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Chennai – 600 036



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दूरभाष : ००९१-४४-२२५७ ०६९४ / ००९१-४४-२२५७ ८००१  
फैक्स : ००९१-४४-२२५७ ८००३ / ००९१-४४-२२५७ ०५०९

प्रो. भास्कर राममूर्ति  
Prof. Bhaskar Ramamurthi  
निदेशक  
Director

DIR/2020

February 3, 2020

To  
The Member Secretary  
Kerala State Pollution Control Board  
Pattom PO  
THRIUVANANTHAPURAM – 695004

Sub: OA No.259/2017 filed before the Hon'ble NGT reg ban of all diesel operated trucks, lorries, autos, taxis etc. from plying for more than 10 years in Kerala – Consitution of Committee – Orders Issued – reg.

Ref: Your letter No. PCB/HO/EE4/NGT/O.A.No.259/2017 (SZ) dt.20/01/2020

Dear Sir,

With reference to your letter, please find attached a copy of the letter addressed to the Registrar, Hon'ble NGT requesting to excuse us, that is self-explanatory.

With warm regards,

Sincerely yours,

(Bhaskar Ramamurthi)

Indian Institute of Technology Madras  
Chennai - 600 036

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प्रो. भास्कर राममूर्ति  
Prof. Bhaskar Ramamurthi  
निदेशक  
Director

DIR/2020  
February 3, 2020

To

The Registrar  
National Green Tribunal  
Southern Zone Bench  
Kalas Mahal, Kamarajar Salai,  
PWD Estate, Chepauk,  
Triplicane,  
CHENNAI - 600005

- Sub: 1. OA No.259/2017 filed before the Hon'ble NGT regarding ban of all diesel operated trucks, Lorries, autos, taxis etc. from plying for more than 10 years in Kerala - Constitution of Committee - Orders Issued - reg.  
2. OA No. 05/2016(SZ) filed before the Hon'ble NGT regarding pollution caused on account of the operation of industries - reg.

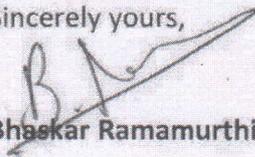
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Dear Sir,

With reference to your orders cited, it is submitted that our faculty members who have expertise in different areas related to NGT cases are already involved in other NGT Committees as shown in Annexure-I. Some experts are involved in multiple Committees already as stated in Annexure I. Given their academic commitments, we are unable to nominate any experts for the new Committees till these Committees complete their assignments. We request to be excused till these Committees complete their work.

With warm regards,

Sincerely yours,

  
Bhaskar Ramamurthi

Encl: as above

**Minutes of the Committee meeting held on 27.02.2020 in Compliance with the Order dated 06.01.2020 of Hon'ble National Green Tribunal in OA No. 259/2017 in the matter of Lawyer's Environmental Awareness Forum (LEAF) Vs. Government of Kerala & Others**

The Hon'ble NGT Southern Zone, Chennai vide order dated 06/01/2020, in the matter of O.A. No. 259/2017 (SZ) directed that a study to be conducted by a committee comprising of Central Pollution Control Board (CPCB), MoEF&CC, Regional Office Chennai, Motor Vehicle Department of Kerala, Kerala State Pollution Control Board (KSPCB), IIT - Chennai and NEERI, Chennai to consider the question of Ambient Air Quality in the State of Kerala, especially in the cities viz., Thiruvananthapuram, Kollam, Kochi, Alappuzha, Kozhikode, Thrissur, Kasaragod and Kannur and to identify the sources of pollution and also to evolve short term and long term steps to reduce pollution index and improve ambient air quality in the State of Kerala and also frame necessary timeline for implementing the directions given in VARDHMAN KAUSHIK case in respect of banning of old vehicles and switching over to alternate clean fuel vehicles, including CNG and electric vehicles and submit a report to the Tribunal within a period of three months. Accordingly, a committee was constituted with representatives of the aforementioned departments with the Kerala State Pollution Control Board as the nodal agency.

The first meeting of the committee was convened on 27.02.2020. The following Joint Committee Members attended the meeting. The list of officials who attended the meeting is enclosed as Annexure I.

1. Dr M.T Karuppiah  
Scientist 'D'  
MoEF & CC  
Regional Office, (South Eastern Zone) - Chennai
  
2. Dr S Prabhu  
Scientist 'C'  
MoEF & CC  
Regional Office (South Zone) - Bengaluru

3. Dr R. Sivacoumar  
Sr. Principal Scientist  
CSIR- NEERI Zonal Centre, Chennai.
4. Smt. Poornima B M  
Scientist 'D'  
Central Pollution Control Board  
Regional Directorate - South (Bengaluru)
5. Dr Deepesh. V  
Scientist 'C'  
Central Pollution Control Board  
Regional Directorate -South (Bengaluru)
6. Sri. Bijumon K  
Regional Transport Officer (Enforcement)  
Motor Vehicle Department, Thiruvananthapuram
7. Smt. Bindhu Radhakrishnan  
Senior Environmental Engineer  
Kerala State Pollution Control Board

As Per the Hon'ble NGT Order, one expert from IIT Chennai was also included in this committee, but expressed their inability, as their experts are currently engaged in the other committees already formed by the Hon'ble NGT. It was also informed that IIT Chennai had already intimated the Hon'ble NGT about their inconvenience in being a part of this committee and copy of the letter is enclosed as **Annexure 2.**

The Committee members had a brief discussion with Prof. K.P Sudheer, Chairman and Smt. Sreekala S, Member Secretary of the Kerala State Pollution Control Board about the NGT Order dated 06.01.2020. The Committee members discussed the availability of manpower, lab facility, and instruments at Kerala State Pollution Control Board.

Smt. Bindhu Radhakrishnan, Senior Environmental Engineer, Kerala State Pollution Control Board cordially welcomed the members of the joint committee to the meeting. Smt. Poornima B M, Scientist 'D', Regional Directorate -

South (Bangalore), Central Pollution Control Board briefed about the OA 137/2016 of NGT Chennai. It was also informed that the NGT has ordered the CPCB to review the Air Pollution Status in Kerala and a report was submitted in August 2016 using the 7-year data (2009-2015) from NAMP stations in Trivandrum, Kollam, Kochi, Thrissur, Kannur, and Calicut. At that time report was submitted based on the annual average concentration of ambient air quality parameters monitored ( only three parameters such as RSPM, SO<sub>2</sub> & NO<sub>2</sub>). After the submission of the report, no further directives were issued by NGT. The original matter of OA 137/2016 was filed in NGT Circuit Bench, Kochi and now this matter has been transferred to NGT Southern Zone, Chennai as OA 259/2017. Further, the objectives of the study by the committee as per the NGT Order in OA No. 259/2017 is outlined as:

- i. To consider the question of Ambient Air Quality in the state of Kerala, especially in the cities viz., Thiruvananthapuram, Kollam, Kochi, Alappuzha, Kozhikode, Thrissur, Kasaragod and Kannur and sources of pollution and also long term and short term steps to be evolved to reduce pollution index and improve ambient air quality in the state of Kerala
- ii. To frame a timeline for implementing the directions given in the VARDHMAN KAUSHIK case in respect of banning of old vehicles and switch over to alternate clean fuel vehicles, including CNG and electric vehicles and submit a report to the Tribunal by e-mail.

As per the directions of NGT, source apportionment study has to be carried out for the eight cities listed above and CPCB along with other organization has already framed a methodology to carry out source apportionment studies. In one of the matters dealt by Hon'ble NGT (OA 681/2018 order dater 08-10-2018) directions have been issued to all the states having non-attainment cities to prepare an action plan with timeline and identification of responsible agencies for the implementation and control of air pollution. It was also directed that the states carry out city-specific source apportionment studies to refine air quality management plans. Further, NGT directed CPCB to prepare a framework to carry out source apportionment studies.

CPCB prepared a framework and communicated to all state boards on January 10, 2020. Therefore, the CPCB representatives informed other committee members to follow the framework methodology for source apportionment studies in this matter.

The Committee members discussed about the strategy to be followed in respect to the Order OA 259/2019 dated 06.01.2020 with specific reference to representative air quality sampling, consideration of meteorological data, Assessment of sources of pollution, identification of the number and the parameters for the study considering the availability of manpower, lab facility, and instrumentation at Kerala State Pollution Control Board.

In one of the matter on deliberations held, committee members expressed their views such as constraints in manpower, facilities, other resources, etc. to carry out such a detailed study. The committee member representing NEERI suggested to carry out this study with past NAMP data and to prepare emission inventory from it and submit an interim report before the Honourable NGT. For the time being, it was suggested to carry out an assessment based on the readily available data with the Motor Vehicle Department of Kerala and Kerala State Pollution Control Board. An interim report shall be submitted before April 5, 2020. Meanwhile, to carry out the source apportionment studies, the site-specific data proposed is to be collected at the eight cities of Kerala-Thiruvananthapuram, Kollam, Kochi, Alappuzha, Kozhikode, Thrissur, Kasaragod and Kannur cited by the NGT as per the order dated 06.01.2020. During the meeting, number of monitoring locations, primary survey of emission sources, no. of parameters to be monitored & analyzed were discussed and finalized as per the CPCB methodology.

The Committee also suggested that Kerala State Pollution Control Board shall prepare a brief report on the availability of manpower, and laboratory facility with respect to the quantum of work involved in source apportionment studies.

The final report shall basically cover site-specific data from the eight cities with respect to Emission Inventorization (Industrial, Transport, Residential & Commercial Sector), Meteorological data, Air quality monitoring based on National Air Quality Monitoring Programme approach inclusive of the 12 parameters. In addition, further monitoring sites shall be identified considering site-specific sources within the cities. The committee also felt the need for, assessing the stock of resources available for carrying out the final study within the timeline and suggested the following.

- Identification of one Co-ordinator each for the eight cities to carry out the primary data collection exercise simultaneously (Emission Inventorization, Meteorological data collection, and Air Quality monitoring) in all the eight cities
- Identification of additional instruments, infrastructure, manpower requirement for the preparation of the final report as per the timeline and methodology to be finalized by the committee members

The Committee members opined that the directives issued in the Vardhaman Kaushik case and its applicability for the State of Kerala needs to be studied and the directives which could be implemented in this state should be identified. Further, the availability of the emission and fuel efficiency of public transport was discussed. Sri. Bijumon K, Regional Transport Officer (RTO), Enforcement, the representative of the motor vehicle department informed that such a database is maintained by Kerala State Road Transport Corporation. It was also brought to attention that such data would be available with the National Transportation Planning and Research Centre (NATPAC) and the Police Department.

Further, the discussion shifted to the methodology of data collection. Dr R. Sivacoumar opined that by collecting the data on the total registered vehicles in each of these cities and the distance covered by these vehicles would give a clear understanding of the transport scenario in the State. GIS map indicating land use

patterns, Industries, Residential area, etc and that the data collected shall be expressed as that for the specific area and not for the entire city.

The tentative plan for carrying out Source Apportionment studies shall be finalized by the committee in the next sitting based on the inputs, arrangements for facilities by Kerala State Pollution Control Board

### **Emission Data proposed to be collected for the interim report**

<b>SL No</b>	<b>Sources</b>	<b>Data sets</b>	<b>Agency</b>	<b>Time Frame</b>
	Automobiles	<ul style="list-style-type: none"> <li>• 10- Year data on</li> <li>• Total vehicle Count</li> <li>• Pollution Under Control</li> <li>• Fuel typed</li> <li>• Engine Capacity</li> <li>• LMV/Heavy vehicles</li> </ul>	<ul style="list-style-type: none"> <li>• Motor Vehicle Department</li> <li>• National Transportation Planning and Research Centre (NATPAC)</li> </ul>	Within a week
	Commercial Areas	DG Set	Electrical Inspectorate	
	Residential Areas	Roadside eateries	Local Self Government Department	
	Industrial Data	<ul style="list-style-type: none"> <li>• Monitoring data from PCB(2016 to 2019)</li> <li>• Details of Industries</li> </ul>	Kerala State Pollution Control Board	

The next meeting of the committee is proposed to be conducted in the 3<sup>rd</sup> week of March.

**Minutes of the second meeting of the Committee held on 08.09.2020 in accordance with the direction issued by the Hon'ble National Green Tribunal on 06.01.2020 in O.A. No. 259/2017**

In the first meeting of the committee convened on 27.02.2020, it was decided to schedule the next meeting in the 3<sup>rd</sup> week of March. But unfortunately, the meeting couldn't be carried out due to the current scenario of the COVID -19 pandemic. Subsequent to the national lockdown, a triple lockdown was declared on 06.07.2020 in Thiruvananthapuram, where the Head Office is located and was lifted on 14.08.2020. The office started functioning at least with 50% attendance with effect from 14.08.2020. So, the second meeting of the Committee could be held only on 08.09.2020 via google meet.

The following Committee Members were present.

1. Dr. M.T Karuppiah,  
Scientist 'E', Regional Office (South Zone)  
MoEF& CC, Regional Office, Chennai
2. Dr. S Prabhu,  
Scientist 'C', Regional Office (South Zone)  
MoEF& CC, Regional Office, Bangalore
3. Smt. Poornima B  
Scientist 'D', Regional Directorate -South (Bengaluru)  
Central Pollution Control Board
4. Dr. Deepesh.V,  
Scientist 'C', Regional Directorate -South (Bengaluru)  
Central Pollution Control Board
5. Dr. R. Sivacoumar, Sr. Principal Scientist, CSIR- NEERI Zonal Centre,  
CSIR Complex, TTTI, Chennai.
6. Sri. Bijumon K,  
Regional Transport Officer, Enforcement, Thiruvananthapuram
7. Smt. Bindhu Radhakrishnan,  
Senior Environmental Engineer

The Meeting commenced at 11:00 am with all the aforementioned members present. Smt. Bindhu Radhakrishnan, Senior Environmental Engineer, Kerala State Pollution Control Board welcomed all the members to the meeting and briefed the agenda of the meeting. Soon after starting, Sri. Bijumon K, Regional Transport Officer, Enforcement, Thiruvananthapuram left the meeting informing that he was engaged in his departmental meeting in which he is the nodal officer and Smt. Poornima M.B also left, citing that she has been relieved from the Committee by Central Pollution Control Board in the event of her transfer to Regional Directorate, Chennai.

Clarification was sought by the Committee members regarding the interim report filed by the KSPCB, which was mentioned by the Hon'ble NGT in the order dated 12.06.2020. It was brought to the notice of the Committee members that the Original Application No. 76 of 2017(SZ), Original Application No.26 of 2017 was heard along with Original Application no. 259 of 2017, and the report mentioned in the order dated 12.06.2020 pertains to the report filed in Original Application No. 76 of 2017.

It was further brought to the attention of the committee members that Original application No. 76 of 2017 was taken up Suo-Motu by the Tribunal based on a News item published in Malayala Manorama newspaper dated 25.03.2017, under the caption 'BLACK CITY'. The Suo-Moto case was in respect of black fumes spews in the air in the city of Cochin alone which causes air pollution.

Original Application No. 260 of 2017, is also a case filed by the same complainant Lawyers Environmental Awareness Forum (LEAF) in respect of alleged air pollution caused especially due to plying of large trucks, buses, Auto rickshaws, Taxi, etc., emitting smoke causing air pollution. As, all these cases are related to the issue regarding the air pollution caused on account of the various sources, particularly vehicular emissions, the cases were taken up together resulting single order dated 12.06.2020.

Majority of the Committee members raised the opinion that, to submit a report based on the NAMP and CAAQM data already available with the Board based on regular air quality monitoring and not to commit a source apportionment study. Committee member representing CPCB insisted on a proper source apportionment and emission inventory studies as per the conceptual guidelines prepared by CPCB. It is also informed that these guidelines are being followed for conducting source apportionment & emission inventory studies and are already circulated to all State Boards and Pollution Control Committees in the matter of non-attainment cities and for studies proposed under National Clean Air Programme (NCAP). The other committee members pointed out that, that the source apportionment and emission inventory studies as per the conceptual guidelines prepared by CPCB would require minimum 14 months for complete the study and by mathematical modelling, arriving conclusion is limited. Further, to carry-out such study it may cost around Rs. 3 to 4 Crores for all 8 cities under consideration. The Committee Members have also admitted that for NGT Court cases, modelling studies are not being preferred as it has constraints to defend. Questions on the legal validity of source apportionment based on modelling studies, infrastructure, and fund requirements were raised by other members, and in reply, CPCB member suggested that the methodology has been adopted in other cities to frame action plans and not for defending any legal contentions. It was suggested, full-fledged studies can be implemented as a project under the NGT EC (Environment Compensation) fund. CPCB member raised apprehensions on the likely outcome of the report based on the available ambient air quality data before and during the lockdown. It was also pointed out that very few NAMP/ CAAQM stations are available in the 8 cities/ towns and not all ambient air quality parameters are being monitored. CPCB member also pointed out that the Hon'ble NGT directed source apportionment/ emission inventory studies as a precautionary measure to prevent Kerala from facing severe air pollution issues in future. In this context, CPCB member opined that, submitting a report based on the available NAMP/ CAAQM data and trying to justify that there is no issue of air pollution are completely out of context and not in line with the NGT directions.

In this regard, other members agreed to extend their technical expertise in case if KSPCB is willing to carry out the source apportionment and emission inventory studies as suggested by the member from CPCB as per the CPCB guidelines subject to the leave of the Hon'ble NGT for such extended period and availability of funds. Further, as the core issue of the case under consideration is to assess the vehicular emission and phasing out the old diesel vehicles in the State of Kerala and also the remedial measures for converting the same with green and clean fuel technology. It was requested the nodal agency (KSPCB) to get the details from the State Government regarding the policy decision taken, if any, in this regard so as to appropriately incorporate in the report.

The Members of the Committee admitted that for NGT Court cases, modelling studies are not being preferred as it has constraints to defend, after a detailed discussion on the methodology, based on the majority opinion, the committee decided the following:

- A report shall be filed before the Hon'ble NGT based on the ambient air quality data (NAMP & CAAQM) available with the KSPCB.
- The report shall be based on the NAMP /CAAQMS data collected immediately before, after, and during the lockdown.
- The QA/QC aspect of the data collected shall be made into consideration
- Draft report will be circulated to all the committee members for approval.

The meeting ended at 01:00 PM with the vote of thanks by Smt. Bindhu Radhakrishnan, Senior Environmental Engineer, KSPCB.

## Members

## Signature

Dr. M.T Karuppiah,  
Scientist 'E',  
MoEF& CC, Regional Office, Chennai



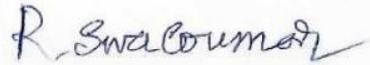
Dr. S Prabhu,  
Scientist 'C',  
MoEF& CC, Regional Office,  
Bangalore



Dr. V Deepesh  
Scientist 'C', CPCB,  
Regional Directorate, Bengaluru



Dr. R. Sivacoumar  
Sr. Principal Scientist,  
CSIR- NEERI Zonal Centre,  
CSIR Complex, TTTI, Chennai.



Sri. Bijumon K  
Regional Transport Officer,  
Enforcement, Thiruvananthapuram

**Bijumon K**

Digitally signed by Bijumon K  
Date: 2020.10.06 13:10:53 +05'30'

Smt. Bindhu Radhakrishnan,  
Senior Environmental Engineer  
Kerala State Pollution Control Board

**BINDHU RADHAKRISHNAN** Digitally signed by BINDHU RADHAKRISHNAN  
Date: 2020.10.06 12:49:22 +05'30'

**Status Report On Ambient Air Quality In The State Of Kerala In  
Thiruvananthapuram, Kollam, Alappuzha, Kochi, Thrissur, Calicut,  
Kannur &Kasaragod Districts.**

**In the matter of Original Application No. 259/2017 Before the  
Honorable National Green Tribunal**



**Kerala State Pollution Control Board  
Head Office, Thiruvananthapuram  
November, 2020**



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# 1 Introduction

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## 1.1 Background of the study

Lawyers Environmental Awareness Forum (LEAF), an organization constituted with members of the Lawyer community, filed an Original Application No. 259/2017 (SZ) before Hon'ble NGT Southern Zone, Chennai. The issue raised by the petitioner, in this case, is regarding the anticipated air pollution that would likely to be caused in the State of Kerala due to vehicular emission and other air emissions. Based on the grievances made by the petitioner, the Hon'ble NGT vide order dated January 6, 2020 directed to Constitute a Committee consisting of:

- Central Pollution Control Board (CPCB)
- MOEF&CC, Regional Office, Chennai
- Motor Vehicle Department, Kerala
- Kerala State Pollution Control Board (KSPCB)
- IIT - Chennai
- NEERI, Chennai

For the consideration of the following matter:

- The question of ambient air quality in the State of Kerala, especially in the cities viz., Thiruvananthapuram, Kollam, Kochi, Alappuzha, Kozhikode, Thrissur, Calicut, Kasargod, and Kannur and sources of pollution and also long term and short term steps to be evolved to reduce pollution index and improve ambient air quality in the State of Kerala. (**Note: Kozhikkode and Calicut are the same**).
- Frame the necessary timeline for implementing the directions given in the VARDHMAN KAUSHIK case in respect of banning of old vehicles and switch over to alternate clean fuel vehicles, including CNG and electric vehicles.

In compliance with the above directives, KSPCB constituted a committee consisting of the following officials:

Dr. M.T Karuppiah  
Scientist 'D', Regional Office (South Zone)  
MoEF& CC Regional Office, Chennai

Dr. S Prabhu  
Scientist 'C'  
Regional Office (South Zone)  
MoEF& CC Regional Office, Bengaluru

Smt. Poornima BM  
Scientist 'D'  
Regional Directorate - South (Bengaluru)  
Central Pollution Control Board

Dr. Deepesh. V  
Scientist 'C'  
Regional Directorate -South (Bengaluru)  
Central Pollution Control Board

Dr. R. Sivacoumar,  
Sr. Principal Scientist  
CSIR- NEERI Zonal Centre  
CSIR Complex, TTTI, Chennai.

Sri. Bijumon K  
Regional Transport Officer  
Enforcement Division, Thiruvananthapuram

Smt. Bindhu Radhakrishnan  
Senior Environmental Engineer  
Kerala State Pollution Control Board  
Thiruvananthapuram

As per the NGT order, a member from IIT – Chennai was to be nominated, however, it was informed that their experts are currently engaged in the other committees formed by NGT and they are unable to nominate the experts and requested to be excused till the experts completes the work in connection with other committees constituted. The communications in this regard are enclosed.

The original Application No. 76 of 2017(SZ), original Application No.26 of 2017 was heard along with Original Application no. 259 of 2017. the Hon. NGT has observed that since the consolidated report has been called for in original application no. 259 of 2017 and 260 of 2017, it is not possible to dispose of the case effectively.

Original application No. 76 of 2017 was taken up Suo-Motu by this Tribunal based on a News item published in Malayala Manorama newspaper dated, 25.03.2017 under the caption ‘BLACK CITY’. The Suo-Moto case was in respect of black fumes spews in the air in the city of Cochin alone which causes air pollution. The main issue, in this case, is regarding Pollution caused due to the uncontrolled use of Vehicles especially large Trucks, Bus, Auto rickshaw, taxi, etc., emitting the smoke. According to the petitioner as per the report on health study made by some organizations about 6,20,000 premature deaths occurred in India due to air pollution-related diseases. Air Pollution is one of the top killers in the world, and the sixth most dangerous killer in South Asia. Outdoor air pollution has become the fifth largest killer in India.

Original Application No. 260 of 2017, is also a case filed by Lawyers Environmental Awareness Forum (LEAF) in respect of air pollution caused especially due to plying of large trucks, bus, Auto rickshaws, Taxi, etc., emitting smoke causing air pollution. So, all these cases are relating to the issue regarding the air pollution caused on account of the various reasons, particularly vehicular emissions, and how to control the same in the State of Kerala.

In the order dated 12.6.2020 in this matter, the court has directed the committee constituted to complete the study and submit the consolidated report considering all the allegations and directions given in all these cases and submit an action plan for remedying the situation including phasing out of the old diesel vehicles in the State and also the remedial measures for converting the same with green and clean fuel technology. The committee, as well as the State Government,

are directed to file the report as well as the status report to this Tribunal on or before 07.10.2020

## 1.2 General Description of Kerala

Kerala is situated in the southwestern end of the Indian subcontinent. Kerala has a long history of art and cultural heritage and foreign trade with other countries. The state with the highest literacy rate in India is noted for its achievements in education, health, gender equality, social justice, law, and order. In addition to these, the state has the lowest infant mortality rate in the country.

Kerala lies between the Arabian Sea in the West and the Western Ghats (Sahyadris) in the East with an area of 38863 sq km. It is one of the five states in the linguistic-cultural area known as South India. The neighbouring states of Kerala are Tamil Nadu and Karnataka. Mayyazhi (Mahe / Mahe) is a part of Pondicherry (Puducherry) and lies within Kerala. Though the Lakshadweep in the Arabian Sea is part of the Union Territories, it has a close alliance with the linguistic and cultural heritage of Kerala.

Before the independence of India, Kerala was one of the princely states in India. Later on 1st July 1949, the princely states of Travancore and Cochin united to form the Travancore-Cochin State. Later, When the Malabar region (formerly part of Madras state) was added to the Travancore-Cochin State. The state was formed on 1 November 1956.

Table 1.1: General Statistics(Economic review, 2018)

1	Geographical Area	38863 Sq. Km
Administrative setup		
2	Revenue division	21
3	Districts	14
4	Taluks	75
5	Villages	1644
6	Towns	520
7	District Panchayath	14
8	Block Panchayath	152
9	Grama Panchayath	941
10	Municipalities	87
11	Co-Operatives	6
12	Population	33406000
13	Density of population	860 Sq. Km
14	Forest Area <sup>1</sup>	1131000 Ha.

<sup>1</sup> Open forest included

15	Factories	23335
16	Total Road length <sup>2</sup>	229349

### 1.2.1 Topography

The tropical climate and the rich monsoons offer beautiful landscapes, the presence of abundant water bodies, long beaches and more than 40 rivers add to the charm. Popular by the name "God's Own Country", the location of Kerala is geographically located between 74 0 7 '47 "and 770 37" 12 "north latitudes and 80 17 '30' and 12 0 47 east longitudes.

Geographically Kerala is divided in the east-west direction into three parts- Highland, Mid plains, and coastal areas. The area in and around the Western Ghats or Sahyadri are mostly hilly and thick evergreen rainforests. The major rivers of Kerala originate from these highlands. Silent Valley in Palakkad district is one of the biodiversity hotspots in the world. The highest peak in Kerala is Anamudi (2695 m). On the West, the Coastal belt lies parallel to the Western Ghats. In between, the highland and coastal plain lies the mid-lands. It is always a combination of hills and valleys. The 41 rivers flowing to the Arabian Sea and the lakes in the west, the three east flowing rivers, the lakes and backwaters make Kerala a water-rich landmass.

### 1.2.2 Climate

Kerala experiences a tropical climate, as it is normally located at a distance of 80 from the equator. There are three types of seasons in Kerala - June-September South-West monsoon (Edavappathy), October - December North-East monsoon (Thula Varsham), and summer season (March-May). The winter season in Kerala during December and February is not a marked one, compared to other parts of India. The climate of Kerala is characterized by mild winds and rapid monsoon showers.

### 1.2.3 Forest Cover:

The forest cover in the state is 20,321sq Km which is 52.30% of the state's geographical area.in terms of forest canopy density classes, the state has 1,663 sq

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<sup>2</sup> Excludes LSGD non pucca roads

Km under very dense forest, 9,407 Sq Km under moderately dense forest, and 9,251 sq Km under open forest.

(STATE OF FOREST REPORT, 2017, p. 218)

#### 1.2.4 Population Profile of the State:

As per the Census of India 2011, the population of Kerala was 3,34,06,061 or 2.76 per cent of India's population. Out of the State's total population, 52 per cent are women and 47.9 per cent are men.

The decadal growth rate of Kerala's population was 4.9 per cent, the lowest among the Indian States. Among the Districts of the State, Malappuram has the highest growth rate (13.4 per cent), and Pathanamthitta has the lowest growth rate (-3.0 per cent). Idukki also has seen a decline in population negative growth rate (-1.8 per cent). The growth rate of population is lower in six southern Districts (Idukki, Kottayam, Alappuzha, Kollam, Pathanamthitta, and Thiruvananthapuram) than in other Districts of the State (Economic Review, 2019, p. 13)

Table 1.2: Vehicle statistics in the state of Kerala

Districts	Area (Sq.Km)	Forest Cover (Sq. Km)	Population in Lakhs (2011 census)	Population Density	Length of roads	No. of vehicles
TVM	2192	1327	33.01	1508	2557.44	1664565
KLM	2491	1356	26.35	1061	2202.869	10449149
PTA	2637	1830	11.97	452	2031.372	553585
ALPA	1414	68	21.28	504	1472.334	912916
KTM	2208	967	19.75	895	3456.214	814649
IDK	4358	3139	11.09	255	2867.366	275002
EKM	3068	1273	32.82	1072	3085.281	194541
TSR	3032	1152	31.21	1031	2064.216	1361561

PLK	4480	1826	28.1	627	2184.693	904345
MLP	3550	1811	41.13	1157	2680.152	1210721
KKD	2344	1484	30.86	1316	2454.647	1227317
WYD	2131	1580	8.17	384	1029.314	206476
KNR	2966	1561	25.23	852	2265.242	826010
KSD	1992	947	13.07	657	1460.622	383237
TOTAL	38863	20321	334.04	860	31812.106	13334984

### 1.2.5 Source activities

The different sources of air pollution in the state are classified under the following categories Transport, Industries, Residential, and Others

#### 1.2.5.1 Transport

The major transport infrastructure of the State consists of 2.73 lakh km of road, 1588 km of railways, 1687 km of inland waterways and 18 ports with 585 km coastal route and 4 airports. Roads play a prominent role in public transportation vis-a-vis other modes of transportation owing to the geographic peculiarities of Kerala with a comparatively lesser rural-urban divide and limited geographical area of 38,863 Sq. km. Kerala has a total fleet of 25,186 buses; of which 19,496 are private buses (77.4 per cent) and 5690 buses belonging to Kerala State Road Transport Corporation (KSRTC) comprising 22.6 per cent of the total fleet. Private buses dominate transport in all districts of Kerala except Thiruvananthapuram. The State has a rail network of 1,257 km route length with a total track length of 1,588 km, operating under the control of Palakkad and Thiruvananthapuram Railway Divisions. In Kerala, there are many water bodies like rivers, lakes, estuaries, backwaters, etc. providing adequate scope for the Inland Water Transport (IWT) system having a length of 1,895 km to connect the rivers from one to another.

Transportation by IWT is considered as the most efficient economic and environment-friendly means of transportation. Transportation by coastal shipping is the mode for most bulk commodities and long hauling traffic. Kerala has the advantage of a 585 km coastline through which bulk cargos can be transported using multi-modal transshipment points along the coastline. Kerala has one major port at Kochi, 17 minor ports, and an upcoming international shipping terminal at Vizhinjam. Out of the 17 minor ports in Kerala, four are considered intermediate ports viz., Vizhinjam, Beypore, Azhikkal, and Kollam based on berthing, cargo handling, and storage facilities available in them. Kerala has four international airports viz., Thiruvananthapuram, Kochi, Kozhikode, and Kannur. All civilian airports functioning in the State are international airports, a feature unique to Kerala. Kerala joined Tamil Nadu as the State with the maximum number of international airports on completion of Kannur international airport. Realizing the advantages of the mass transport system in meeting the intracity commuter needs of major cities, GoK has embarked on Metro Rail Project for Kochi. With the commissioning of the Mass Rapid Transit System (MRTS), major urban corridors are expected to be decongested in these cities. (Economic Review, 2019, p. 412)

**Table 1.3: Registered vehicular Growth in the state of Kerala (Economic Review, 2019)**

Year	1970-71	1980-81	1990-91	2000-01	2010-11	2011-12	2016-17	2017-18	2018-19
Railway Route (Km)	892	921	988	1148	1257	1257	1257	1257	1257
Total Road Length (Km)	18037	94145	128403	125835	151652	244373	218942	229349	31812
Motor Vehicles('000s)	86234	195000	648000	2111885	6072019	8048673	11030037	12042691	13334984

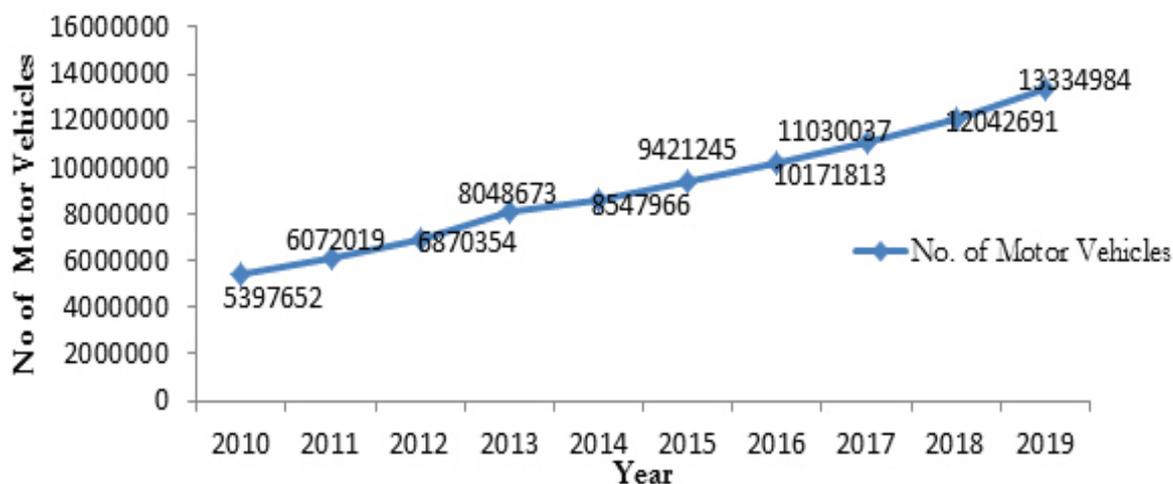


Figure 1.1: Vehicular Growth in the state of Kerala

### 1.2.5.2 Industries

The manufacturing sector in Kerala is relatively small in size. The manufacturing sector accounted for a share of only 12.8 per cent of Kerala's GSVA (at constant 2011-12 prices) and 11.8 per cent of total employment in the State in 2017-18. In comparison, the manufacturing sector accounted for 18.0 per cent of India's and 29.3 per cent of China's GDP in 2017.

Notably, a new set of modern industries are growing in size in Kerala. The top industries in Kerala concerning value-added are chemicals, refined petroleum products, rubber and plastic products, electronic products, and pharmaceuticals and medicinal botanical products. Bharat Petroleum Corporation Limited's (BPCL)-Kochi Refinery has been undergoing a major expansion of its refining and petrochemical production capabilities and this holds great promise for the chemical and allied industries in Kerala. Between 2011-12 and 2016-17, value-added by refined petroleum products increased by eight times in Kerala. Growth of value added by the manufacturing sector as a whole as well several industries including chemicals, garments, pharmaceuticals, furniture, jewellery, and medical instruments were much faster in Kerala compared to the corresponding national averages.

### 1.2.5.3 Domestic Sources

The residential population relies mainly on LPG for cooking. The lower-income classes use wood and kerosene for cooking. Most shopping malls, big

hospitals have their diesel generators to overcome any disruption in power supply from the grid.

#### 1.2.5.4 Others

In the miscellaneous category, Crematoria and roadside garbage burning are included as primary contributors to air pollution. In addition to these bakeries, restaurants, roadside tea shops, etc also contribute to air pollution.

### 1.3 Objectives and scope of the current study

As per the NGT order dated 06.01.2020 in the matter of O.A No. 259/2017, the objectives of the study are:

- To study the Ambient Air Quality in the State of Kerala, especially in the cities viz., Thiruvananthapuram, Kollam, Kochi, Alappuzha, Kozhikode, Thrissur, Calicut, Kasarkode, and Kannur and sources of pollution and also long term and short-term steps to be evolved to reduce pollution index and improve ambient air quality in the State of Kerala
- Frame the necessary timeline for implementing the directions given in the VARDHMAN KAUSHIK case in respect of banning of old vehicles and switch over to alternate clean fuel vehicles, including CNG and electric vehicles.

Pneumonia of unknown cause detected in Wuhan; China was first reported to the WHO Country Office in China on 31<sup>st</sup> December 2019. The outbreak was declared a Public Health Emergency of International Concern on 30<sup>th</sup> January 2020. On 11<sup>th</sup> February 2020, WHO announced a name for the new coronavirus disease: COVID-19. To tide with the alarming situation, some of the Governments of the world nations including India have taken a drastic measure of imposing the ‘complete lockdown’ in their respective countries.

In India, a complete lockdown as Janata curfew was imposed on 22.3.2020 and further Lockdown measures came into force from March 24<sup>th</sup>, for three weeks which was extended further.

#### 1.3.1 Pre -Lockdown Phase ( 1<sup>st</sup> March -23<sup>rd</sup> March)

This period is taken for assessing the situation when there is the least restriction on vehicular activity nor industrial activity.

### 1.3.2 Lockdown Phase 1 (24<sup>th</sup> March – 14<sup>th</sup> April)

On 24<sup>th</sup> March, the first day of the lockdown, nearly all services and factories were suspended. ([https://en.wikipedia.org/wiki/COVID-19\\_pandemic\\_lockdown\\_in\\_India\\_-\\_cite\\_note-38](https://en.wikipedia.org/wiki/COVID-19_pandemic_lockdown_in_India_-_cite_note-38)) People were hurrying to stock essentials in some parts.

Before the announcement of the nationwide lockdown, on 22<sup>nd</sup> March, the government had announced that the Indian Railways would suspend passenger operations through 31<sup>st</sup> March. The national rail network has maintained its freight operations during the lockdown, to transport essential goods. On 29<sup>th</sup> March, the Indian Railways announced that it would start services for special parcel trains to transport essential goods.

### 1.3.3 Lockdown Phase 2 (15<sup>th</sup> April – 3<sup>rd</sup> May)

On 14<sup>th</sup> April, The Hon Prime minister extended the nationwide lockdown till 3 May, with a conditional relaxation promised after 20<sup>th</sup> April for the regions where the spread had been contained by then.

The government also announced certain relaxations from 20<sup>th</sup> April, allowing agricultural businesses, including dairy, aquaculture, and plantations, as well as shops selling farming supplies, to open. Public works programs were also allowed to reopen with instructions to maintain social distancing. Cargo vehicles, including trucks, trains, and planes, would run. Banks and government centres distributing benefits would open as well.

On 25<sup>th</sup> April, small retail shops were allowed to open with half the staff. Again social distancing norms were to be followed.

### 1.3.4 Lockdown Phase 3 (4<sup>th</sup> – 17<sup>th</sup> May)

On 1<sup>st</sup> May, the Ministry of Home Affairs (MHA) and the Government of India (GoI) further extended the lockdown period to two weeks beyond 4<sup>th</sup> May, with some relaxations. The country has been split into 3 zones: red zones (130 districts), orange zones (284 districts) and green zones (319 districts). Red zones are those with high coronavirus cases and a high doubling rate, orange zones are those with comparatively fewer cases than red zone and green zones are those without any cases in the past 21 days. Normal movement is permitted in green zones with buses limited to 50 per cent capacity. Orange zones would allow only

private and hired vehicles but no public transportation. The red zones would remain under lockdown. The zone classification would be revised once a week.

### 1.3.5 Phase 4 (18<sup>th</sup> –31<sup>st</sup> May)

On 17<sup>th</sup> May, the National Disaster Management Authority (NDMA) and the Ministry of Home Affairs (MHA) extended the lockdown for a period for two weeks beyond 18<sup>th</sup> May, with additional relaxations.

The COVID-19 Induced lockdown has provided a rare opportunity to study air pollution utilizing the data from the existing air quality monitoring network in the state, as the air pollution load from various sources was minimal since industries, establishments were closed and transportation was limited to essential purposes only.

### 1.3.6 Post-Lockdown Phase ( 1<sup>st</sup> June – 30<sup>th</sup> June )

This period is taken for assessing the situation when the restrictions rolled back and vehicular activity nor industrial activity.

### 1.3.7 Effect of lockdown on vehicle utilization

The Kerala State Planning Board published a report ‘**QUICK ASSESSMENT OF THE IMPACT OF THE COVID-19 PANDEMIC AND LOCKDOWN ON KERALA’S ECONOMY**’. The assessment is based on secondary data, the inputs, and the feedback obtained from the questionnaire circulated among the various agencies and associations related to this sector. A part of the data regarding vehicle utilization is tabulated as Table 1.2

Figure 1.2: Vehicle Utilisation during the lockdown

Type of Transport	Type of vehicle	No. of valid registered vehicles	Lockdown Scenario Utilisation
Passenger Transport	Autorickshaws	6,71,906	0.065
	Taxis	1,37,181	0.07
	Stage Carriers	22,500	0.01

	Contract Carriers	77,133	0.005
<b>Goods Transport</b>	Three-wheeler and tempo	4,77,027	0.175
	Four-Wheeler trucks/lorries	4,77,027	0.175
	Trailers	14,296	0.05
	Tillers	2,813	0

(QUICK ASSESSMENT OF THE IMPACT OF THE COVID-19 PANDEMIC AND LOCKDOWN ON KERALA'S ECONOMY, 2020, p. 64)

From the above figures it can be assessed that during the lockdown period, the priority of transport organizations has been to maintain a core transport system operates to ensure the movement of freight and essential workers.

In the normal scenario, KSRTC operates 4,500 buses daily covering 16.5 lakh km. During the lockdown scenario, all the fleets are idle. Only about 50 buses operated for emergency purposes (QUICK ASSESSMENT OF THE IMPACT OF THE COVID-19 PANDEMIC AND LOCKDOWN ON KERALA'S ECONOMY, p. 65)

From the above facts, it can be established that vehicular traffic during the lockdown was minimal.

## 1.4 The approach used in the study

The air quality monitoring network in the state can be classified as (i) online and (ii) manual. The pollutant parameters, frequency of measurement, and monitoring methodologies for the two networks are different and explained below.

### 1.4.1 Manual Monitoring Stations

In Kerala, air quality is being monitored manually at 28 locations under the National Ambient Air Quality Monitoring Programme (NAMP) and 7 locations under the State Ambient Air Quality Monitoring Programme(SAMP). In most of these manually-operated stations NO<sub>x</sub>, PM<sub>10</sub>, SO<sub>2</sub> are monitored regularly. 24-hour ambient air quality monitoring is conducted with a sampling frequency of two days/week. Sulfur dioxide ( SO<sub>2</sub>) and Nitrogen Oxides ( NO<sub>x</sub>) are monitored at a four-hour interval and Respirable Suspended particulate Matter (RSPM) at

eight-hour interval. The Board had started PM<sub>2.5</sub> Monitoring at 14 stations [ Alappuzha (2), Ernakulam (6), Palakkad (2), Kozhikode (2), Wayanad (1) and Kannur (1) ]recently and action is being taken to establish PM<sub>2.5</sub> monitoring in all the manual monitoring stations. The monitoring of pollutants is carried out for 24 hours (4-hourly sampling for gaseous pollutants and 8-hourly sampling for particulate matter) with a frequency of twice a week, to have a minimum of 104 observations in a year.

#### 1.4.2 Continuous Ambient Air Quality Monitoring Stations (CAAQMS)

These are automated air quality monitoring stations that record continuous hourly, monthly or annually-averaged data. Continuous Ambient Air Quality Monitoring Stations (CAAQMS) has been established at Thiruvananthapuram(2), Kollam(1) and Kozhikode(1), Kochin(3), and Kannur (1).

## 2 Air Quality Status

### 2.1 Introduction

Under the objectives of the current report, the air quality which was routinely monitored by the Kerala State Pollution Control Board as the part of the Ambient Air Quality Monitoring program is analyzed with reference to the COVID -19 pandemic induced lockdowns. This was a rare opportunity to study the baseline emissions and the impact of automobiles on the air quality of the state. The details of the selected monitoring locations, air quality measurement, and analysis are presented below.

### 2.2 Methodology

The details of the air quality monitoring stations in the seven selected cities of Kerala along with their land use pattern are shown in Table 2.1. The monitoring of ambient air quality parameters as specified by CPCB is carried out around the year in the manual monitoring stations. The data collected during the time of lockdown and immediately before and after it is used for analysis.

Table 2.1: Air Quality Stations in the state of Kerala

NO	CITY	SITE	SCHEME	AREA TYPE	LAND USE PATTERN
1	Thiruvananthapuram	Cosmo Politian Hospital	NAMP	Sensitive	Hospital, Residential, Major Road
2		SMV School	NAMP	Sensitive	Commercial establishments, Major Road, Railway hub
3		Filatex - Veli	NAMP	Industrial	Industries, roads, commercial
4		Plamood	NAMP	Residential	Commercial establishments, major roads, residential area
5		Kaaryavattom	CAAQMS	Residential	College, Stadium, major roads, residential area
6		Plammood	CAAQMS	Residential	Commercial, major roads, residential area
7	Kollam	Kadappakada	NAMP	Residential	Minor Roads, Commercial establishment
8		KMML, Chavara	NAMP	Industrial	Red Category industry, Major Road

9		Polayathode	CAAQMS	Residential	Major Roads, Traffic Junction, Commercial Establishments
10	Alappuzha	District Office	NAMP	Residential	Residential Area, Minor Roads
11		WilliamGood Acre	NAMP	Industrial	Industries, major roads, Commercials, traffic
12	Kochi	Eloor -1 Methanam	NAMP	Residential	Residential
13		Eloor -2 TCC	NAMP	Industrial	Industrial Establishments
14		Near South Overbridge	NAMP	Residential, Rural And Others	Commercial Establishment, Industries
15		Vyttila	NAMP	Residential, Rural And Others	Major Roads, Traffic Junction, Commercial Establishments
16		Irumpanam	NAMP	Industrial	Industries
17		Kalammasery	NAMP	Industrial	Major Roads, Traffic Junction, Commercial Establishments
18		MG Road	NAMP	Residential And Others	Commercial Area
19		Vyttila	CAAQMS	Commercial	Major Roads, Traffic Junction, Commercial Establishments
20		Udyogamandal	CAAQMS	Industrial	Industries, Residential, Commercial Establishment
21		Kacheripady	CAAQMS	Commercial	Major Roads, Traffic Junction, Commercial Establishments
22		Thrissur	Punkunnam	NAMP	Residential
23	Peringadoor		NAMP	Industrial	Industrial area
24	Kozhikode	Kozhikkode City	NAMP	Residential, Rural And Others	Hospitals, Major Road, Commercial Establishments
25		Palayam	CAAQMS	Commercial	Commercial Area, Transportation Hub
26		Nallalam	NAMP	Industrial	Industrial area, Diesel Power Plant
27	Kannur	Mangattuparambu	SAMP	Residential, Rural And Others	Residential Area, Commercial Establishments, Educational Hub, Industries
28		Thavakkara	CAAQMS	Commercial	Commercial Establishment, Railway Hub, Transport terminal
29	Kasaragod	Kasaragod	SAMP	Residential, Rural And Others	Residential Area, Commercial Establishments, Major Roads

30		Kanhangad	SAMP	Residential, Rural And Others	Residential Area, Commercial Establishments, Railway station
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## 2.3 Monitoring Parameters

The list of pollutants monitored, instruments used and the frequency of sampling at manual monitoring stations are given in Table 2.2.

Table 2.2: Principle of monitoring of various pollutants

Particulars	Pollutants				
	SPM	RSPM	SO <sub>2</sub>	NO <sub>x</sub>	PM <sub>2.5</sub>
<b>Equipment</b>	High Volume Sampler	Respirable dust sampler	Impingers attached to HVS	Impingers attached to HVS	PM <sub>2.5</sub> Analyzer
<b>Measuring Principle</b>	Aerodynamic sampling followed by Gravimetric measurement	Gravimetric	Colorimetry	Colorimetry	Sampling by Impaction and measurement by Gravimetry
<b>Flow rate</b>	0.8-1.2 m <sup>3</sup> /min	0.8-1.2 m <sup>3</sup> /min	0.5ipm	0.5 pm	1m <sup>3</sup> /hr
<b>Sampling period</b>	8/24 hrly	8/24 hrly	8/24 hrly	8/24 hrly	8/24 hrly
<b>Sampling frequency</b>	One month Continuous ( 3 seasons)	One month continuous ( 3 seasons )	One month continuous ( 3 seasons)	One month Continuous ( 3 seasons)	One month continuous ( 3 seasons )
<b>Analytical Method</b>	Gravimetric	Gravimetric	Improved West & Gaeke	Jacobs & Hochheiser modified	Gravimetric
<b>Absorption wave length ( x max)</b>	-	-	560nm	550nm	-
<b>Minimum reportable value</b>	10	10	3	9	5

CO and CO<sub>2</sub> are gaseous pollutants and have a limited impact on particulate pollution through atmospheric transformation. Therefore, these two may be kept aside from carbon particles.

CO is included in NAAQS and the monitoring methodology is prescribed in the notification. Manual monitoring of CO is not feasible and it has both hourly and 24-hourly standards, hence real-time monitoring of CO is prescribed. The only prescribed and worldwide used method for CO is real-time NDIR technology to fulfill the data requirement in NAAQS.

CO<sub>2</sub> in ambient air is a climate pollutant and always not included in NAAQS. The methodology for CO<sub>2</sub> is also NDIR based instruments. Equipment is available in the form of low-cost sensors, however these fit for indicative and survey 'purpose only, the data quality always remains questionable. CO<sub>2</sub> is not currently being monitored in these cities

The list of pollutants monitored and the principle of measurement of CAAQMS is given in Table 2.3 and Table 2.4.

Table 2.3: Parameters monitored at various CAAQM stations

SI No	Station	Parameters Monitored
1.	Plamood, Thiruvananthapuram	PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , NH <sub>3</sub> , CO, NO <sub>x</sub> , O <sub>3</sub> , Atmospheric Temperature(AT), Relative Humidity (RH), Wind Speed (WS), Wind Density (WD), Solar Radiation, RainFall
2.	MG Road, Ernakulam	PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , NH <sub>3</sub> , CO, NO <sub>x</sub> , THC, H <sub>2</sub> S, Benzene
3.	Vyttila, Ernakulam	PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , NH <sub>3</sub> , CO, NO <sub>x</sub> , O <sub>3</sub> , Benzene
4.	Eloor, Ernakulam	PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , NH <sub>3</sub> , CO, NO <sub>x</sub> , Atmospheric Temperature (AT), Relative Humidity (RH), Wind Speed (WS), Wind Density (WD), Solar Radiation, Rainfall
5.	Palayam, Kozhikode	PM <sub>10</sub> , PM <sub>2.5</sub> , SO <sub>2</sub> , NH <sub>3</sub> , CO, NO <sub>x</sub> , O <sub>3</sub> , Atmospheric Temperature (AT), Relative Humidity (RH), Wind Speed (WS), Wind Density (WD), Solar Radiation, Rainfall

Table 2.4: Principles of CAAQMS Analysers

SI No	Parameter	Principle
1.	Sulphur Dioxide (SO <sub>2</sub> )	UV Fluorescence
2.	Oxides of Nitrogen (NO <sub>x</sub> )	Chemiluminescence
3.	Ammonia (NH <sub>3</sub> )	Chemiluminescence

<b>4.</b>	PM <sub>10</sub>	β-ray attenuation
<b>5.</b>	PM <sub>2.5</sub>	β-ray attenuation
<b>6.</b>	Ozone (O <sub>3</sub> )	UV Photometric / absorption/chemiluminescence
<b>7.</b>	Carbon Monoxide (CO)	Non-dispersive Infra-Red (NDIR)
<b>8.</b>	Benzene, Toluene, Ethyl-Benzene, O, M, P-Xylenes (BTX)	Based on Gas Chromatographic separation and Photo Ionization Detector (PID)

The various aspect of Quality Assurance and Quality Control used in the Manual Monitoring as well as continuous monitoring is given below.

### 3 Quality Assurance Of Manual Ambient Air Quality Monitoring Program.

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CPCB Guidelines for Ambient Air Quality Monitoring is being followed as mentioned below.

#### 3.1.1 Methods

The following methods will be used for measuring the following air pollutants:

- Sulfur dioxide (SO<sub>2</sub>) – Modified West and Geake method
- Nitrogen dioxide (NO<sub>2</sub>) – Modified Jacobs & Hochheiser method
- Suspended Particulate Matter (SPM) – High volume method (Gravimetric method)
- Respirable Suspended Particulate Matter (RSPM) – Gravimetrically with GFA/EPM 2000 filter paper using respirable dust sampler (Cyclonic Flow Technique)

#### 3.1.2 Precautions for Sampling, Analysis, and Data Reporting

##### 3.1.2.1 Sampling:

The following precautions are followed in the sampling of air pollutants:

- The high-volume sampler (HVS)/respirable dust sampler (RDS) are properly calibrated to get the correct flow rate.
- Timely corrective and preventive maintenance of the HVS/RDS is being done.
- The filter used for sampling is of Whatman or Equivalent quality (having better mechanical stability, chemical stability, particle sampling efficiency, flow, resistance, cost, and availability, etc.)
- The filter is always mounted properly on the support screen with the rough side of the filter facing upwards.
- The wingnuts are tightened properly to avoid any leakage.
- Weighing of filter paper is done after conditioning in desiccators

having active moisture absorbent (Silica Gel).

- Weighing of filter paper is done in Microbalance having an accuracy of 0.00001g
- Magnesium and silica gel bottle is kept in the weighing chamber to avoid error while weighing.
- Distilled water is used in a manometer tube and water is changed every fortnight and zero levels are checked every time.
- Proper Shelter is provided at the sampling site for the protection of instruments during the rainy season.
- Ice is kept in the sampling tray during sampling to avoid any evaporation loss and better absorption.
- Evaporation loss if any is made up of distilled water.

#### *3.1.2.2 Analysis:*

The following precautions are followed in the analysis of air pollutants:

- Properly clean glassware is used.
- Class A set of glassware is calibrated as per requirement.
- All critical chemicals used are of analytical grade.
- Glassware and storage bottles are rinsed with distilled water and chemicals, respectively.
- The desiccant in the desiccators is changed as per requirements.
- The chemicals whose strength changes with time is standardized before use.
- Reagent bottles are made airtight before storage.
- Key reagents such as Pararosaline, sodium hypochlorite, formaldehyde solution, etc. are prepared fresh on the date of analysis.
- Storage of chemicals is done as per recommendations like away from sunlight, etc.
- Active silica gel bottles with holes are placed inside the weighing chamber.
- The analytical balance has a sensitivity of  $\leq 2\text{mg}$ .

#### *3.1.2.3 Data Reporting:*

- SPM/RSPM values, which are very high, are reported in round figures (without decimal place).

- Any outlier values found should be checked for contamination of the sample, sudden change of environmental conditions in the vicinity of the monitoring site, etc. and discarded, if necessary.
- SPM values must always be greater than the corresponding RSPM values. In case Respirable Dust Sampler is used for measuring SPM and RSPM, then, Particulate matter collected on filter paper represents RSPM (size < 10µm).
- Particulate matter collected in the cup below cyclone represents Non-respirable Suspended particulate matter (NRSPM, size > 10 µm).
- Sum of particulate matter collected in the cup below cyclone and filter the paper indicates SPM.
- In case SPM is less than the corresponding RSPM, then data is rechecked.
- The values below the detection limit as per the method is not reported.

