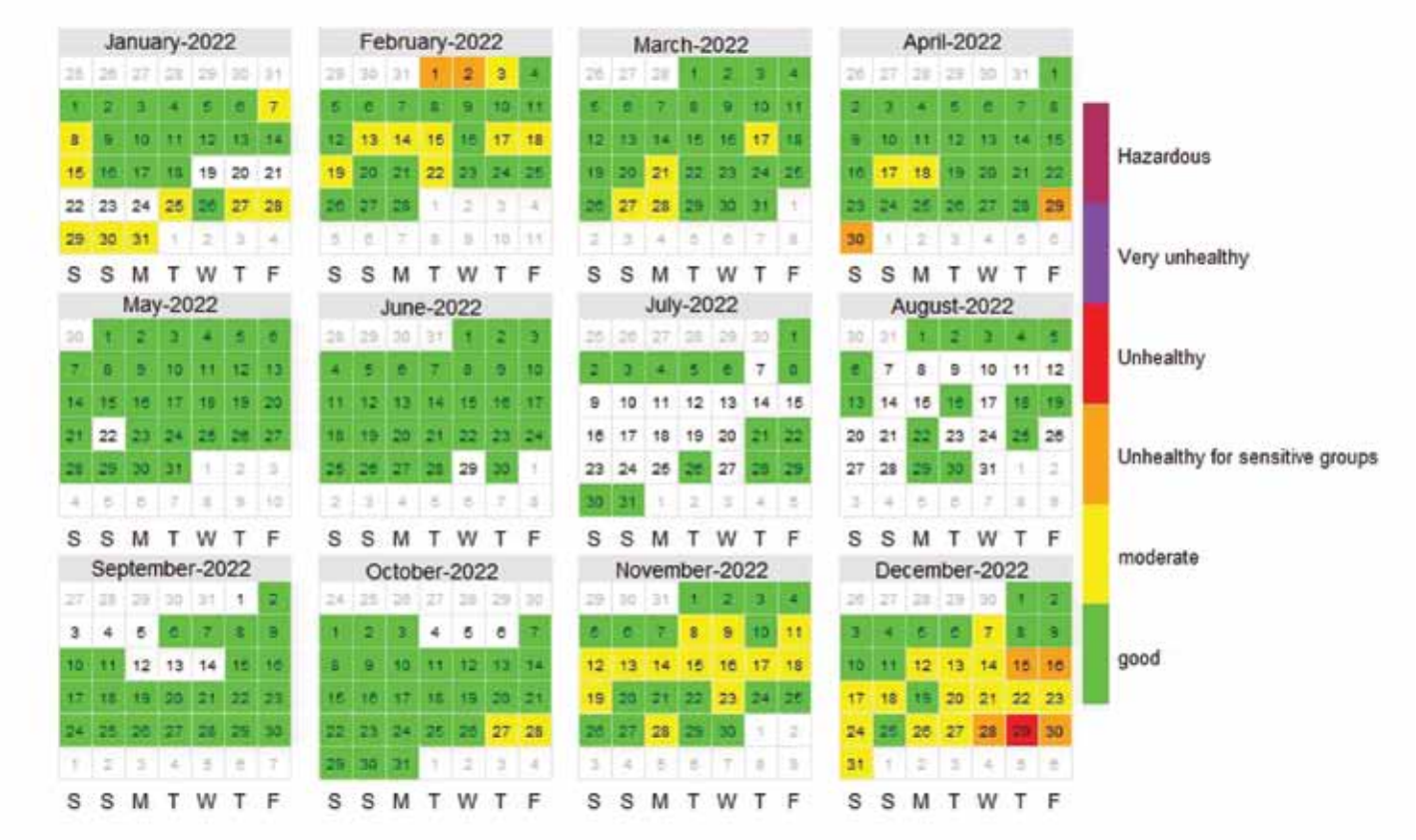

Figure 55: Calendar plot of $PM_{2.5}$ for Hetauda Station

2.2.2.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 1.1 µg m^{-3} to 289.9 µg m^{-3}. The lowest and highest concentration of PM_{10} were observed on 15th July at 4:00 and 29th April at 14:00. The statistical summary of the hourly average is presented in the table below

Table 17: Summary of hourly average of PM_{10} for Hetauda Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 µg m^{-3}	6.1 µg m^{-3}	13.0 µg m^{-3}	15.7 ± 14.1 µg m^{-3}	20.9 µg m^{-3}	289.9 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-30) and as values increase, the frequency of observations decreases rapidly.

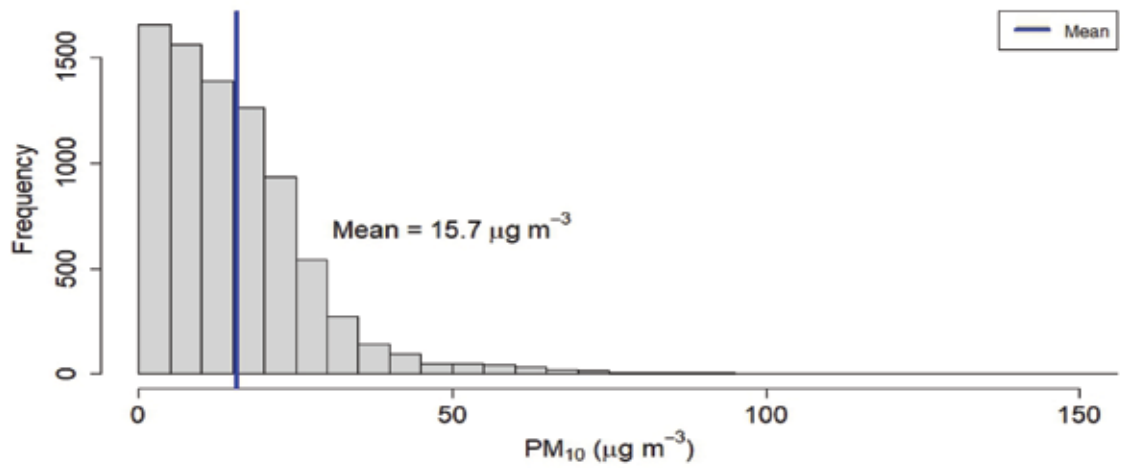

Figure 56: Histogram of PM_{10} for Hetauda Station

Diurnal variation:

The hourly mean of PM_{10} reached its peaks at 8:00 which again decreases and gains height at 17:00.

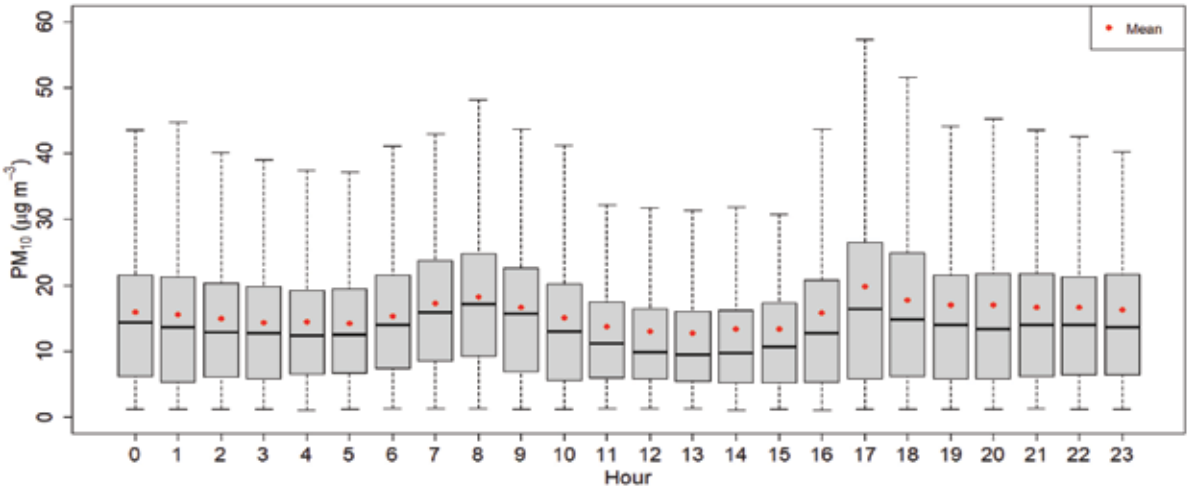

Figure 57: Diurnal variation of PM_{10} for Hetauda Station

Monthly variation:

A high variation of PM_{10} concentration was seen during December, whereas less during September.

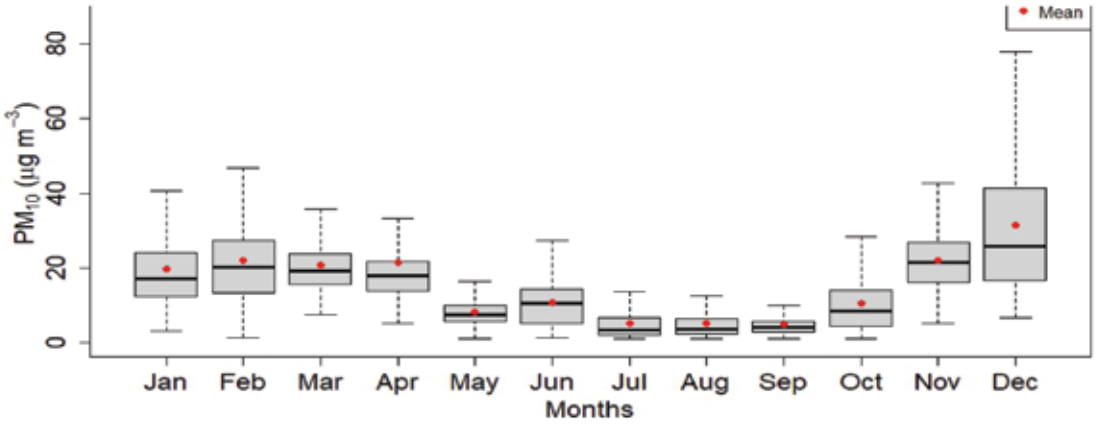

Figure 58: Monthly variation of PM_{10} for Hetauda Station

2.2.2.3 TIME AVERAGED DATA ANALYSIS FOR PM_{10}

Daily average:

The daily average data was available only for 315 days. Figure 59 explains the daily trend of PM_{10} throughout the year.

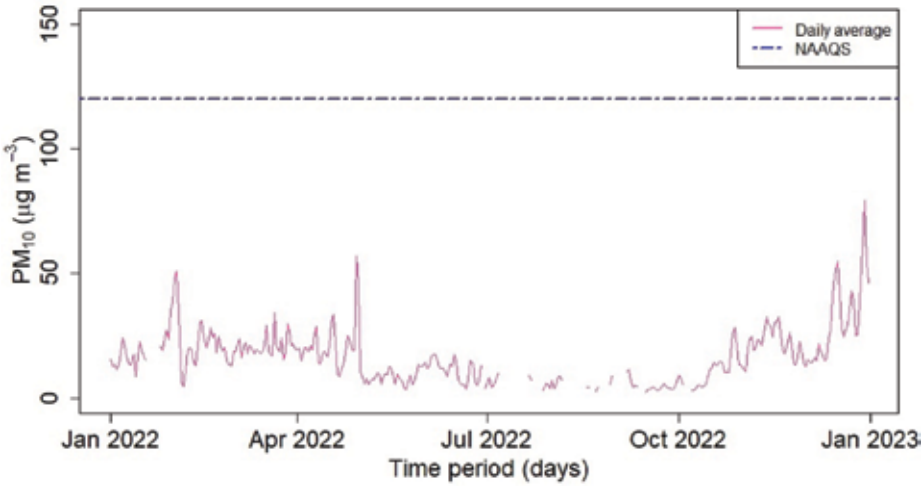

Figure 59: Daily average of PM_{10} for Hetauda Station

Table 18: Summary of daily average of PM_{10} for Hetauda Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.2 µg m^{-3}	7.6 µg m^{-3}	14.8 µg m^{-3}	16.4 ± 11.2 µg m^{-3}	20.9 µg m^{-3}	79.5 µg m^{-3}

Within the available data, the lowest and the highest daily average concentration of PM_{10} was found to be 2.2 µg m^{-3} to 79.5 µg m^{-3} on 15th September and 29th December respectively (table 26). The total available PM_{10} concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of PM_{10}. The average concentration of PM_{10} ranges from 4.9 µg m^{-3} in September to 31.3 µg m^{-3} in December.

Figure 60: Monthly average of PM_{10} for Hetauda Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}.The highest concentration of PM_{10} was found during winter season (35 µg m^{-3}) followed by pre-monsoon (16.8 µg m^{-3}), post-monsoon (16.7 µg m^{-3}) and monsoon (7.3 µg m^{-3}) as presented in the figure 61.

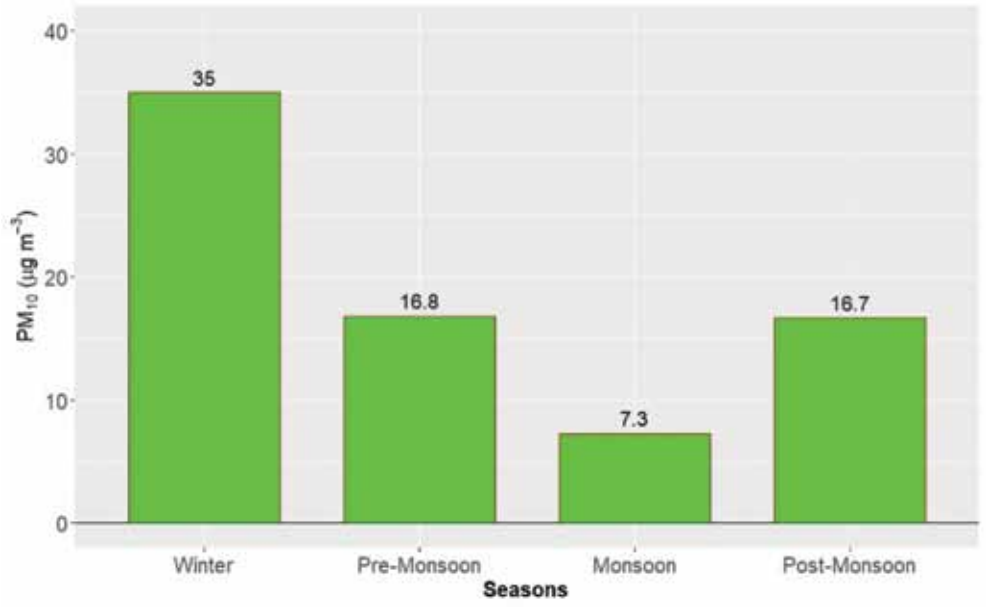

Figure 61: Seasonal average of PM_{10} for Hetauda Station

Compliance status:

Out of the total 315 days of measurement, none of the day exceeded the NAAQS as shown in figure 62.

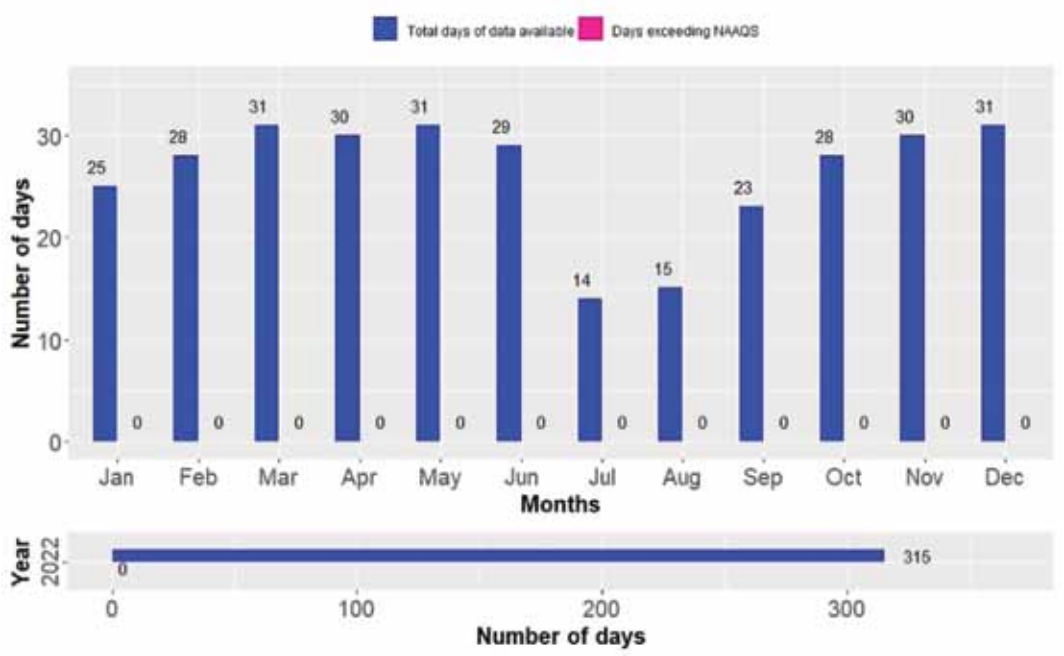

Figure 62: Compliance status of PM_{10} for Hetauda Station

2.2.2.4 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 1.1 μg m^{-3} to 584.7 μg m^{-3}. The lowest and the highest concentration of TSP were observed on 15th July at 4:00 and 29th April at 14:00. The statistical summary of the hourly average is presented in the table below:

Table 19: Summary of hourly average of TSP for Hetauda Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 μg m^{-3}	6.8 μg m^{-3}	14.7 μg m^{-3}	18.5 ± 20.5 μg m^{-3}	23.7 μg m^{-3}	584.7 μg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-25) and as values increase, the frequency of observations decreases rapidly.

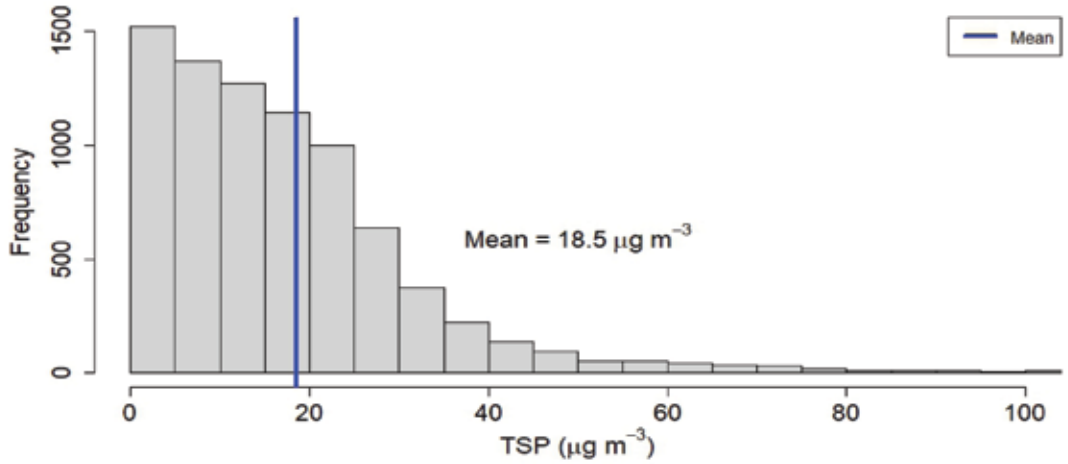

Figure 63: Histogram of TSP for Hetauda Station

Diurnal variation:

The hourly mean of TSP reached to its peaks at 8:00 which again decreases and gains height at 17:00.

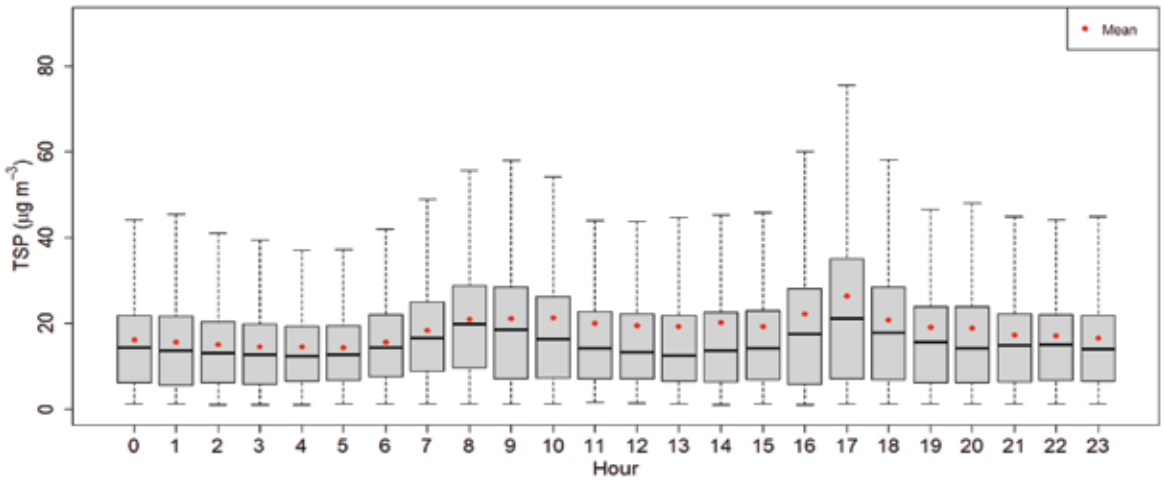

Figure 64: Diurnal variation of TSP for Hetauda Station

Monthly variation:

A high variation of TSP concentration was seen during December, whereas less during September.

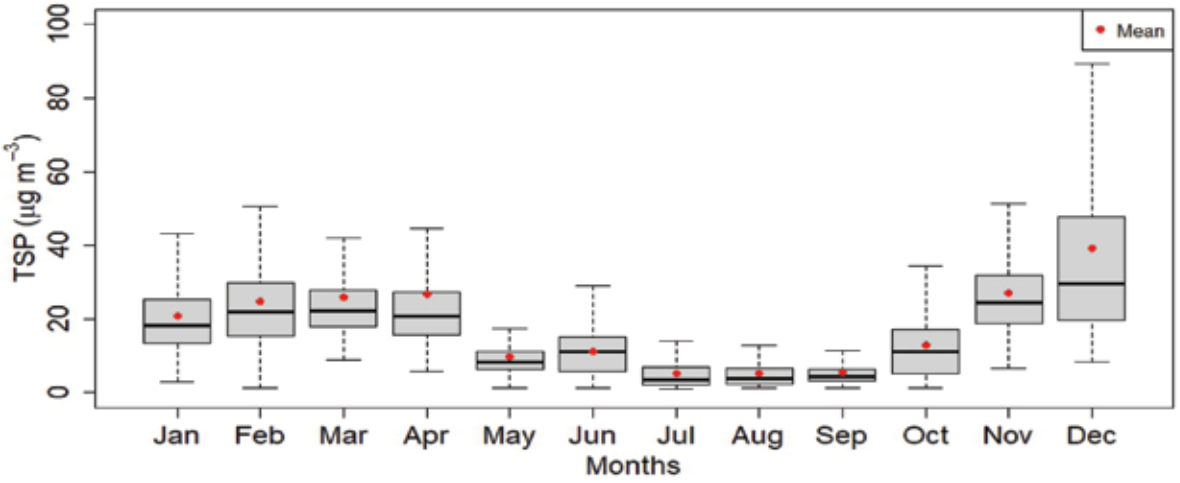

Figure 65: Monthly variation of TSP for Hetauda Station

Daily average:

The daily average data was available for 315 days. Figure 66 explains the daily trend of TSP throughout the year.

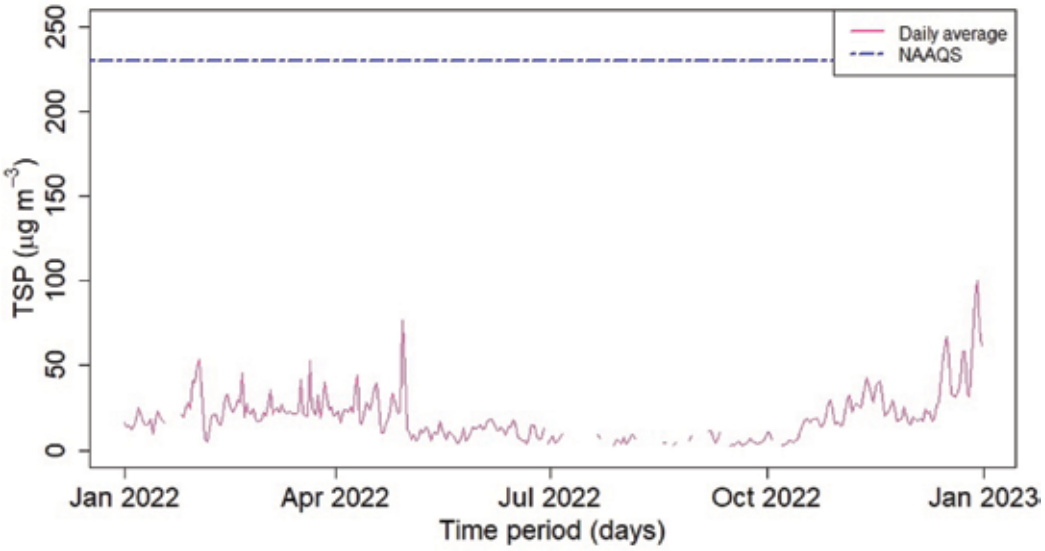

Figure 66: Daily average of TSP for Hetauda Station

Table 20: Summary of daily average of TSP for Hetauda Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.2 µg m^{-3}	8.9 µg m^{-3}	17.3 µg m^{-3}	19.5 ± 14.3 µg m^{-3}	24.7 µg m^{-3}	100.2 µg m^{-3}

Within the available data, the lowest and highest daily average concentration of TSP was found to be 2.2 µg m^{-3} to 100.2 µg m^{-3} on 15th September and 29th December respectively (table 29). The total available TSP concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. The average concentration of TSP ranges from 5.6 µg m^{-3} in September to 39.3 µg m^{-3} in December.

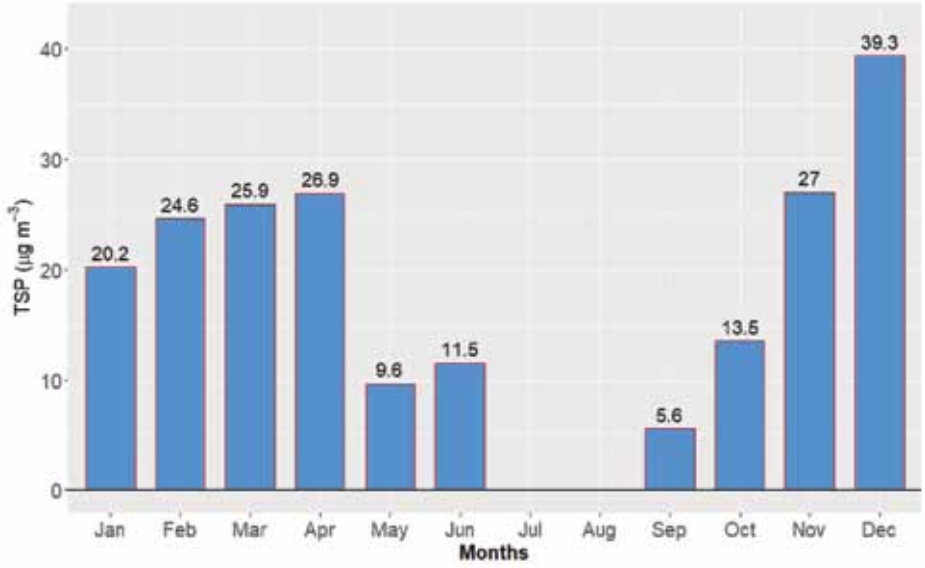

Figure 67: Monthly average of TSP for Hetauda Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP. The highest concentration of TSP is found during winter season (44.1 µg m^{-3}) followed by pre-monsoon (20.7 µg m^{-3}). Concentration of TSP was found the least during monsoon season (7.8 µg m^{-3}) as presented in the figure 68.

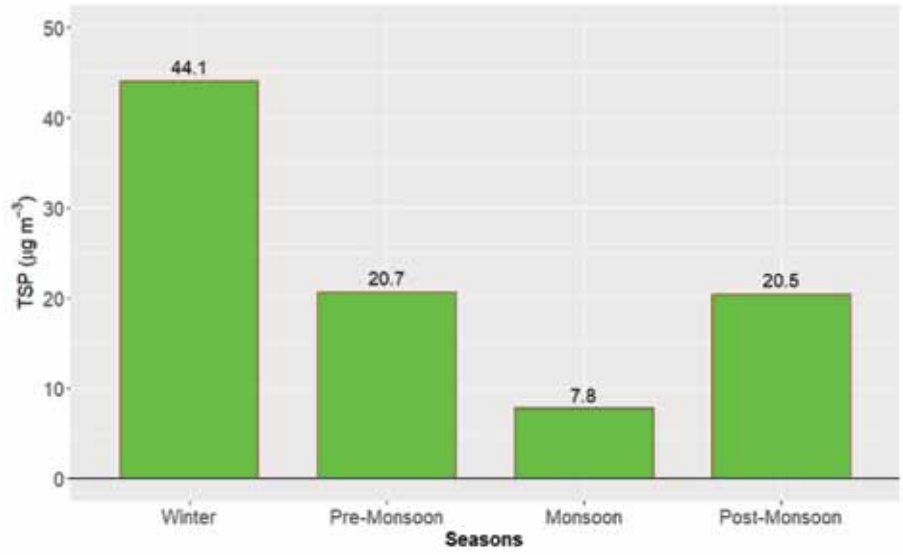

Figure 68: Seasonal average of TSP for Hetauda Station

Compliance status:

Out of the total 315 days of measurement, none of the day exceeded the NAAQS as shown in figure 69.

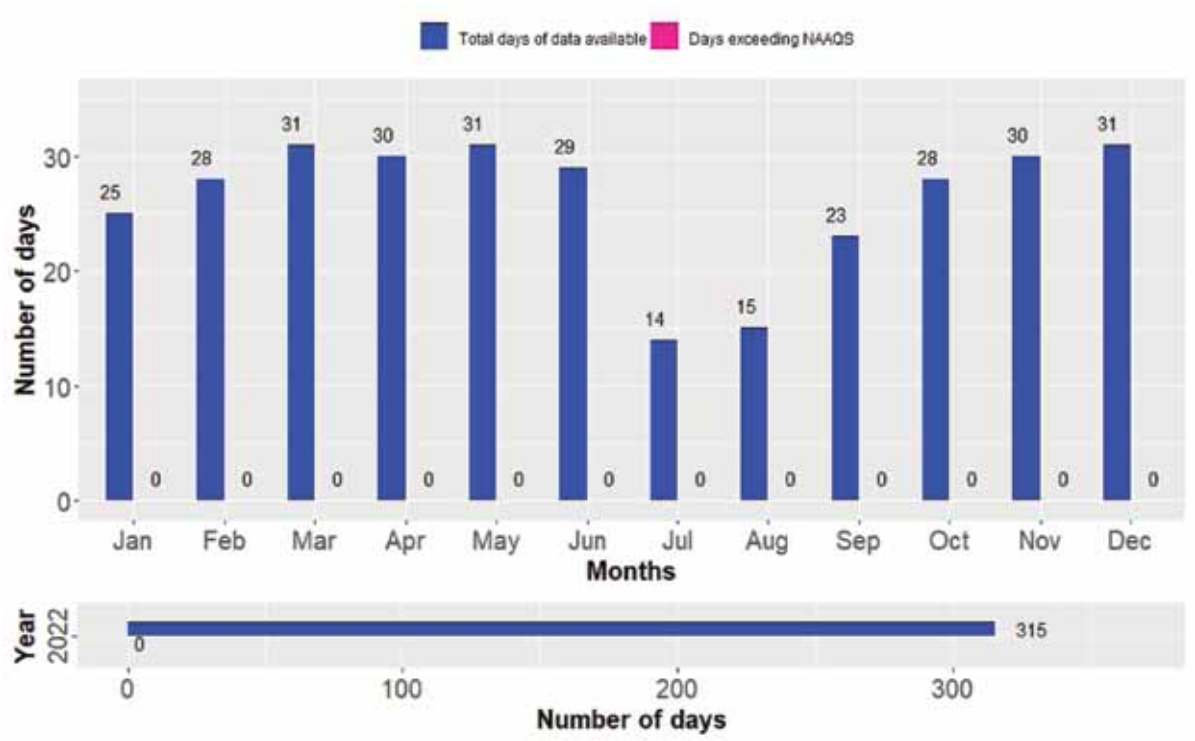

Figure 69: Compliance status of TSP for Hetauda Station

2.2.3 KHUMALTAR AIR QUALITY MONITORING STATION

Khumaltar air quality monitoring station is established in 2022 at Lalitpur Municipality in Lalitpur district, Bagmati Province. It is located at rooftop of ICIMOD building and represents the urban area.

Emission from the vehicles is the main source of pollution in this area. Occasional construction activities around the area also contribute to the particulate matter measured by this station.

2.2.3.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 1.4 µg m^{-3} to 185.4 µg m^{-3}. The lowest and highest concentration of $PM_{2.5}$ was observed on 2nd August at 14:00 and 28th March at 7:00. The statistical summary of the hourly average is presented in the table below:

Table 21: Summary of hourly average of $PM_{2.5}$ for Khumaltar Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.4 µg m^{-3}	15.3 µg m^{-3}	32.0 µg m^{-3}	38.1 ± 27.5 µg m^{-3}	53.7 µg m^{-3}	185.4 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (10-55) and as values increase, the frequency of observations decreases rapidly.

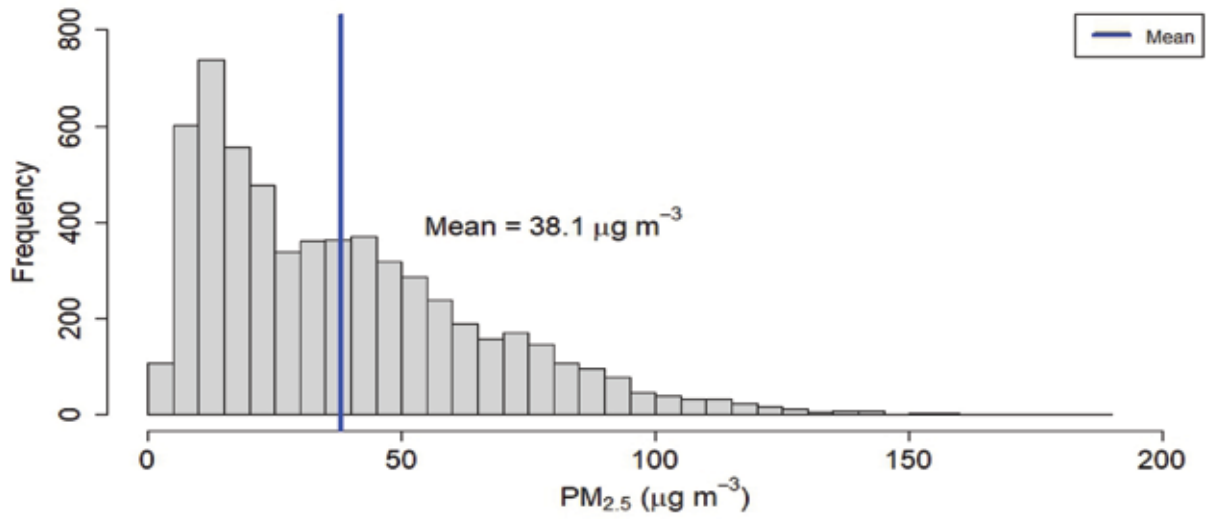

Figure 70: Histogram of $PM_{2.5}$ for Khumaltar Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ progressively increases with time and reached to its peak at 7:00 which again decreases and gains height after 19:00-20:00. The mean value was slightly more than median throughout the day.

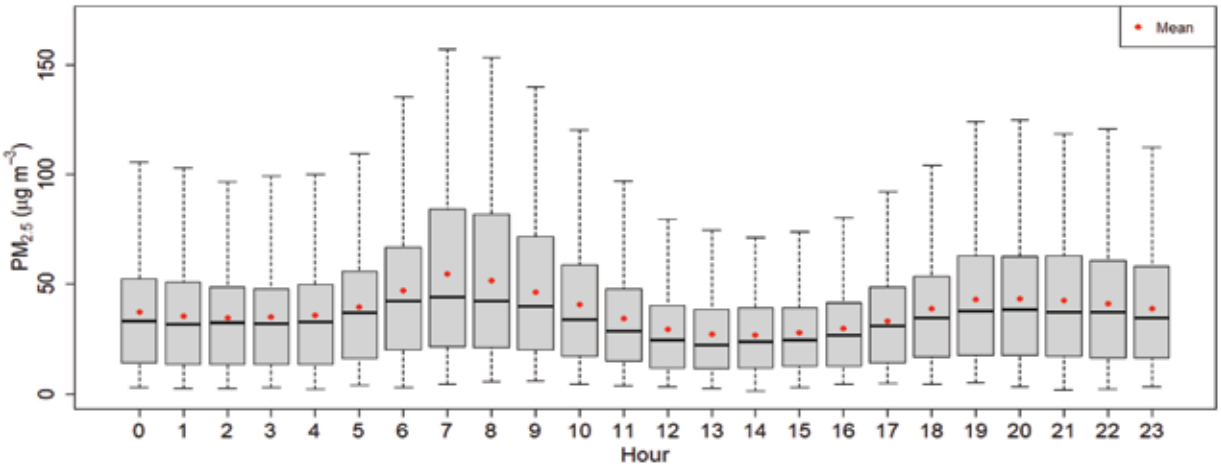

Figure 71: Diurnal variation of $PM_{2.5}$ for Khumaltar Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during December, whereas less during July and August.

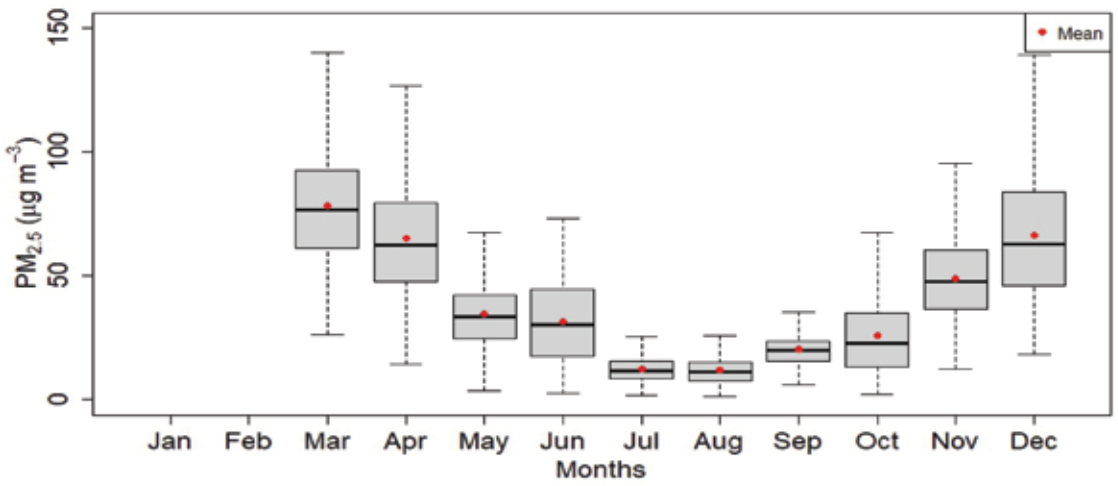

Figure 72: Monthly variation of $PM_{2.5}$ for Khumaltar Station

Daily average:

The daily average data was available for 243 days. Figure 73 explains the daily trend of $PM_{2.5}$ throughout the year.

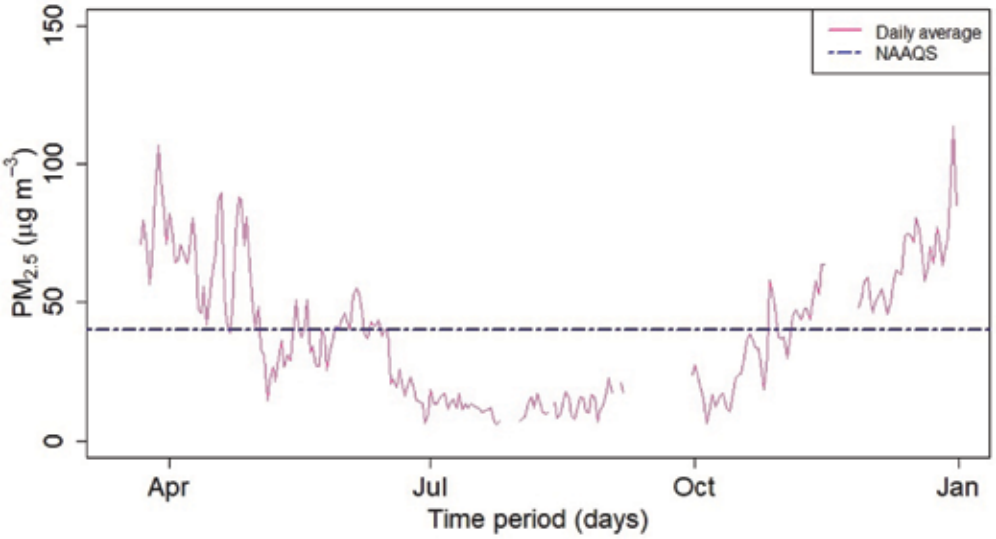

Figure 73: Daily average of $PM_{2.5}$ for Khumaltar Station

Table 22: Summary of daily average of $PM_{2.5}$ for Khumaltar Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
5.6 µg m^{-3}	16.1 µg m^{-3}	37.3 µg m^{-3}	38.5 ± 24.2 µg m^{-3}	55.1 µg m^{-3}	113.7 µg m^{-3}

Within the available data, the lowest and highest concentration of $PM_{2.5}$ was found to be 5.6 µg m^{-3} to 113.7 µg m^{-3} on 24th July and 30th December respectively (table 32). the $PM_{2.5}$ concentration was found to be below NAAQS almost in half of the measured days.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. The monthly average concentration of $PM_{2.5}$ for April and December was similar (65.1 µg m^{-3}, 66.5µg m^{-3}) and was more than other months as shown in figure 74.

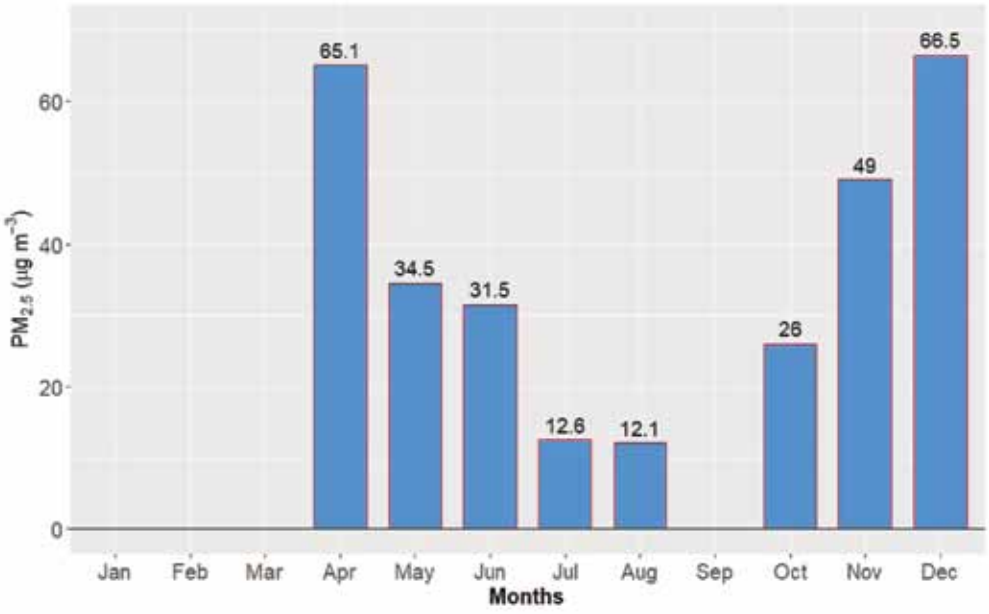

Figure 74: Monthly average of $PM_{2.5}$ for Khumaltar Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Because of limited data, the averages of only three seasons- pre-monsoons, monsoon and post monsoon, were presented in the figure 75. Of these seasons, the concentration of the pre-monsoon season (53.7 µg m^{-3}) was more than monsoon (19.2 µg m^{-3}) and post-monsoon (34.8 µg m^{-3}).

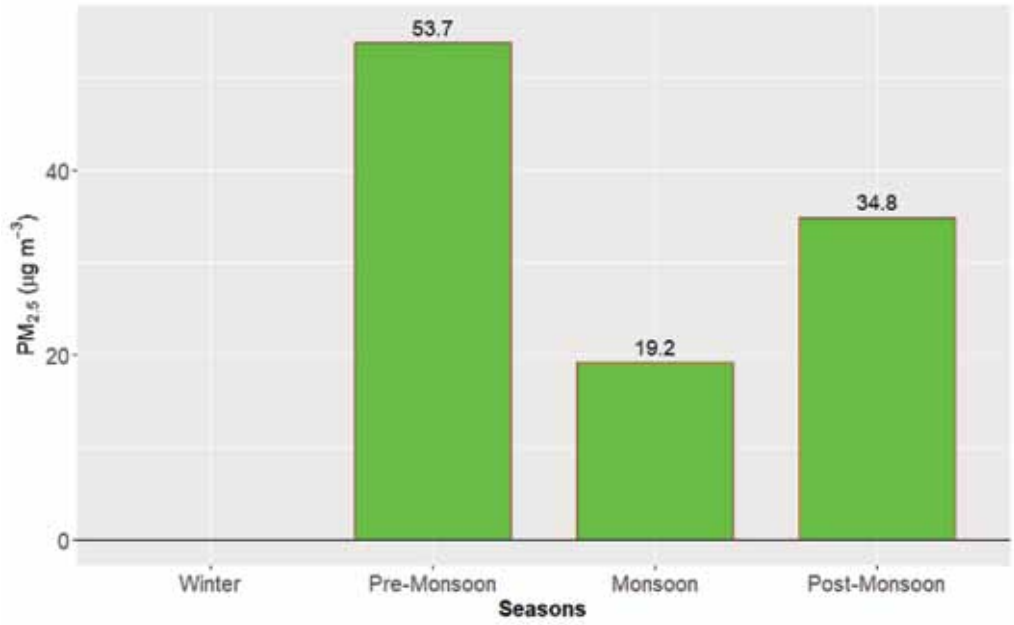

Figure 75: Seasonal average of $PM_{2.5}$ for Khumaltar Station

Compliance status:

Out of the total 243 days of valid measurement, 112 days exceeded the NAAQS. Those noncompliance days were included in all measured months except in July, August and September as shown in figure 76.

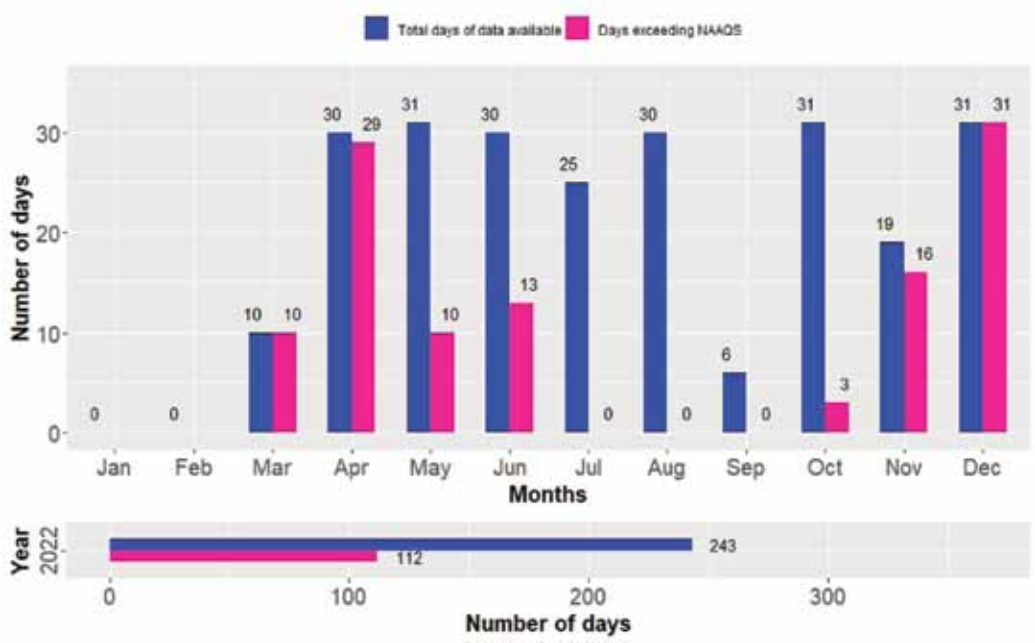

Figure 76: Compliance status of $PM_{2.5}$ for Khumaltar Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 77), out of the total 243 valid days, the majority of days showed an AQI of good to moderate. Days in March, April, November and December reached an unhealthy state. Few days in May, June and October were also found to be unhealthy for the sensitive group.

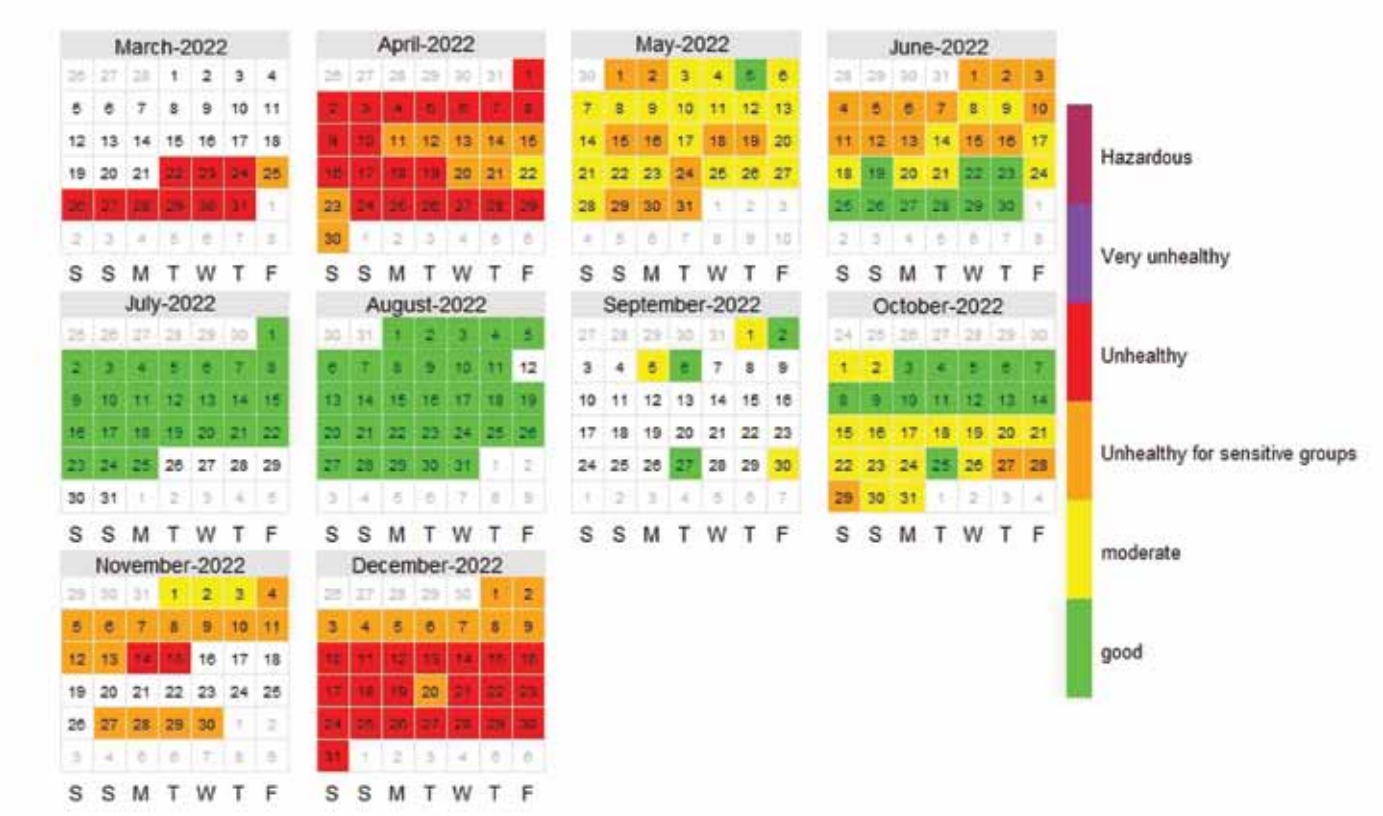

Figure 77: Calendar plot of $PM_{2.5}$ for Khumaltar Station

2.2.3.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 1.9 μg m^{-3} to 697.3 μg m^{-3}. The lowest and highest concentration of PM_{10} were observed on 2nd August at 14:00 and 27th March at 7:00. The statistical summary of the hourly average is presented in the table below

Table 23: Summary of hourly average of PM_{10} for Khumaltar Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.9 μg m^{-3}	28.3 μg m^{-3}	61.8 μg m^{-3}	76.6 ± 65.4 μg m^{-3}	103.3 μg m^{-3}	697.3 μg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-100) and as values increase, the frequency of observations decreases rapidly.