Table 3.1: Minimum detection in manual monitoring stations

Parameter	Lower Detection Limit	Method
SO <sub>2</sub>	4 µg/m <sup>3</sup>	Modified West and Geake method
NO <sub>2</sub>	9 µg/m <sup>3</sup>	Modified Jacobs & Hochheiser method (Reagent : Sodium Arsenite)
RSPM and SPM	5 µg/m <sup>3</sup>	High volume sampling/ Respirable Dust Sampling

- For calculating 24 hourly average of various parameters, BDL is considered as half the lower detection limit, i.e.
  - For calculating 24 hourly average of SO<sub>2</sub>, if any 4-hourly average is BDL then for calculation purpose its value is taken as 2 µg/m<sup>3</sup>
  - For calculating 24 hourly average of NO<sub>2</sub>, if any 4-hourly average is BDL then for calculation purpose its value is taken as 4.5 µg/m<sup>3</sup>
  - For calculating 24 hourly average of SPM and RSPM, if any 8-hourly average is BDL then for calculation purpose its value is taken as 3 µg/m<sup>3</sup>

### 3.1.2.4 Calculation of 24-hourly Average and Monthly Average

Values monitored for 16 hours and more in a day are considered for calculation of the 24-hour average. The average of 24-hourly averages (calculated as mentioned above) is taken as the monthly average.

## 3.2 Instruments/Techniques used in CAAQMS Quality Assurance aspect of Continuous Ambient Air Quality Monitoring Stations

This Section gives the Quality Assurance aspect of various CAAQMS Stations in the State of Kerala. Automated calibration is being done daily and manual calibration is done routinely.

Table 3.2: Quality Assurance aspects of CAAQM Station at Plammod, Thiruvananthapuram

Particulars /Equipment	Pollutants					
	Ozone Analyzer	CO Analyzer	NOx/NH3 Analyzer	SO <sub>2</sub> Analyzer	PM <sub>10</sub> Analyzer	PM <sub>2.5</sub> Analyzer
Measuring Principle	Ultraviolet (UV) absorption	Non-Dispersive Infra-Red Gas filter correlation technology	Gas-Phase Chemiluminescence	UV - fluorescent radiation technology	Particulate Concentration by Beta ray Attenuation	Particulate Concentration by Beta ray Attenuation
Make/Model	Ecotech/Serinus 10	Ecotech/Serinus 30	Ecotech/Serinus 44	Ecotech/Serinus 50	Ecotech/Spirant BAM1000	Ecotech/Spirant BAM1100
Min. Detection limit	0.5 ppb	0.04 ppm	0.4 ppb	0.3 ppb	Less than 1.0 µg/m <sup>3</sup>	Less than 1.0 µg/m <sup>3</sup>
Range	Working Range 0 - 200 ppb 0-20 ppm auto-ranging	Working Range 0 – 40ppm 0-200 ppm auto-ranging	Working Range 0 – 400ppb 0-20 ppm auto-ranging	Working Range 0 – 400ppb 0-20 ppm auto-ranging	Working Range 0 - 1000 µg/m <sup>3</sup> User selectable up to 10,000 µg/m <sup>3</sup>	Working Range 0 - 1000 µg/m <sup>3</sup> User selectable up to

						10,000 µg/m <sup>3</sup>
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Table 3.3: Quality Assurance of CAAQM Station at Karyavattom, Thiruvananthapuram

Particulars	Pollutants						
	PM 10	PM 2.5	SO <sub>2</sub>	CO	NO <sub>X</sub> & CNH <sub>3</sub>	OZONE	VOC
<b>Measuring Principle</b>	Cyclic measurement by Beta rays gauge	Cyclic measurement by Beta rays gauge	UV Fluorescence	Non-Dispersive Infra-Red	Chemiluminescence	UV Photometry	Gas Chromatography
<b>Make/Model</b>	Environnement S.A. MP101M+(10)	Environnement S.A. MP101M+(2.5)	Environnement S.A. AF22e	Environnement S.A. CO12e	Environnement S.A. AC32e	Environnement S.A. O342e	Environnement S.A. VOC72M
<b>Flow rate</b>	16.67 liter/min	16.67 liter/min	0.415 liter/min	~1 liter/min	0.66 liter/min	~1 liter/min	50 ml/min
<b>Sampling frequency</b>	15Min/30Min/11Hr/2Hr	15Min/30Min/11Hr/2Hr	Continues	Continues	Continues	Continues	Continues
<b>Min. Detection limit</b>	0.5 µg/m <sup>3</sup> (24h average)	0.5 µg/m <sup>3</sup> (24h average)	< 0.4 ppb	< 20 ppb	< 0.2 ppb	0.2 ppb	≤ 0.05 µg/m <sup>3</sup> benzene
<b>Range</b>	0-10 000 µg/m <sup>3</sup> (user-selectable & programmable)	0-10 000 µg/m <sup>3</sup> (user-selectable & programmable)	0-1 ppm / 0-10 ppm (user selectable or auto-ranging)	0-50 ppm (or 0-300 ppm on custom basis request)	0-1 ppm / 0-10 ppm (user selectable or auto-ranging)	0-500 ppb / 0-10 ppm (user selectable & programmable)	Max. 1000 µg/m <sup>3</sup> (programmable)
<b>Certification if any for ensuring QA/QC</b>	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV
<b>Calibration schedule (at what time)</b>	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended

Table 3.4: Quality Assurance of CAAQM station at Polaythode, Kollam

Particulars	Pollutants						
	PM 10	PM 2.5	SO <sub>2</sub>	CO	NOX & CNH <sub>3</sub>	OZONE	VOC
<b>Measuring Principle</b>	Cyclic measurement by Beta rays gauge	Cyclic measurement by Beta rays gauge	UV Fluorescence	Non-Dispersive Infra-Red	Chemiluminescence	UV Photometry	Gas Chromatography
<b>Make/Model</b>	Environment S.A. MP101M+(10)	Environment S.A. MP101M+(2.5)	Environment S.A. AF22e	Environment S.A. CO12e	Environment S.A. AC32e	Environment S.A. O342e	Environment S.A. VOC72M
<b>Flow rate</b>	16.67 liter/min	16.67 liter/min	0.415 liter/min	~1 liter/min	0.66 liter/min	~1 liter/min	50 ml/min
<b>Sampling frequency</b>	15Min/30Min/11Hr/2Hr	15Min/30Min/11Hr/2Hr	Continues	Continues	Continues	Continues	Continues
<b>Min. Detection limit</b>	0.5 µg/m <sup>3</sup> (24h average)	0.5 µg/m <sup>3</sup> (24h average)	< 0.4 ppb	< 20 ppb	< 0.2 ppb	0.2 ppb	≤ 0.05 µg/m <sup>3</sup> benzene
<b>Range</b>	0-10 000 µg/m <sup>3</sup> (user-selectable & programmable)	0-10 000 µg/m <sup>3</sup> (user-selectable & programmable)	0-1 ppm / 0-10 ppm (user selectable or auto-ranging)	0-50 ppm (or 0-300 ppm on custom basis request)	0-1 ppm / 0-10 ppm (user selectable or auto-ranging)	0-500 ppb / 0-10 ppm (user selectable & programmable)	Max. 1000 µg/m <sup>3</sup> (programmable)
<b>Certification if any for ensuring QA/QC</b>	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV
<b>Calibration frequency</b>	Reference gauge	Reference gauge	(0-90 %) 20-120 seconds	(0-90 %) 20-90seconds	(0-90 %) 40"programmable	(0-90 %) 20-90 seconds	(0-90 %) of cycles (15mins cycle)
<b>Calibration schedule (at what time)</b>	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended

Table 3.5: Quality Assurance aspect of CAAQMS at Vytilla, Ernakulam

Particulars	Pollutants							
	PM 10	PM 2.5	SO2	CO	O3	NOX	NH3	BTEX
Equipment	Beta Ray Attenuation	Beta Ray Attenuation	UV fluorescence	Non-Dispersive Infrared	UV Photometric	Chemiluminescence	Chemiluminescence	Gas Chromatography, PID
Measuring Principle	Beta Ray Attenuation	Beta Ray Attenuation	UV fluorescence	Non-Dispersive Infrared	UV Photometric	Chemiluminescence	Chemiluminescence	Gas Chromatography, PID
Make/Model	Met one (BAM-1020)	Met One (BAM-1020)	Teledyne (T100)	Teledyne (T300)	Teledyne (T400)	Teledyne (T201)	Teledyne (T201)	Chromatic (GC 866)
Flow rate	16.7 LPM	16.7L PM	650 cc/min ±10%	800 cc/min ±10%	800 cc/min ±10%	500 cc/min ± 10%	500 cc/min ± 10%	19.9 ml/min
Sampling frequency	1Hr	1Hr	Continuous	Continuous	Continuous	Continuous	Continuous	15 min
Min. Detection limit	< 1ug/m3	< 1ug/m3	0.4 ppb	< 0.04 ppm	< 0.4 ppb	0.4 ppb	1 ppb	0.01ppb
Range	0-1000 ug/m3	0-1000 ug/m3	0-500 ug/m3	0-50 ppm	0-500 ug/m3	0-500 ug/m3	0-500 ug/m3	0-50 ug/m3
Certification if any for ensuring QA/QC	USEPA	USEPA	USEPA	USEPA	USEPA	USEPA	USEPA	USEPA
Calibration frequency	3 month	3 month	3 month	3month	3 month	3 month	3 month	3 Month

Table 3.6: Quality Assurance of CAAQM station at MG Road, Kochi

Particulars/ Equipment	Pollutants							BTEX
	PM 10	PM 2.5	SO2 & H2S	CO	THC	NOX	NH3	
Measuring Principle	Beta Ray Attenuation	Beta Ray Attenuation	UV fluorescence	Non-Dispersive Infrared	Gas Chromatography, FID	Chemiluminescence	Chemiluminescence	Gas Chromatography, PID

Make/Model	Met one (BAM-1020)	Met One (BAM-1020)	Teledyne (T101)	Teledyne (T300)	Synspec (Alpha 115)	Teledyne (T201)	Teledyne (T201)	Synspec GC 955(601)
Flow rate	16.7 lpm	16.7lpm	650 cc/min ±10%	800 cc/min. ±10%		500 cc/min ± 10%	500 cc/min ± 10%	
Sampling frequency	1Hr	1Hr	Continuous	Continuous	3 min	Continuous	Continuous	15 min
Min. Detection limit	< 1ug/m3	< 1ug/m3	0.4 ppb	< 0.04 ppm	0.05 ppm	0.4 ppb	1 ppb	0.1ug/m3
Range	0-1000 ug/m3	0-1000 ug/m3	0-500 ug/m3	0-50 ppm	0-100 ppm	0-500 ug/m3	0-500 ug/m3	0-50 ug/m3
Certification for ensuring QA/QC	USEPA	USEPA	USEPA	USEPA	CE,EN	USEPA	USEPA	CE, EN

Table 3.7: Quality Assurance of CAAQM station at Kozhikkode

Particulars	Pollutants						
	PM 10	PM 2.5	SO2	CO	O3	NOX	NH3
Equipment	Beta Ray Attenuation	Beta Ray Attenuation	UV fluorescence	Non-Dispersive Infrared	UV Photometric	Chemiluminescence	Chemiluminescence
Make/Model	Met one (BAM-1020)	Met One (BAM-1020)	Teledyne (T100)	Teledyne (T300)	Teledyne (T400)	Teledyne (T201)	Teledyne (T201)
Flow rate	16.7 lpm	16.7lpm	650 cc/min ±10%	800 cc/min. ±10%	800 cc/min ±10%	500 cc/min ± 10%	500 cc/min ± 10%
Sampling frequency	1Hr	1Hr	Continuous	Continuous	Continuous	Continuous	Continuous
Min. Detection limit	< 1ug/m3	Less than 1ug/m3	0.4 ppb	< 0.04 ppm	< 0.4 ppb	0.4 ppb	1 ppb
Range	0-1000 ug/m3	0-1000 ug/m3	0-500 ug/m3	0-50 ppm	0-500 ug/m3	0-500 ug/m3	0-500 ug/m3
Certification if any for ensuring QA/QC	USEPA	USEPA	USEPA	USEPA	USEPA	USEPA	USEPA
Calibration frequency	3 month	3 month	3 month	3month	3 month	3 month	3 month

Table 3.8: Quality Assurance at Kannur CAAQM Station

Particulars	Pollutants						
Equipment	PM 10	PM 2.5	SO <sub>2</sub>	CO	NO <sub>x</sub> & CNH <sub>3</sub>	OZONE	VOC
<b>Measuring Principle</b>	Cyclic measurement by Beta rays gauge	Cyclic measurement by Beta rays gauge	UV Fluorescence	Non-Dispersive Infra-Red	Chemiluminescence	UV Photometry	Gas Chromatography
<b>Make/Model</b>	Environnement S.A. MP101M+(10)	Environnement S.A. MP101M+(2.5)	Environnement S.A. AF22e	Environnement S.A. CO12e	Environnement S.A. AC32e	Environnement S.A. O342e	Environnement S.A. VOC72M
<b>Flow rate</b>	16.67 liter/min	16.67 liter/min	0.415 liter/min	~1 liter/min	0.66 liter/min	~1 liter/min	50 ml/min
<b>Sampling frequency</b>	15Min/30Min/11Hr/2Hr	15Min/30Min/11Hr/2Hr	Continues	Continues	Continues	Continues	Continues
<b>Min. Detection limit</b>	0.5 µg/m <sup>3</sup> (24h average)	0.5 µg/m <sup>3</sup> (24h average)	< 0.4 ppb	< 20 ppb	< 0.2 ppb	0.2 ppb	≤ 0.05 µg/m <sup>3</sup> benzene
<b>Range</b>	0-10 000 µg/m <sup>3</sup> (user-selectable & programmable)	0-10 000 µg/m <sup>3</sup> (user-selectable & programmable)	0-1 ppm / 0-10 ppm (user selectable or auto-ranging)	0-50 ppm (or 0-300 ppm on custom basis request)	0-1 ppm / 0-10 ppm (user selectable or auto-ranging)	0-500 ppb / 0-10 ppm (user selectable & programmable)	Max. 1000 µg/m <sup>3</sup> (programmable)
<b>Absorption wavelength (x max)</b>	–	–	214 nm	4.67 um	610 nm	250 to 270 nm	–
<b>Certification if any for ensuring QA/QC</b>	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV	US EPA / TUV
<b>Calibration frequency</b>	Reference gauge	Reference gauge	(0-90 %) 20-120 seconds	(0-90 %) 20-90seconds	(0-90 %) 40"programmable	(0-90 %) 20-90 seconds	(0-90 %) of cycles (15mins cycle)
<b>Calibration schedule (at what time)</b>	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended	3 month OEM Recommended

## 4 Thiruvananthapuram City

The list of Monitoring stations in the city is tabulated in table 4.1 along with the land use pattern.

Table 4.1: Ambient air quality monitoring stations in Thiruvananthapuram

Site	Co-ordinates	Scheme	Type	Land Use Pattern
<b>Cosmo Politian Hospital</b>	8.5158817, 76.9356147	NAMP	Sensitive	Hospital, Residential, Major Road
<b>SMV School</b>	8.4891229, 76.9480276	NAMP	Sensitive	Commercial, Major Road, Railway hub
<b>Filatex – Veli</b>	8.504571, 76.896381	NAMP	Industrial	Industries, roads, commercial
<b>Plamood</b>	8.513777, 76.945902	NAMP	Commercial cum Residential	Major roads, residential
<b>Kaaryavattom</b>	8.563700, 76.886500	CAAQMS	Residential	College, Stadium, major roads, residential
<b>Plamood</b>	8.5149093, 76.9435879	CAAQMS	Commercial cum Residential	Major roads, residential

Table 4.2 gives the increase in the number of vehicles in the district of Thiruvananthapuram, it has shown steady growth.

Table 4.2: Vehicle count in Thiruvananthapuram district

Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
<b>No of vehicles</b>	1066318	1175647	1290592	1401090	1523414	1664564

### 4.1 Plamood (Commercial cum Residential)-Manual Monitoring Station

Plamood is a residential area in the city through which a National high way passes through. The land use pattern includes major roads, commercial and residential area.

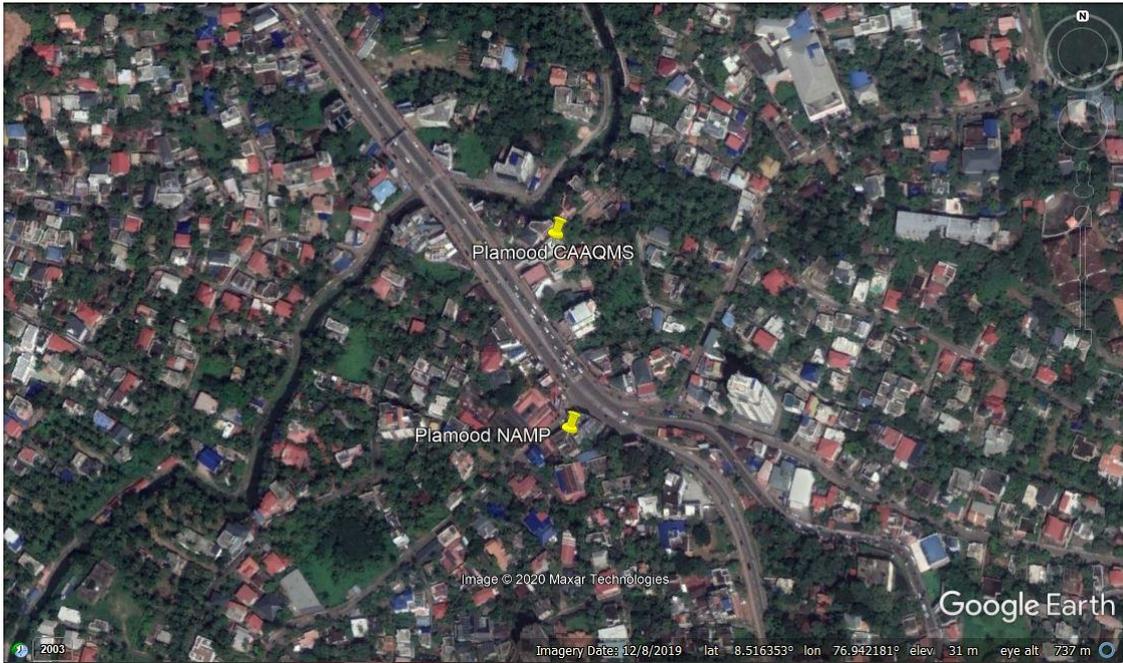


Figure 4.1 Land use pattern at plamood station

### 4.1.1 Before Lockdown

The 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Plamood station before lockdown is represented in Figure 4.2.

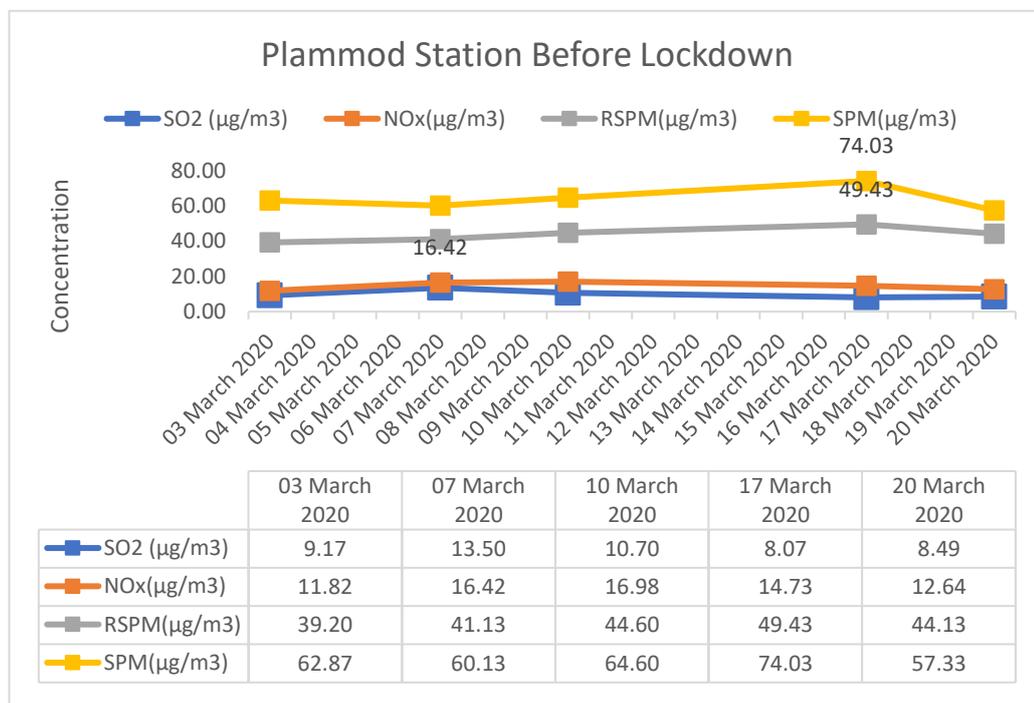


Figure 4.2: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Plamood station before lockdown

The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100  $\mu\text{g}/\text{m}^3$ . The highest RSPM and SPM values were found to be 49.43 $\mu\text{g}/\text{m}^3$  and 74.03  $\mu\text{g}/\text{m}^3$  respectively on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is way below the NAAQS standards of 80  $\mu\text{g}/\text{m}^3$ . The highest values registered are 13.5  $\mu\text{g}/\text{m}^3$  and 16.98  $\mu\text{g}/\text{m}^3$  respectively for SO<sub>2</sub> and NO<sub>x</sub>.

#### 4.1.2 During Lockdown

The 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Plamood station during the lockdown is depicted in Figure 4.3

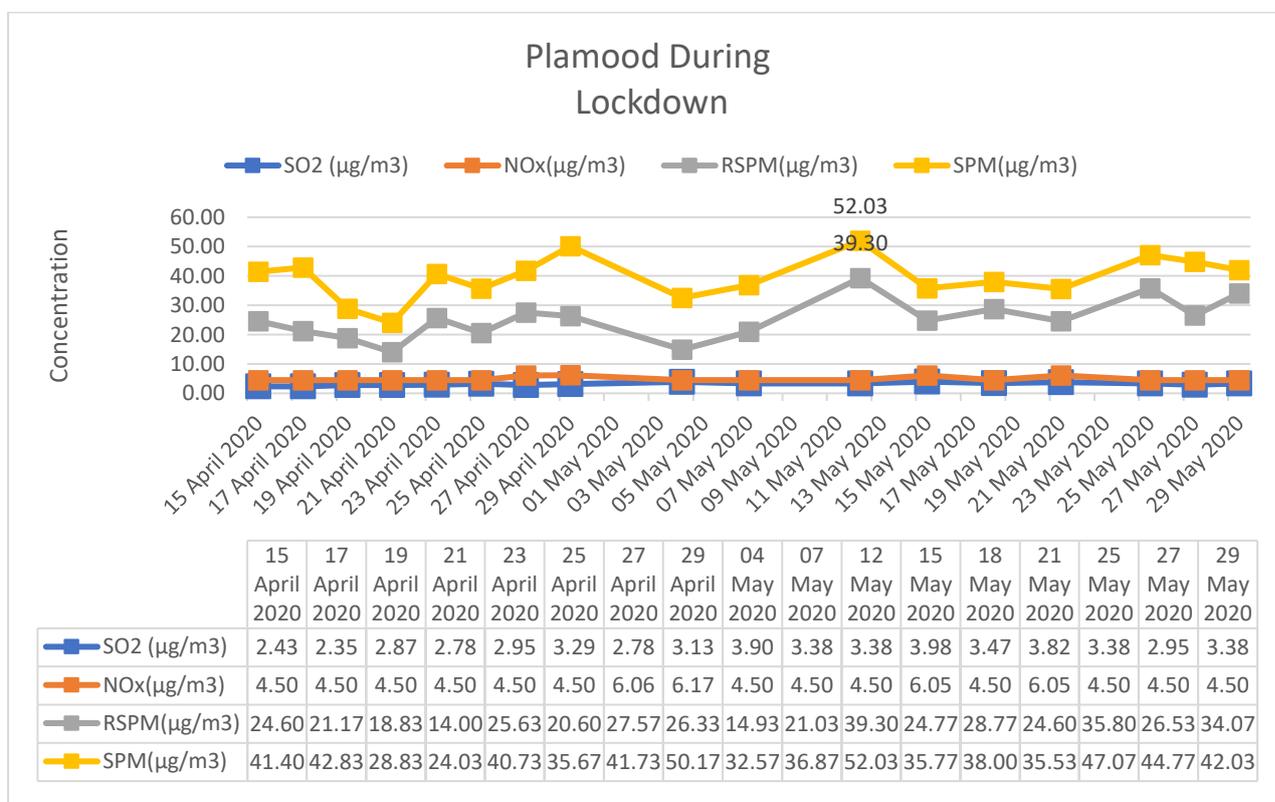


Figure 4.3: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Plamood station during the lockdown

The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100  $\mu\text{g}/\text{m}^3$ . The highest values of RSPM and SPM value recorded is 39.30  $\mu\text{g}/\text{m}^3$  and 52.03  $\mu\text{g}/\text{m}^3$  respectively on 12<sup>th</sup> May 2020. The

concentration of SO<sub>2</sub> and NO<sub>x</sub> way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 3.98 g/m<sup>3</sup> and 6.17 g/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 4.1.3 After Lockdown

Figure 4.4 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Plamood station after lockdown.

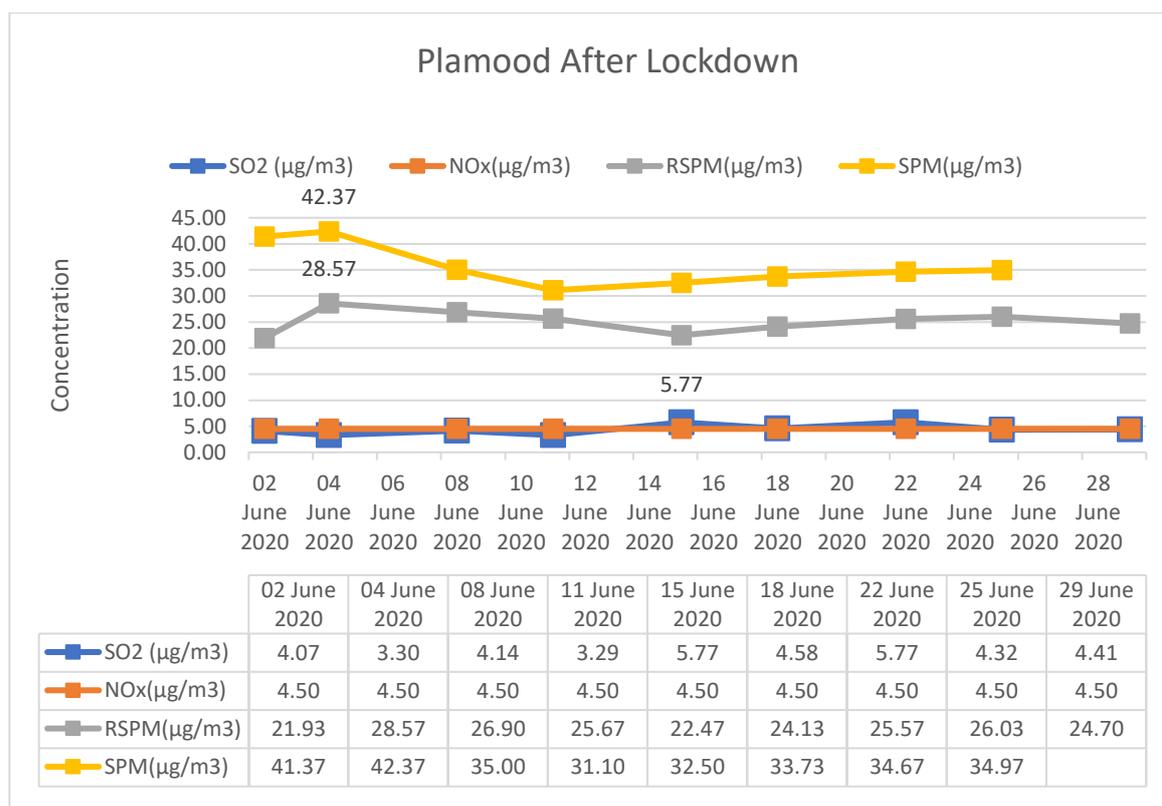


Figure 4.4.4: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Plamood station after the lockdown

The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest values of RSPM and SPM were 28.57 µg/m<sup>3</sup> and 42.37 µg/m<sup>3</sup> respectively recorded on 4<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 5.77 µg/m<sup>3</sup> for SO<sub>2</sub> on the 15<sup>th</sup>. The value of NO<sub>x</sub> remained constant at the lower limit of 4.5 µg/m<sup>3</sup>

### 4.1.4 Result analysis

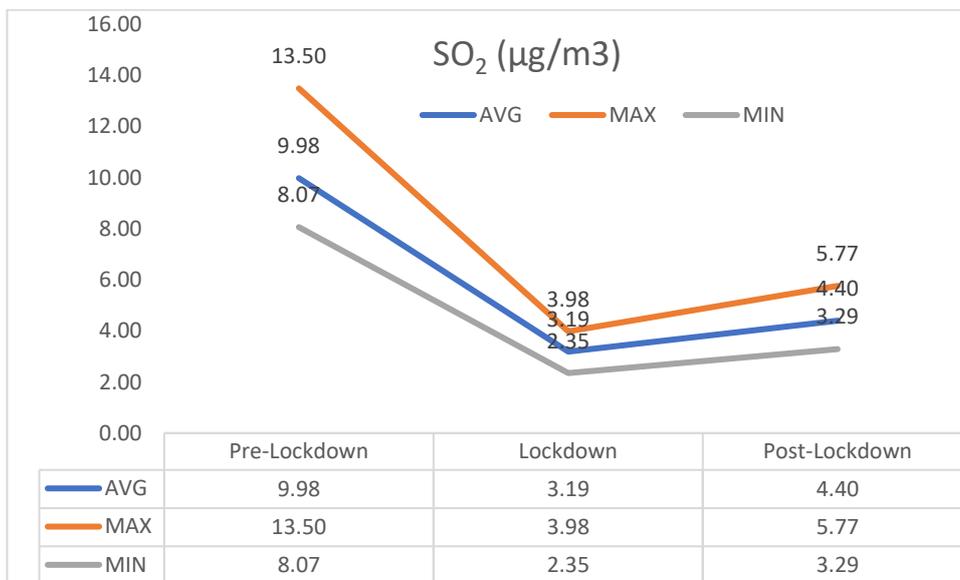


Figure 4.4.5: SO<sub>2</sub> Values of Plamood station before, during, and after lockdown

Figure 4.5 shows that average, maximum, and minimum values for SO<sub>2</sub> registered a notable decrease during the lockdown period which later increased slightly as the lockdown was lifted at the Plamood station.

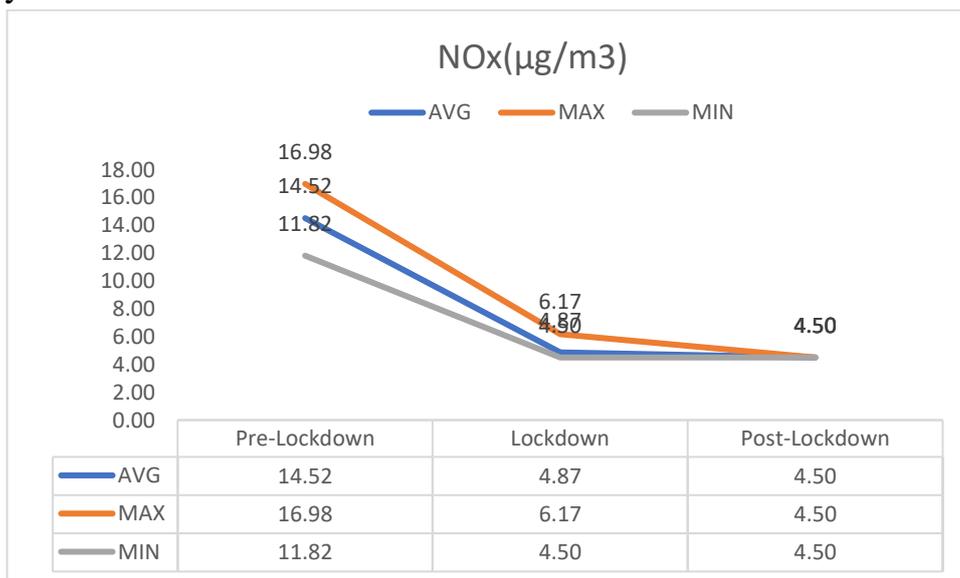


Figure 4.6: NO<sub>x</sub> Values of Plamood station before, during and after lockdown.

Figure 4.6 shows that average and maximum values for NO<sub>x</sub> registered a notable decrease during and after the lockdown at Plammod station. The minimum value remained at 4.5 µg/m<sup>3</sup>

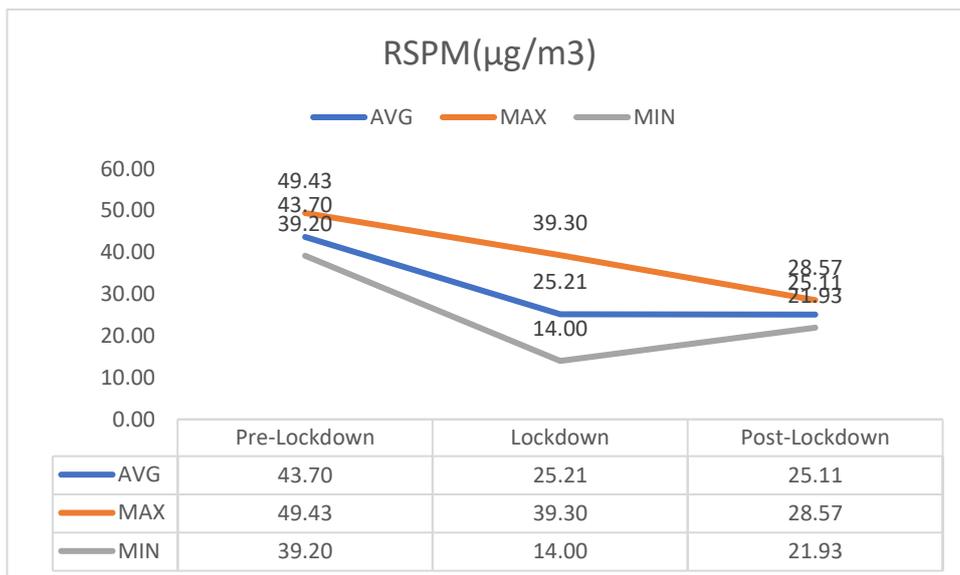


Figure 4.7: RSPM Values of Plamood station before, during, and after lockdown.

From Figure 4.7 and 4.8, it can be noted that the average and peak values of RSPM and SPM showed a notable decrease after the lockdown at the Plammod station whereas the minimum value showed a slight relapse after lifting of the lockdown.

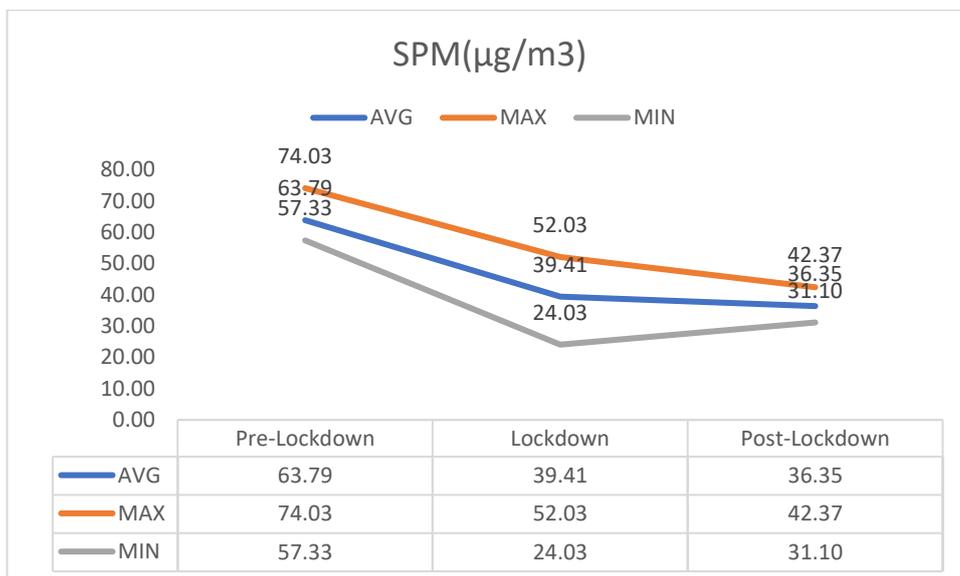


Figure 4.8: SPM Values of Plamood station before, during and after lockdown.

## 4.2 cosmopolitan Hospital (Sensitive) -Manual Monitoring Station

The cosmopolitan station is located in a sensitive area in the city with multiple hospitals and adjoining commercial establishments in the area. The land use pattern includes hospital, residential and major roads.

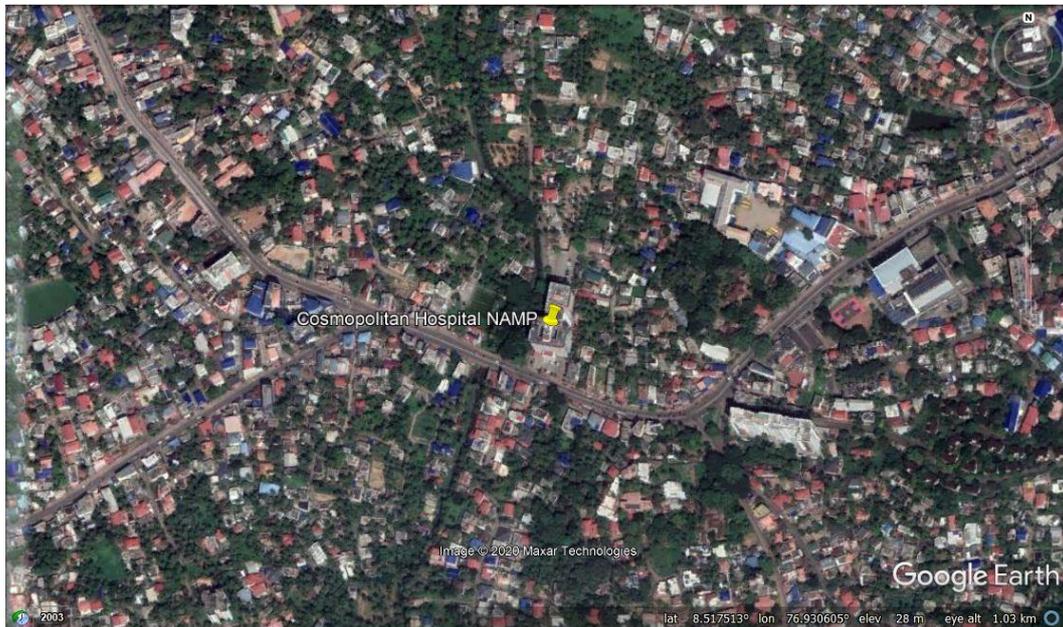


Figure 4.9: Land use pattern at the Cosmopolitan station

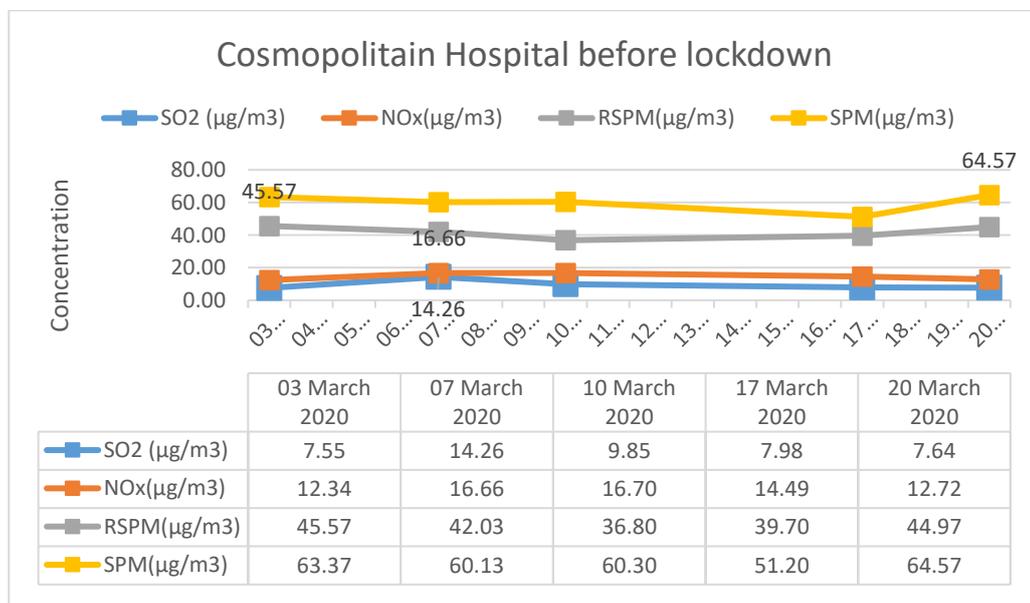


Figure 4.10: SO2, NOX, RSPM, and SPM measured at cosmopolitan Hospital before Lockdown

Figure 4.10 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Cosmopolitan Hospital station before lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM values were found to be 45.97µg/m<sup>3</sup> and 64.57 µg/m<sup>3</sup> respectively on 20<sup>th</sup> March and 3<sup>rd</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 14.26 µg/m<sup>3</sup> and 16.66 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

Due to construction activities at the site monitoring couldn't be carried out during the lockdown and thereafter.

### 4.3 Veli (Industrial)-Manual Monitoring Station

The Veli station is located in a designated industrial area. The land use pattern includes industries, minor roads and commercial establishment.

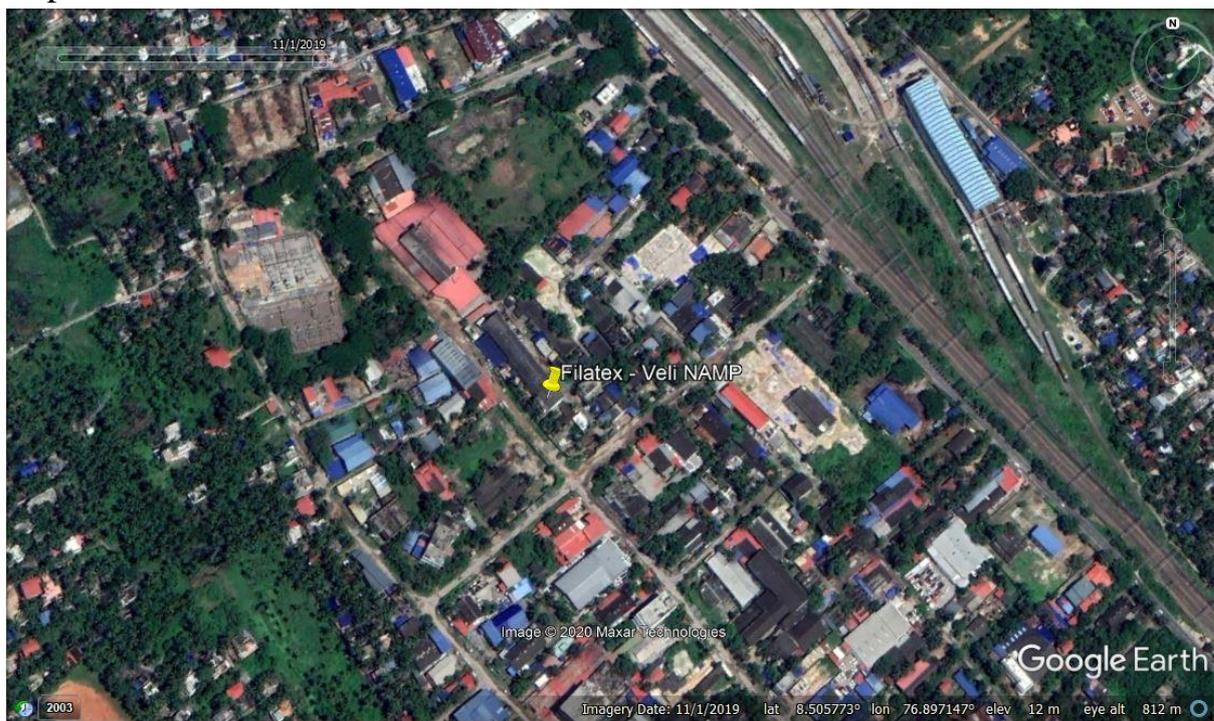


Figure 4.11: Land use pattern at the Veli station

### 4.3.1 Before Lockdown

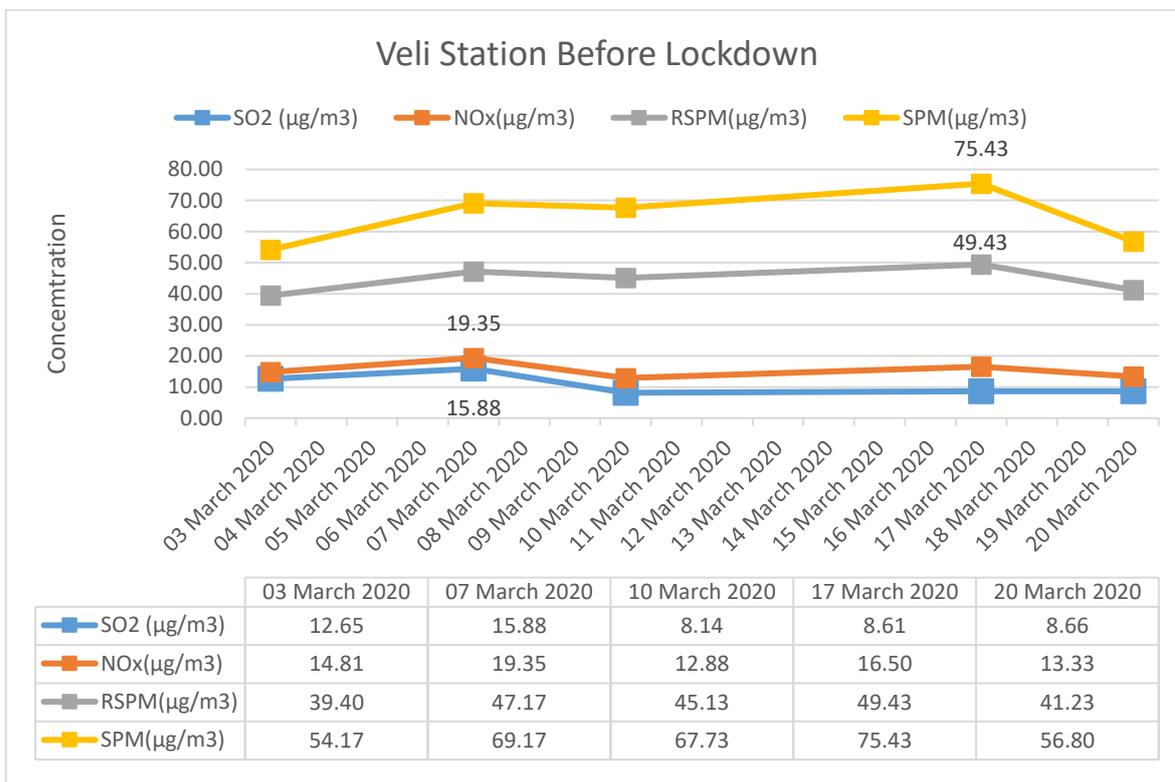


Figure 4.12: SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Veli Station Before Lockdown

Figure 4.12 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Veli station before lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM is found to be 49.43 µg/m<sup>3</sup> and that of SPM was found to be 75.43µg/m<sup>3</sup> on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 15.88 µg/m<sup>3</sup> and 19.35 µg/ <sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub> on 07<sup>th</sup> March 2020.

### 4.3.2 During Lockdown

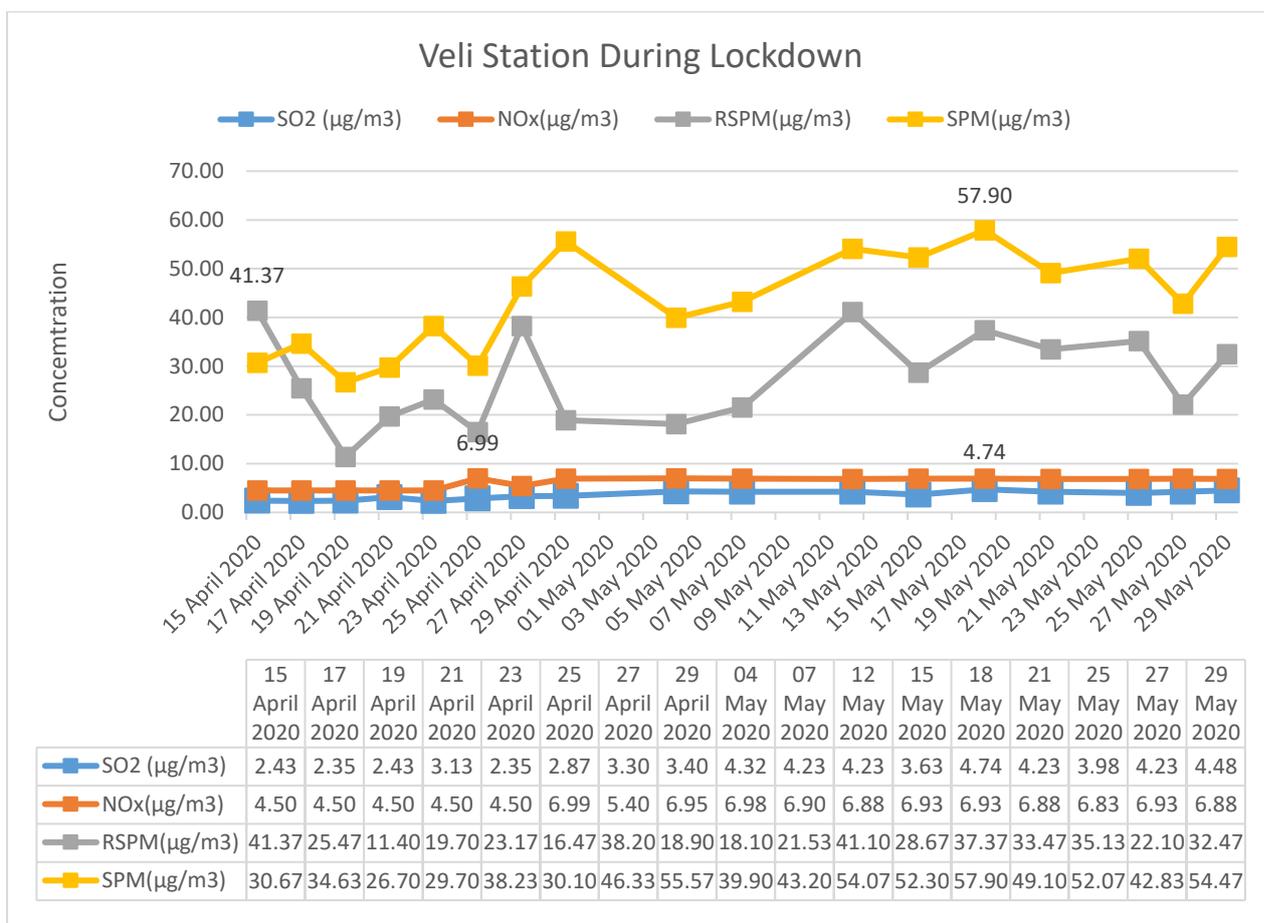


Figure 4.13: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Veli Station during Lockdown

Figure 4.13 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Veli station during the lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM values were found to be 41.37 µg/m<sup>3</sup> and 57.90 µg/m<sup>3</sup> on 15<sup>th</sup> April 2020 and 18<sup>th</sup> May 2020 respectively. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 4.74 µg/m<sup>3</sup> and 6.99 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 4.3.3 After Lockdown.

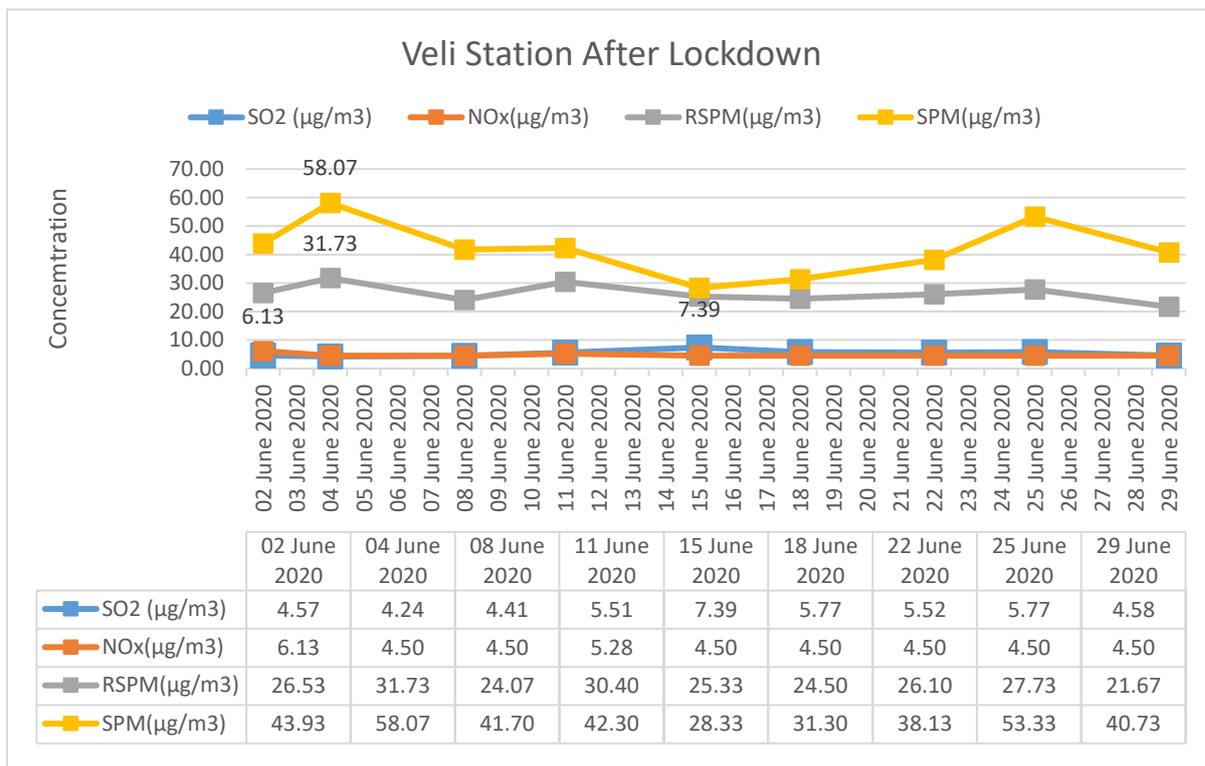


Figure 4.14: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Veli Station after Lockdown

Figure 4.14 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Veli station after lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM values were found to be 31.73 µg/m<sup>3</sup> and 58.07 µg/m<sup>3</sup> respectively on 4<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 7.39 µg/m<sup>3</sup> and 6.13 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 4.3.4 Result Analysis



Figure 4.15: SO<sub>2</sub> Values at veli station before, during and after lockdown.

Figure 4.15 shows that average, maximum and minimum values for SO<sub>2</sub> registered a notable decrease during the lockdown period which later increased slightly as the lockdown was lifted at veli station.