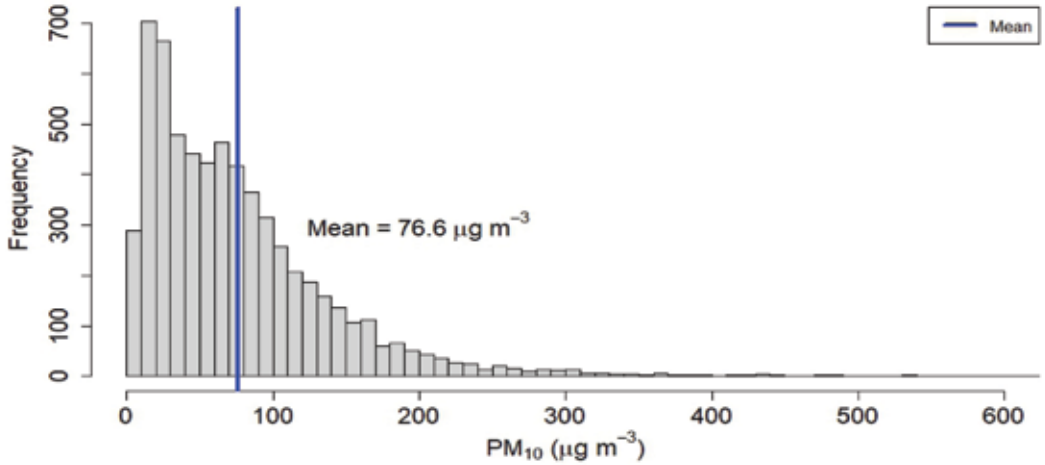

Figure 78: Histogram of PM_{10} for Khumaltar Station

Diurnal variation:

The hourly mean of PM_{10} progressively increases with time and reached its peaks at 9:00 which again decreases and remain almost in same level till 23:00.

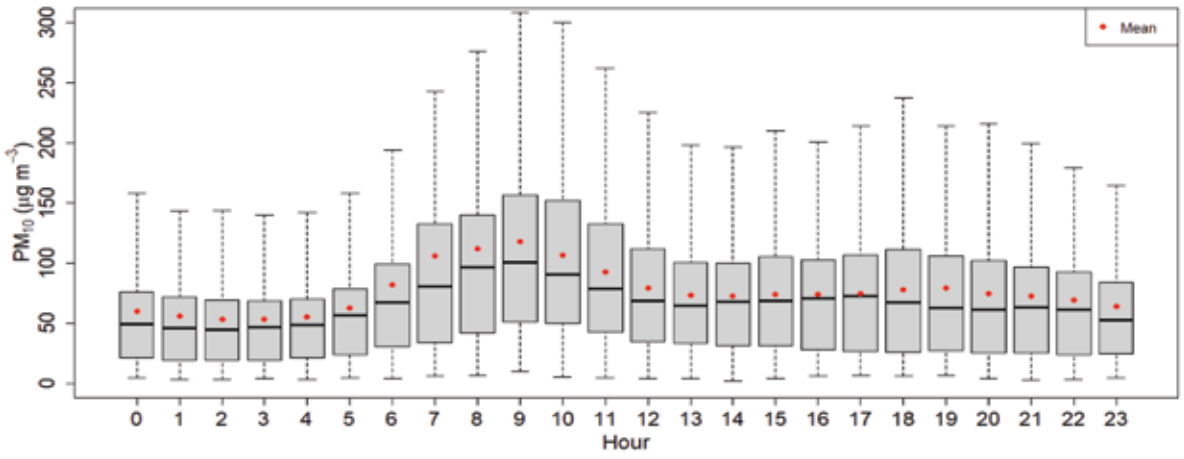

Figure 79: Diurnal variation of PM_{10} for Khumaltar Station

Monthly variation:

A high variation of PM_{10} concentration was seen during March, whereas less during July to September.

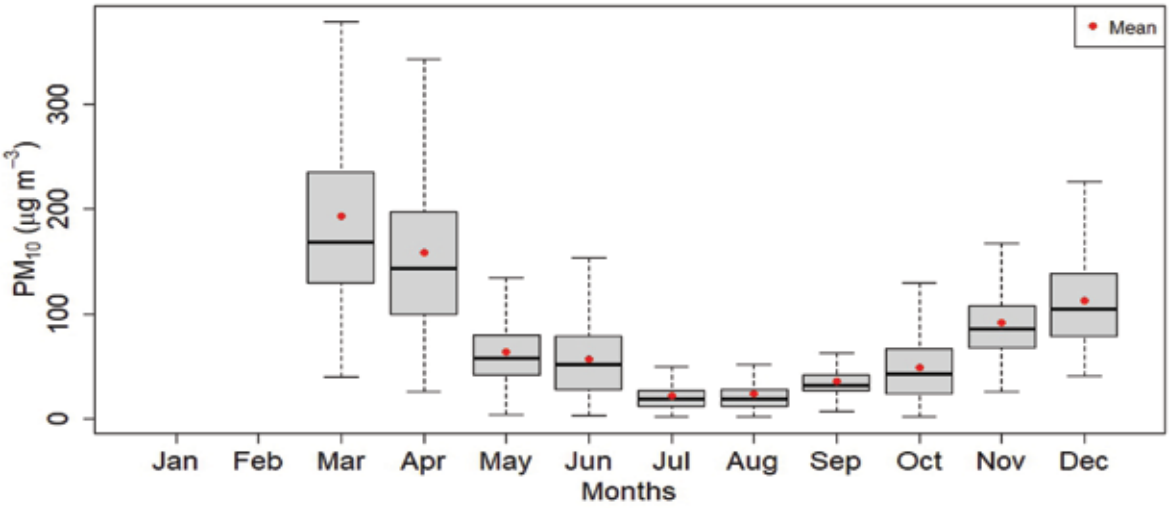

Figure 80: Monthly variation of PM_{10} for Khumaltar Station

Daily average:

The daily average data was available for 254 days. Figure 81 explains the daily trend of PM_{10} throughout the year.

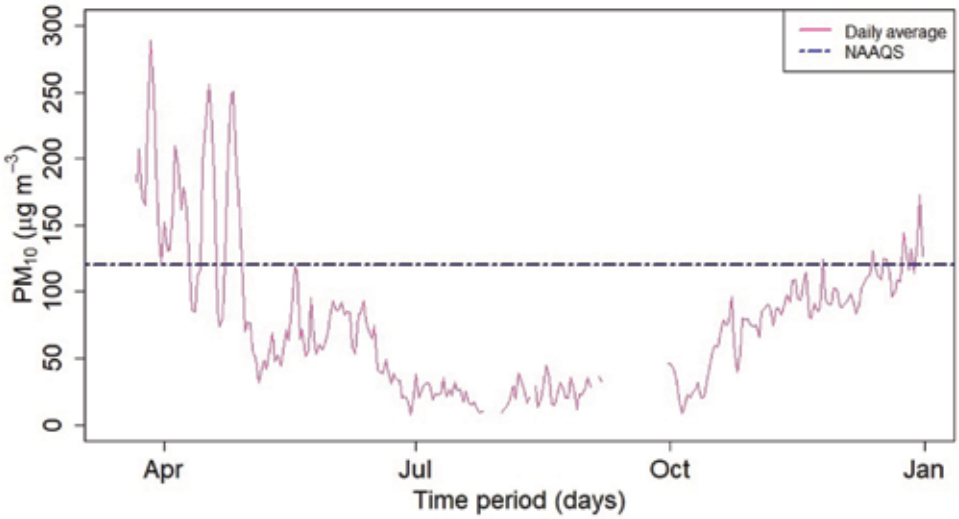

Figure 81: Daily average of PM_{10} for Khumaltar Station

Table 24: Summary of daily average of PM_{10} for Khumaltar Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
7.9 µg m^{-3}	31.4 µg m^{-3}	72.6 µg m^{-3}	77.3 ± 55.5 µg m^{-3}	101.4 µg m^{-3}	288.8 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 7.9 µg m^{-3} to 288.8 µg m^{-3} on 29th June and 27th March respectively (table 35). In most of the measured days, daily average PM_{10} concentration was found below NAAQS.

Monthly average:

The average monthly concentration of PM_{10} was shown in the bar chart. The monthly average concentration of PM_{10} was the lowest during July (23.2 µg m^{-3}) and highest during April (158 µg m^{-3}).

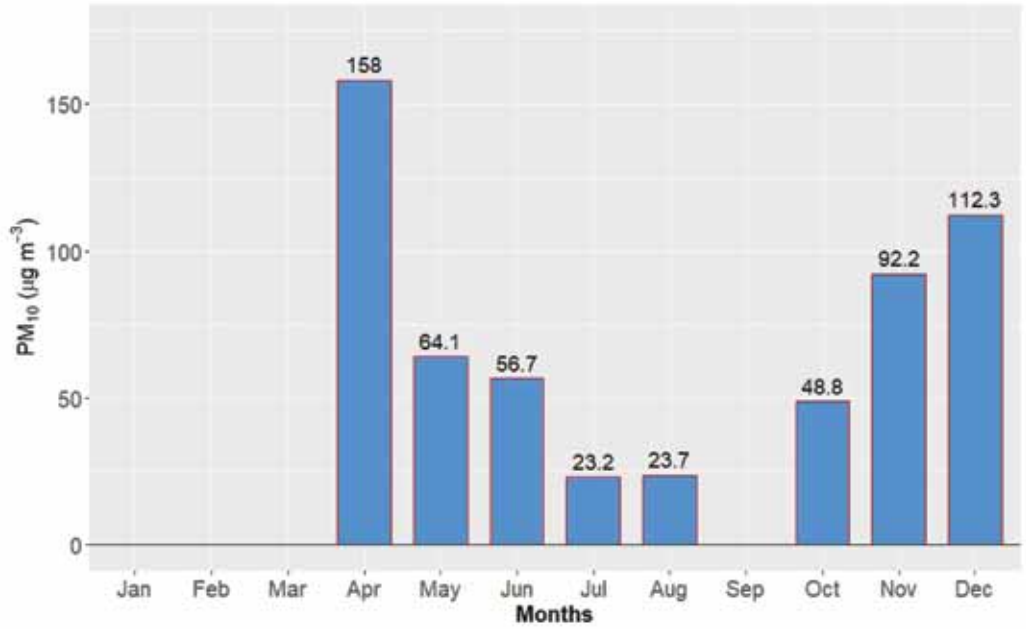

Figure 82: Monthly average of PM_{10} for Khumaltar Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{10.}$ Because of limited data, the averages of only three seasons- pre-monsoons, monsoon and post monsoon, were presented in the figure 83. Of these seasons, the concentration of the pre-monsoon season (122.2 µg m^{-3}) is more than monsoon (35.3 µg m^{-3}) and post-monsoon (70.1 µg m^{-3}).

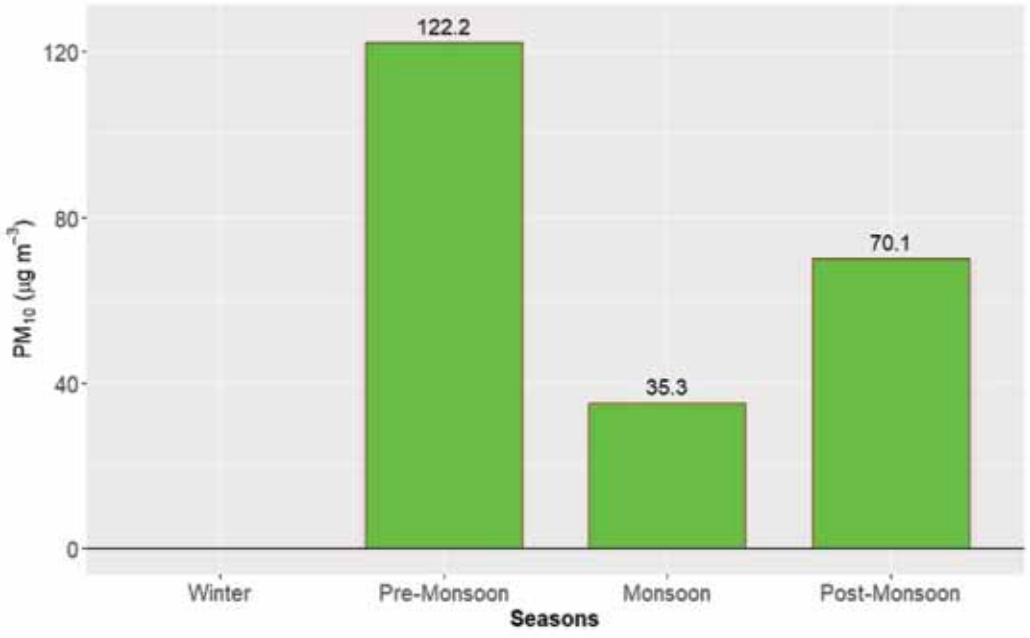

Figure 83: Seasonal average of PM_{10} for Khumaltar Station

Compliance status:

Out of the total 254 days of valid measurement, only 42 days exceeded the NAAQS. Those noncompliance days were included in March, April, November and December as shown in figure 84.

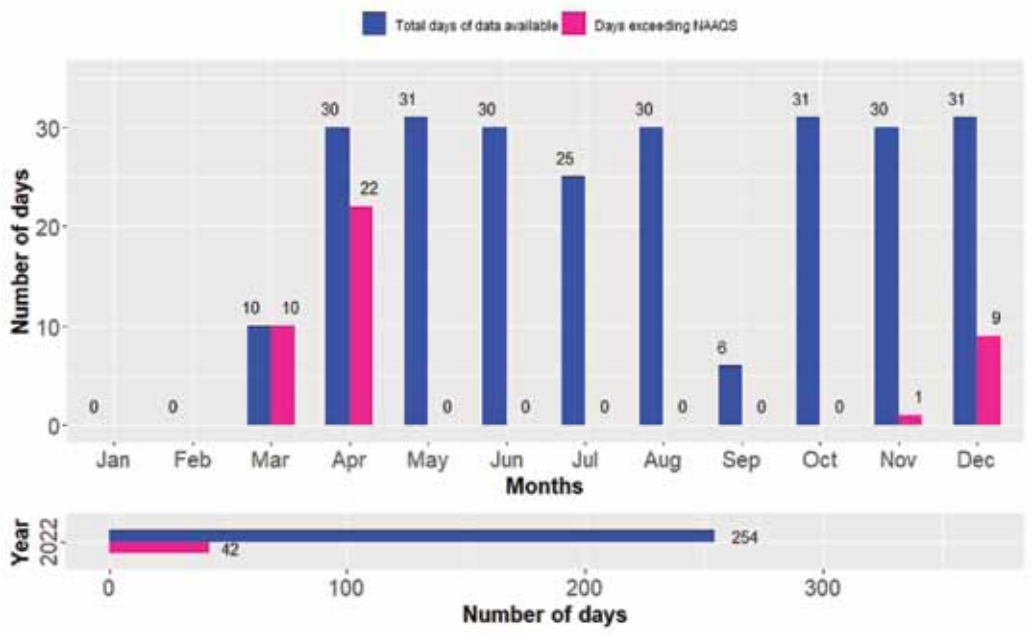

Figure 84: Compliance status of PM_{10} for Khumaltar Station

2.2.4 RATNAPARK AIR QUALITY MONITORING STATION

Ratnapark Air Quality Monitoring Station was established in the year 2016 at Shankhadhar park near Rani Pokhari. This station is situated at the center of the Kathmandu and represents the urban area.

Emissions from the vehicles is the main source of pollution in the area. In the winter season solid waste burning during winter season is also a major source of air pollution. Regional haze is also the common problem of this location. In Pre-monsoon season pollution from forest fire in different parts of the country become one of the major sources of pollution.

2.2.4.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 1.2 µg m^{-3} to 167.7 µg m^{-3}. The lowest and the highest concentration of $PM_{2.5}$ was observed on 26th April at 6:00 and 13th January at 4:00. The statistical summary of the hourly average is presented in the table below:

Table 25: Summary of hourly average of $PM_{2.5}$ for Ratnapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.2 µg m^{-3}	15.7 µg m^{-3}	26.4µg m^{-3}	33.0 ± 22.2 µg m^{-3}	46.1 µg m^{-3}	167.7 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (10-60) and as values increase, the frequency of observations decreases rapidly.

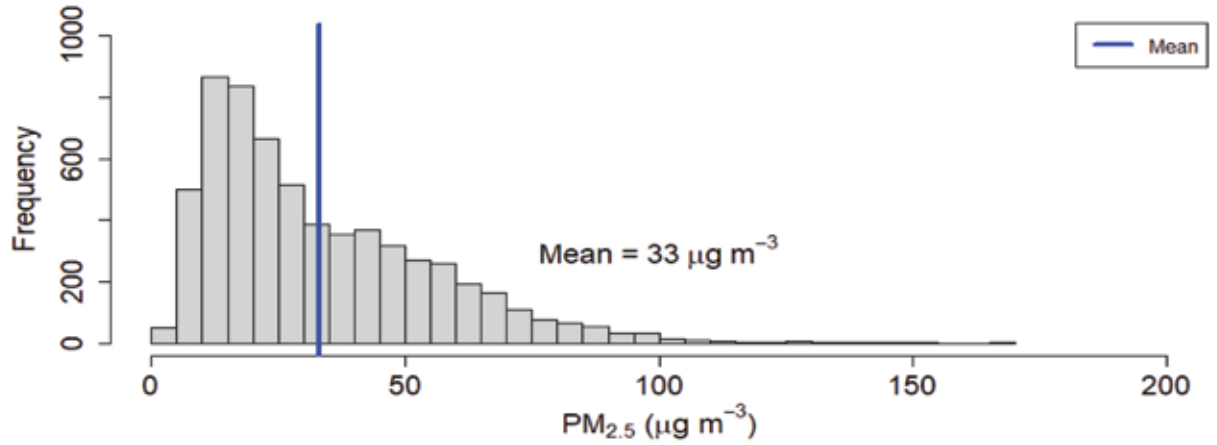

Figure 85: Histogram of $PM_{2.5}$ for Ratnapark Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ progressively decreases till 4:00 then increases with time and reached to its peak at 8:00. Thereafter it decreases till 14:00 and again starts to rise from 16:00 and peaks at 20:00.

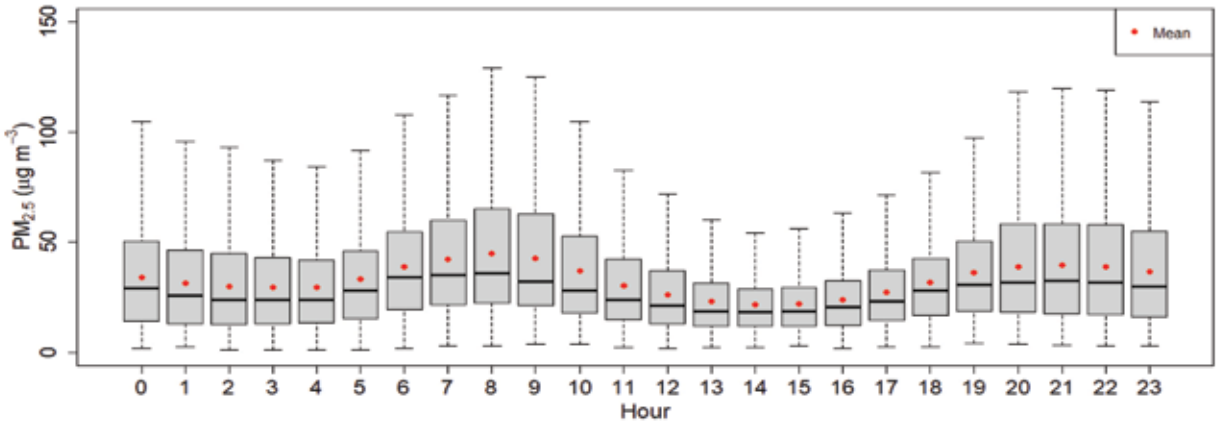

Figure 86: Diurnal variation of $PM_{2.5}$ for Ratnapark Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during April.

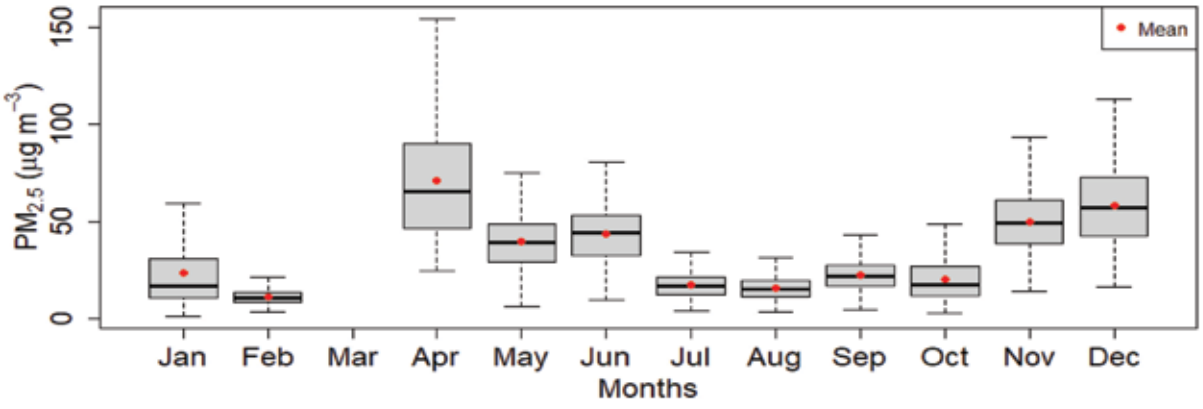

Figure 87: Monthly variation of $PM_{2.5}$ for Ratnapark Station

Daily average:

The daily average data was available for 250 days. Figure 88 explains the daily trend of $PM_{2.5}$ throughout the year.

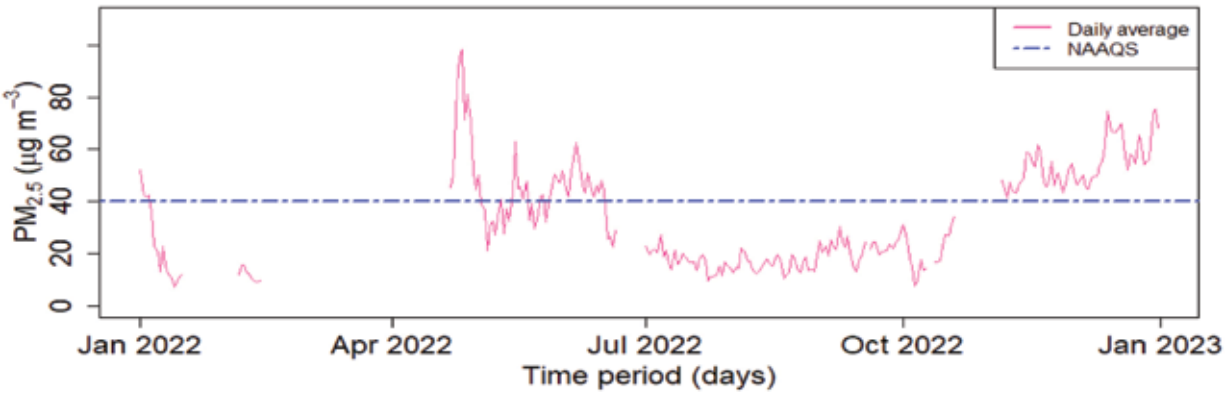

Figure 88: Daily average of $PM_{2.5}$ for Ratnapark Station

Table 26: Summary of daily average of $PM_{2.5}$ for Ratnapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
7.2 µg m^{-3}	17.1 µg m^{-3}	27.0 µg m^{-3}	33.3 ± 19.0 µg m^{-3}	47.5 µg m^{-3}	98.2 µg m^{-3}

Within the available data, the lowest and highest concentration of $PM_{2.5}$ was found to be 7.2 µg m^{-3} to 98.2 µg m^{-3} on 13th January and 26th April respectively (table 38).

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. It can be seen that the monthly average of $PM_{2.5}$ was the lowest in August (15.7 µg m^{-3}) and highest in December (58.2 µg m^{-3}) while monthly average was not available for February, March and April.

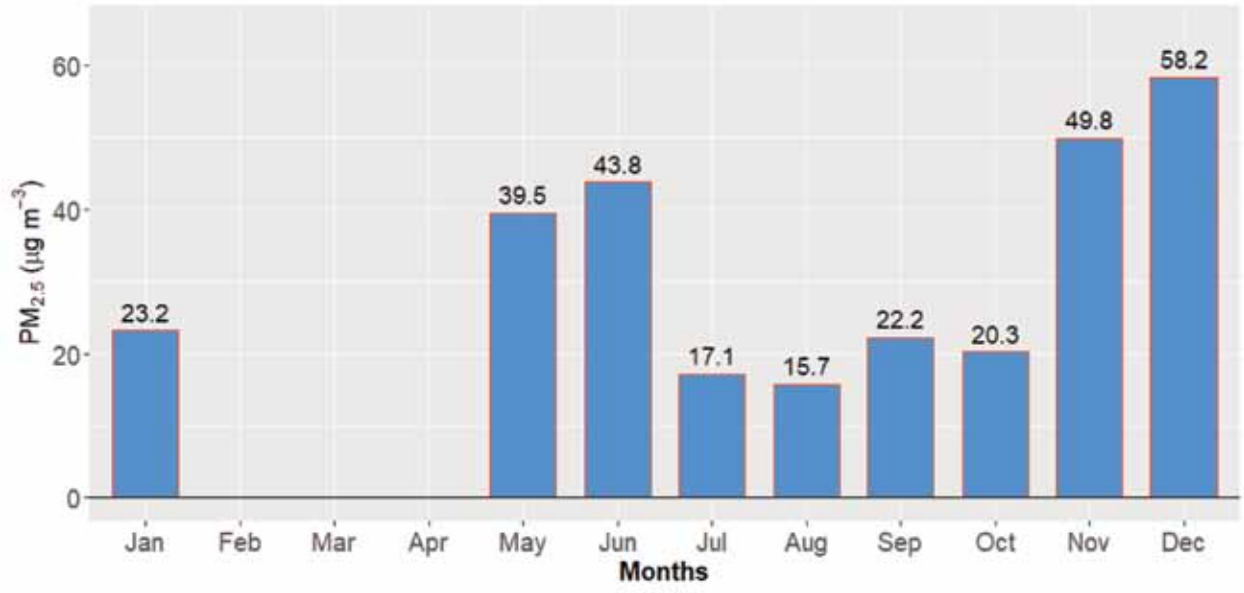

Figure 89: Monthly average of $PM_{2.5}$ for Ratnapark Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Winter and Post-Monsoon have almost similar seasonal average (38.9 µg m^{-3} and 38.1 µg m^{-3}) while Monsoon have lower seasonal average (22.9 µg m^{-3}). Seasonal average for Pre-Monsoon season was not available.

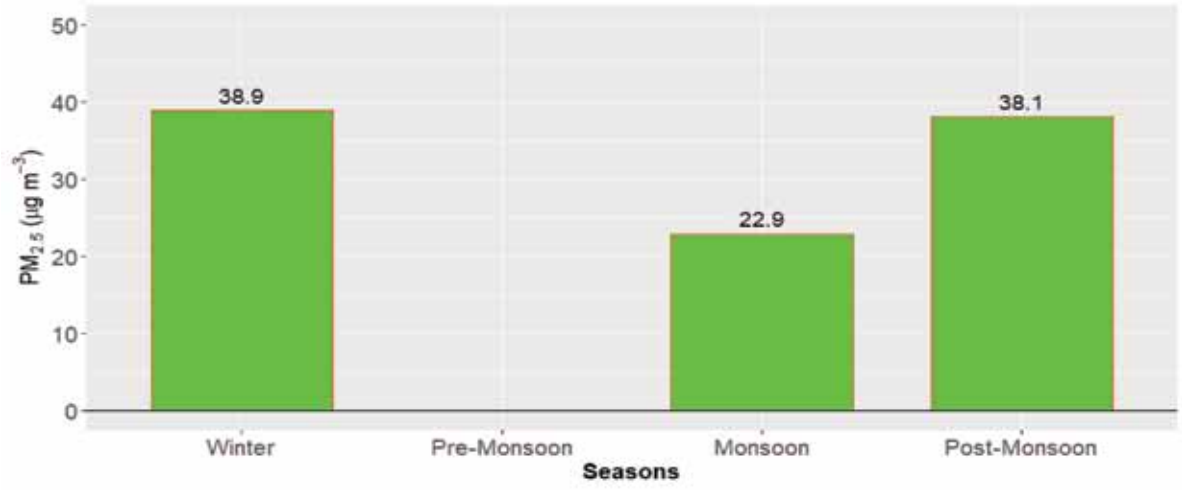

Figure 90: Seasonal average of $PM_{2.5}$ for Ratnapark Station

Compliance status:

Out of the total 250 days of valid measurement, 101 days exceeded the NAAQS.

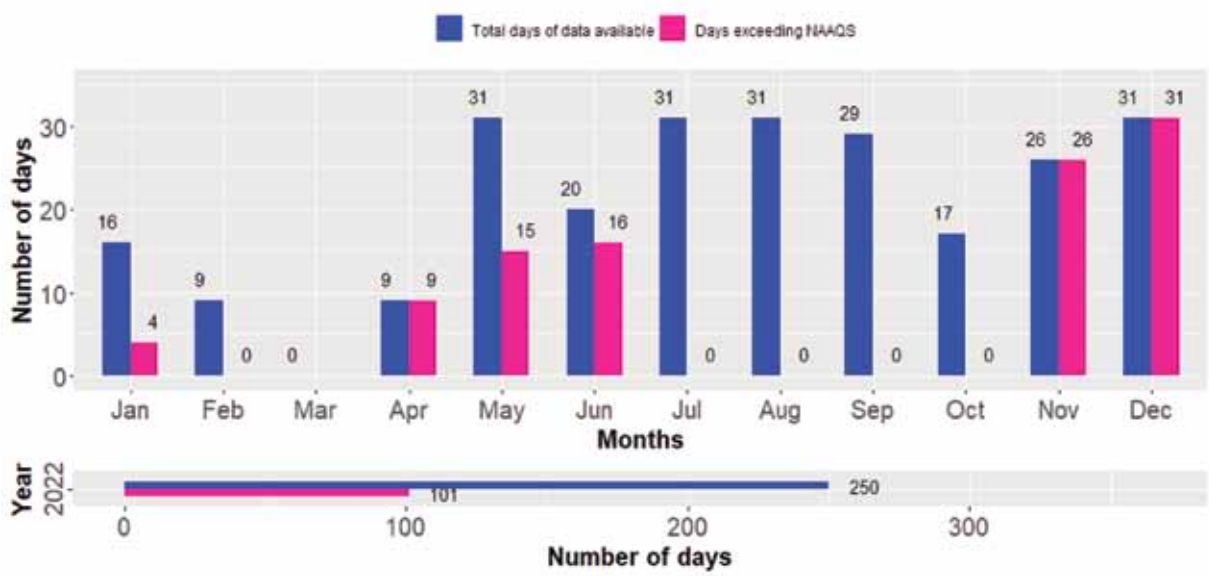

Figure 91: Compliance status of $PM_{2.5}$ for Ratnapark Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 92), the worst category of AQI seen was Unhealthy. Unhealthy category of AQI was seen in April, May, June, November and December. March was not included in the plot due to unavailability of daily average data.

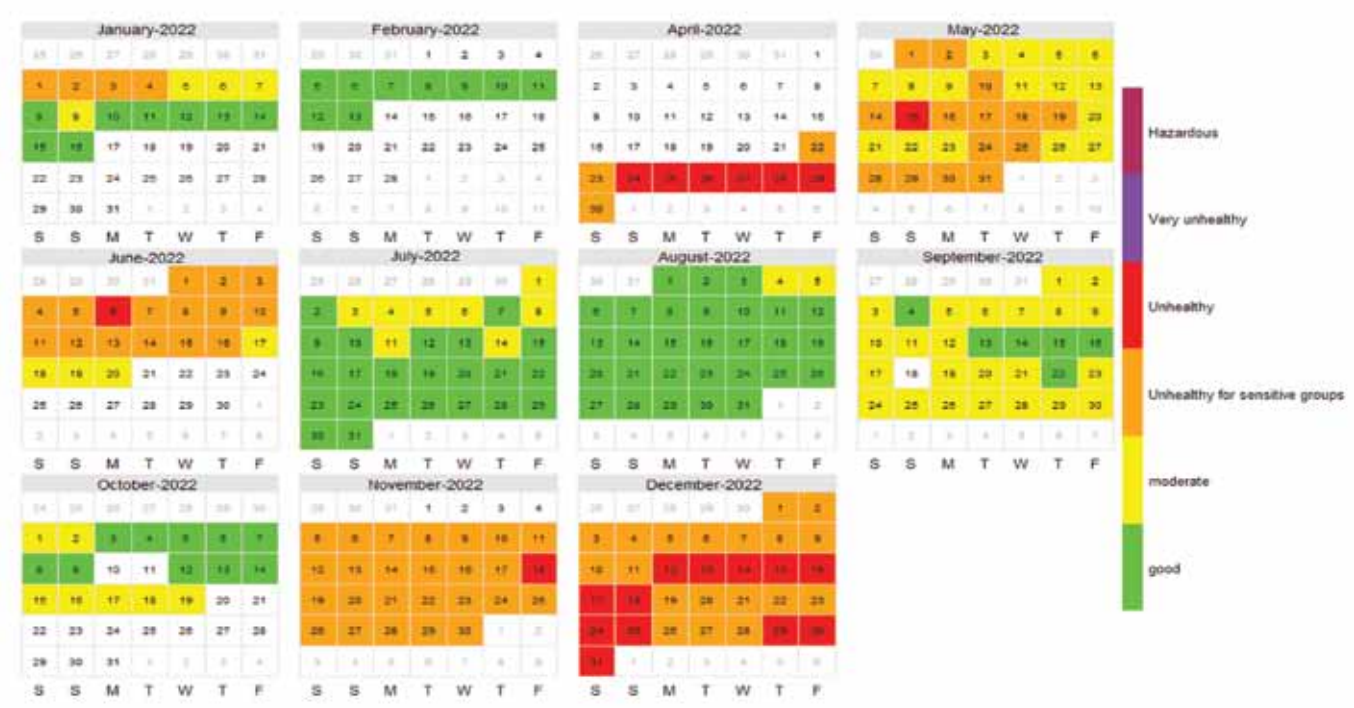

Figure 92: Calendar plot of $PM_{2.5}$ for Ratnapark Station

2.2.4.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 1.2 μg m^{-3} to 349.2 μg m^{-3}. The lowest and highest concentration of PM_{10} was observed on 13th January at 4:00 and 26th April at 8:00. The statistical summary of the hourly average is presented in the table below:

Table 27: Summary of hourly average of PM_{10} for Ratnapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.2 μg m^{-3}	26.0 μg m^{-3}	42.0 μg m^{-3}	48.5 ± 33.1 μg m^{-3}	64.2 μg m^{-3}	349.2 μg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (10-70) and as values increase, the frequency of observations decreases rapidly.

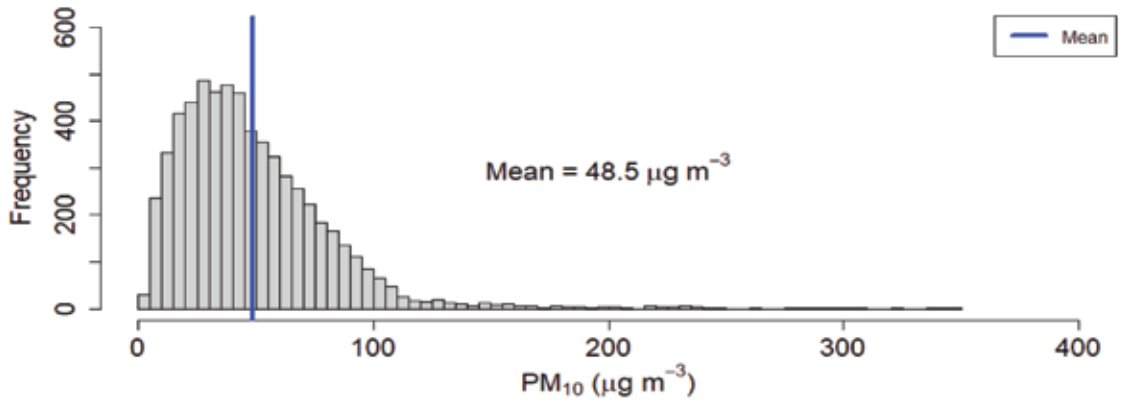

Figure 93: Histogram of PM_{10} for Ratnapark Station

Diurnal variation:

The hourly mean of PM_{10} progressively decreases till 4:00 then increases with time and reaches to its peak at 9:00. Thereafter it decreases till 15:00 and again starts to rise from 18:00 and peaks at 20:00.

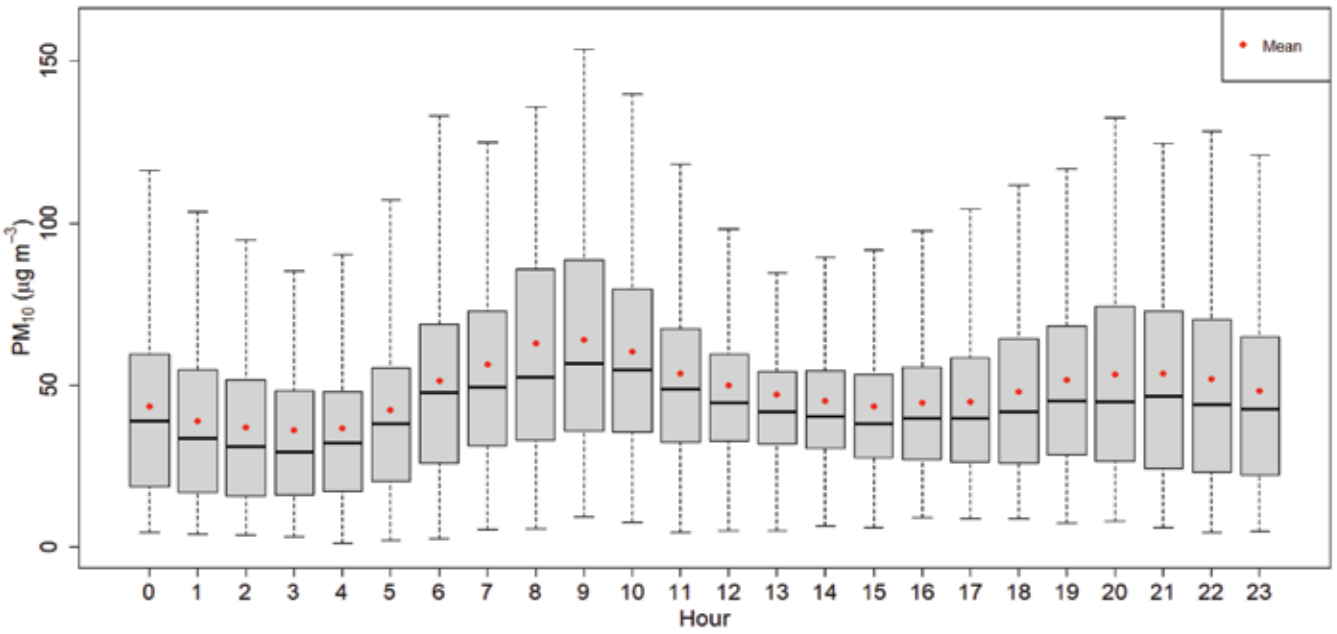

Figure 94: Diurnal variation of PM_{10} for Ratnapark Station

Monthly variation:

A high variation of PM_{10} concentration was seen during April and low during February.

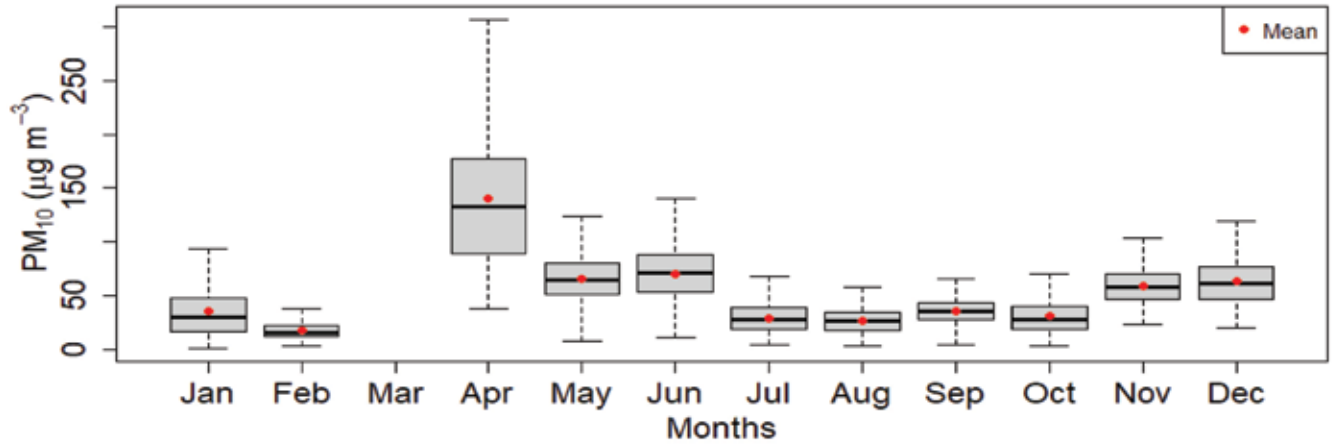

Figure 95: Monthly variation of PM_{10} for Ratnapark Station

Daily average:

The daily average data was available for 250 days. Figure 96 explains the daily trend of PM_{10} throughout the year.

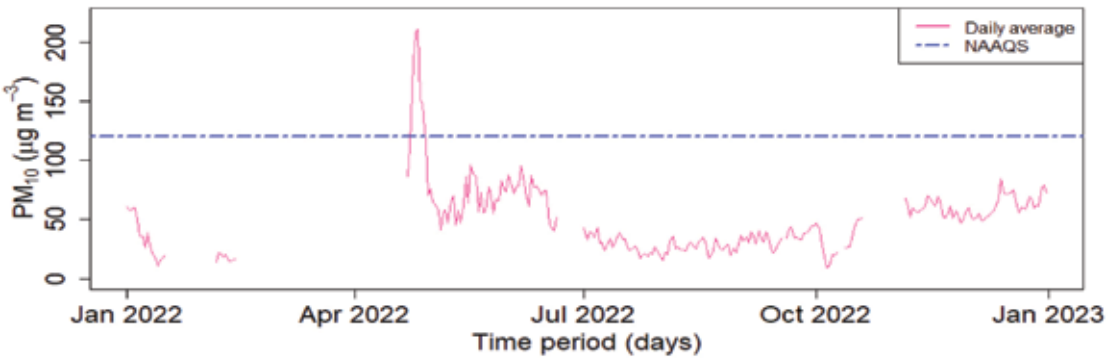

Figure 96: Daily average of PM_{10} for Ratnapark Station

Table 28: Summary of daily average of PM_{10} for Ratnapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
9.3 µg m^{-3}	27.8 µg m^{-3}	44.1 µg m^{-3}	48.9 ± 28.6 µg m^{-3}	62.1 µg m^{-3}	211.3 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 9.3 µg m^{-3} to 211.3 µg m^{-3} on 5th October and 26th April respectively. In majority of days PM_{10} concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. The monthly average of $PM_{2.5}$ was the lowest in August (26.6 µg m^{-3}) and highest in June (71.1 µg m^{-3}) while monthly average was not available for February to April.

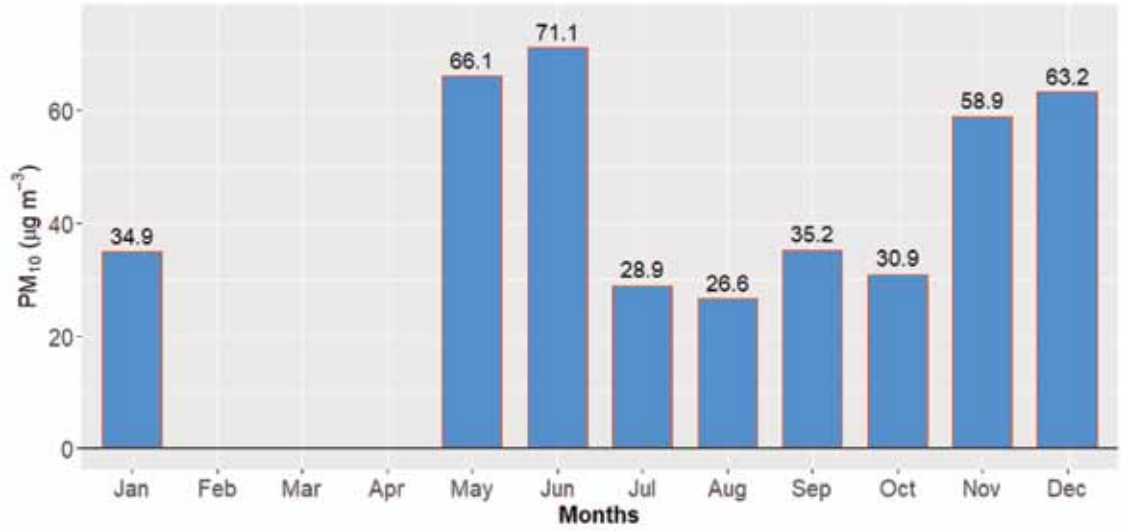

Figure 97: Monthly average of PM_{10} for Ratnapark Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}. This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Winter and post-monsoon have similar seasonal average (57.7 µg m^{-3} and 47.8 µg m^{-3}) while monsoon have lower seasonal average (37.5 µg m^{-3}). Seasonal average for pre-monsoon season was not available.

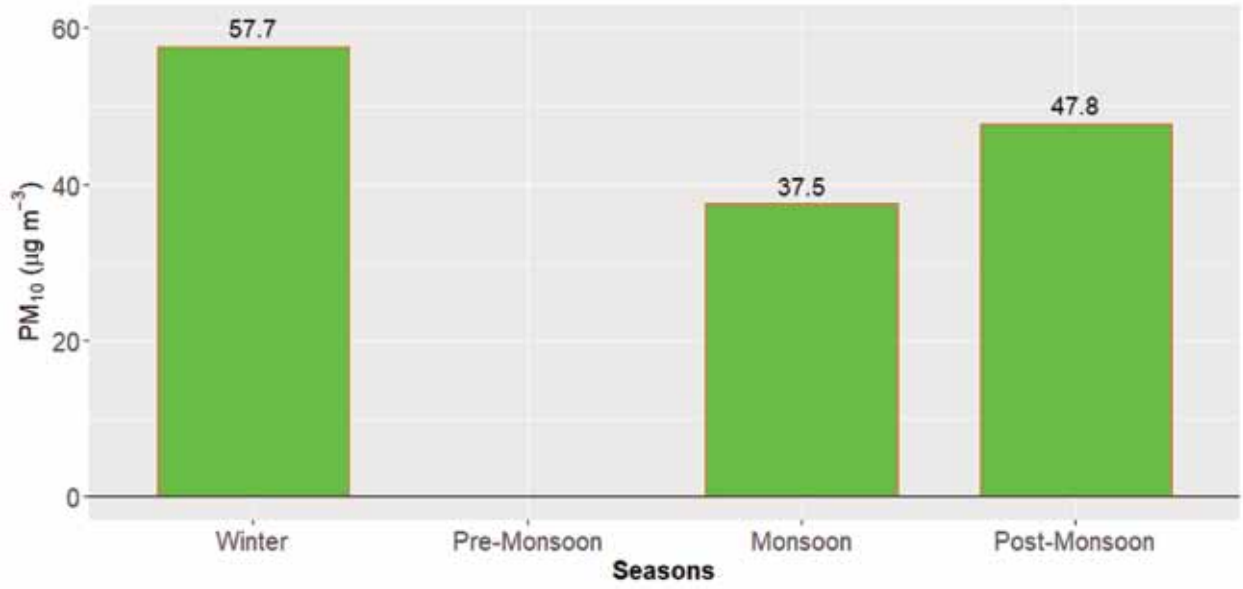

Figure 98: Seasonal average of PM_{10} for Ratnapark Station

Compliance status:

Out of the total 250 days of measurement, only 5 days in April exceeded the NAAQS.

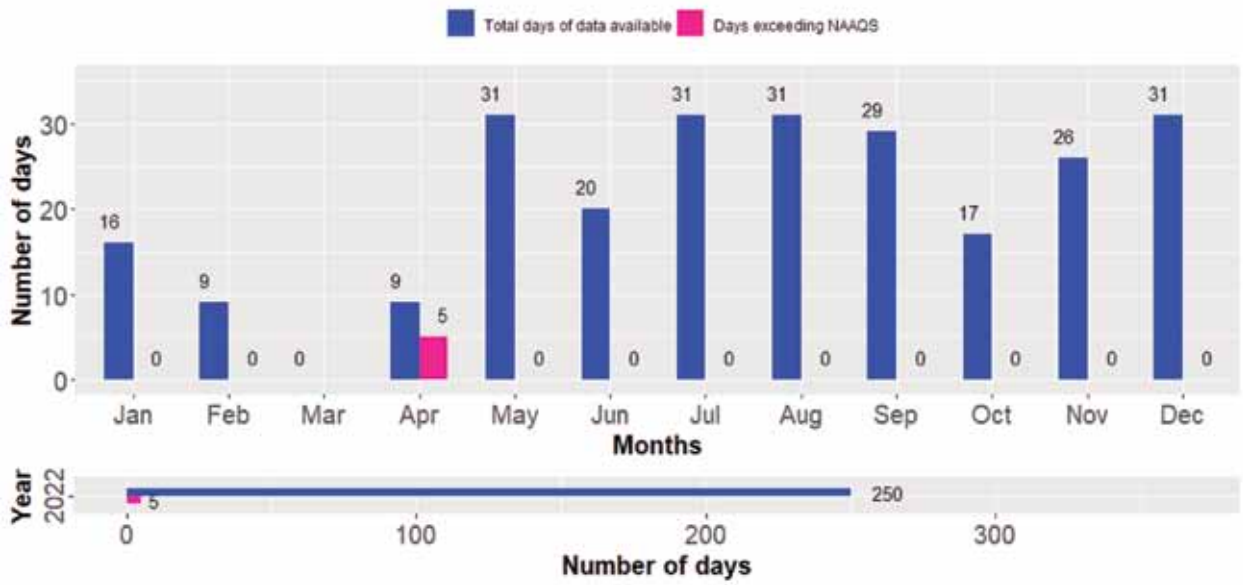

Figure 99: Compliance status of PM_{10} for Ratnapark Station

2.2.4.3 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 1.3 µg m^{-3} to 697.3 µg m^{-3}. The lowest and the highest concentration of TSP was observed on 13th January at 4:00 and 20th February at 14:00. The statistical summary of the hourly average is presented in the table below:

Table 29: Summary of hourly average of TSP for Ratnapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.3 µg m^{-3}	36.4 µg m^{-3}	64.4 µg m^{-3}	80.6 ± 67.7 µg m^{-3}	103.1 µg m^{-3}	697.3 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-100) and as values increase, the frequency of observations decreases rapidly.

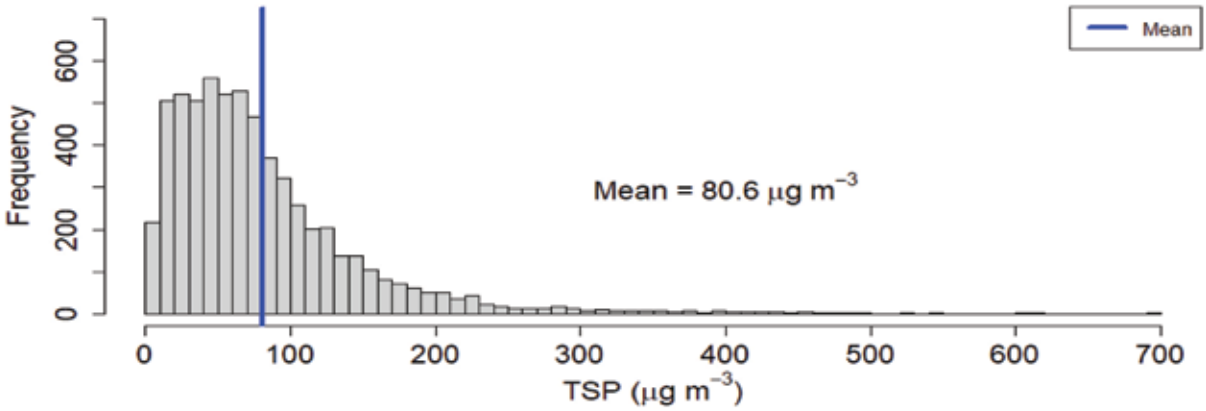

Figure 100: Histogram of TSP for Ratnapark Station

Diurnal variation:

The hourly mean of TSP is high in day time. It peaks at 13:00.

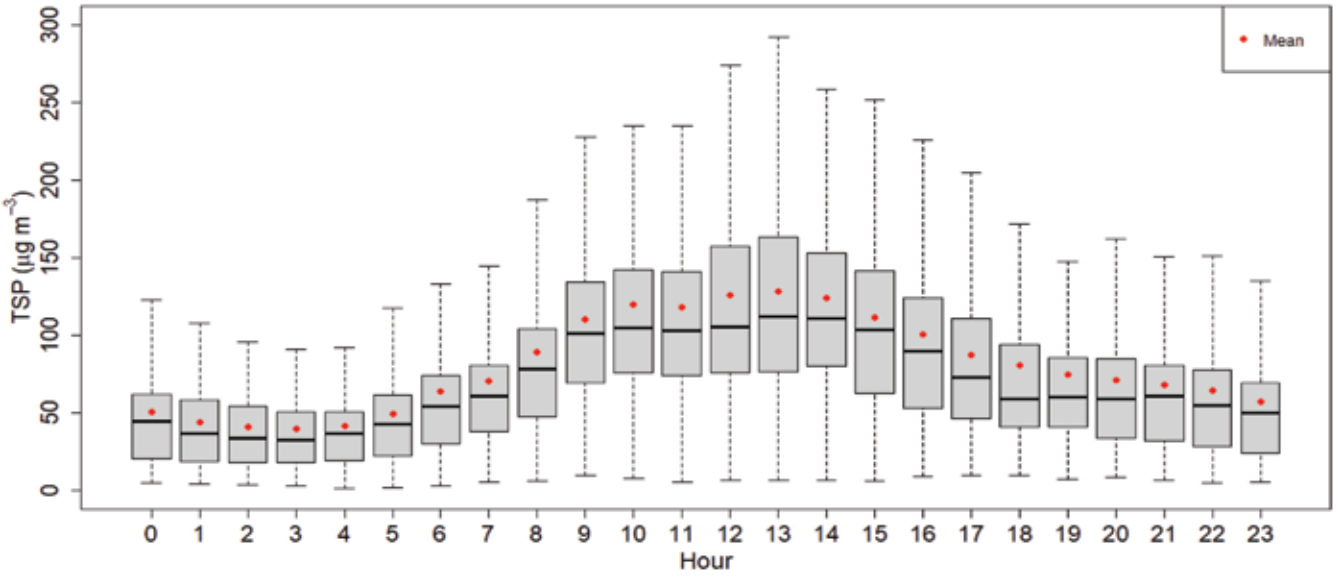

Figure 101: Diurnal variation of TSP for Ratnapark Station

Monthly variation:

A high variation of TSP concentration was seen during April, November and December have the lowest variation.

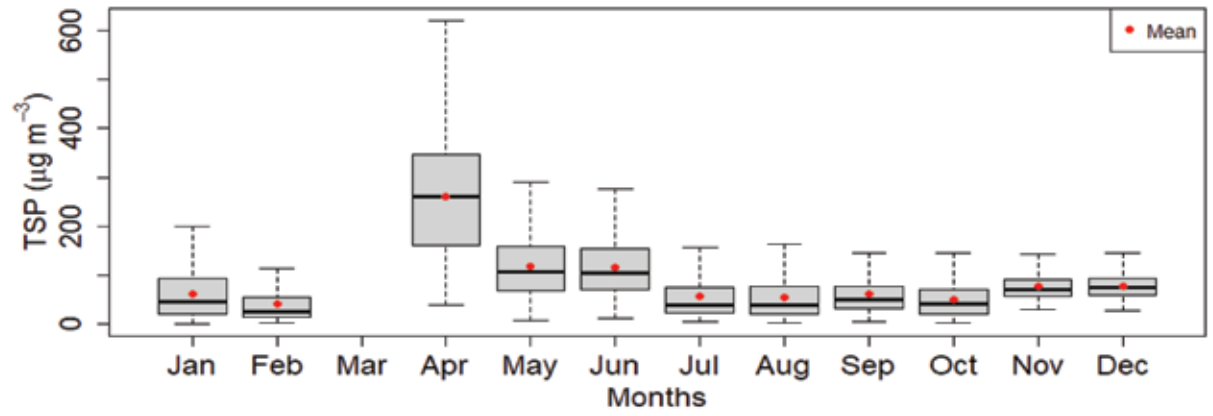

Figure 102: Monthly variation of TSP for Ratnapark Station

Daily average:

The daily average data was available for 250 days. Figure 103 explains the daily trend of TSP throughout the year.

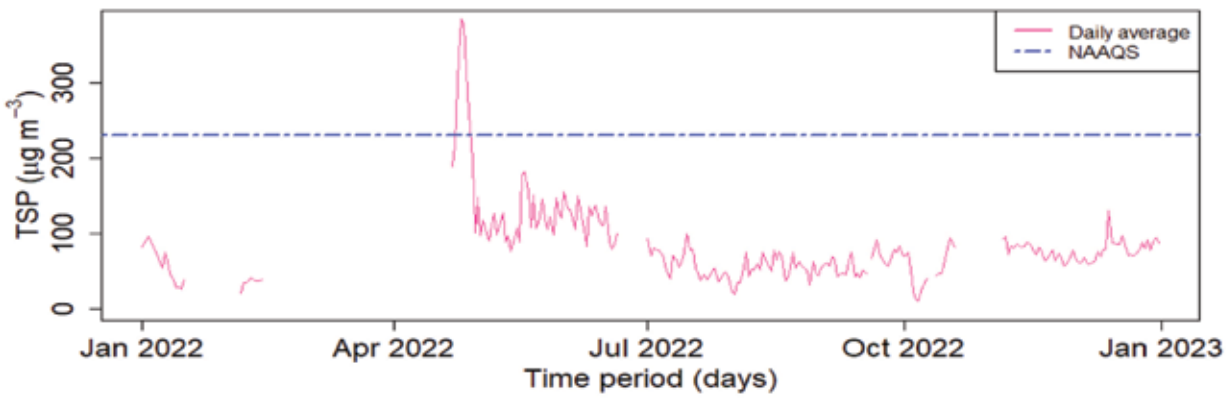

Figure 103: Daily average of TSP for Ratnapark Station

Table 30: Summary of daily average of TSP for Ratnapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
10.3 µg m^{-3}	52.6 µg m^{-3}	72.9 µg m^{-3}	80.7 ± 49.8 µg m^{-3}	90.7 µg m^{-3}	384.0 µg m^{-3}

Within the available data, the lowest and highest concentration of TSP was found to be 10.3 µg m^{-3} to 384.0 µg m^{-3} on 6th October and 25th April respectively (table 44).

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. The monthly average of TSP was found to be the the lowest in October (51.2 µg m^{-3}) and highest in May (118.0 µg m^{-3}). The monthly average for February, March and April was not available.

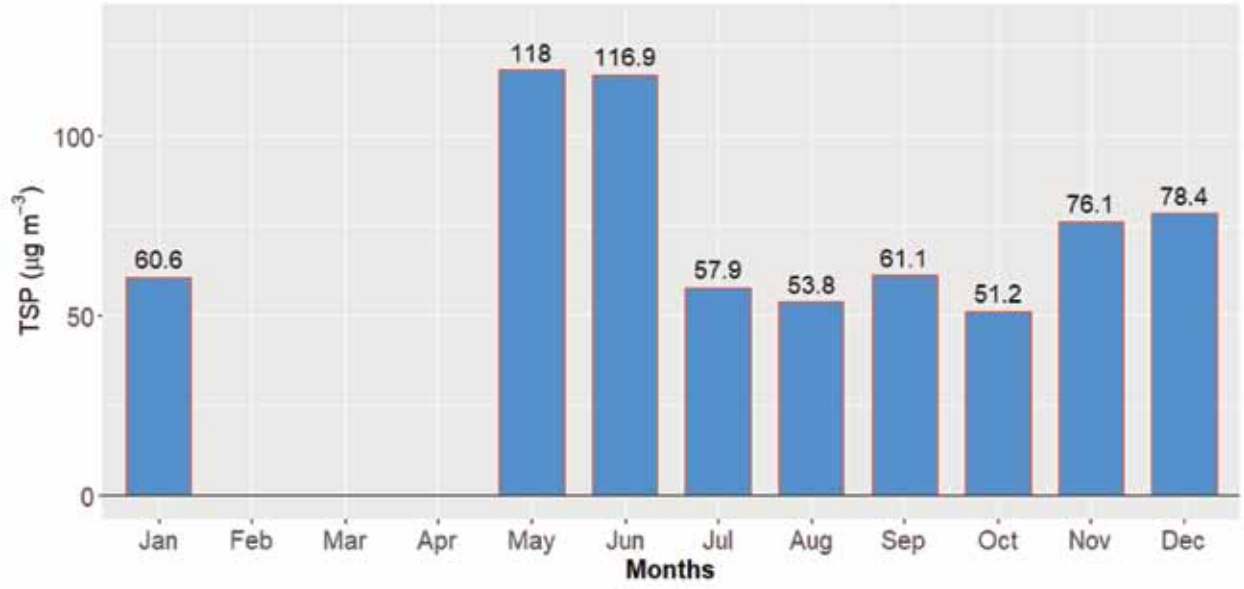

Figure 104: Monthly average of TSP for Ratnapark Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP

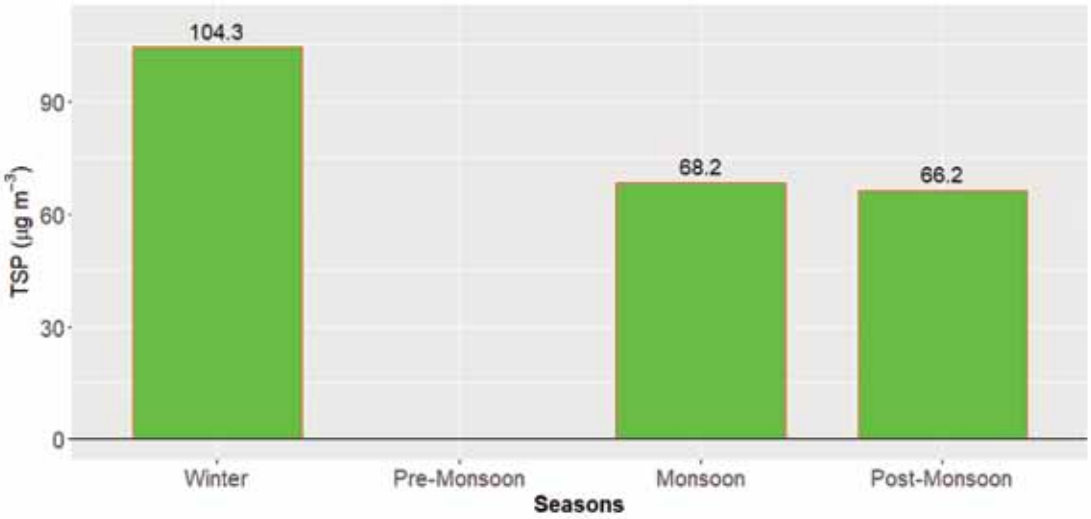

Figure 105: Seasonal average of TSP for Ratnapark Station

This bar chart illustrates the seasonal distribution of the concentration of TSP. Winter season has the highest seasonal average of TSP (104.3 µg m^{-3}) while Monsoon and Post-Monsoon have similar seasonal average (68.2 µg m^{-3} and 66.2 µg m^{-3}) Seasonal average for Pre-Monsoon season is not available.

Compliance status:

Out of the total 250 days of measurement, only 5 days in April exceeded the NAAQS.

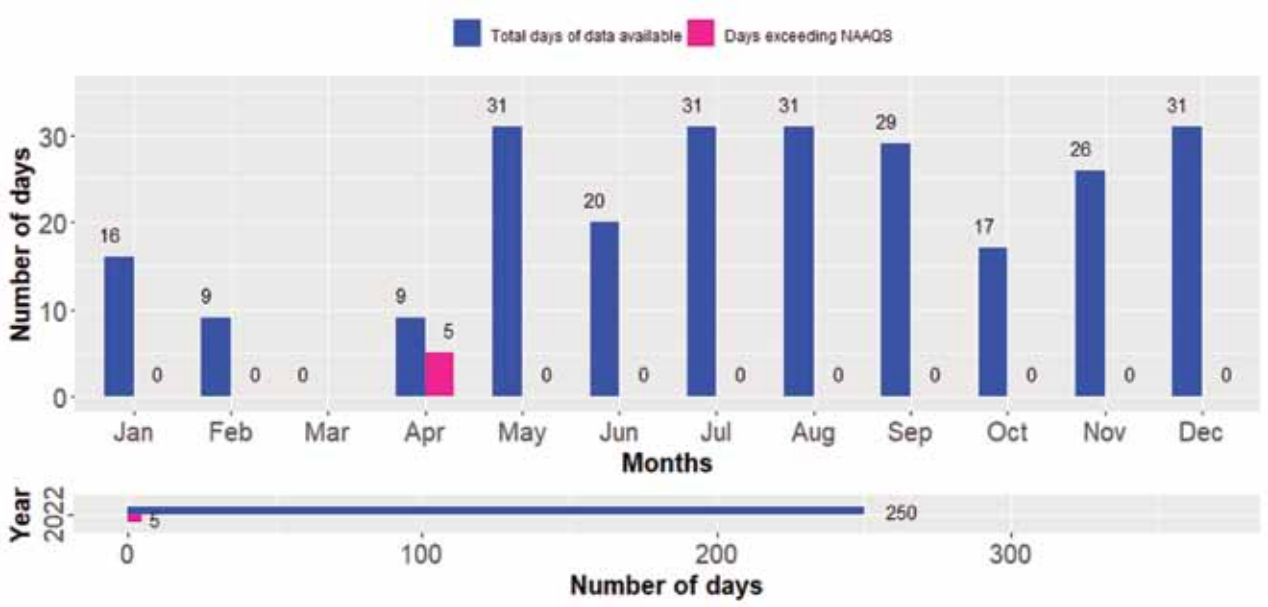

Figure 106: Compliance status of TSP for Ratnapark Station

2.2.5 SHANKHAPARK AIR QUALITY MONITORING STATION

Shankhapark Air Quality Monitoring Station was established in the year 2017 at Shankhapark near Ring road in Kathmandu. It represents the urban area.

Emissions from the vehicles and re-suspended dust from road along with solid waste burning in winter season are the main source of pollution in the area. In Pre-monsoon season pollution from forest fire in different parts of the country become one of the major source of pollution.

2.2.5.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 2.8 µg m^{-3} to 151.8 µg m^{-3}. The lowest and highest concentration of $PM_{2.5}$ is observed on 5th October at 5:00 and 30th December at 8:00. The statistical summary of the hourly average is presented in the table below:

Table 31: Summary of hourly average of $PM_{2.5}$ for Shankhapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.8 µg m^{-3}	24.1 µg m^{-3}	38.1 µg m^{-3}	44.6 ± 26.5 µg m^{-3}	59.8 µg m^{-3}	151.8 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (10-80) and as values increase, the frequency of observations decreases rapidly.

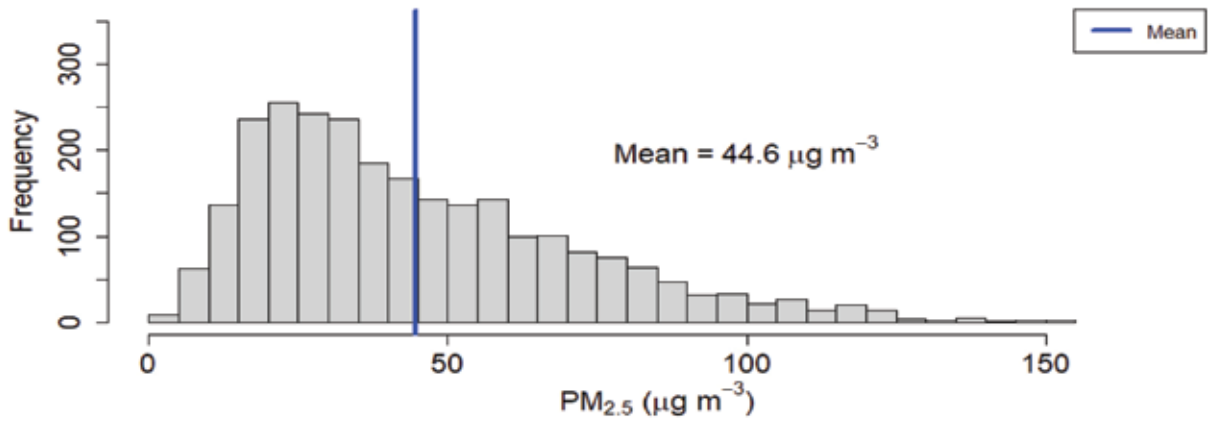

Figure 107: Histogram of $PM_{2.5}$ for Shankhapark Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ progressively increases with time and reached to its peak at 8:00 which again decreases and become lowest at 15:00 and again gains height around 20:00-21:00. The mean value was almost similar to the median throughout the day.

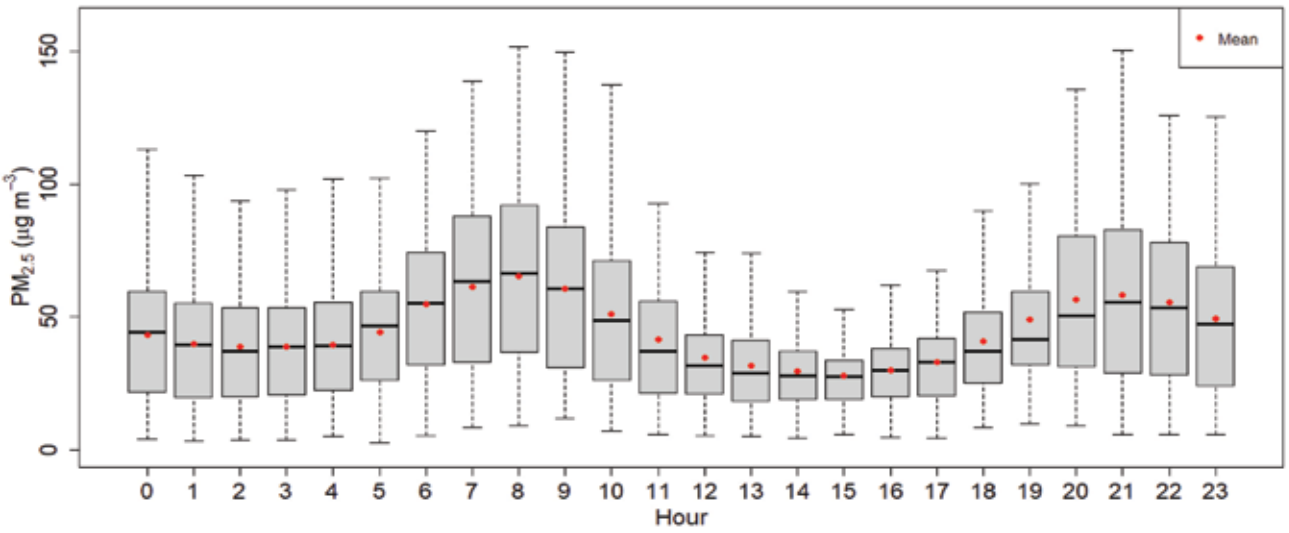

Figure 108: Diurnal variation of $PM_{2.5}$ for Shankhapark Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during December, whereas less during September.

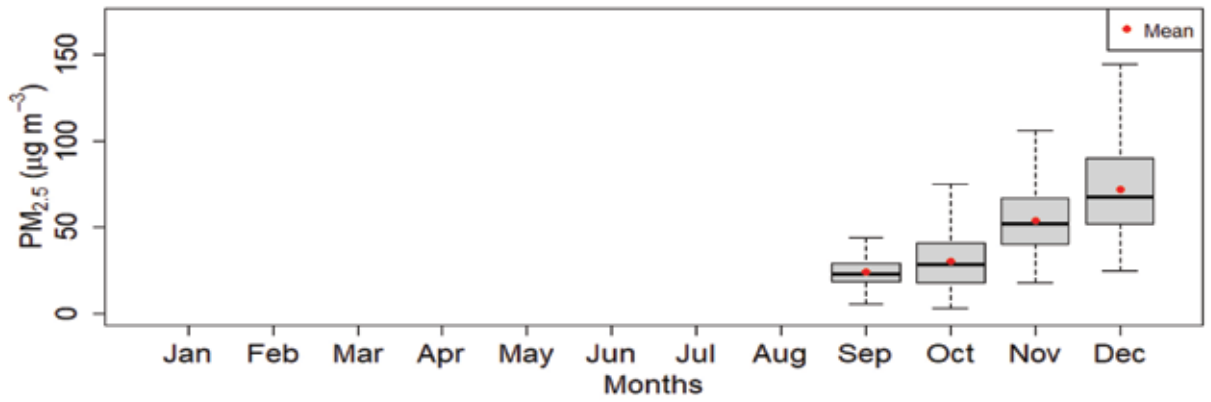

Figure 109: Monthly variation of $PM_{2.5}$ for Shankhapark Station

Daily average:

The daily average data was available only for 102 days.

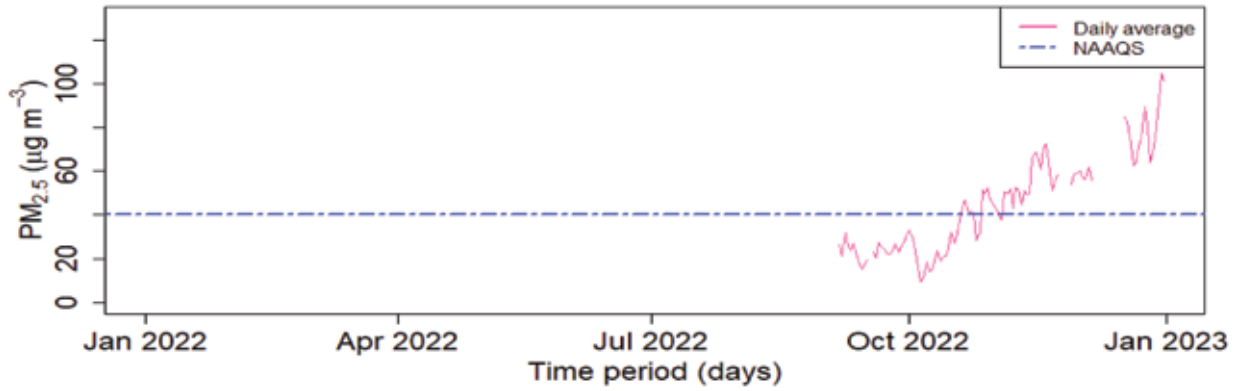

Figure 110: Daily average of $PM_{2.5}$ for Shankhapark Station

Table 32: Summary of daily average of $PM_{2.5}$ for Shankhapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
9.2 µg m^{-3}	24.3 µg m^{-3}	42.7 µg m^{-3}	43.9 ± 21.9 µg m^{-3}	59.0 µg m^{-3}	104.9 µg m^{-3}

Within the available data, the lowest and highest concentration of $PM_{2.5}$ was found to be 9.2 µg m^{-3} to 104.9 µg m^{-3} on 5th October and 30th December respectively (table 47). After 20th October most of the days exceeded NAAQS.

Monthly average:

The bar chart illustrated the monthly average concentration of $PM_{2.5}$. The monthly average of $PM_{2.5}$ was found to be the lowest in September (23.8 µg m^{-3}) and highest in December (73.5 µg m^{-3}).

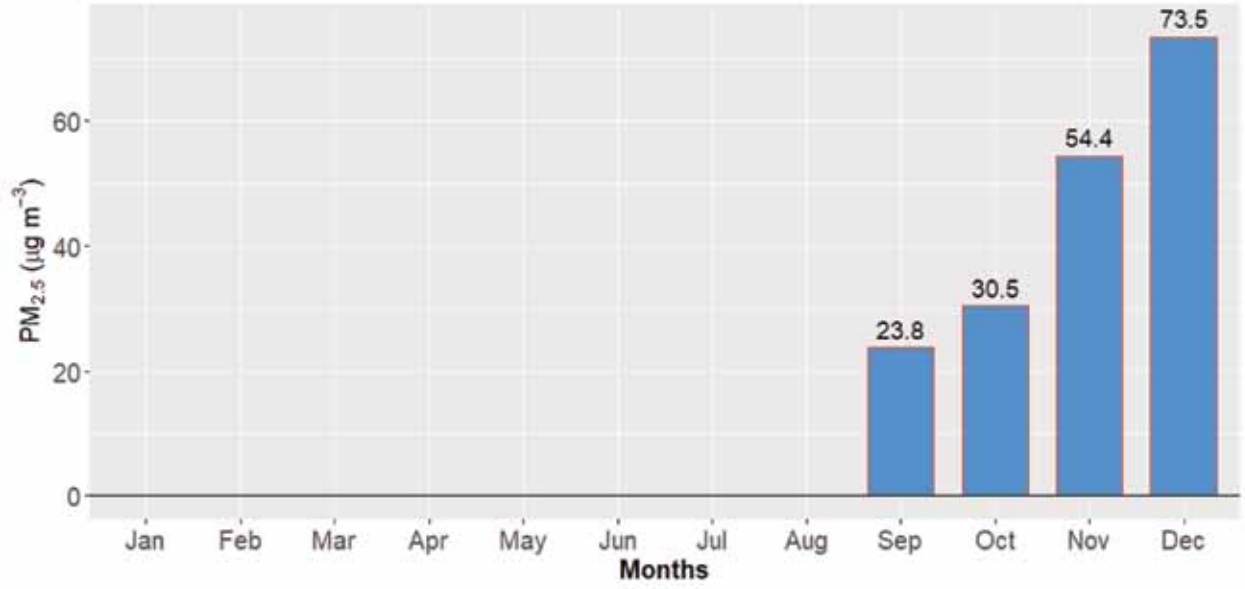

Figure 111: Monthly average of $PM_{2.5}$ for Shankhapark Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Because of limited data, the seasonal averages of only post-monsoon was available (41.4 µg m^{-3}).

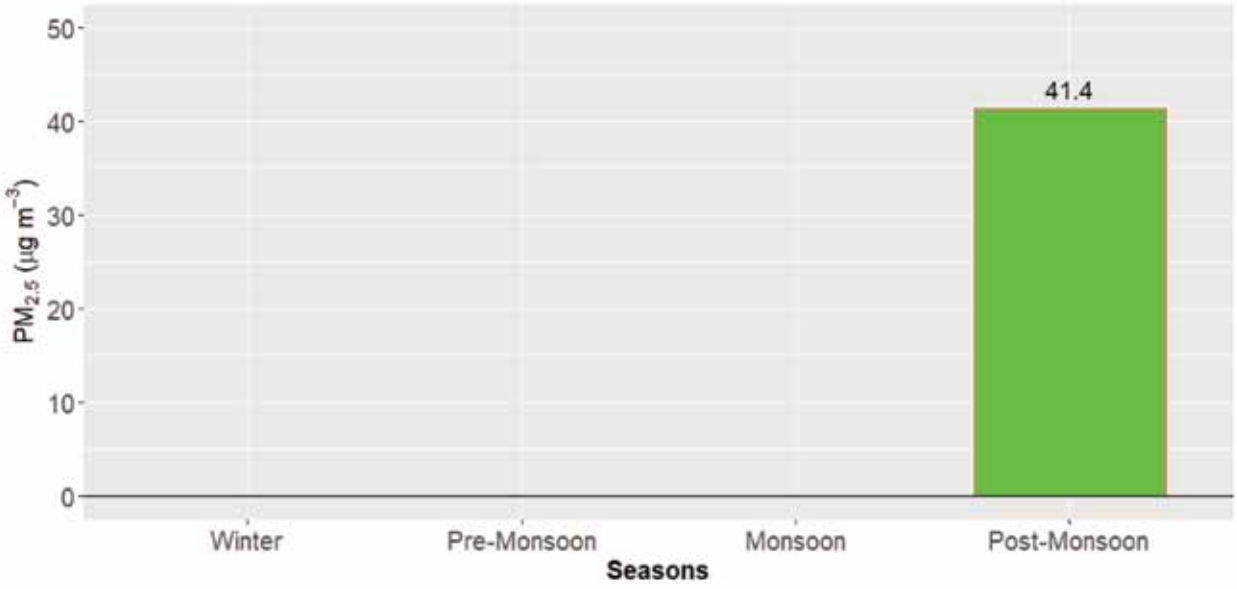

Figure 112: Seasonal average of $PM_{2.5}$ for Shankhapark Station

Compliance status:

Out of the total 102 days of valid measurement, 55 days exceeded the NAAQS. Those noncompliance days were included in October to December as shown in figure 113.

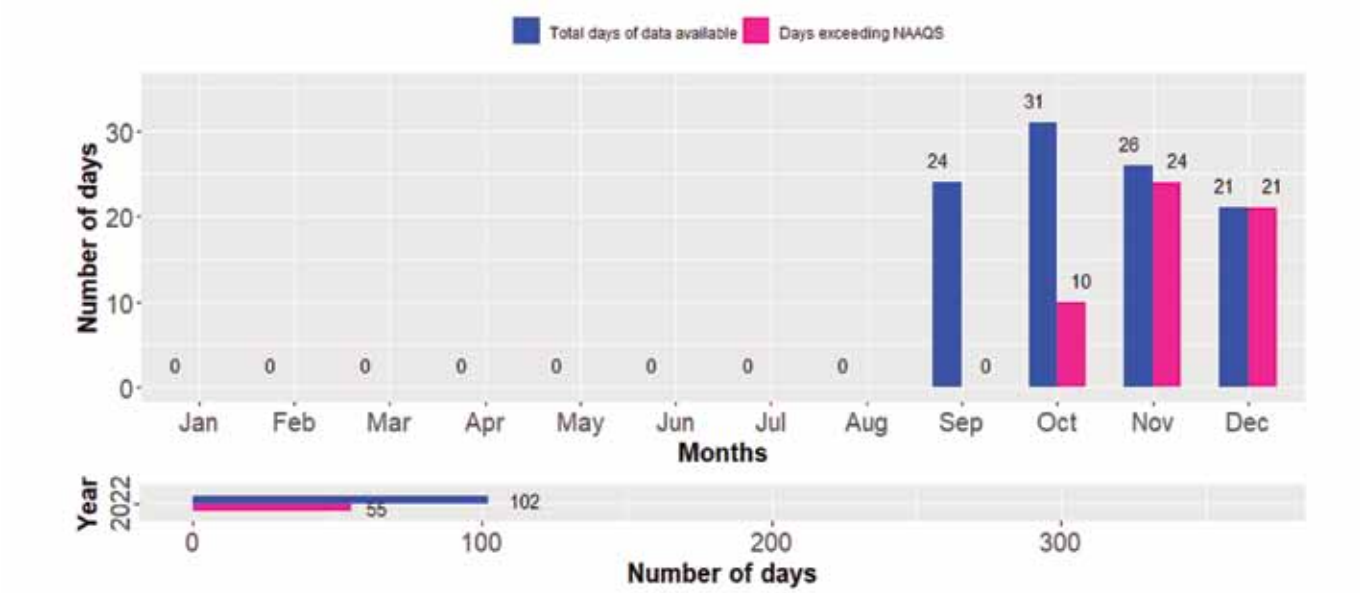

Figure 113: Compliance status of $PM_{2.5}$ for Shankhapark Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 114), out of the total 102 valid days, the daily AQI group shown were good to Unhealthy. Unhealthy category of AQI were seen in November and December.

Figure 114: Calendar plot of $PM_{2.5}$ for Shankhapark Station

2.2.5.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 3.2 µg m^{-3} to 203.0 µg m^{-3}. The lowest and the highest concentration of PM_{10} was observed on 5th October at 5:00 and 30th December at 9:00. The statistical summary of the hourly average is presented in the table below:

Table 33: Summary of hourly average of PM_{10} for Shankhapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
3.2 µg m^{-3}	34.1 µg m^{-3}	58.0 µg m^{-3}	62.9 ± 35.7 µg m^{-3}	84.9 µg m^{-3}	203.0 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (20-110) and as values increase, the frequency of observations decreases rapidly.

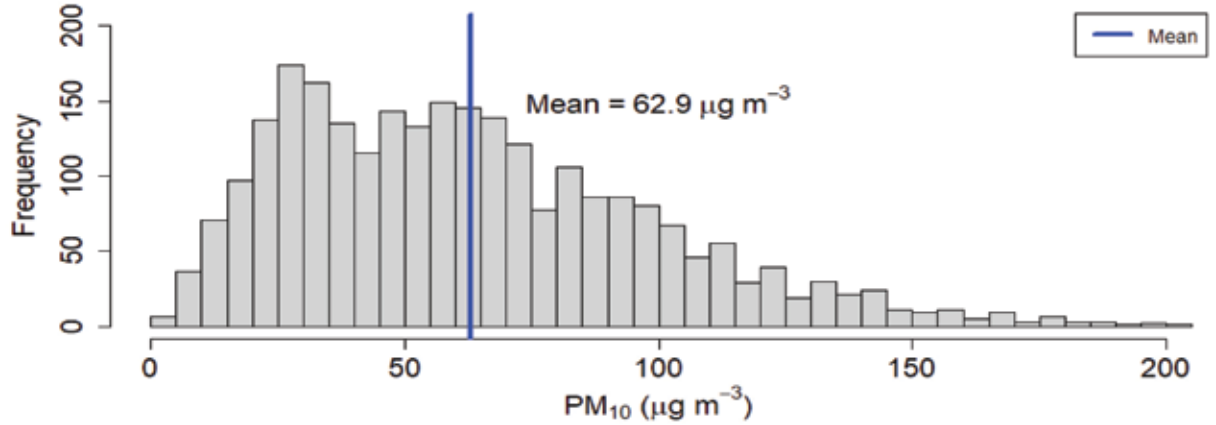

Figure 115: Histogram of PM_{10} for Shankhapark Station

Diurnal variation:

The hourly mean of PM_{10} progressively increases with time from 4:00 and peak at 9:00. Thereafter it decreases till 17: 00 after that it again increases and peak at 21:00. After that it again decreases with time.

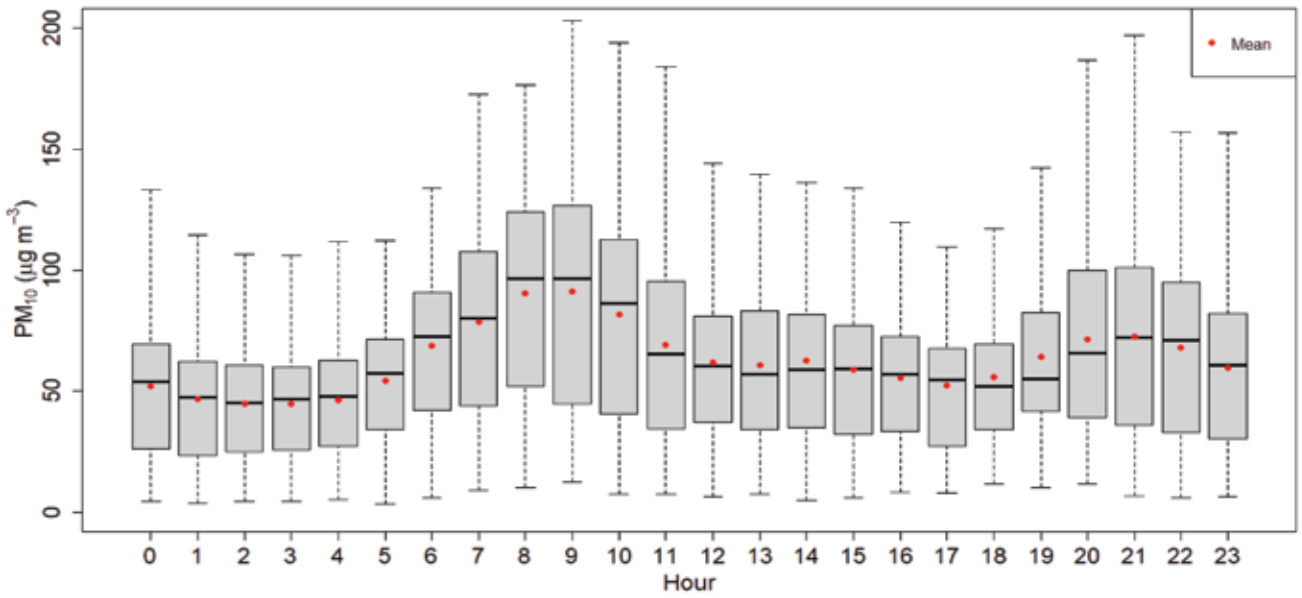

Figure 116: Diurnal variation of PM_{10} for Shankhapark Station

Monthly variation:

A high variation of PM_{10} concentration was seen during December, whereas less during September.

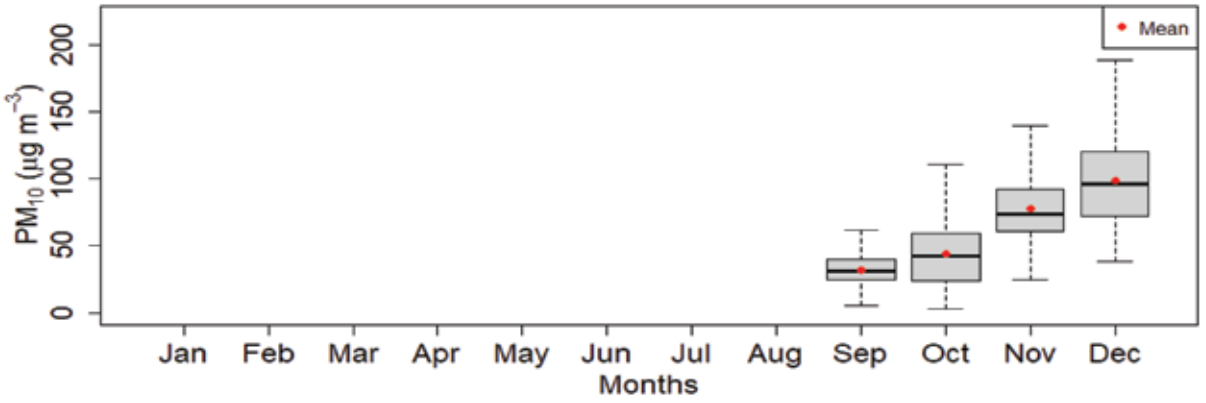

Figure 117: Monthly variation of PM_{10} for Shankhapark Station

Daily average:

Figure 118 explains the daily trend of PM_{10} throughout the year.

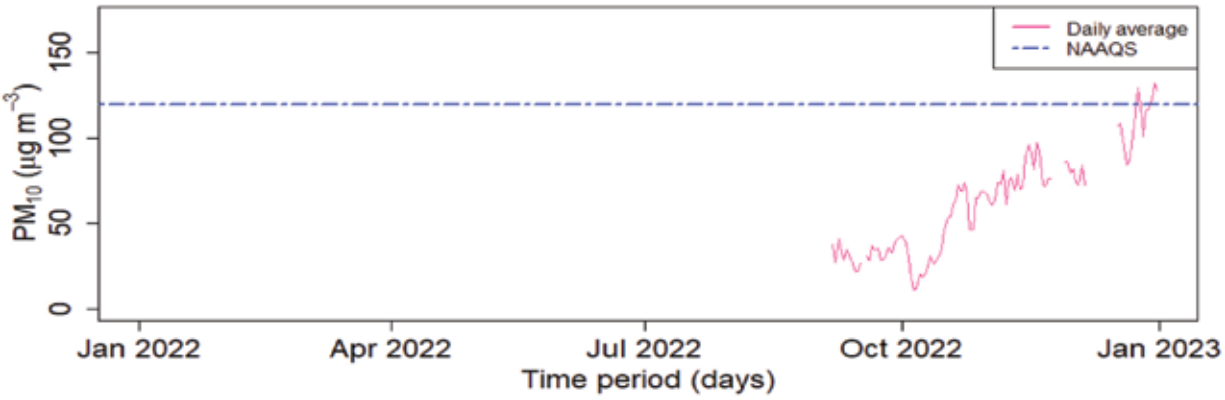

Figure 118: Daily average of PM_{10} for Shankhapark Station

Table 34: Summary of daily average of PM_{10} for Shankhapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
11.1 µg m^{-3}	33.6 µg m^{-3}	65.1 µg m^{-3}	61.6 ± 30.3 µg m^{-3}	81.7 µg m^{-3}	132.0 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 11.1 µg m^{-3} to 132.0 µg m^{-3} on 5th October and 30th December respectively (table 50). Almost total available PM_{10} concentration was found to be within NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of PM_{10}. The monthly average of PM_{10} was lowest in September (32.3 µg m^{-3}) and highest in December (101.1 µg m^{-3}).

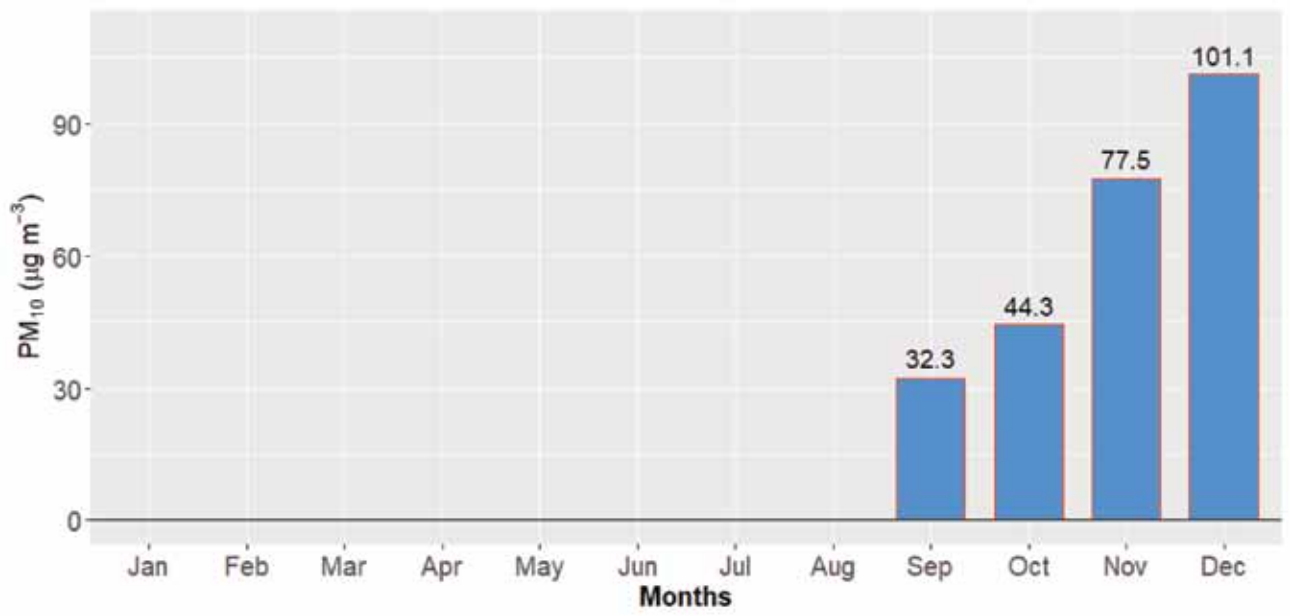

Figure 119: Monthly average of PM_{10} for Shankhapark Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}. Because of limited data, the seasonal averages of only post-monsoon is available (59.5 µg m^{-3}).

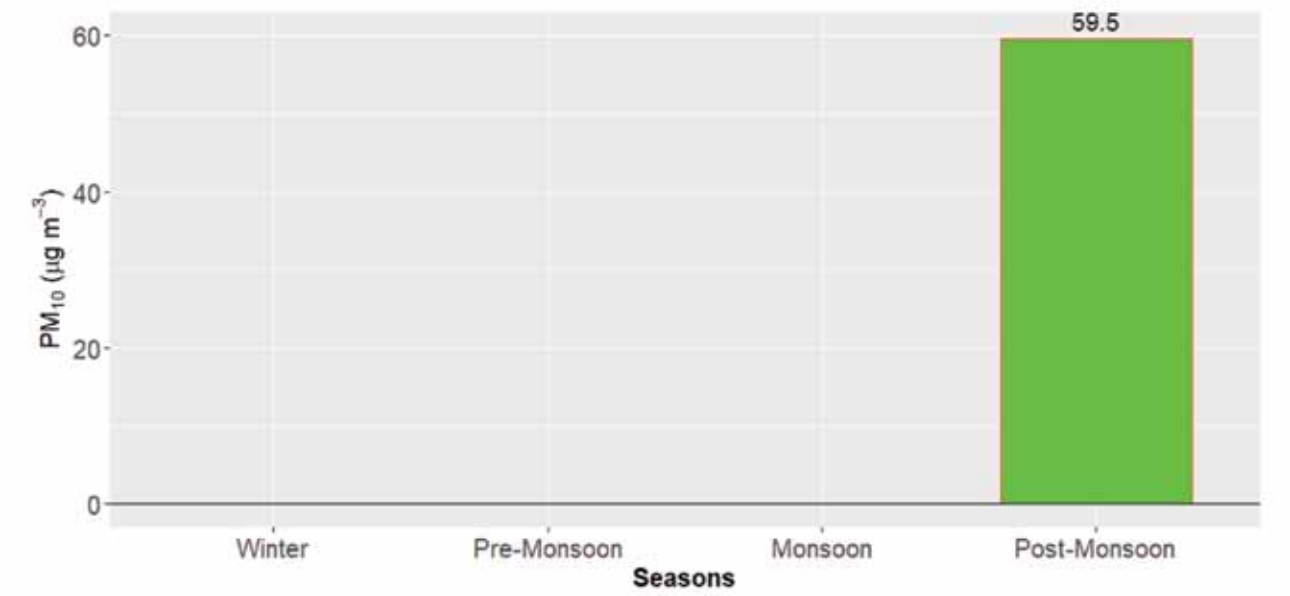

Figure 120: Seasonal average of PM_{10} for Shankhapark Station

Compliance status:

Out of the total 102 days of valid measurement, only 4 days in December exceeded the NAAQS.

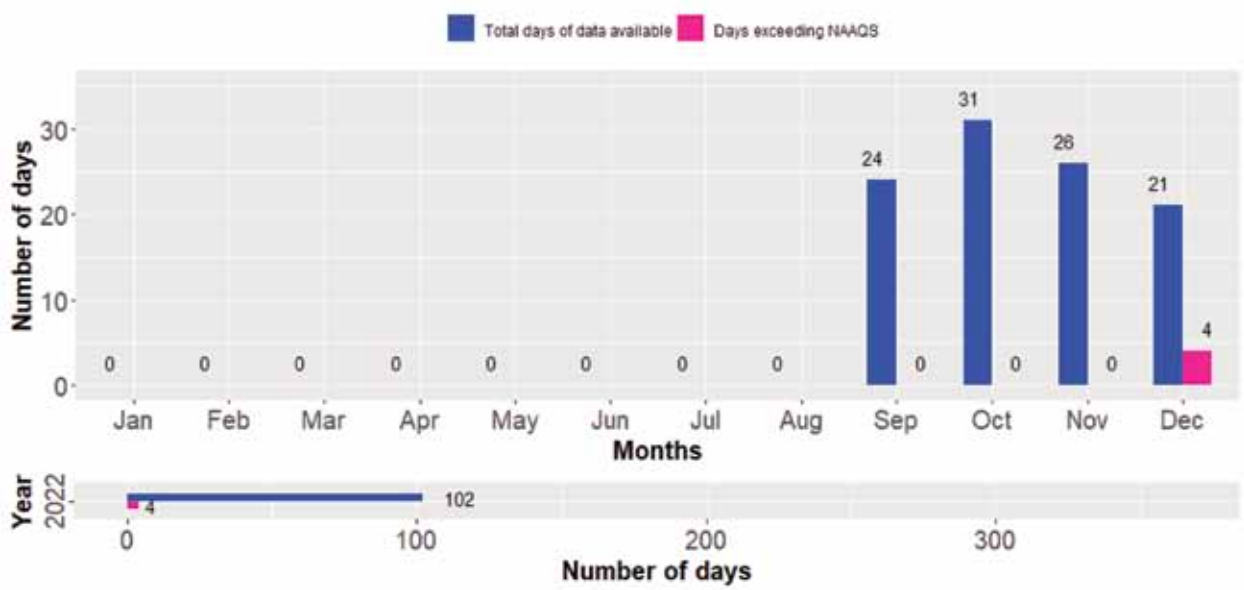

Figure 121: Compliance status of PM_{10} for Shankhapark Station

2.2.5.3 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 3.2 µg m^{-3} to 735.8 µg m^{-3}. The lowest and the highest concentration of TSP was observed on 5th October at 5:00 and 24rd December at 15:00 respectively. The statistical summary of the hourly average is presented in the table below:

Table 35: Summary of hourly average of TSP for Shankhapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
3.2 µg m^{-3}	44.6 µg m^{-3}	82.9 µg m^{-3}	115.2 ± 99.9µg m^{-3}	154.3 µg m^{-3}	735.8 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-150) and as values increase, the frequency of observations decreases rapidly.

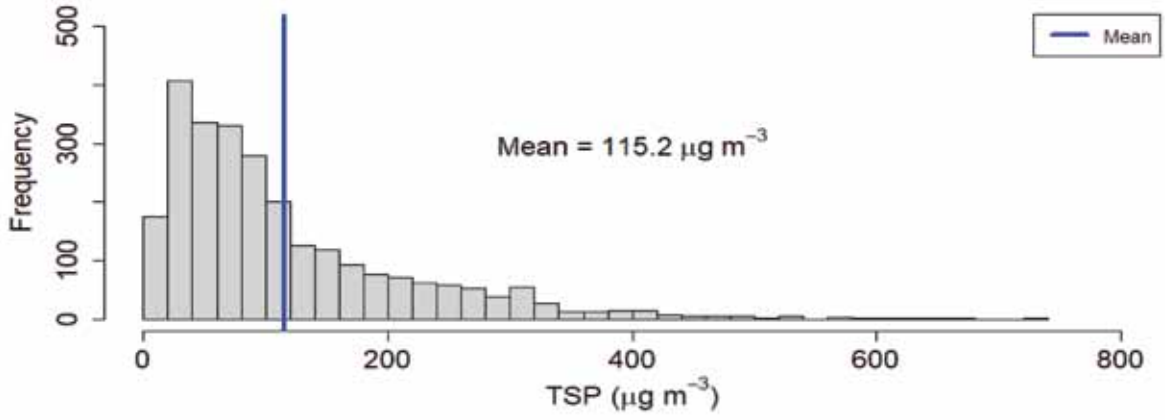

Figure 122: Histogram of TSP for Shankhapark Station

Diurnal variation:

Hourly average of TSP progressively increases with time from 4:00 till 9:00. It peaks at 14:00 after that decreases with time.