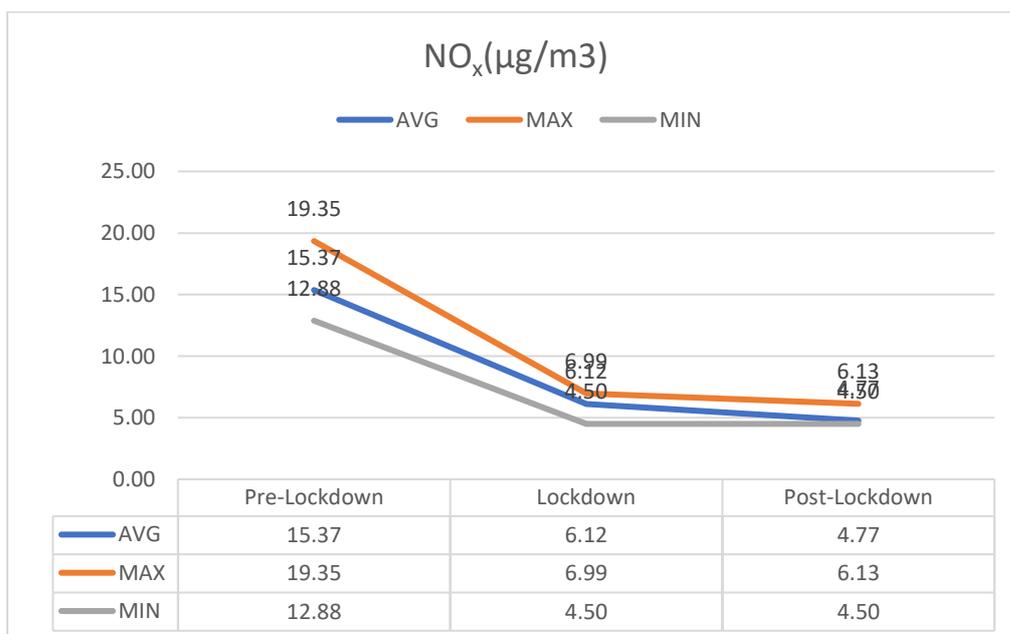


Figure 4.16: NO<sub>x</sub> Values of veli station before, during and after lockdown

Figure 4.16 shows that average, maximum, and minimum values for NO<sub>x</sub> registered a notable decrease during the lockdown period at veli station.

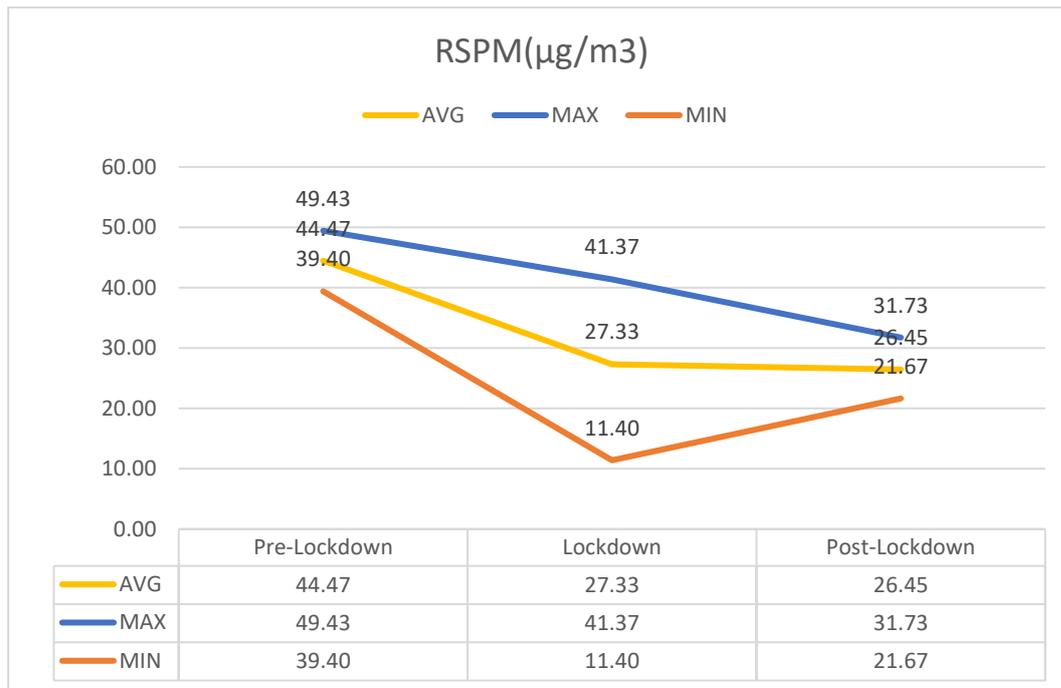


Figure 4.17: RSPM Values of veli station before, during and after lockdown

Figure 4.17 and 4.18 shows that average and minimum values for RSPM and SPM registered a notable decrease during the lockdown period which later increased slightly as the lockdown was lifted at veli station, whereas the maximum value registered a steady decline.

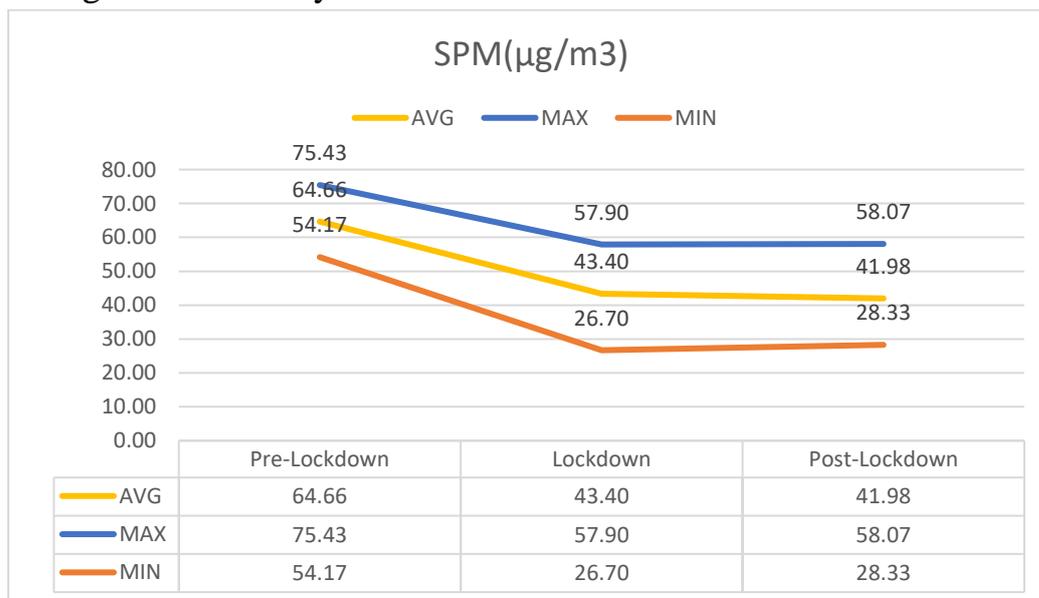


Figure 4.18: SPM Values of veli station before, during and after lockdown.

## 4.4 SMV School(Commercial)- Manual Monitoring Station

The SMV School station is located in a commercial area. The land use pattern includes Commercial establishments, Educational Institutions, Major Road & Railway hub.



**Figure 4.19: Land use pattern at SMV School Station**

The monitoring at SMV school station couldn't be carried out during and after the lockdown as the site was situated in the compounds of SMV School which was designated as a Covid-19 relief centre.

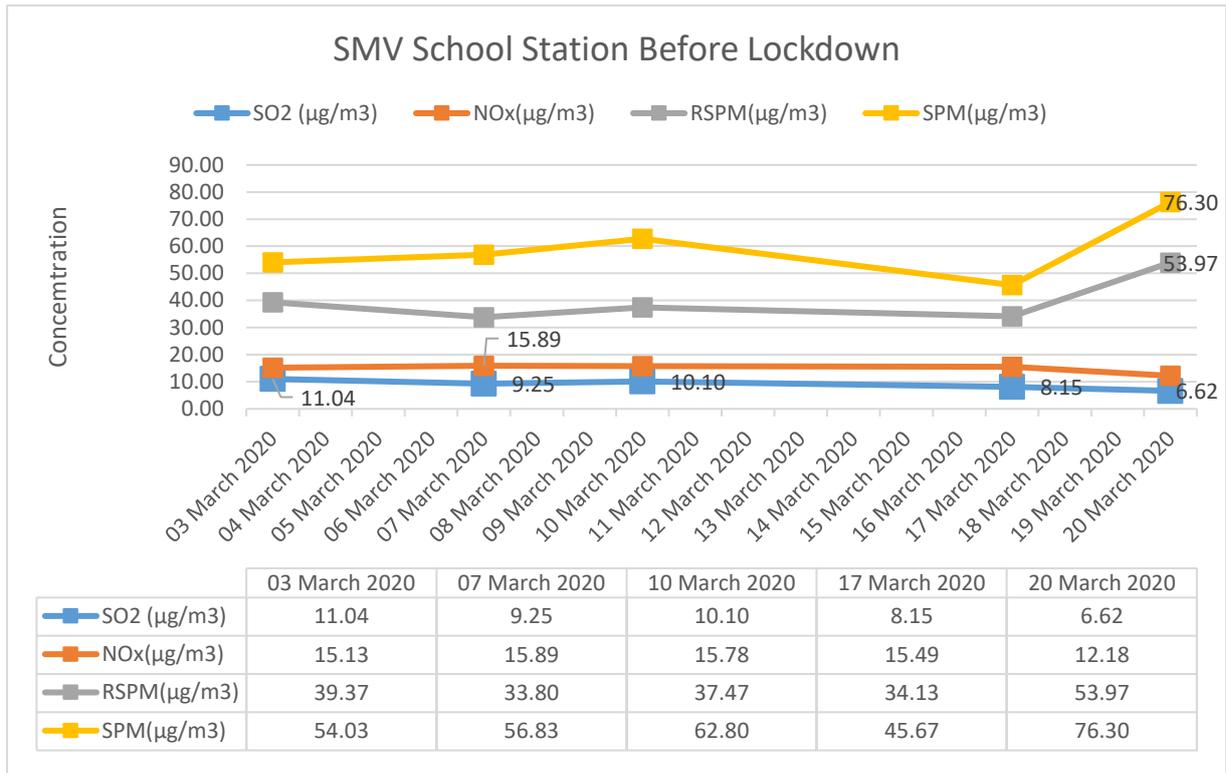


Figure 4.20: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at SMV School before Lockdown

Figure 4.20 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at SMV School station before lockdown. The data analysis indicated that the RSPM and SPM were always below 100 µg/m<sup>3</sup>. The highest RSPM and SPM values were found to be 54 µg/m<sup>3</sup> and 76.30 µg/m<sup>3</sup> respectively on 20<sup>th</sup> March 2020 and 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered for SO<sub>2</sub> and NO<sub>x</sub> are 11.04 µg/m<sup>3</sup> and 15.89 µg/m<sup>3</sup> respectively.

## 4.5 Plamood CAAQMS (Residential cum Commercial)

Plamood is a residential cum commercial area in the city through which a National High Way passes through. The land use pattern includes major roads, residential and commercial establishment. The CAAQMS is located nearby the manual monitoring station mentioned in section 4.1

### 4.5.1 Before Lockdown

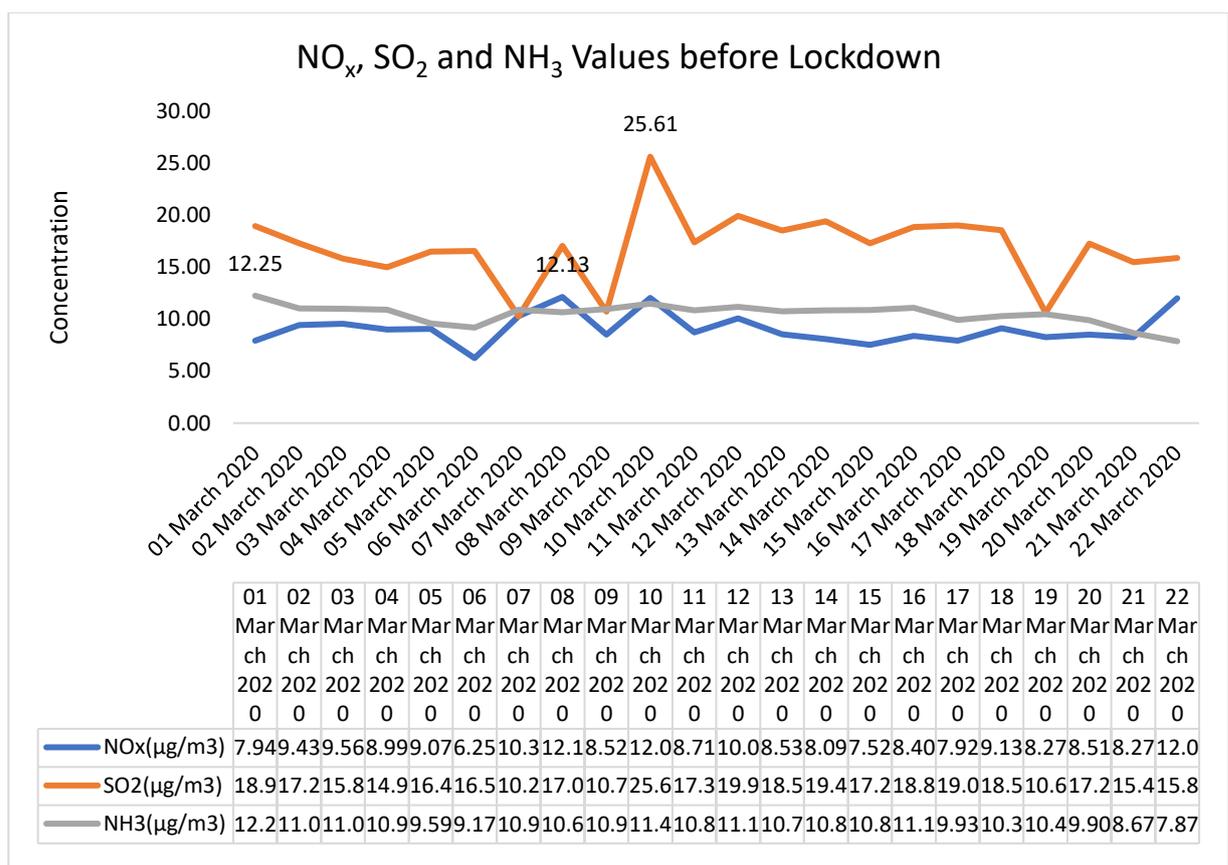


Figure 4.21: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Plamood CAAQM Station before Lockdown

Figure 4.21 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Plamood CAAQM station before lockdown. The data analysis indicates that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80  $\mu\text{g}/\text{m}^3$ . The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 25.61  $\mu\text{g}/\text{m}^3$  and 12.13  $\mu\text{g}/\text{m}^3$  respectively on 10<sup>th</sup> March 2020 and 8<sup>th</sup> March 2020. The concentration of

NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 12.25 µg/m<sup>3</sup> on 1<sup>st</sup> March 2020 for NH<sub>3</sub>.

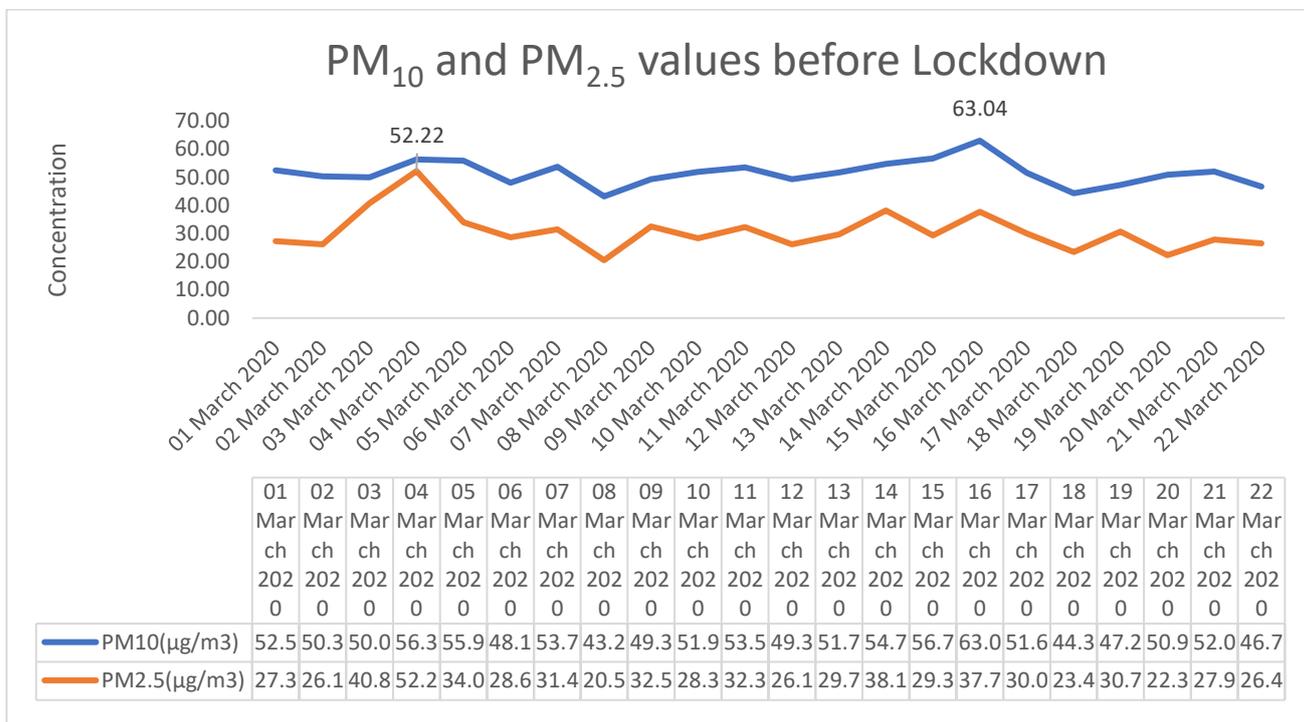
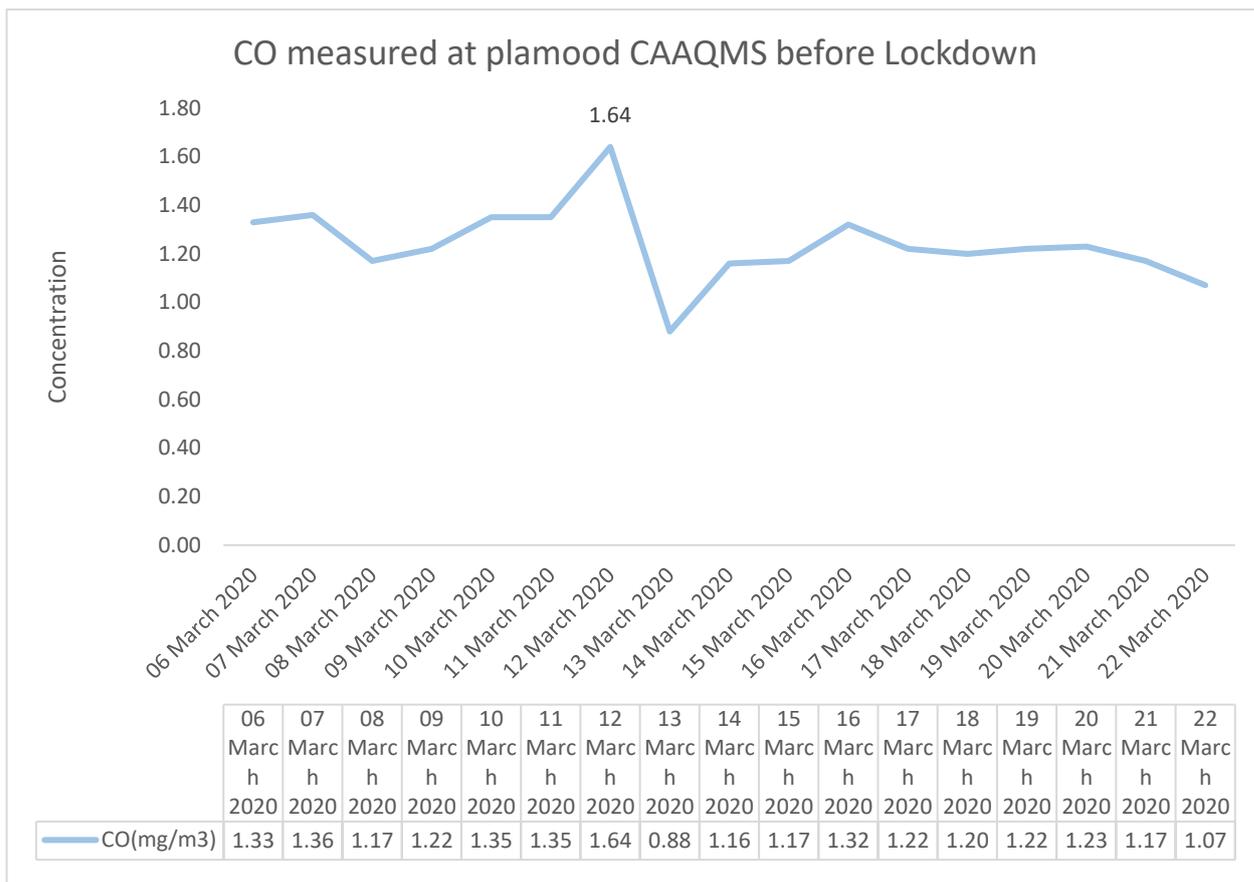


Figure 4.22: PM<sub>10</sub> and PM<sub>2.5</sub> measured at plamood CAAQM Station before Lockdown

Figure 4.22 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Plamood station before lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 63.04 µg/m<sup>3</sup> and 52.2 µg/m<sup>3</sup> respectively on 16<sup>th</sup> March 2020 and 4<sup>th</sup> March 2020.



**Figure 4.23: CO measured at Plamood CAAQM Station before Lockdown**

Figure 4.23 shows the 24-hr average values for CO measured at Plamood station before lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 1.64 mg/m<sup>3</sup> on 12<sup>th</sup> March 2020.

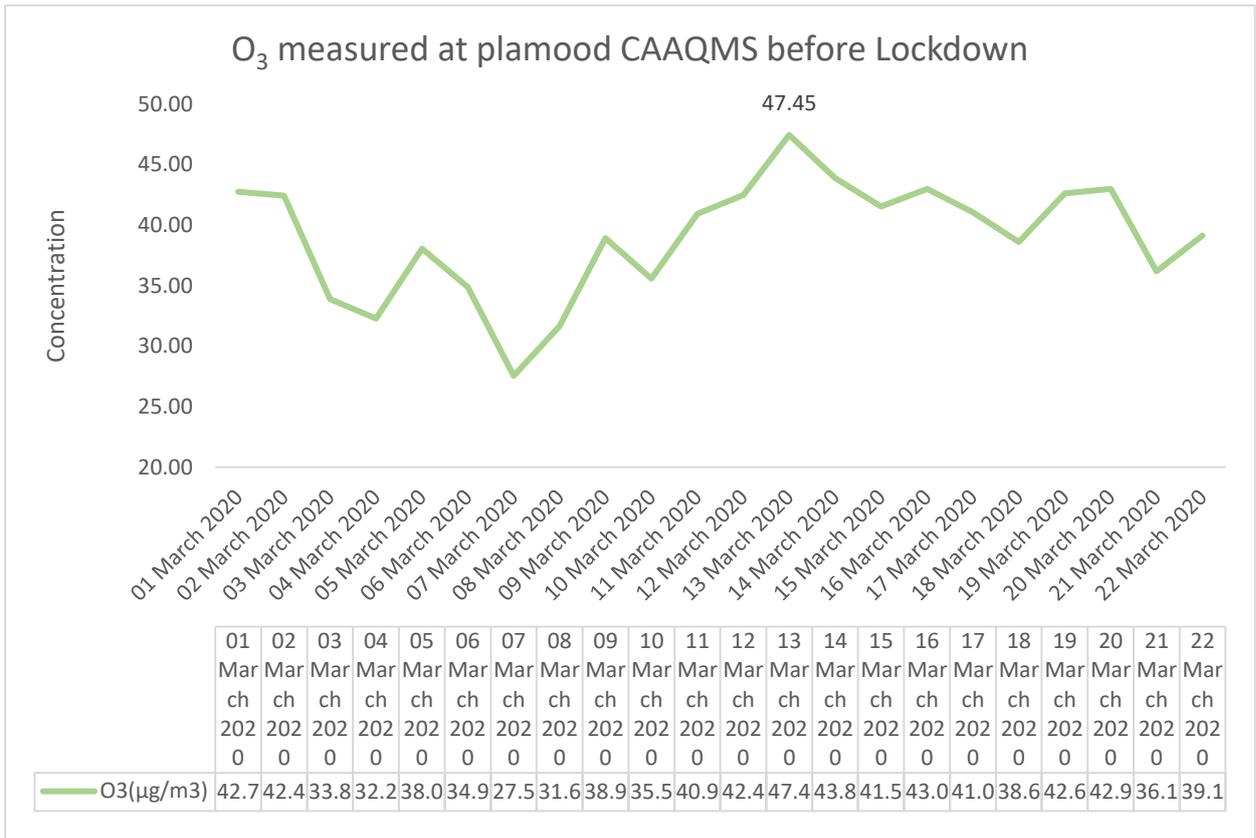


Figure 4.24:: O<sub>3</sub> measured at plamood CAAQM Station before Lockdown

Figure 4.24 shows the 24-hr average values for O<sub>3</sub> measured at Plamood station before lockdown. The data analysis indicated that the O<sub>3</sub> was always below the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 47.45 µg/m<sup>3</sup> on 13<sup>th</sup> March 2020.

## 4.5.2 During Lockdown

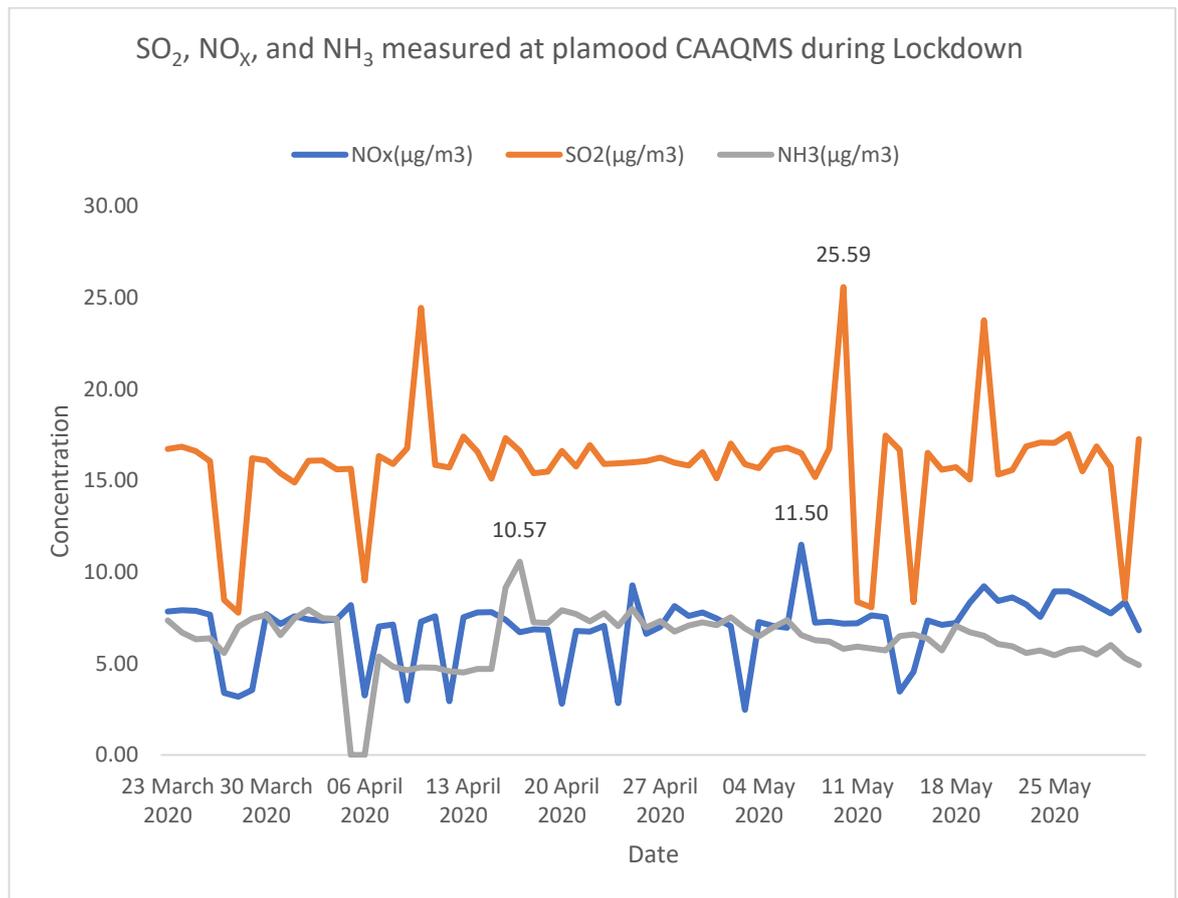
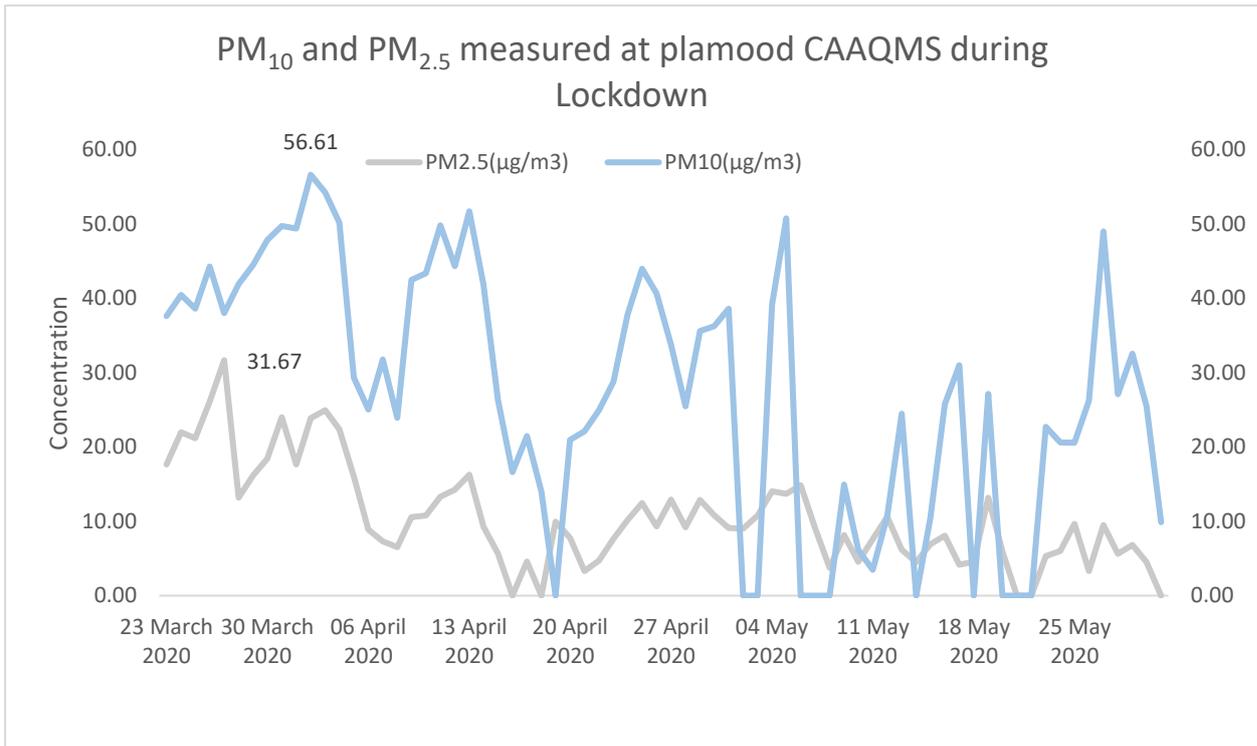


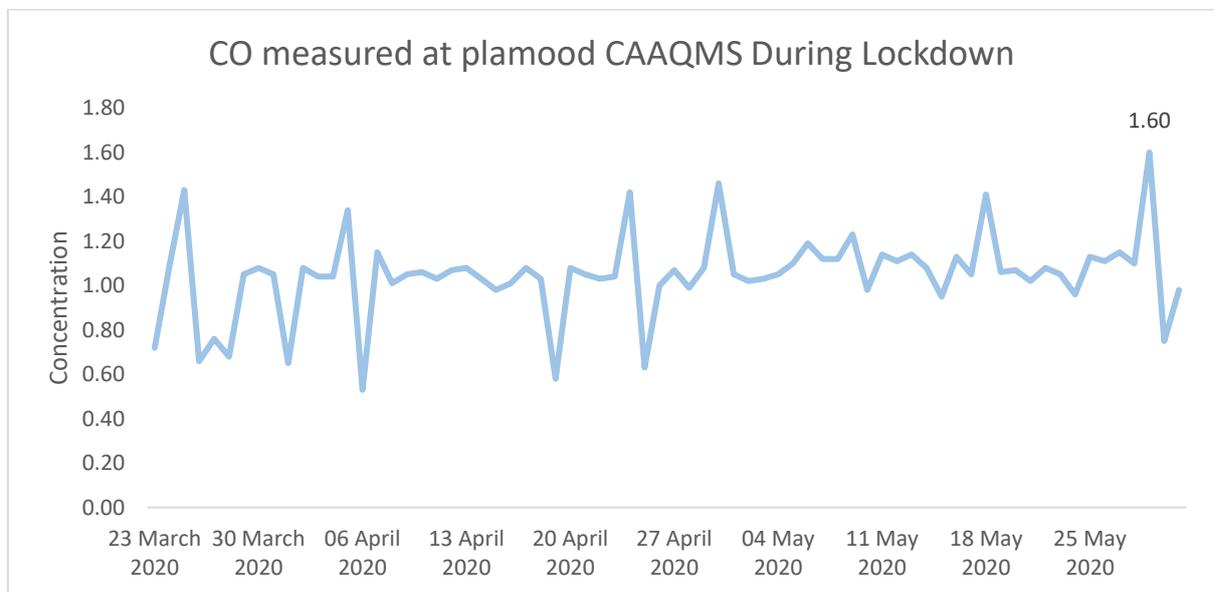
Figure 4.25: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Plamood CAAQM Station during Lockdown

Figure 4.25 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Plamood station during the lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 25.59 µg/m<sup>3</sup> and 11.50 µg/m<sup>3</sup> respectively on 10<sup>th</sup> May 2020 and 7<sup>th</sup> May 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest values registered are 10.57 µg/m<sup>3</sup> on 17<sup>th</sup> April 2020 for NH<sub>3</sub>.



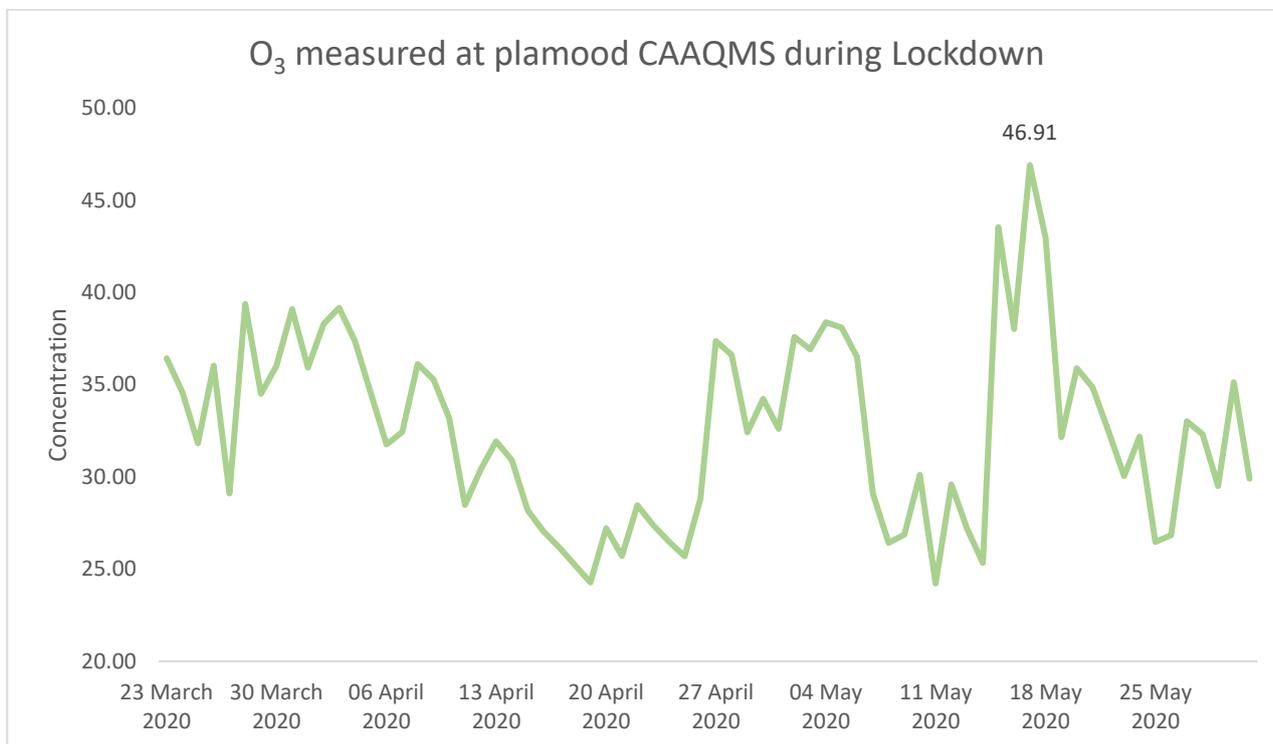
**Figure 4.26: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Plamood CAAQM Station during Lockdown**

Figure 4.26 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Plamood station during a lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 56.61 µg/m<sup>3</sup> and 31.67 µg/m<sup>3</sup> respectively on 2<sup>nd</sup> April 2020 and 27<sup>th</sup> March 2020.



**Figure 4.27: CO measured at Plamood CAAQM Station during Lockdown**

Figure 4.27 shows the 24-hr average values for CO measured at Plamood station during a lockdown. The data analysis indicated that the CO was always below the 8 hour standard of  $2 \mu\text{g}/\text{m}^3$ . The highest value was found to be  $1.60 \mu\text{g}/\text{m}^3$  on 29<sup>th</sup> May 2020.



**Figure 4.28: O<sub>3</sub> measured at Plamood CAAQM Station during Lockdown**

Figure 4.28 shows the 24-hr average values for O<sub>3</sub> measured at Plamood station during the lockdown. The data analysis indicated that the O<sub>3</sub> was always below the 8 hour standard of  $100 \mu\text{g}/\text{m}^3$ . The highest value was found to be  $46.91 \mu\text{g}/\text{m}^3$  on 17<sup>th</sup> May 2020.

### 4.5.3 After Lockdown

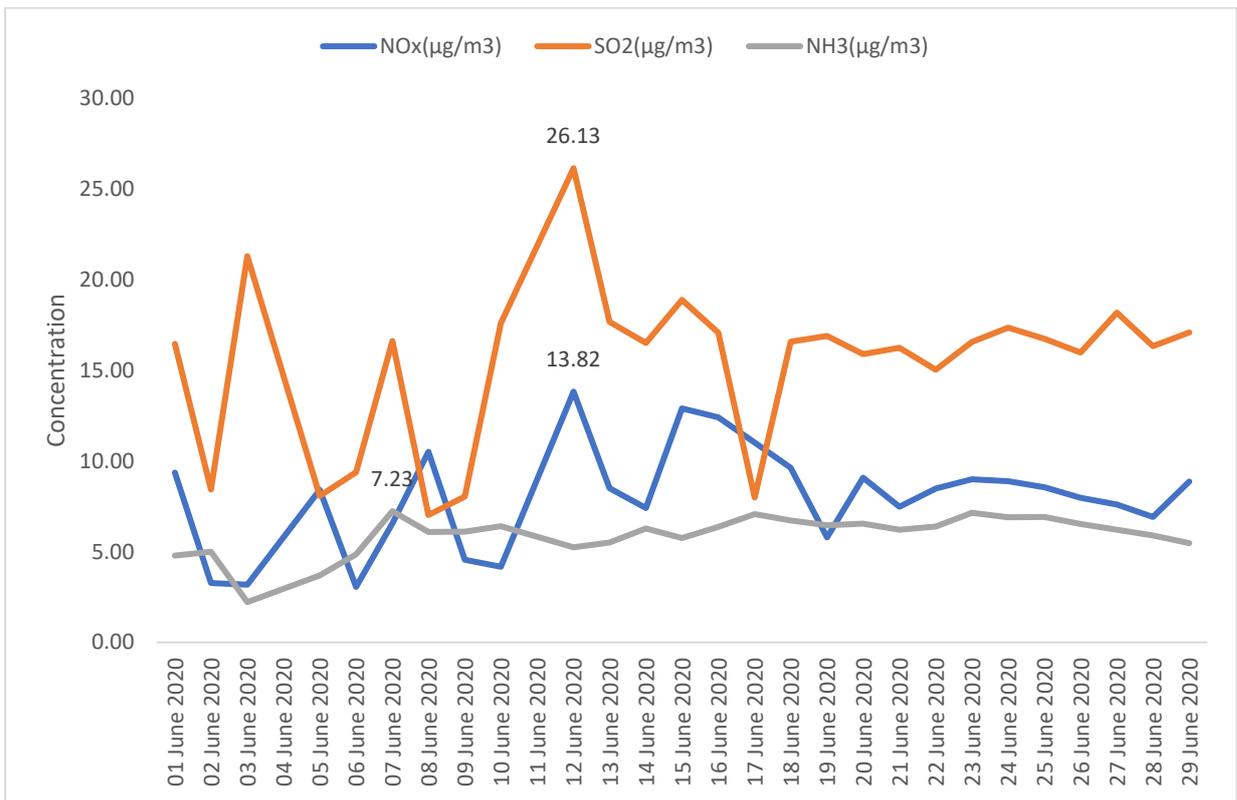
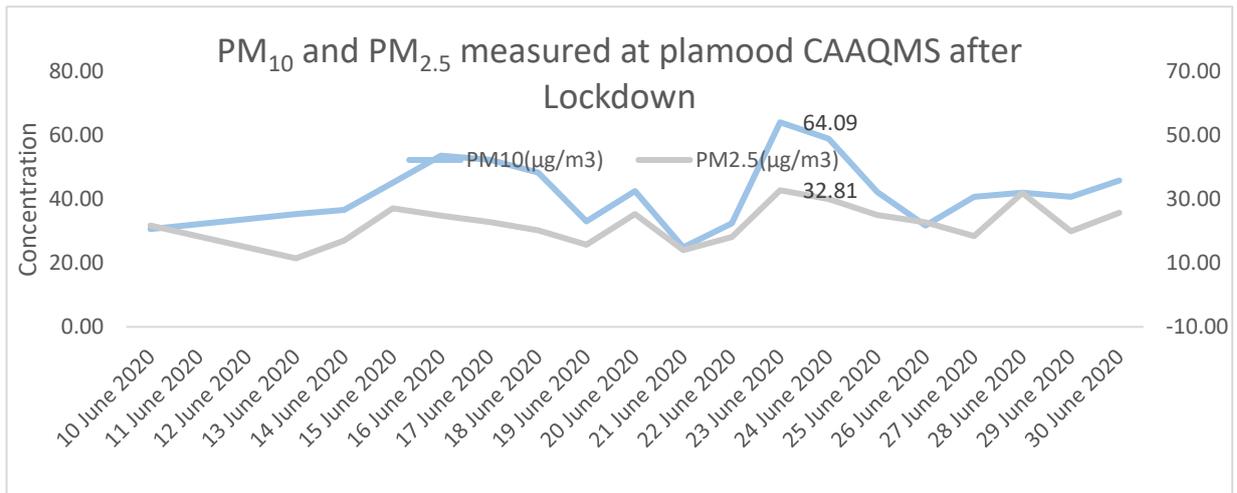


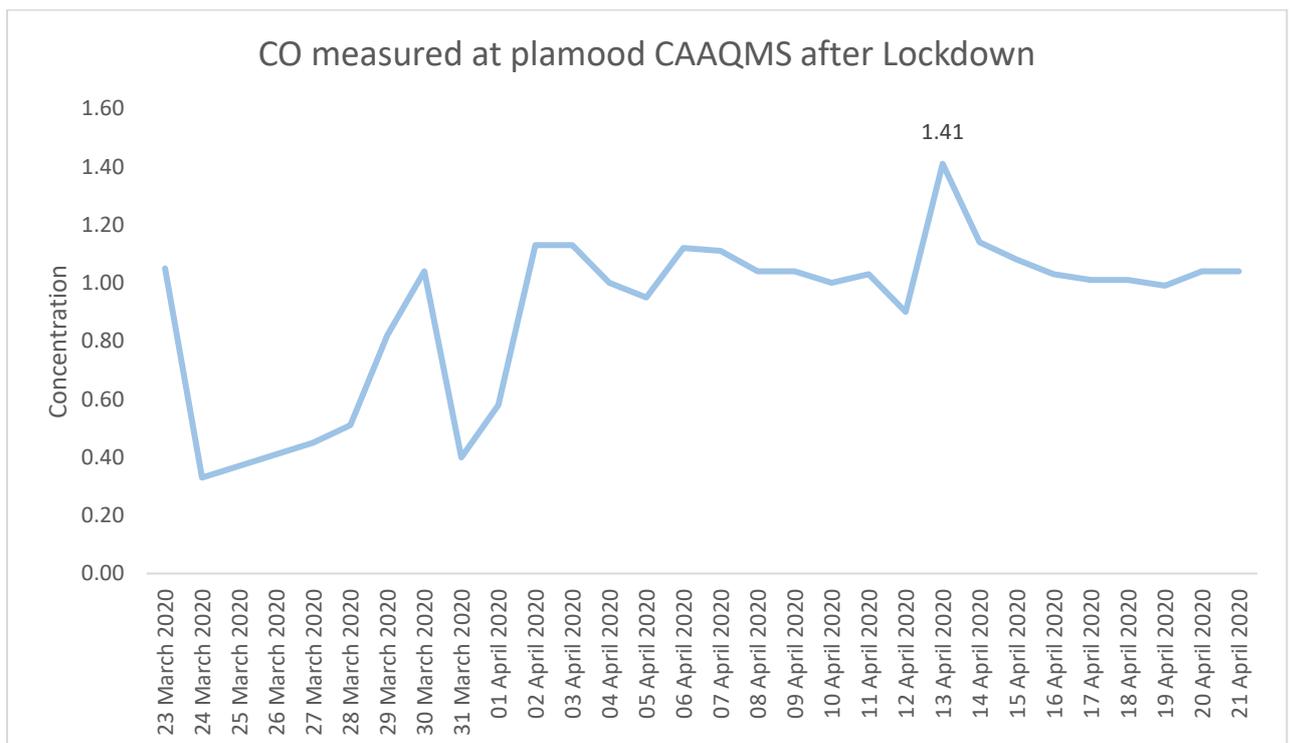
Figure 4.29: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at plamood CAAQM Station after Lockdown

Figure 4.29 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Plamood station after lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 26.13 µg/m<sup>3</sup> and 13.82 µg/m<sup>3</sup> respectively on 12<sup>th</sup> June 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest values registered are 7.23 µg/m<sup>3</sup> on 7<sup>th</sup> June 2020 for NH<sub>3</sub>.



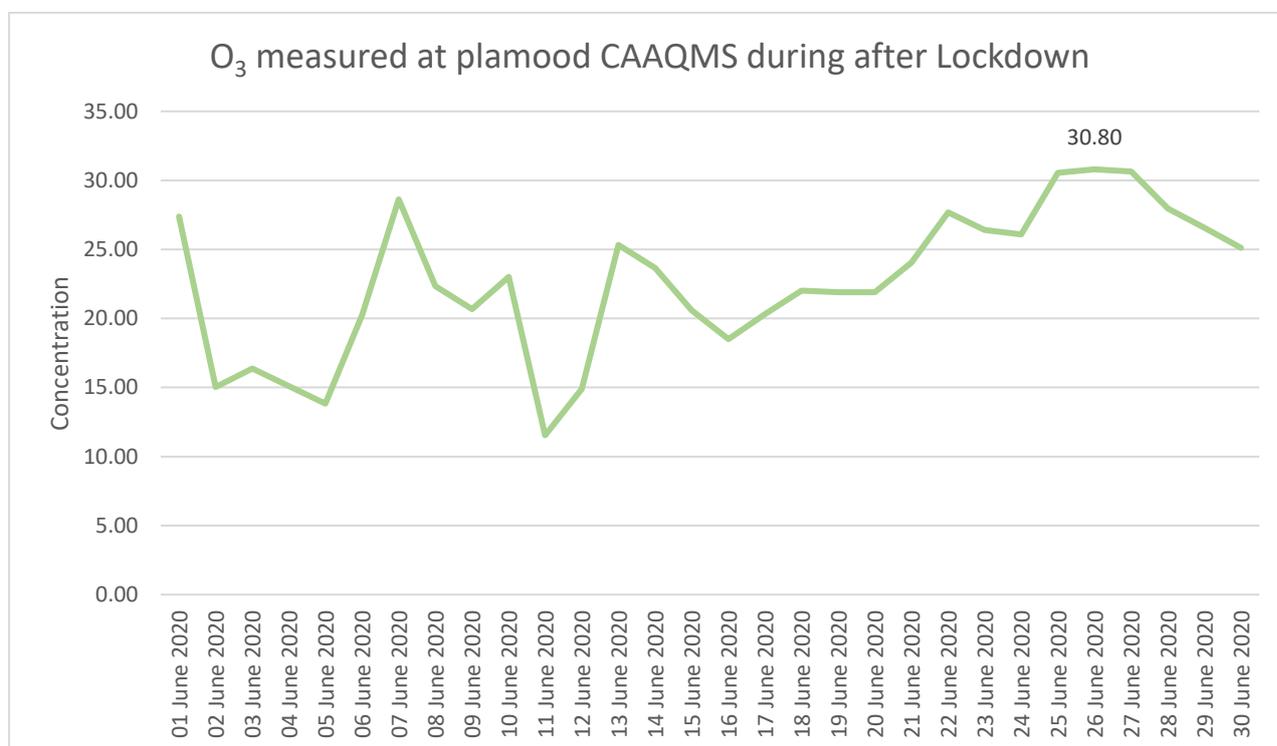
**Figure 4.30: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Plamood CAAQM Station after Lockdown**

Figure 4.30 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at plamood station after lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 64.09 µg/m<sup>3</sup> and 32.81 µg/m<sup>3</sup> respectively on 23<sup>rd</sup> June 2020.



**Figure 4.31: CO measured at Plamood CAAQM Station after Lockdown**

Figure 4.31 shows the 24-hr average values for CO measured at Plamood station during the lockdown. The data analysis indicated that the CO was always below the 8 hour standard of  $2 \mu\text{g}/\text{m}^3$ . The highest value was found to be  $1.41 \mu\text{g}/\text{m}^3$  on 13<sup>th</sup> April 2020.



**Figure 4.32: O<sub>3</sub> measured at Plamood CAAQM Station after Lockdown**

Figure 4.32 shows the 24-hr average values for O<sub>3</sub> measured at Plamood station during the lockdown. The data analysis indicated that the O<sub>3</sub> was always below the 8 hour standard of  $100 \mu\text{g}/\text{m}^3$ . The highest value was found to be  $30.80 \mu\text{g}/\text{m}^3$  on 26<sup>th</sup> June 2020.

#### 4.5.4 Result Analysis

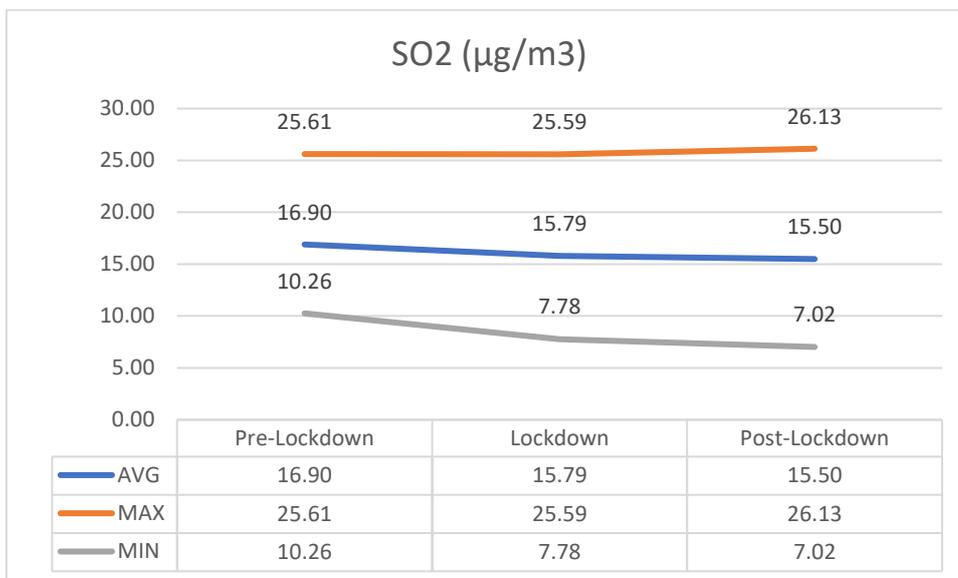


Figure 4.33: SO<sub>2</sub> Values of Plamoodu CAAQM station before, during, and after lockdown.

Figure 4.33 shows that average and minimum values for SO<sub>2</sub> registered a slight decrease during the lockdown period and increased slightly as the lockdown was lifted. The peak value remained nearly the same throughout.

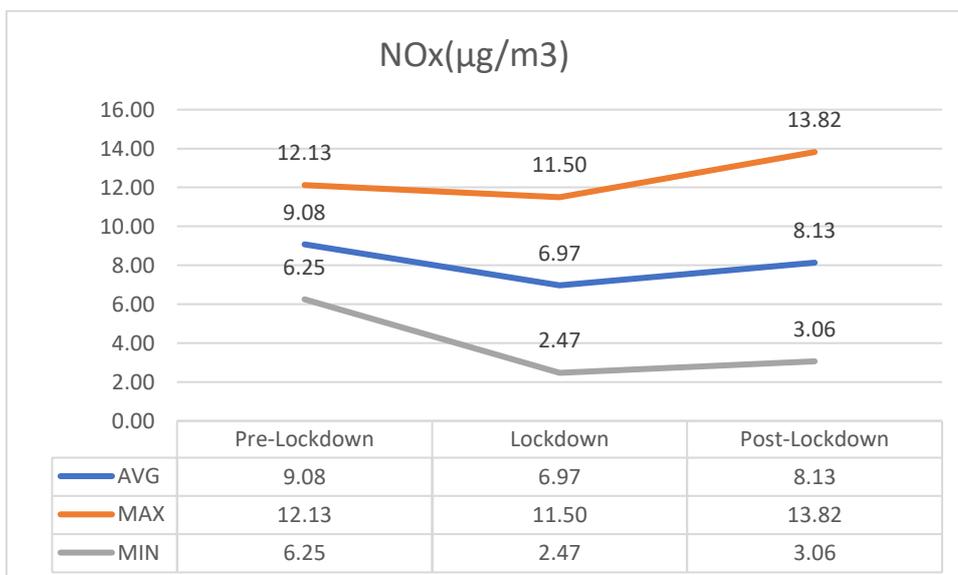


Figure 4.34: NO<sub>x</sub> Values of Plammodu CAAQM Station before, during and after lockdown.

Figure 4.34 shows that average, maximum and minimum values for NO<sub>x</sub> registered a decrease during the lockdown period at Plamood CAAQMS and increased after the lockdown was lifted.