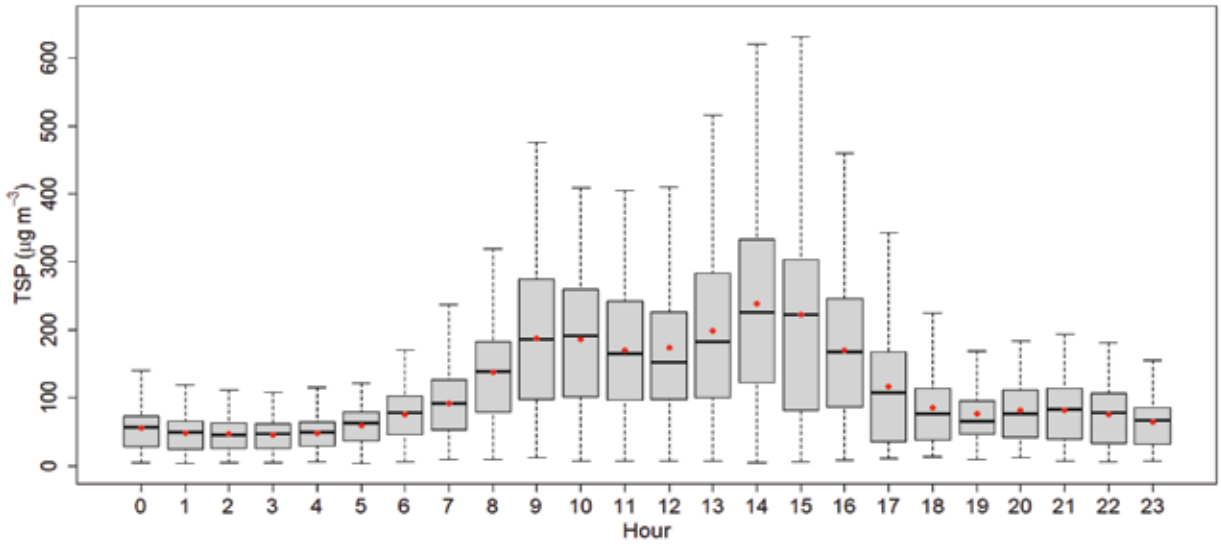

Figure 123: Diurnal variation of TSP for Shankhapark Station

Monthly variation:

A high variation of TSP concentration was seen during December, whereas less during September.

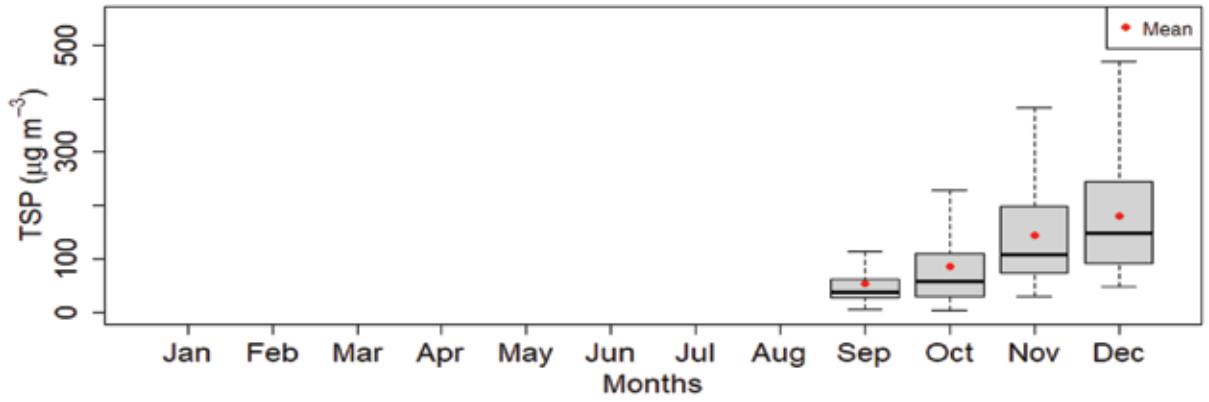

Figure 124: Monthly variation of TSP for Shankhapark Station

Daily average:

Figure 125 explains the daily trend of TSP.

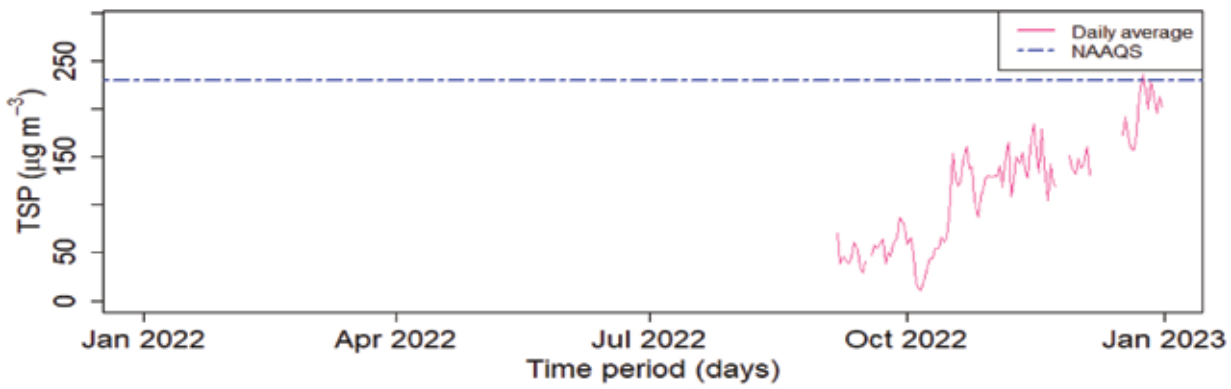

Figure 125: Daily average of TSP for Shankhapark Station

Table 36: Summary of daily average of TSP for Shankhapark Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
11.4 µg m-3	58.3 µg m-3	125.0 µg m-3	112.2 ± 56.8 µg m-3	152.3 µg m-3	236.2 µg m-3

Within the available data, the lowest and highest concentration of TSP was found to be 11.4 µg m^{-3} to 236.2 µg m^{-3} on 6th October and 24th December respectively (table 53).

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. The monthly average of TSP was lowest in September (53.7 µg m^{-3}) and highest in December (183.1 µg m^{-3}).

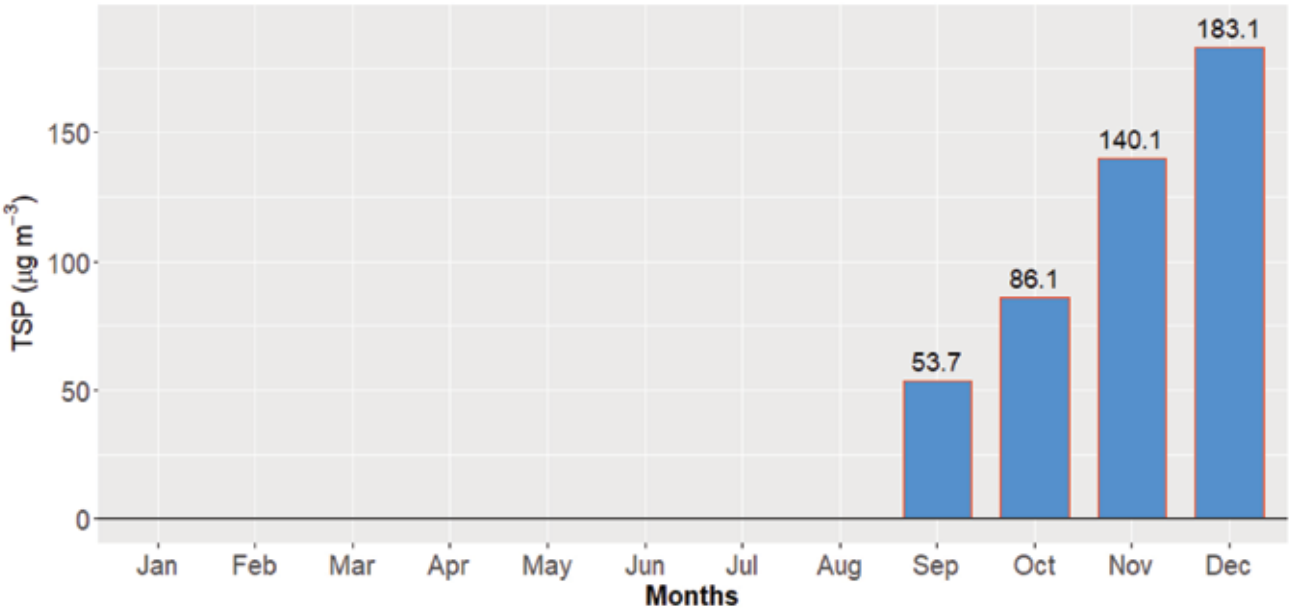

Figure 126: Monthly average of TSP for Shankhapark Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP. Because of limited data, the seasonal averages of only Post-Monsoon is available (110.7 µg m^{-3}).

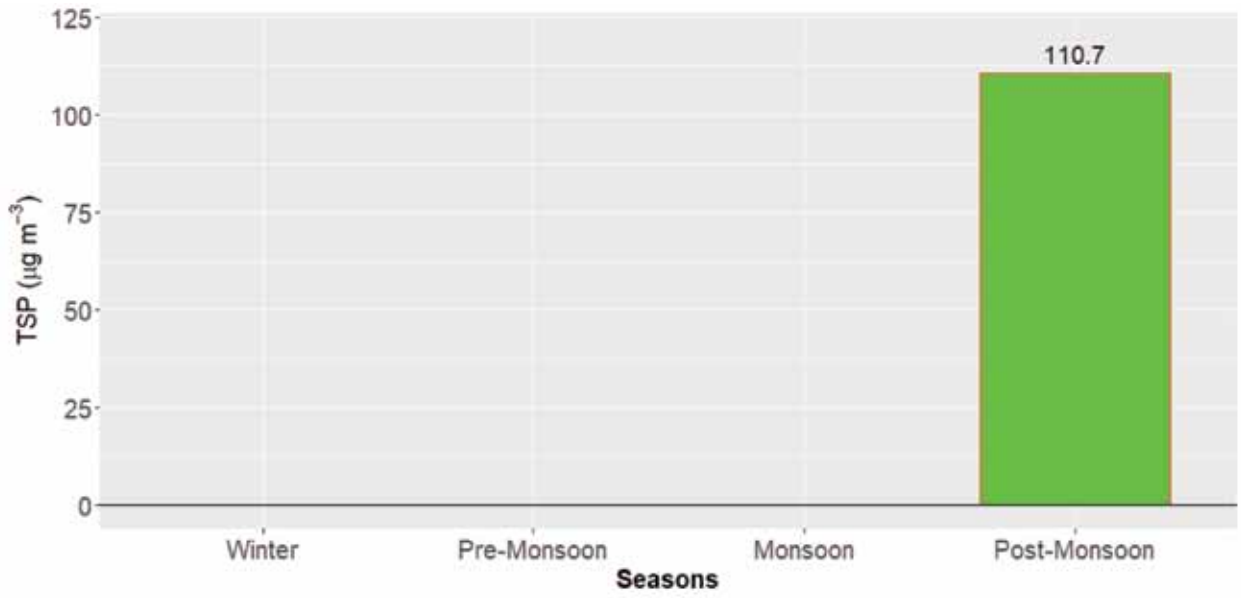

Figure 127: Seasonal average of TSP for Shankhapark Station

Compliance status:

Out of the total 102 days of valid measurement, only 2 days in December exceeded the NAAQS.

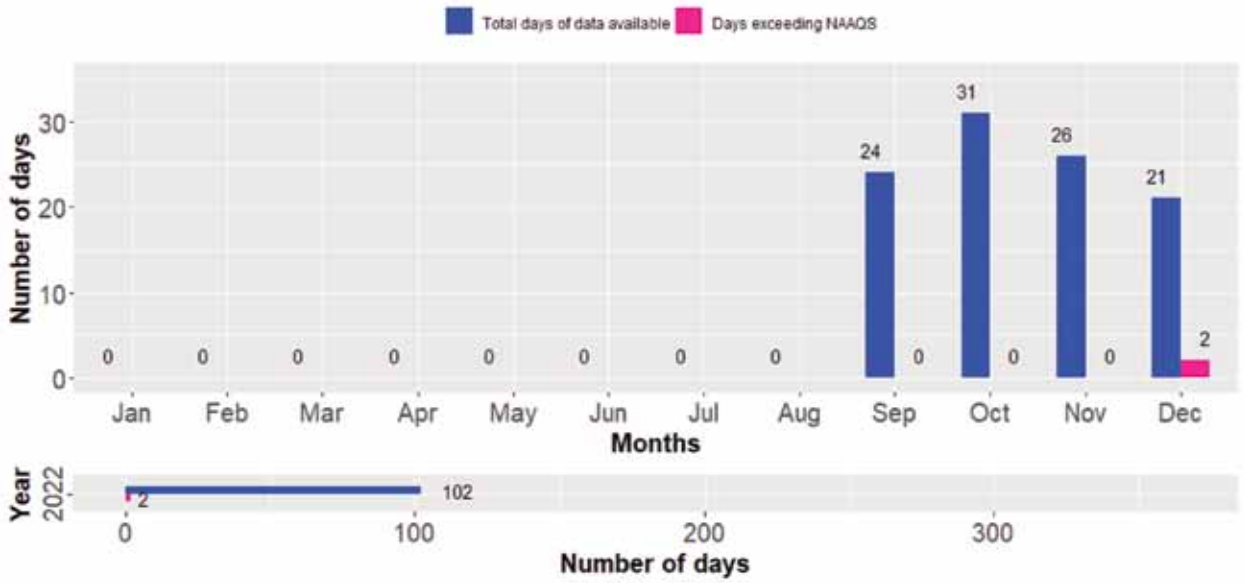

Figure 128: Compliance status of TSP for Shankhapark Station

2.2.6 TU KIRTIPUR AIR QUALITY MONITORING STATION

TU Air Quality Monitoring Station was established in the year 2016. It lies inside the premises of Tribhuvan university near DHM weather station.

Being situated within the university premises, there is relatively low traffic in the immediate vicinity of the station. However, the Ring-Road is nearby, within a distance of less than 1 kilometer. The station is positioned on the eastern side of Kirtipur municipality, with Kathmandu Metropolitan City lying to the east, signifying its urban setting. Emissions from the vehicles is the main source of pollution in the area. Besides emission from industries is another main source. In the winter season solid waste burning is also major source. Sometimes pollution from other parts of the country enters the city. In Pre-monsoon season pollution from forest fire in different parts of the country become one of the major source of pollution.

2.2.6.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 2.6 μg m^{-3} to 167.7 μg m^{-3}. The lowest and the highest concentration of $PM_{2.5}$ was observed on 5th October at 5:00 and 1st January at 11:00 respectively. The statistical summary of the hourly average is presented in the table below:

Table 37: Summary of hourly average of $PM_{2.5}$ for Kirtipur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.6 μg m^{-3}	20.4 μg m^{-3}	39.2 μg m^{-3}	44.8 ± 28.9 μg m^{-3}	64.2 μg m^{-3}	167.7 μg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (10-80) and as values increase, the frequency of observations decreases rapidly.

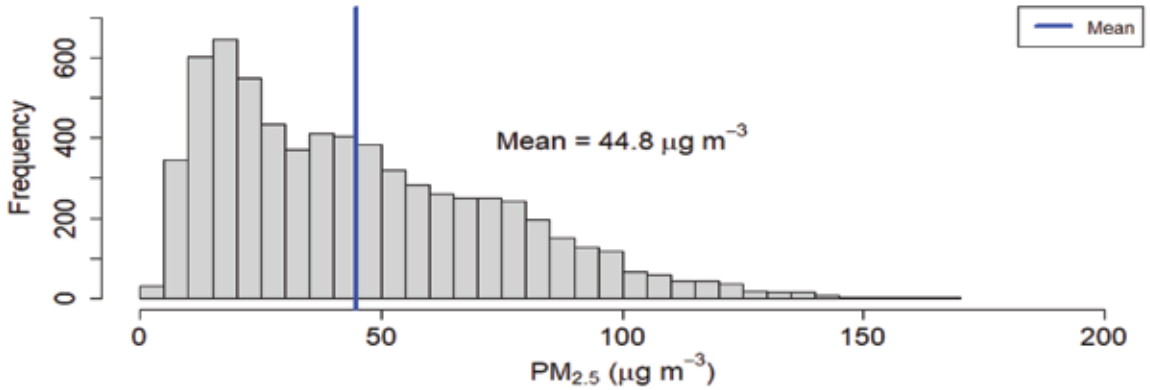

Figure 129: Histogram of PM2.5for Kirtipur Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ progressively increases with time from 6:00 and reaches to its peak at 7:00-8:00. Thereafter it decreases and become lowest at 14:00. From 16:00 it again rises with time gains height around 21:00-22:00.

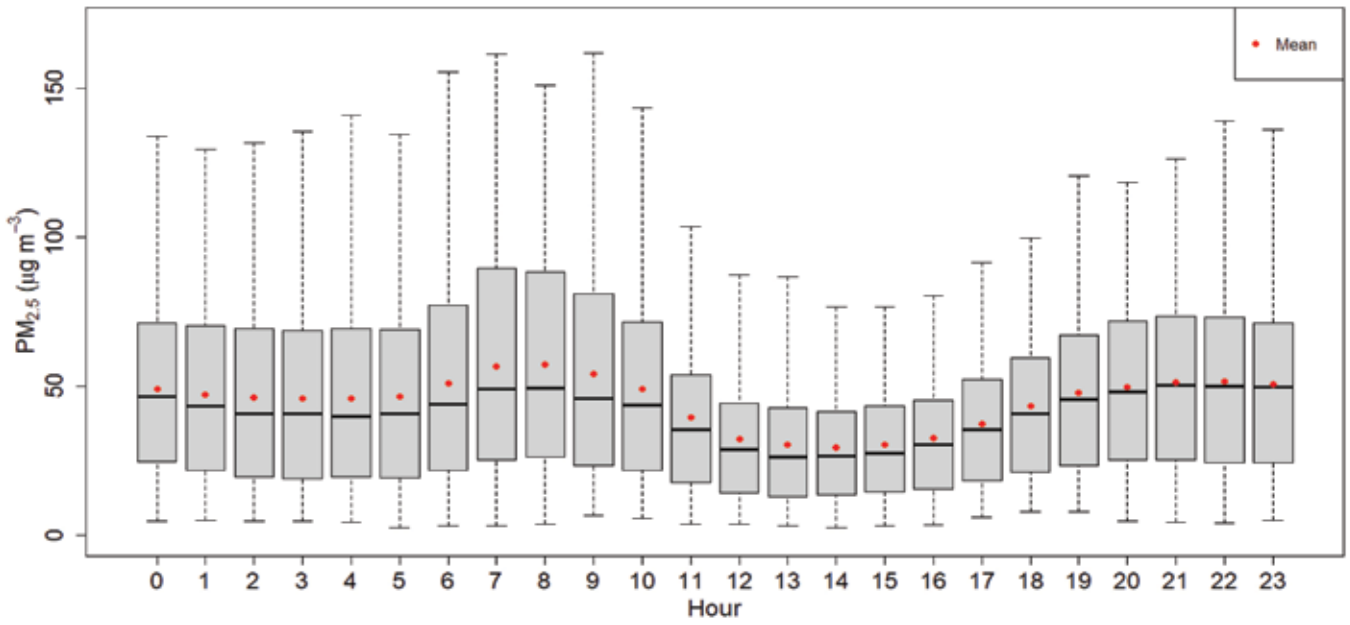

Figure 130: Diurnal variation of $PM_{2.5}$ for Kirtipur Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during January to April, whereas less during August.

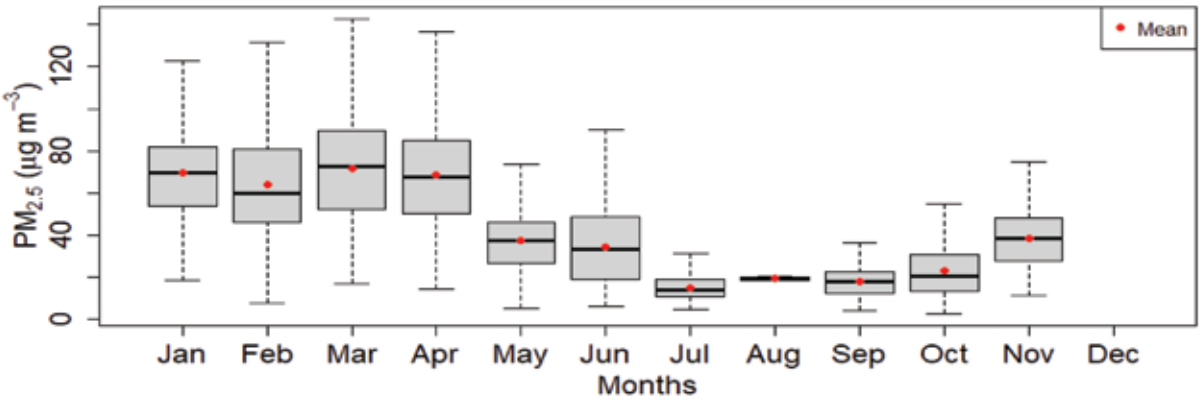

Figure 131: Monthly variation of $PM_{2.5}$ for Kirtipur Station

Daily average:

The daily average data was available only for 275 days. Figure 132 explain the daily trend of $PM_{2.5}$ throughout the year.

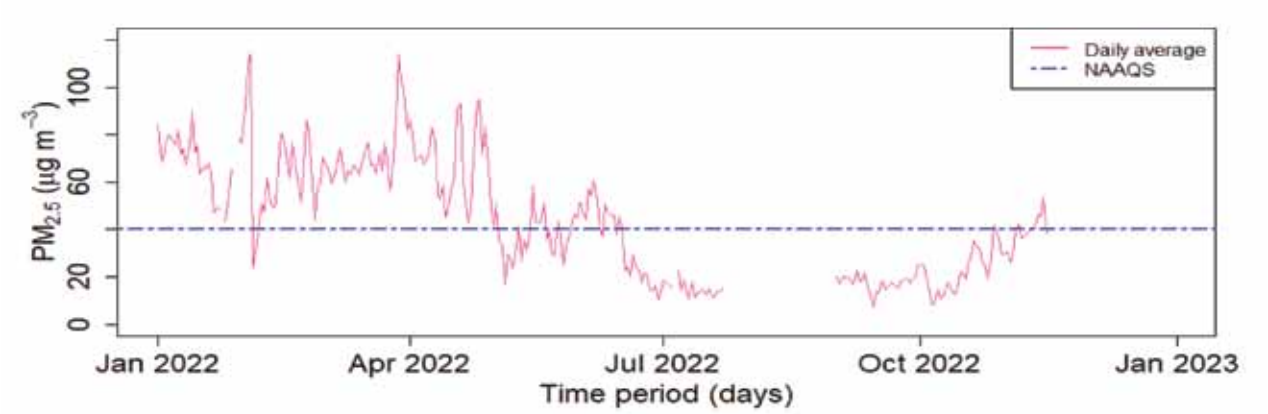

Figure 132: Daily average of $PM_{2.5}$ for Kirtipur Station

Table 38: Summary of daily average of $PM_{2.5}$ for Kirtipur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
7.3 µg m^{-3}	20.6 µg m^{-3}	42.8 µg m^{-3}	44.8 ± 24.8 µg m^{-3}	65.7 µg m^{-3}	114.2 µg m^{-3}

Within the available data, the lowest and highest concentration of $PM_{2.5}$ was found to be 7.3 µg m^{-3} to 114.2 µg m^{-3} on 14th September and 3rd February respectively (table 56). During the majority of days, $PM_{2.5}$ concentration was found to be above NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. The average concentration of $PM_{2.5}$ was the the lowest in July (15.0 µg m^{-3}) and highest in March (71.8 µg m^{-3}). Monthly average of August and December was not available due to limited availability of data.

Figure 133: Monthly average of $PM_{2.5}$ for Kirtipur Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Seasonal average of $PM_{2.5}$ Winter season was highest (72.1 µg m^{-3}) and that of Monsoon season was lowest (23.2 µg m^{-3}).

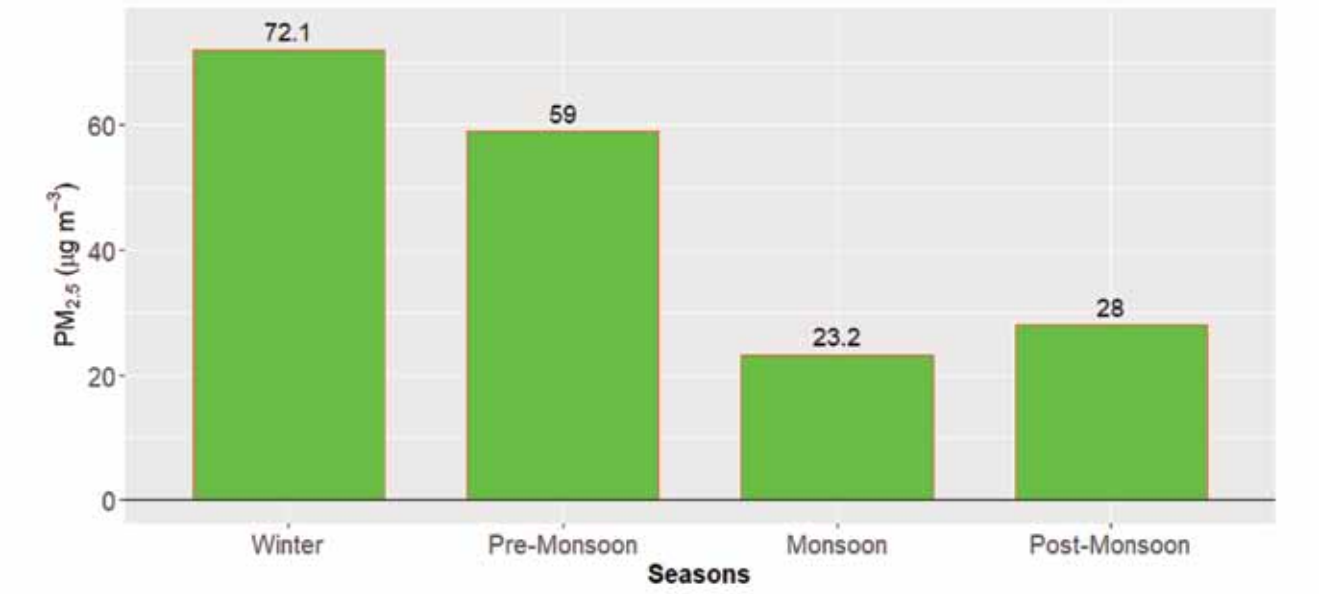

Figure 134: Seasonal average of $PM_{2.5}$ for Kirtipur Station

Compliance status:

Out of the total 275 days of valid measurement, 149 days exceeded the NAAQS.

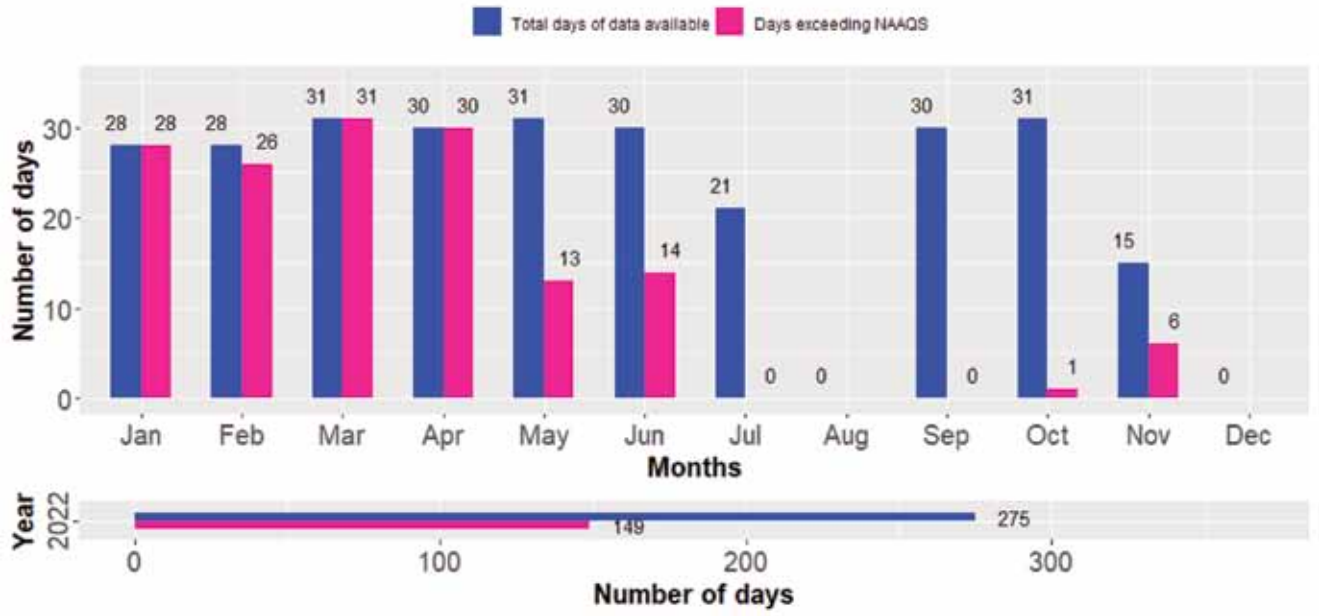

Figure 135: Compliance status of $PM_{2.5}$ for Kirtipur Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 136), out of the total 275 valid days, AQI category of good to unhealthy was seen throughout the day. A lot of Unhealthy categories of days can be seen on January to April.

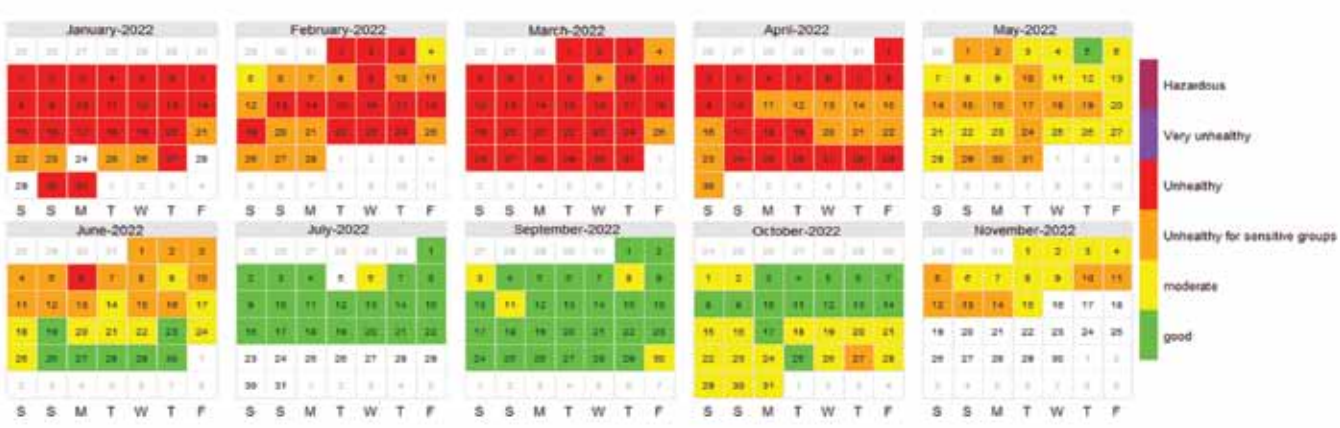

Figure 136: Calendar plot of $PM_{2.5}$ for Kirtipur Station

2.2.6.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 3.2 μg m^{-3} to 381.5 μg m^{-3}. The lowest and highest concentration of PM_{10} was observed on 6th October at 14:00 and 24th April at 21:00 respectively. The statistical summary of the hourly average is presented in the table below:

Table 39: Summary of hourly average of PM_{10} for Kirtipur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
3.2 μg m^{-3}	34.8 μg m^{-3}	67.2 μg m^{-3}	80.3 ± 57.7 μg m^{-3}	110.1 μg m^{-3}	381.5 μg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (10-150) and as values increase, the frequency of observations decreases rapidly.

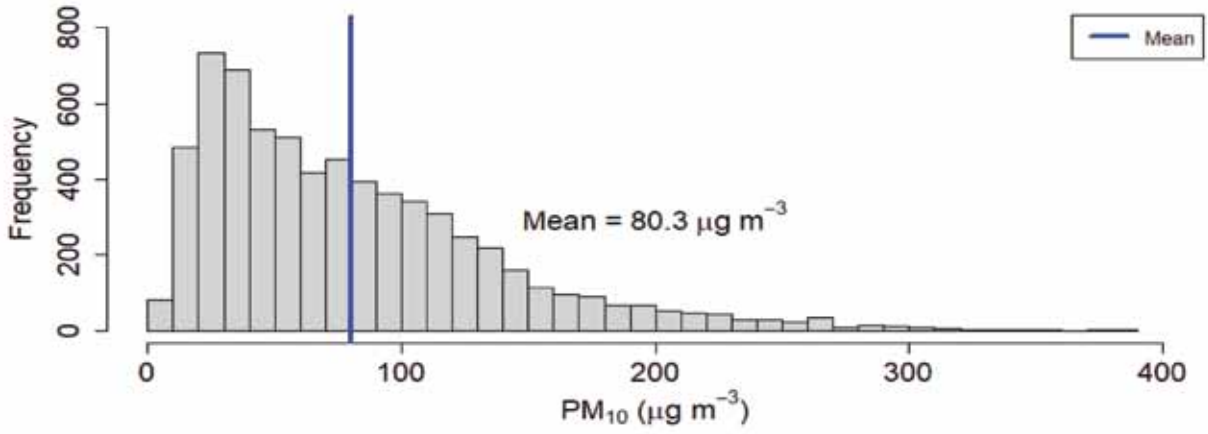

Figure 137: Histogram of PM_{10} for Kirtipur Station

Diurnal variation:

The hourly mean of PM_{10} progressively increases with time from 5:00 and reached to its peak at 9:00. Thereafter it decreases till 14. There after it increases slightly with time till 18:00. There after it decreases slightly with time.

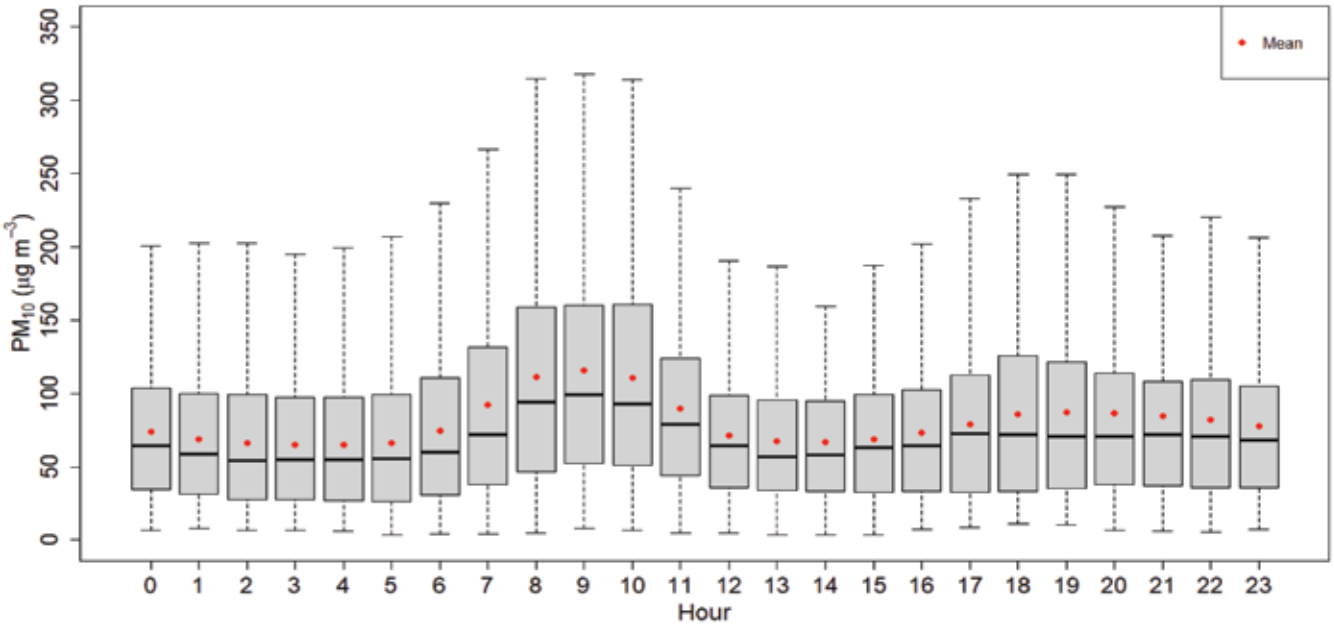

Figure 138: Diurnal variation of PM_{10} for Kirtipur Station

Monthly variation:

A high variation of PM_{10} concentration was seen during March and April whereas less occurs during July to August.

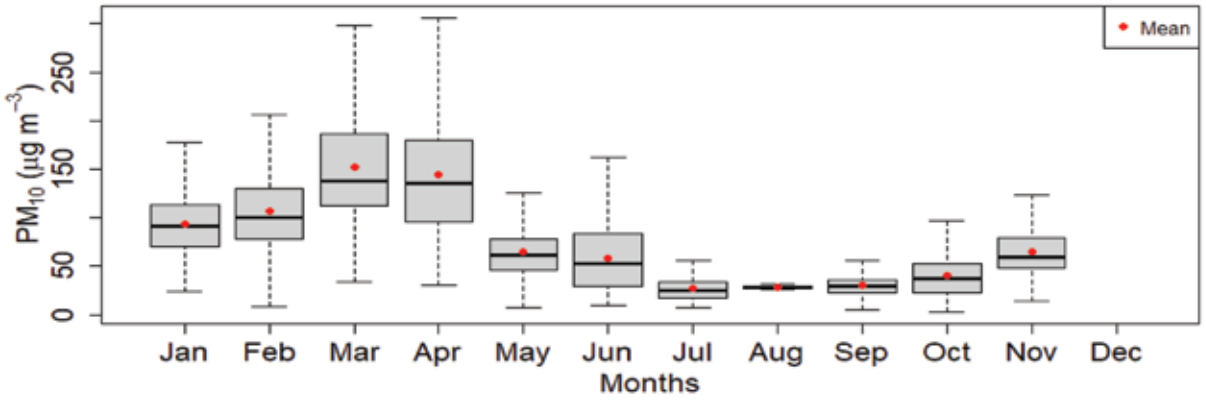

Figure 139: Monthly variation of PM_{10} for Kirtipur Station

Daily average:

Figure 140 explains the daily trend of PM_{10} throughout the year.

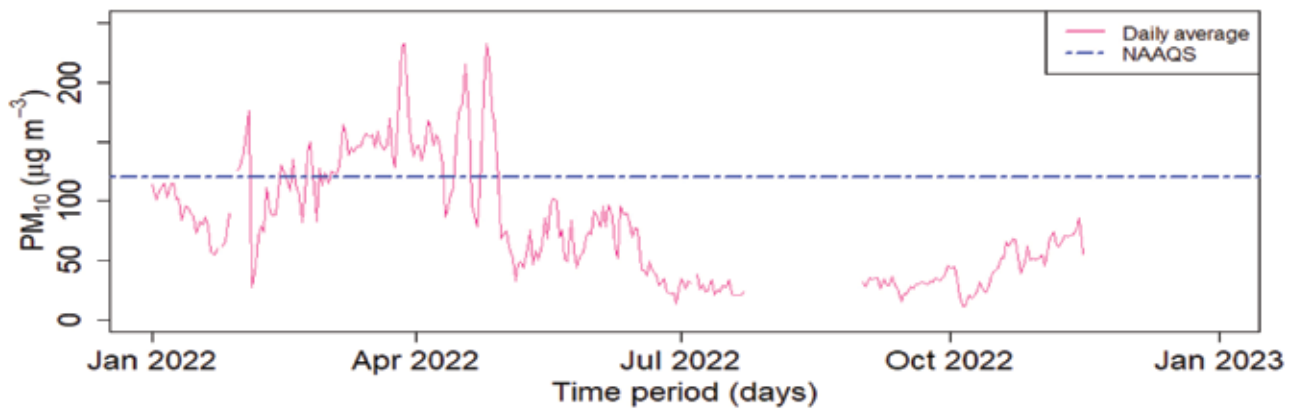

Figure 140: Daily average of PM_{10} for Kirtipur Station

Table 40: Summary of daily average of PM_{10} for Kirtipur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
11.2 µg m^{-3}	36.0 µg m^{-3}	71.2 µg m^{-3}	80.4 ± 49.7 µg m^{-3}	113.2 µg m^{-3}	232.7 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 11.2 µg m^{-3} and 232.7 µg m^{-3} on 5th October and 25th April respectively (table 59).

Monthly average:

The average monthly concentration of PM_{10} was shown in the bar chart. The monthly average value of PM_{10} was the lowest in July (26.8 µg m^{-3}) and highest in April (152.4 µg m^{-3}).

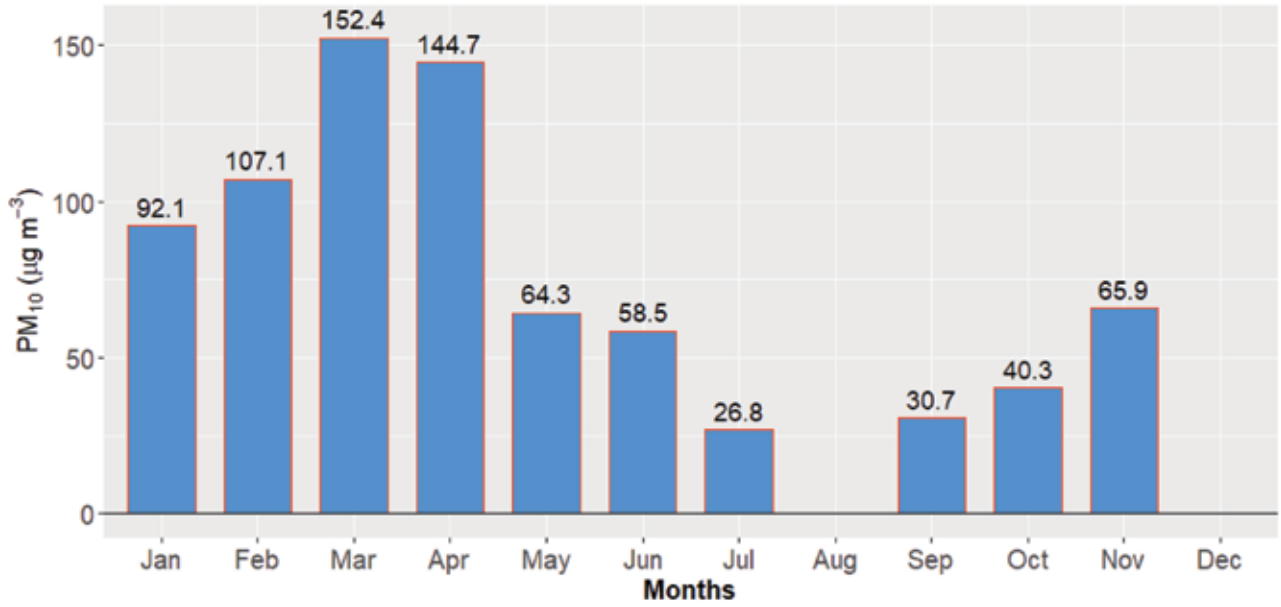

Figure 141: Monthly average of PM_{10} for Kirtipur Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}. Pre-Monsoon season has the highest seasonal average (120.2 µg m^{-3}) and monsoon season has the lowest seasonal value (40.0 µg m^{-3}).

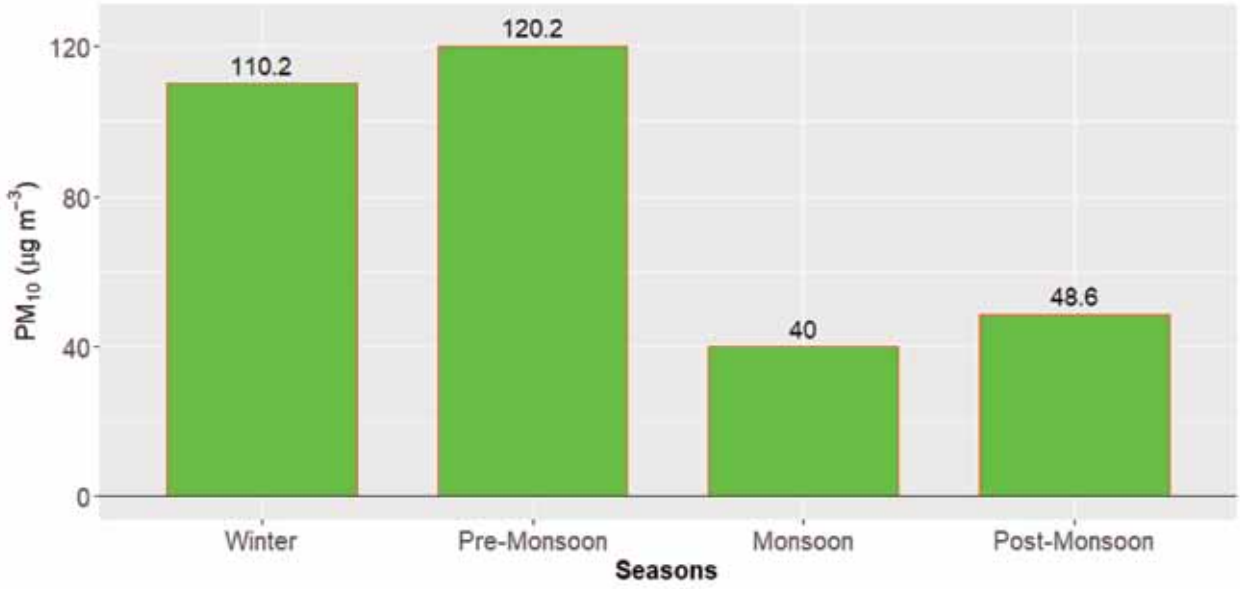

Figure 142: Seasonal average of PM_{10} for Kirtipur Station

Compliance status:

Out of the total 275 days of measurement, 61 days exceeded the NAAQS.

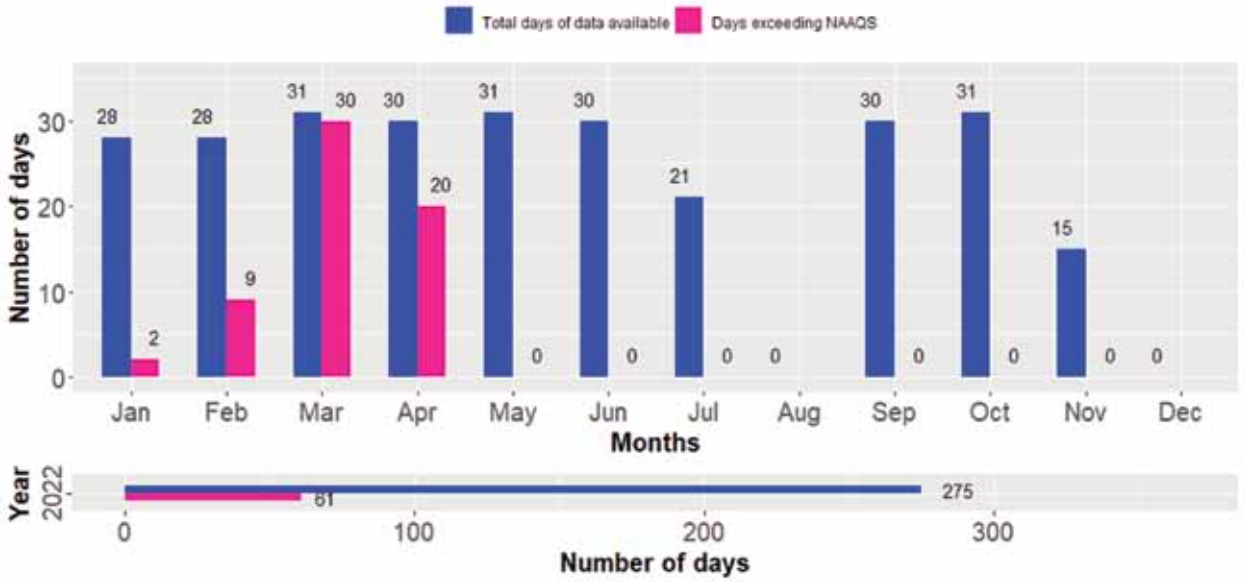

Figure 143: Compliance status of PM_{10} for Kirtipur Station

2.2.6.3 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 3.5 µg m^{-3} to 1008.6 µg m^{-3}. The lowest and the highest concentration of TSP was observed on 6th October at 14:00 and 24th April at 22:00 respectively. The statistical summary of the hourly average is presented in the table below:

Table 41: Summary of hourly average of TSP for Kirtipur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
3.5 μg m^{-3}	54.0 μg m^{-3}	108.6 μg m^{-3}	150.5 ± 131.0 μg m^{-3}	200.0 μg m^{-3}	1008.6 μg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-200) and as values increase, the frequency of observations decreases rapidly.

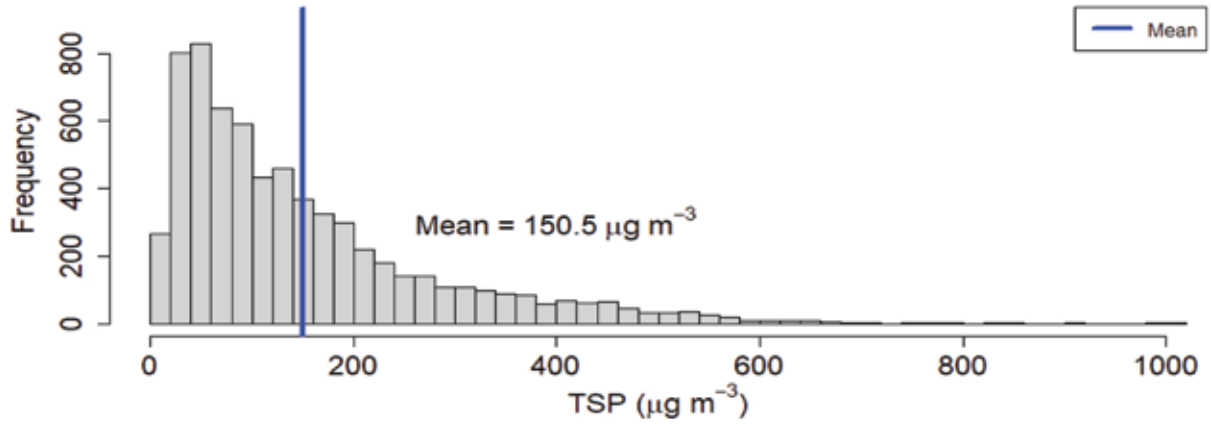

Figure 144: Histogram of TSP for Kirtipur Station

Diurnal variation:

The hourly mean of TSP progressively increases with time and reached to its peaks at 10:00 which again decreases and gains height around 17:00-18:00.

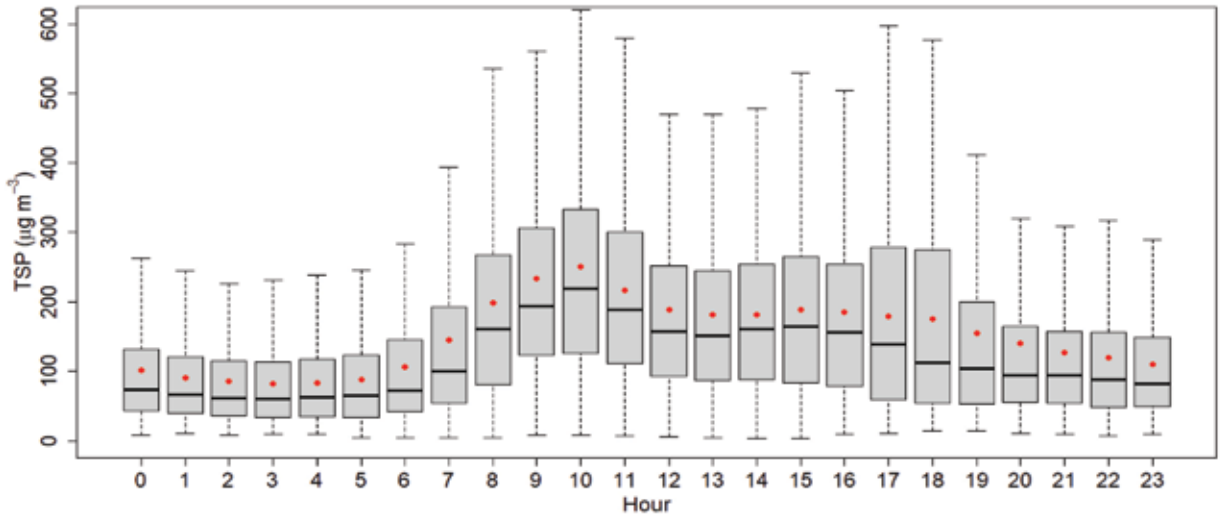

Figure 145: Diurnal variation of TSP for Kirtipur Station

Monthly variation:

A high variation of TSP concentration was seen during March and April, whereas less occurs during August.

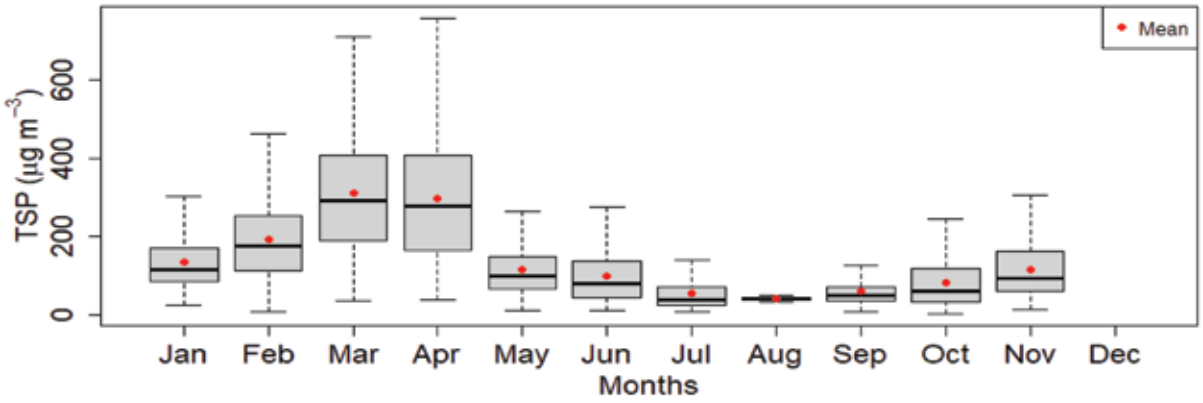

Figure 146: Monthly variation of TSP for Kirtipur Station

Daily average:

Figure 147 explains the daily trend of TSP throughout the year.

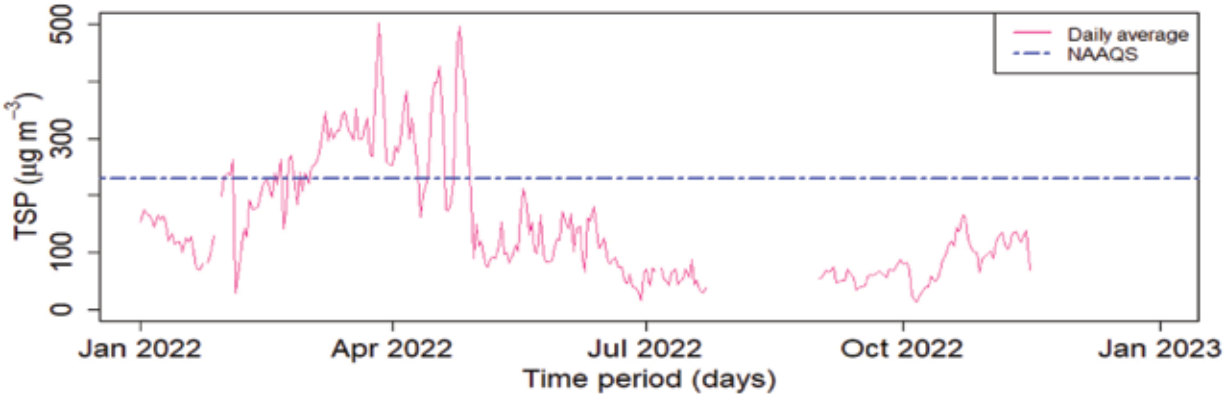

Figure 147: Daily average of TSP for Kirtipur Station

Table 42: Summary of daily average of TSP for Kirtipur Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
14.1 µg m^{-3}	71.6 µg m^{-3}	119.0 µg m^{-3}	151.0 ± 103.2 µg m^{-3}	209.5 µg m^{-3}	502.8 µg m^{-3}

Within the available data, the lowest and highest concentration of TSP was found to be 14.1 µg m^{-3} and 502.8 µg m^{-3} on 6th October and 27th March respectively (table 62). Most of the available TSP concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. July has the lowest (55.1 µg m^{-3}) and March has the highest monthly average value of TSP (311.9 µg m^{-3}).

Figure 148: Monthly average of TSP for Kirtipur Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP. Pre-Monsoon season has the highest seasonal average of TSP (240.7 µg m^{-3}) and Monsoon has the lowest seasonal average (73.2 µg m^{-3}).

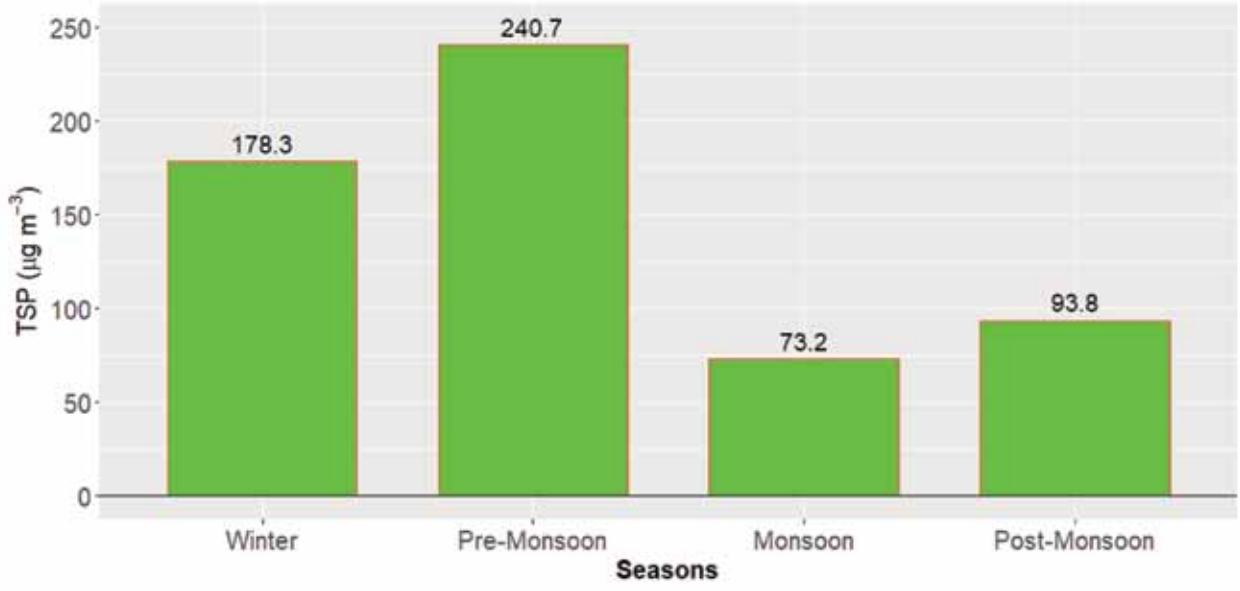

Figure 149: Seasonal average of TSP for Kirtipur Station

Compliance status:

Out of the total 275 days of measurement, 60 days exceeded the NAAQS.

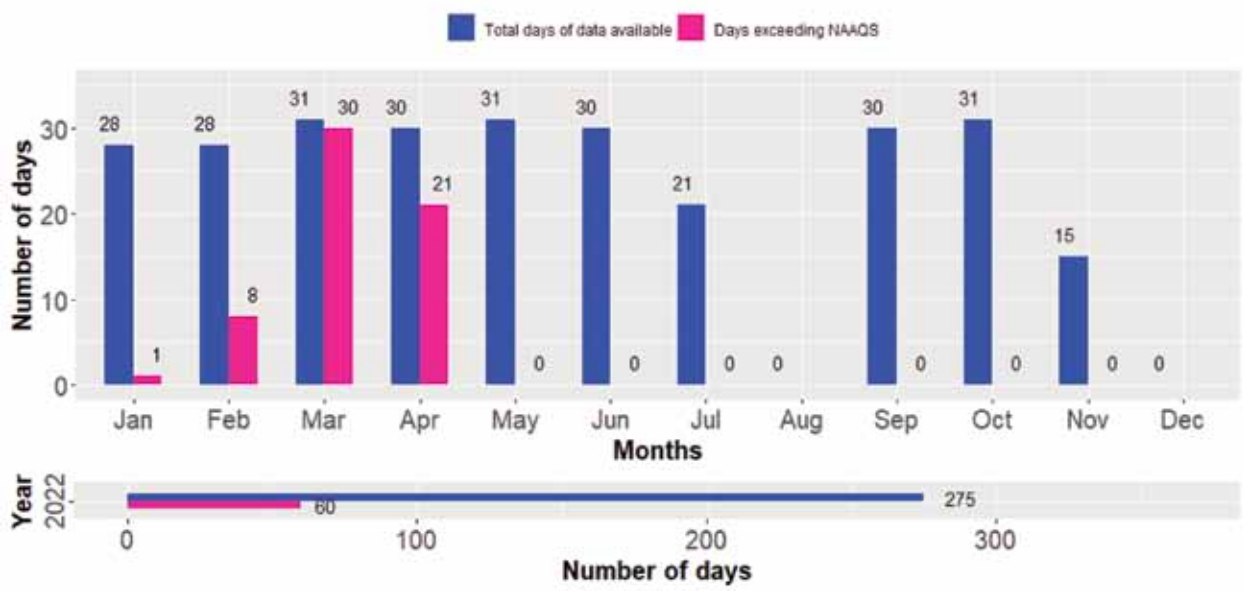

Figure 150: Compliance status of TSP for Kirtipur Station

2.3 LUMBINI PROVINCE

2.3.1 DANG AIR QUALITY MONITORING STATION

Dang air quality monitoring station was established in 2018 at Ghorahi Sub-Metropolitan City in Dang district, Lumbini Province. This station is located at Rampur near the office of Ward number 4. This station represents the urban area.

Emission from the vehicles and industries are the main sources of pollution in the area around the station. Another likely source of air pollution in this region is the extensive burning of agricultural.

2.3.1.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 1.1 µg m^{-3} to 413.9 µg m^{-3}. The lowest and the highest concentration of $PM_{2.5}$ was observed on 7th October at 3:00 and 5th May at 17:00. The statistical summary of the hourly average is presented in the table below:

Table 43: Summary of hourly average of $PM_{2.5}$ for Dang Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 µg m^{-3}	9.0 µg m^{-3}	17.0 µg m^{-3}	23.7 ± 21.6 µg m^{-3}	31.6 µg m^{-3}	413.9 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-25) and as values increase, the frequency of observations decreases rapidly.

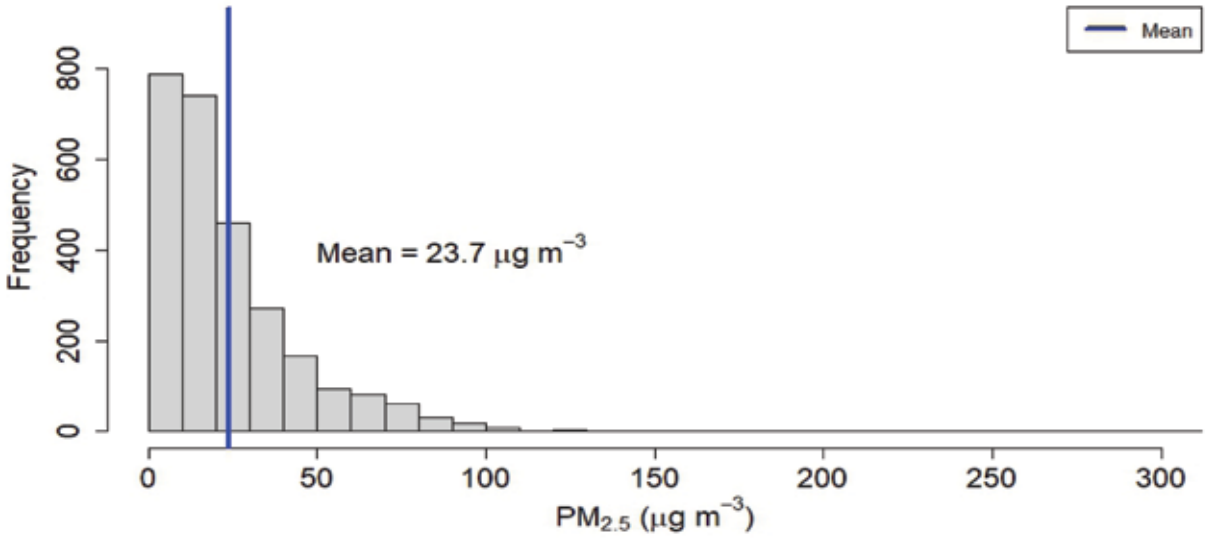

Figure 151: Histogram of $PM_{2.5}$ for Dang Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ progressively increases with time and reached to its peak at 7:00-9:00 which again decreases and gain height around 18:00. The mean value was found more than median throughout the day.

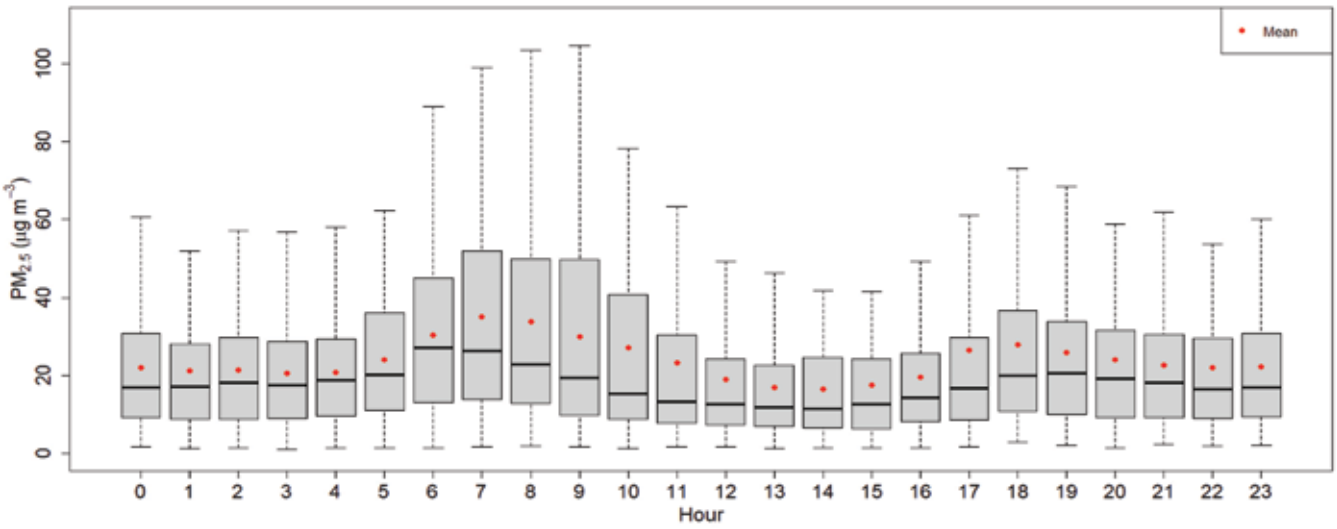

Figure 152: Diurnal variation of $PM_{2.5}$ for Dang Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during January, whereas less during August and September.

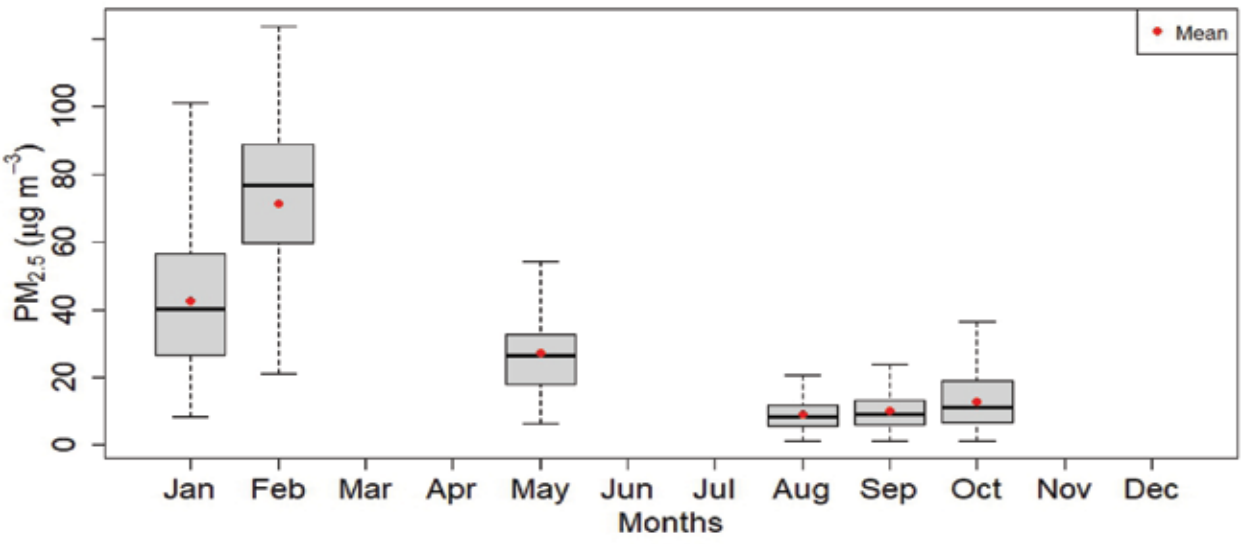

Figure 153: Monthly variation of $PM_{2.5}$ for Dang Station

Daily average:

The daily average data is available only for 98 days.

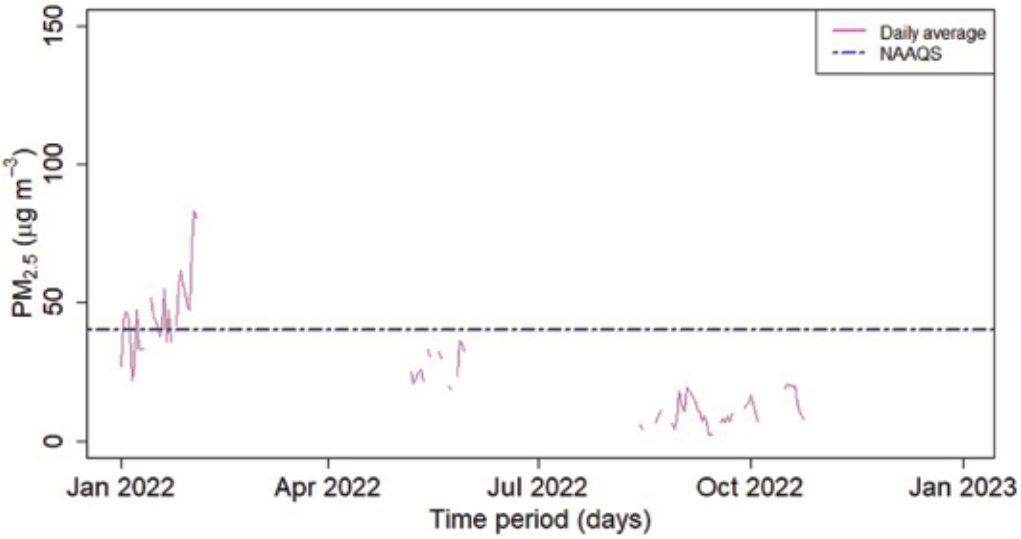

Figure 154: Daily average of $PM_{2.5}$ for Dang Station

Table 44: Summary of daily average of $PM_{2.5}$ for Dang Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.2 µg vm^{-3}	10.4 µg m^{-3}	19.9 µg m^{-3}	25.1 ± 18.2 µg m^{-3}	35.9 µg m^{-3}	83.4 µg m^{-3}

Within the available data, the lowest and highest concentration of $PM_{2.5}$ was found to be 2.2 µg m^{-3} to 83.4 µg m^{-3} on 13th September and 2nd February respectively (table 65). During the majority of days, $PM_{2.5}$ concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. The average concentration of $PM_{2.5}$ ranges from 10.3 µg m^{-3} in September to 42.8 µg m^{-3} in January.

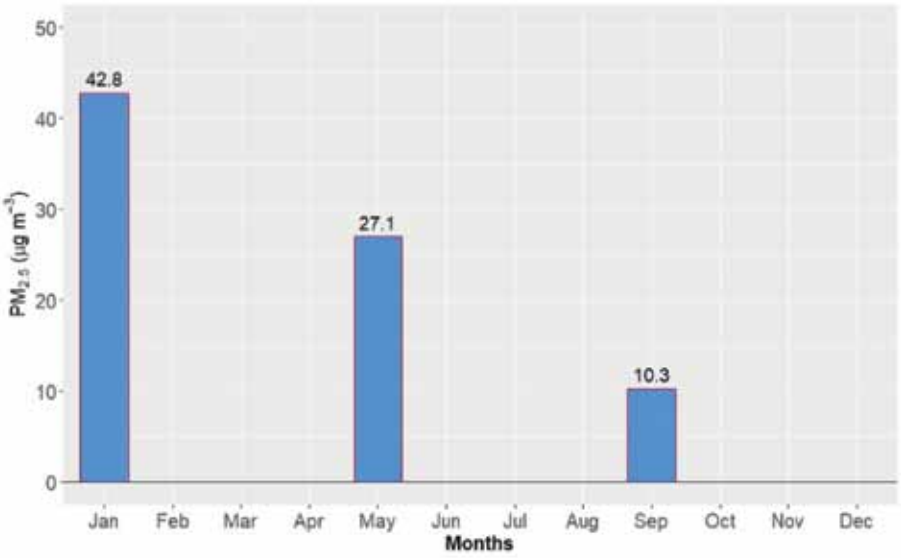

Figure 155: Monthly average of $PM_{2.5}$ for Dang Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Because of limited data, the averages of only one season- winter (45.3 µg m^{-3}) was presented in the figure 156

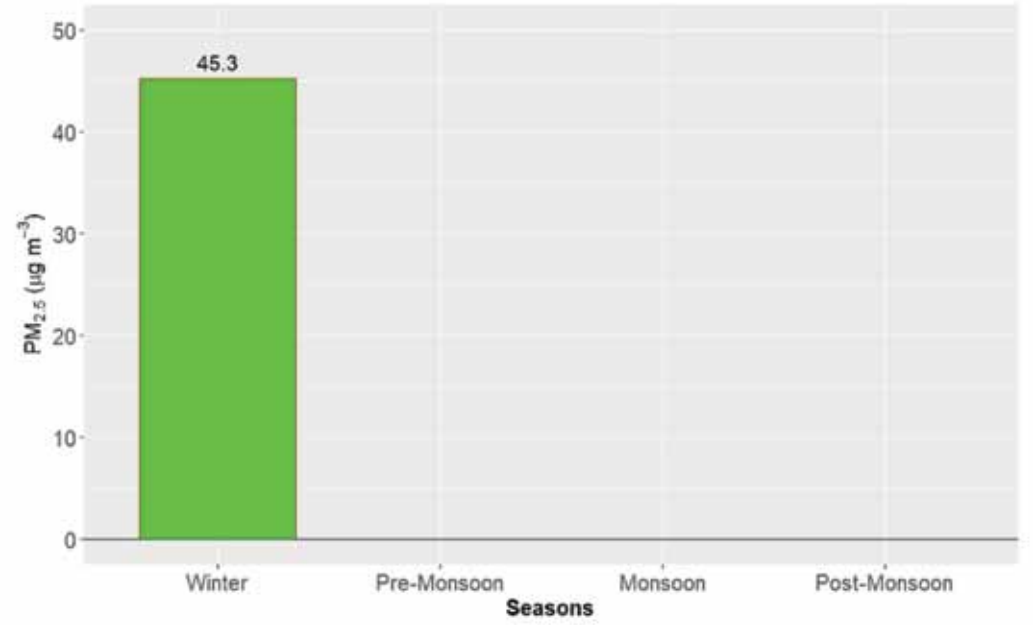

Figure 156: Seasonal average of $PM_{2.5}$ for Dang Station

Compliance status:

Out of the total 96 days of valid measurement, only 21 days exceeded the NAAQS. Those noncompliance days were included in January to May as shown in figure 157.

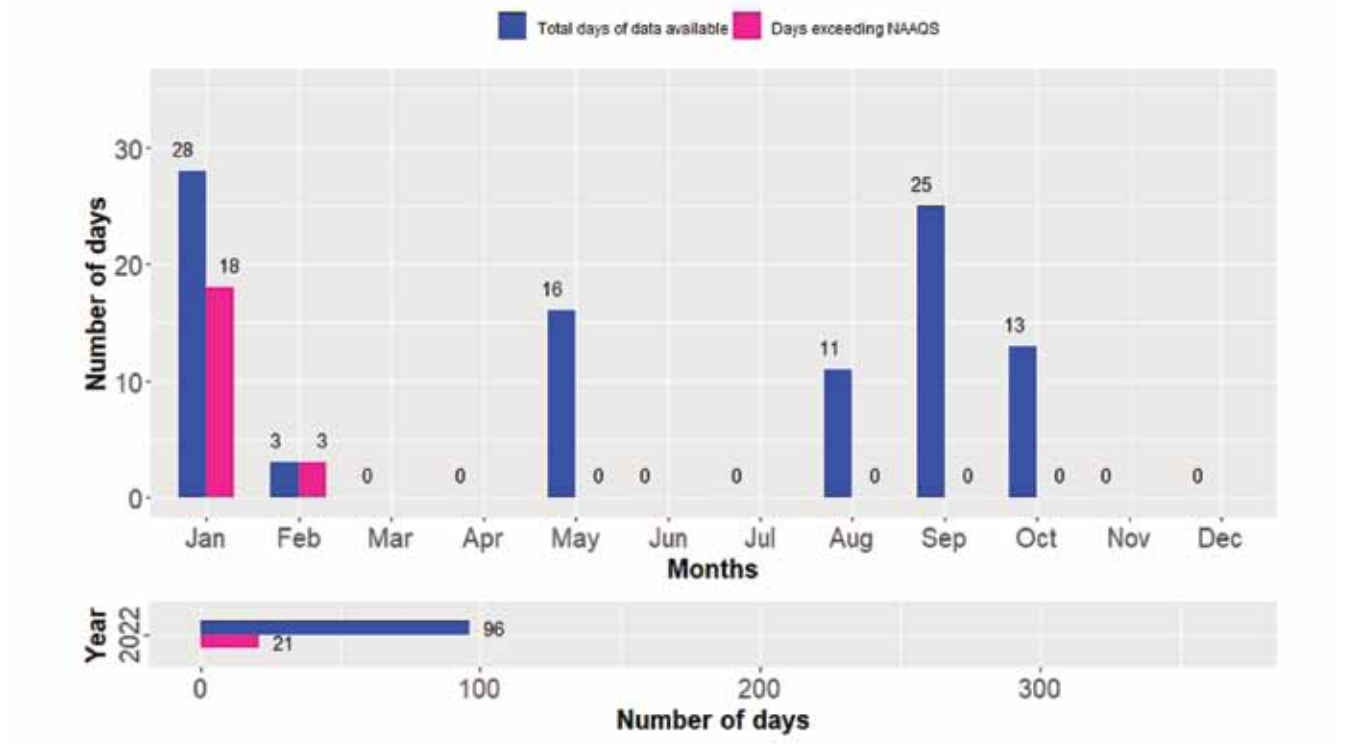

Figure 157: Compliance status of $PM_{2.5}$ for Dang Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 158), out of the total 98 valid measurement days, the majority of days showed an AQI of good to moderate. Only one day in January and three days in February reached an unhealthy state. Few days in January are also found to be unhealthy for the sensitive group.

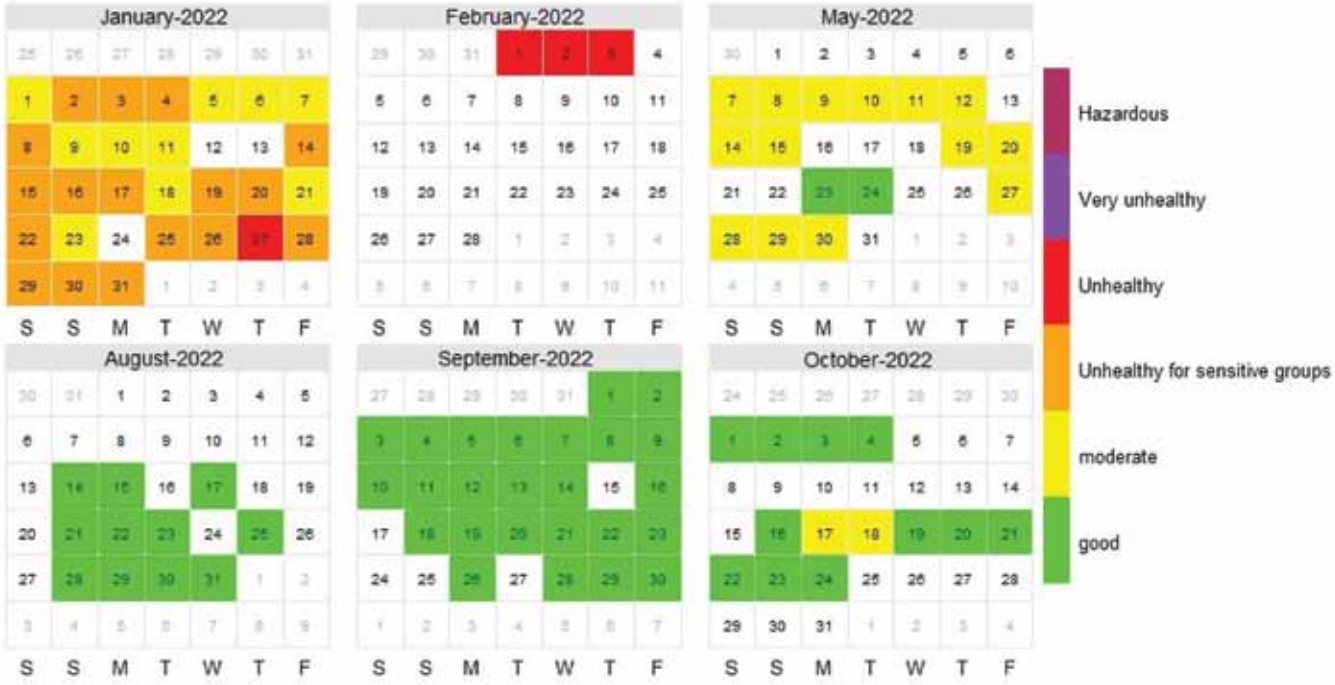

Figure 158: Calendar plot of $PM_{2.5}$ for Dang Station

2.3.1.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 1.1 µg m^{-3} to 442.8 µg m^{-3}. The lowest and highest concentration of PM_{10} was observed on 7th October at 3:00 and 5th May at 17:00. The statistical summary of the hourly average is presented in the table below:

Table 45: Summary of hourly average of PM_{10} for Dang Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 µg m^{-3}	9.9 µg m^{-3}	20.1 µg m^{-3}	29.0 ± 26.7µg m^{-3}	41.6 µg m^{-3}	442.8 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-35) and as values increase, the frequency of observations decreases rapidly.

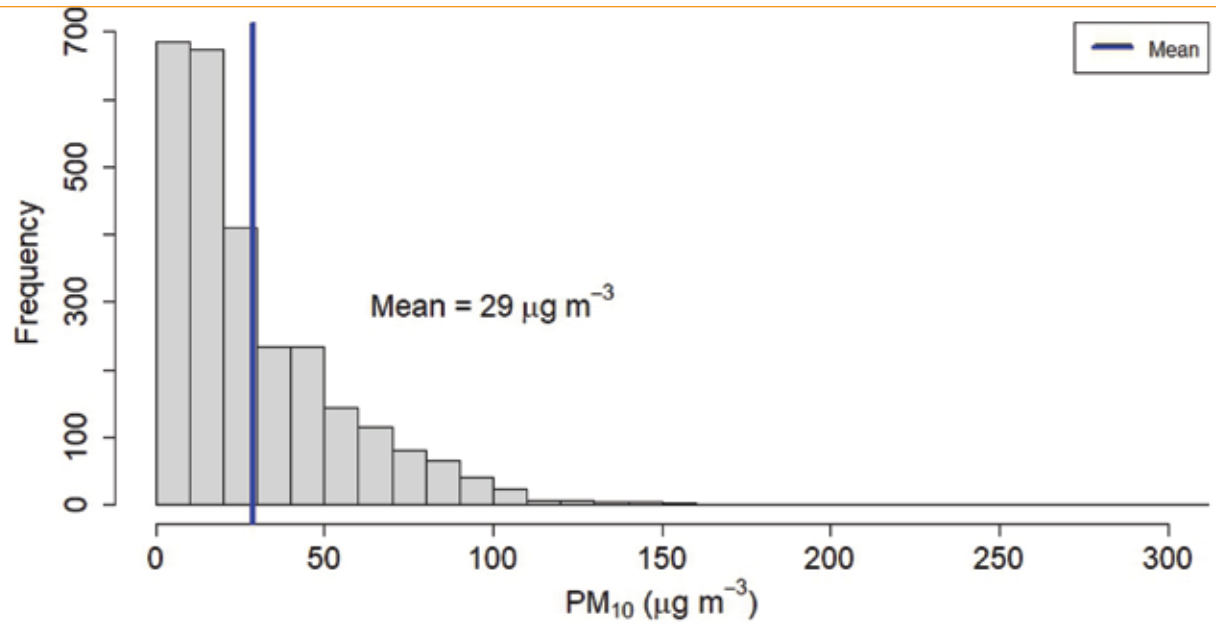

Figure 159: Histogram of PM_{10} for Dang Station

Diurnal variation:

The hourly mean of PM_{10} progressively increases with time and reached to its peaks at 7:00-8:00 which again decreases and gain height around 18:00.

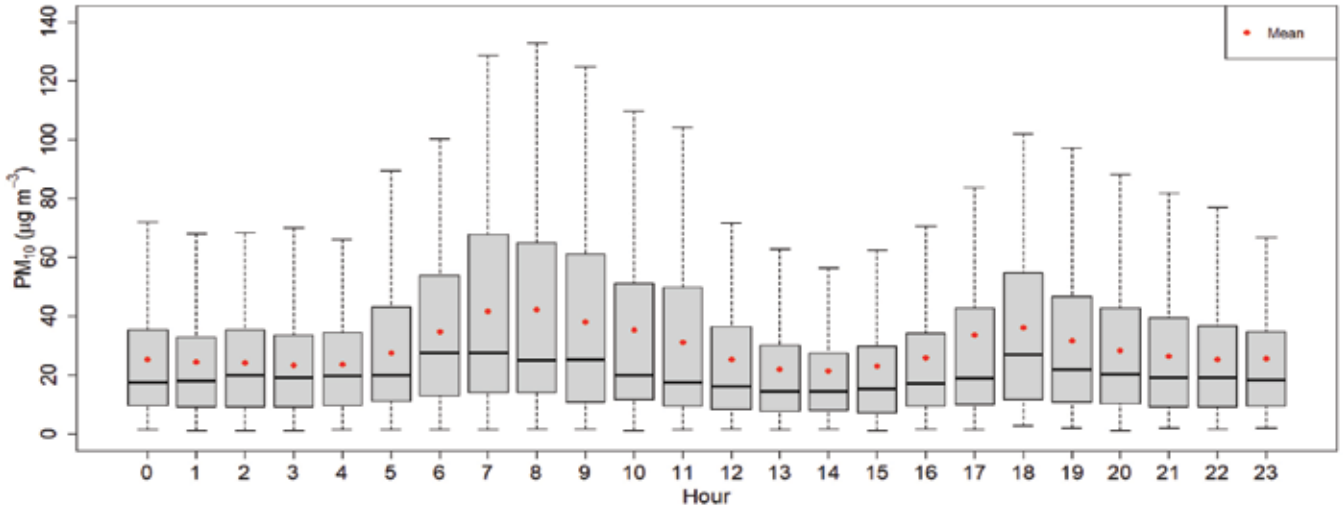

Figure 160: Diurnal variation of PM_{10} for Dang Station

Monthly variation:

A high variation of PM_{10} concentration was seen during January, whereas less during August and September.

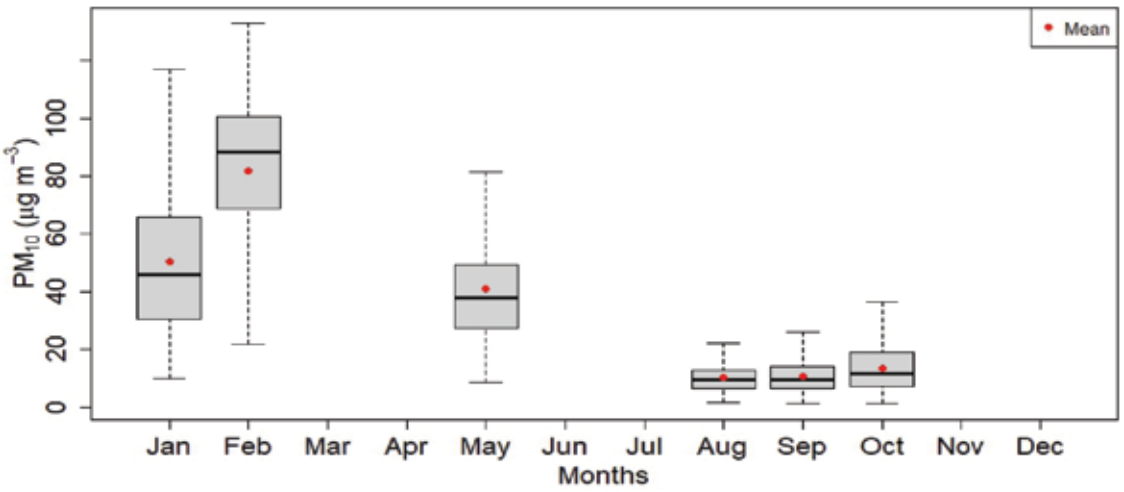

Figure 161: Monthly variation of PM_{10} for Dang Station

Daily average:

The daily average data was available only for 97 days.

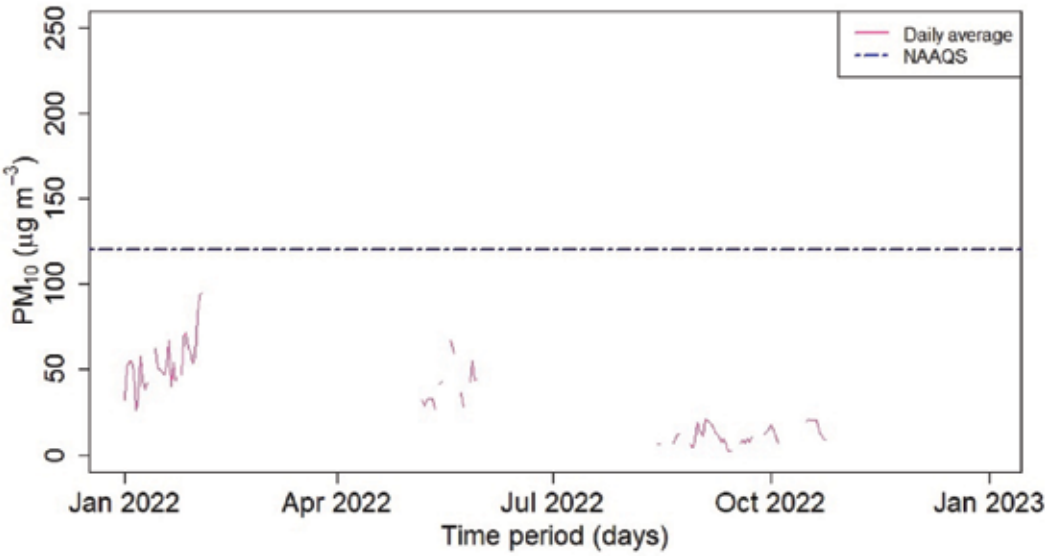

Figure 162: Daily average of PM_{10} for Dang Station

Table 46: Summary of daily average of PM_{10} for Dang Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.4 µg m^{-3}	11.1 µg m^{-3}	21.2 µg m^{-3}	30.4 ± 22.4 µg m^{-3}	47.1 µg m^{-3}	94.9 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 2.4 µg m^{-3} to 94.9 µg m^{-3} on 16th September and 3rd February respectively (table 68). The total available PM_{10} concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of PM_{10}. The average concentration of $PM_{2.5}$ ranges from 11 µg m^{-3} in September to 50.8 µg m^{-3} in January.

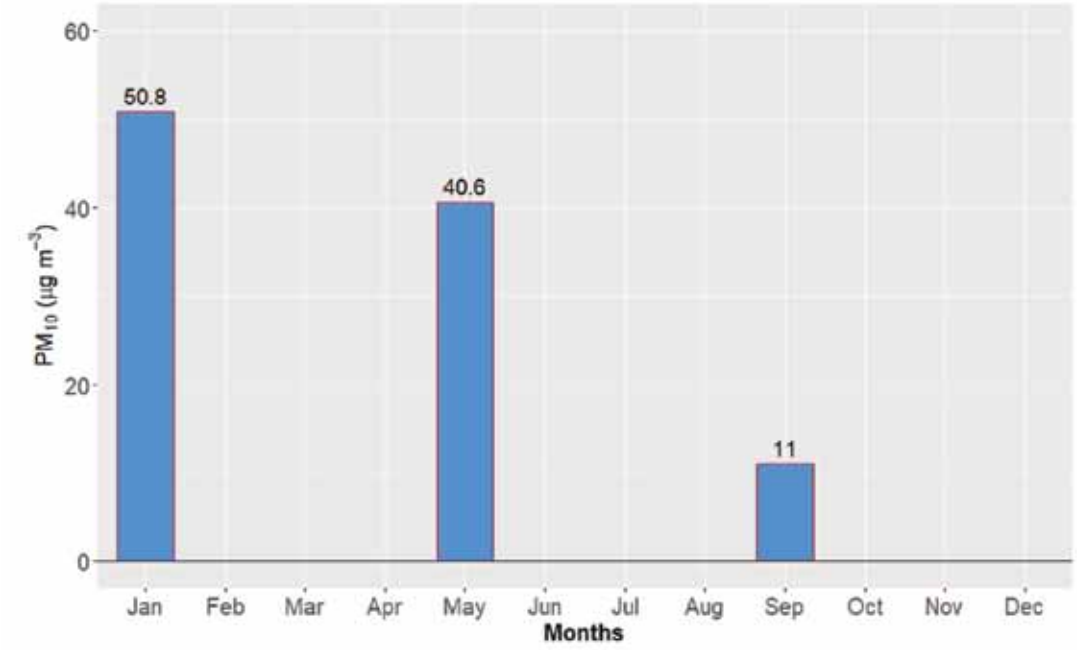

Figure 163: Monthly average of PM_{10} for Dang Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}. Because of limited data, the averages of only one season- winter (58.6 µg m^{-3}) was presented in the figure 164.

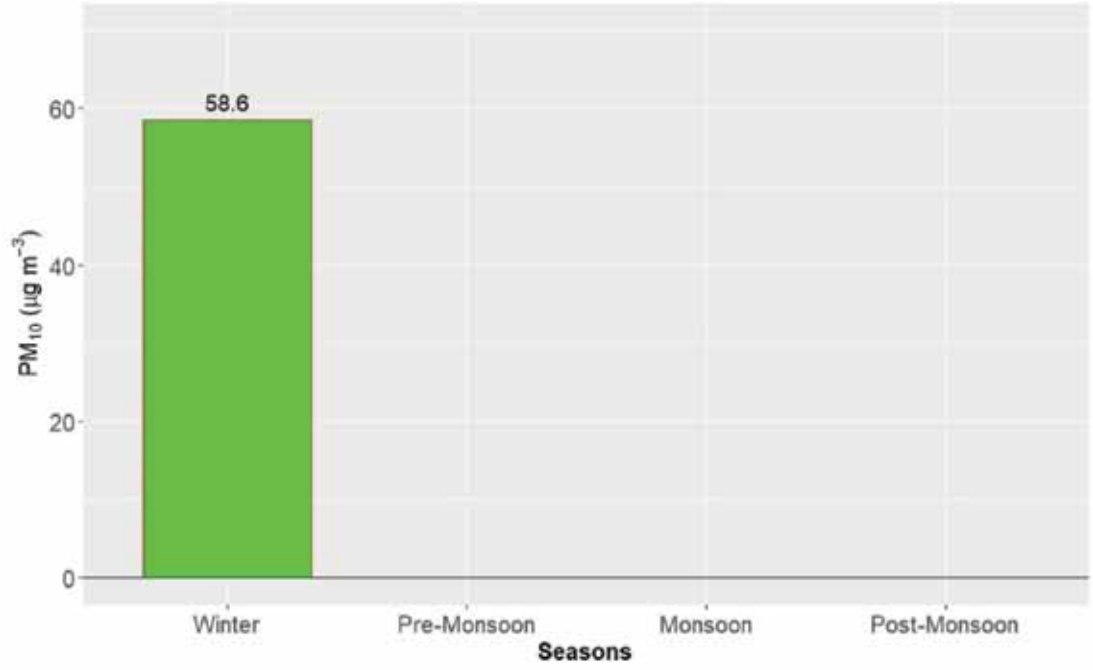

Figure 164: Seasonal average of PM_{10} for Dang Station

Compliance status:

Out of the total 96 days of valid measurement, none of the days exceeded the NAAQS as shown in figure 165.

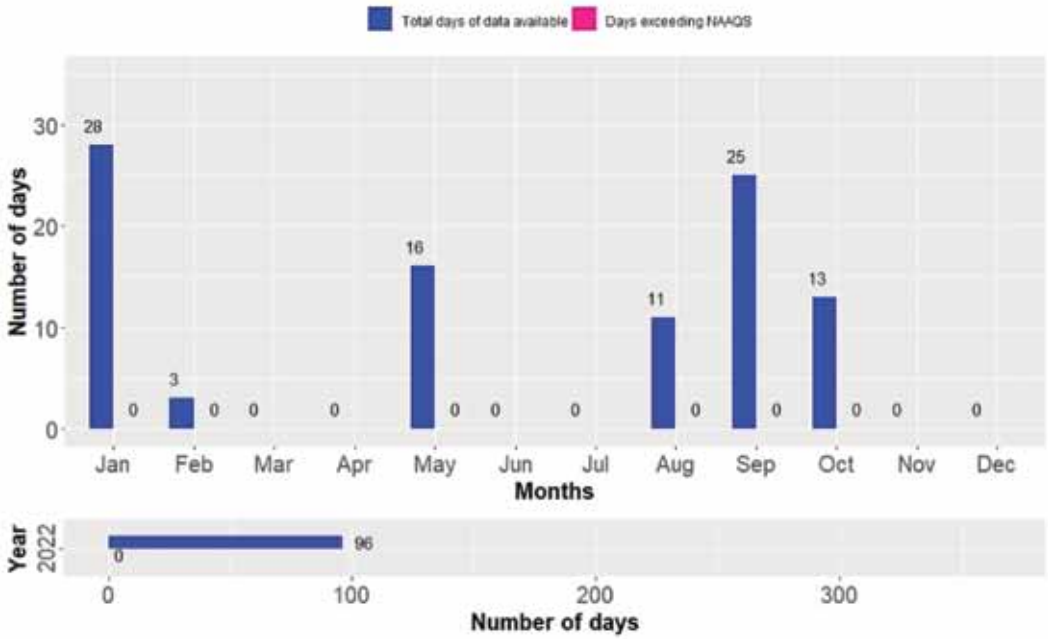

Figure 165: Compliance status of PM_{10} for Dang Station

2.3.1.3 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 1.1 µg m^{-3} to 859.9 µg m^{-3}. The lowest and the highest concentration of TSP were observed on 7th October at 3:00 and 23rd May at 18:00. The statistical summary of the hourly average was presented in the table below:

Table 47: Summary of hourly average of TSP for Dang Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 µg m^{-3}	10.8 µg m^{-3}	23.1 µg m^{-3}	39.1± 46.7 µg m^{-3}	53.6 µg m^{-3}	859.9 µg m^{-3}

The dataset is clustered on the lower end of values (0-50) and as values increase, the frequency of observations decreases rapidly.

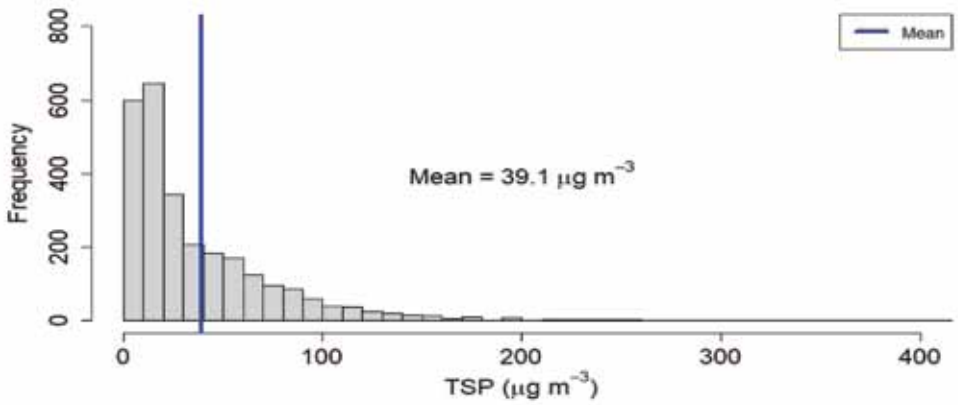

Figure 166: Histogram of TSP for Dang Station

Diurnal variation:

The hourly mean of TSP progressively increases with time and reached to its peak at 10:00 which again decreases slightly and gains height around 18:00.

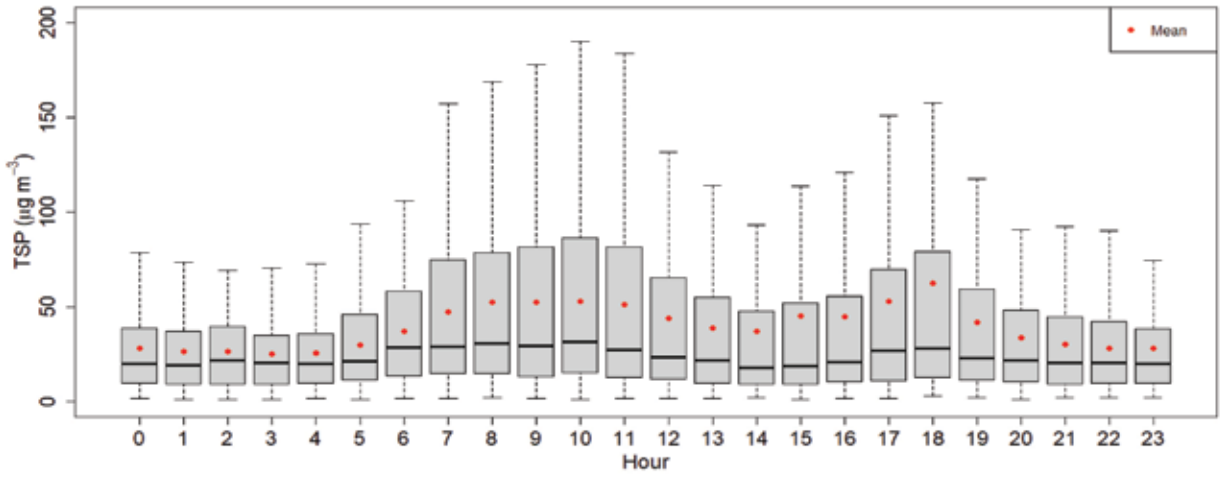

Figure 167: Diurnal variation of TSP for Dang Station

Monthly variation:

A high variation of TSP concentration was seen during May whereas less during August and September.

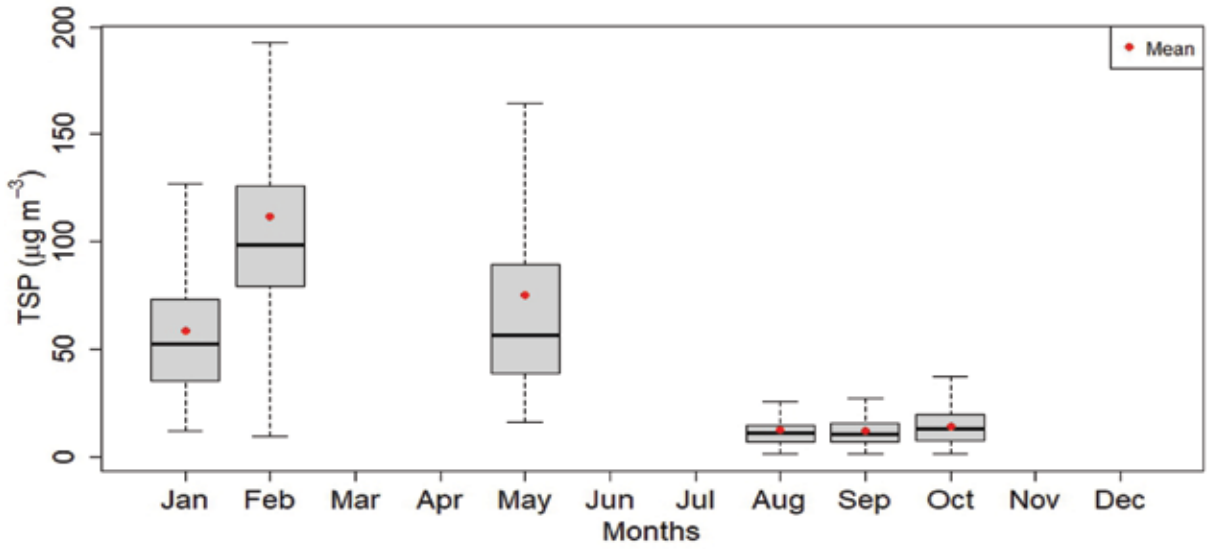

Figure 168: Monthly variation of TSP for Dang Station

Daily average:

The daily average data was available only for 98 days.