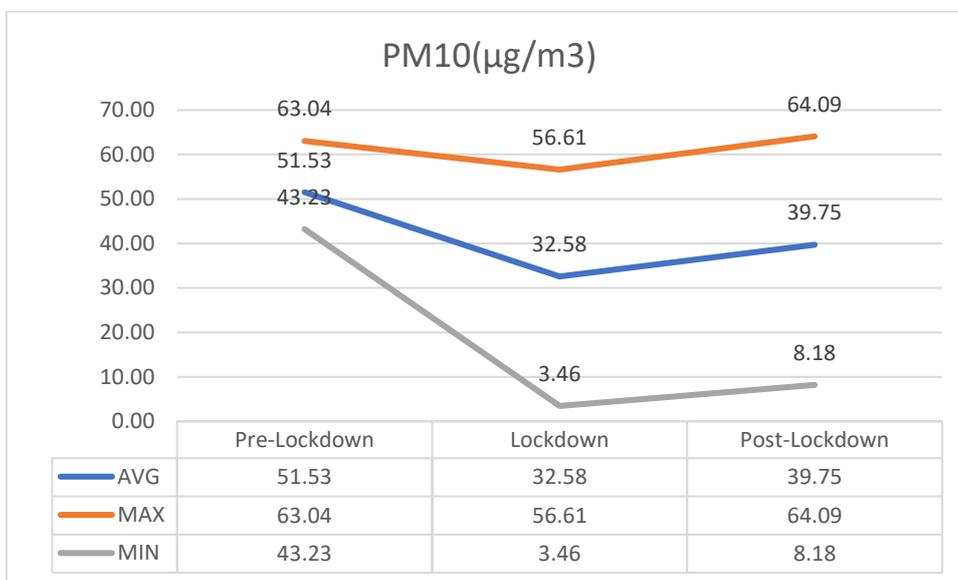


Figure 4.4.35: PM<sub>10</sub> Values of Plamood CAAQM Station before, during and after lockdown.

Figure 4.35 shows that average, maximum and minimum values for PM<sub>10</sub> registered a notable decrease during the lockdown period which later increased slightly as the lockdown was lifted.

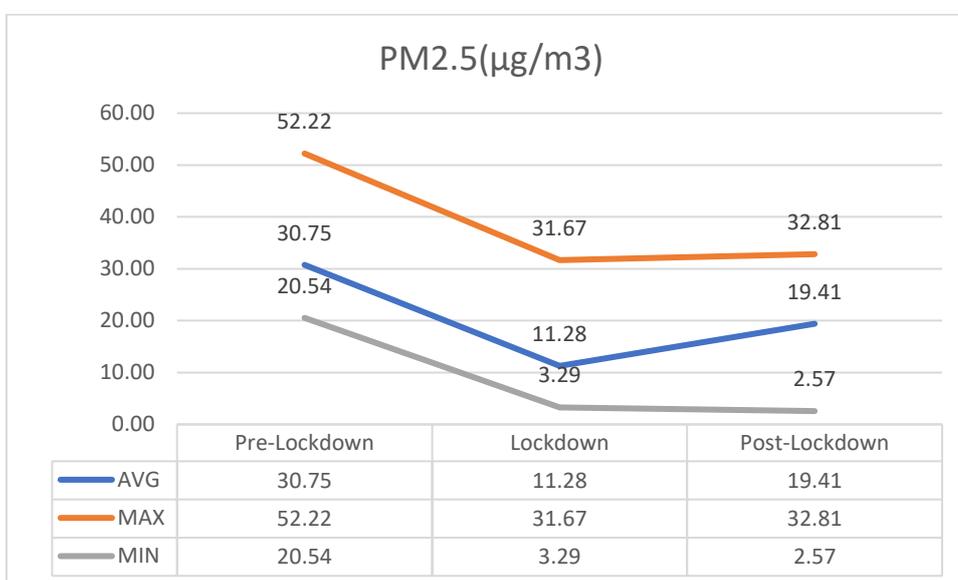


Figure 4.36: PM<sub>2.5</sub> Values of Plamood CAAQM Station before, during, and after lockdown.

Figure 4.36 shows that average, maximum, and minimum values for PM<sub>10</sub> registered a notable decrease during the lockdown period which later increased slightly as the lockdown was lifted except that the minimum value showed a decreasing trend even afterwards.

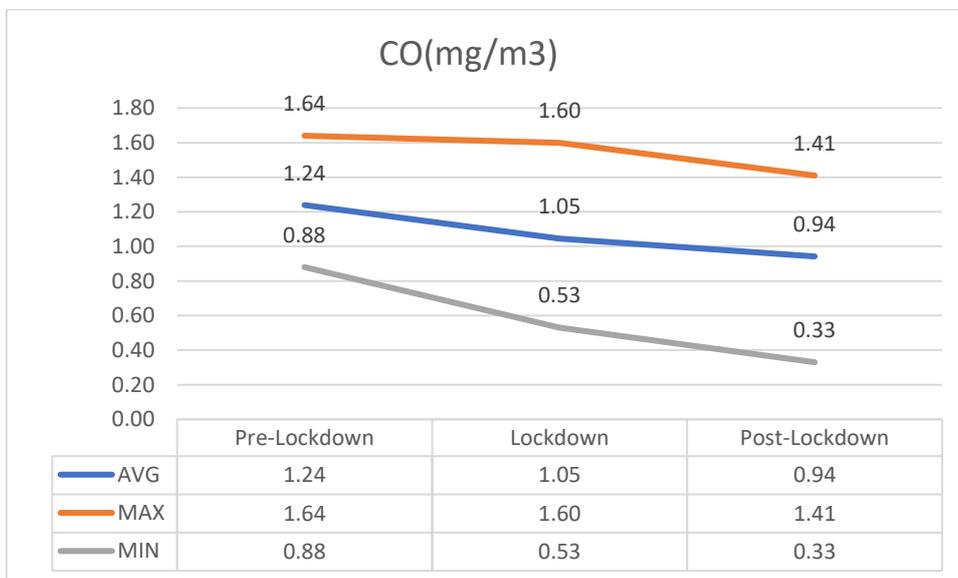


Figure 4.37: CO Values of Plamood CAAQM Station before, during and after lockdown.

Figure 4.37 shows that average, maximum and minimum values for CO registered a decrease during the lockdown period. These values continued to show a decreasing trend even afterwards.

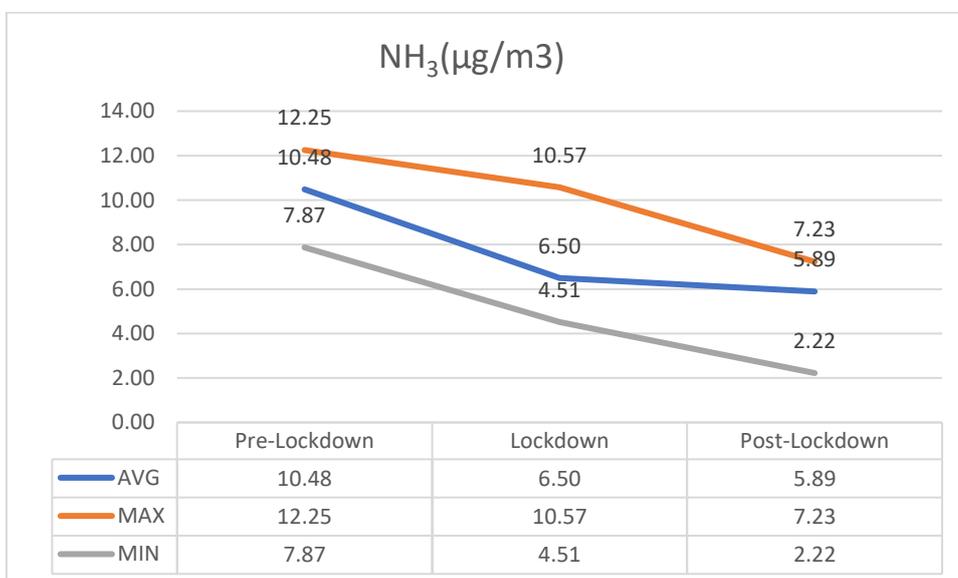


Figure 4.38: NH<sub>3</sub> Values of Plamood CAAQM Station before, during and after lockdown.

Figure 4.38 shows that average, maximum and minimum values for NH<sub>3</sub> registered a notable decrease during the lockdown period. These values continued to show a decreasing trend which later decreased to that lower than the pre-lockdown value.

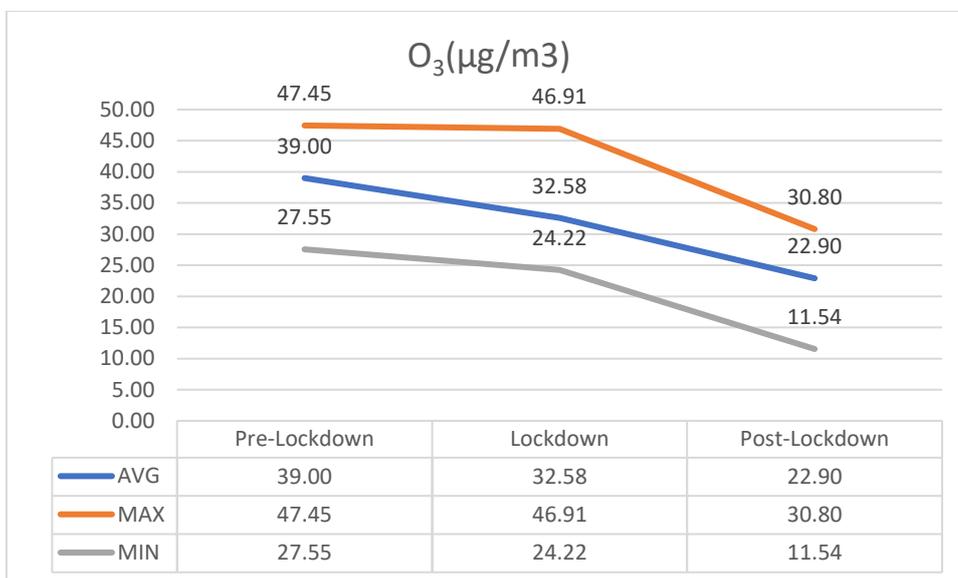


Figure 4.39: O<sub>3</sub> Values of Plamood CAAQMS before, during, and after lockdown.

Figure 4.39 shows that average, maximum and minimum values for O<sub>3</sub> registered a notable decrease during the lockdown period. These values continued to show a decreasing trend to a lower value than the pre-lockdown value.

#### 4.6 Karyavattom CAAQMS (Residential)

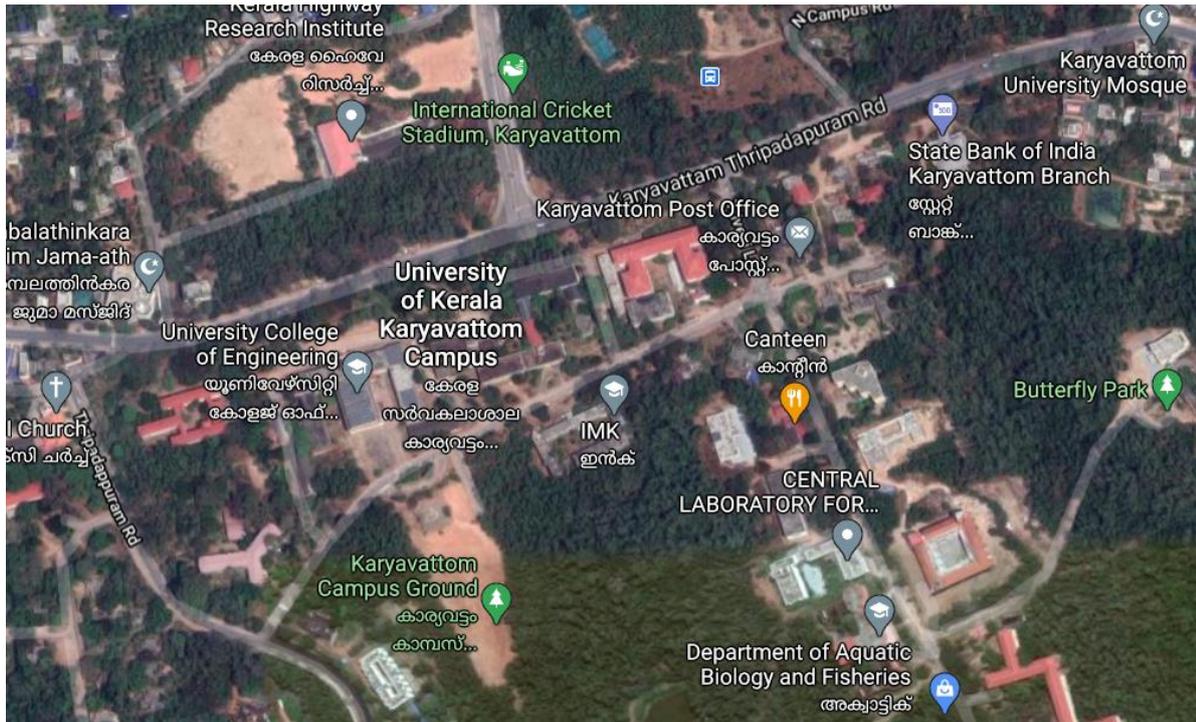


Figure 4.40: Land use pattern at Karyavattom CAAQM Station

The CAAQMS is located in a residential area with college, stadium and IT hub nearby. The land use pattern has already been depicted in Table 4.1

#### 4.6.1 Before Lockdown

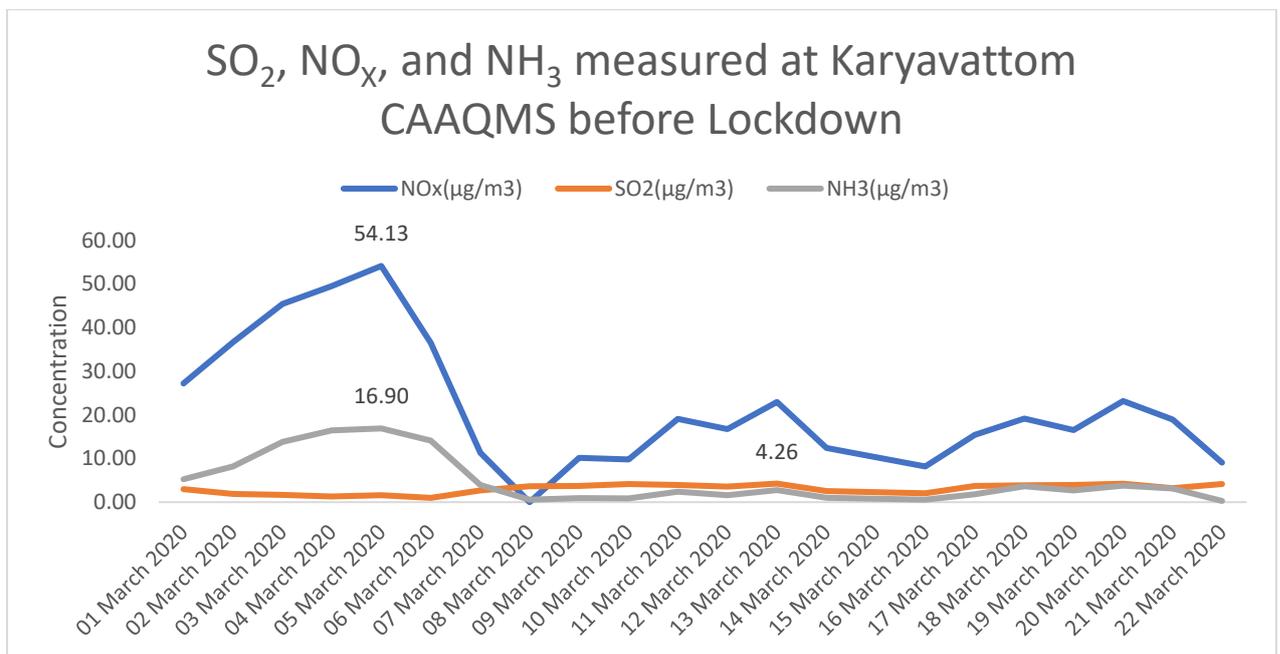


Figure 4.41: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Karyavattom CAAQM Station before Lockdown

Figure 4.41 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Karyavattom CAAQMS before lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> values were well below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 4.26 µg/m<sup>3</sup> and 54.13 µg/m<sup>3</sup> respectively on 13<sup>th</sup> March 2020 and 5<sup>th</sup> March 2020. The concentration of NH<sub>3</sub> is well within the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 16.90 µg/m<sup>3</sup> on 5<sup>th</sup> March 2020.

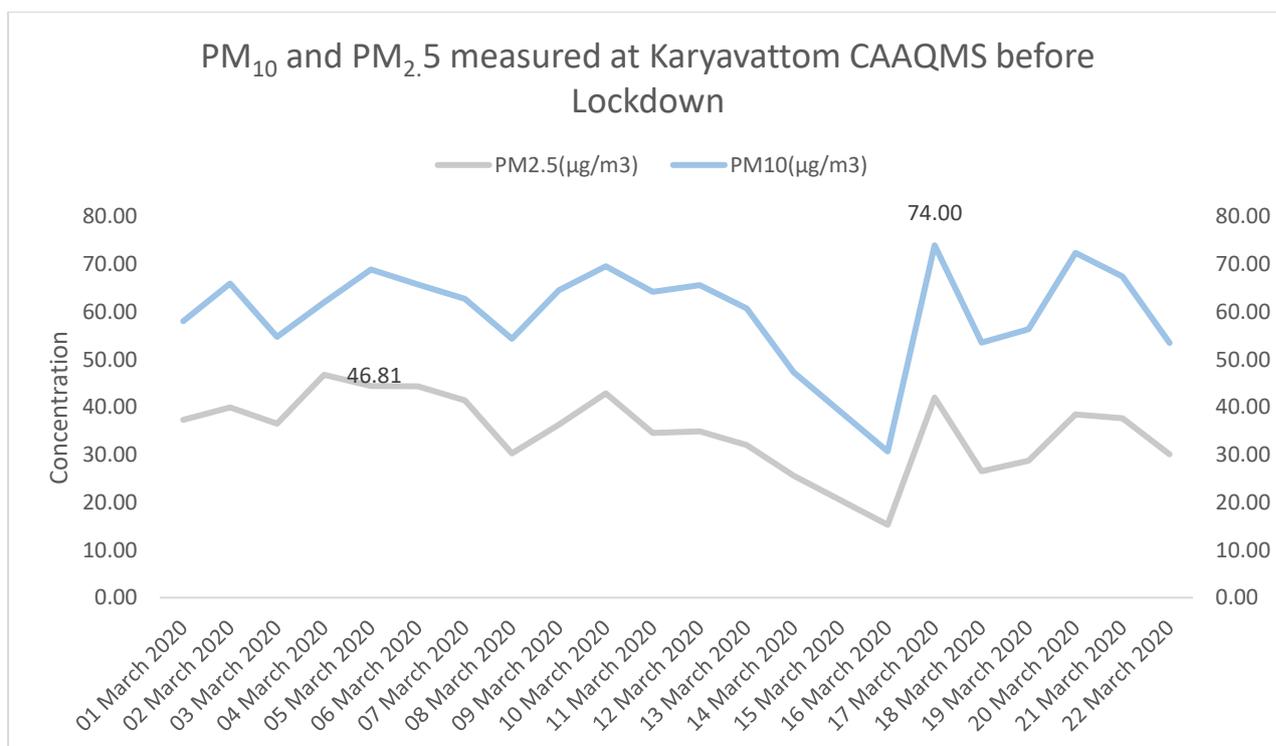


Figure 4.42: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Karyavattom CAAQM Station before Lockdown

Figure 4.42 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Karyavattom CAAQMS before lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> values were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 74.00 µg/m<sup>3</sup> and 46.81 µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020 and 4<sup>th</sup> March 2020.

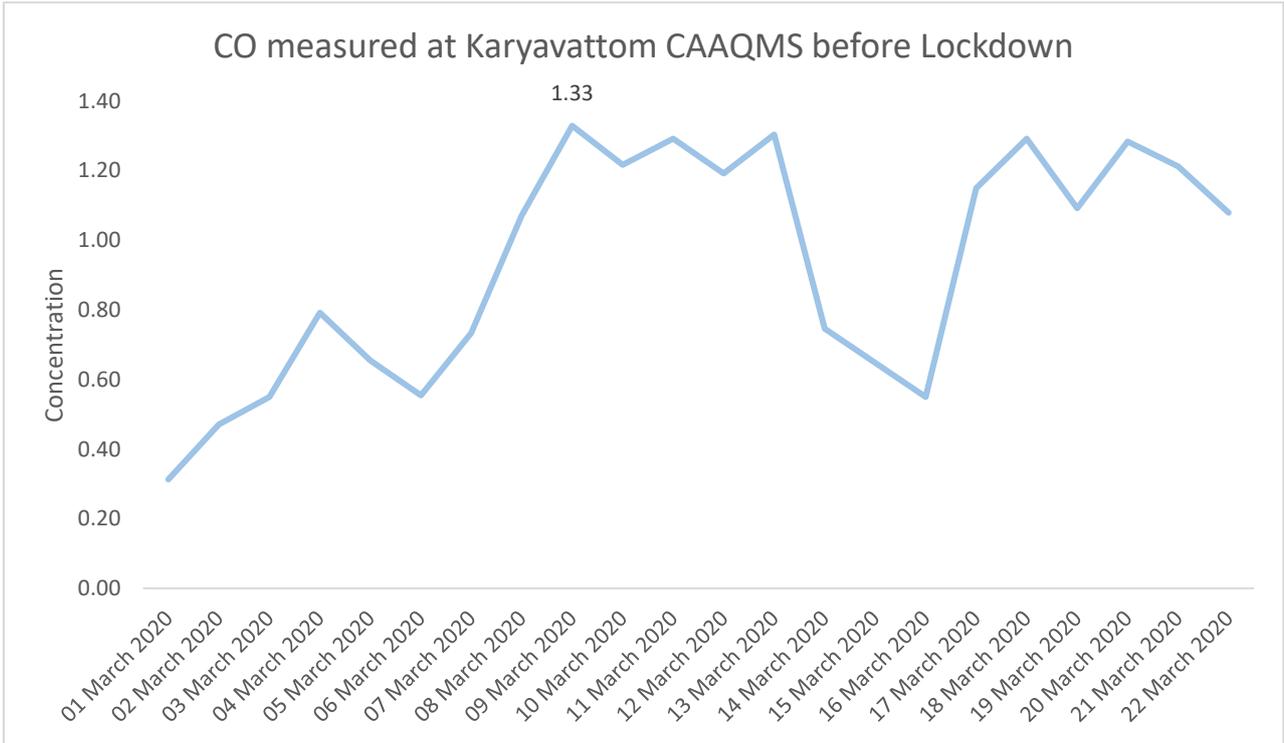


Figure 4.43: CO measured at Plamood CAAQM Station before Lockdown

Figure 4.43 shows the 24-hr average values for CO measured at Plamood station before lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 1.33 mg/m<sup>3</sup> on 9<sup>th</sup> March 2020.

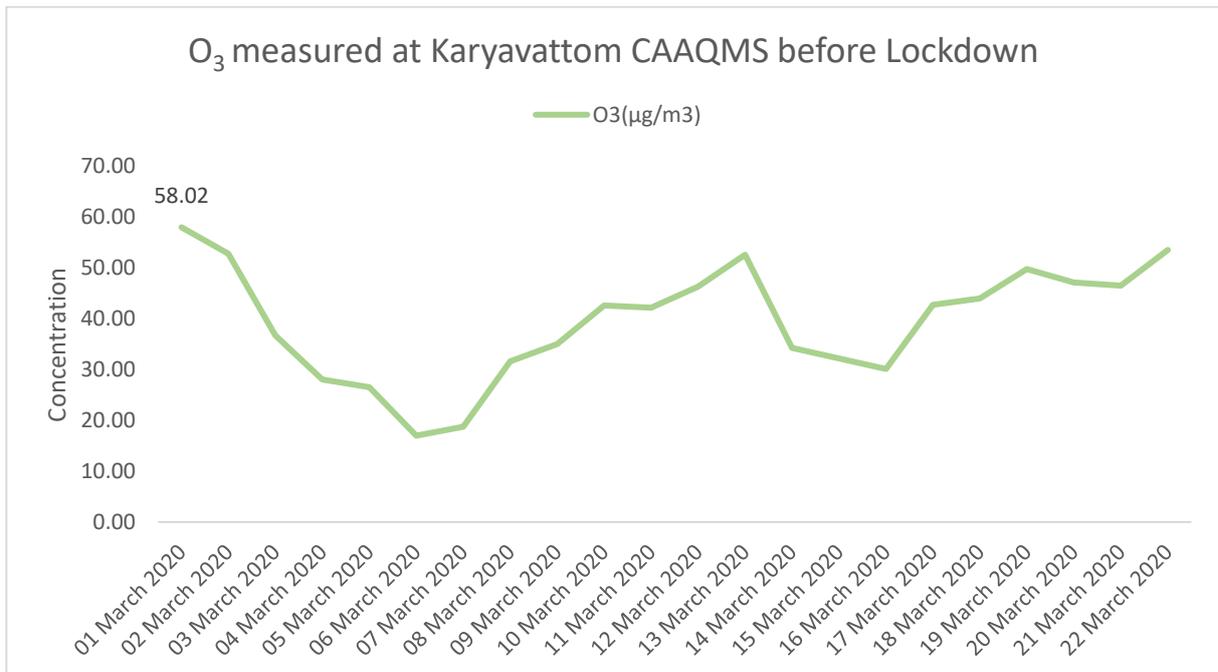


Figure 4.44: O<sub>3</sub> measured at Karyavattom CAAQM Station before Lockdown

Figure 4.44 shows the 24-hr average values for O<sub>3</sub> measured at Karyavattom station before lockdown. The data analysis indicated that the O<sub>3</sub> was well within the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 58.02 µg/m<sup>3</sup> on 1<sup>st</sup> March 2020.

#### 4.6.2 During Lockdown

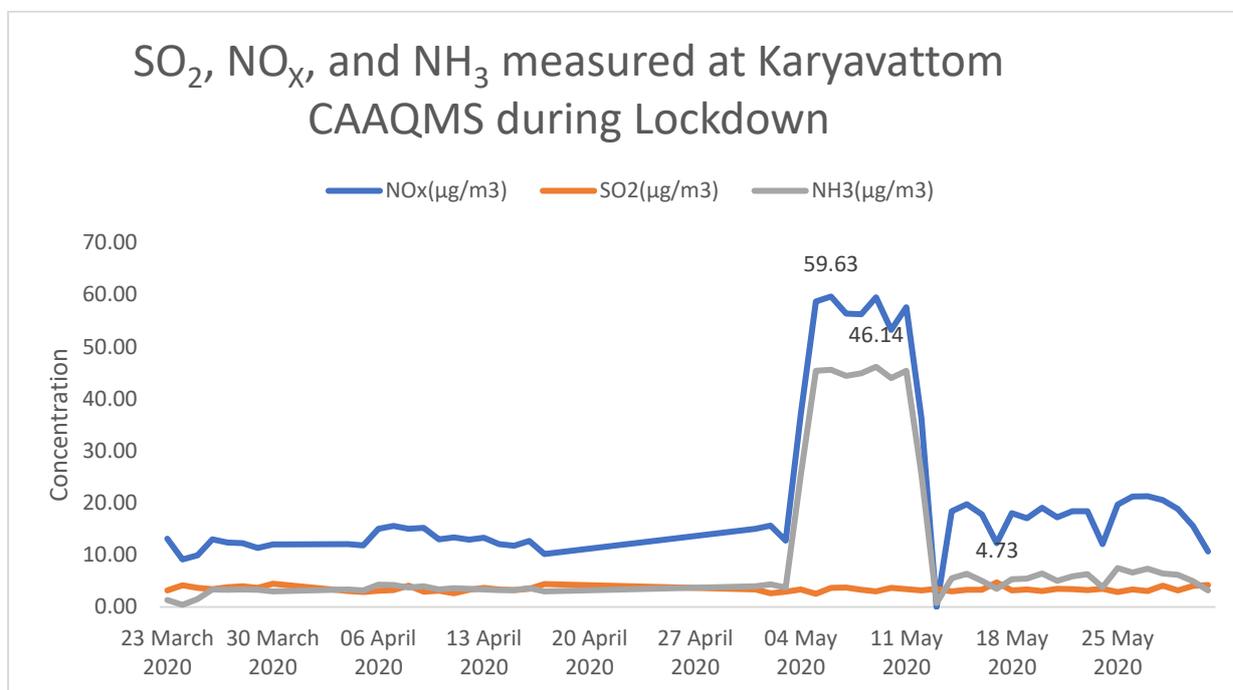
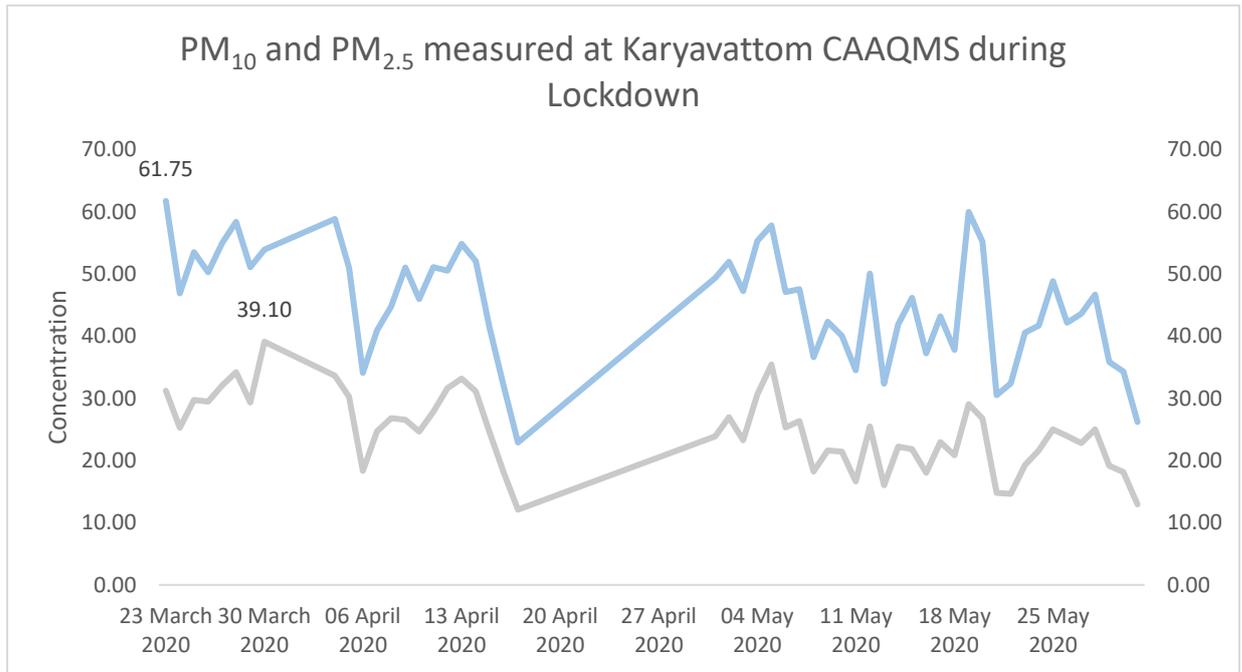


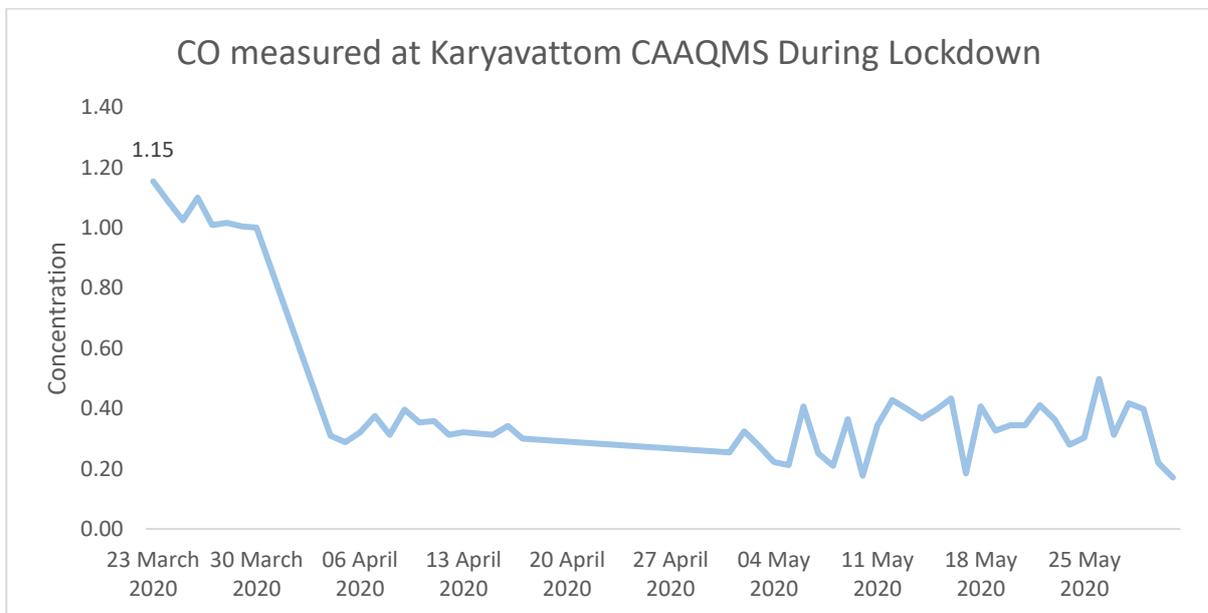
Figure 4.45: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Karyavattom CAAQM Station during Lockdown

Figure 4.45 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Karyavattom CAAQMS during the lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> were well below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 4.73 µg/m<sup>3</sup> and 59.63 µg/m<sup>3</sup> respectively on 17<sup>th</sup> May 2020 and 6<sup>th</sup> May 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest values registered are 46.14 µg/m<sup>3</sup> on 9<sup>th</sup> May 2020 for NH<sub>3</sub>.



**Figure 4.46: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Karyavattom CAAQM Station during Lockdown**

Figure 4.46 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Karyavattom CAAQMS after lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were well below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 61.75 µg/m<sup>3</sup> and 39.10 µg/m<sup>3</sup> respectively on 23<sup>rd</sup> March 2020 and 30<sup>th</sup> March 2020.



**Figure 4.47: CO measured at Karyavattom CAAQM Station during Lockdown**

Figure 4.47 shows the 24-hr average values for CO measured at Karyavattom CAAQMS during the lockdown. The data analysis indicates that the CO is well below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 1.15 mg/m<sup>3</sup> on 23<sup>rd</sup> March 2020.

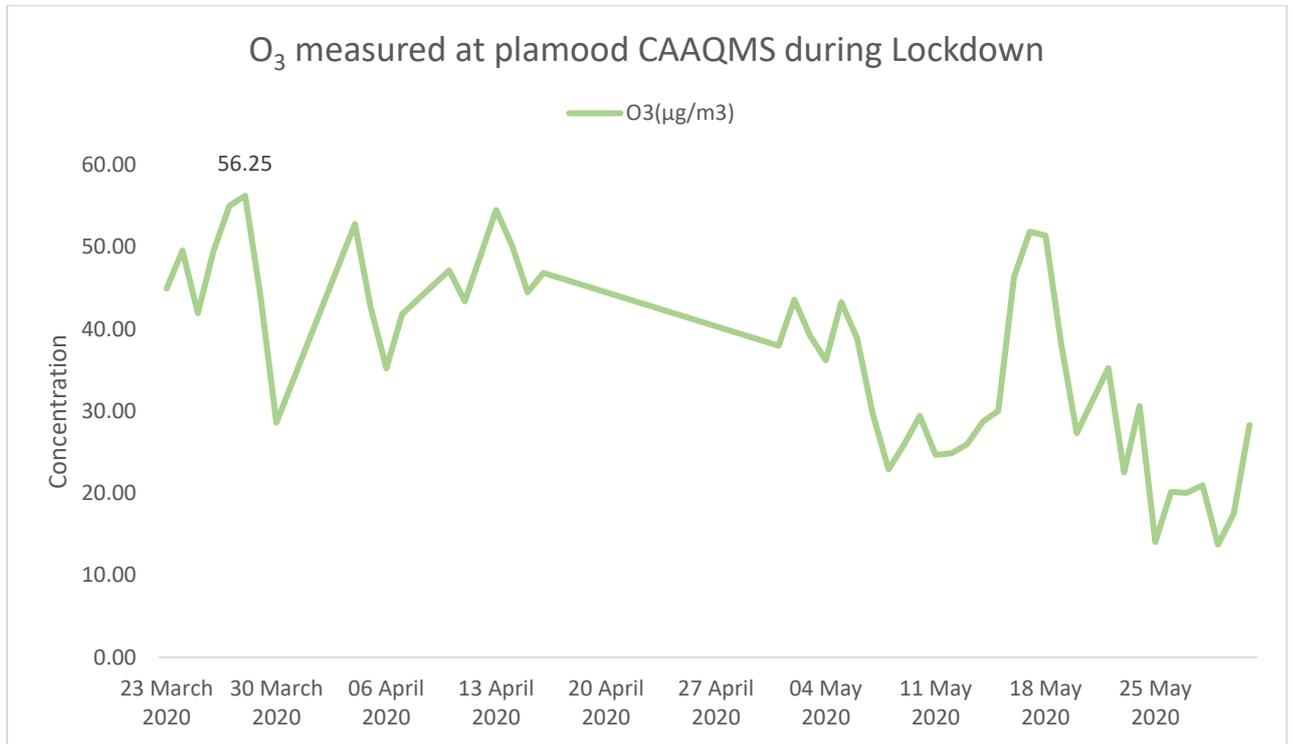


Figure 4.48: O<sub>3</sub> measured at Karyavattom CAAQM Station during Lockdown

Figure 4.48 shows the 24-hr average values for O<sub>3</sub> measured at Karyavattom CAAQMS station during the lockdown. The data analysis indicates that the O<sub>3</sub> was well below the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value is found to be 56.25 µg/m<sup>3</sup> on 28<sup>th</sup> March 2020.

### 4.6.3 After Lockdown

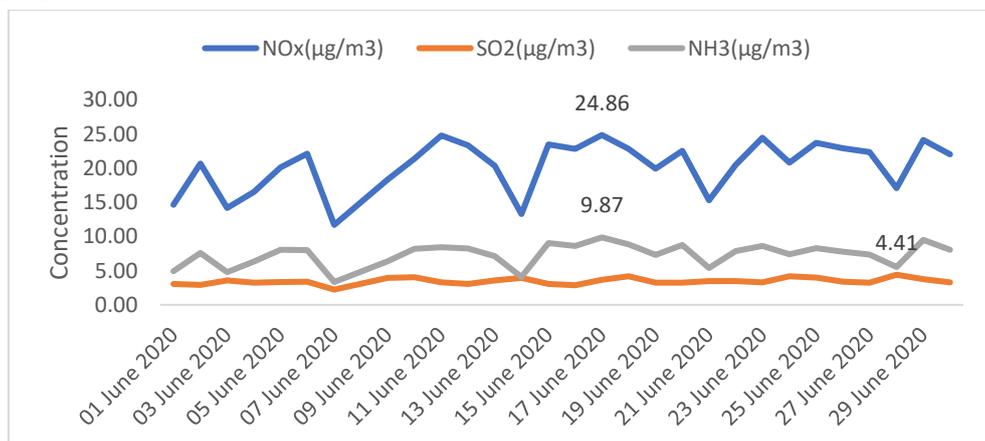
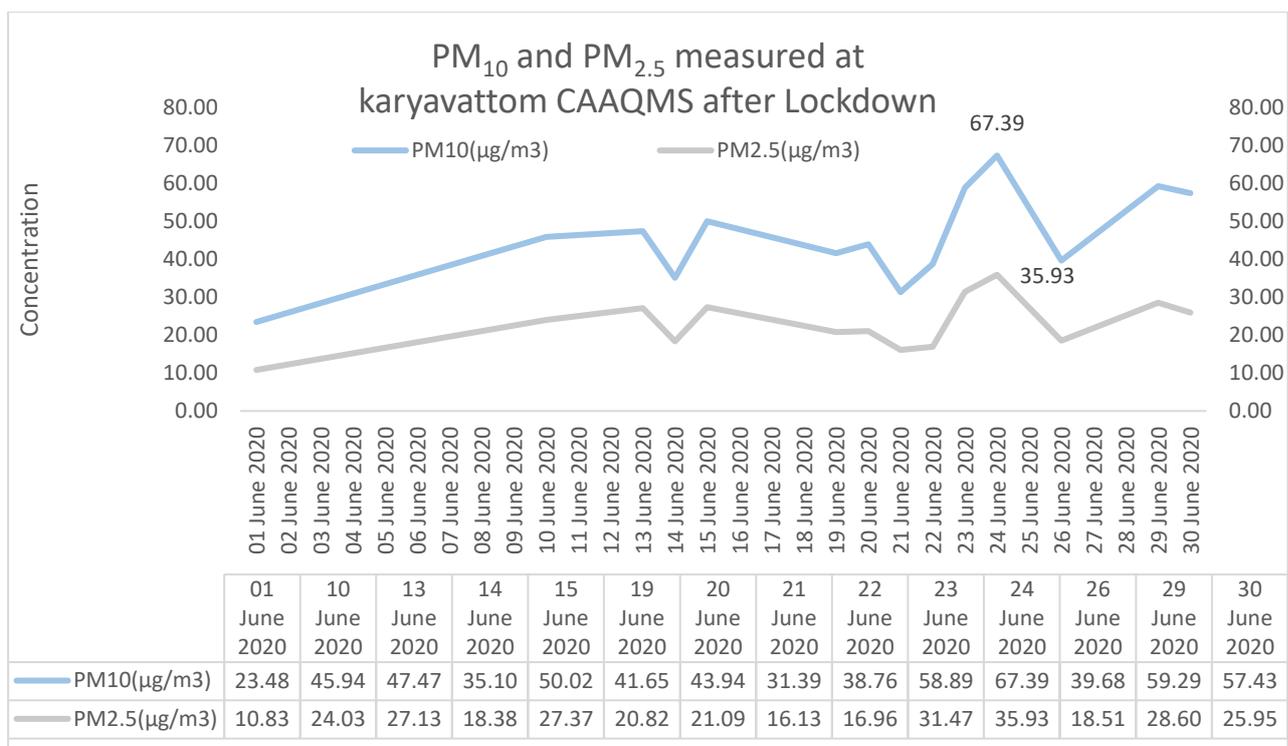


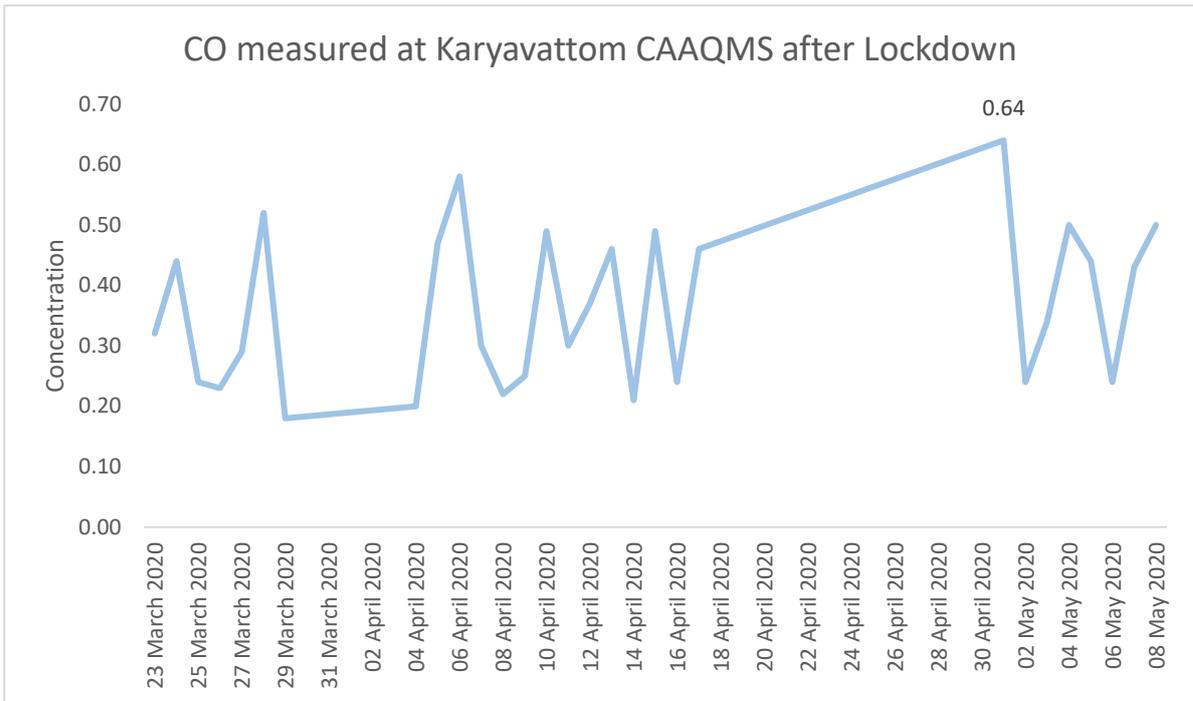
Figure 4.49: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Karyavattom CAAQM Station after Lockdown

Figure 4.49 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Karyavattom CAAQMS after lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> were well below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 4.41 µg/m<sup>3</sup> and 24.86 µg/m<sup>3</sup> respectively on 28<sup>th</sup> June 2020 and 17<sup>th</sup> June 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest values registered are 9.87 µg/m<sup>3</sup> on 17<sup>th</sup> June 2020 for NH<sub>3</sub>.



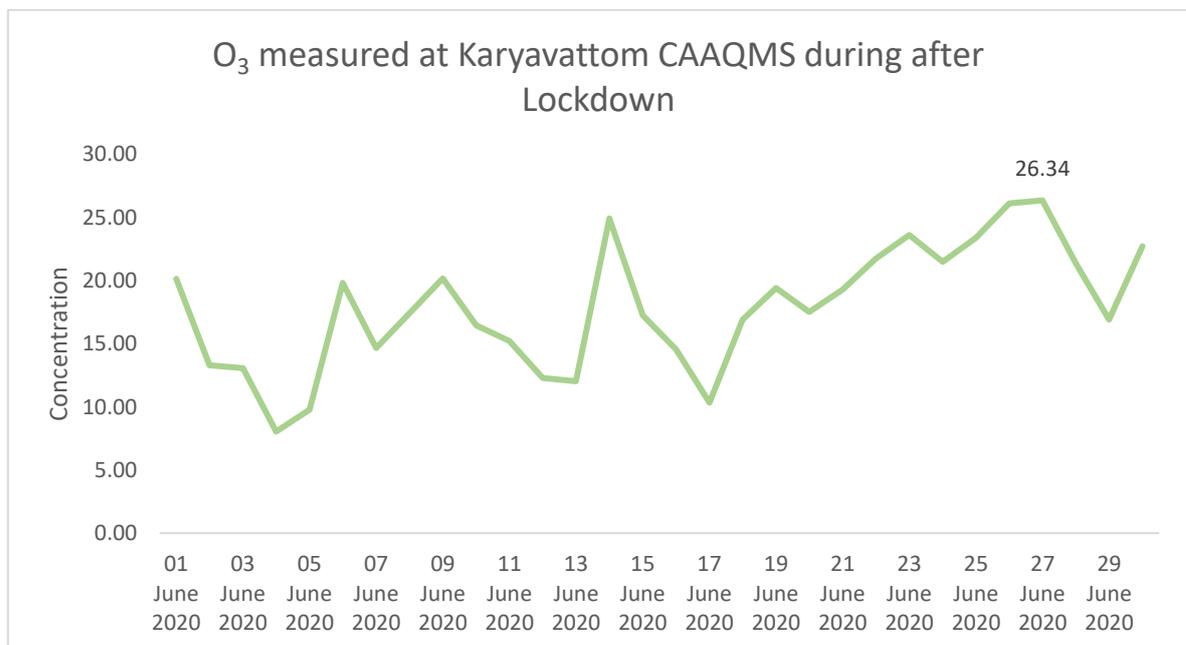
**Figure 4.50: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Karyavattom CAAQM Station after Lockdown**

Figure 4.50 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Karyavattom CAAQMS after lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were well below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 67.39 µg/m<sup>3</sup> and 35.93 µg/m<sup>3</sup> respectively on 24<sup>th</sup> June 2020.



**Figure 4.51: CO measured at Karyavattom CAAQM Station after Lockdown**

Figure 4.51 shows the 24-hr average values for CO measured at Karyavattom CAAQMS after lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 0.64 mg/m<sup>3</sup> on 1<sup>st</sup> May 2020.



**Figure 4.52: O<sub>3</sub> measured at Karyavattom CAAQM Station after Lockdown**

Figure 4.52 shows the 24-hr average values for O<sub>3</sub> measured at Karyavattom CAAQMS station after lockdown. The data analysis indicated that the O<sub>3</sub> was always below the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 26.34 µg/m<sup>3</sup> on 27<sup>th</sup> June 2020.

#### 4.6.4 Result Analysis

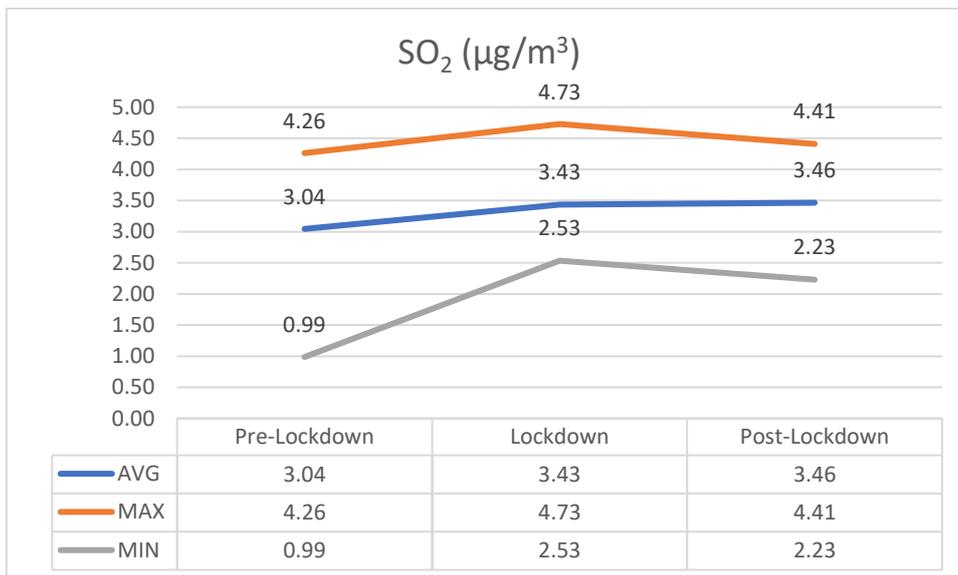


Figure 4.53: SO<sub>2</sub> Values of Karyavattom CAAQM Station before, during and after lockdown.

Figure 4.53 shows that average, maximum and minimum values for SO<sub>2</sub> registered a slight increase during the lockdown period which later decreased as the lockdown was lifted.

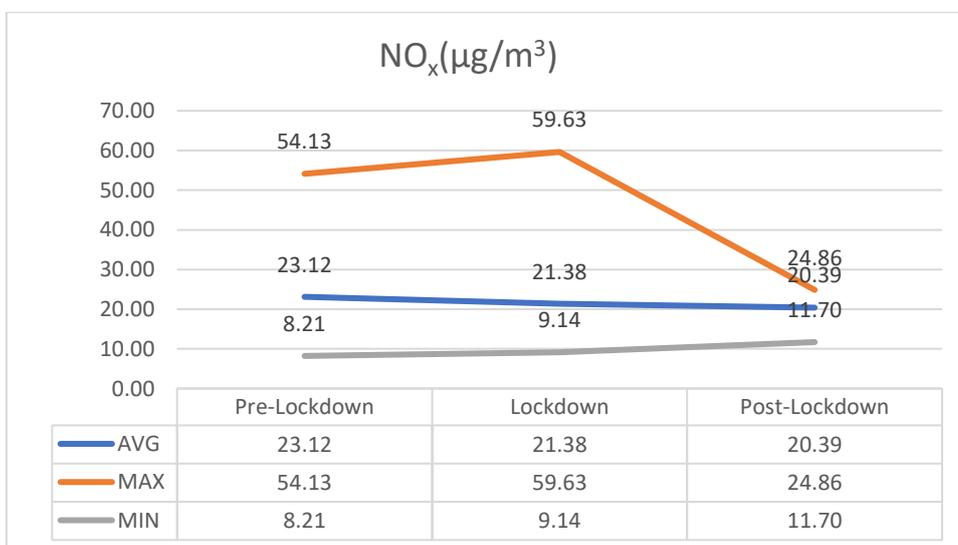


Figure 4.54: NO<sub>x</sub> Values of Karyavattom CAAQMS before, during and after lockdown.

Figure 4.54 shows that average, maximum and minimum values for NO<sub>x</sub> registered a slight increase during the lockdown period at Karyavattom CAAQMS but the peak value decrease after the lockdown.

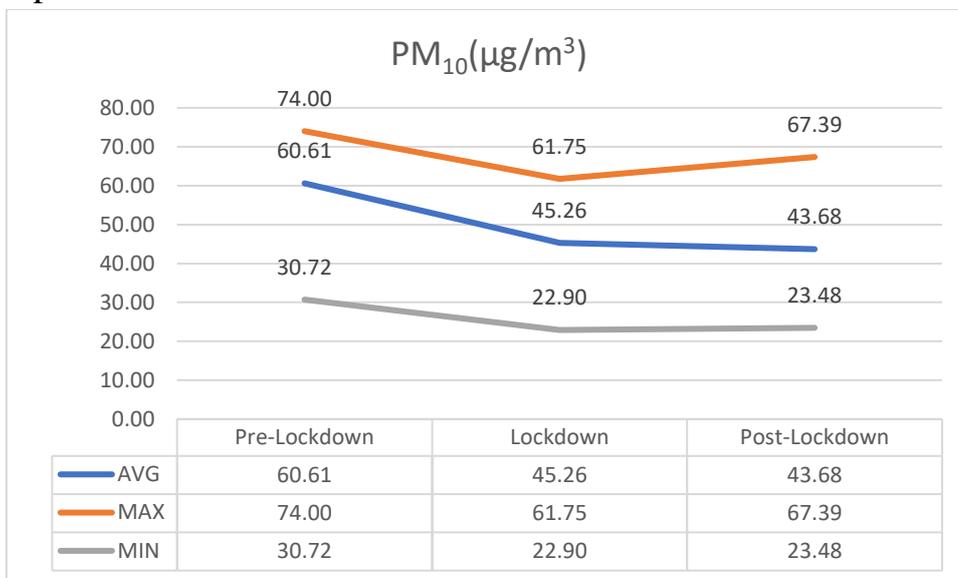


Figure 4.55: PM<sub>10</sub> Values of Karyavattom CAAQMS before, during and after lockdown.

Figure 4.55 shows that average and minimum values for PM<sub>10</sub> registered a notable decrease during the lockdown period. The peak value registered a comeback as the lockdown was lifted, whereas the average value continued in a decreasing trend.

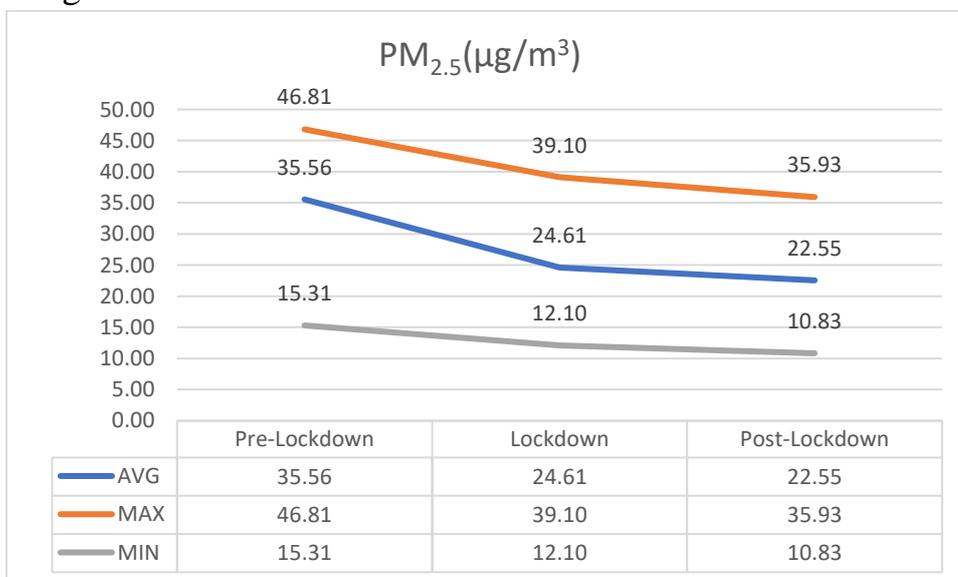


Figure 4.56: PM<sub>2.5</sub> Values of Karyavattom CAAQMS before, during and after lockdown.