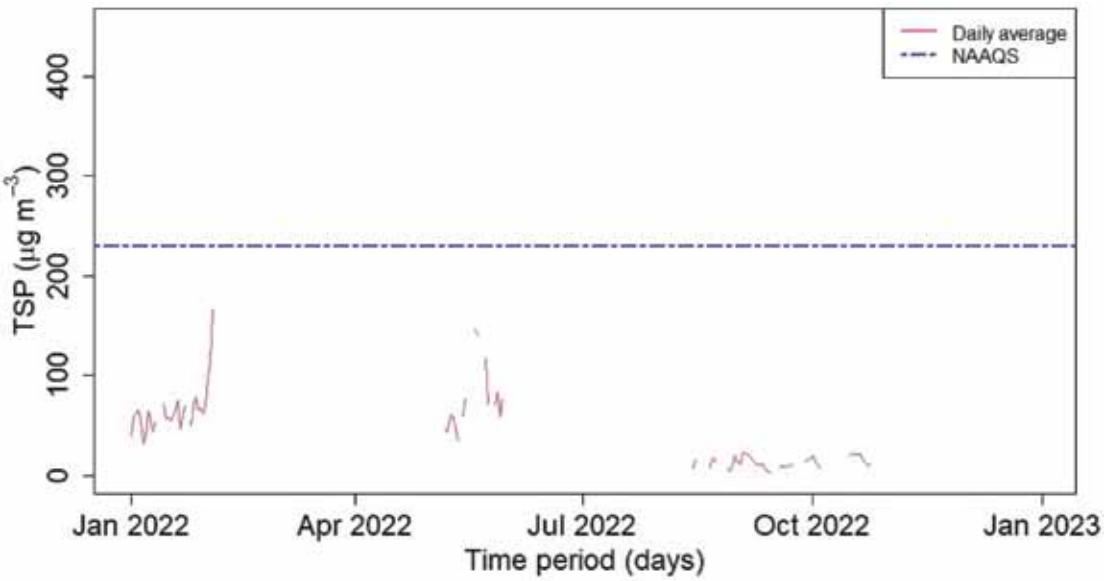

Figure 169: Daily average of TSP for Dang Station

Table 48: Summary of daily average of TSP for Dang Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.4 µg m^{-3}	12.1 µg m^{-3}	22.9 µg m^{-3}	40.1 ± 34.0 µg m^{-3}	61.1 µg m^{-3}	166.2 µg m^{-3}

Within the available data, the lowest and highest concentration of TSP was found to be 2.4 µg m^{-3} to 166.2 µg m^{-3} on 16th September and 3rd February respectively (table 71). The total available TSP concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. The average concentration of TSP ranges from 12.1 µg m^{-3} in September to 74.3 µg m^{-3} in May.

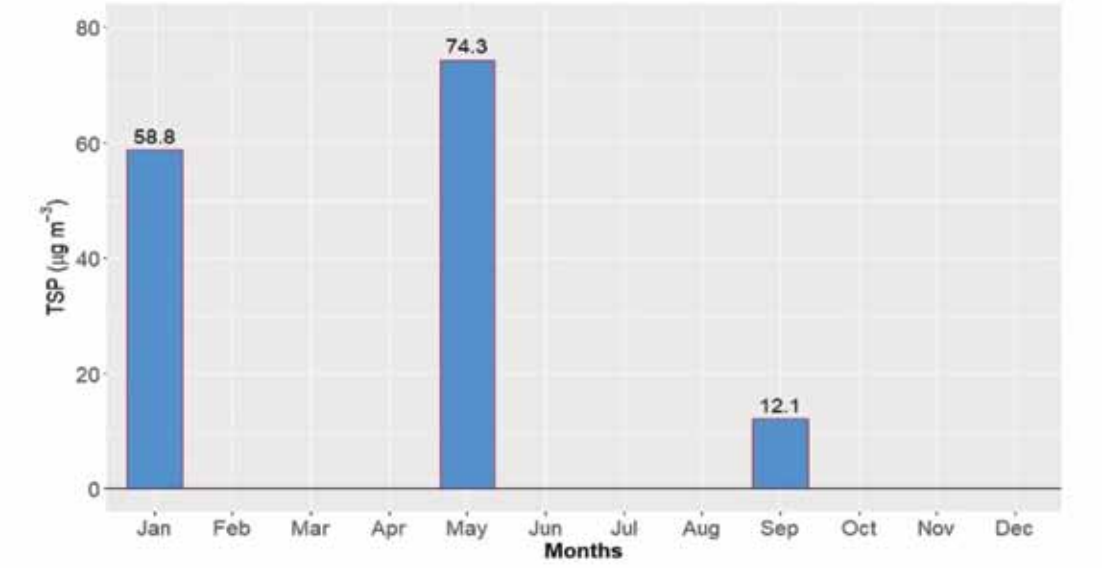

Figure 170: Monthly average of TSP for Dang Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP. Because of limited data, the averages of only one season- winter (75.1 μg m^{-3}) was presented in the figure 171.

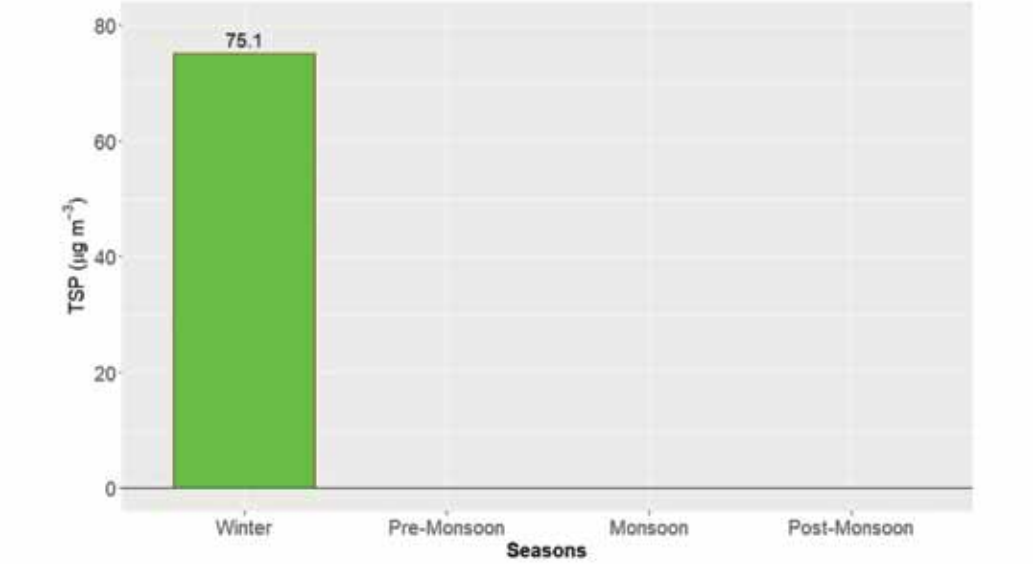

Figure 171: Seasonal average of TSP for Dang Station

Compliance status:

Out of the total 96 days of valid measurement, none of the days exceeded the NAAQS as shown in figure 172.

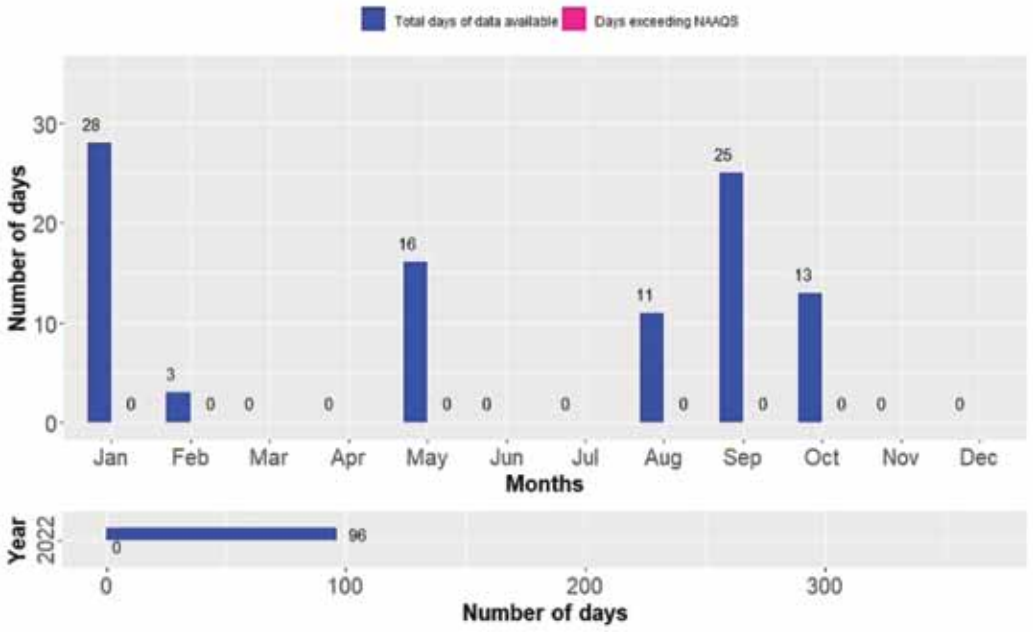

Figure 172: Compliance status of TSP for Dang Station

2.3.2 NEPALGUNJ AIR QUALITY MONITORING STATION

Nepalgunj Air Quality Monitoring Station was established in the year 2018 in the premises of district administration office of Banke, Lumbini province. It represents the urban area. The main sources of pollution

in this region are vehicles and industries. Banke Industrial estate is also near to the station. Agriculture residue buring and forest fire are also major source during winter and pre-monsoon seasons.

2.3.2.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 3.9 μg m^{-3} to 195.3 μg m^{-3}. The lowest and highest concentration of $PM_{2.5}$ was observed on 12th May at 16:00 and 31st January at 21:00 respectively. The statistical summary of hourly average was presented in the table below:

Table 49: Summary of hourly average of $PM_{2.5}$ for Nepalgunj Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
3.9 μg m^{-3}	17.8 μg m^{-3}	33.9 μg m^{-3}	39.0 ± 26.2 μg m^{-3}	53.5 μg m^{-3}	195.3 μg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (10-70) and as values increase, the frequency of observations decreases rapidly.

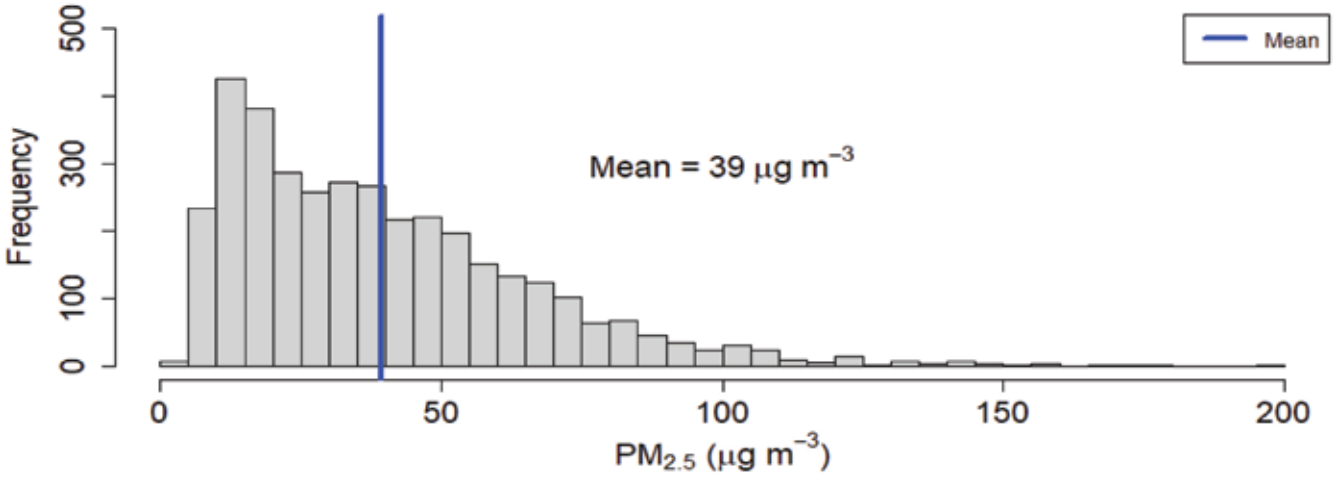

Figure 173: Histogram of $PM_{2.5}$ for Nepalgunj Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ progressively increases with time and reached to its peaks at 8:00 which again decreases and gain height around 21:00. In general mean value was greater than median value throughout the day except at 7:00 when mean is less than median.

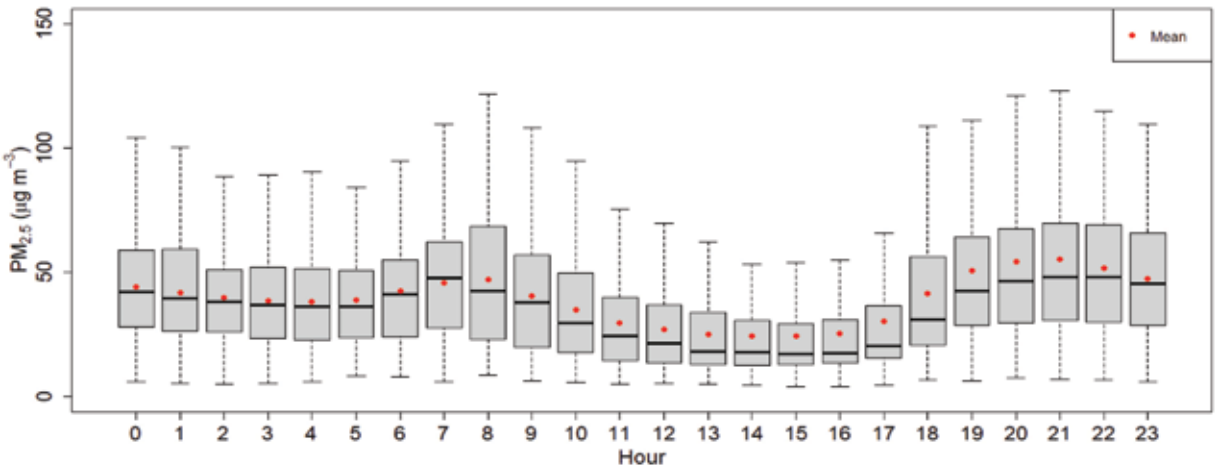

Figure 174: Diurnal variation of $PM_{2.5}$ for Nepalgunj Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during January, whereas less during October.

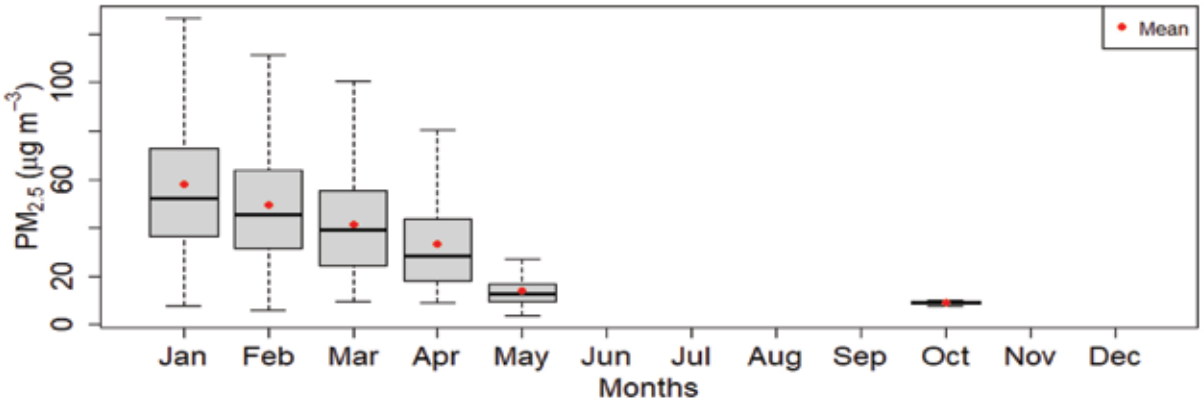

Figure 175: Monthly variation of $PM_{2.5}$ for Nepalgunj Station

Daily average:

The daily average data is available only from 1st January to 30th May.

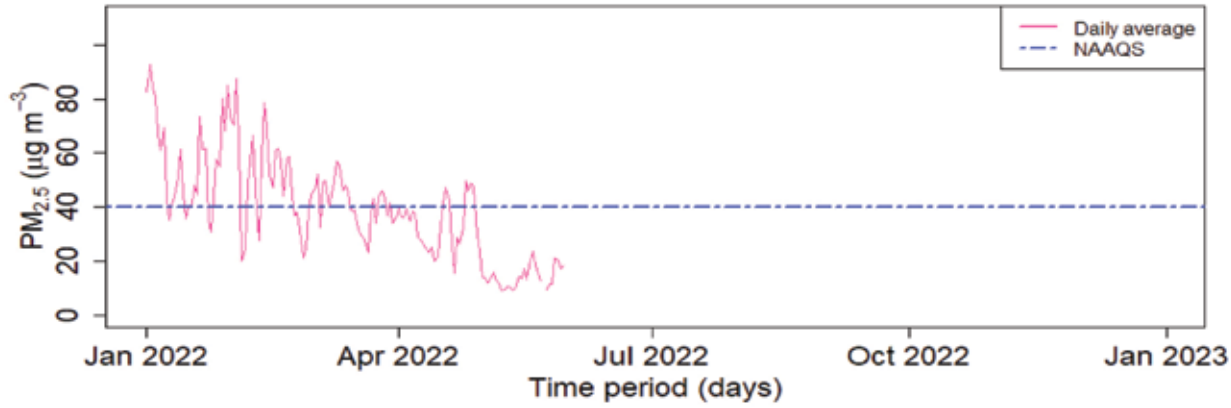

Figure 176: Daily average of $PM_{2.5}$ for Nepalgunj Station

Table 50: Summary of daily average of $PM_{2.5}$ for Nepalgunj Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
9.0 µg m^{-3}	24.3 µg m^{-3}	38.8 µg m^{-3}	39.4 ± 19.5 µg m^{-3}	49.7 µg m^{-3}	92.7 µg m^{-3}

Within the available data, the lowest and the highest concentration of $PM_{2.5}$ was found to be 9.0 µg m^{-3} and 92.7 µg m^{-3} on 12th May and 2nd January respectively (table 74). During majority of days, $PM_{2.5}$ concentration was found to be above NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. The average concentration of $PM_{2.5}$ was the highest in January (57.9 µg m^{-3}) and decreases thereafter and become lowest at May (14.1µg m^{-3}). After may monthly average data was not available.

Figure 177: Monthly average of $PM_{2.5}$ for Nepalgunj Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Because of limited data, the averages of only two seasons- winter and pre-monsoon, were presented in the figure 178. Of these two seasons, the seasonal average of winter season (53.1 µg m^{-3}) was found more than that of pre-monsoon season (29.9 µg m^{-3}).

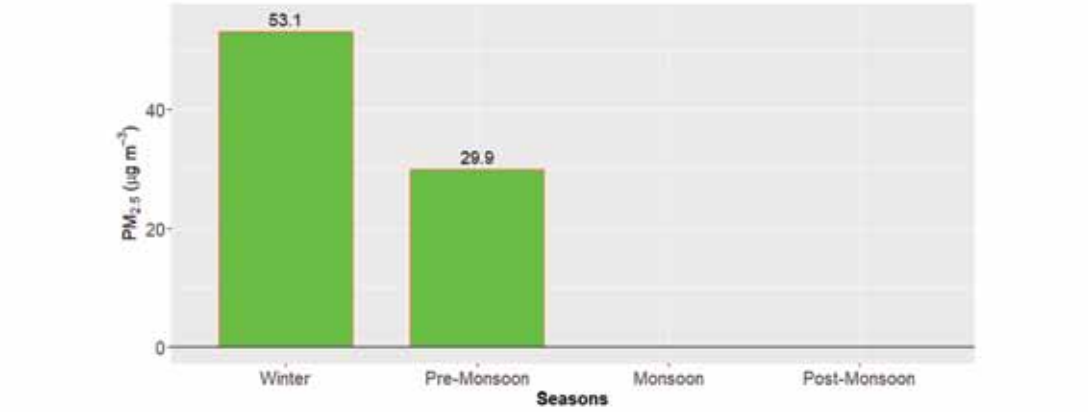

Figure 178: Seasonal average of $PM_{2.5}$ for Nepalgunj Station

Compliance status:

Out of the total 149 days of valid measurement, 70 days exceeded the NAAQS. Those noncompliance days were included in January to April as shown in figure179.

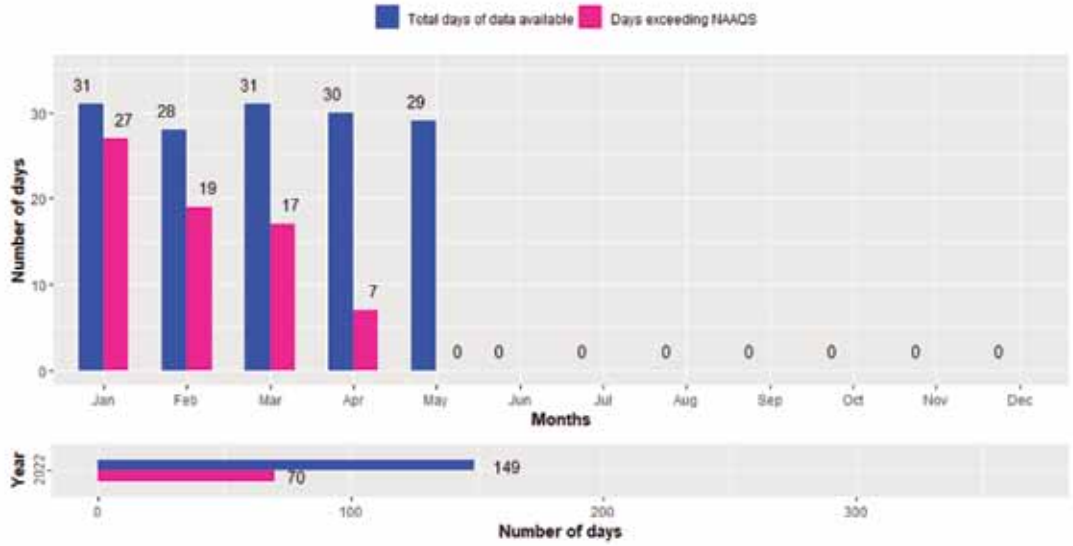

Figure 179: Compliance status of $PM_{2.5}$ for Nepalgunj Station

Calendar plot

As per the calendar plot for $PM_{2.5,}$ out of the total 149 measured days, good to unhealthy category of AQI class can be seen. Unhealthy categories of AQI can be seen in January and February.

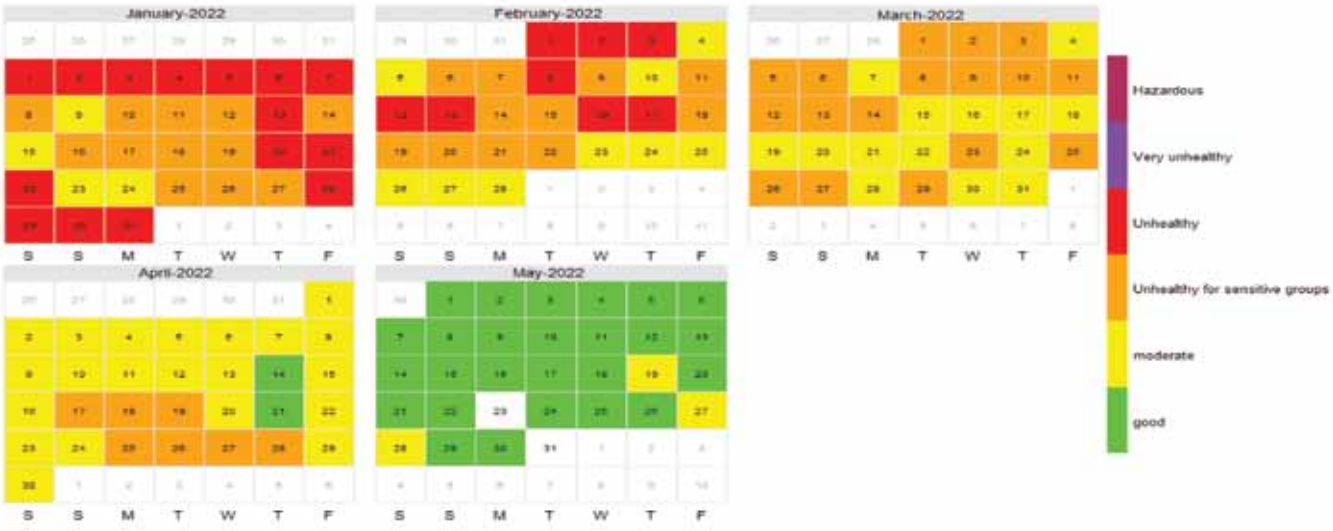

Figure 180: Calendar plot of $PM_{2.5}$ for Nepalgunj Station

2.3.2.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 6.0 µg m^{-3} to 364.5 µg m^{-3}. The lowest and the highest concentration of PM_{10} was observed on 4th February at 7:00 and 18th May at 19:00 respectively. The statistical summary of hourly average is presented in the table below:

Table 51: Summary of hourly average of PM_{10} for Nepalgunj Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
6.0 µg m^{-3}	31.5 µg m^{-3}	47.1 µg m^{-3}	52.6 ± 29.7 µg m^{-3}	68.9 µg m^{-3}	364.5 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (10-90) and as values increase, the frequency of observations decreases rapidly.

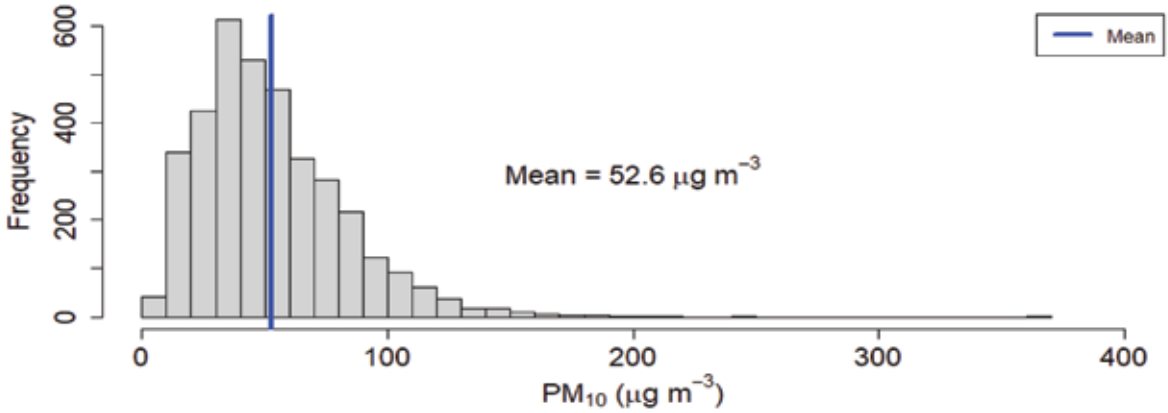

Figure 181: Histogram of PM_{10} for Nepalgunj Station

Diurnal variation:

The hourly mean of PM_{10} progressively decrease from 0:00 to 5:00 then increases with time and reached to its peaks at 8:00 which again decreases up to 15:00 and is almost similar up to 16:00. After that it again starts to rise and gain height around 19:00- 21:00 there after it decreases.

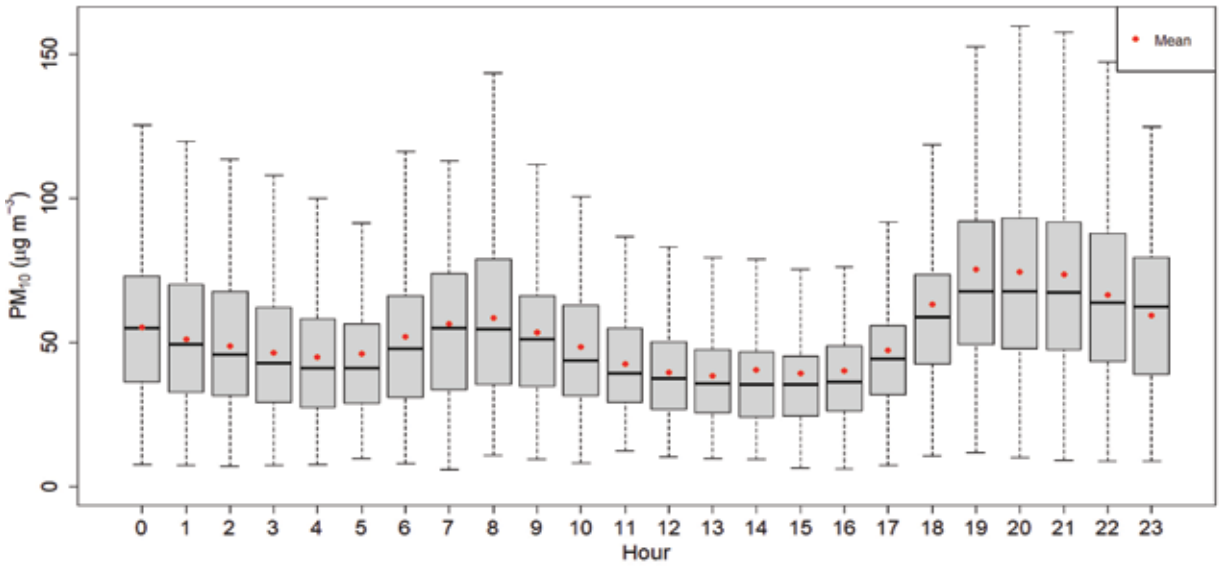

Figure 182: Diurnal variation of PM_{10} for Nepalgunj Station

Monthly variation:

A high variation of PM_{10} concentration was seen during April, whereas less during October.

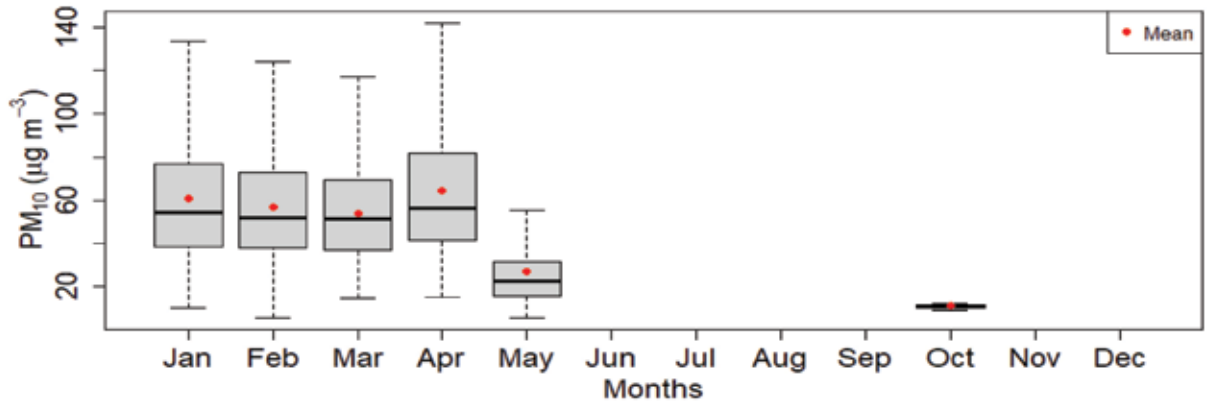

Figure 183: Monthly variation of PM_{10} for Nepalgunj Station

Daily average:

The daily average data was available only from 1st January to 30th May.

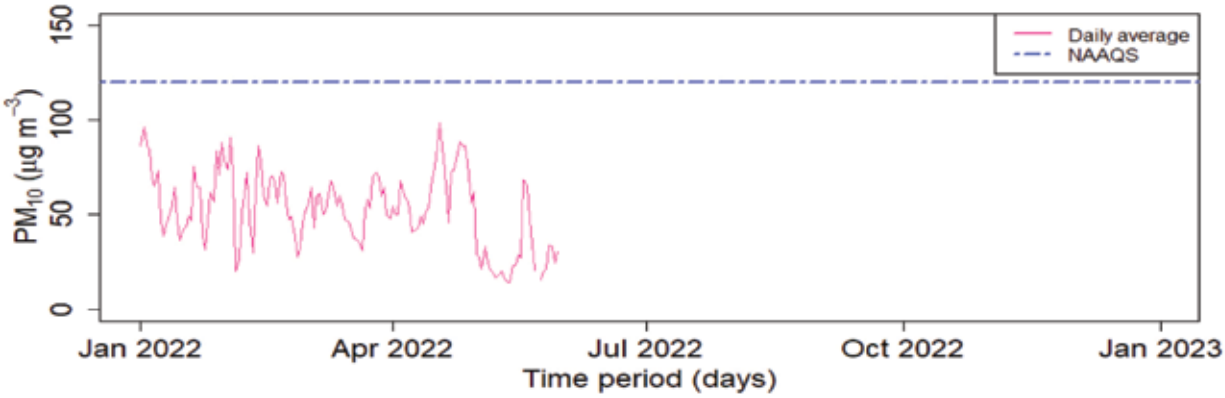

Figure 184: Daily average of PM_{10} for Nepalgunj Station

Table 52: Summary of daily average of PM_{10} for Nepalgunj Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
13.9 µg m^{-3}	38.1 µg m^{-3}	53.3 µg m^{-3}	52.9 ± 20.2 µg m^{-3}	68.0 µg m^{-3}	98.3 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 13.9 µg m^{-3} and 98.3 µg m^{-3} on 4th February and 18th April respectively (table 77). The all the available daily average PM_{10} concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of PM_{10}. The monthly average of May was found to be the lowest (27.4 µg m^{-3}) and that of April was found to be the highest (64.2 µg m^{-3}).

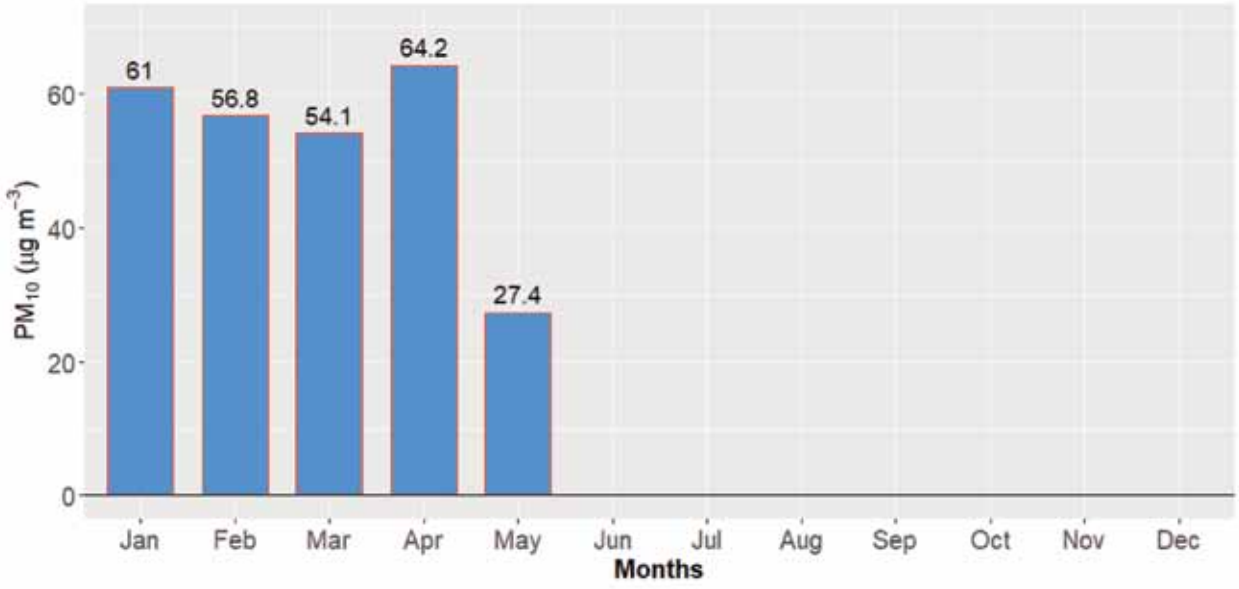

Figure 185: Monthly average of PM_{10} for Nepalgunj Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}. Because of limited data, the averages of only two seasons- winter and pre-monsoon, are presented in the figure 186. Of the two seasons, the seasonal average of the winter season (58.6 µg m^{-3}) was found more than that of pre-monsoon (48.9 µg m^{-3}).

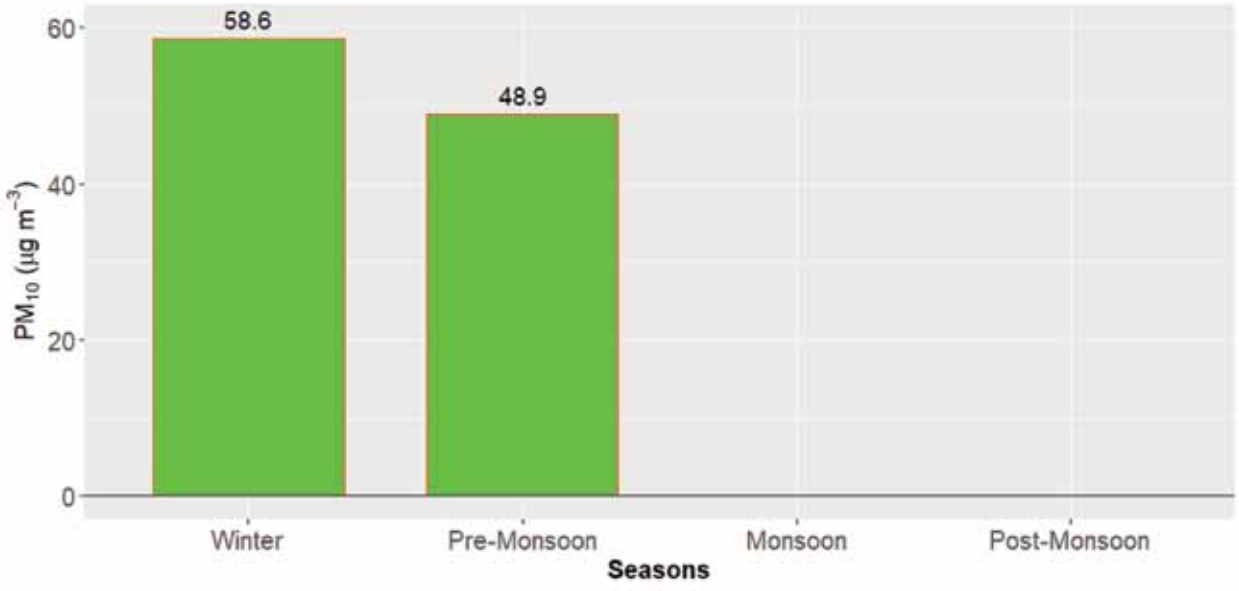

Figure 186: Seasonal average of PM_{10} for Nepalgunj Station

Compliance status:

Out of the total 149 days of valid measurement, none of the day exceeded the NAAQS.

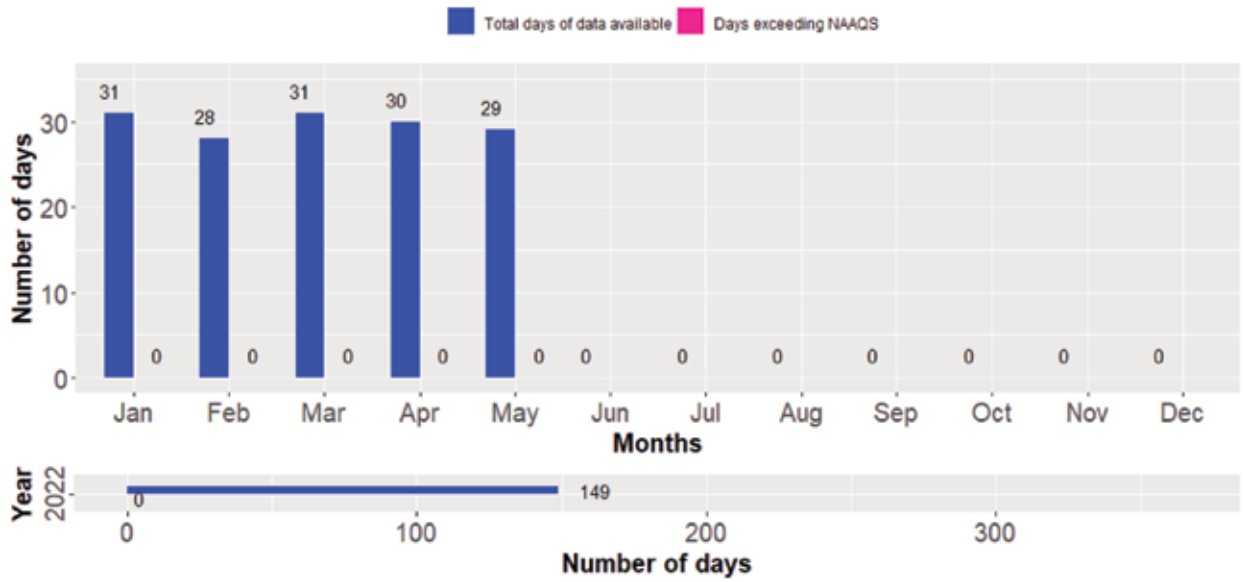

Figure 187: Compliance status of PM_{10} for Nepalgunj Station

2.3.2.3 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 1.1 µg m^{-3} to 1120.2 µg m^{-3}. The lowest and the highest concentration of TSP was observed on 4th February at 7:00 and 18th May at 19:00. The statistical summary of hourly average is presented in the table below:

Table 53: Summary of hourly average of TSP for Nepalgunj Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 g m^{-3}	43.6 µg m^{-3}	63.8 µg m^{-3}	75.9 ± 58.3 µg m^{-3}	92.5 µg m^{-3}	1120.2 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (10-150) and as values increase, the frequency of observations decreases rapidly.

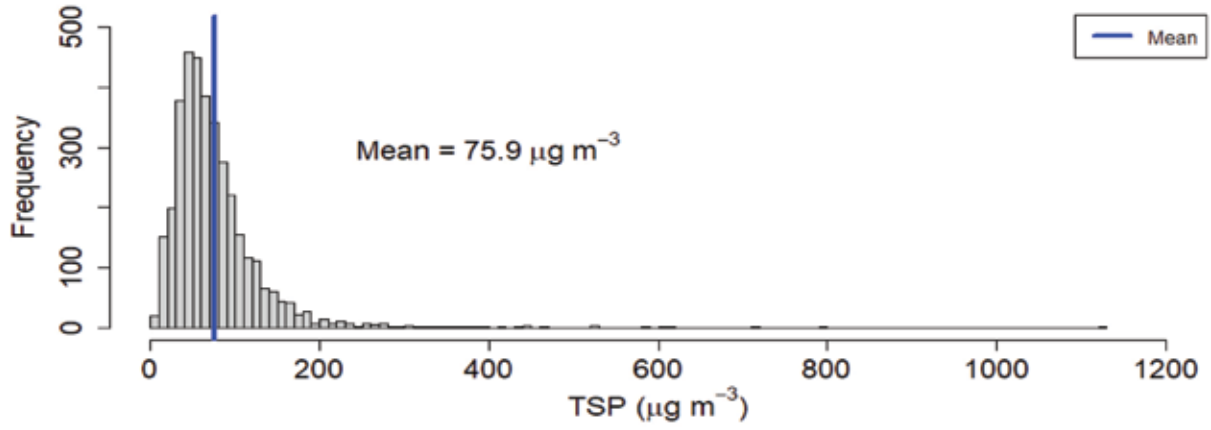

Figure 188: Histogram of TSP for Nepalgunj Station

Diurnal variation:

The hourly mean of TSP progressively decreases from 0:00 to 5:00 then increases with time and reached to its peak at 9:00 which again decreases up to 12:00 and it again peak at 19:00 and thereafter it decreases.

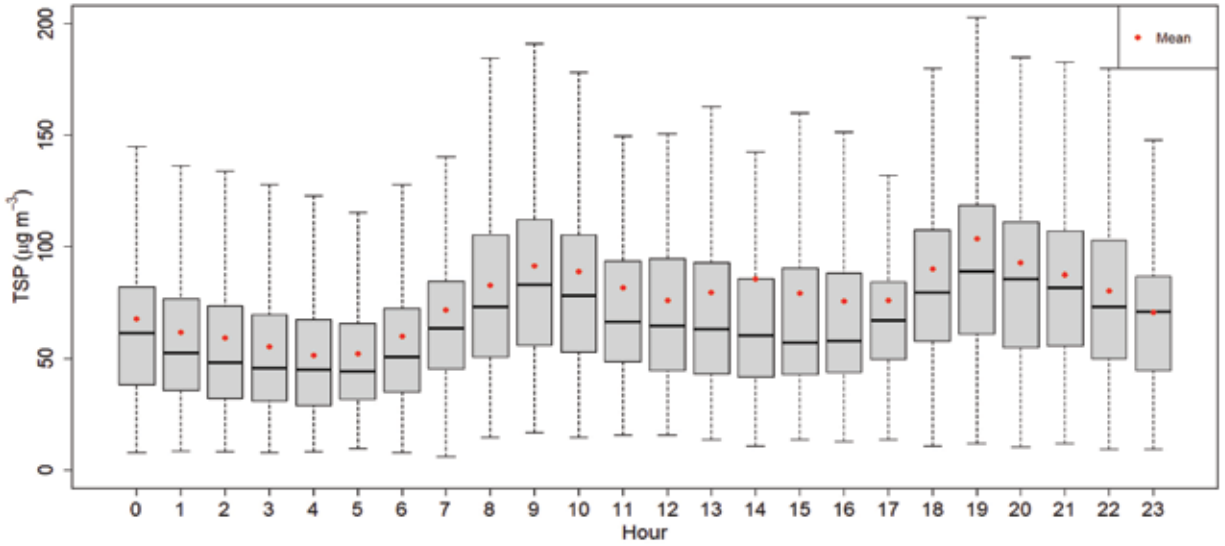

Figure 189: Diurnal variation of TSP for Nepalgunj Station

Monthly variation:

A high variation of TSP concentration was seen during April, whereas less during October.

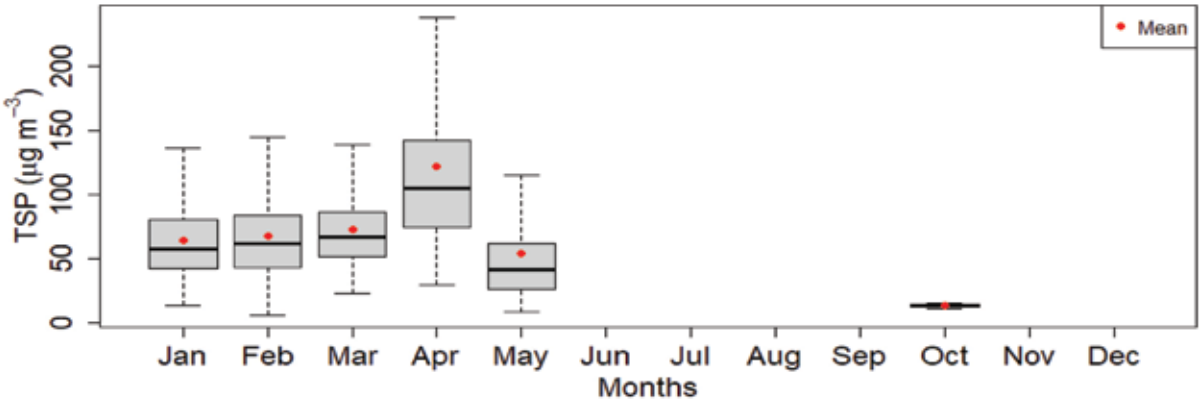

Figure 190: Monthly variation of TSP for Nepalgunj Station

Daily average:

Figure 191 explains the daily trend of TSP throughout the year.

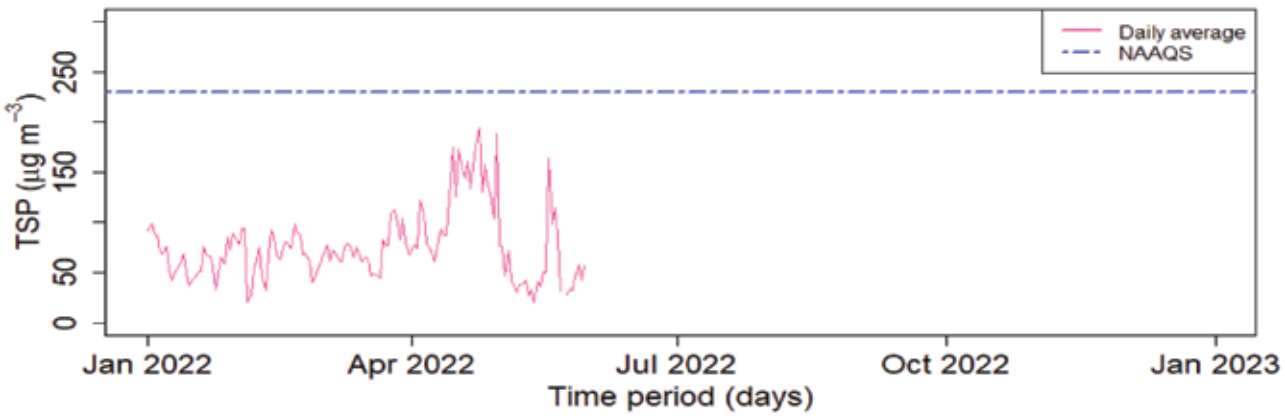

Figure 191: Daily average of TSP for Nepalgunj Station

Table 54: Summary of daily average of TSP for Nepalgunj Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
20.2 µg m^{-3}	50.8 µg m^{-3}	70.7 µg m^{-3}	76.1 ± 35.7 µg m^{-3}	87.6 µg m^{-3}	194.4 µg m^{-3}

Within the available data, the lowest and the highest concentration of TSP was found to be 20.2 µg m^{-3} and 194.4µg m^{-3} on 24th April and 4th February respectively (table 80). All the available daily average of TSP was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. It can be seen that out of the available monthly average data May has the lowest (53.6 µg m^{-3}) and April has highest (122.1 µg m^{-3}) value.

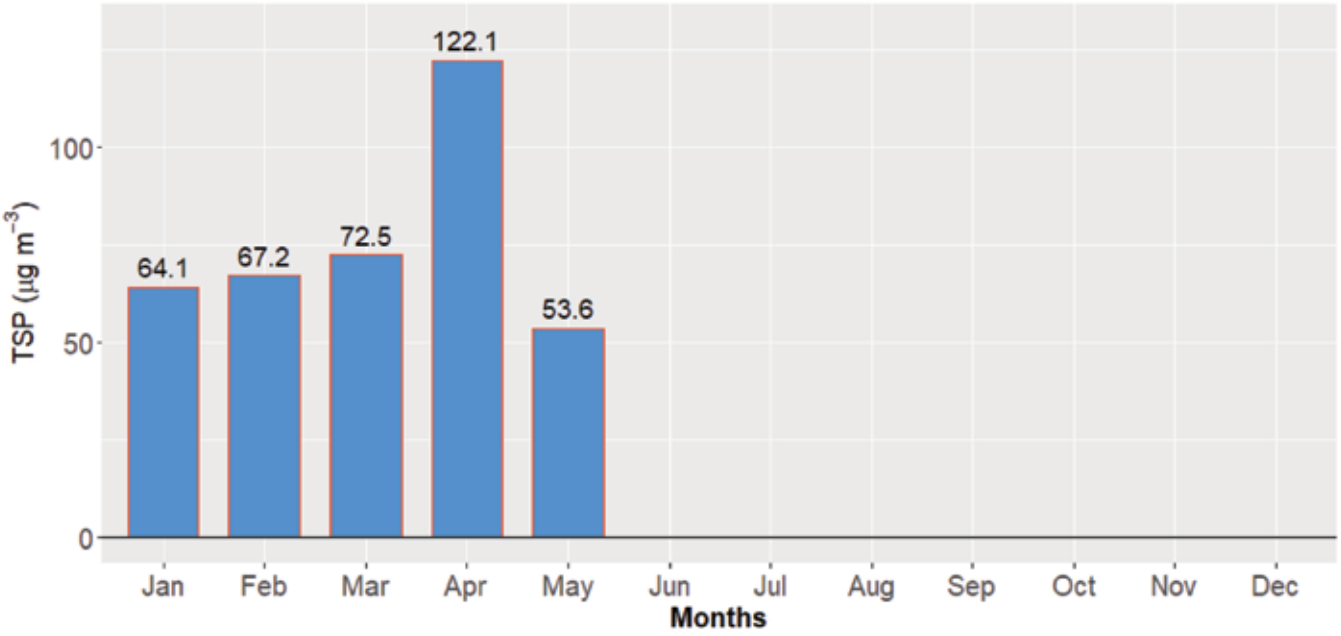

Figure 192: Monthly average of TSP for Nepalgunj Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP. Because of limited data, the averages of only two seasons- winter and pre-monsoon, were presented in the figure 193. Of the two seasons, the concentration of the pre-monsoon season (82.9 µg m^{-3}) is found more than that of winter season (65.2 µg m^{-3}).