Figure 4.56 shows that the average and minimum values for PM<sub>2.5</sub> registered a notable decrease during the lockdown period. The peak value registered a

comeback as the lockdown was lifted, whereas the average value continued in a decreasing trend.

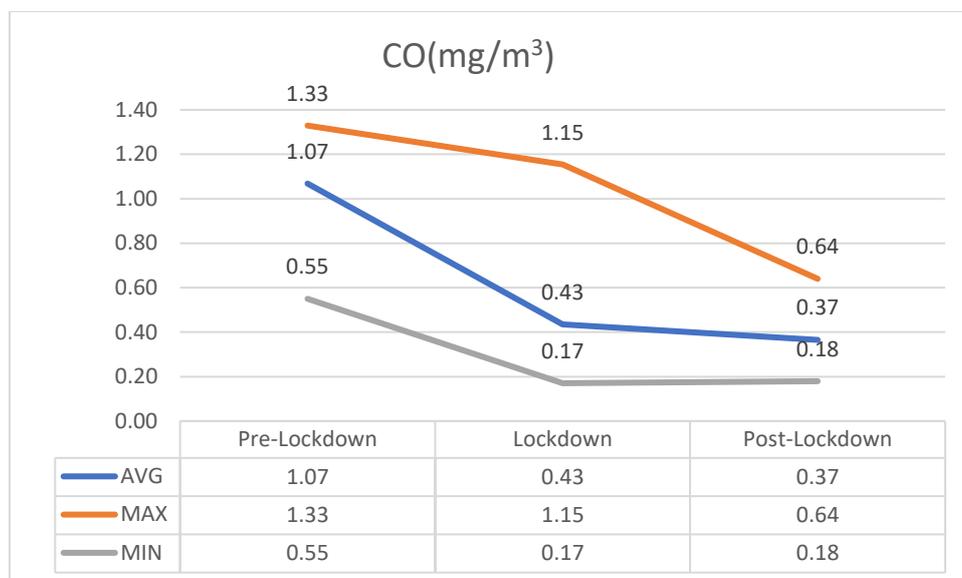


Figure 4.57: CO Values of Karyavattom CAAQMS before, during and after lockdown.

Figure 4.57 shows that average and maximum values show a decreasing trend after the lockdown also.

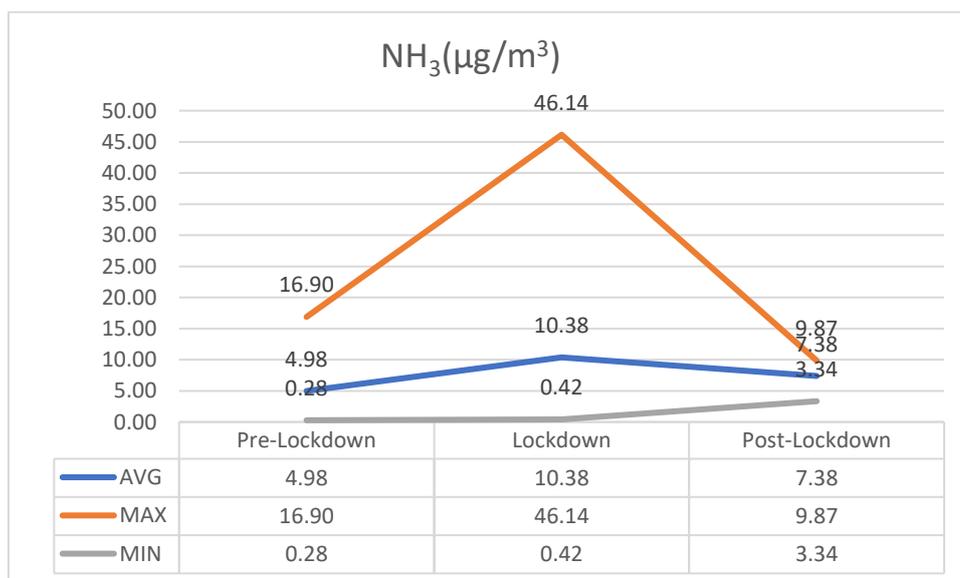
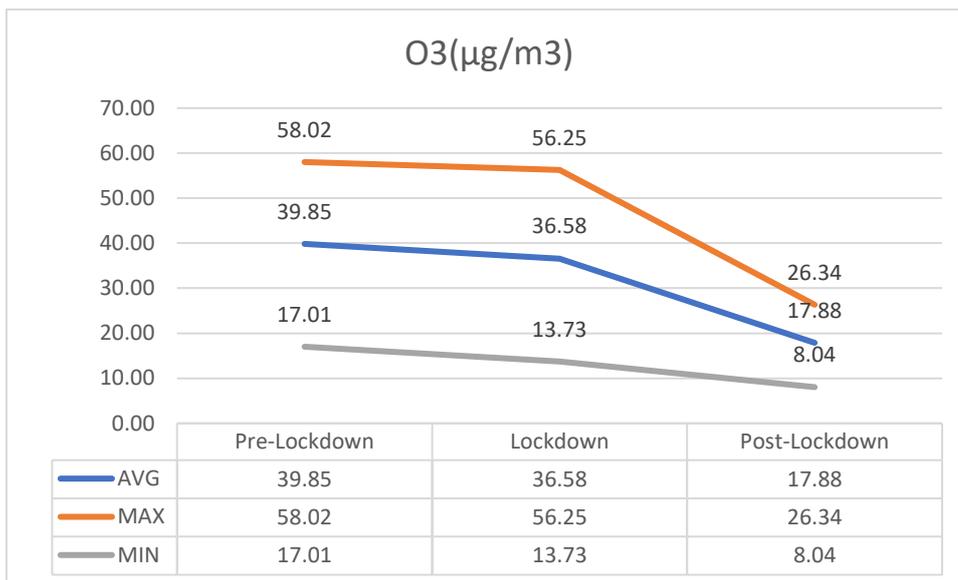


Figure 4.58: NH<sub>3</sub> Values of Karyavattom CAAQMS before, during and after lockdown.

Figure 4.58 shows that though the average and maximum values for NH<sub>3</sub> registered a notable increase during the lockdown period, these values later decreased to that lower than the pre-lockdown value.



**Figure 4.59: O<sub>3</sub> Values of Karyavattom CAAQMS before, during and after lockdown.**

Figure 4.59 shows that even though the average, maximum and minimum values for O<sub>3</sub> registered a decrease during the lockdown period. These values continued to show a decreasing trend which later decreased to that lower than the pre-lockdown value.

## 5 Kollam City

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The list of Monitoring stations in the city is tabulated in Table 5.1. The land use pattern is also depicted in the table

Table 5.1: List of Monitoring Stations in Kollam

Site	Co-Ordinates	Scheme	Type	Land Use Pattern
Kadappakkada	8.884458, 76.583476	Namp	Residential	Commercial,major roads,residential
KMML,Chavara	9.001898, 76.533474	Namp	Industrial	Industrial, major roads
Polayathode	8.8787, 76.6073	CAAQMS	Residential	Commercial,major roads,residential

Table 5.2 gives the growth of vehicles in the district of Kollam, which has shown steady growth in numbers

Table 5.2: Vehicular Count in the city

Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
No of vehicles	600398	661896	776314	778218	868077	1049149

## 5.1 Kadappakada (Residential) - Manual Monitoring Station

Kadappakda is a residential area in the city through which a National High Way passes through. The land use pattern includes Commercial, major roads and residential

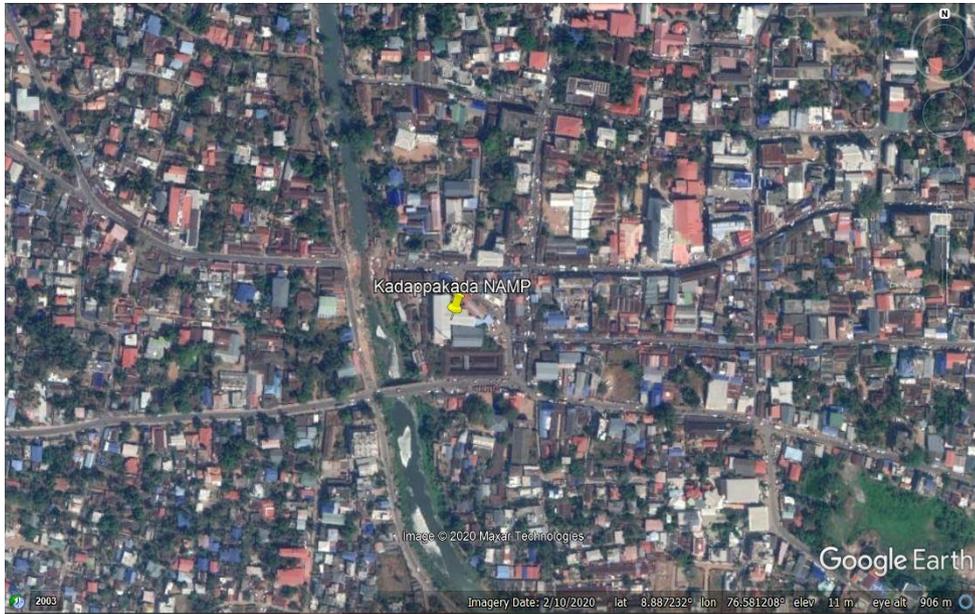


Figure 5.1: Land use pattern at Kadappakada

### 5.1.1 Before Lockdown

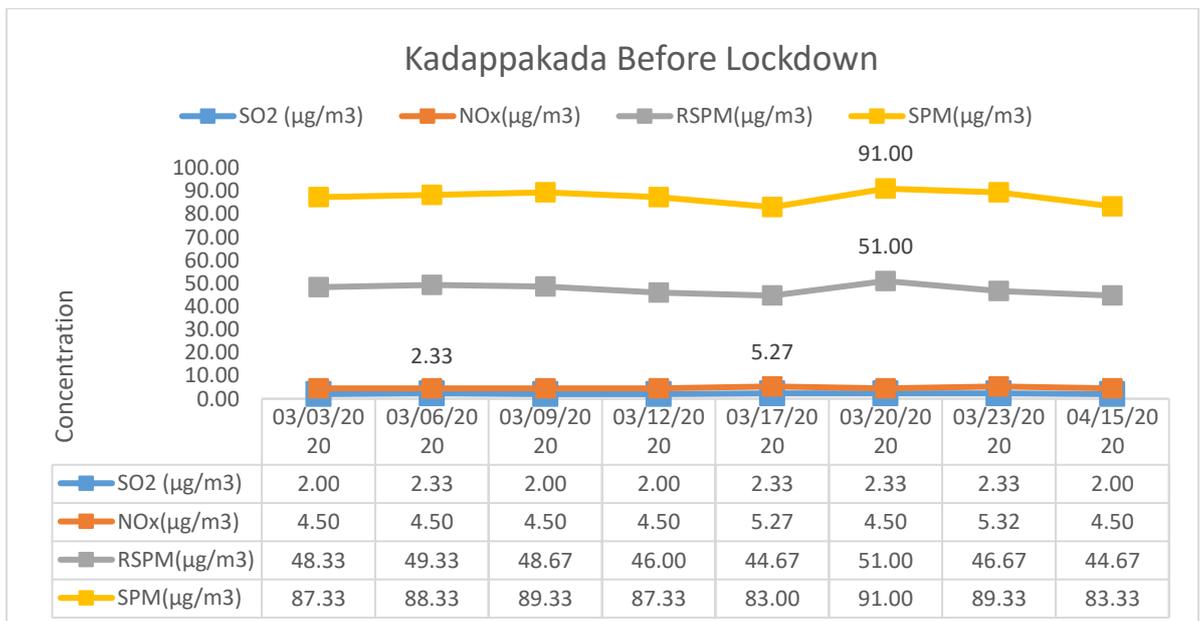


Figure 5.2: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Kadappakada station before lockdown

Figure 5.2 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Kadappakada station before Lockdown. The data analysis indicates that the RSPM and SPM are always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest value of the RSPM and SPM recorded as on 20<sup>th</sup> March 2020, as 51 µg/m<sup>3</sup> and 91 µg/m<sup>3</sup> respectively. The concentration of SO<sub>2</sub> and NO<sub>x</sub> are well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.3 µg/m<sup>3</sup> and 5.27 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 5.1.2 During Lockdown

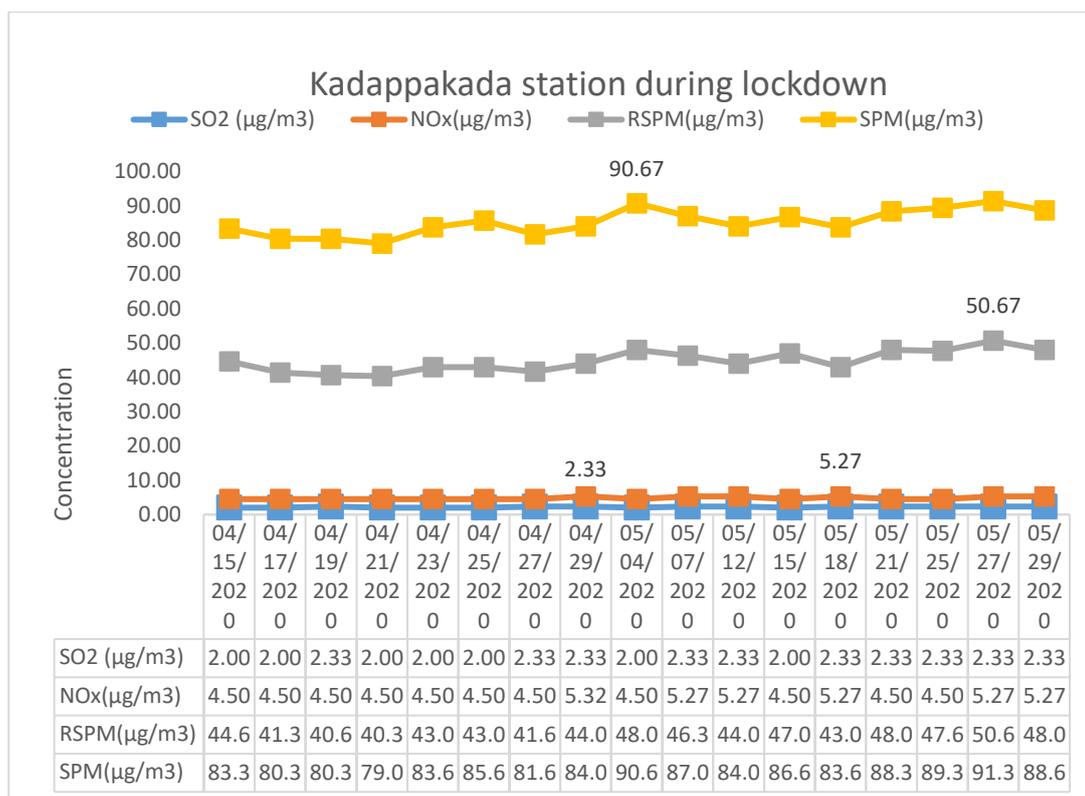


Figure 5.3: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Kadappakada station during the lockdown

Figure 5.3 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Kadappakada station during the lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest values of RSPM and SPM value were recorded as 90.6 µg/m<sup>3</sup> and 50.6 µg/m<sup>3</sup> respectively on 4<sup>th</sup> April 2020 and 27<sup>th</sup> April 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.33 µg/m<sup>3</sup> and 5.27 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 5.1.3 After Lockdown

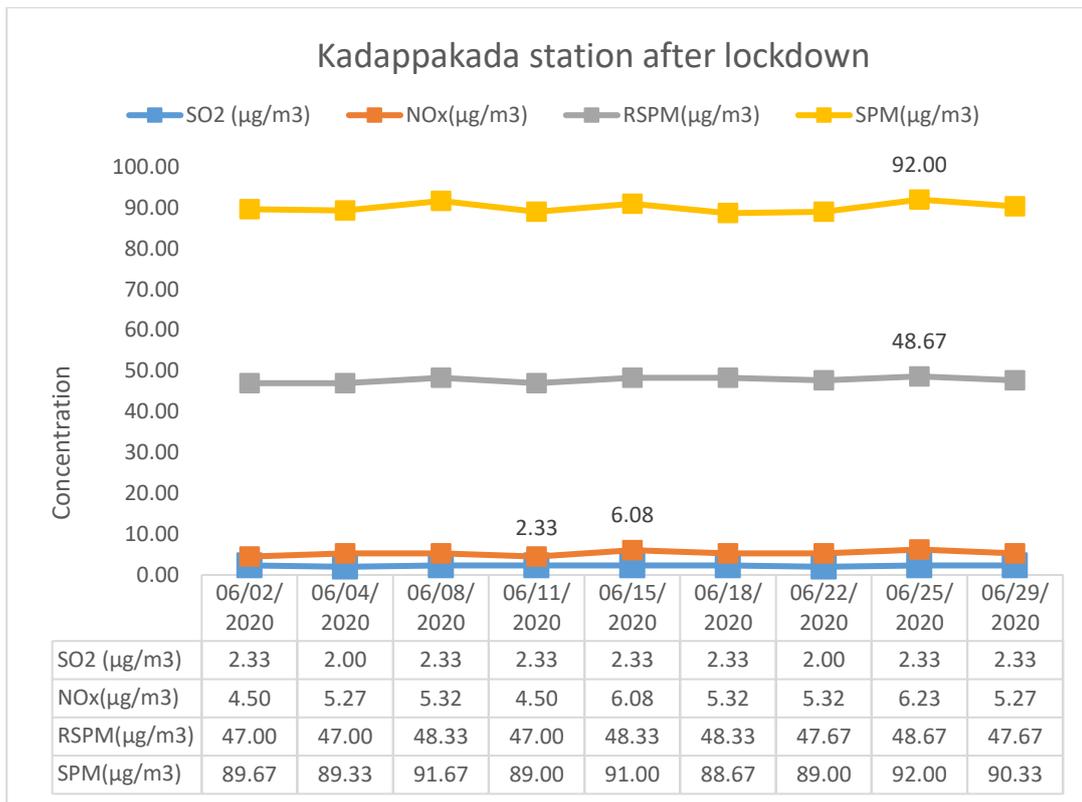


Figure 5.4: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at kadappakada station after lockdown

Figure 5.4 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Kadappakada station after lockdown. The data analysis indicates that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest values of RSPM and SPM value was 92 µg/m<sup>3</sup> and 48.67µg/m<sup>3</sup> respectively recorded on 6<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> are well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.33 µg/m<sup>3</sup> and 6.08 µg/m<sup>3</sup> for SO<sub>2</sub> and NO<sub>x</sub> respectively.

### 5.1.4 Result analysis

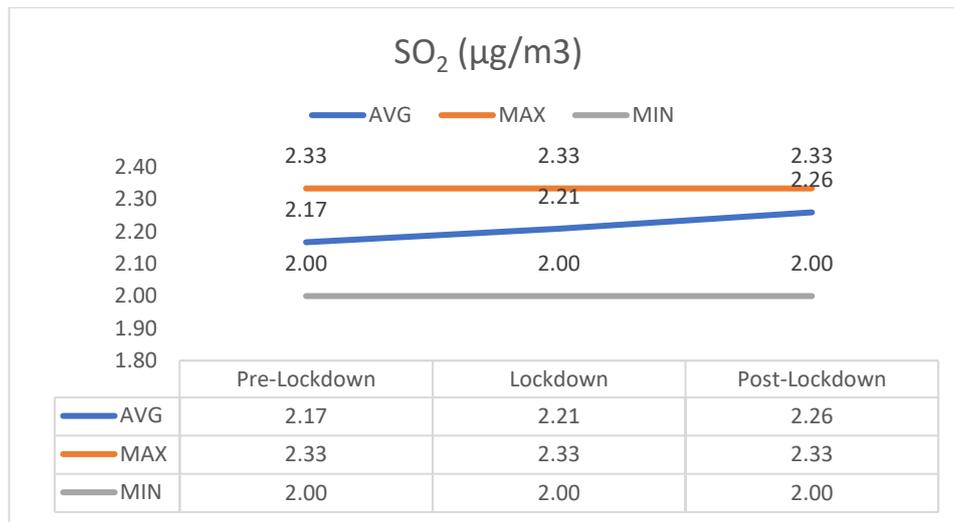


Figure 5.5: SO<sub>2</sub> values at Kadappakda station before, during and after lockdown.

Figure 5.5 shows that average, maximum and minimum values for SO<sub>2</sub> remained almost the same before, during and after the lockdown period at Kadappakada station.

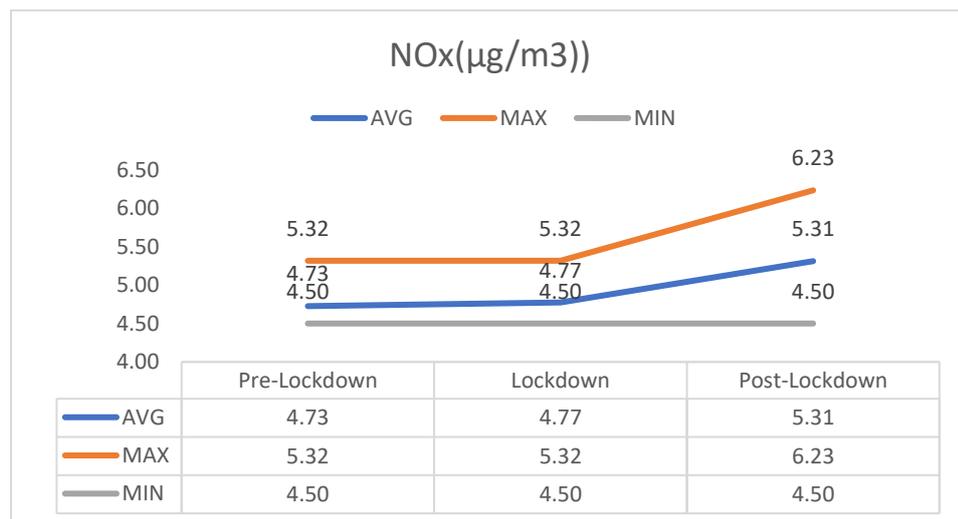


Figure 5.6: NO<sub>x</sub> values at Kadappakda station before, during and after lockdown.

Figure 5.6 shows that average and peak values for NO<sub>x</sub> registered a slight increase after the lockdown at Kadappakada station.

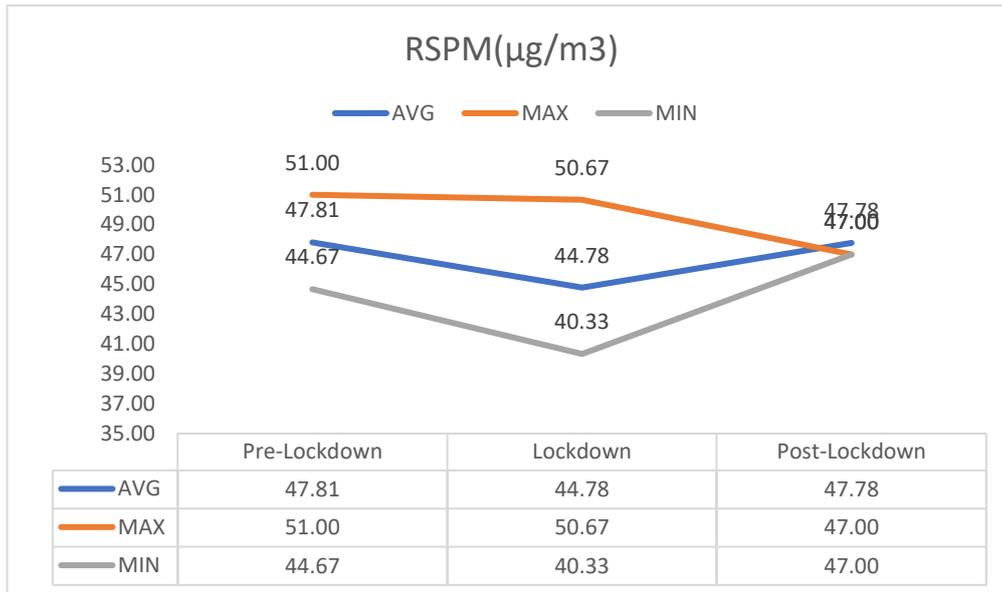


Figure 5.7: RSPM Values at Kadappakda station before, during and after lockdown.

From Figure 5.7 and 5.8, it can be noted that the average and minimum values of RSPM and SPM showed a notable decrease during the lockdown at Kadappakada station.

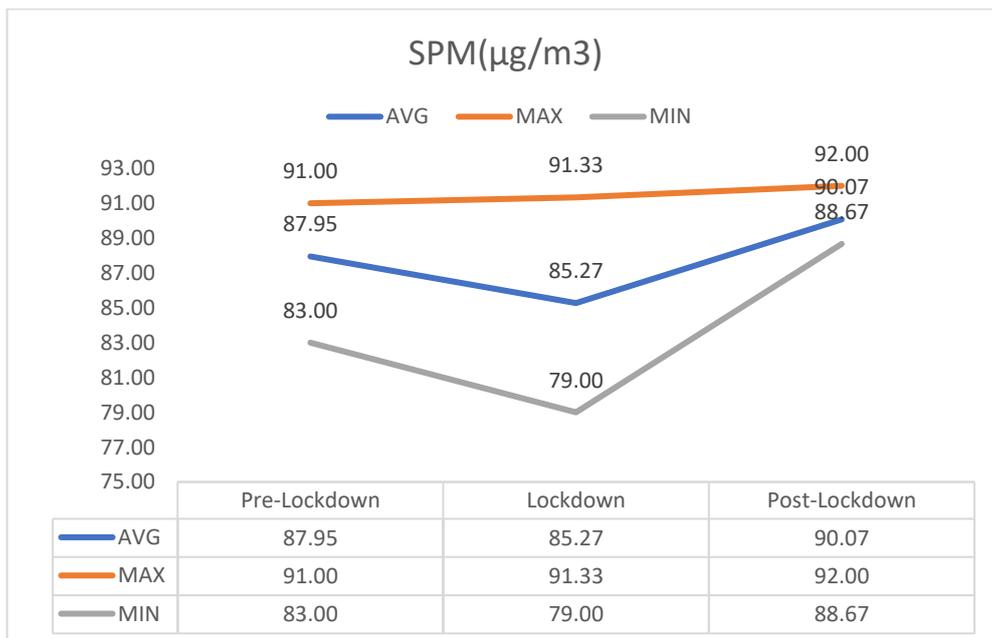


Figure 5.8: SPM Values at Kadappakda station before, during and after lockdown.

## 5.2 Chavara (Industrial) - Manual Monitoring Station

The Chavara station is located in an industrial area with red category industries. The land use pattern includes red category industries, residential and major roads.



Figure 5.9: Land use pattern at chavara station

### 5.2.1 Before Lockdown

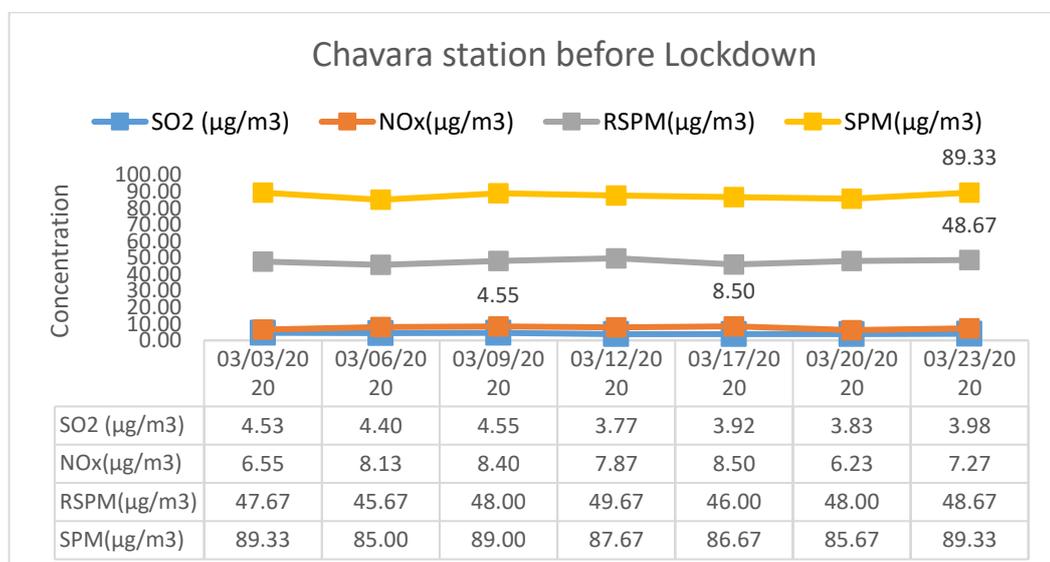


Figure 5.10: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Chavara station before lockdown

Figure 5.10 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Chavara station before lockdown. The data analysis indicated that the RSPM and SPM are always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were found to be 89.33µg/m<sup>3</sup> and 48.67 µg/m<sup>3</sup> respectively on 23<sup>rd</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> fall well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 4.55 µg/m<sup>3</sup> and 8.50 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 5.2.2 During Lockdown

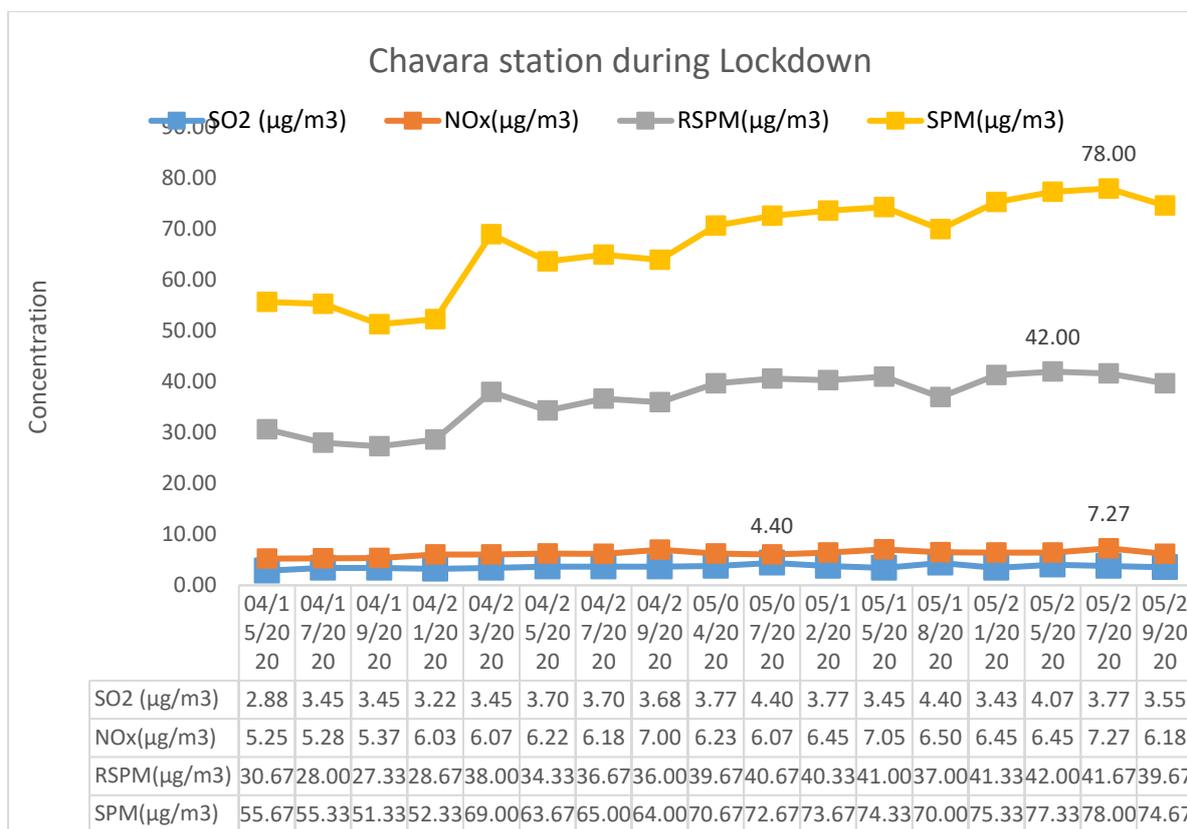


Figure 5.11: SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Chavara station during the lockdown

Figure 5.11 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Chavara station during the lockdown. The data analysis indicates that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM values are found as 42 µg/m<sup>3</sup> and 78 µg/m<sup>3</sup>. Respectively the concentration of SO<sub>2</sub> and NO<sub>x</sub> are well below the

NAAQS standards of  $80 \mu\text{g}/\text{m}^3$ . The highest values registered are  $4.40 \mu\text{g}/\text{m}^3$  and  $7.27 \mu\text{g}/\text{m}^3$  respectively for  $\text{SO}_2$  and  $\text{NO}_x$ .

### 5.2.3 After Lockdown

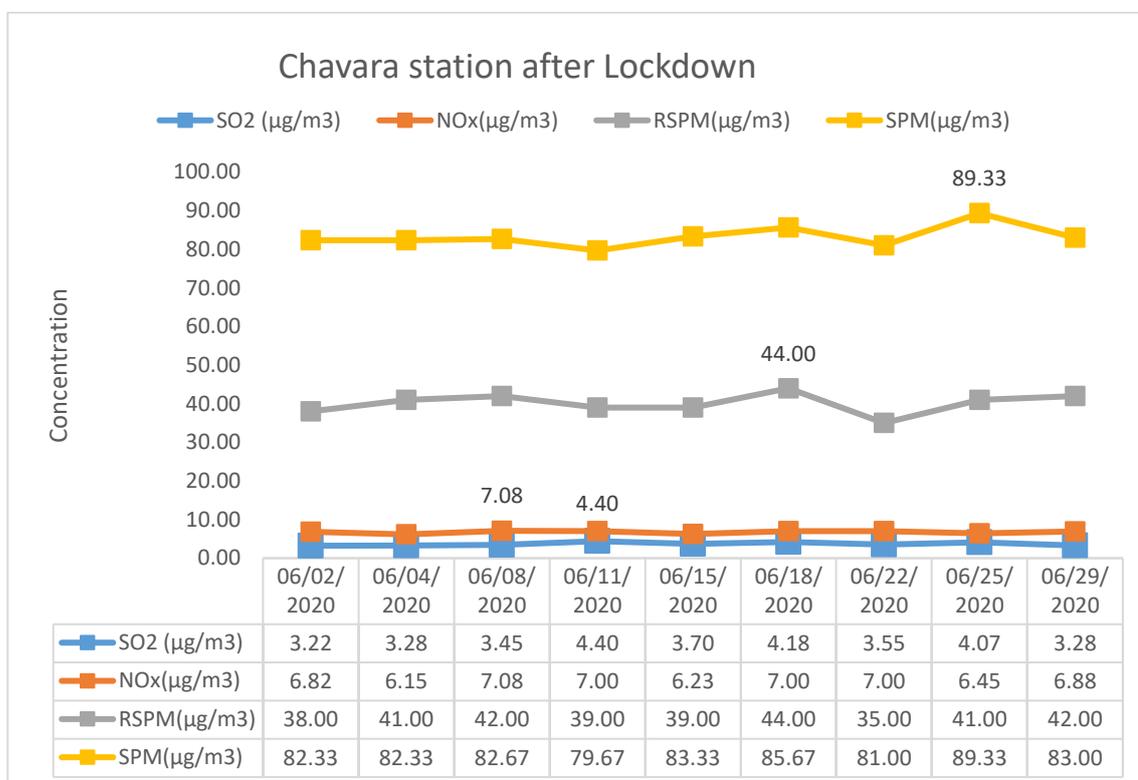


Figure 5.12:  $\text{SO}_2$ ,  $\text{NO}_x$ , RSPM, and SPM measured at Chavara station after the lockdown

Figure 5.12 shows the 24-hr average values for  $\text{SO}_2$ ,  $\text{NO}_x$ , RSPM and SPM measured at Chavara station after lockdown. The data analysis indicates that the RSPM and SPM are always below the 24 hr average standard of  $100 \mu\text{g}/\text{m}^3$ . The highest RSPM and SPM value were recorded as  $44 \mu\text{g}/\text{m}^3$  and  $89.33 \mu\text{g}/\text{m}^3$  on 18<sup>th</sup> June 2020 and 25<sup>th</sup> June 2020. The concentration of  $\text{SO}_2$  and  $\text{NO}_x$  are well below the NAAQS standards of  $80 \mu\text{g}/\text{m}^3$ . The highest values registered are  $4.40 \mu\text{g}/\text{m}^3$  and  $7.08 \mu\text{g}/\text{m}^3$  respectively for  $\text{SO}_2$  and  $\text{NO}_x$

## 5.2.4 Result analysis

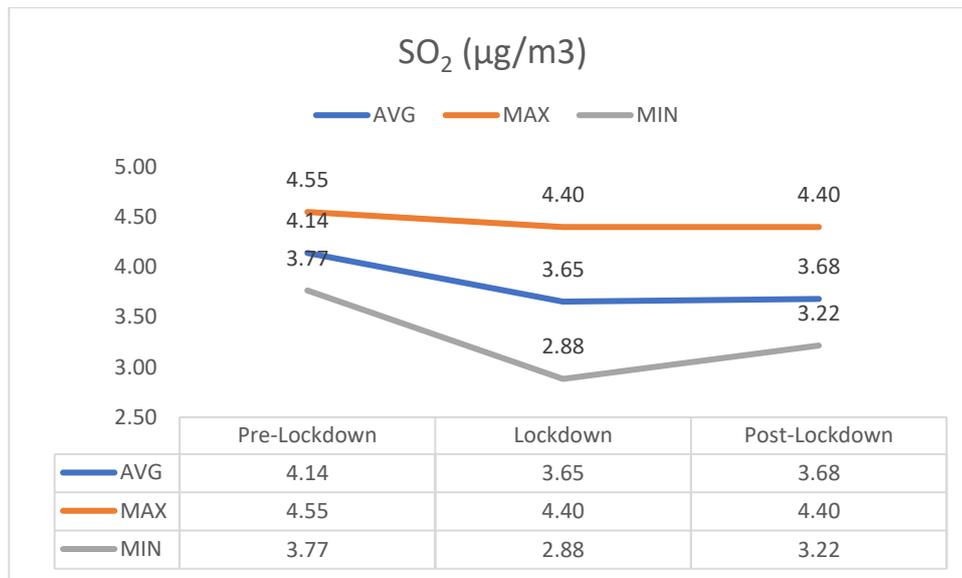


Figure 5.13: SO<sub>2</sub> Values at Chavara station before, during and after lockdown.

Figure 5.13 shows that average, maximum and minimum values for SO<sub>2</sub> registered a notable decrease during the lockdown period which later increased slightly as the lockdown was lifted.

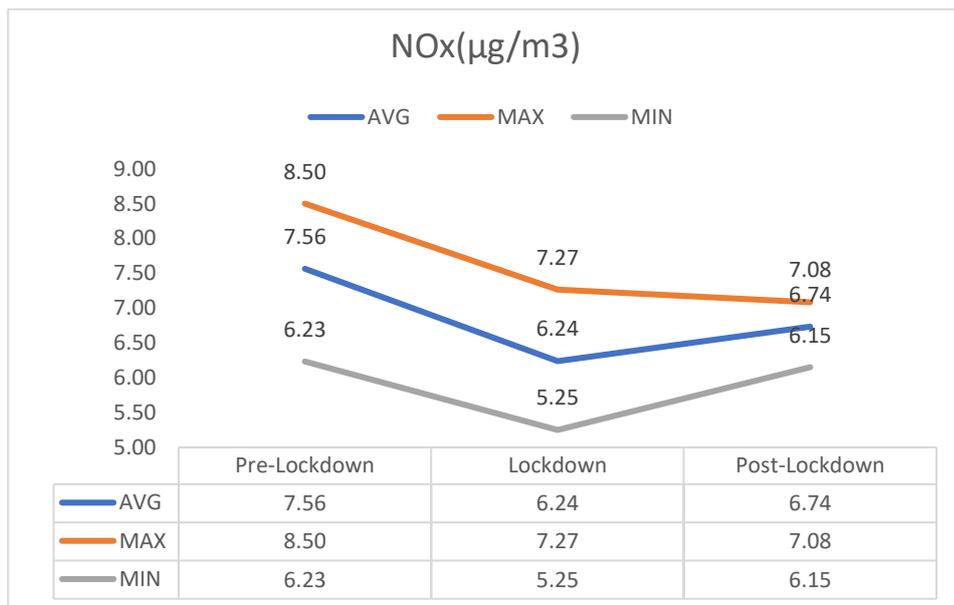
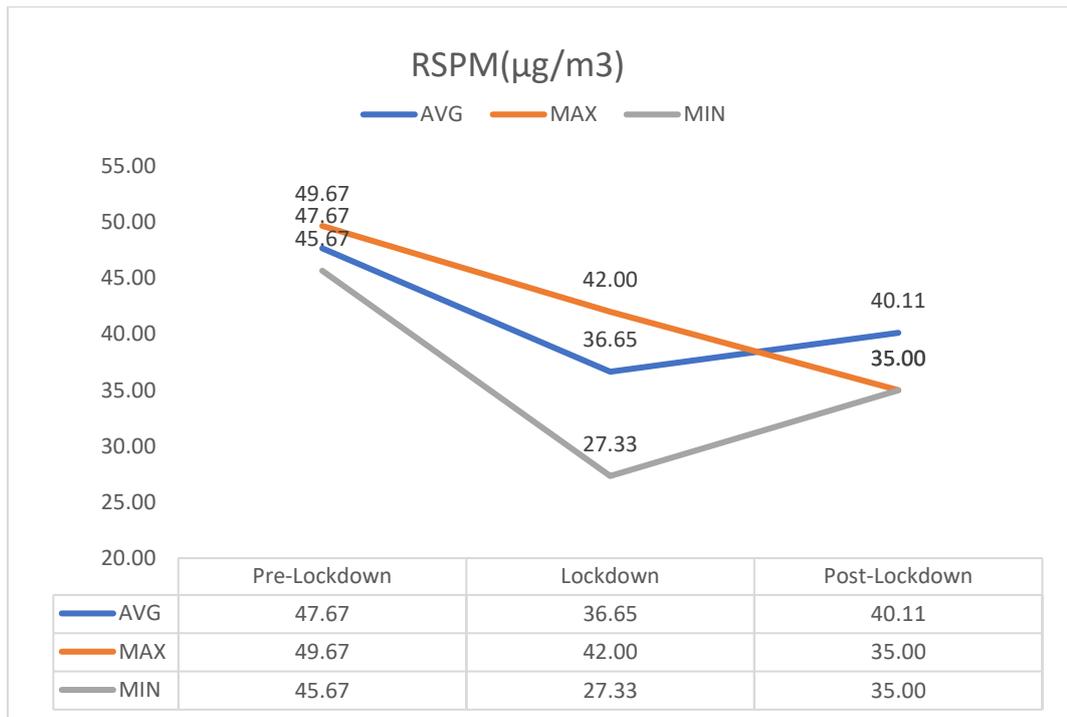


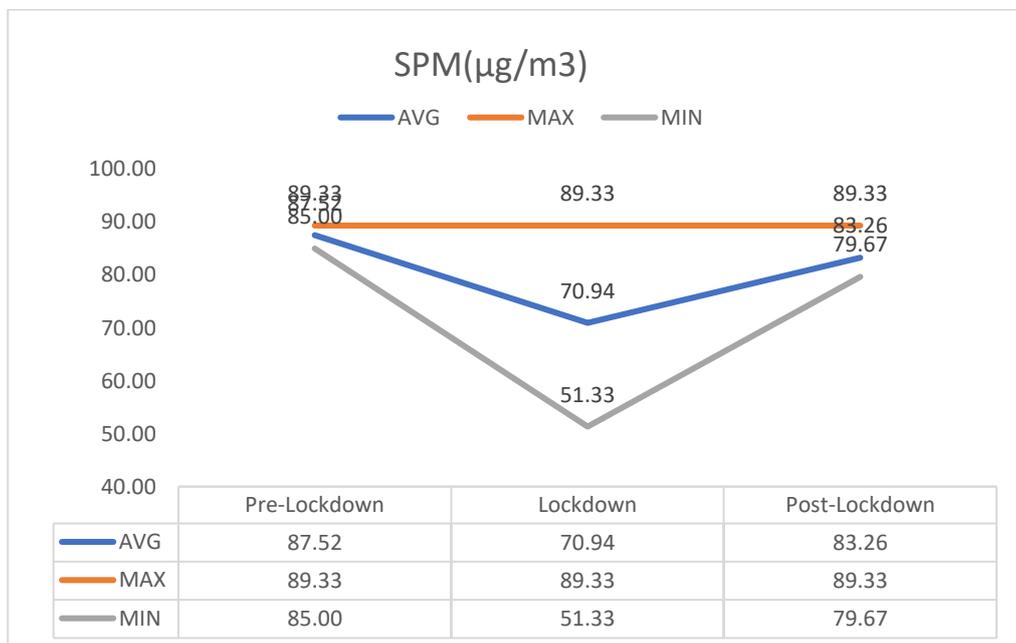
Figure 5.14: NO<sub>x</sub> Values at Chavara station before, during and after lockdown.

Figure 5.14 shows that average, maximum and minimum values for NO<sub>x</sub> also registered a notable decrease during the lockdown period which later increased slightly as the lockdown lifted.



**Figure 5.15: RSPM Values at Chavara station before, during and after lockdown.**

From Figure 5.15 and 5.16, it can be noted that the average and minimum values of RSPM and SPM showed a notable decrease during the lockdown at Chavara station. The peak value of RSPM shows a decreasing trend even after lifting of the lockdown whereas the peak value of SPM remains the same.



**Figure 5.16: RSPM Values at Chavara station before, during and after lockdown**

### 5.3 Polaythode CAAQMS (Commercial)

The CAAQMS at Polaythode is located in a residential area with the land use pattern as Commercial, major roads, residential

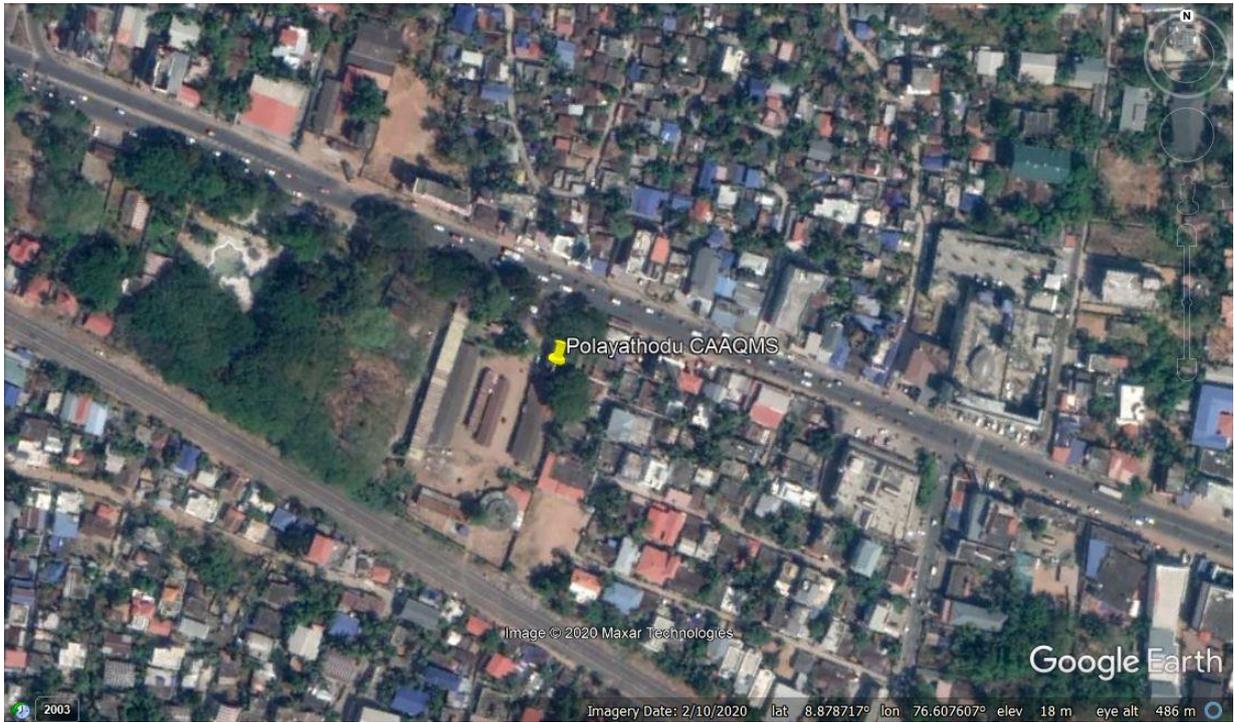


Figure 5.17: Land use pattern at Polaythode.

#### 5.3.1 Before Lockdown

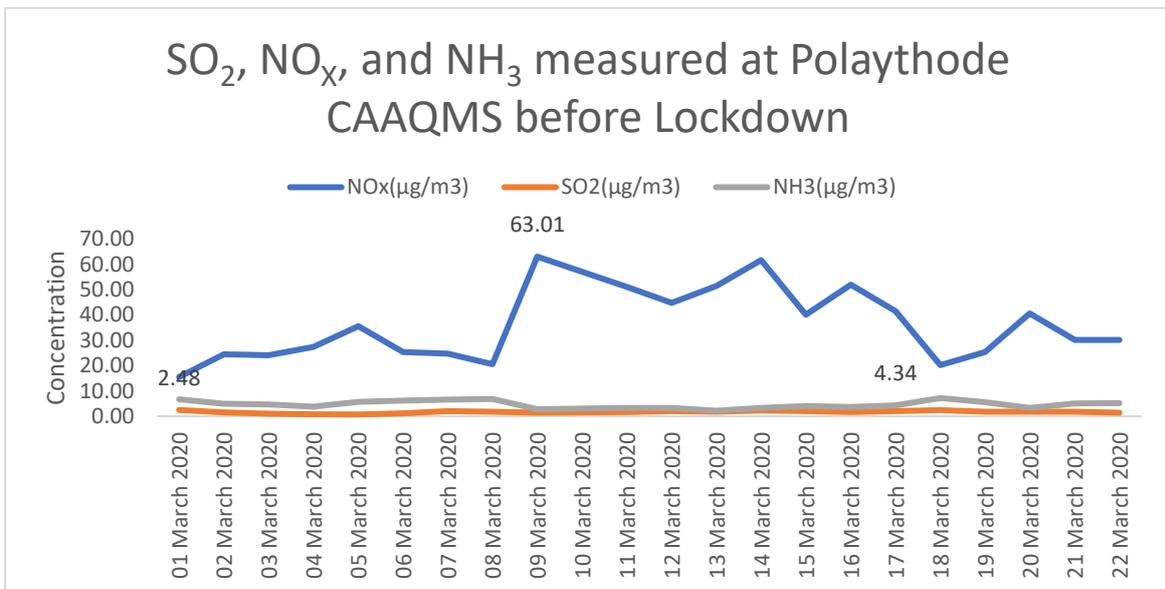
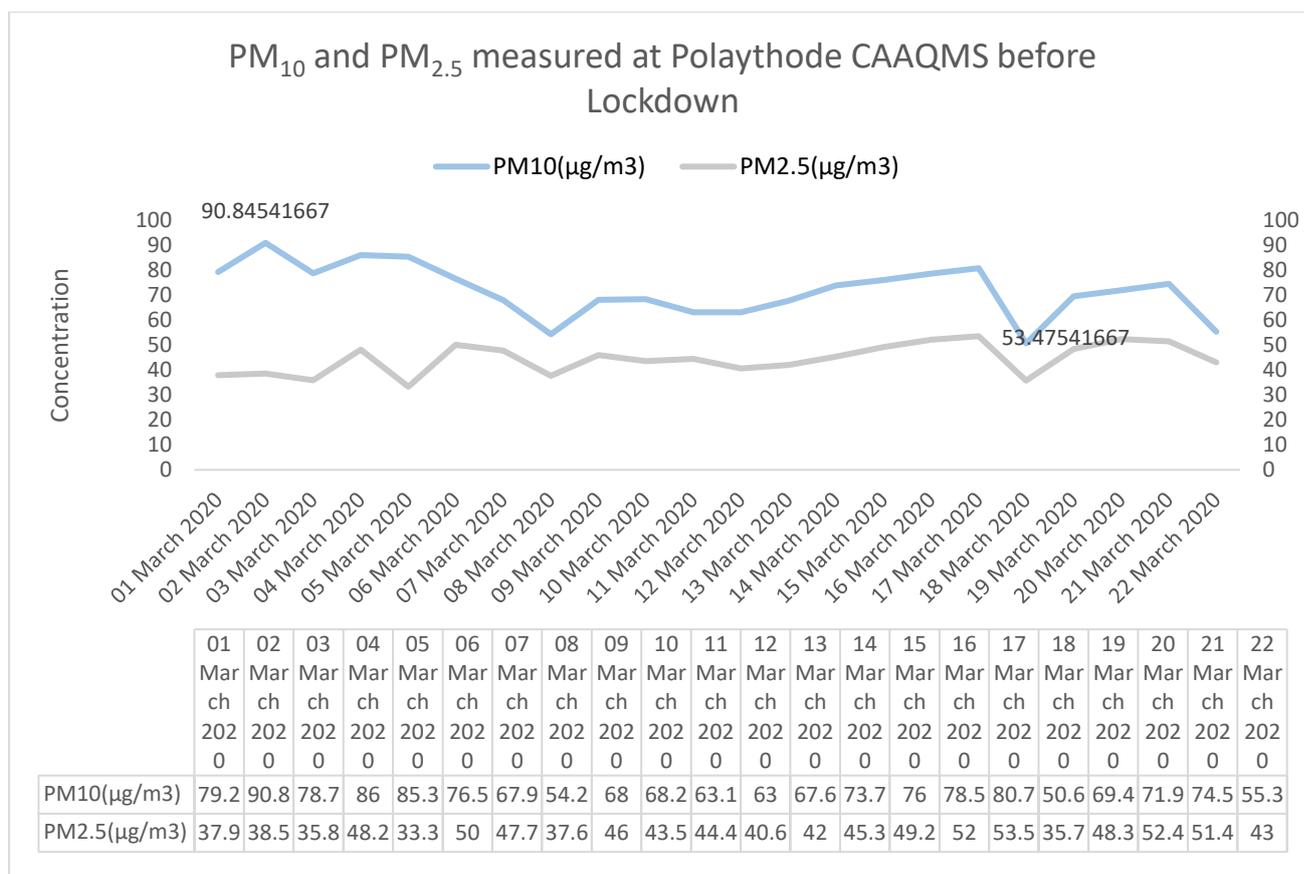


Figure 5.18: SO2, NOX, and NH3 measured at Polaythode CAAQM Station before Lockdown

Figure 5.18 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Polaythode CAAQMS before lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 2.48 µg/m<sup>3</sup> and 63.01 µg/m<sup>3</sup> respectively on 1<sup>st</sup> March 2020 and 9<sup>th</sup> march 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 4.34 µg/m<sup>3</sup> on 17<sup>th</sup> March 2020 for NH<sub>3</sub>.