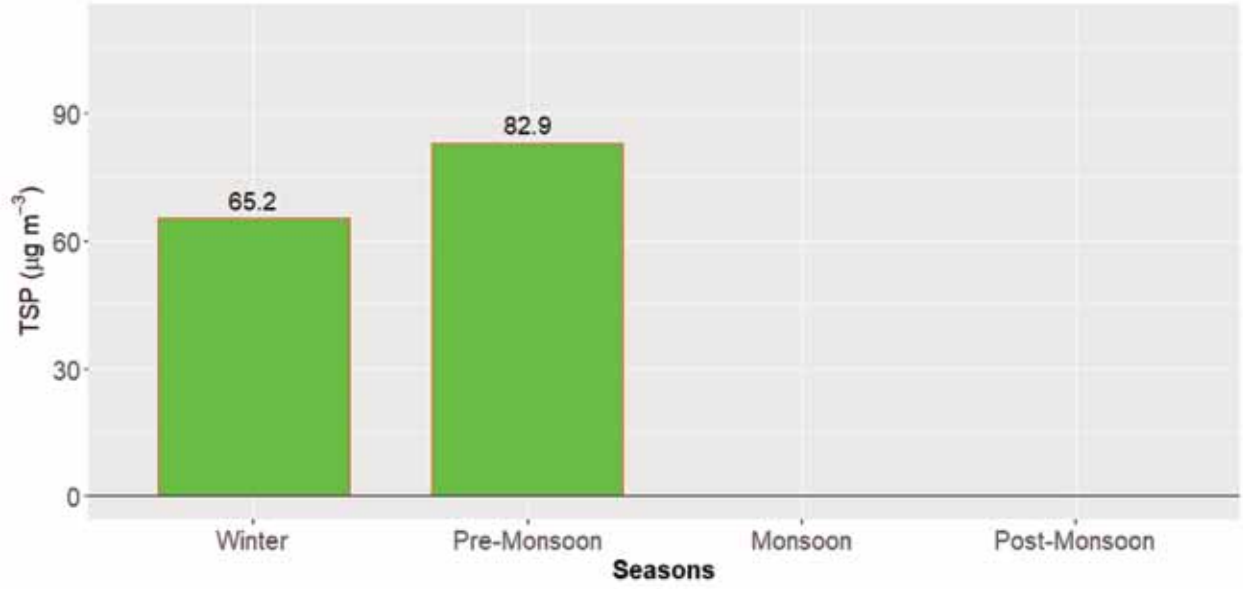

Figure 193: Seasonal average of TSP for Nepalgunj Station

Compliance status:

Out of the total 149 days of valid measurement, none of the day exceeded the NAAQS.

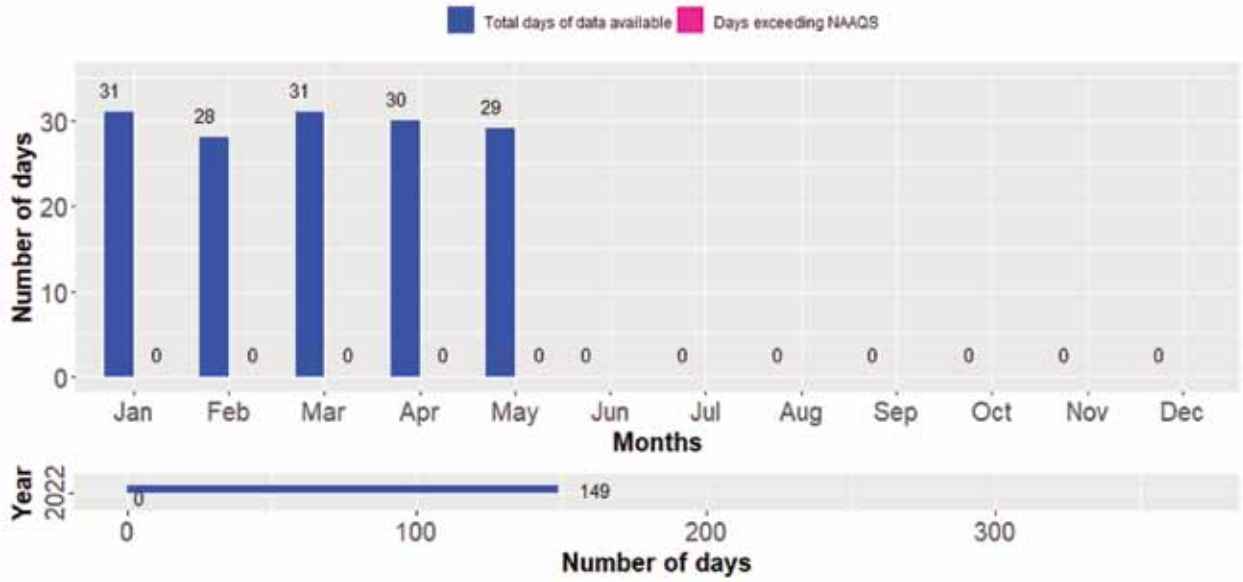

Figure 194: Compliance status of TSP for Nepalgunj Station

2.4 KARNALI PROVINCE

2.4.1 RARA AIR QUALITY MONITORING STATION

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). The local air quality might be influenced by regional haze, regional fire and local emission activities.

2.4.1.1 POINT DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 1.1 µg m^{-3} to 124.4 µg m^{-3}. The lowest and highest concentration of $PM_{2.5}$ was observed on 12th October at 1:00 28th and April at 20:00 respectively. The statistical summary of hourly average is presented in the table below:

Table 55: Summary of hourly average of $PM_{2.5}$ for Rara Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 µg m^{-3}	3.2 µg m^{-3}	6.7 µg m^{-3}	13.2 ± 15.7 µg m^{-3}	16.7 µg m^{-3}	124.4 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-20) and as values increase, the frequency of observations decreases rapidly.

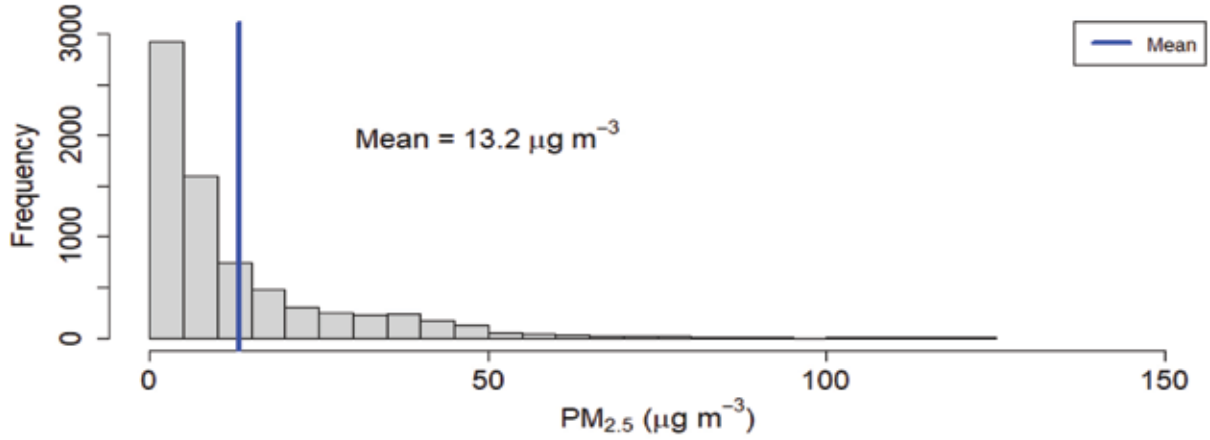

Figure 195: Histogram of $PM_{2.5}$ for Rara Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ was not much variable throughout the day but it is slightly lower during the day time. It reached to the lowest point at 13:00.

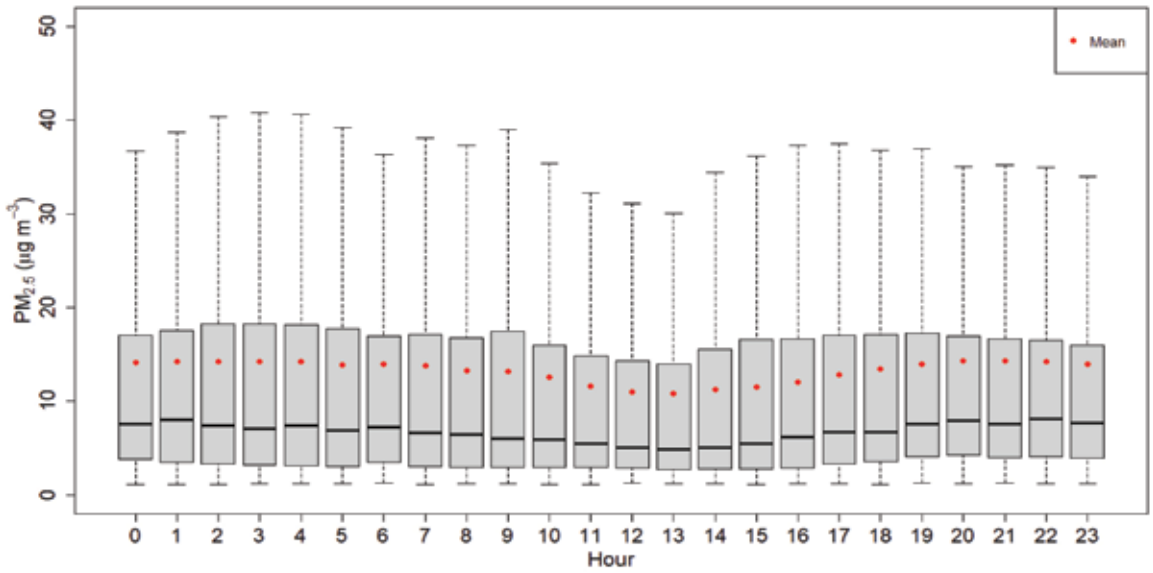

Figure 196: Diurnal variation of $PM_{2.5}$ for Rara Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during June whereas less during November.

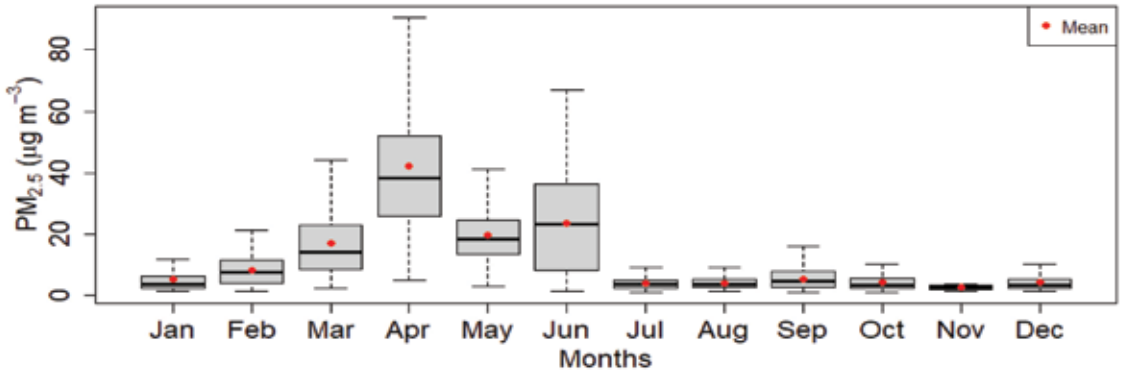

Figure 197: Monthly variation of $PM_{2.5}$ for Rara Station

Daily average:

Figure 198 shows the daily trend of $PM_{2.5}$ throughout the year.

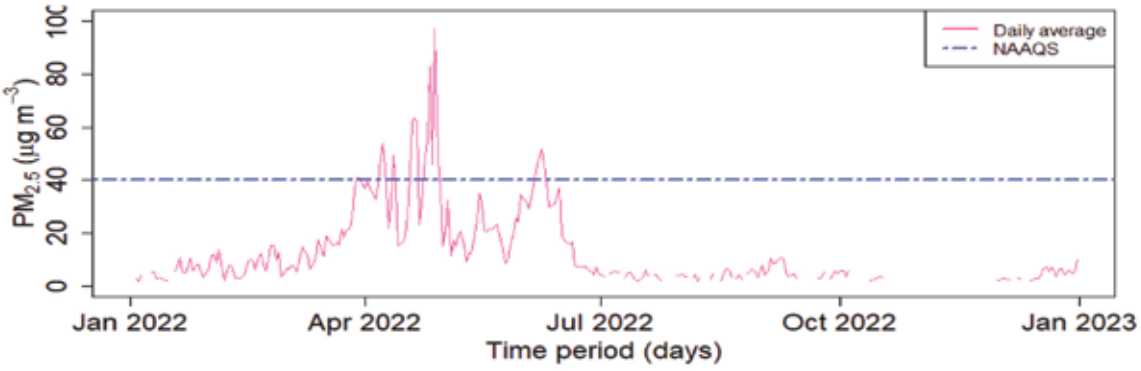

Figure 198: Daily average of $PM_{2.5}$ for Rara Station

Table 56: Summary of daily average of $PM_{2.5}$ for Rara Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.8 µg m^{-3}	4.1 µg m^{-3}	7.4 µg m^{-3}	13.9 ± 15 µg m^{-3}	17.9 µg m^{-3}	97.0 µg m^{-3}

Within the available data, the lowest and the highest daily average of $PM_{2.5}$ was found to be 1.8 µg m^{-3} and 97.0 µg m^{-3} on15th July and 28th April respectively (table 83). During majority of days, $PM_{2.5}$ concentration was found to be below NAAQS. However, many days in April and May exceed the NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. The monthly average was found lowest in July and August (4 µg m^{-3}) and highest in April (42.2 µg m^{-3}). Monthly average was not available for October and November.

Figure 199: Monthly average of $PM_{2.5}$ for Rara Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Because of limited data, the averages of post-monsoon season were not available. The seasonal average of pre-monsoon season was highest (26.1µg m^{-3}) and that of winter season was the lowest (6.3 µg m^{-3}).

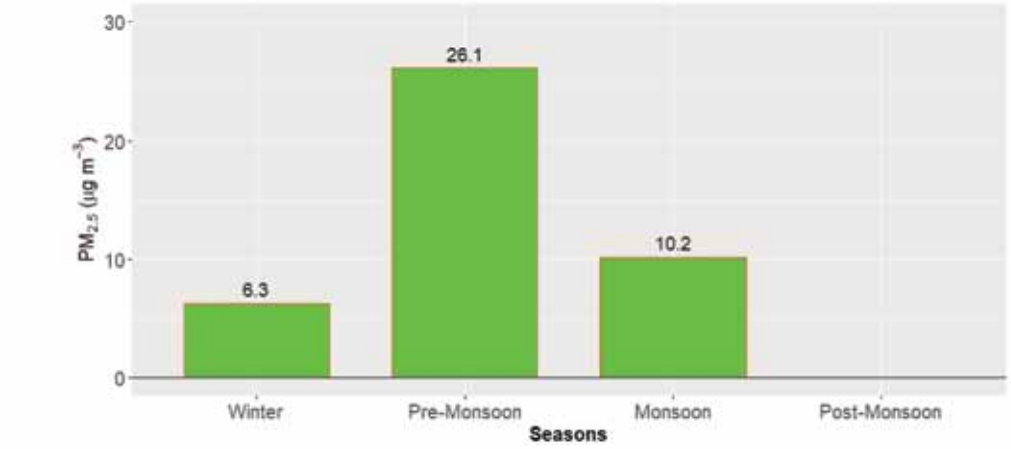

Figure 200: Seasonal average of $PM_{2.5}$ for Rara Station

Compliance status:

Out of the total 284 days of valid measurement, only 19 days exceeded the NAAQS. Those noncompliance days were March, April and June.

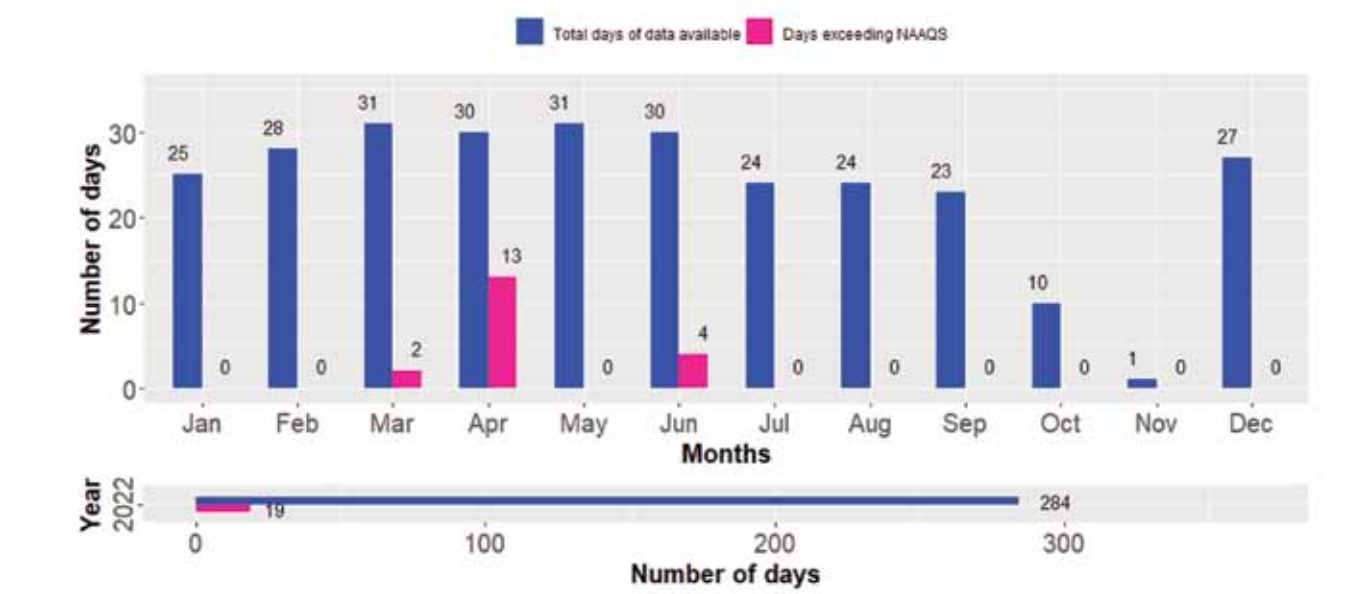

Figure 201: Compliance status of $PM_{2.5}$ for Rara Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 202), out of the total 284 valid days, majority of days showed AQI of good state. The AQI of five days in April reached to unhealthy state.

Figure 202: Calendar plot of $PM_{2.5}$ for Rara Station

2.4.1.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 1.2 µg m^{-3} to 160.7 µg m^{-3}. The lowest and the highest concentration of PM_{10} was observed on 12th October at 1:00 and 28th April at 20:00. The statistical summary of hourly average is presented in the table below:

Table 57: Summary of hourly average of PM_{10} for Rara Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.2 µg m^{-3}	4.0 µg m^{-3}	8.2 µg m^{-3}	19.0 ± 23.2 µg m^{-3}	25.0 µg m^{-3}	160.7 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-20) and as values increase, the frequency of observations decreases rapidly.

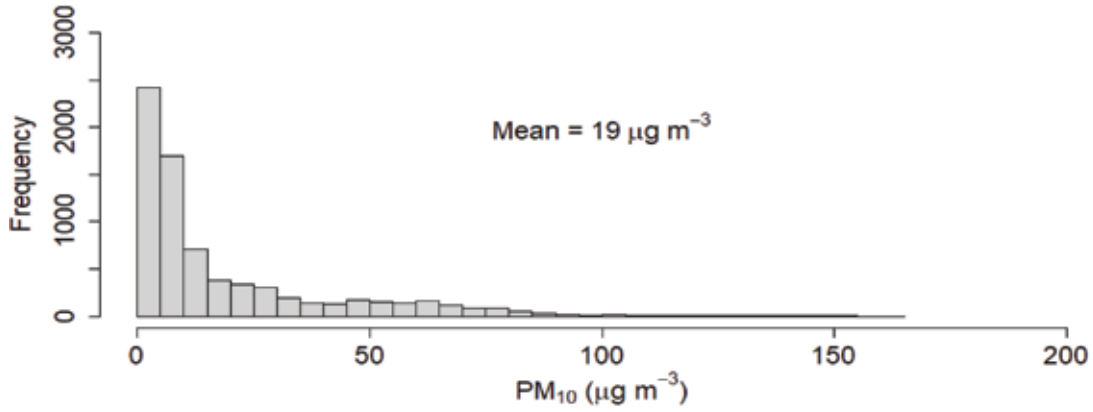

Figure 203: Histogram of PM_{10} for Rara Station

Diurnal variation:

The hourly mean of PM_{10} was not much variable throughout the day but it is slightly lower during the day time. It is lowest at 13:00.

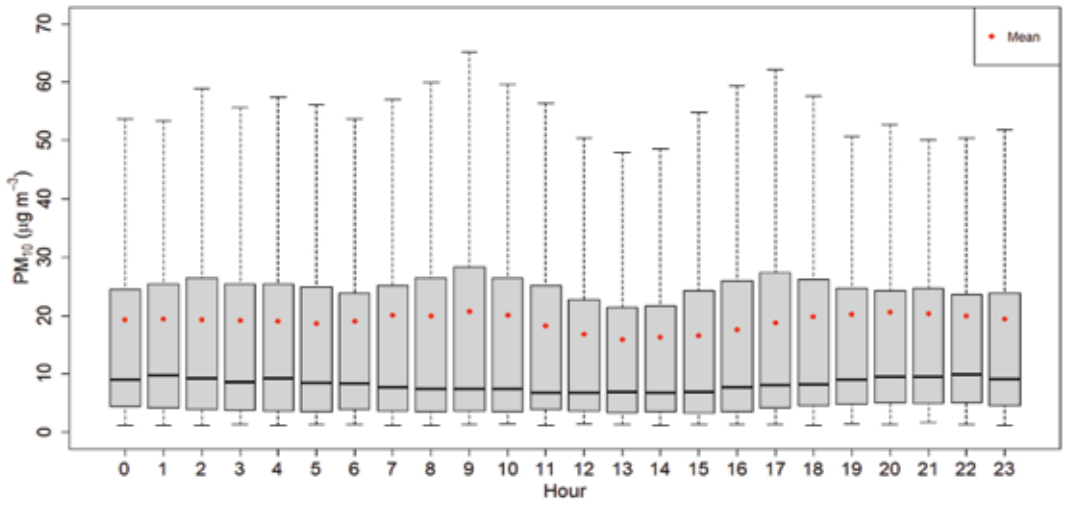

Figure 204: Diurnal variation of PM_{10} for Rara Station

Monthly variation:

A high variation of PM_{10} concentration was seen during April and June whereas less during July to December.

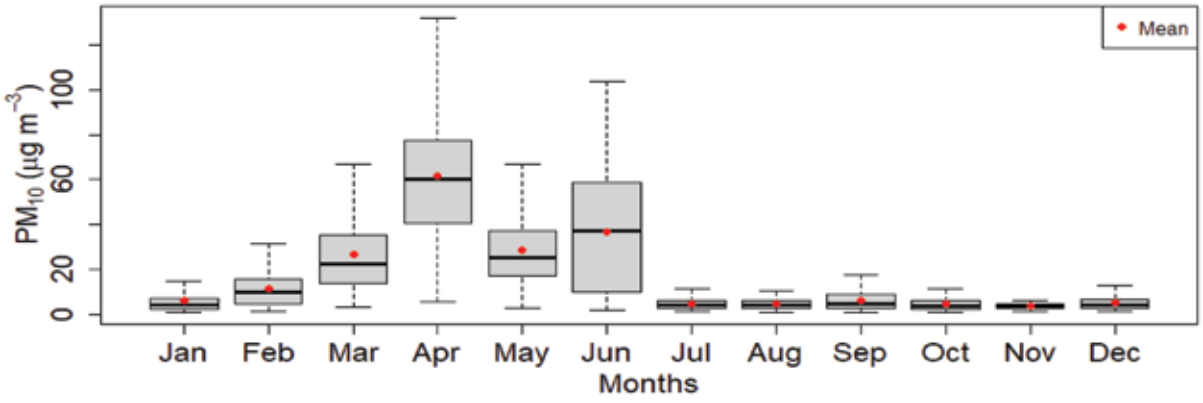

Figure 205: Monthly variation of PM_{10} for Rara Station

Daily average:

Figure 206 explains the daily trend of PM_{10} throughout the year.

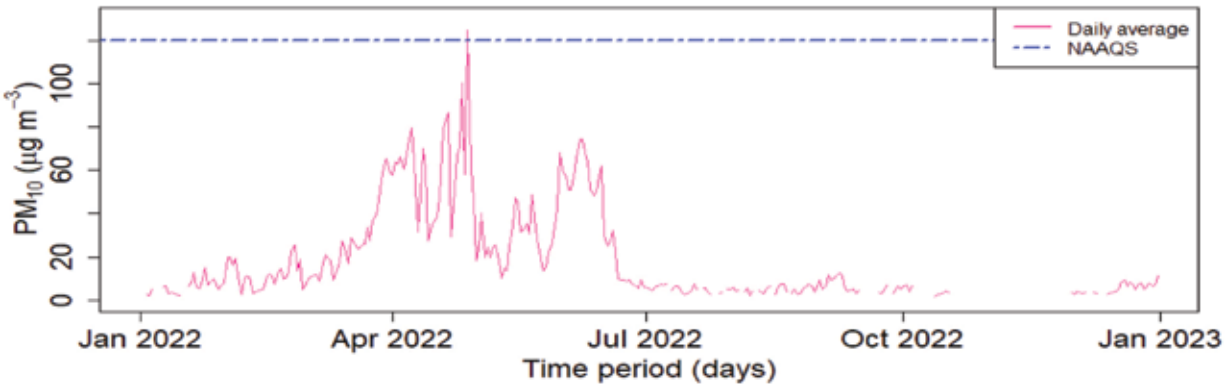

Figure 206: Daily average of PM_{10} for Rara Station

Table 58: Summary of daily average of PM_{10} for Rara Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
2.0 µg m^{-3}	5.0 µg m^{-3}	9.1 µg m^{-3}	19.8 ± 22.1 µg m^{-3}	27.3 µg m^{-3}	124.7 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 2.0 µg m^{-3} and 124.7 µg m^{-3} on 12th October and 28th April respectively (table 86). Daily average value of only one day exceeded the NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of PM_{10}. The monthly average was lowest in August (4.8 µg m^{-3}) and highest in April (61.5 µg m^{-3}). Monthly average was not available for October and November.

Figure 207: Monthly average of PM_{10} for Rara Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}. Because of limited data, the averages of post-monsoon season were not available. The seasonal average of pre-monsoon season was highest (38.7µg m^{-3}) and that of winter season was lowest (8.5 µg m^{-3}).

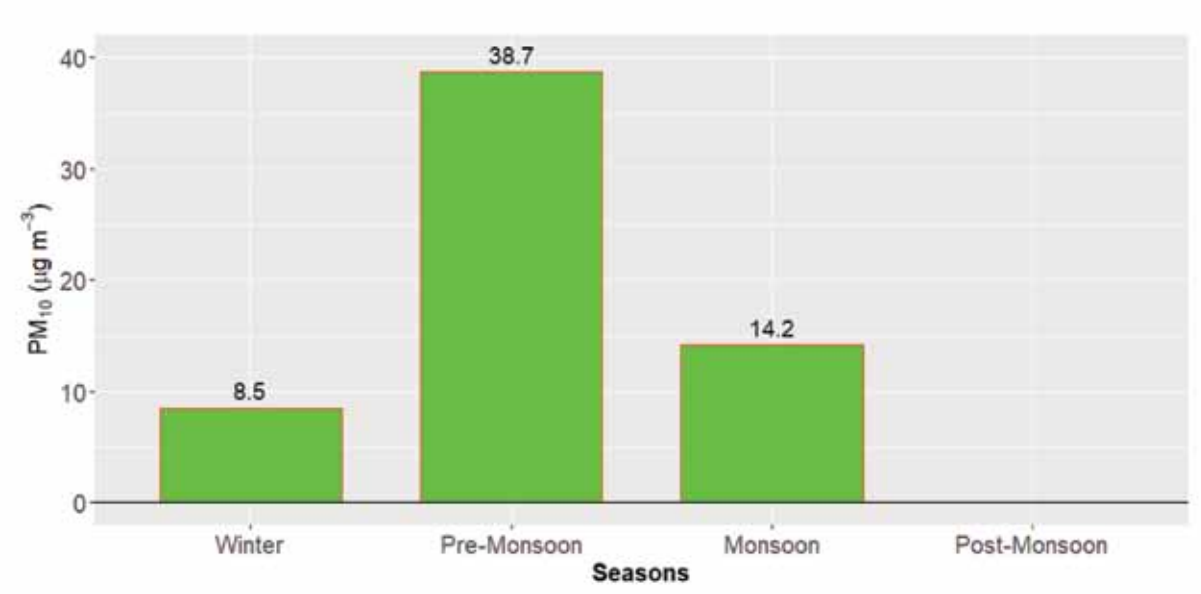

Figure 208: Seasonal average of PM_{10} for Rara Station

Compliance status:

Out of the total 291 days of measurement, only one day exceeded the NAAQS.

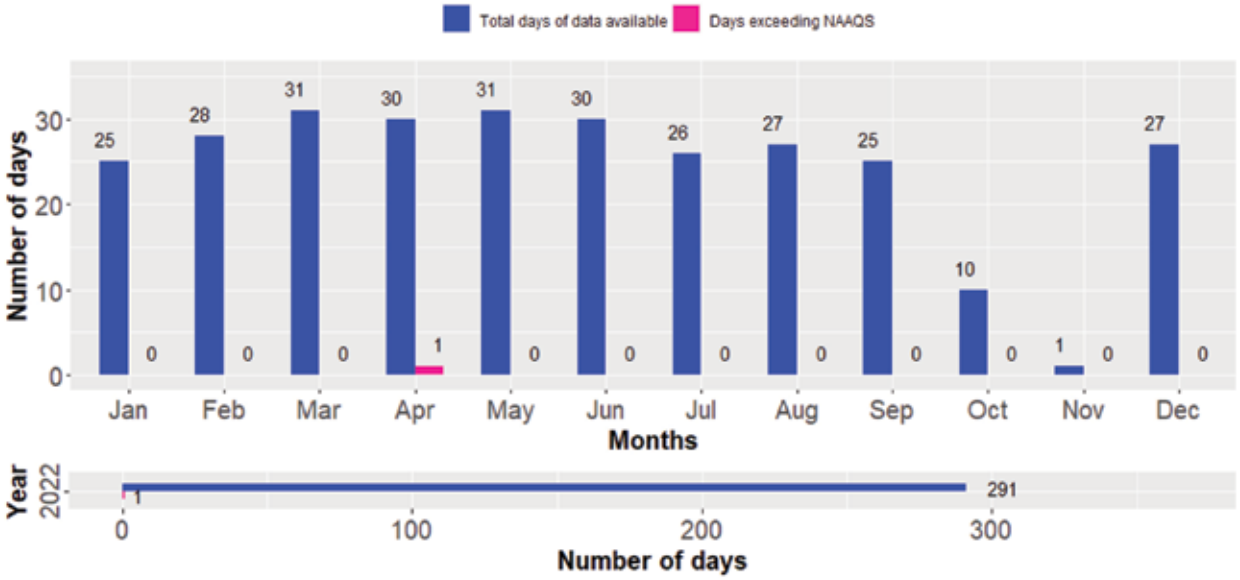

Figure 209: Compliance status of PM_{10} for Rara Station

2.4.1.3 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 1.2 µg m^{-3} to 710.0 µg m^{-3}. The lowest and the highest concentration of TSP was observed on 12th October at 1:00 and 3rd February at 2:00. The statistical summary of hourly average is presented in the table below:

Table 59: Summary of hourly average of TSP for Rara Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.2 g m^{-3}	5.1 µg m^{-3}	11.3 µg m^{-3}	31.1 ± 42.5 µg m^{-3}	38.8 µg m^{-3}	710.0 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-50) and as values increase, the frequency of observations decreases rapidly.

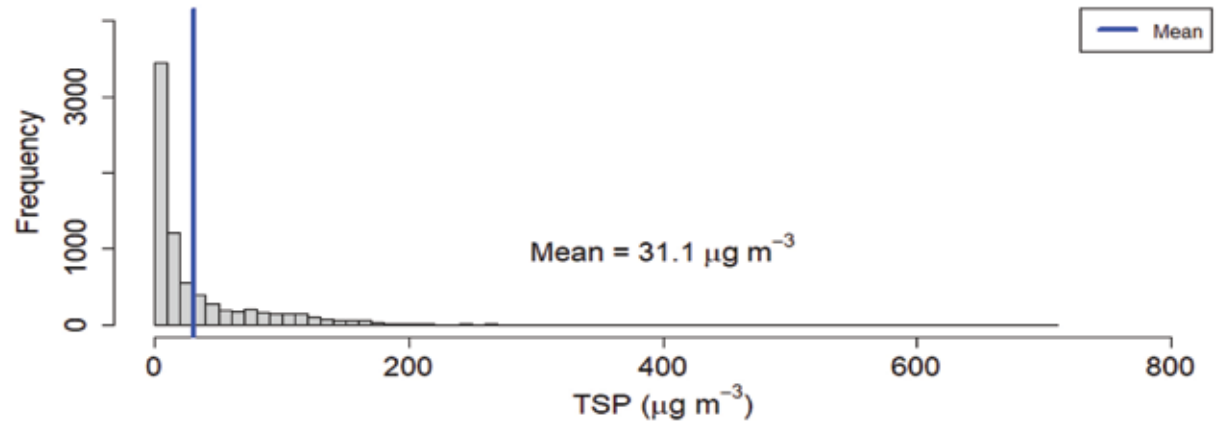

Figure 210: Histogram of TSP for Rara Station

Diurnal variation:

The hourly mean of TSP is not much varied throughout the days. It peaks at 9:00.

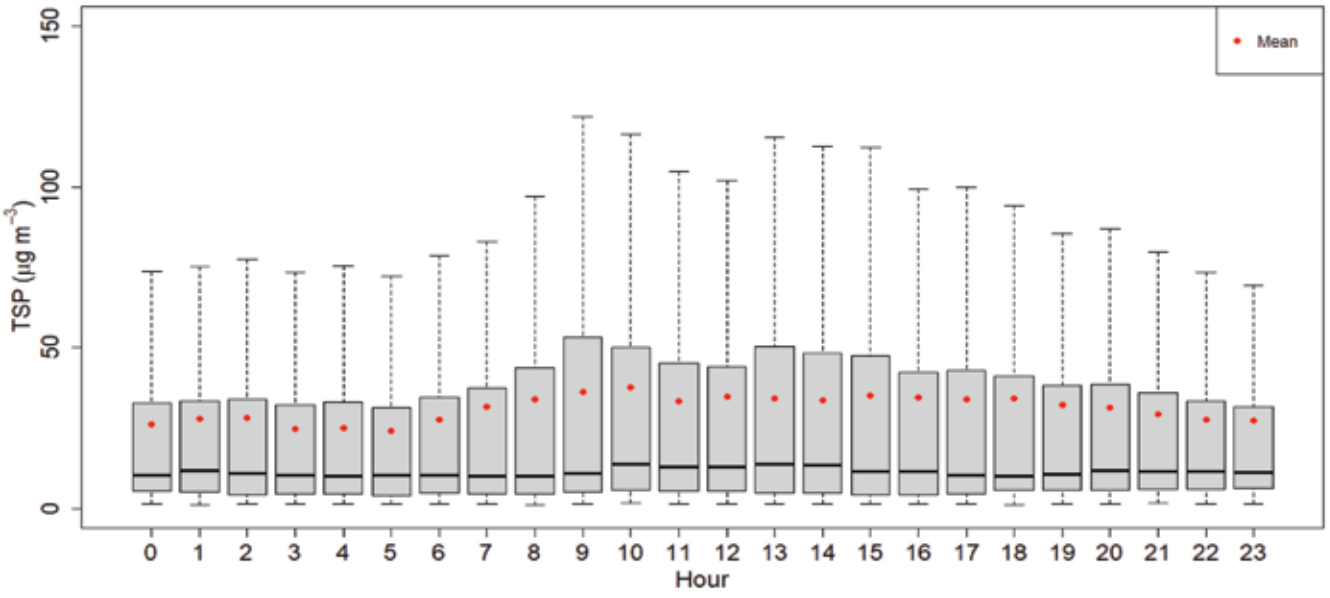

Figure 211: Diurnal variation of TSP for Rara Station

Monthly variation:

A high variation of TSP concentration was seen during June whereas less during July to December.

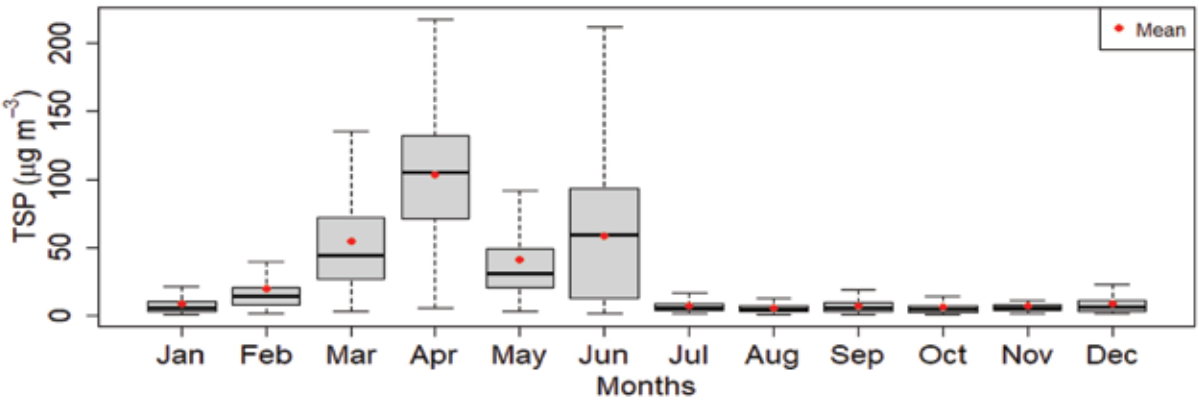

Figure 212: Monthly variation of TSP for Rara Station

Daily average:

Figure 213 explains the daily trend of TSP throughout the year.

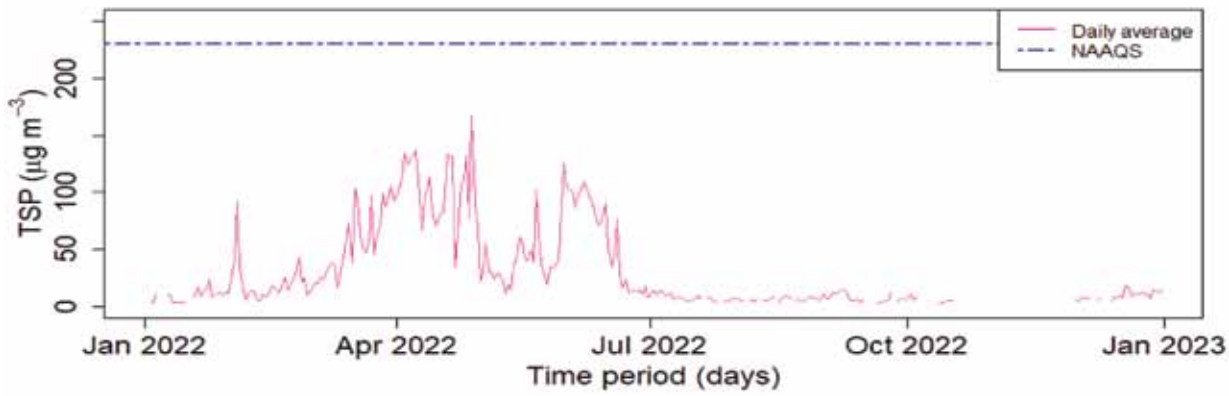

Figure 213: Daily average of TSP for Rara Station

Table 60: Summary of daily average of TSP for Rara Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
20.2 µg m^{-3}	50.8 µg m^{-3}	70.7 µg m^{-3}	76.1 ± 35.7 µg m^{-3}	87.6 µg m^{-3}	194.4 µg m^{-3}

The lowest and the highest concentration of TSP was found to be 20.2 µg m^{-3} and 194.4µg m^{-3} on 12th October and 28th April respectively (table 89). All of the available daily average TSP value was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. It can be seen that the monthly average was lowest in August (6.0 µg m^{-3}) and highest in April (103.4 µg m^{-3}). Monthly average was not available for October and November.

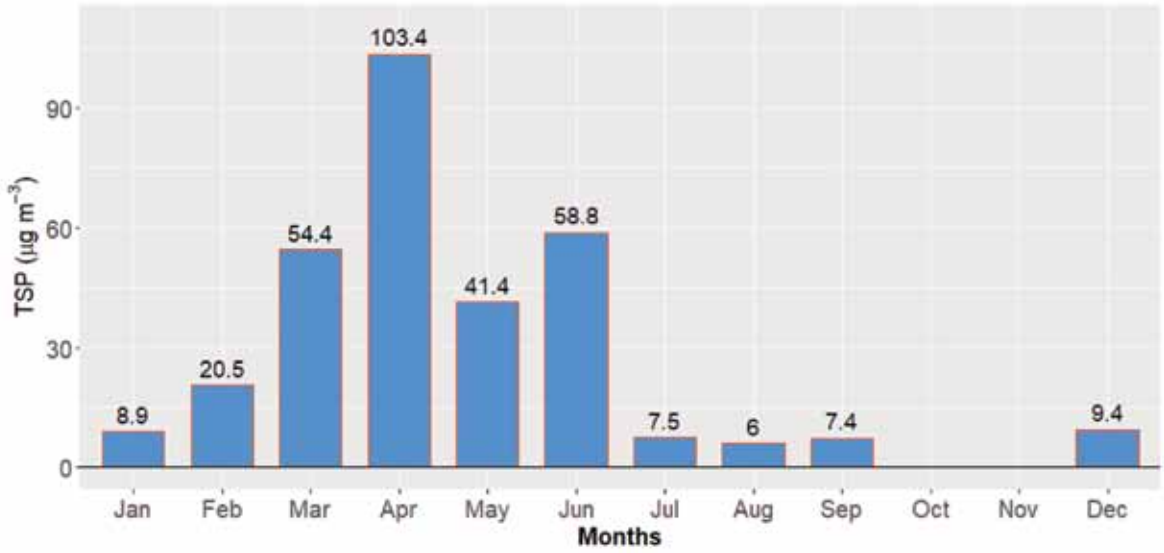

Figure 214: Monthly average of TSP for Rara Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP. Because of limited data, the averages of post-monsoon season were not available. The seasonal average of pre-monsoon season was highest (66.0µg m^{-3}) and that of winter season was the lowest (14.3 µg m^{-3}).

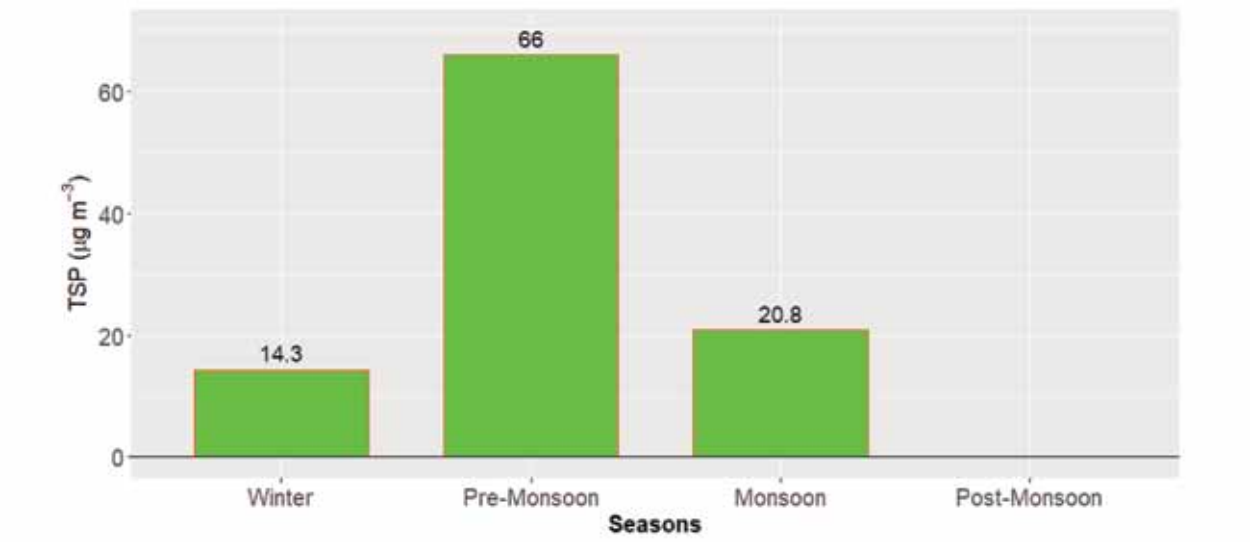

Figure 215: Seasonal average of TSP for Rara Station

Compliance status:

Out of the total 295 days of measurement, none of the day exceeded the NAAQS.

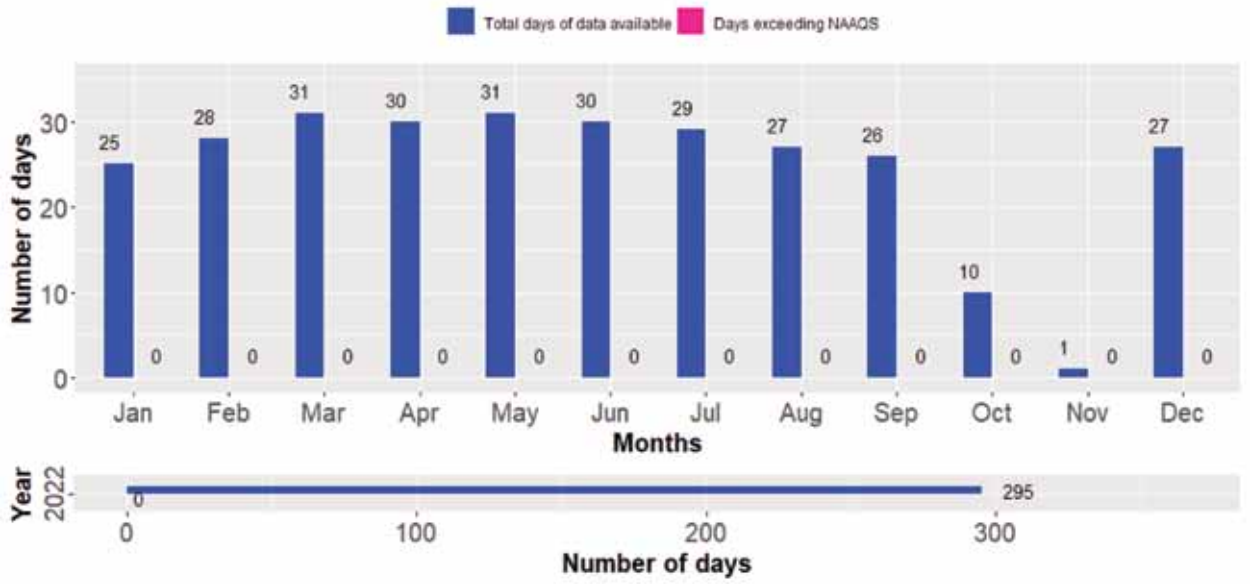

Figure 216: Compliance status of TSP for Rara Station

2.4.2 SURKHET AIR QUALITY MONITORING STATION

Surkhet air quality monitoring station was established in 2019 at Birendranagar Municipality in Surkhet district, Karnali Province. This station is inside premises of Karnali Province police office. Many government offices are located near the station. This station represents the urban area.

Emission from the vehicles are the main sources of pollution in the area around the station. A lot of agricultural residue burning is practiced and a lot of forest fire are observed during the pre-monsoon season, which is another probable source of air pollution in this area. Pollution from other region is also major source of pollution.

2.4.2.1 DATA ANALYSIS FOR $PM_{2.5}$

Hourly average:

The hourly average ranges from 1.1 μg m^{-3} to 194.1 μg m^{-3}. The lowest and the highest concentration of $PM_{2.5}$ was observed on 2nd June at 9:00 and 2nd February at 18:00. The statistical summary of the hourly average is presented in the table below:

Table 61: Summary of hourly average of $PM_{2.5}$ for Surkhet Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 μg m^{-3}	16.1 μg m^{-3}	25.9 μg m^{-3}	28.4 ± 18.7 μg m^{-3}	37.6 μg m^{-3}	194.1 μg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-50) and as values increase, the frequency of observations decreases rapidly.

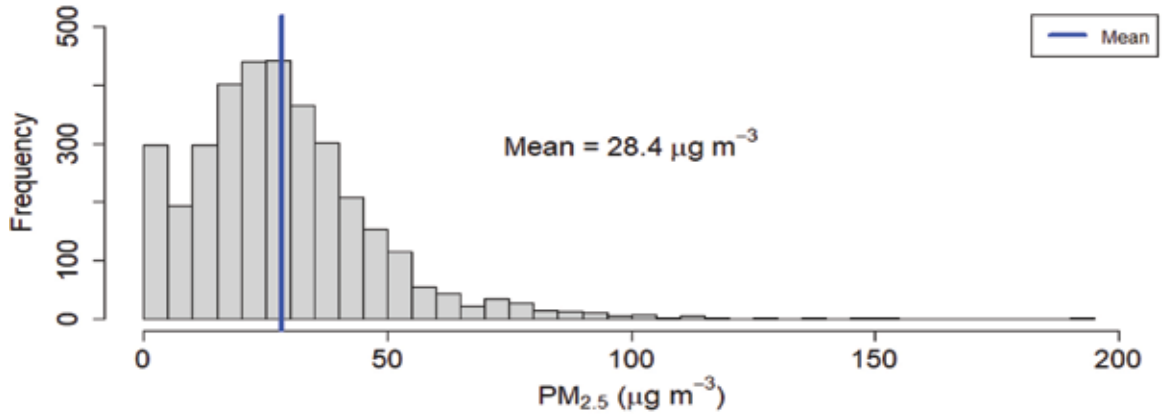

Figure 217: Histogram of $PM_{2.5}$ for Surkhet Station

Diurnal variation:

The hourly mean of $PM_{2.5}$ progressively increases with time and reaches to its peak at 8:00 which again decreases and gains height around 18:00-19:00. The mean value was similar to the median throughout the day.

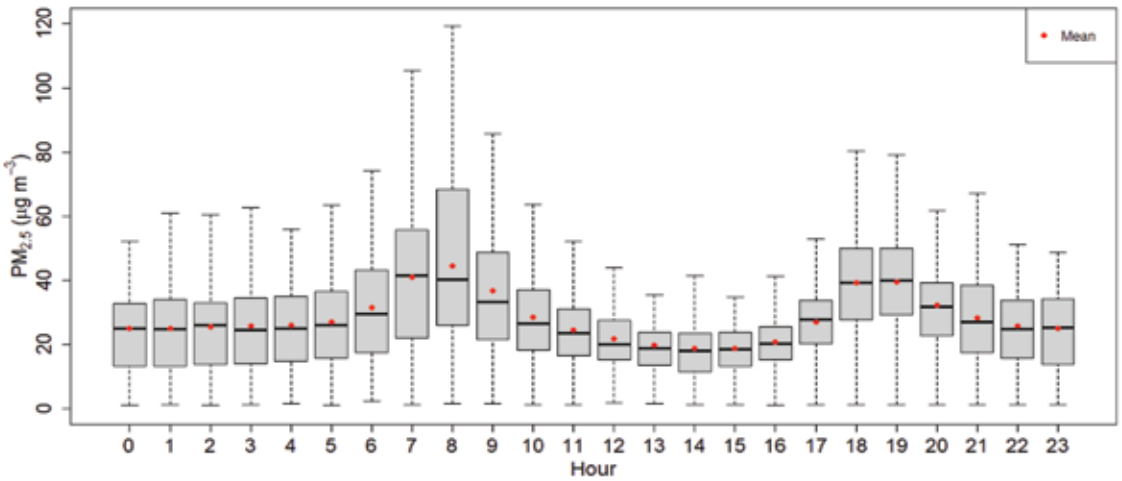

Figure 218: Diurnal variation of $PM_{2.5}$ for Surkhet Station

Monthly variation:

A high variation of $PM_{2.5}$ concentration was seen during February, whereas less occurs during June.