**Figure 5.19: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Karyavattom CAAQMS before Lockdown**

Figure 5.19 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Polaythode CAAQMS before lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 90.84 µg/m<sup>3</sup> and 53.475 µg/m<sup>3</sup> respectively on 2<sup>nd</sup> March 2020 and 17<sup>th</sup> march 2020.

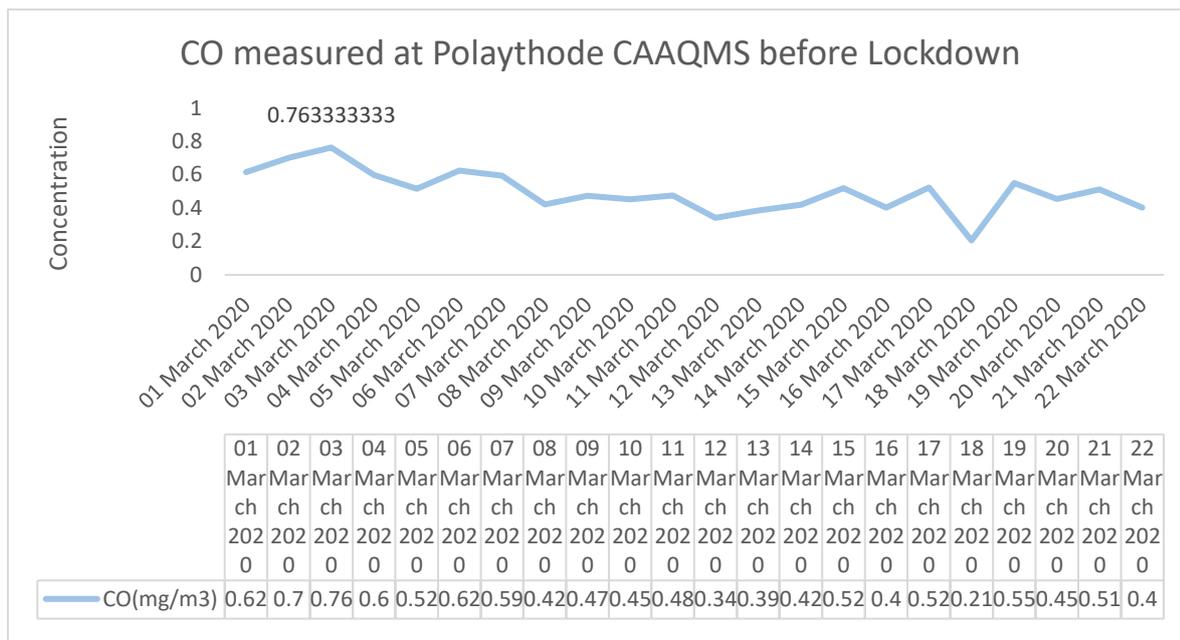


Figure 5.20: CO measured at plamood CAAQM Station before Lockdown

Figure 5.20 shows the 24-hr average values for CO measured at plamood station before lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 0.76 mg/m<sup>3</sup> on 3<sup>rd</sup> March 2020.

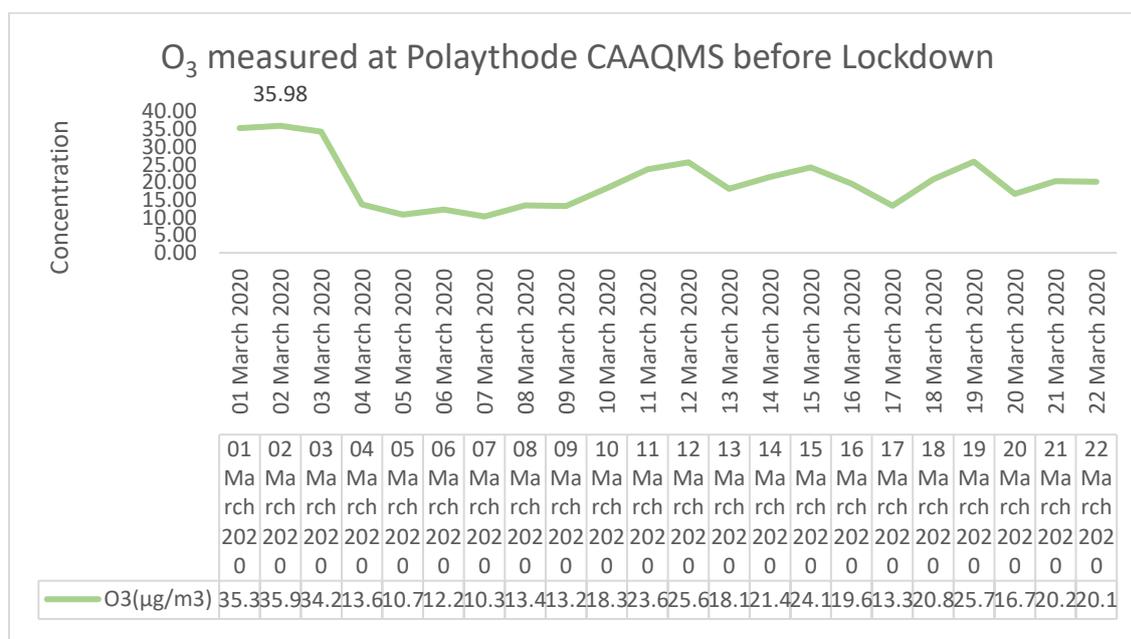


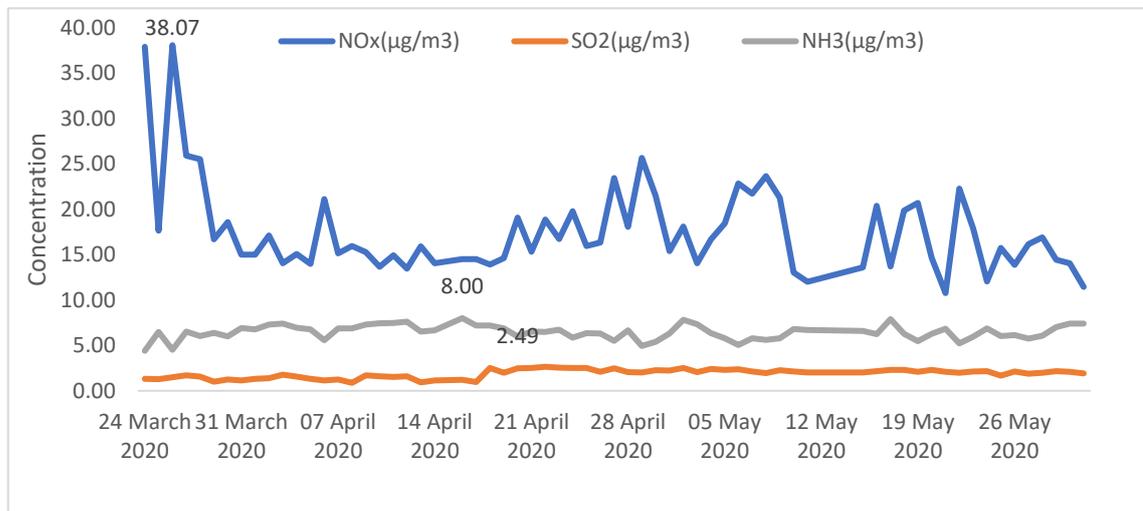
Figure 5.21: O<sub>3</sub> measured at Polaythode CAAQM Station before Lockdown

Figure 5.21 shows the 24-hr average values for O<sub>3</sub> measured at Polaythode station before lockdown. The data analysis indicated that the O<sub>3</sub> was always below

the 8 hour standard of 100  $\mu\text{g}/\text{m}^3$ . The highest value was found to be  $\mu\text{g}/\text{m}^3$  on 2<sup>nd</sup> March 2020.

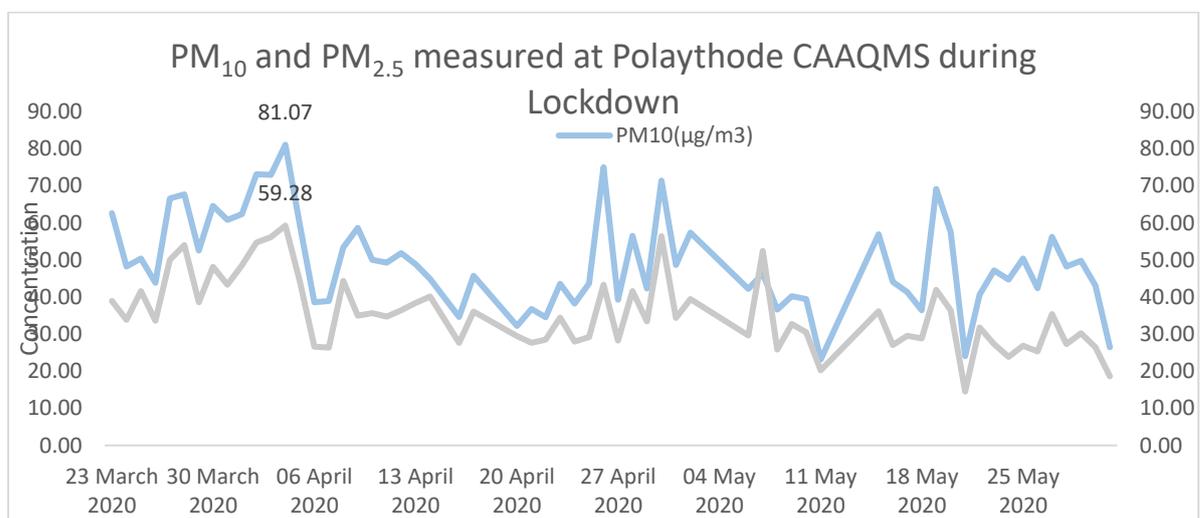
35.98

### 5.3.2 During Lockdown



**Figure 5.22: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at polaythode CAAQM Station during Lockdown**

Figure 5.22 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at polaythode CAAQMS during the lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80  $\mu\text{g}/\text{m}^3$ . The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 2.49  $\mu\text{g}/\text{m}^3$  and 38.07  $\mu\text{g}/\text{m}^3$  respectively on 20<sup>th</sup> April 2020 and 26<sup>th</sup> March 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400  $\mu\text{g}/\text{m}^3$ . The highest values registered are 8.00  $\mu\text{g}/\text{m}^3$  on 16<sup>th</sup> April 2020 for NH<sub>3</sub>.



**Figure 5.23: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Polaythode CAAQMS during the lockdown**

Figure 5.23 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at polaythode CAAQMS after lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 81.07 µg/m<sup>3</sup> and 59.28 µg/m<sup>3</sup> respectively on 4<sup>th</sup> April 2020.

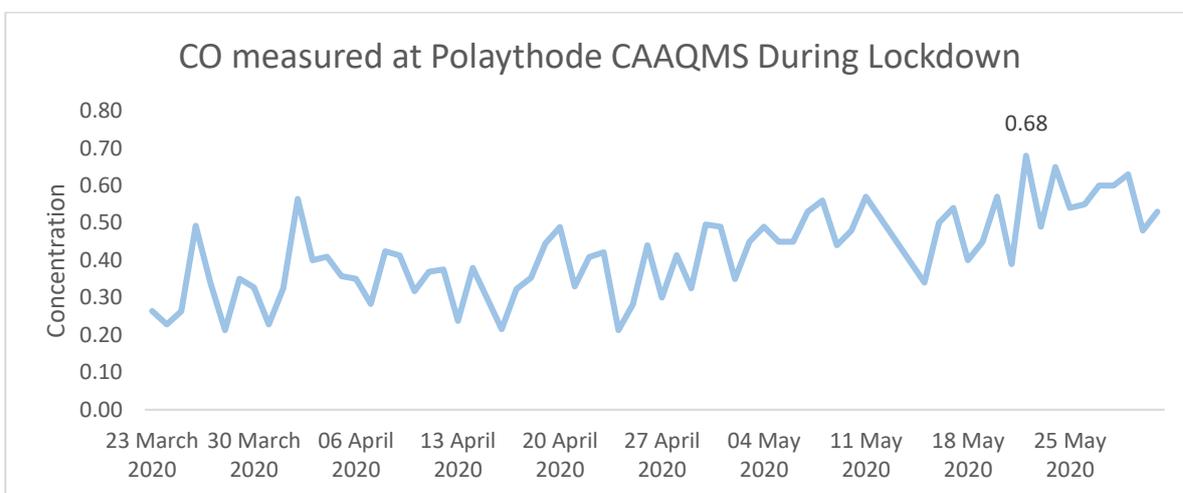


Figure 5.24: CO measured at Polaythode CAAQM Station during the lockdown

Figure 5.24 shows the 24-hr average values for CO measured at Polaythode CAAQMS during the lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 0.68 mg/m<sup>3</sup> on 22<sup>nd</sup> May 2020.

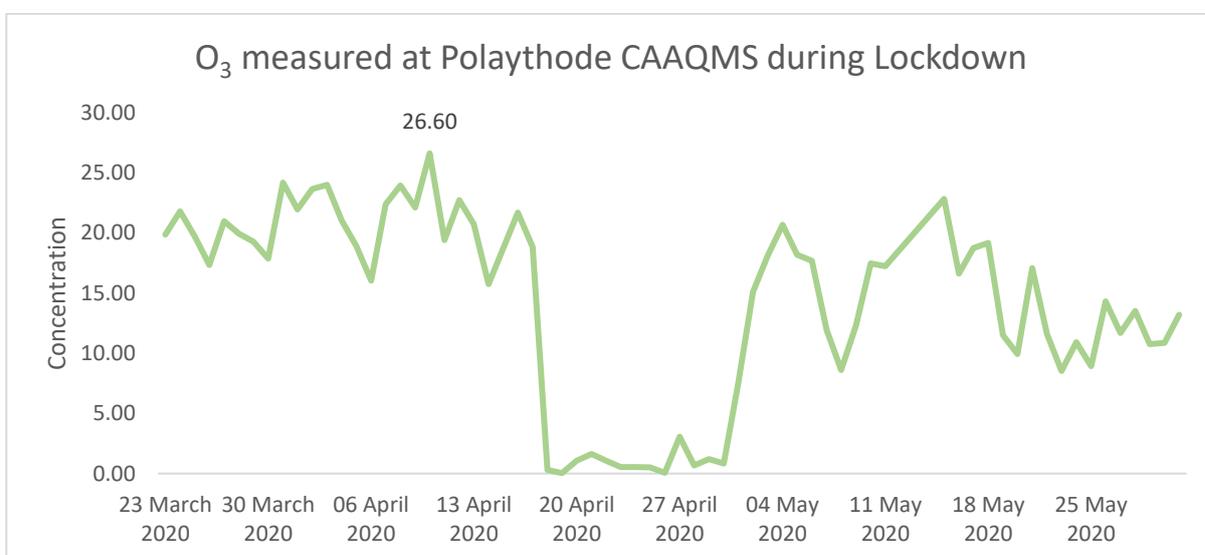


Figure 5.25: O<sub>3</sub> measured at Polaythode CAAQM Station during the lockdown

Figure 5.25 shows the 24-hr average values for O<sub>3</sub> measured at Polaythode CAAQMS station during the lockdown. The data analysis indicated that the O<sub>3</sub> was always below the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value is found to be 26.60 µg/m<sup>3</sup> on 10<sup>th</sup> April 2020.

### 5.3.3 After Lockdown

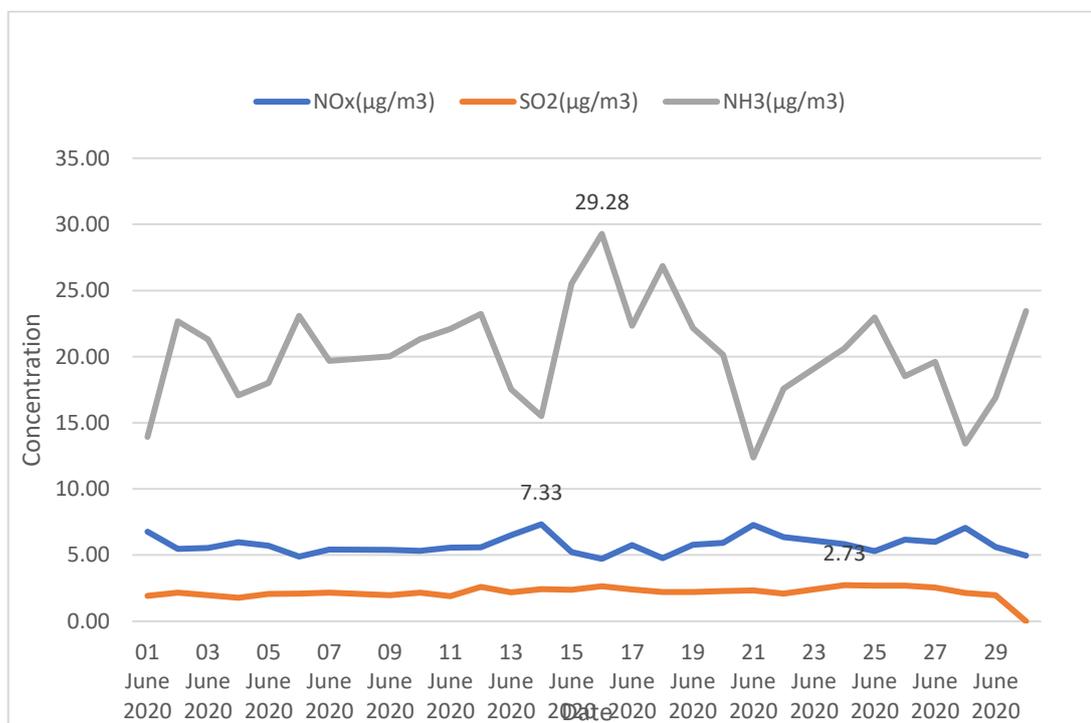
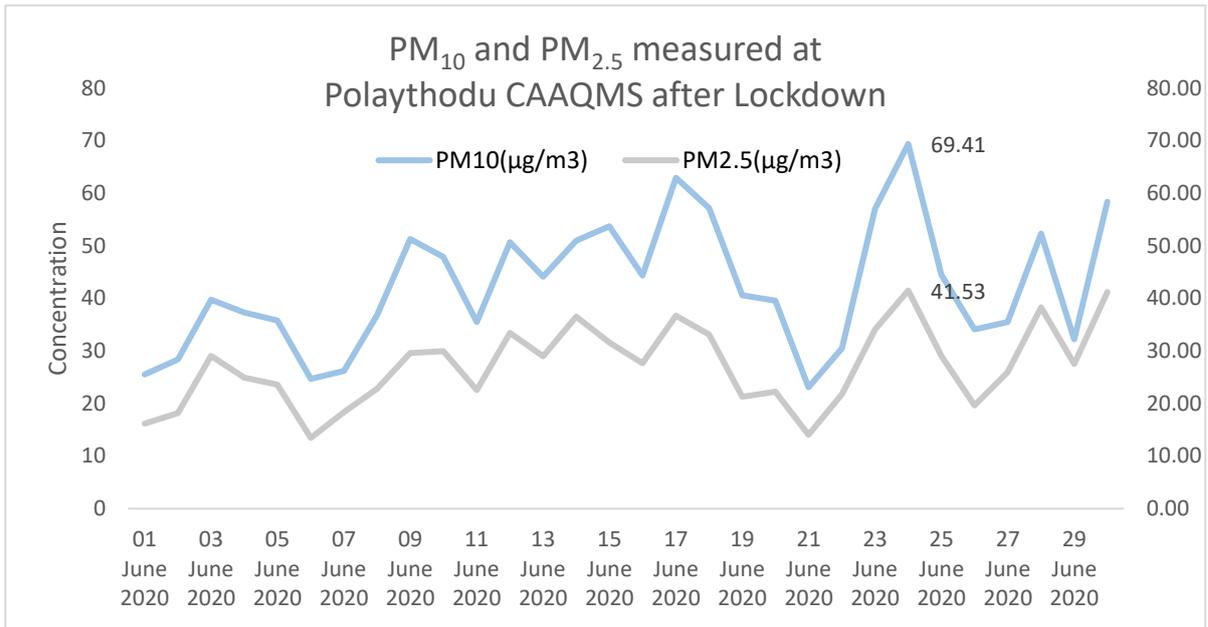


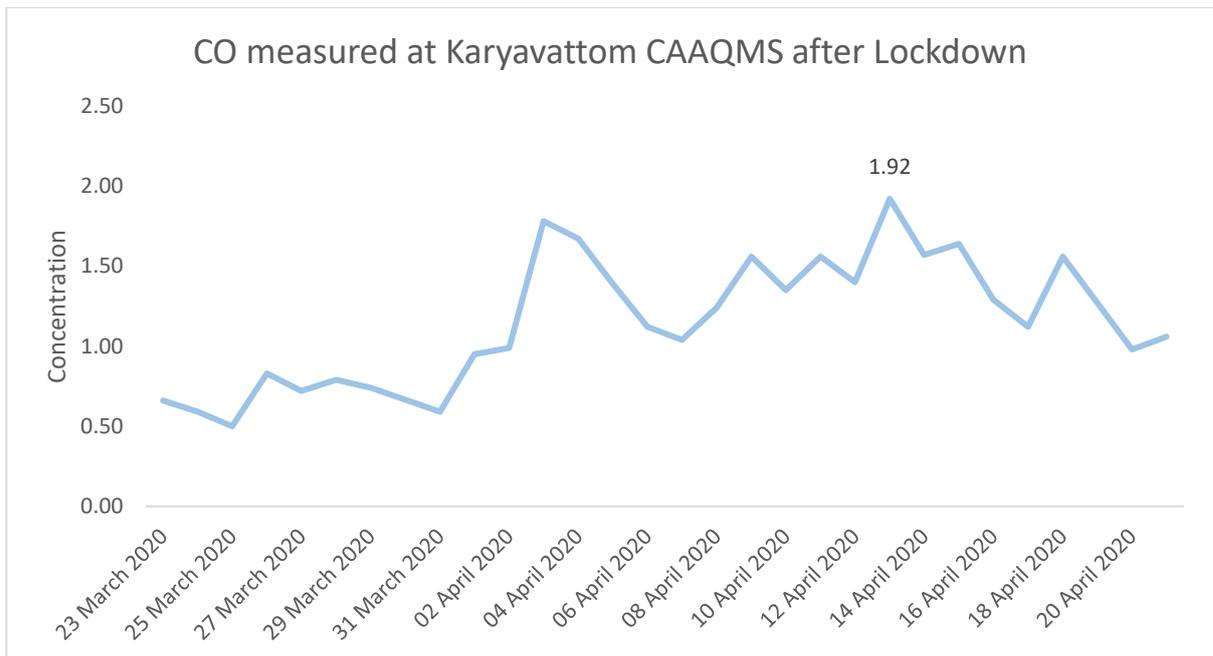
Figure 5.26: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Polaythode CAAQM Station after Lockdown

Figure 5.26 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Polaythode CAAQMS after lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 2.73 µg/m<sup>3</sup> and 7.33 µg/m<sup>3</sup> respectively on 24<sup>th</sup> June 2020 and 14<sup>th</sup> June 2020. The concentration of NH<sub>3</sub> falls well below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest values registered is 29.28 µg/m<sup>3</sup> on 16<sup>th</sup> June 2020.



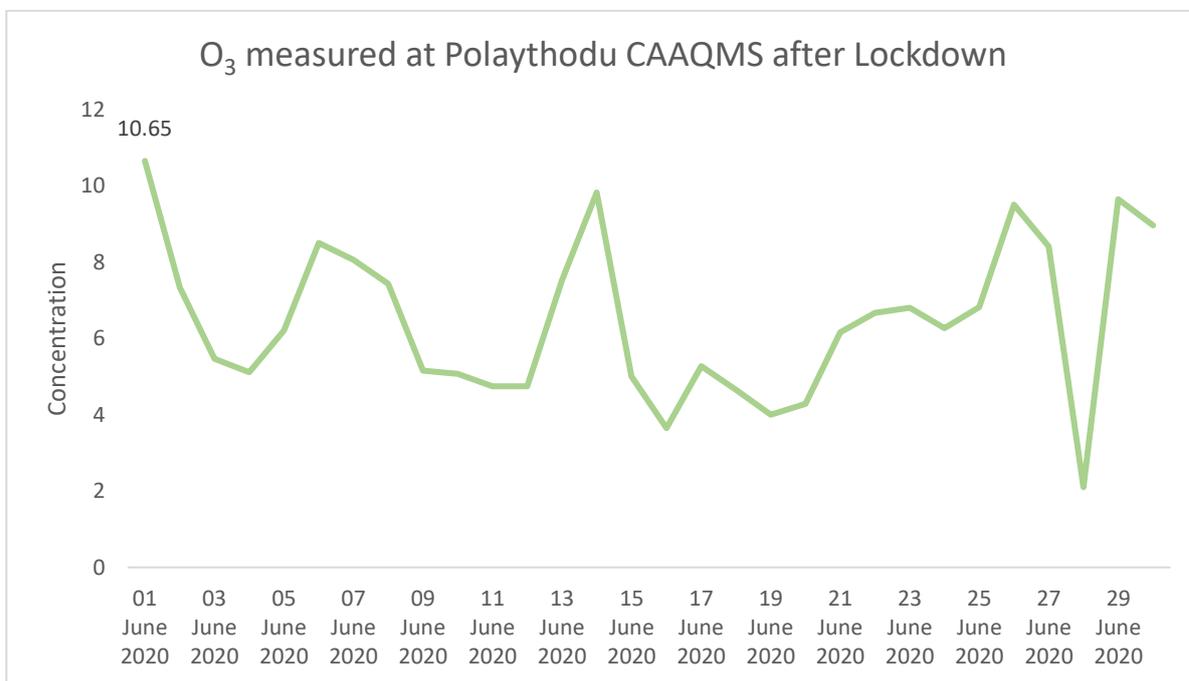
**Figure 5.27: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Polaythodu CAAQMS after Lockdown**

Figure 5.27 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Polaythodu CAAQMS after lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 69.41 µg/m<sup>3</sup> and 41.53 µg/m<sup>3</sup> respectively on 24<sup>th</sup> June 2020.



**Figure 5.28: CO measured at Polaythodu CAAQMS after Lockdown**

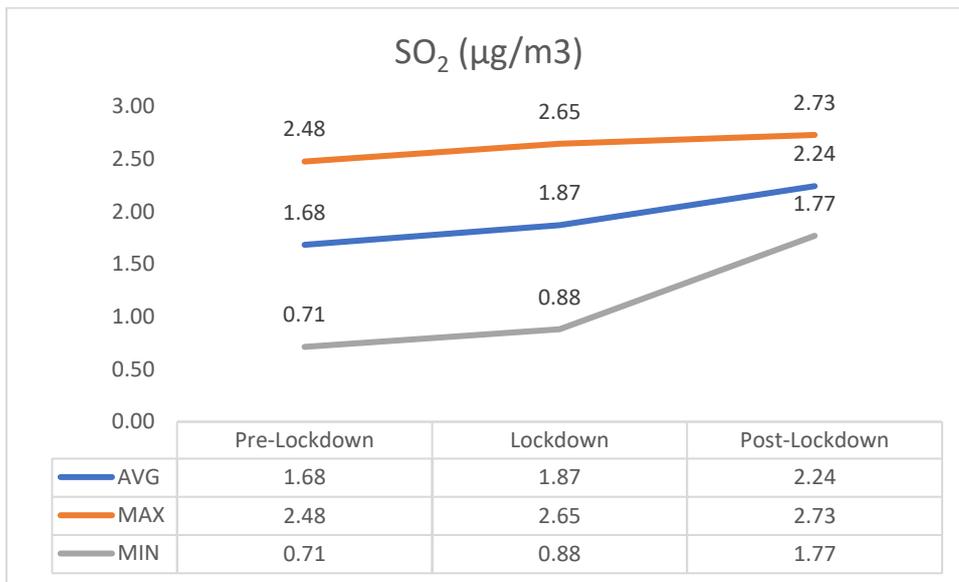
Figure 5.28 shows the 24-hr average values for CO measured at Polaythodu CAAQMS after lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 1.92 m/m<sup>3</sup> on 13th April 2020.



**Figure 5.29: O<sub>3</sub> measured at Polaythode CAAQMS after Lockdown**

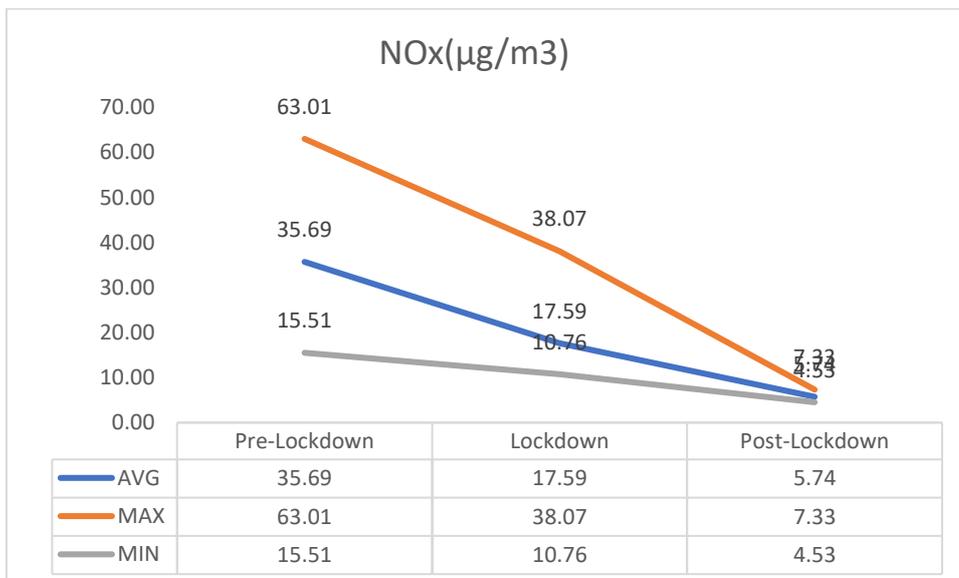
Figure 5.29 shows the 24-hr average values for O<sub>3</sub> measured at Polaythodu CAAQMS station after lockdown. The data analysis indicated that the O<sub>3</sub> was always below the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 10.65µg/m<sup>3</sup> on 1<sup>st</sup> June 2020.

### 5.3.4 Result Analysis



**Figure 5.30: SO<sub>2</sub> Values of Polaythodu CAAQM Station before, during and after lockdown.**

Figure 5.30 shows that average, maximum and minimum values for SO<sub>2</sub> registered a slight increase during the lockdown period which further increased as the lockdown was lifted.



**Figure 5.31: NO<sub>x</sub> Values of Polaythodu CAAQM Station before, during and after lockdown.**

Figure 5.31 shows that average, maximum and minimum values for NO<sub>x</sub> registered a decreased during the lockdown period at Polaythodu CAAQMS which further decrease after the lockdown.

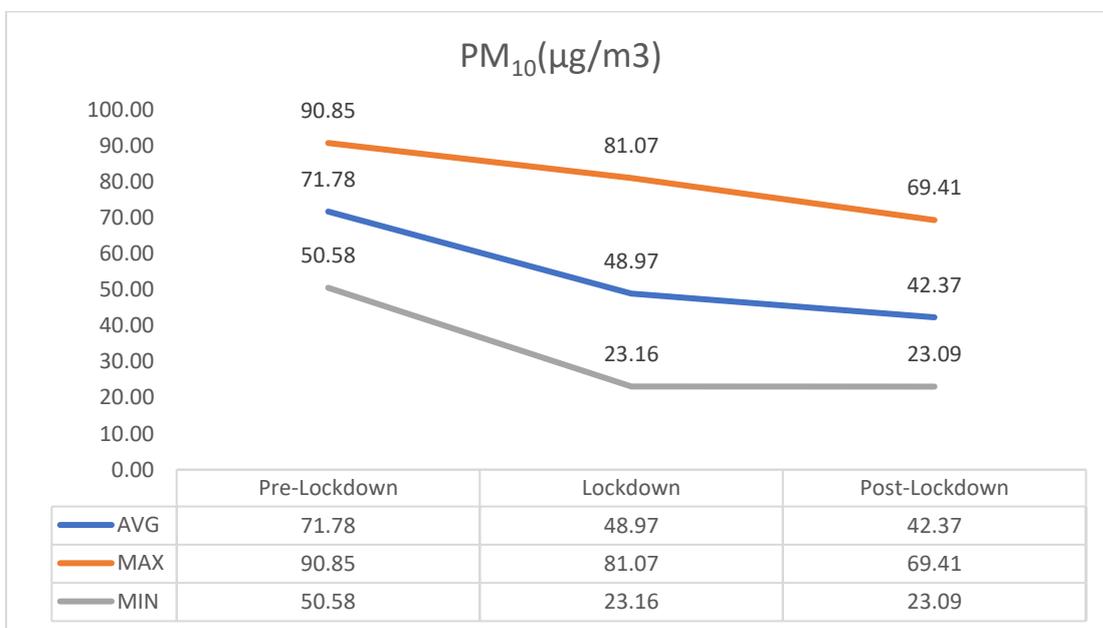


Figure 5.32: PM<sub>10</sub> Values of Polaythodu CAAQM Station before, during and after lockdown.

Figure 5.32 shows that average and minimum values for PM<sub>10</sub> registered a notable decrease during the lockdown period and thereafter.

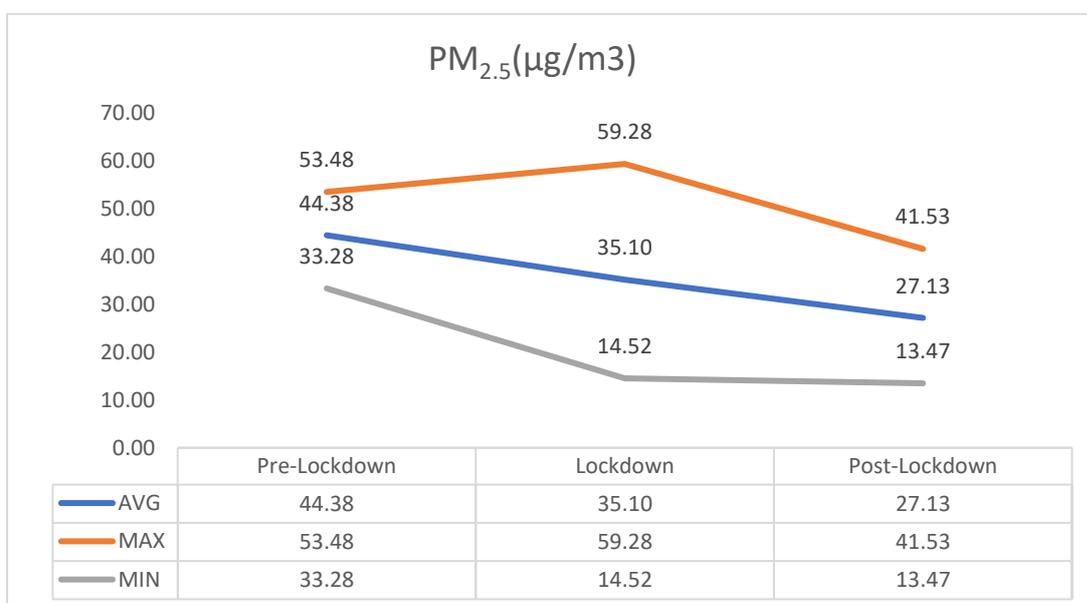


Figure 5.33: PM<sub>2.5</sub> Values of Polaythodu CAAQM Station before, during and after lockdown.

Figure 5.33 shows that average and minimum values for PM<sub>2.5</sub> registered a notable decrease during the lockdown period. The Peak value though registered a hike during the lockdown it came down to the level of that below the pre-lockdown period.

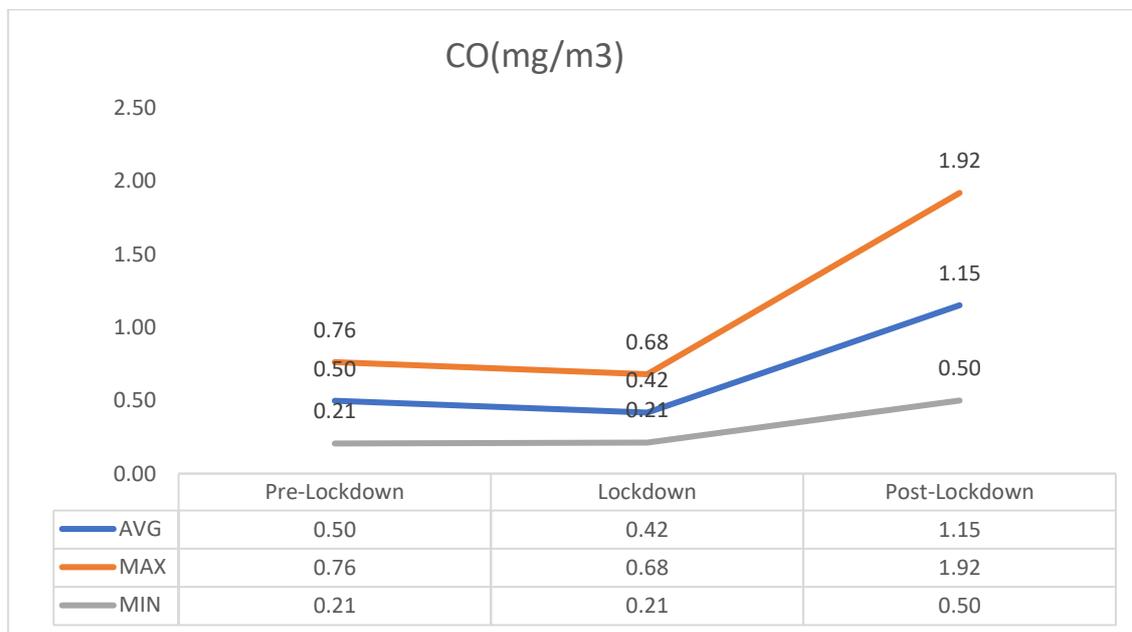


Figure 5.34: Co Values of Polaythodu CAAQMS before, during and after lockdown.

Figure 5.34 shows that average and maximum values show a decreasing trend during Lockdown but increase to the levels greater than before lockdown.

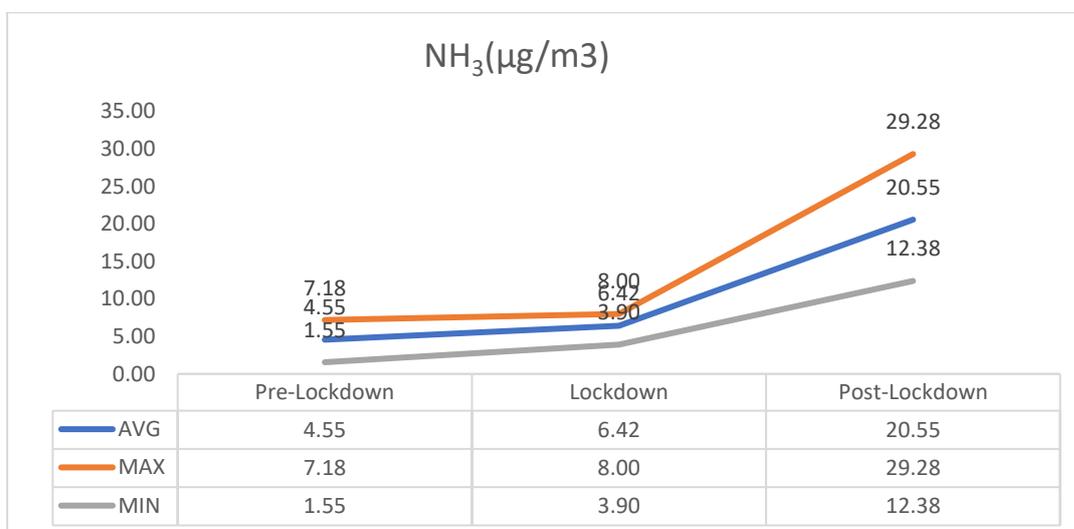


Figure 5.35: NH<sub>3</sub> Values of Polaythodu CAAQMS before, during and after lockdown.

Figure 5.35 shows that the average, minimum and maximum values for NH<sub>3</sub> registered a notable increase during the lockdown period, these values continued on an increasing trend even after lifting of the lockdown.

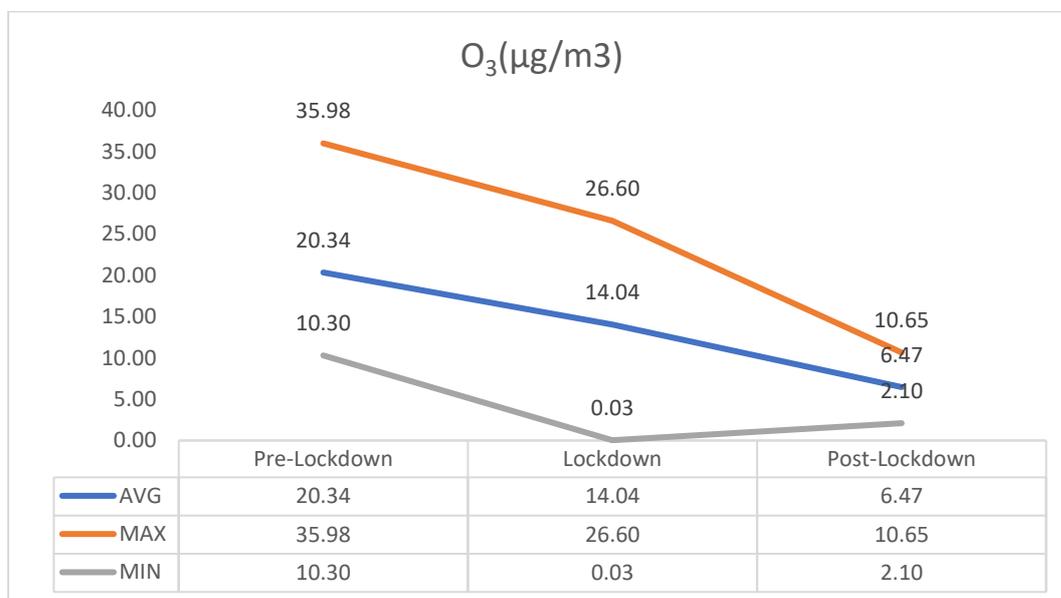


Figure 5.36: O<sub>3</sub> Values of Polaythodu CAAQMS before, during and after lockdown.

Figure 5.36 shows that even though the average, maximum and minimum values for O<sub>3</sub> registered a decrease during the lockdown period. These values continued to show a decreasing trend which later decreased to that lower than the pre-lockdown value.

## 6 Alappuzha

The list of Monitoring stations in the city is tabulated in Table 6.1. The land use pattern at these stations is also depicted

Table 6.1: List of monitoring stations in Alappuzha

Site	Co-ordinates	Scheme	Type	Land Use Pattern
District Office	9.506506, 76.343025	Namp	Residential	Residential
WilliamGood Acre	9.498658, 76.328382	Namp	Industrial	Industries, major roads, commercials, traffic

Table 6.2 gives the growth of vehicles in the district of Alappuzha, it has shown steady growth.

Table 6.2: Vehicular count in Alappuzha

Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
No of vehicles	561495	618697	697203	762880	830790	912916

### 6.1 District Office (Residential) - Manual Monitoring Station

District office station is located in a residential area in the city. The land use pattern includes residential and minor roads.

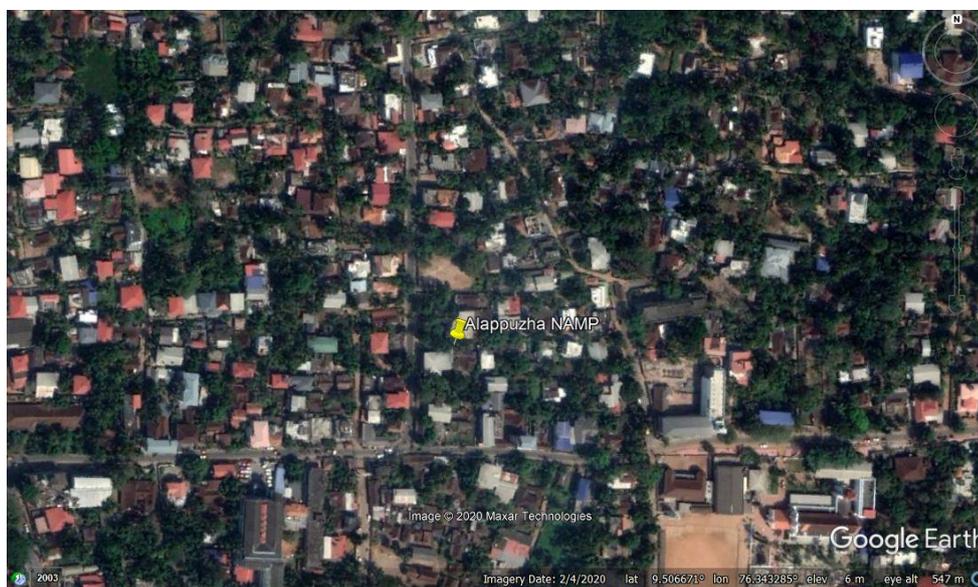


Figure 6.1: Land use pattern at District office station

### 6.1.1 Before Lockdown

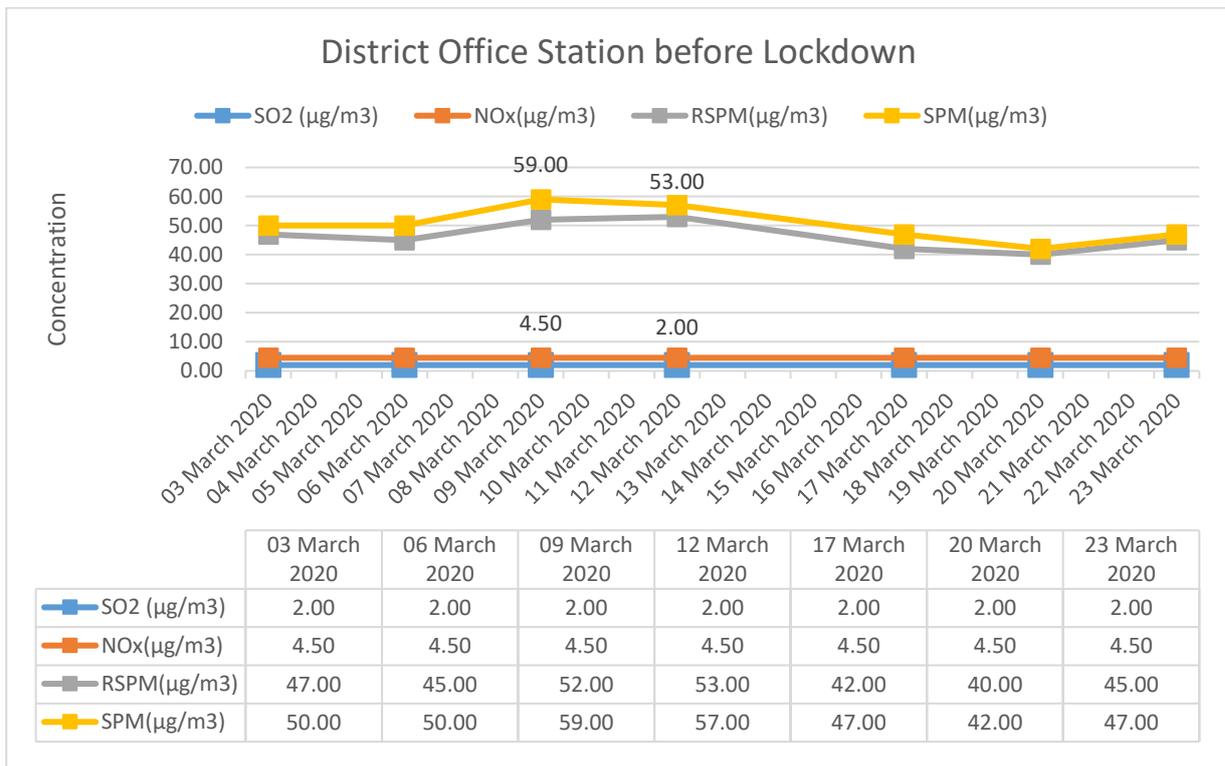


Figure 6.2: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at District office station before Lockdown

Figure 6.2 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at District office station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 53 µg/m<sup>3</sup> and 59 µg/m<sup>3</sup> respectively on 12<sup>th</sup> and 9<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 4.5 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 6.1.2 During Lockdown

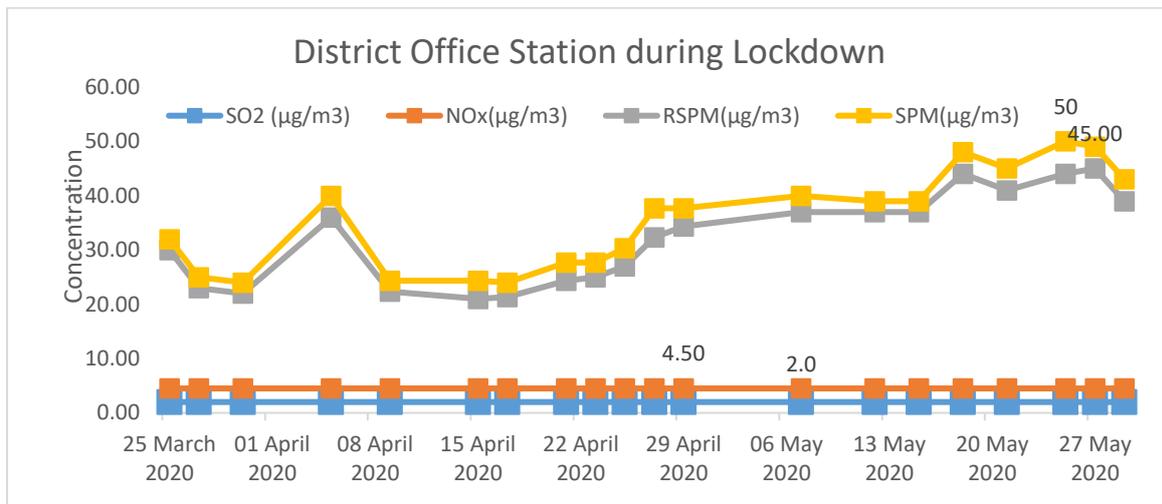


Figure 6.3: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at District office station during the lockdown

Figure 6.3 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at District office station during the lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest values of RSPM and SPM value were recorded as 45 µg/m<sup>3</sup> and 50 µg/m<sup>3</sup> respectively on 27<sup>th</sup> May 2020 and 25<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The value registered remained the same at 2µg/m<sup>3</sup> and 4.5 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 6.1.3 After Lockdown

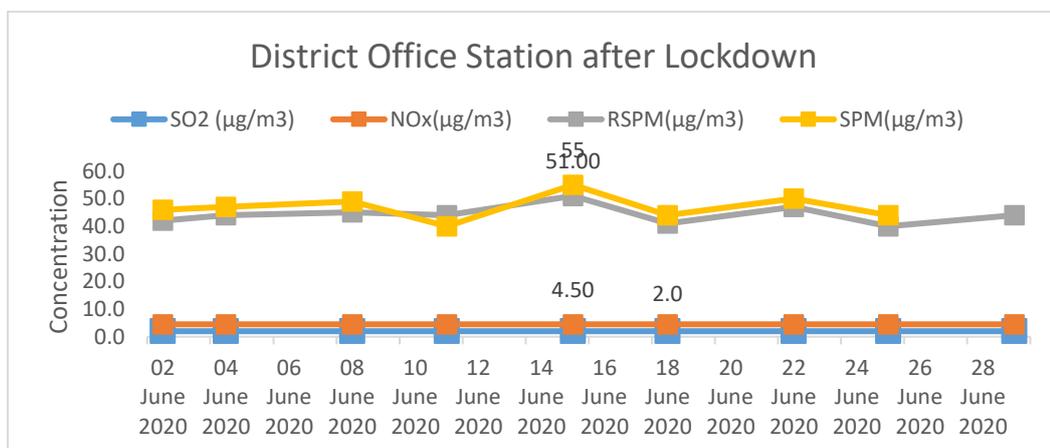


Figure 6.4: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at District office station after lockdown

Figure 6.4 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at District office station after lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest values of RSPM and SPM value was 51 µg/m<sup>3</sup> and 55 µg/m<sup>3</sup> respectively on 15<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is way below the NAAQS standards of 80 µg/m<sup>3</sup>. The value registered remained the same at 2.0 µg/m<sup>3</sup> and 4.5 µg/m<sup>3</sup> for SO<sub>2</sub> and NO<sub>x</sub> respectively.

#### 6.1.4 Result analysis

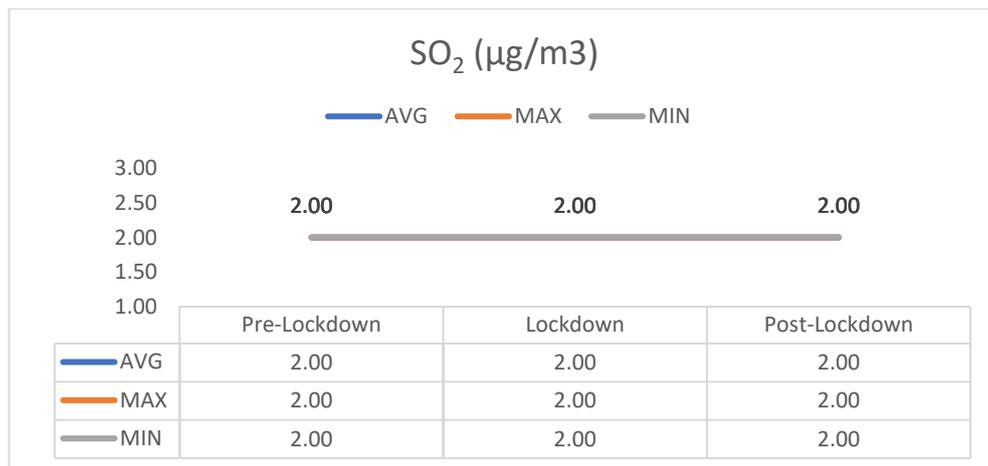


Figure 6.5: SO<sub>2</sub> Values at District office station before, during and after lockdown

Figure 6.5 and 6.6 shows that the average, maximum and minimum values for SO<sub>2</sub>, NO<sub>x</sub> remained the same before, during and after the lockdown period at the district office as it registered a constant minimum value.

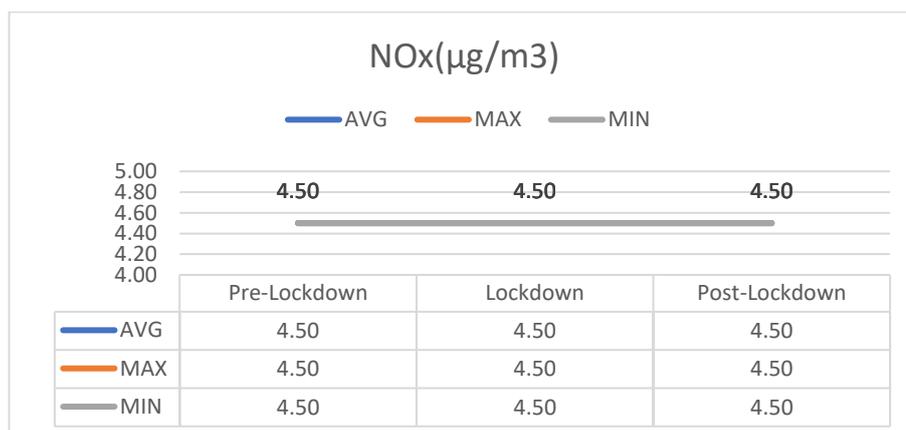
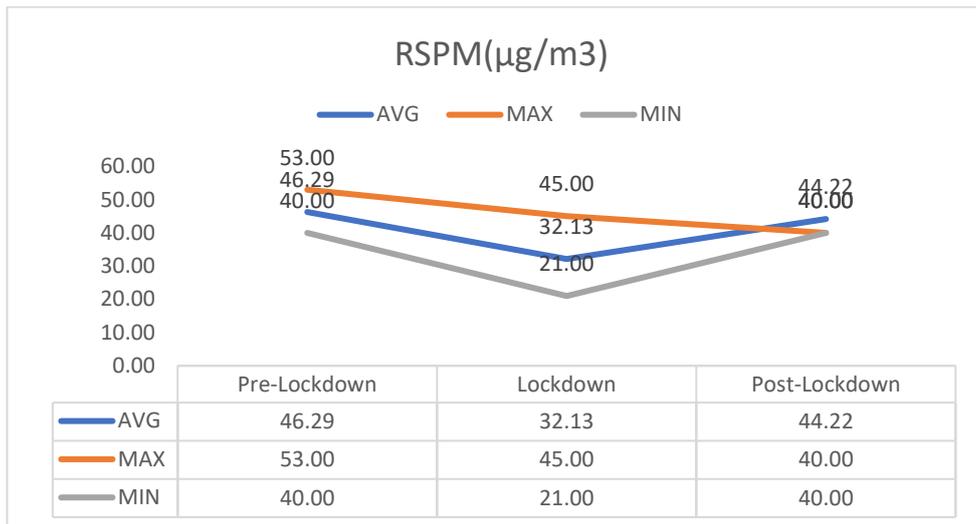
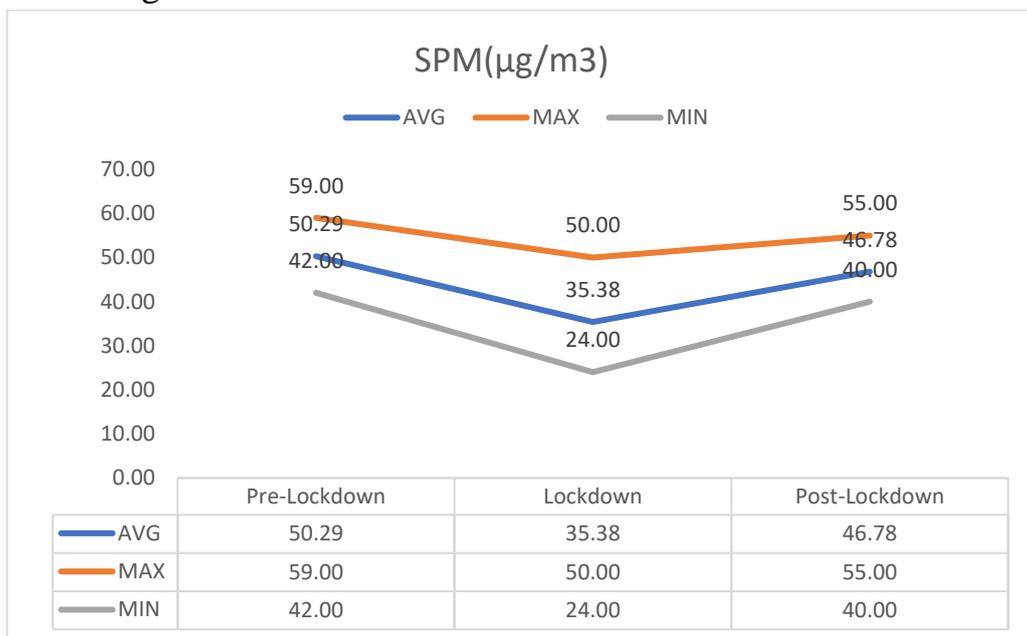


Figure 6.6: NO<sub>x</sub> Values at District office station before, during and after lockdown



**Figure 6.7: RSPM Values at District office station before, during and after lockdown**

From figure 6.7 and 6.8, it can be noted that the average, peak and minimum values of RSPM and SPM showed a notable decrease during the lockdown at District office station whereas the peak value of RSPM showed a decreasing trend even after lifting of the lockdown.



**Figure 6.8: SPM Values at District office station before, during and after lockdown**

## 6.2 William Good Acre station (Industrial)- - Manual Monitoring Station

The William Good Acre station is located in an industrial area with National highway passing nearby. The land use pattern includes industries, major roads, commercial establishments and traffic junction.



Figure6.9: Land use pattern at WilliamGood Acre

### 6.2.1 Before Lockdown

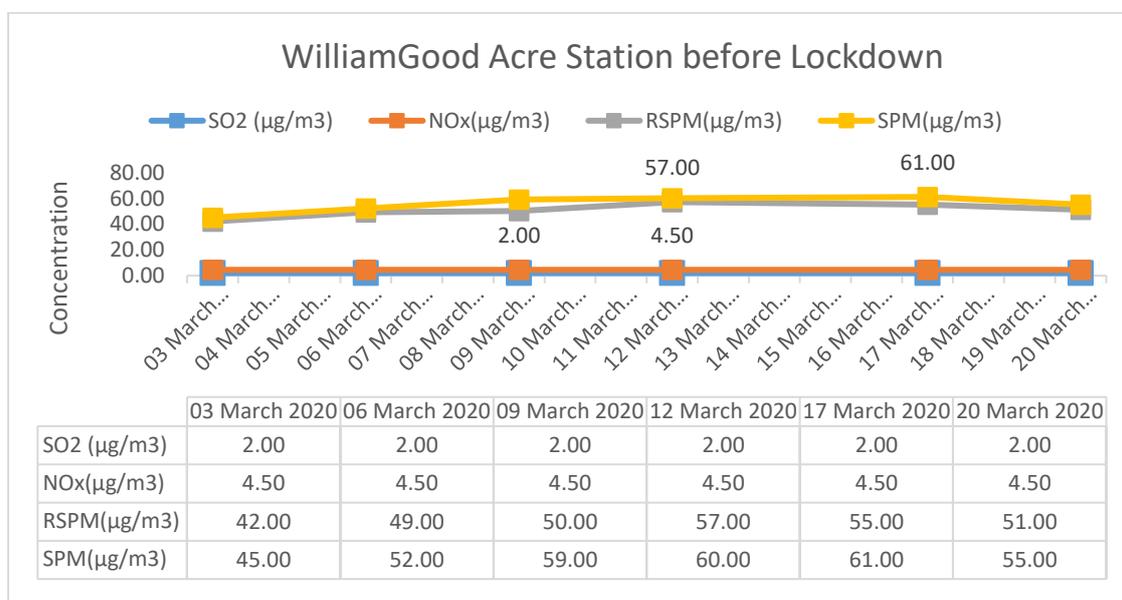


Figure 6.10: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at William Good Acre station before lockdown.

Figure 6.10 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at William Good Acre station before lockdown. . The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were found to be 57 µg/m<sup>3</sup> and 61 µg/m<sup>3</sup> respectively on 12<sup>th</sup> March 2020 and 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> way below the NAAQS standards of 80 µg/m<sup>3</sup>. The values registered remained constant at 2.00 µg/m<sup>3</sup> and 4.50 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 6.2.2 During Lockdown

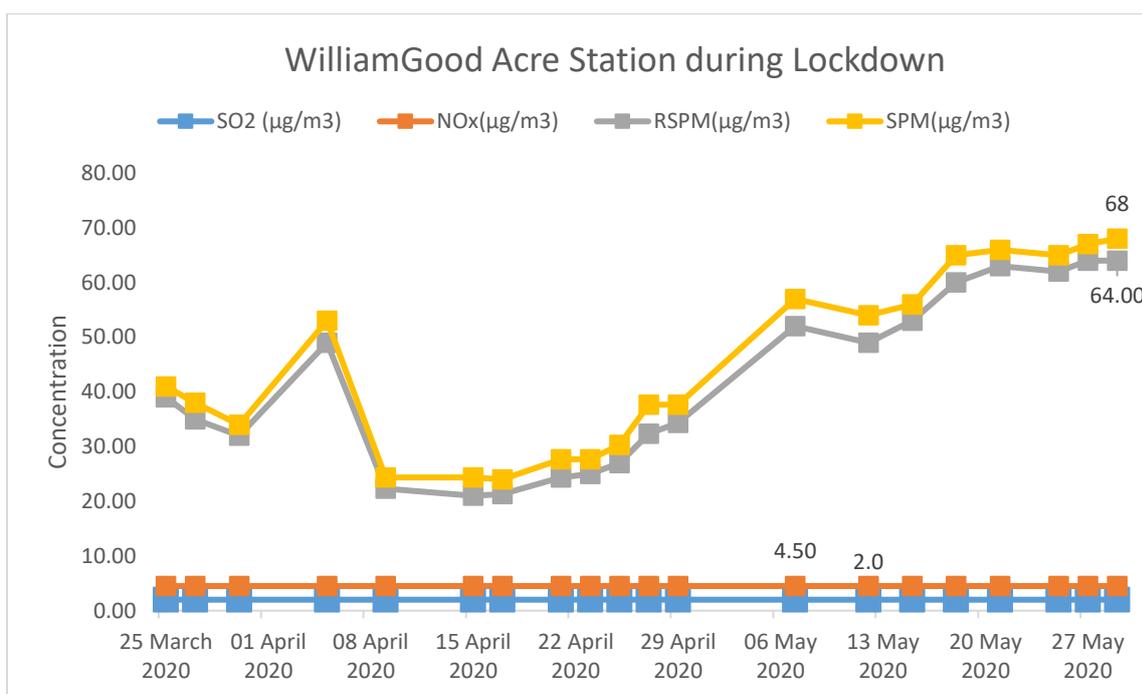


Figure 6.11: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at William Good Acre station during the lockdown

Figure 6.11 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at William Good Acre station during the lockdown. . The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 64 µg/m<sup>3</sup> and 68 µg/m<sup>3</sup> respectively on 29<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The values registered remained the same at 2.0 µg/m<sup>3</sup> and 4.5 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 6.2.3 After Lockdown

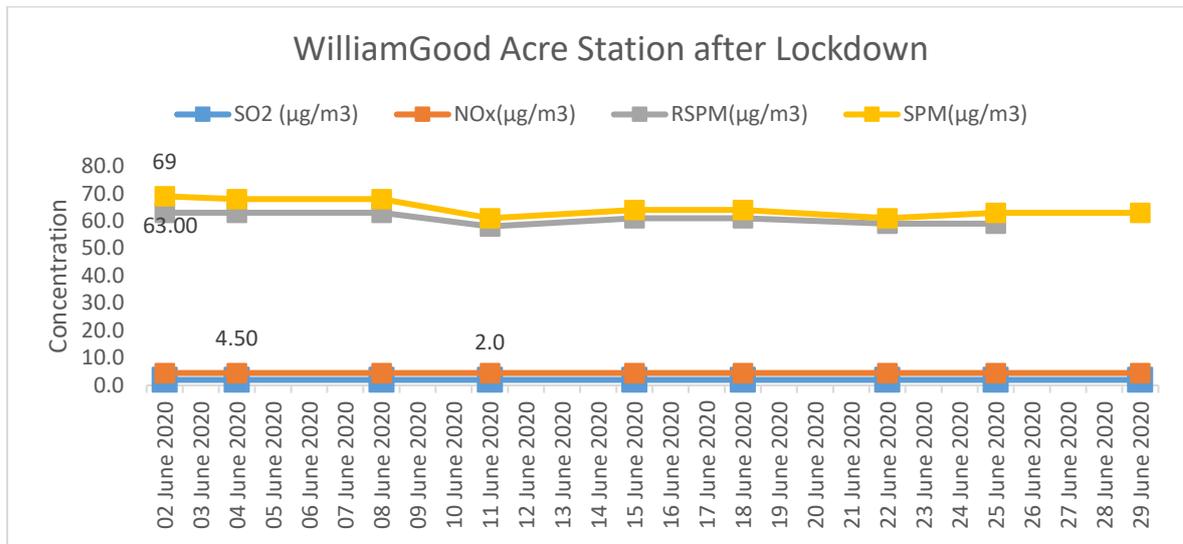


Figure 6.12: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at William Good Acre station after lockdown.

Figure 6.12 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at William Good Acre station after lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 63 µg/m<sup>3</sup> and 69 µg/m<sup>3</sup> on 2<sup>nd</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The values registered remained the same at 2 µg/m<sup>3</sup> and 4.5 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 6.2.4 Result analysis

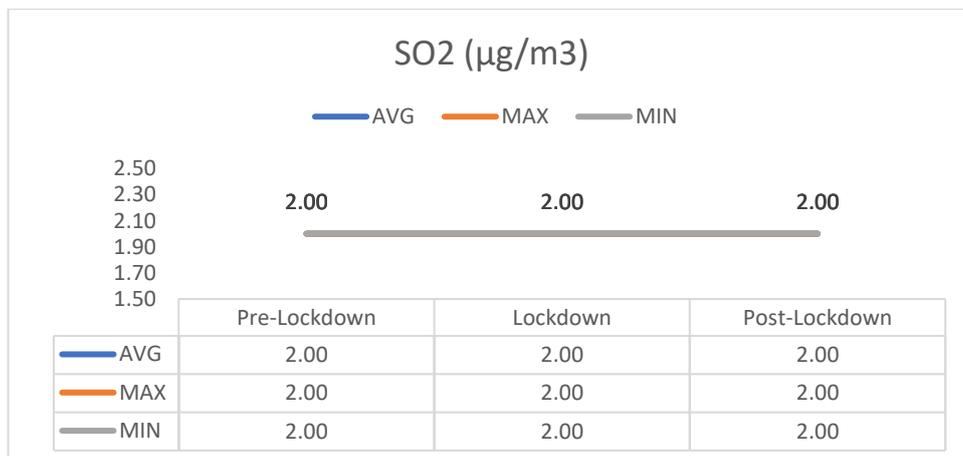
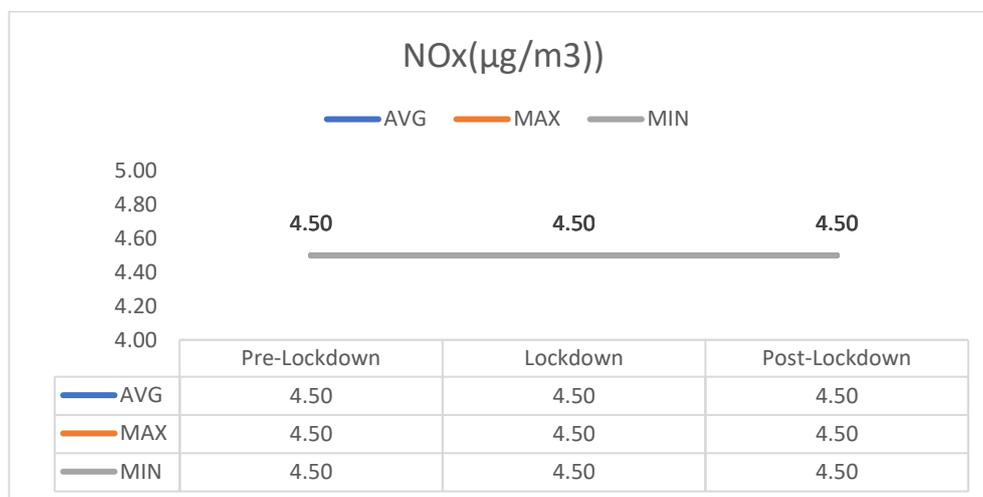
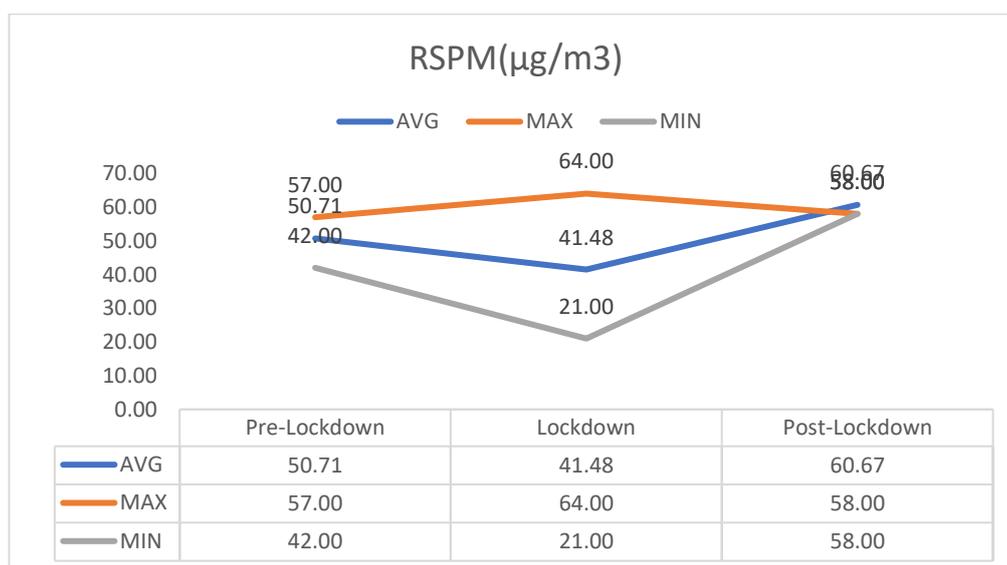


Figure 6.13: SO<sub>2</sub> Values at WilliamGood Acre station before, during and after lockdown

Figure 6.13 and 6.14 shows that the average, maximum and minimum values for SO<sub>2</sub> NO<sub>x</sub> remained the same before, during and after the lockdown period at William Good Acre station as it registered a constant minimum value.

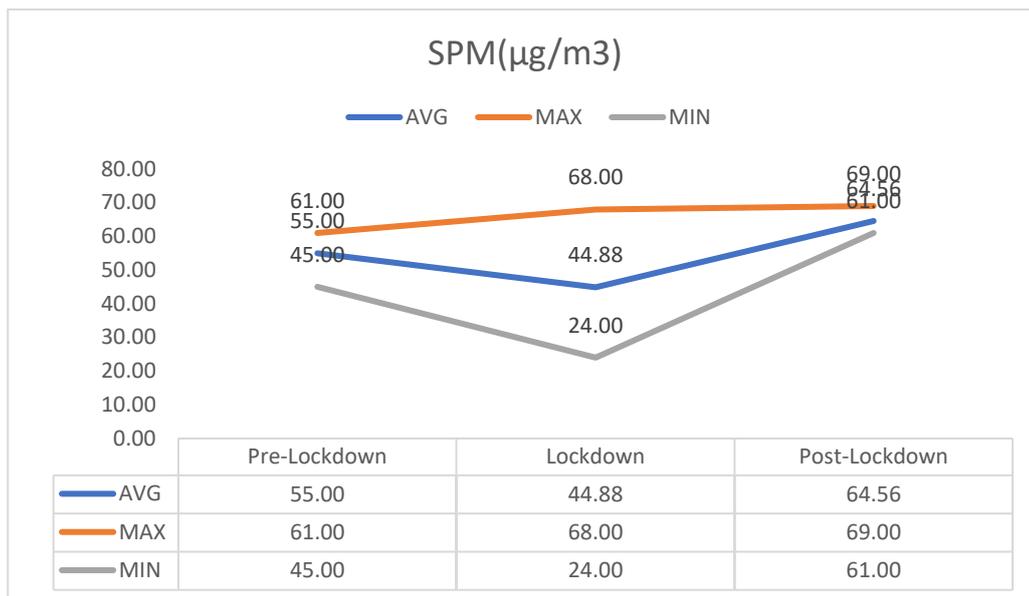


**Figure 6.14: NO<sub>x</sub> Values at WilliamGood Acre station before, during and after lockdown**



**Figure 6.15: RSPM Values at WilliamGood Acre station before, during and after lockdown**

From figure 6.14 and 6.15, it can be noted that the average, peak and minimum values of RSPM and SPM showed a notable decrease during the lockdown at William Good Acre station whereas the peak value of RSPM and SPM showed a decreasing trend even after lifting of the lockdown.



**Figure 6.16: SPM Values at WilliamGood Acre station before, during and after lockdown**

## 7 Kochi

The list of Monitoring stations in the city is tabulated in Table 7.1. The land use pattern at these stations is also depicted

Table 7.1: List of monitoring stations in Kochi

Site	Co-ordinates	Scheme	Type	Land Use Pattern
<b>Eloor -1 Methanam</b>	10.0932305, 76.29446734	NAMP	Residential	In a residential area, Industries
<b>Eloor-2 TCC</b>	10.0740494, 76.3078814	NAMP	Industrial	Industrial Area
<b>Ernakulam South</b>	9.97366, 76.29311	NAMP	Residential, Rural And Others	Commercial Establishment, Industries
<b>Vyttila</b>	9.958208, 76.281928	NAMP	Residential, Rural And Others	Major Roads, Traffic Junction, Commercial Establishments
<b>Irumpanam</b>	9.9876151, 76.3513846	NAMP	Industrial	Industries
<b>Kalammasery</b>	10.0502914, 76.3125027	NAMP	Industrial	Major Roads, Traffic Junction, Commercial Establishments
<b>MG Road</b>	9.971541, 76.281928	NAMP	Residential And Others	Commercial Area
<b>Vyttila</b>	9.969447, 76.321186	CAAQMS		Major Roads, Traffic Junction, Commercial Establishments
<b>Udyogamandal</b>	10.073232, 76.302765	CAAQMS		Industries, Residential, Commercial Establishment
<b>Kacheripady</b>	9.985653, 76.281342	CAAQMS		Major Roads, Traffic Junction, Commercial Establishments
<b>Perumbavoor</b>		NAMP	Industrial	Industries, Residential, Commercial Establishment

Table 7.2 gives the growth of vehicles in the district of Ernakulam (Kochi), it has shown steady growth.

Table 7.2: Vehicular Count in Kochi

Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
<b>No of vehicles</b>	1467028	1617972	1559270	1675199	1796868	1945451

## 7.1 Methanam (Residential) -Manual Monitoring Station

Methanam station is located in a residential area in the city. The land use pattern also includes industries.

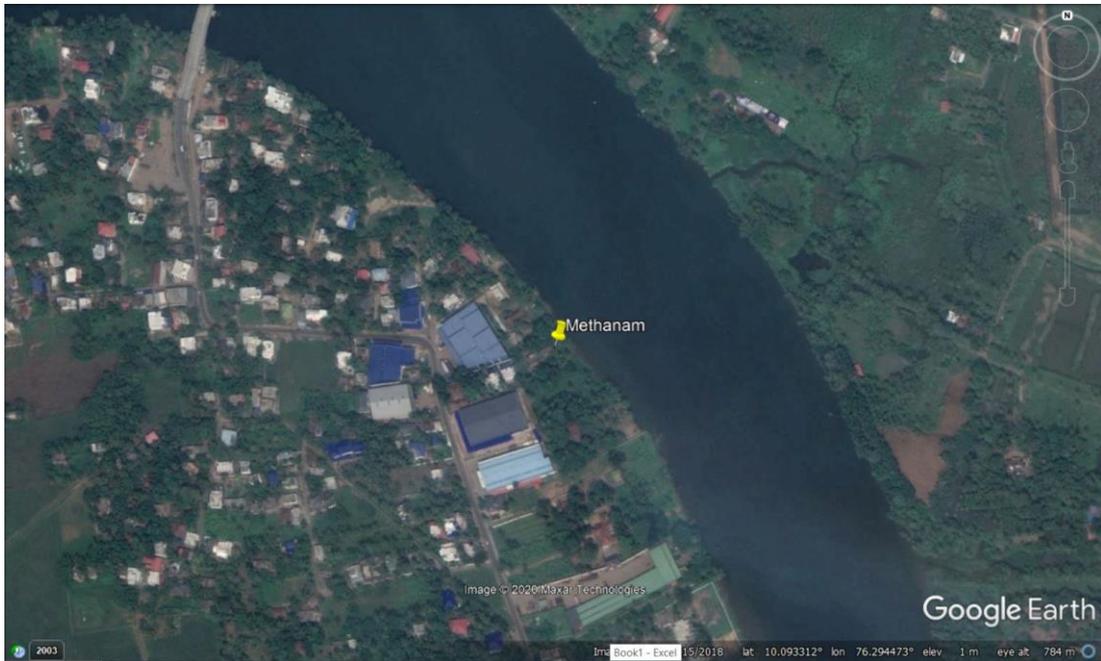


Figure 7.1: Land use pattern at Methanam station

### 7.1.1 Before Lockdown

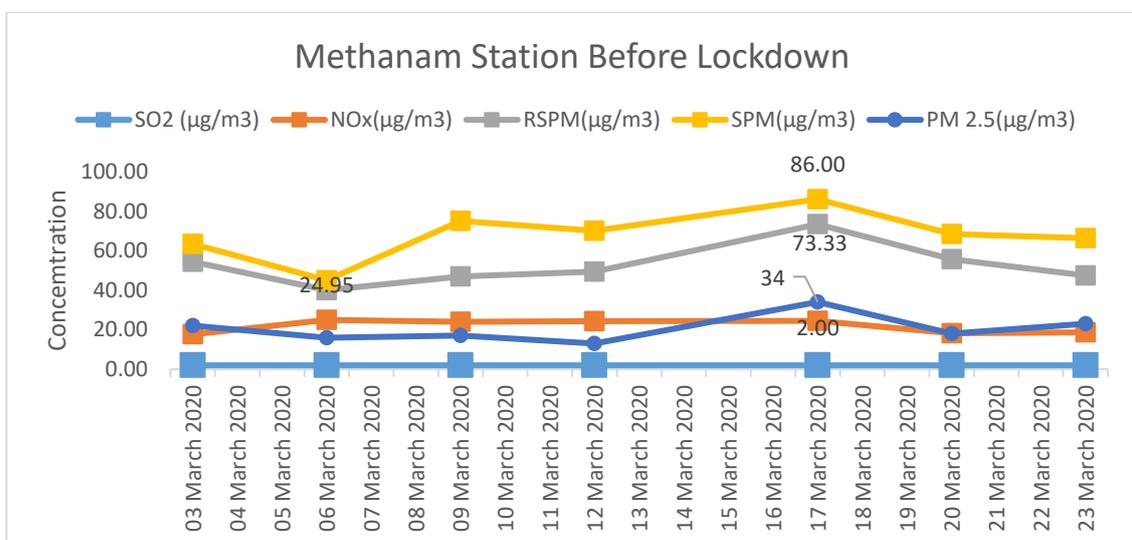


Figure 7.2: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Methanam station before Lockdown

Figure 7.2 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Methanam station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 73.33 µg/m<sup>3</sup> and 86 µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 24.95 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 34 µg/m<sup>3</sup> on 17<sup>th</sup> March 2020.

### 7.1.2 During Lockdown

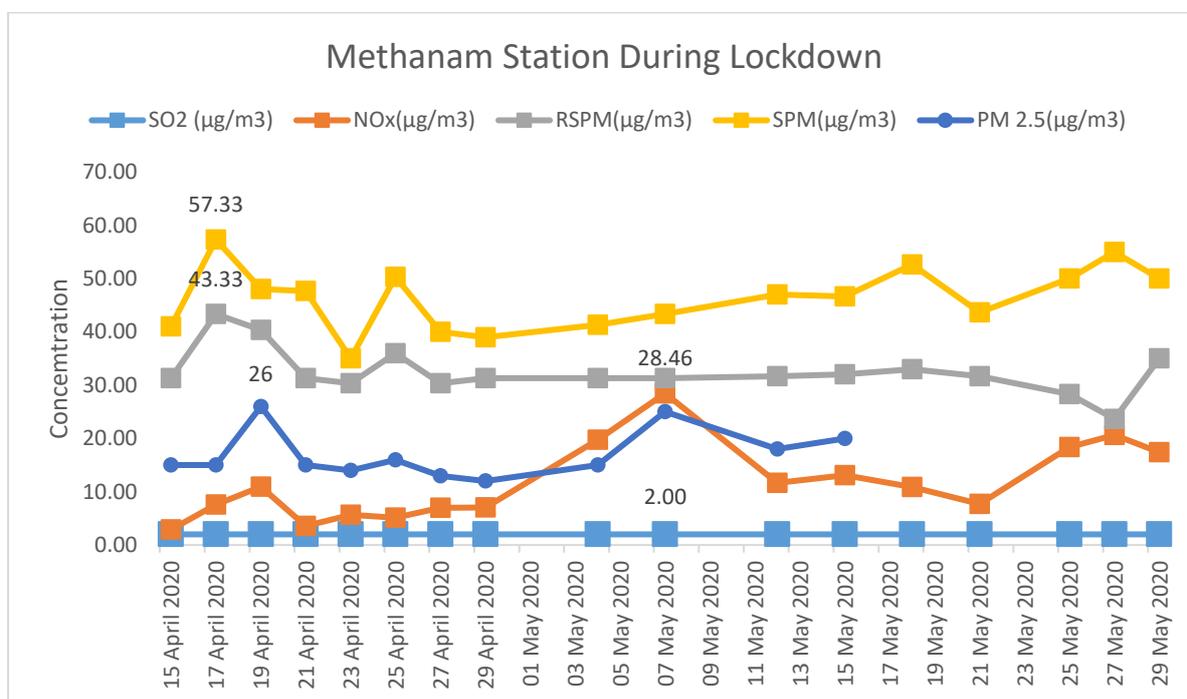


Figure 7.3: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Methanam station during the lockdown

Figure 7.3 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Methanam station during the lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest values of RSPM and SPM value were recorded as 43.33 µg/m<sup>3</sup> and 57 µg/m<sup>3</sup> respectively on 17<sup>th</sup> April 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The value registered remained the same at 2µg/m<sup>3</sup> for SO<sub>2</sub>. The Highest value of NO<sub>x</sub> was 28.46 µg/m<sup>3</sup> and for PM<sub>2.5</sub> was 26 µg/m<sup>3</sup>.

### 7.1.3 After Lockdown

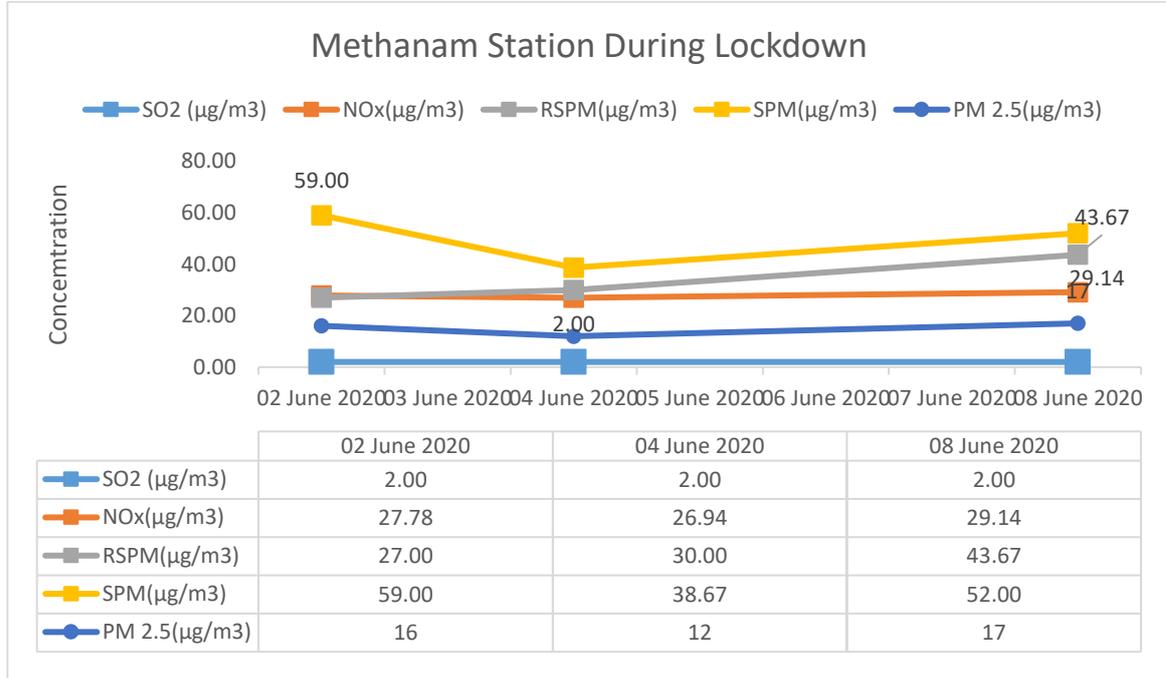


Figure 7.4: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Methanam station after lockdown

Figure 7.4 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Methanam station after lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest values of RSPM and SPM value was 43.67 µg/m<sup>3</sup> and 59 µg/m<sup>3</sup> respectively on 8<sup>th</sup> June 2020 and 2<sup>nd</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The value registered remained the same at 2.0 µg/m<sup>3</sup> for SO<sub>2</sub>. The peak value of NO<sub>x</sub> and PM<sub>2.5</sub> is 29.14 µg/m<sup>3</sup> respectively. and 17 µg/m<sup>3</sup> respectively.

### 7.1.4 Result analysis

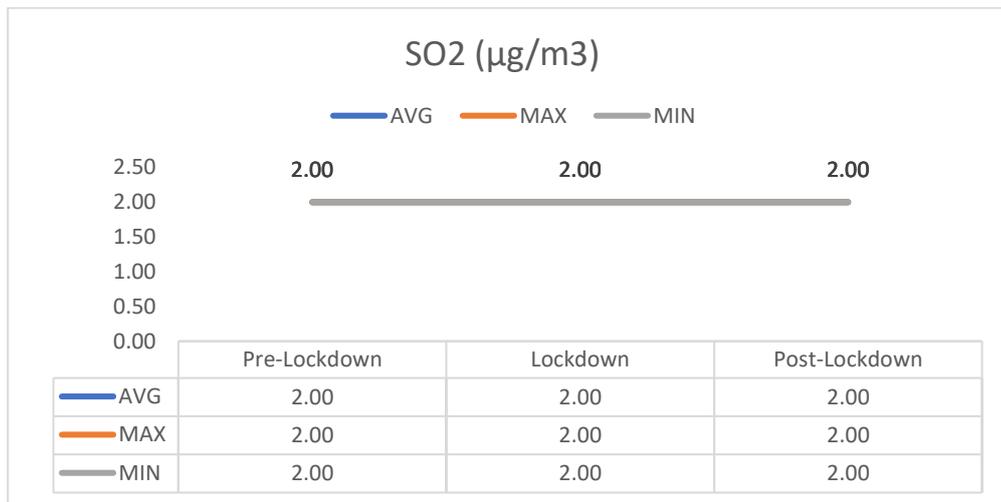


Figure 7.5: SO<sub>2</sub> Values at Methanam station before, during and after lockdown

Figure 7.5 and 7.6 shows that the average, maximum and minimum values for SO<sub>2</sub> NO<sub>x</sub> remained the same before, during and after the lockdown period at Methanam station as it registered a constant minimum value.

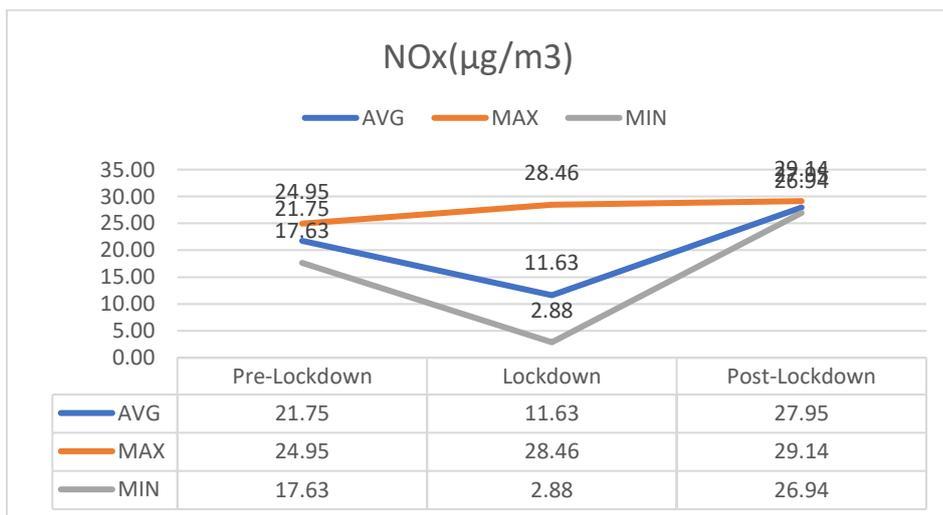


Figure 7.6: NO<sub>x</sub> Values at Methanam office station before, during and after lockdown.

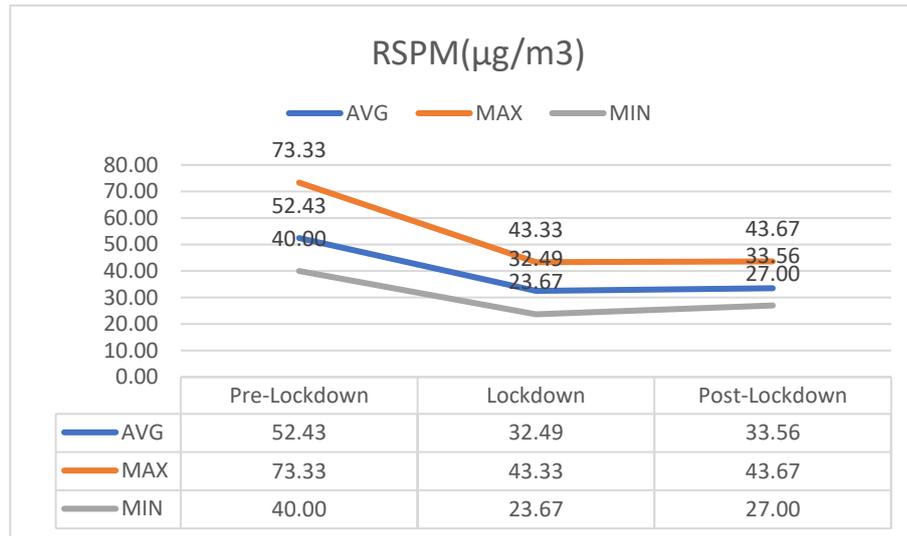


Figure 7.7: RSPM Values at Methanam station before, during and after lockdown

From figure 7.7 and 7.8, it can be noted that the average, peak and minimum values of RSPM and SPM showed a notable decrease during the lockdown at Methanam station whereas the peak value of SPM showed a decreasing trend after registering a short increase during the lockdown.

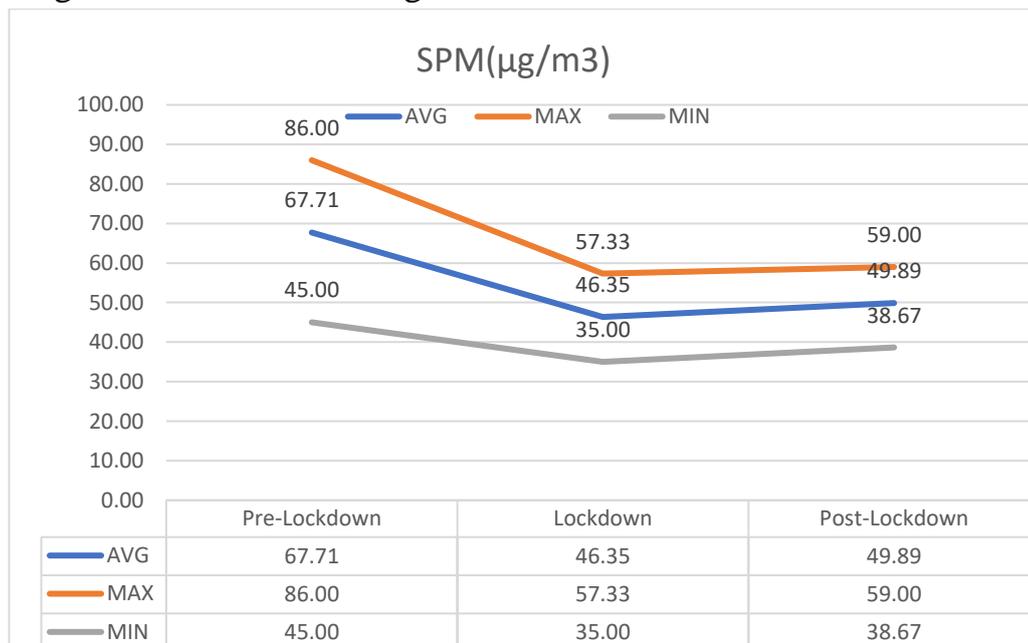


Figure 7.8: SPM Values at Methanam Station before, during and after lockdown

## 7.2 South Over Bridge Station (Residential, Rural & Others)

The South Over Bridge Station is located in that part of the city with Residential, Rural and other land use pattern

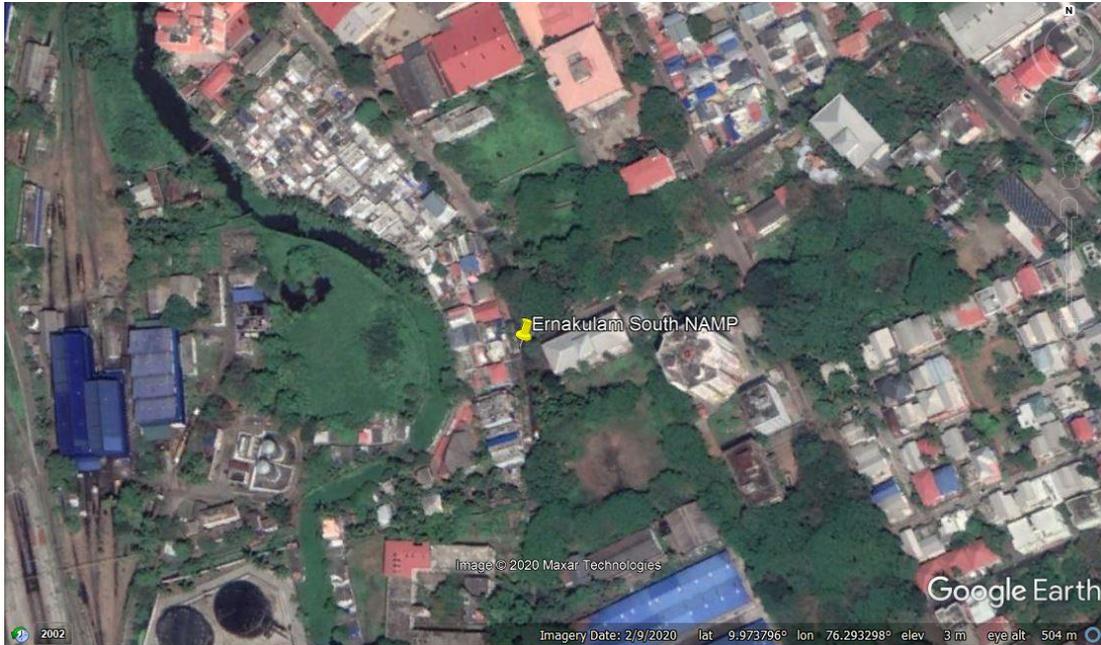


Figure 7.9: Land use pattern at South Over Bridge Station

### 7.2.1 Before Lockdown

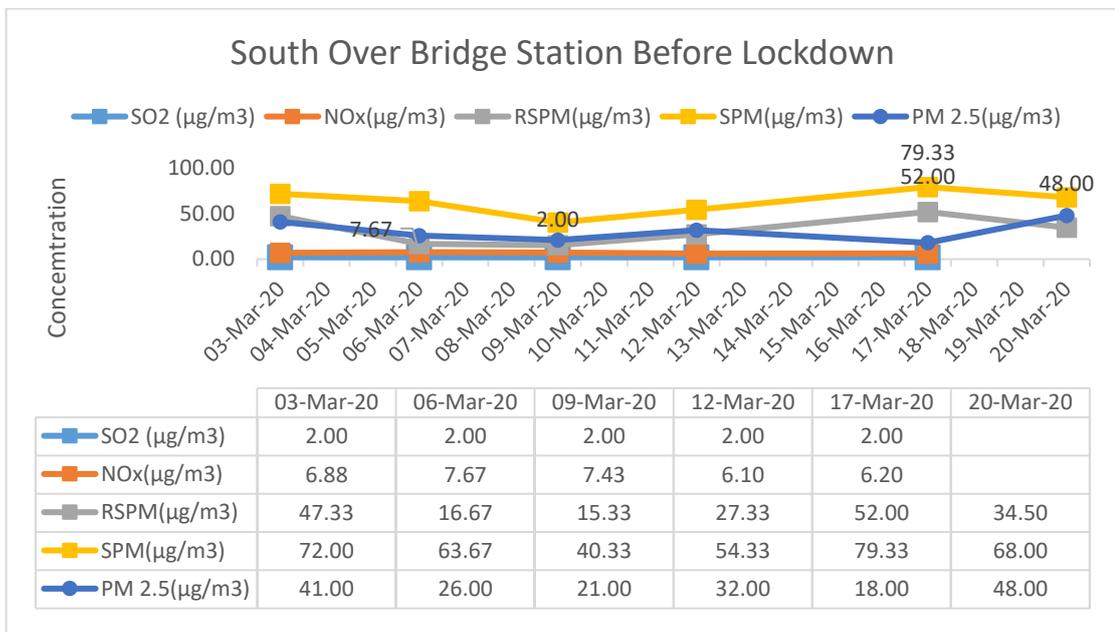


Figure 7.10: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and PM<sub>2.5</sub> measured at South Over Bridge Station before Lockdown

Figure 7.10 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at South Over Bridge Station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 52 µg/m<sup>3</sup> and 79.33 µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 7.67 µg/m<sup>3</sup> and 2.00 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 48 µg/m<sup>3</sup> on 20<sup>th</sup> March 2020.

### 7.2.2 During Lockdown

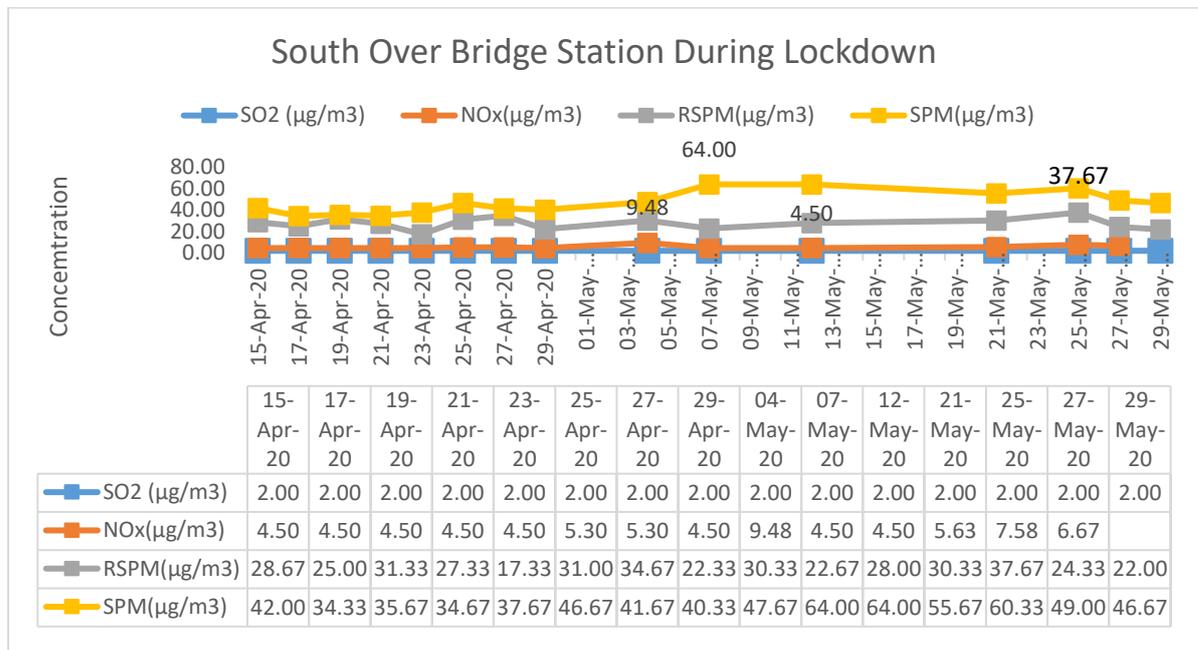
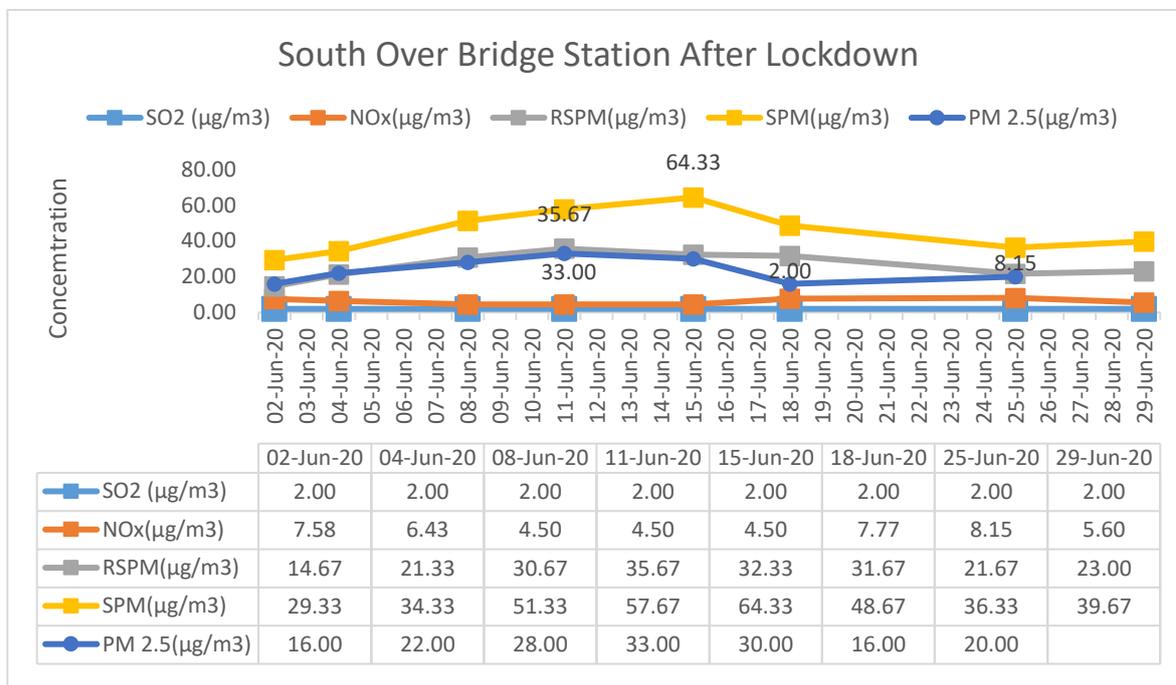


Figure 7.11: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at South Over Bridge Station during Lockdown

Figure 7.11 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at South Over Bridge Station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 37.67 µg/m<sup>3</sup> and 64 µg/m<sup>3</sup> respectively on 25<sup>th</sup> May 2020 and 12<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 9.48 µg/m<sup>3</sup> and 2.00 µg/m<sup>3</sup> respectively

for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 53 µg/m<sup>3</sup> on 14<sup>th</sup> May 2020.

### 7.2.3 After Lock Down



**Figure 7.12: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at South Over Bridge Station during Lockdown**

Figure 7.12 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at South Over Bridge Station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 35.67 µg/m<sup>3</sup> and 64.33 µg/m<sup>3</sup> respectively on 11<sup>th</sup> June 2020 and 15<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 8.15 µg/m<sup>3</sup> and 2.00 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 33 µg/m<sup>3</sup> on 11<sup>th</sup> June 2020.

## 7.2.4 Result Analysis

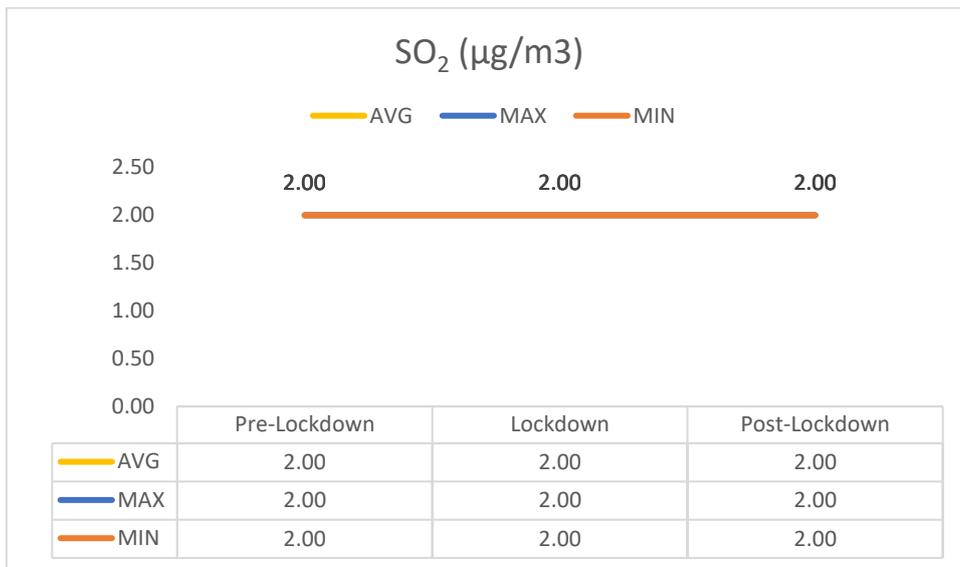


Figure 7.13: SO<sub>2</sub> Values at South Over Bridge station before, during and after lockdown

Figure 7.13 shows that the average, maximum and minimum values for SO<sub>2</sub> remained the same before, during and after the lockdown period at South Over Bridge Station as it registered a constant minimum value.

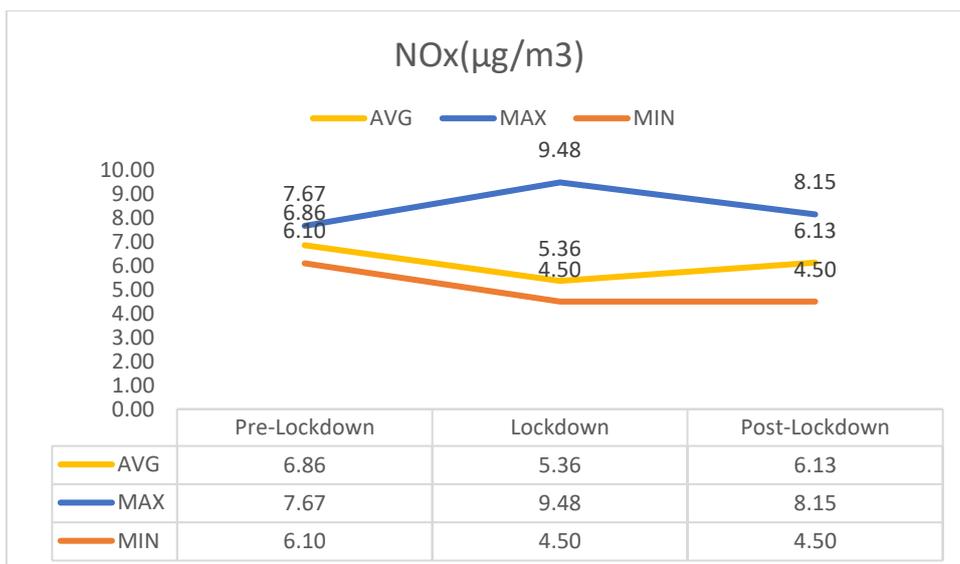


Figure 7.14: NO<sub>x</sub> Values at South Over Bridge station before, during and after lockdown

Figure 7.14 shows that the average, maximum and minimum values for NO<sub>x</sub> remained the same before, during and after the lockdown period at South Over Bridge Station. The Peak value registered an increase during lockdown which showed a relative decrease as the lockdown was lifted.