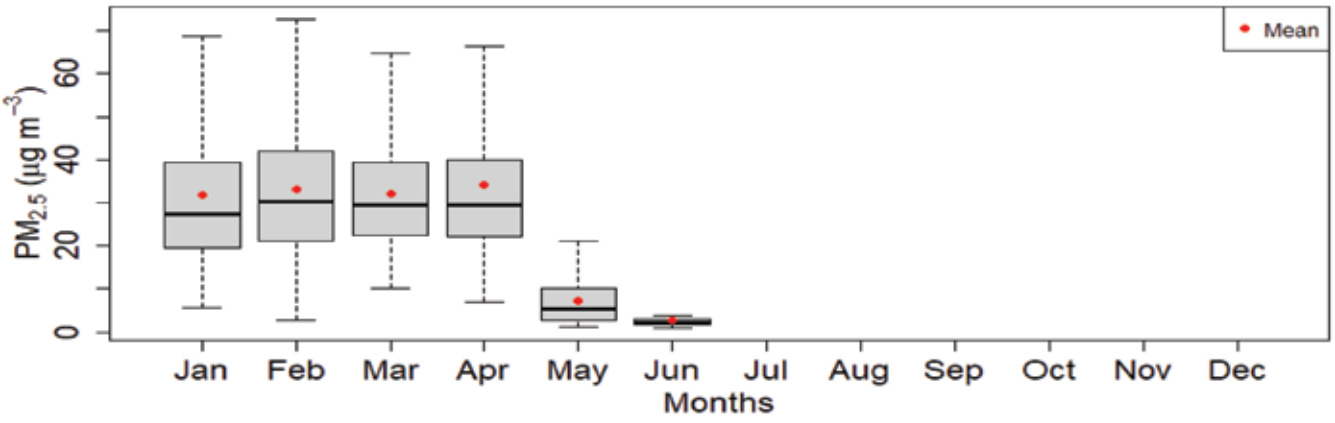

Figure 219: Monthly variation of $PM_{2.5}$ for Surkhet Station

Daily average:

The daily average data was available only from 1st January to 12th May.

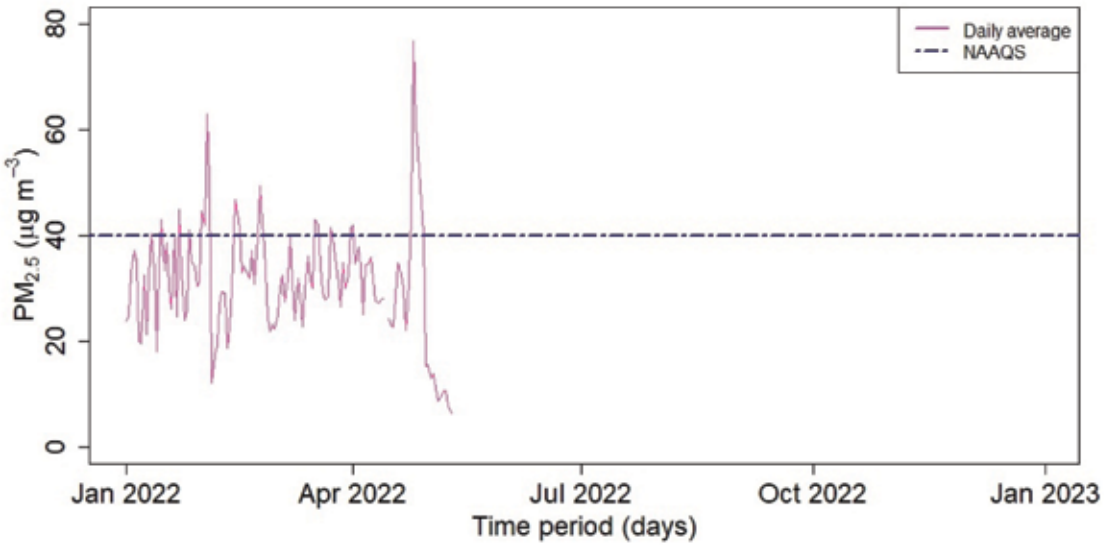

Figure 220: Daily average of $PM_{2.5}$ for Surkhet Station

Table 62: Summary of daily average of $PM_{2.5}$ for Surkhet Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
4.3 µg m^{-3}	24.5 µg m^{-3}	31.1 µg m^{-3}	30.9 ± 11.3 µg m^{-3}	36.9 µg m^{-3}	76.8 µg m^{-3}

Within the available data, the lowest and highest concentration of $PM_{2.5}$ was found to be 4.3 µg m^{-3} to 76.8 µg m^{-3} on 12th May and 25th April respectively (table 92). During the majority of days, $PM_{2.5}$ concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of $PM_{2.5}$. It can be seen that the average concentration of $PM_{2.5}$ was similar in all four months: January (31.8 µg m^{-3}), February (33.3 µg m^{-3}), March (32.0 µg m^{-3}) and April (34.6 µg m^{-3}).

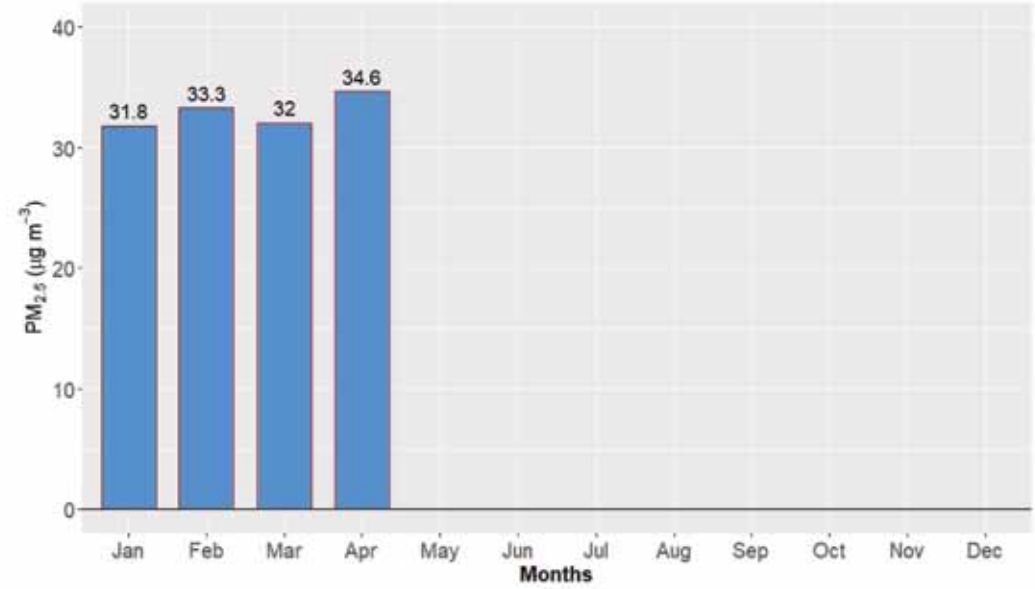

Figure 221: Monthly average of $PM_{2.5}$ for Surkhet Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of $PM_{2.5}$. Because of limited data, the averages of only two seasons- winter and pre-monsoon, were presented in the figure 222. Of the two seasons, the concentration of the winter season (32.5 µg m^{-3}) was found slightly more than pre-monsoon (29.7 µg m^{-3}).

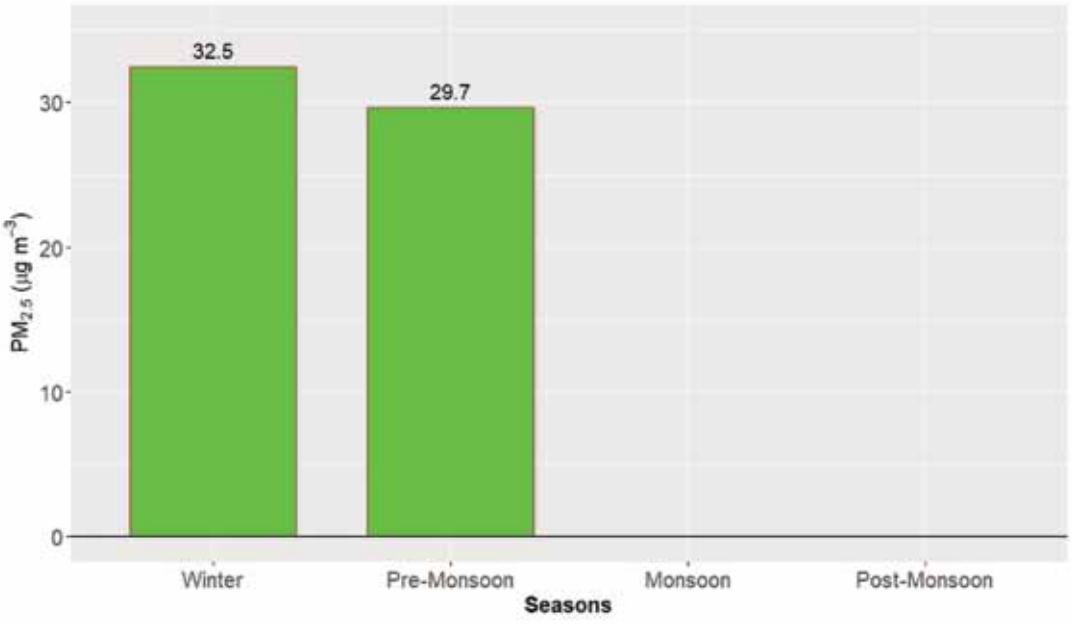

Figure 222: Seasonal average of $PM_{2.5}$ for Surkhet Station

Compliance status:

Out of the total 130 days of valid measurement, only 24 days exceeded the NAAQS. Those noncompliance days were included in January to April as shown in figure 223.

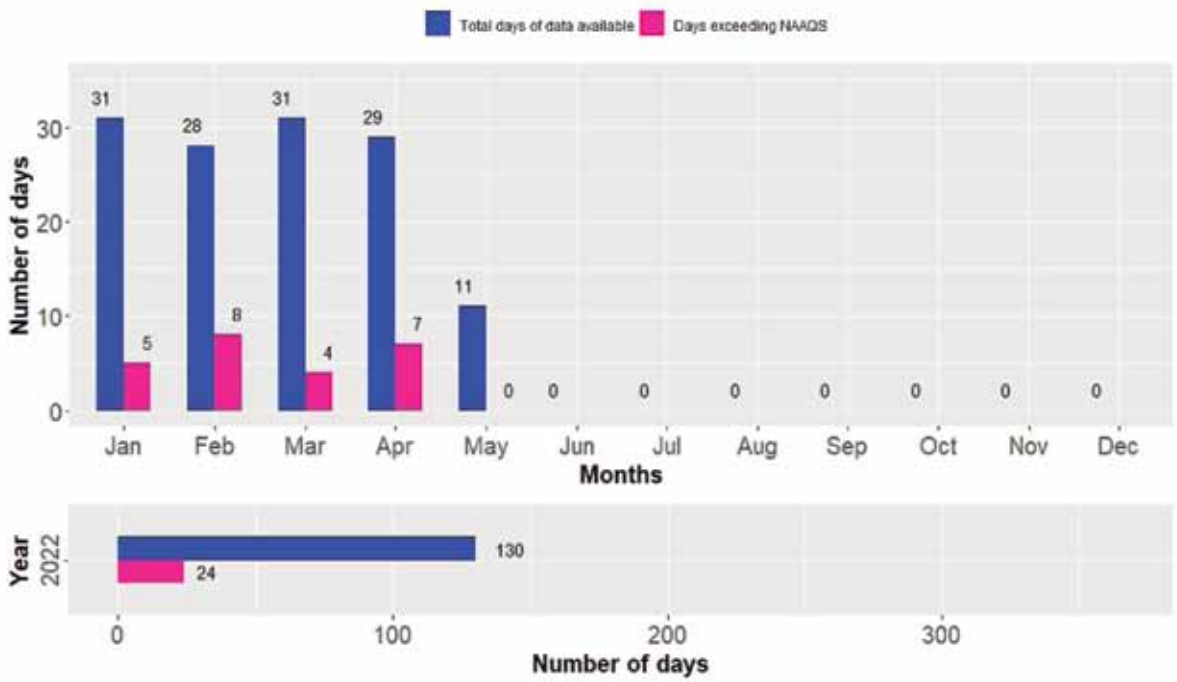

Figure 223: Compliance status of $PM_{2.5}$ for Surkhet Station

Calendar plot

As per the calendar plot for $PM_{2.5}$ (figure 224), out of the total 130 valid days, the majority of days showed an AQI of good to moderate. Only three days (February 2, April 25 and 26) reached an unhealthy state. Few days in January to April are also found to be unhealthy for the sensitive group.

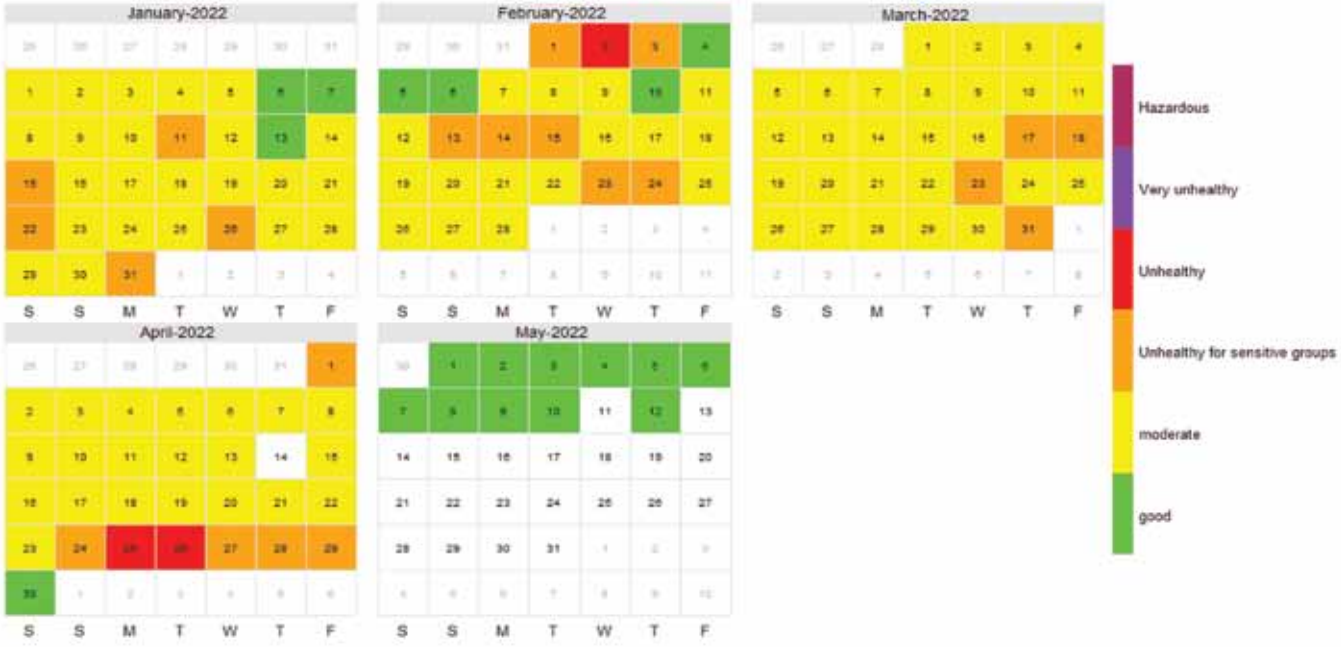

Figure 224: Calendar plot of $PM_{2.5}$ for Surkhet Station

2.4.2.2 DATA ANALYSIS FOR PM_{10}

Hourly average:

The hourly average ranges from 1.1 µg m^{-3} to 294.8 µg m^{-3}. The lowest and highest concentration of PM_{10} were observed on 4th June at 5:00 and 14th April at 1:00. The statistical summary of the hourly average is presented in the table below:

Table 63: Summary of hourly average of PM_{10} for Surkhet Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 µg m^{-3}	18.3 µg m^{-3}	30.3 µg m^{-3}	32.8 ± 22.2 µg m^{-3}	42.9 µg m^{-3}	294.8 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-50) and as values increase, the frequency of observations decreases rapidly.

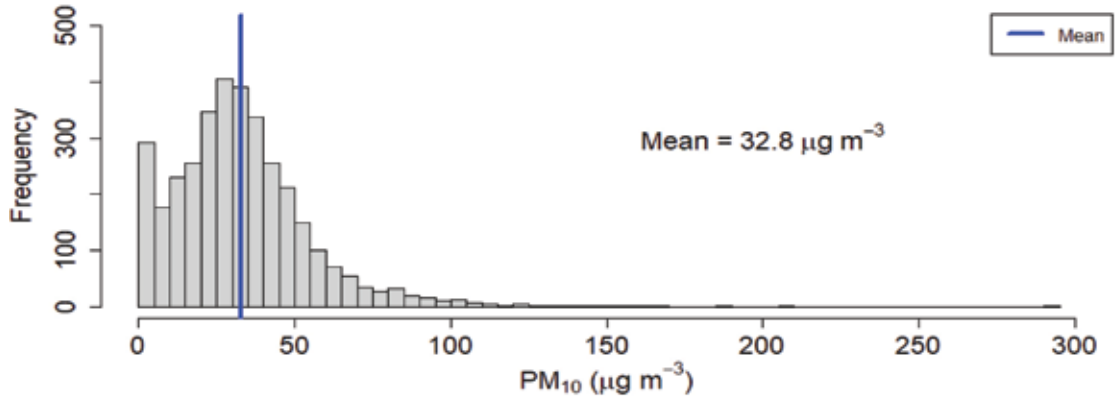

Figure 225: Histogram of PM_{10} for Surkhet Station

Diurnal variation:

The hourly mean of PM_{10} progressively increases with time and reaches its peak at 8:00 which again decreases and gains height around 18:00.

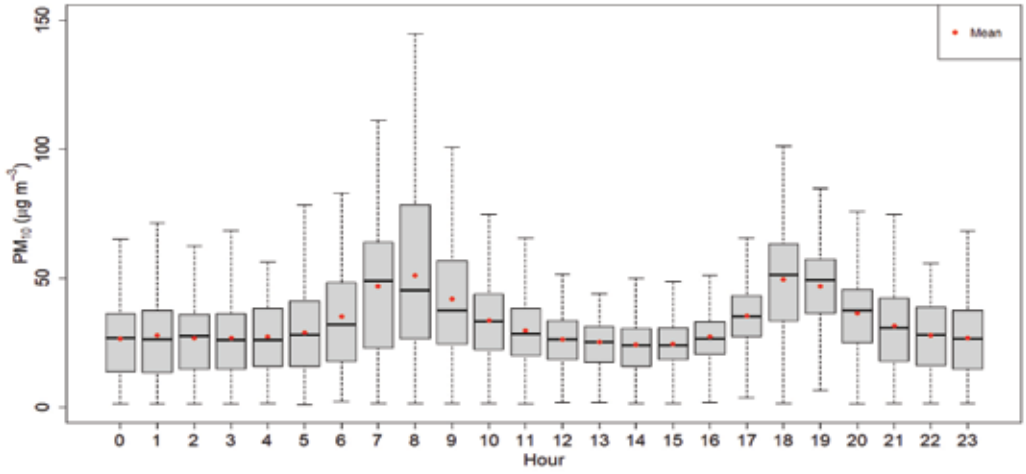

Figure 226: Diurnal variation of PM_{10} for Surkhet Station

Monthly variation:

A high variation of PM_{10} concentration was seen during February, whereas less occurs during June.

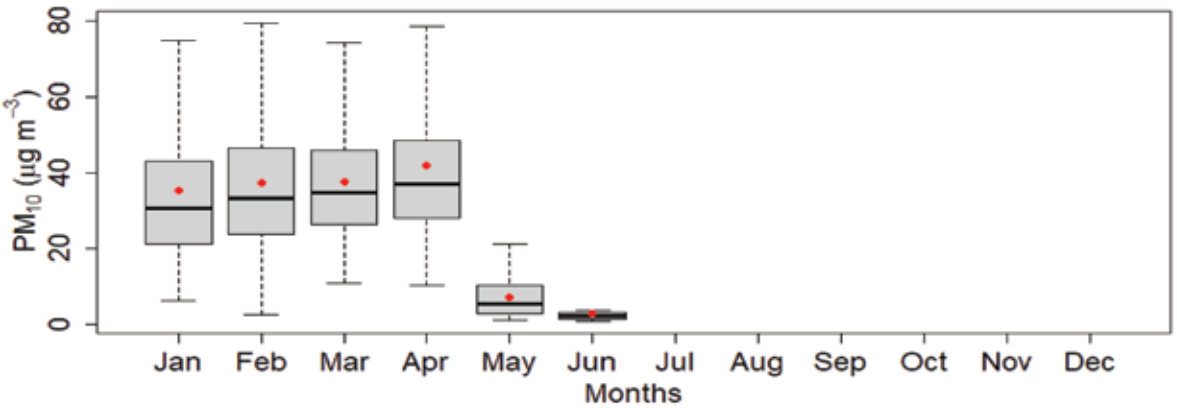

Figure 227: Monthly variation of PM_{10} for Surkhet Station

Daily average:

The daily average data was available only from 1st January to 12th May.

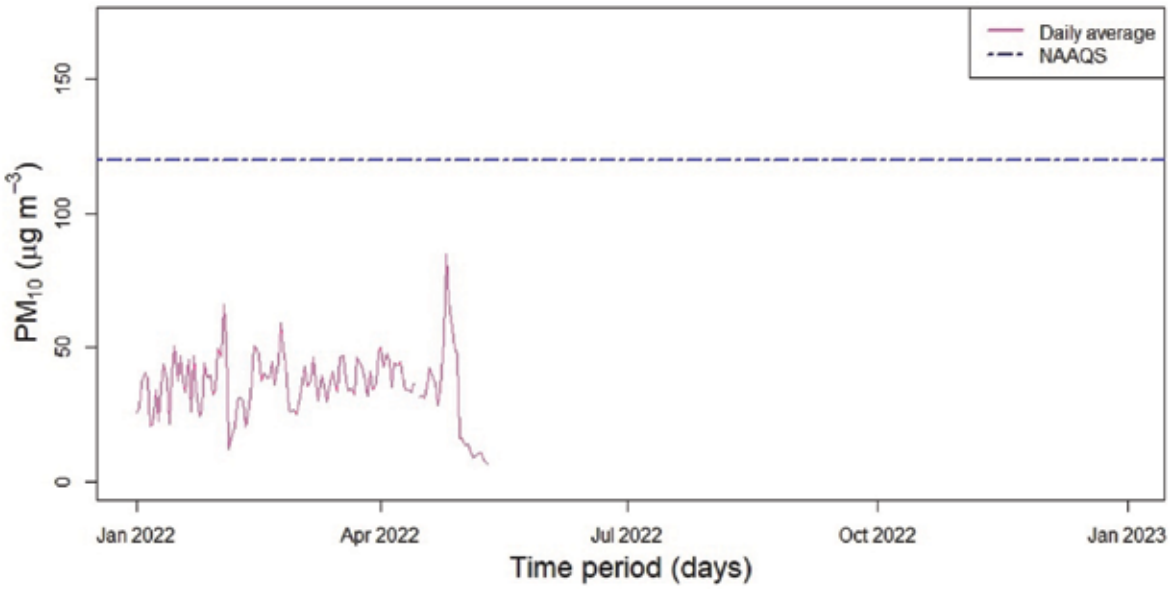

Figure 228: Daily average of PM_{10} for Surkhet Station

Table 64: Summary of daily average of PM_{10} for Surkhet Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
4.4 µg m^{-3}	29.7 µg m^{-3}	36.7 µg m^{-3}	35.7 ± 12.9 µg m^{-3}	43.9 µg m^{-3}	84.9 µg m^{-3}

Within the available data, the lowest and the highest concentration of PM_{10} was found to be 4.4 µg m^{-3} to 84.9 µg m^{-3} on 12th May and 25th April respectively (table 95). The total available PM_{10} concentration was found to be below NAAQS.

Monthly average:

The average monthly concentration of PM_{10} is shown in the bar chart. It can be seen that the average concentration of PM_{10} was similar in all four months- January (35.3 µg m^{-3}), February (37.3 µg m^{-3}), March (37.7 µg m^{-3}) and April (42.1 µg m^{-3}).

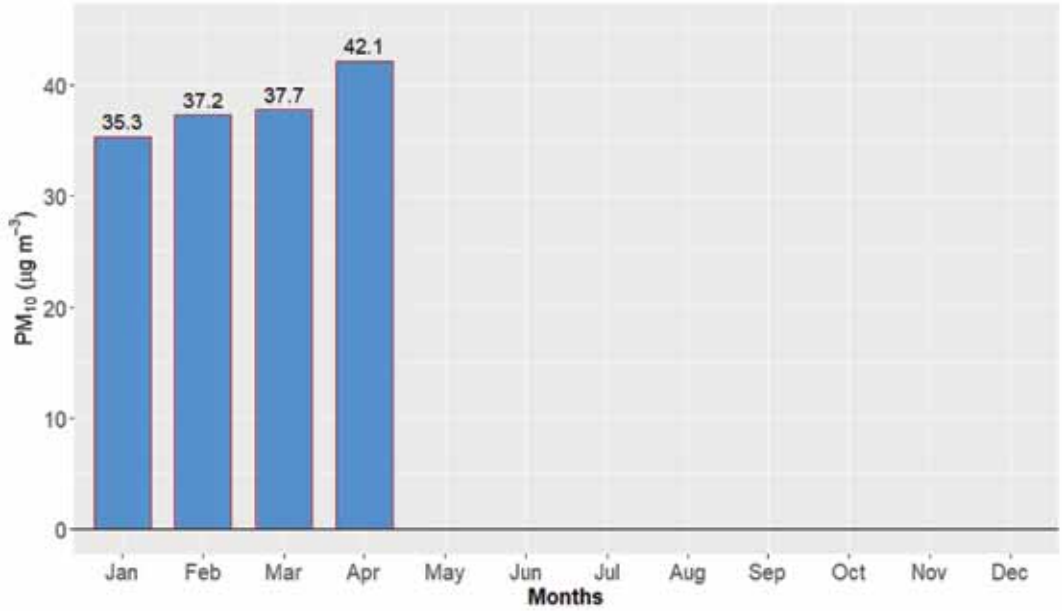

Figure 229: Monthly average of PM_{10} for Surkhet Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of PM_{10}. Because of limited data, the averages of only two seasons- winter and pre-monsoon, were presented in the figure 230. Of the two seasons, the concentration of the winter season (36.2 µg m^{-3}) was slightly higher than that of pre-monsoon (35.3 µg m^{-3}).

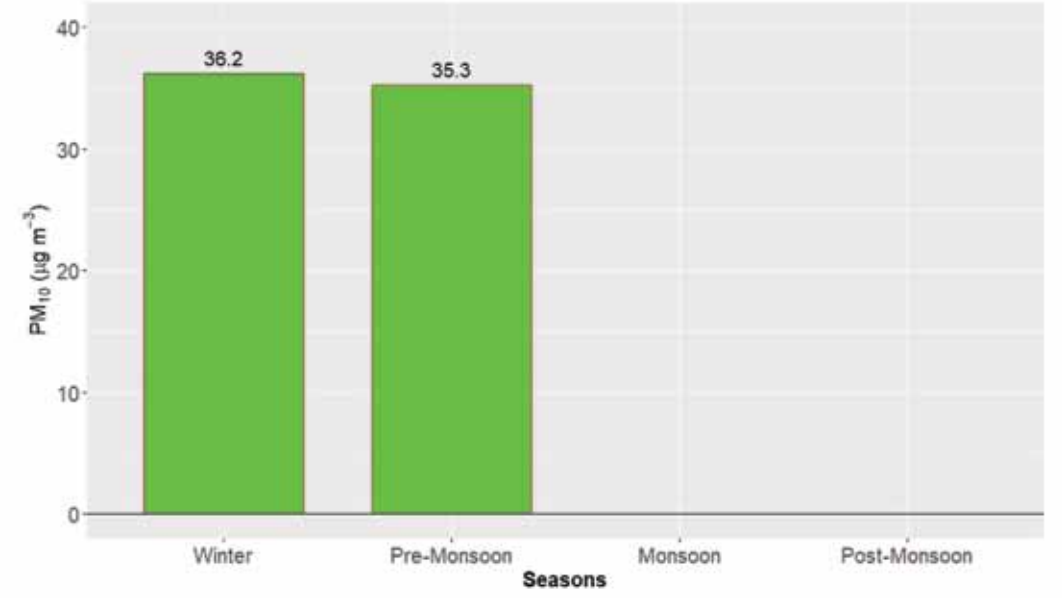

Figure 230: Seasonal average of PM_{10} for Surkhet Station

Compliance status:

Out of the total 130 days of measurement, none of the day exceeded the NAAQS.

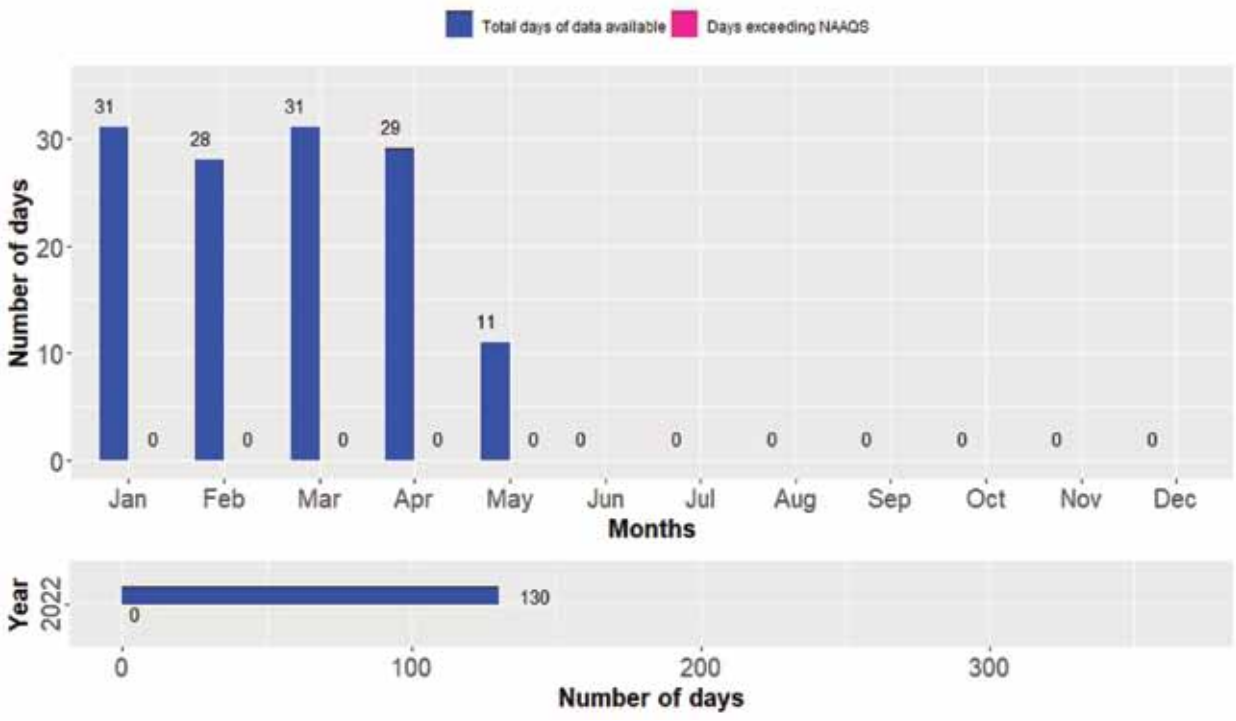

Figure 231: Compliance status of PM_{10} for Surkhet Station

2.4.2.3 DATA ANALYSIS FOR TSP

Hourly average:

The hourly average ranges from 1.1 µg m^{-3} to 467.1 µg m^{-3}. The lowest and the highest concentration of TSP were observed on 4th June at 5:00 and14th April at 1:00. The statistical summary of the hourly average is presented in the table below:

Table 65: Summary of hourly average of TSP for Surkhet Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
1.1 µg m^{-3}	18.7 µg m^{-3}	31.5 µg m^{-3}	34.3 ± 24.7 µg m^{-3}	45.0 µg m^{-3}	467.1 µg m^{-3}

Histogram:

The dataset is clustered on the lower end of values (0-70) and as values increase, the frequency of observations decreases rapidly.

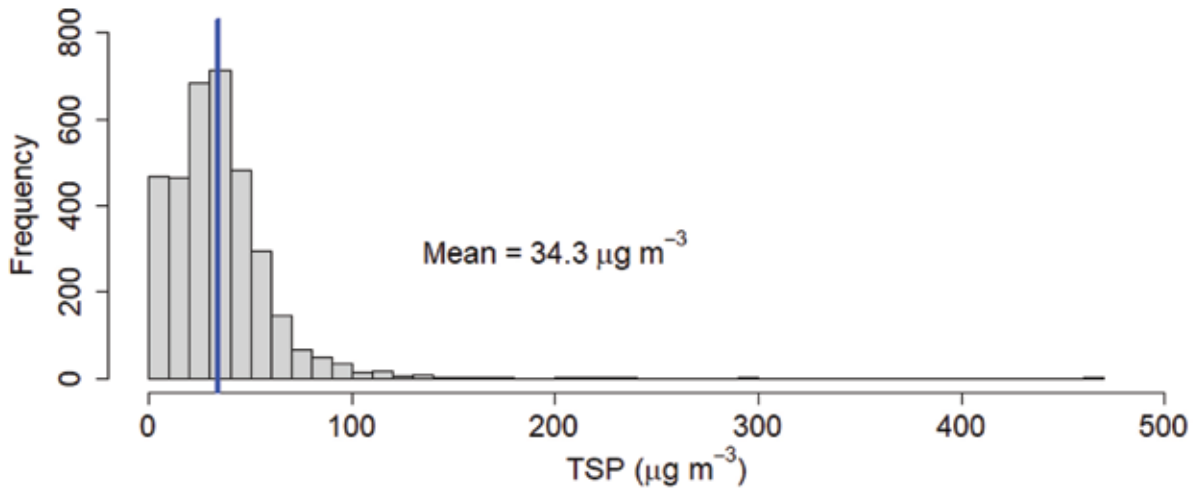

Figure 232: Histogram of TSP for Surkhet Station

Diurnal variation:

The hourly mean of TSP progressively increases with time and reached to its peak at 8:00 which again decreases and gains height around 18:00.

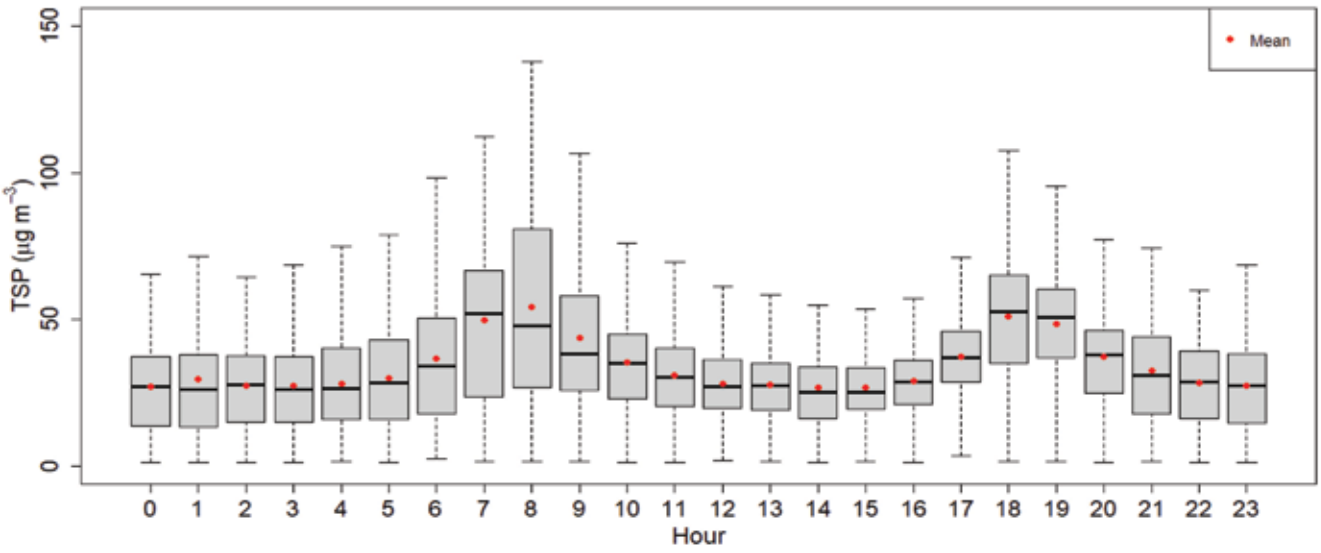

Figure 233: Diurnal variation of TSP for Surkhet Station

Monthly variation:

A high variation of TSP concentration was seen during January, whereas less occurs during June.

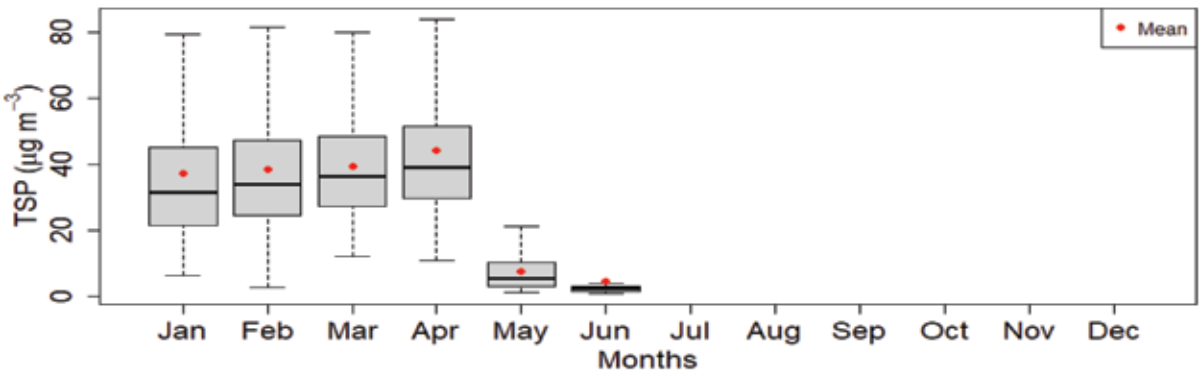

Figure 234: Monthly variation of TSP for Surkhet Station

Daily average:

The daily average data is available only from 1st January to 12th May.

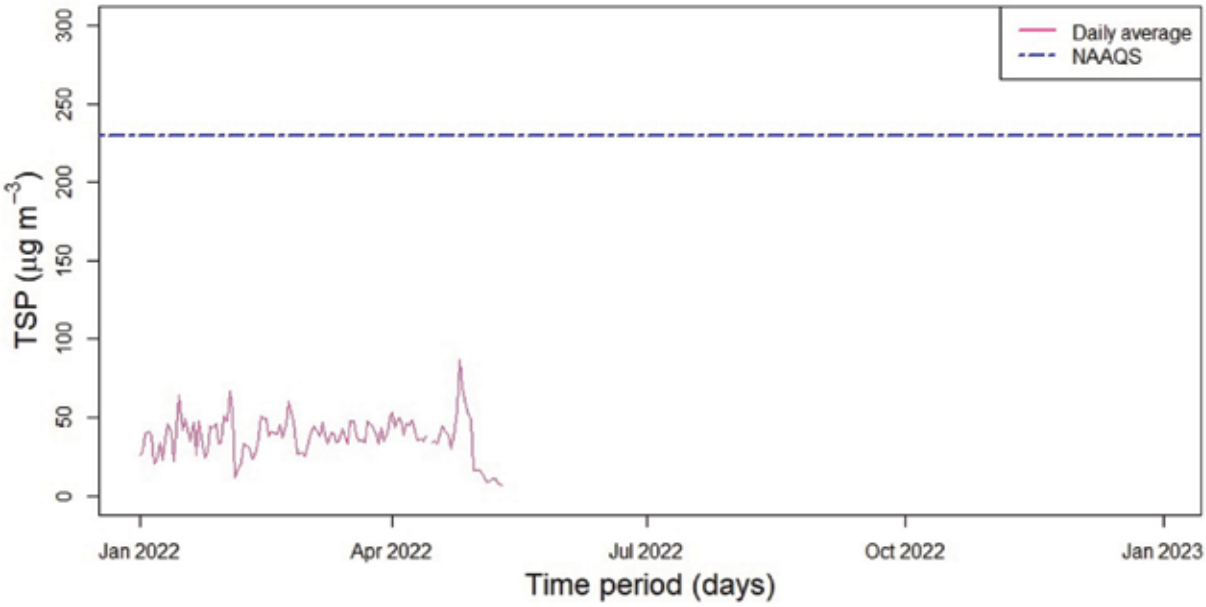

Figure 235: Daily average of TSP for Surkhet Station

Table 66: Summary of daily average of TSP for Surkhet Station

Minimum	1st quartile	Median	Mean ± SD	3rd quartile	Maximum
4.4 µg m^{-3}	32.3 µg m^{-3}	38.8 µg m^{-3}	37.3 ± 13.4 µg m^{-3}	45.7 µg m^{-3}	86.9 µg m^{-3}

Within the available data, the lowest and highest concentration of TSP was found to be 4.4 µg m^{-3} to 86.9 µg m^{-3} on 12th May and 25th April respectively. The total available TSP concentration was found to be below NAAQS.

Monthly average:

The bar chart illustrates the monthly average concentration of TSP. It can be seen that the average concentration of TSP was similar in all four months: January (37.2 µg m^{-3}), February (38.4 µg m^{-3}), March (39.4 µg m^{-3}) and April (44.2 µg m^{-3}).

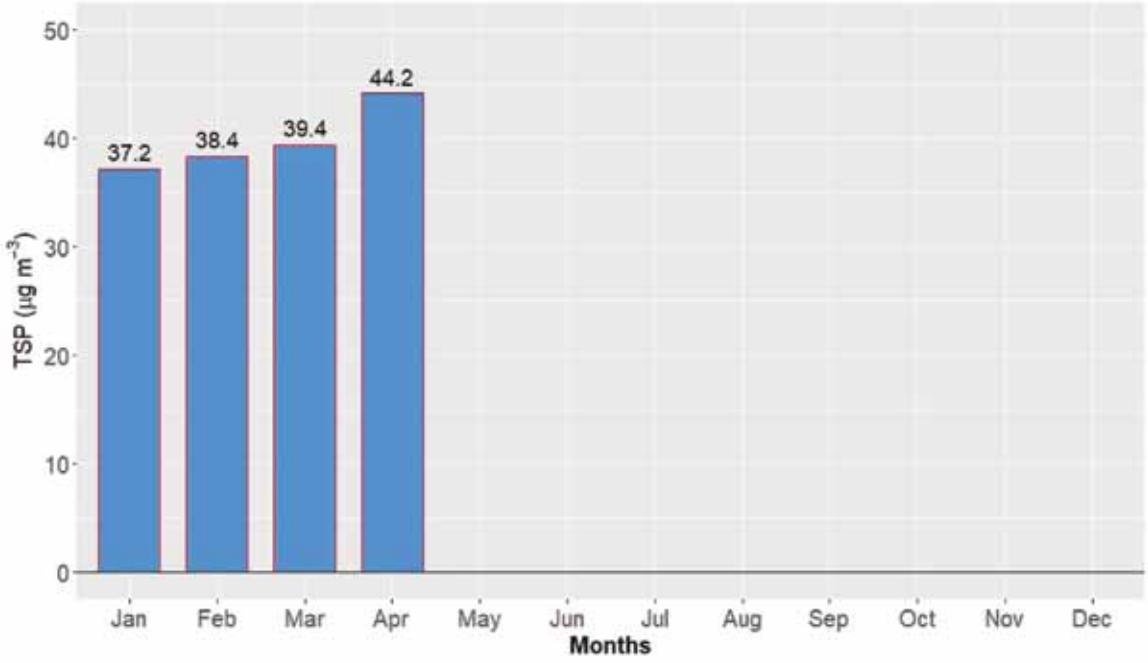

Figure 236: Monthly average of TSP for Surkhet Station

Seasonal average:

This bar chart illustrates the seasonal distribution of the concentration of TSP. Because of limited data, the averages of only two seasons- winter and pre-monsoon were presented in the figure 237. Of the two seasons, the concentration of the winter season (37.7 µg m^{-3}) was found slightly more than pre-monsoon (36.9 µg m^{-3}).

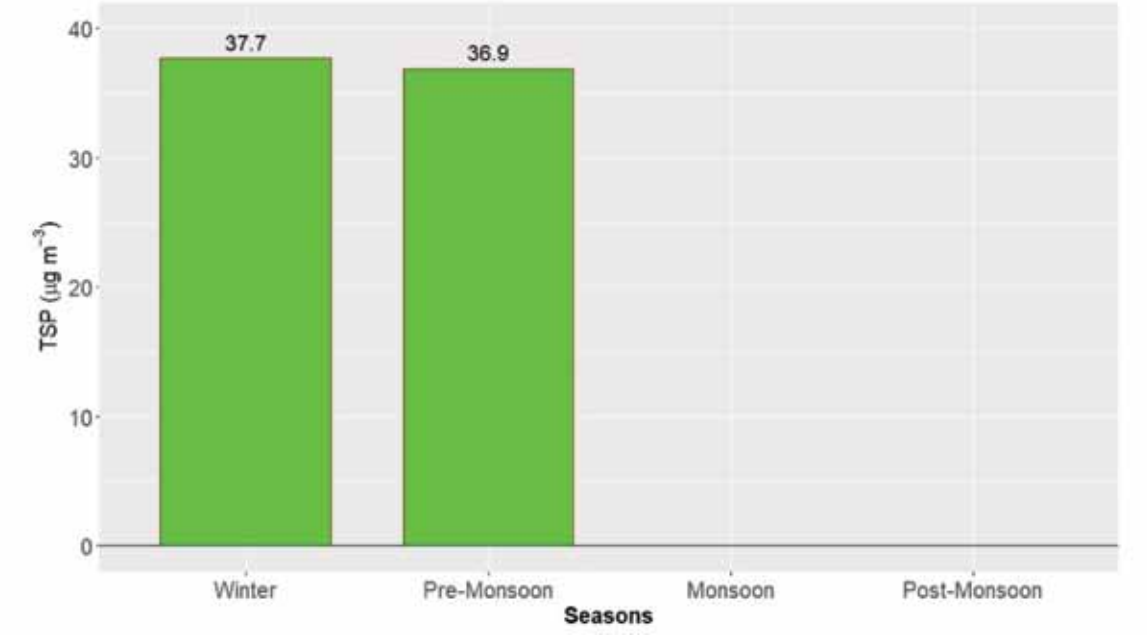

Figure 237: Seasonal average of TSP for Surkhet Station

Compliance status:

Out of the total 130 days of measurement, none exceeded the NAAQS.

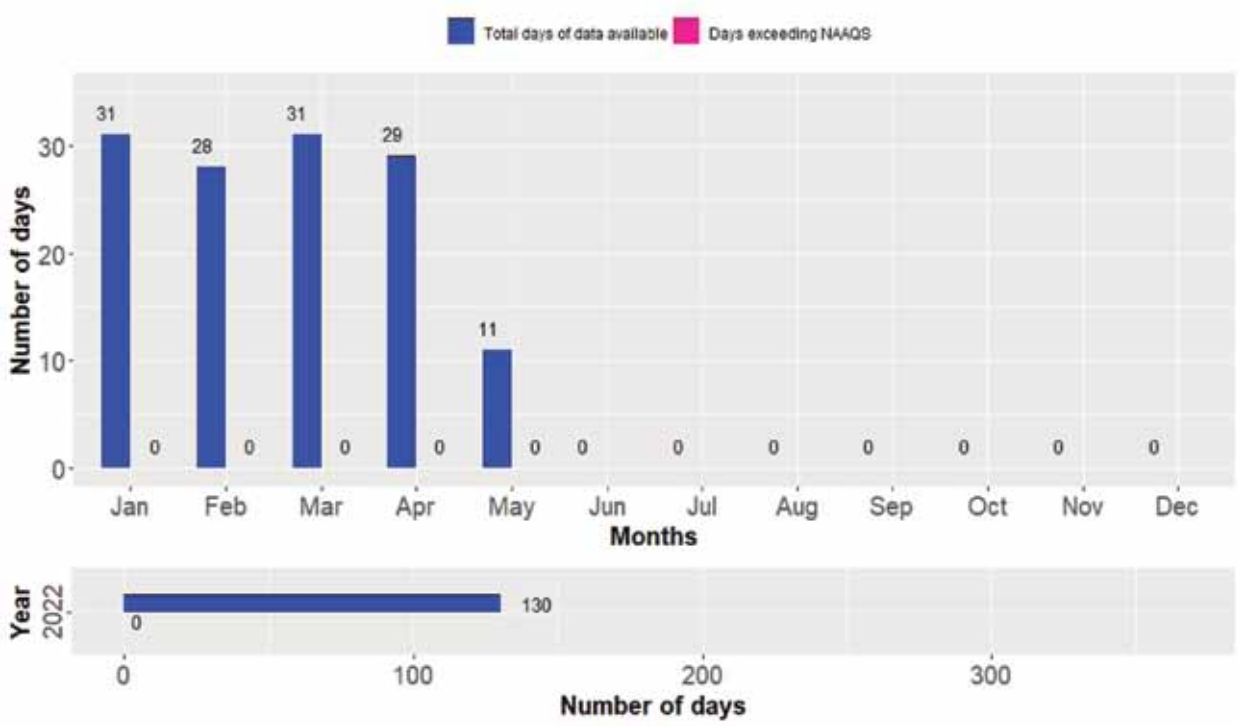

Figure 238: Compliance status of TSP for Surkhet Station

CHAPTER 3: CONCLUSION

This report analyzes particulate matter data from Grimm EDM collected from 11 air quality monitoring sites from 1st January to 31st December 2022 operated by Department of Environment. Out of seven Provinces, those 11 monitoring stations represent four Provinces of Nepal- Koshi Province, Bagmati Province, Lumbini Province and Karnali Province.

The condition of air quality varied both temporally and spatially. In most of the stations particulate pollution was found high during winter, pre-monsoon and post-monsoon. However, in Rara station it is high during pre-monsoon and low during the rest of the seasons. The daily fluctuation of $PM_{2.5}$ and PM_{10} was highest in the morning (5:00-10:00) and evening (17:00-23:00) and lowest throughout the day at the majority of the stations. TSP, however, exhibits distinct patterns from $PM_{2.5}$ and PM_{10} trends, the reason for which might be a difference in their sources.

Looking at the compliance status, the concentration of $PM_{2.5}$ was found least complied and that of TSP was found to have complied the most with NAAQS. Even though the concentration of PM_{10} and TSP in Kathmandu Valley has improved over 2016, the condition of $PM_{2.5}$ remains the same. The major sources of $PM_{2.5}$ include vehicles, industries, biomass burning, forest fires, etc.

Not only in major cities like Kathmandu but in small cities like Dhankuta, the concentration of $PM_{2.5}$ was found very high. Local sources of $PM_{2.5}$ could not justify the level of $PM_{2.5}$ concentration in cities like Dhankuta, Nepalgunj and Bharatpur, which indicate transboundary movement of pollutants. Even in the AQMS situated at 2990 masl, particulate pollution was found high during March and April. This might be due to local and regional forest fires in the year 2021.

$PM_{2.5}$ represents small dust particles that can easily transport long distances, reach our lungs and even enter our bloodstream. Hence compliance status of $PM_{2.5}$ is urging urgent intervention.

Published by:
Government of Nepal
Department of Environment
Babarmahal, Kathmandu
Phone: 01-5320837
Email: info@doenv.gov.np
Website: www.doenv.gov.np