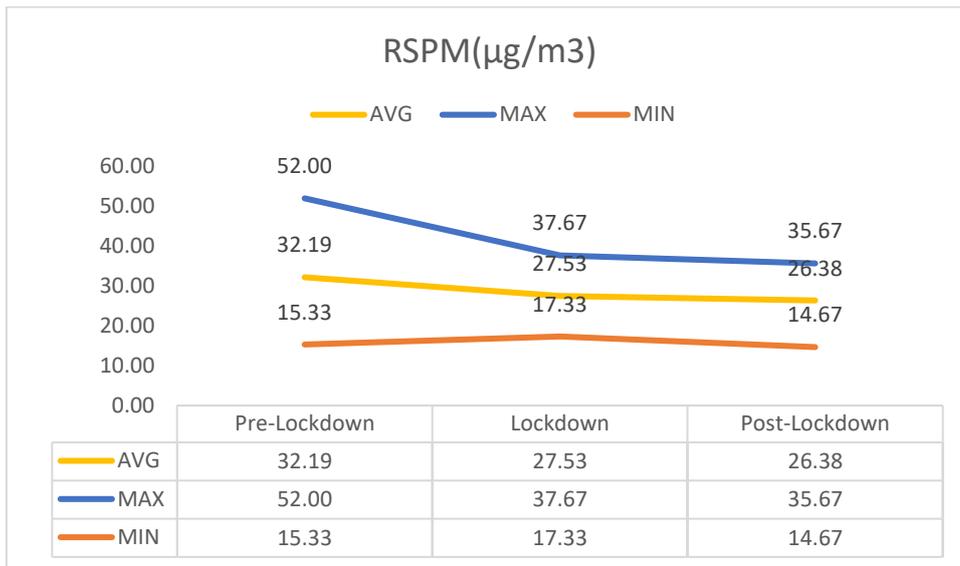


Figure 7.15: RSPM Values at South Over Bridge station before, during and after lockdown

Figure 7.15 shows that the average, maximum and minimum values for RSPM remained the same before, during and after the lockdown period at South Over Bridge Station. Though the average and peak value registered a decrease during the lockdown the minimum value showed a slight increase during the lockdown which later got reduced that of the pre lockdown value.

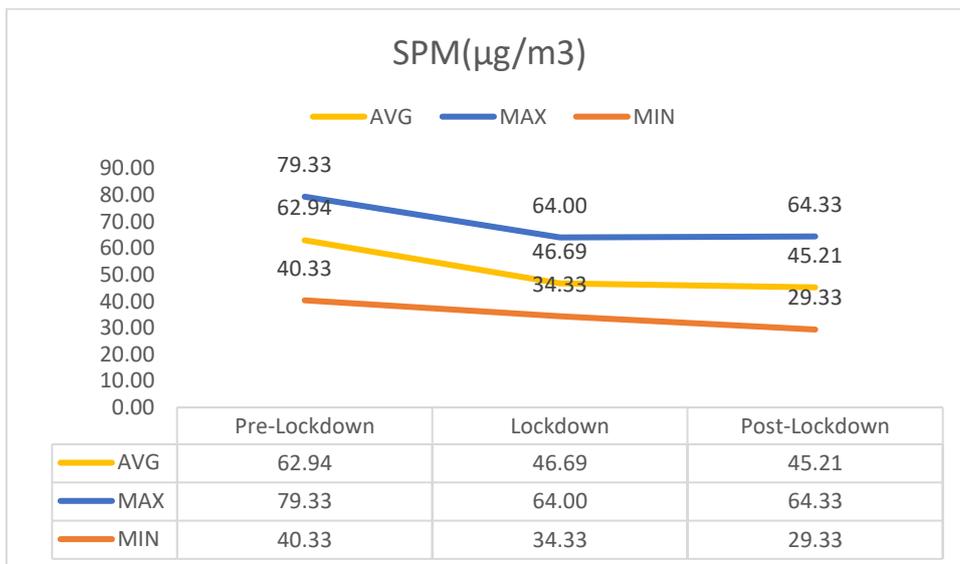
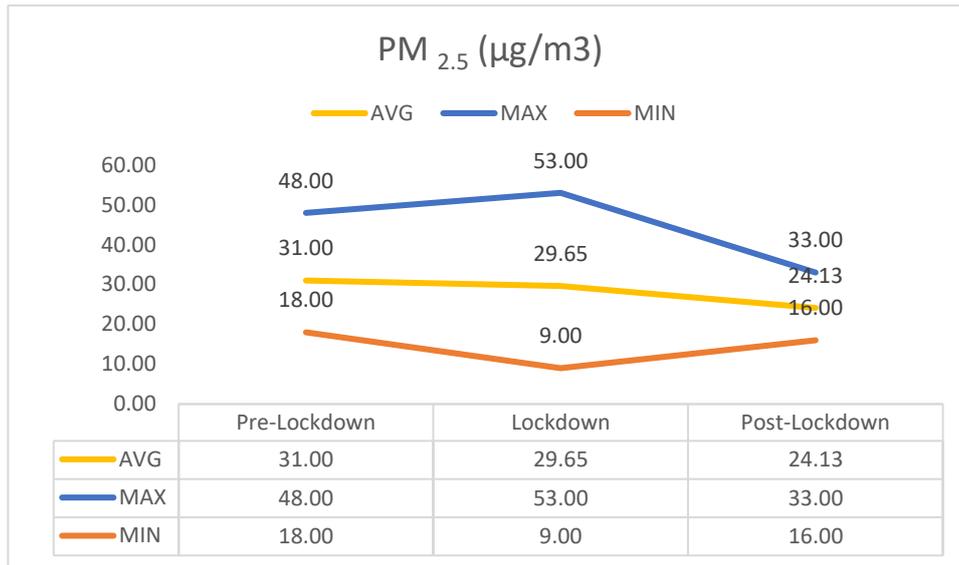


Figure 7.16: SPM Values at South Over Bridge station before, during and after lockdown

Figure 7.16 shows that the Average Maximum and the minimum value of SPM at South overbridge Station showed a decreasing trend during and after lockdown



**Figure 7.17: PM<sub>2.5</sub> Values at South Over Bridge station before, during and after lockdown**

From figure 7.17, it can be noted that the average and peak values of PM<sub>2.5</sub> showed a notable decrease during the lockdown at South Over Bridge Station whereas the minimum value registered a decrease during the lockdown which showed a comeback after the lockdown.

### 7.3 TCC Station (Industrial) -Manual Monitoring Station

The TCC (Travancore Cochin Chemicals) station is located in a designated industrial area with red category industries.



Figure 7.18: Land Use pattern at TCC Station

#### 7.3.1 Before Lockdown.

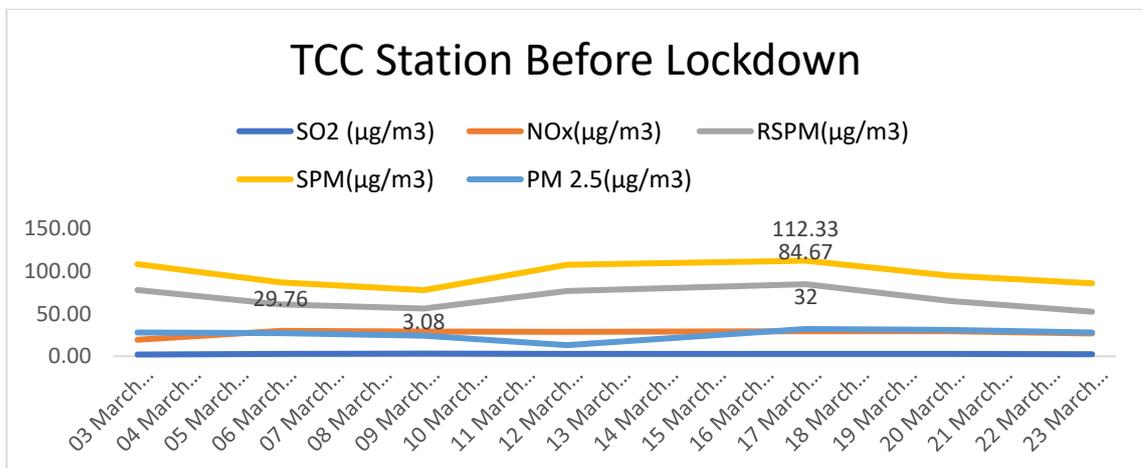


Figure 7.19: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at TCC Station before Lockdown

Figure 7.19 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at TCC Station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 84.67 µg/m<sup>3</sup> and 112.33 µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 3.08 µg/m<sup>3</sup> and 29.76 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 32 µg/m<sup>3</sup> on 17<sup>th</sup> March 2020.

### 7.3.2 During Lockdown

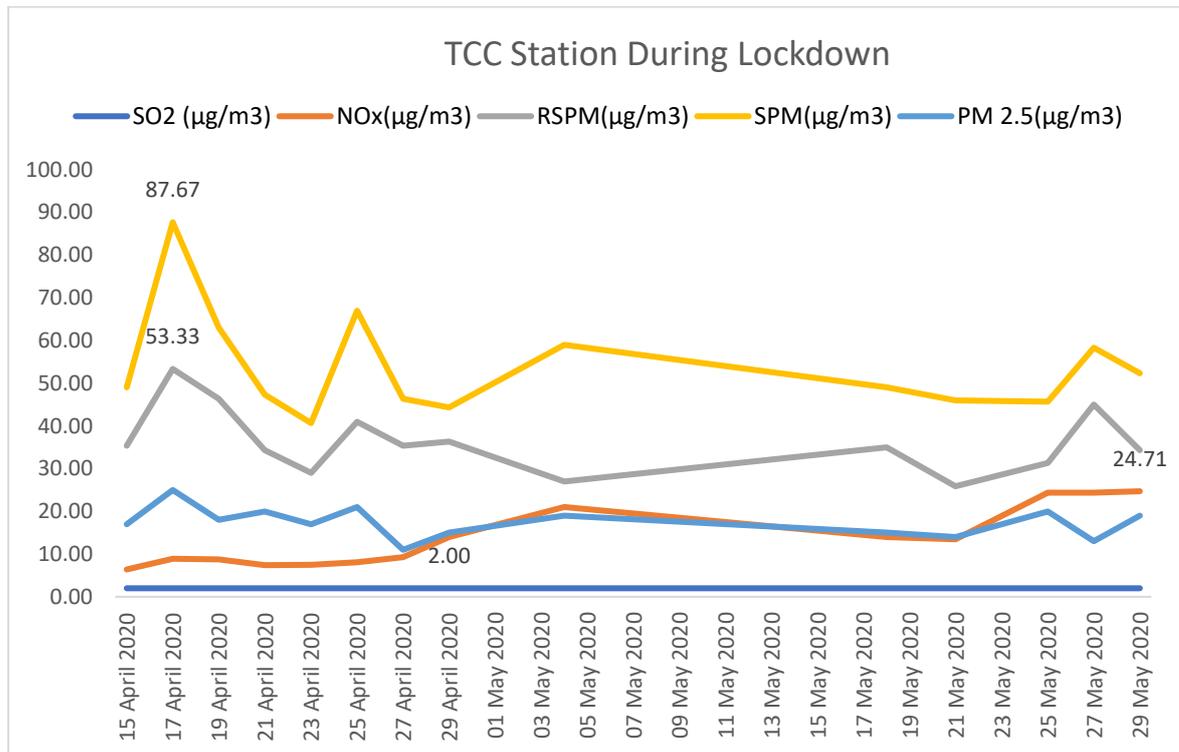


Figure 7.20: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at TCC Station during Lockdown

Figure 7.20 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at TCC Station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 53.33 µg/m<sup>3</sup> and 87.67 µg/m<sup>3</sup> respectively on 17<sup>th</sup> April 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 24.71 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 27 µg/m<sup>3</sup> on 7<sup>th</sup> May 2020

### 7.3.3 After Lockdown

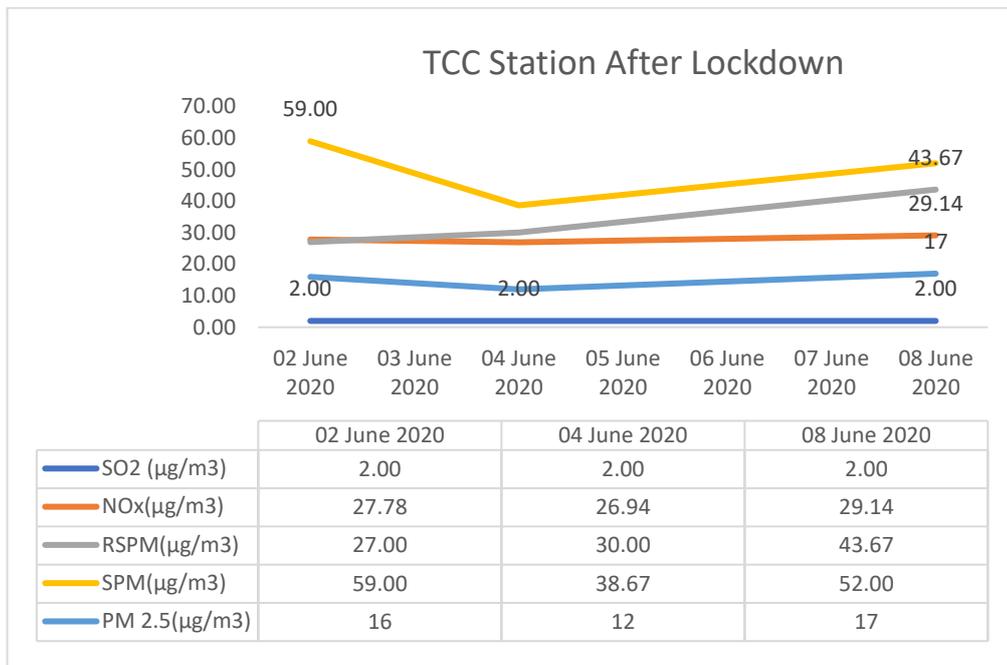


Figure 7.21: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at TCC Station after Lockdown

Figure 7.21 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at TCC Station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 43.67 µg/m<sup>3</sup> and 59 µg/m<sup>3</sup> respectively on 8<sup>th</sup> June 2020 and 2<sup>nd</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 29.14 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 17 µg/m<sup>3</sup> on 8<sup>th</sup> June 2020.

### 7.3.4 Result Analysis

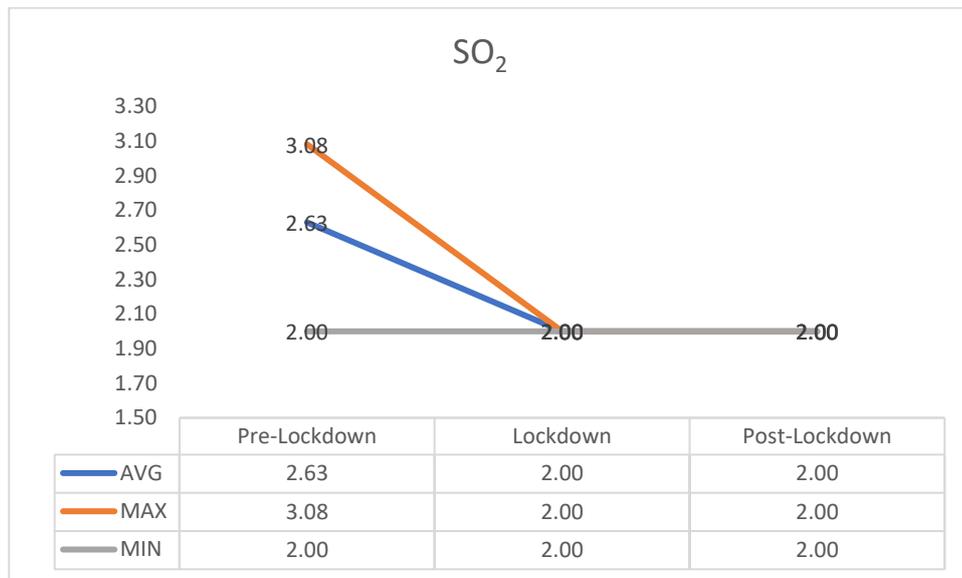


Figure 7.22: SO<sub>2</sub> Values at TCC station before, during and after lockdown

Figure 7.22 shows that the average, maximum values for SO<sub>2</sub> decrease during the lockdown to a minimum of 2.0 µg/m<sup>3</sup>. It then remained the same after the lockdown period at TCC Station.

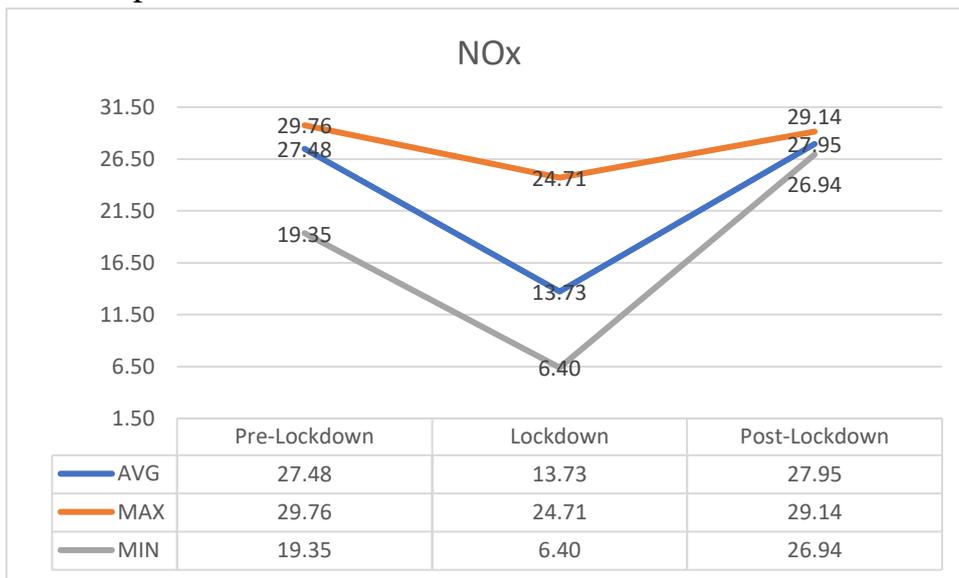


Figure 7.23: NO<sub>x</sub> Values at TCC station before, during and after lockdown

Figure 7.23 shows that average, maximum and minimum values for NO<sub>x</sub> registered a notable decrease during the lockdown period which later relapsed as the lockdown was lifted at TCC Station.

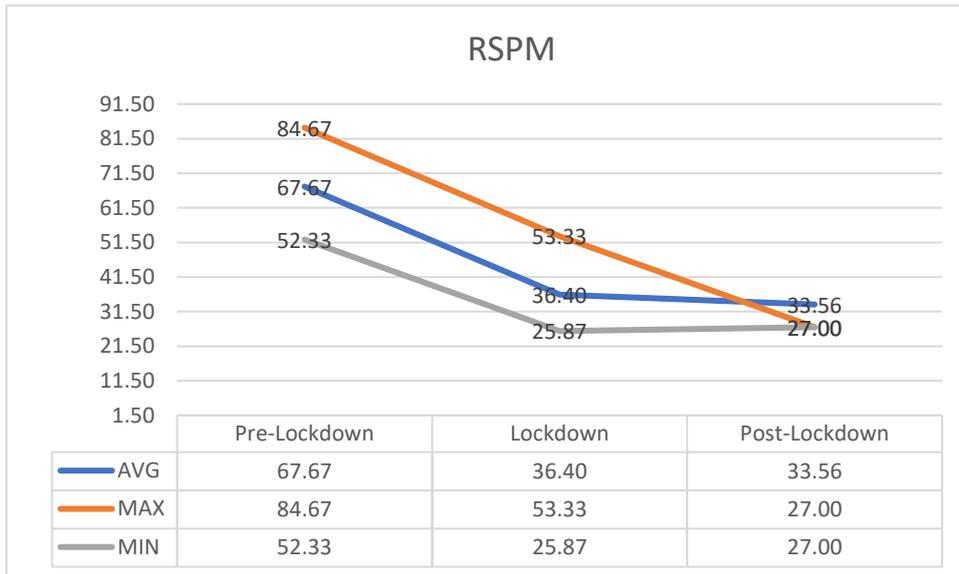


Figure 7.24: RSPM Values at TCC station before, during and after lockdown

Figure 7.24 and Figure 7.25 shows that average, maximum and minimum values for RSPM and SPM. The average and minimum value increased slightly as the lockdown was lifted at TCC Station. The peak value remained in a decreasing trend even after the lifting of the lockdown.

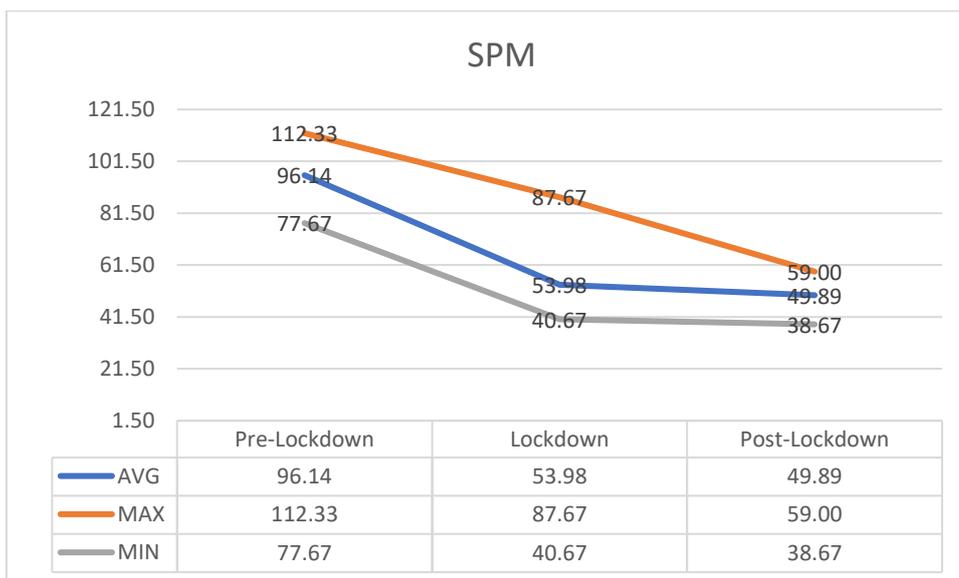


Figure 7.25: SPM Values at TCC station before, during and after lockdown

Figure 7.26 clearly shows that the average, maximum and minimum value of  $PM_{2.5}$  showed a decreasing trend during and after the lockdown

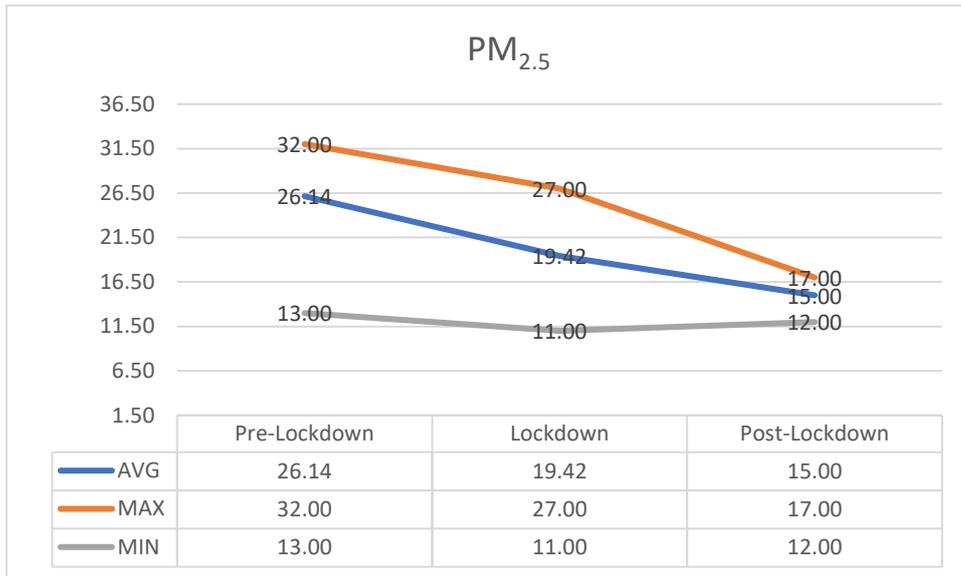


Figure 7.26: PM<sub>2.5</sub> Values at TCC station before, during and after lockdown

## 7.4 Vytilla Station(Residential, Rural & Others) -Manual Monitoring Station

The Vytilla Station is located in that part of the city with Residential, Rural and other land use pattern.

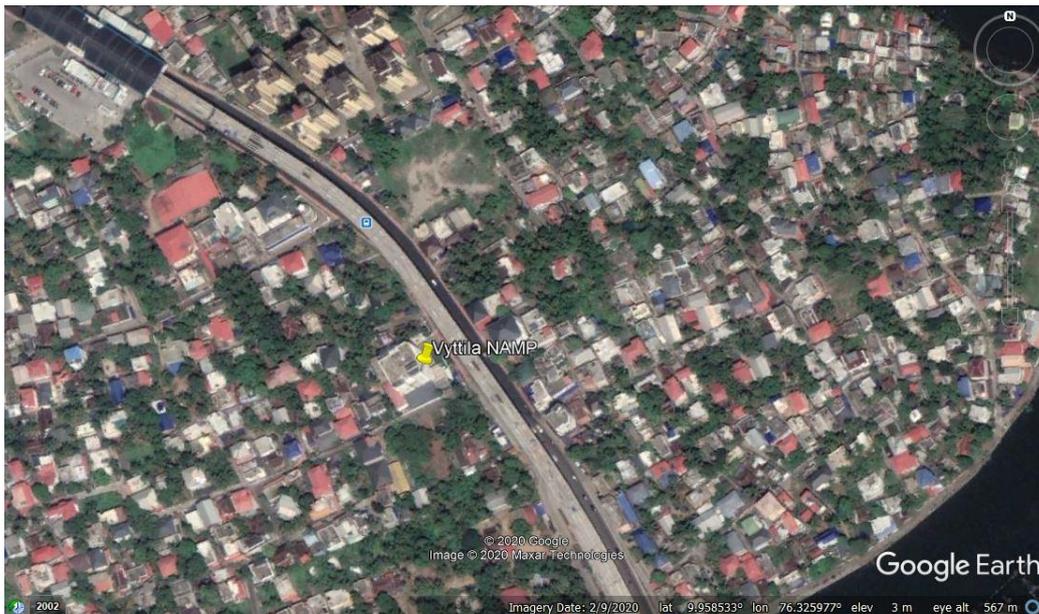


Figure 7.27: Land use pattern at Vytilla Station

### 7.4.1 Before Lockdown

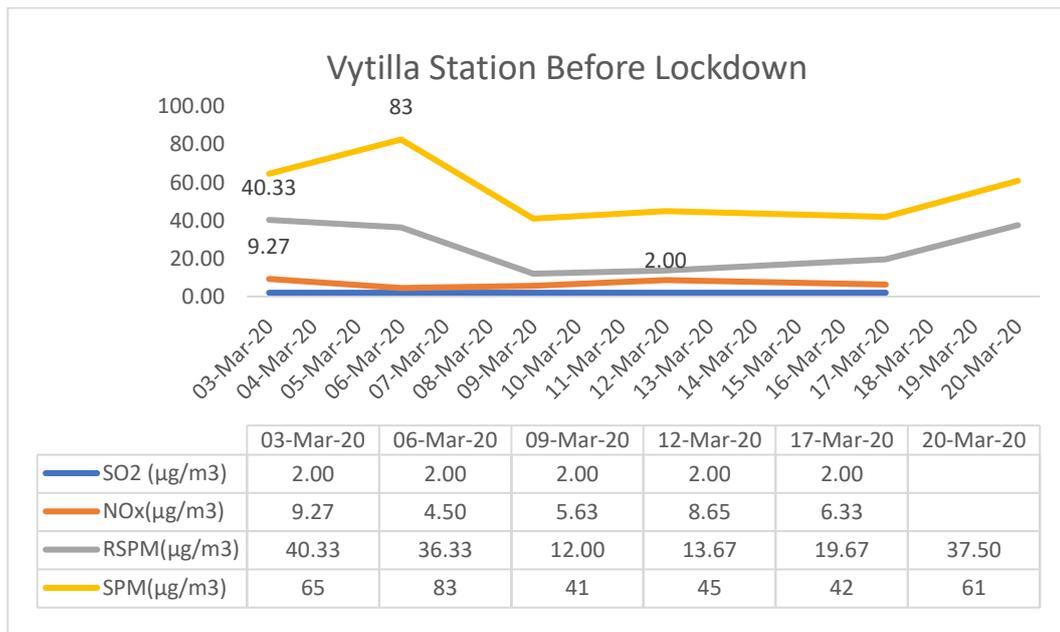


Figure 7.28: Land use pattern at Vytila Station

Figure 7.28 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at vytila Station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 40.33µg/m<sup>3</sup> and 83 µg/m<sup>3</sup> respectively on 3<sup>rd</sup> March 2020 and 6<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 9.27 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 7.4.2 During Lockdown

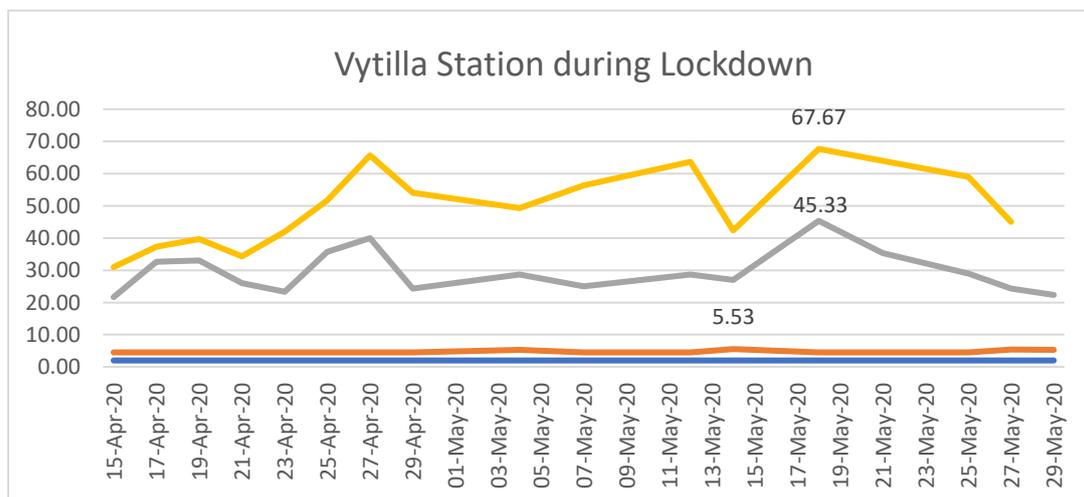


Figure 7.29: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Vytilla Station during Lockdown

Figure 7.29 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Vytilla Station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 45.33 µg/m<sup>3</sup> and 67.67 µg/m<sup>3</sup> respectively on 18<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 5.53 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 7.4.3 After Lockdown

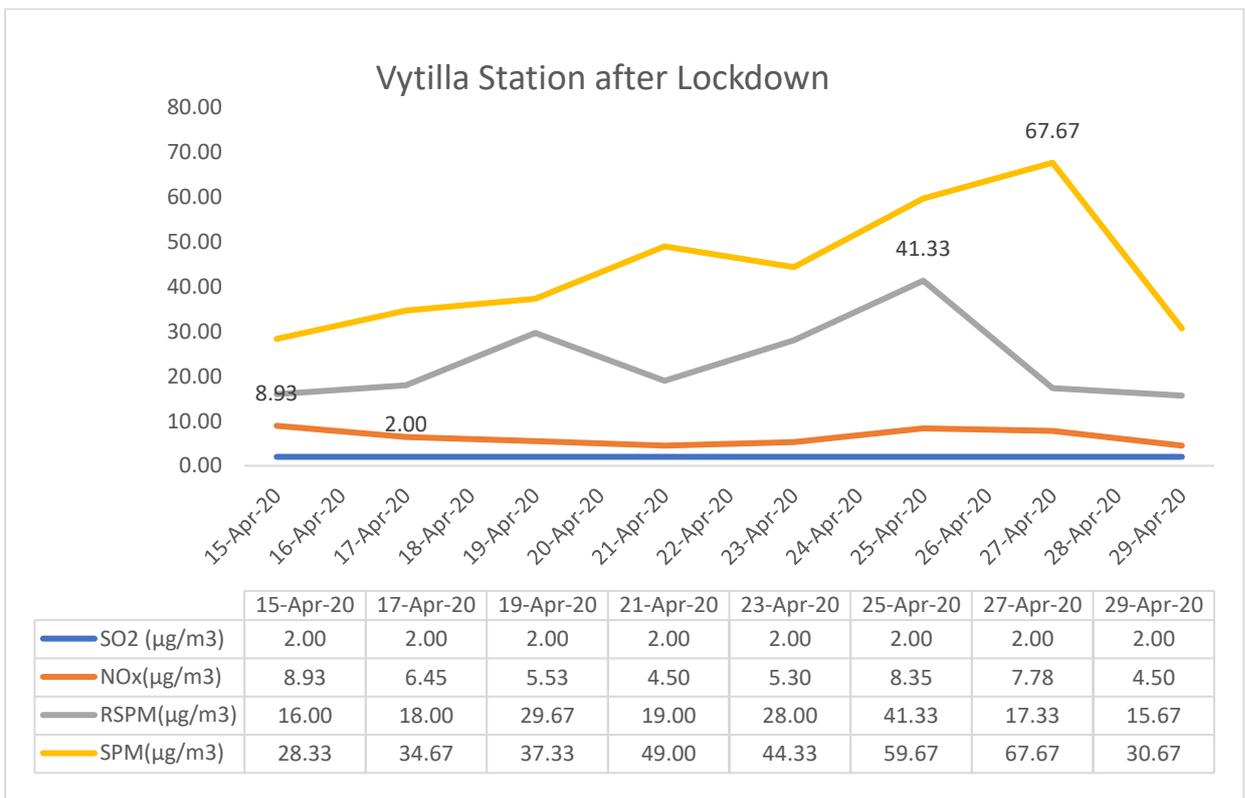


Figure 7.30: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Vytilla Station after Lockdown

Figure 7.30 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Vytilla Station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24-hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 41.33 µg/m<sup>3</sup> and 67.67 µg/m<sup>3</sup> on 25<sup>th</sup> April 2020 and 27<sup>th</sup> April 2020 respectively. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 8.93 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 7.4.4 Result Analysis

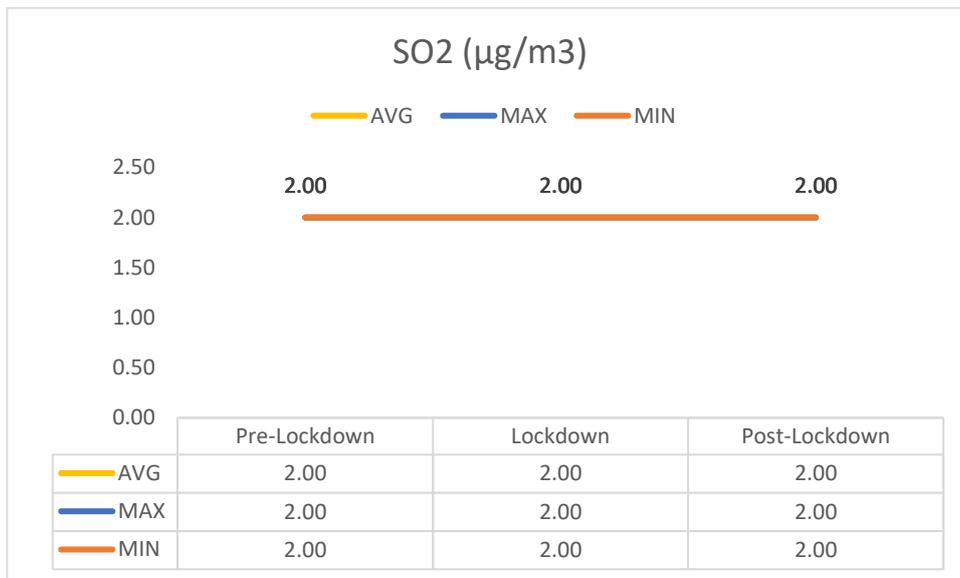


Figure 7.31: SO<sub>2</sub> Values at Vytilla station before, during and after lockdown

Figure 7.31 shows that the average, maximum and minimum values for SO<sub>2</sub> remained the same before, during and after the lockdown period at Vytilla Station, as it registered a constant minimum value.

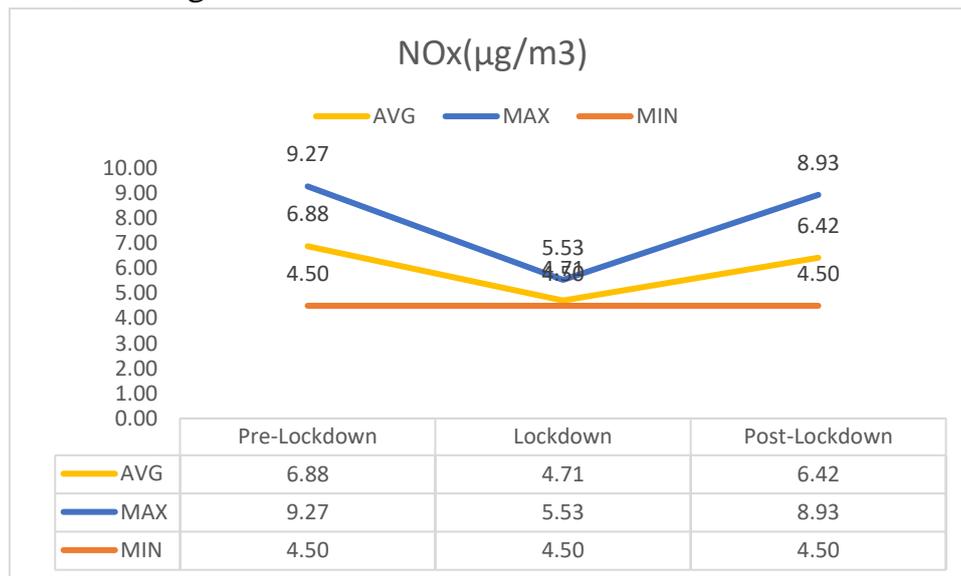


Figure 7.32: NO<sub>x</sub> Values at Vytilla station before, during and after lockdown

Figure 7.32 shows that the average, maximum values for NO<sub>x</sub> decreased during the lockdown period at Vytilla Station which relapsed after the lockdown was lifted. The minimum value remained constant at 4.5 µg/m<sup>3</sup>.

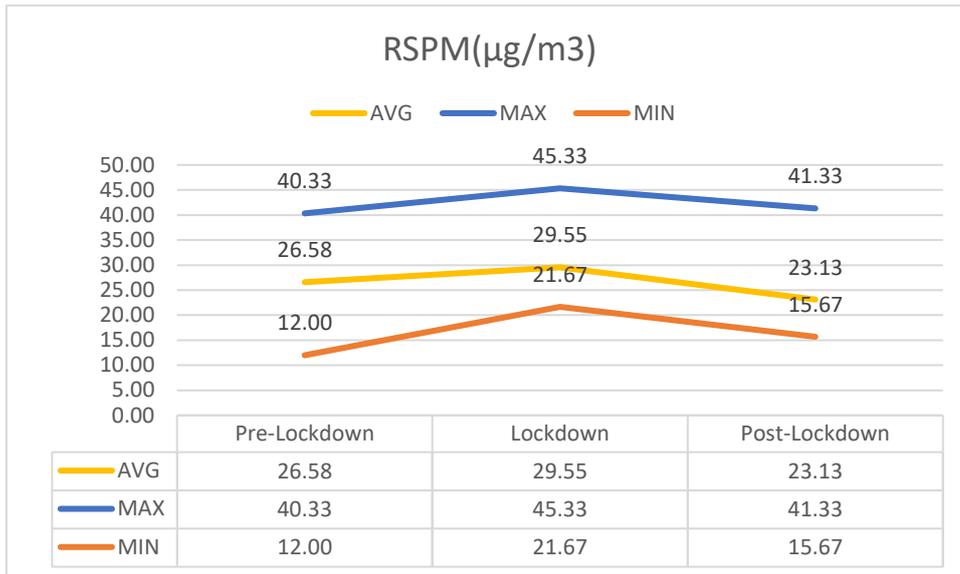


Figure 7.33: RSPM Values at Vytilla station before, during and after lockdown

Figure 7.33 shows that the average, maximum and minimum values for RSPM increased during the lockdown period at Vytilla Station which decreased after the lockdown was lifted.

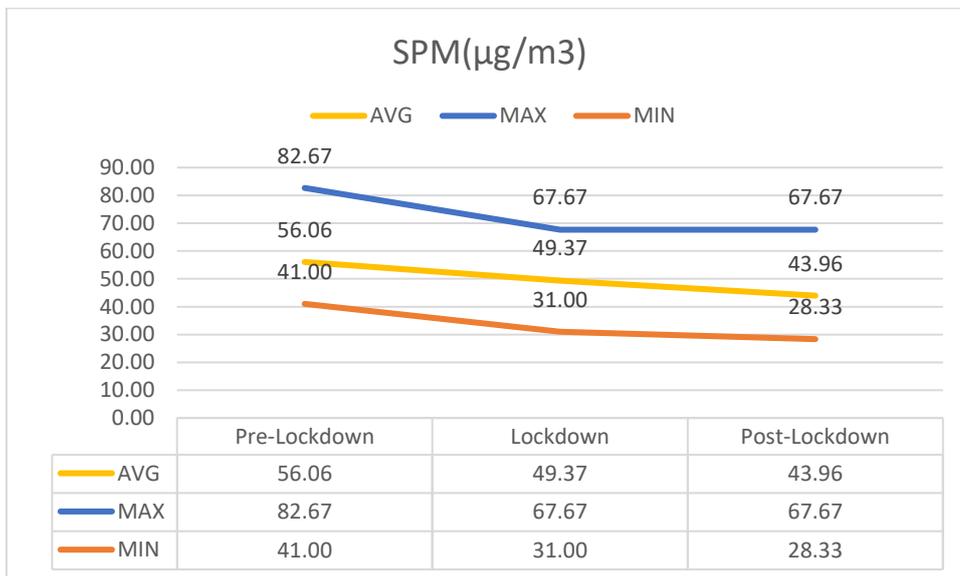


Figure 7.34: SPM Values at Vytilla station before, during and after lockdown

Figure 7.34 shows that the average, maximum and minimum values for SPM decreased during the lockdown period at Vytilla Station which remained in a decreasing trend even after lifting the lockdown.

## 7.5 Irumpana Station(Industrial) -Manual Monitoring Station

Irumpana manual air quality monitoring station is located in an industrial area.



Figure 7.35: Land use pattern at Irumpana Station

### 7.5.1 Before Lockdown

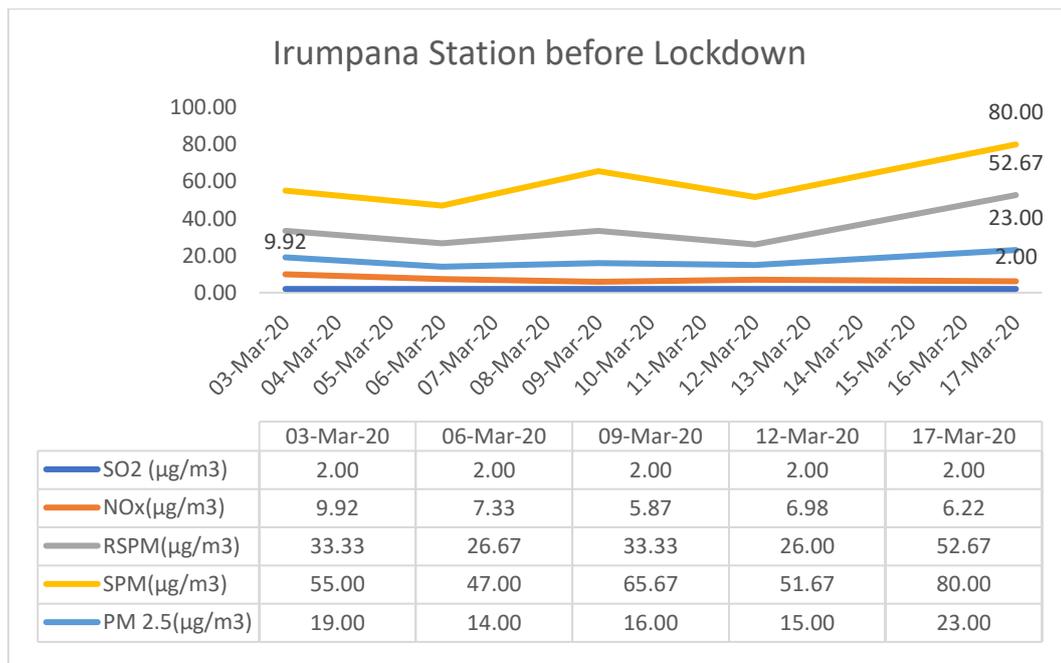


Figure 7.36: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Irumpana Station before Lockdown

Figure 7.36 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Irumpana Station before Lockdown. The data analysis indicated

that the RSPM and SPM were always below the 24 hr average standard of 100  $\mu\text{g}/\text{m}^3$ . The highest RSPM and SPM value were recorded as 52 $\mu\text{g}/\text{m}^3$  and 80  $\mu\text{g}/\text{m}^3$  respectively on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80  $\mu\text{g}/\text{m}^3$ . The highest values registered are 2.0  $\mu\text{g}/\text{m}^3$  and 9.92  $\mu\text{g}/\text{m}^3$  respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value for PM<sub>2.5</sub> was observed as 23.00  $\mu\text{g}/\text{m}^3$  on 17<sup>th</sup> March 2020.

### 7.5.2 During Lock Down

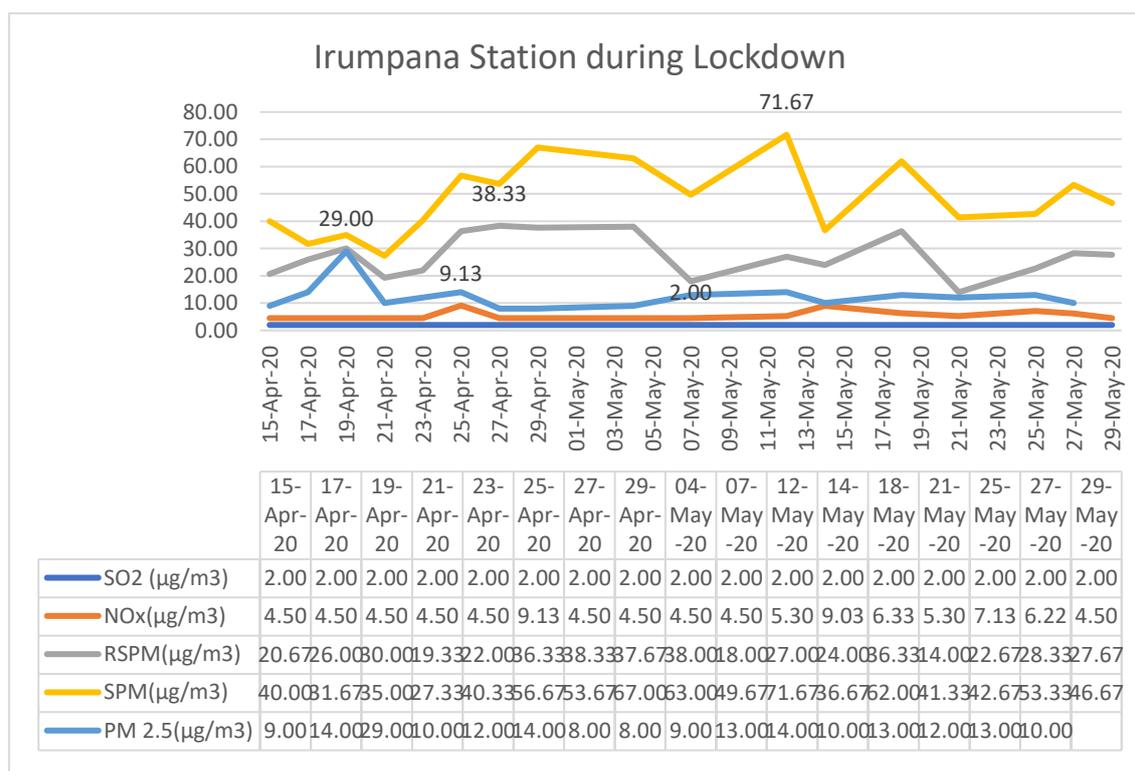


Figure 7.37: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Irumpana Station after Lockdown

Figure 7.37 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Irumpana Station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100  $\mu\text{g}/\text{m}^3$ . The highest RSPM and SPM value were recorded as 38.33 $\mu\text{g}/\text{m}^3$  and 71.67  $\mu\text{g}/\text{m}^3$  respectively on 27<sup>th</sup> April 2020 and 12<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80  $\mu\text{g}/\text{m}^3$ . The highest values registered are 2.0  $\mu\text{g}/\text{m}^3$  and 9.92  $\mu\text{g}/\text{m}^3$  respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value for PM<sub>2.5</sub> was observed as 29.00  $\mu\text{g}/\text{m}^3$  on 19<sup>th</sup> April 2020.

### 7.5.3 After Lockdown

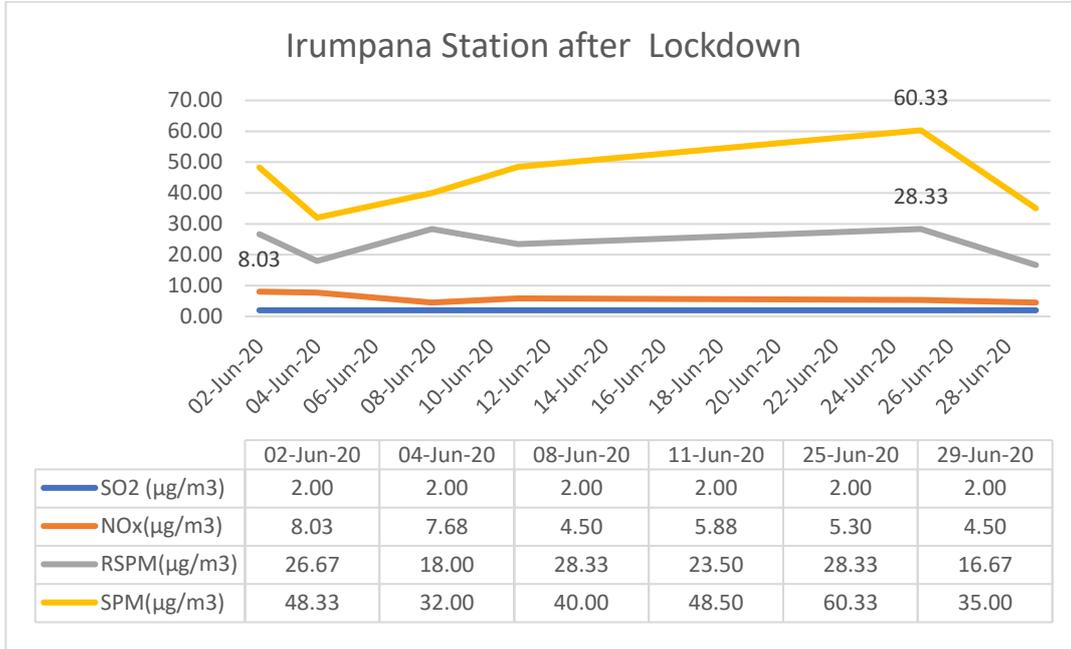


Figure 7.38: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Irumpana Station after Lockdown

Figure 7.38 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Irumpana Station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 28.33µg/m<sup>3</sup> and 60.33 µg/m<sup>3</sup> respectively on 25<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 8.03 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

## 7.5.4 Result Analysis

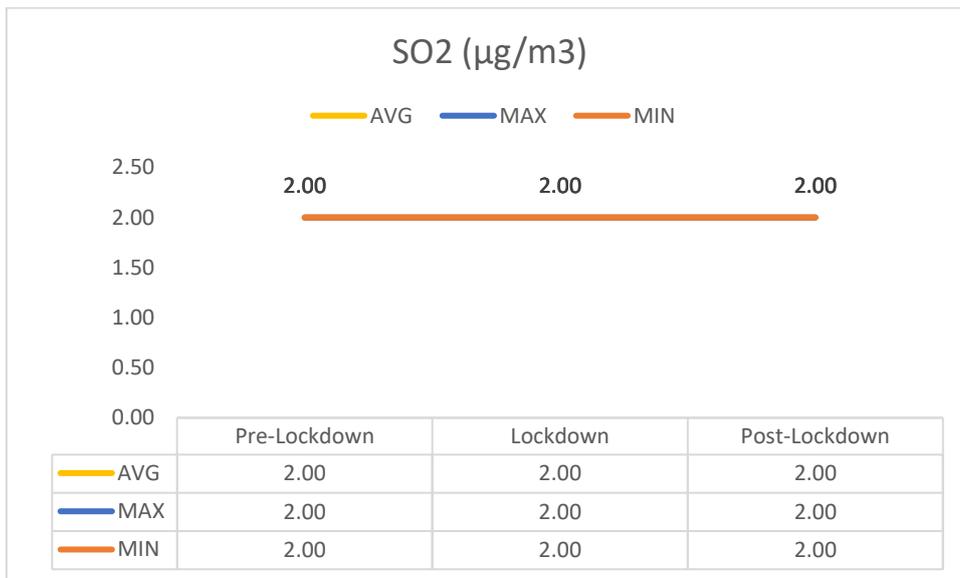


Figure 7.39: SO<sub>2</sub> Values at Irumpana Station before, during and after lockdown

Figure 7.39 shows that the average, maximum and minimum values for SO<sub>2</sub> remained the same before, during and after the lockdown period at Irumpana Station as it registered a constant minimum value.

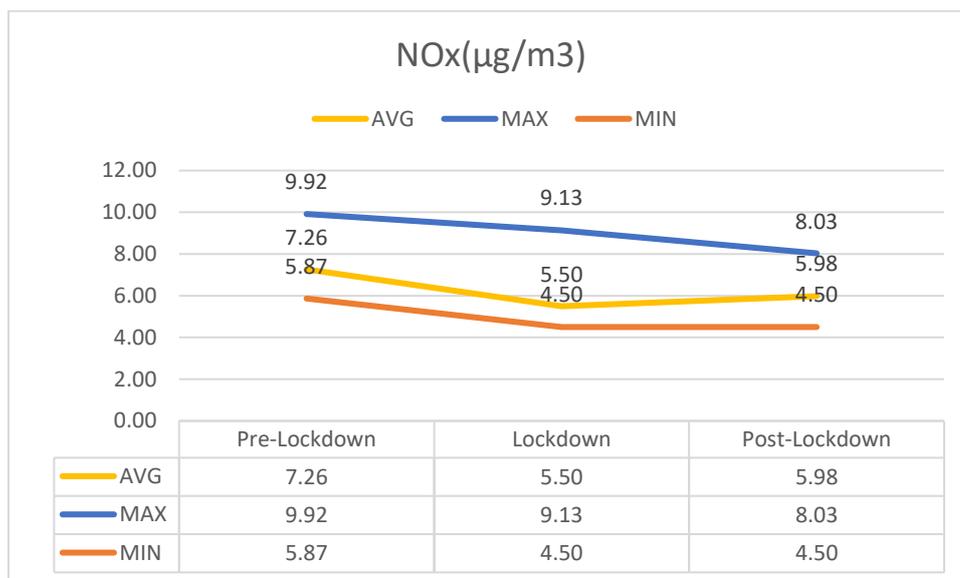


Figure 7.40: NO<sub>x</sub> Values at Irumpana Station before, during and after lockdown

Figure 7.40 shows that the average, maximum and minimum values for NO<sub>x</sub> decreased during and the lockdown period at Irumpana Station. The average value registered a slight increase after the lockdown.

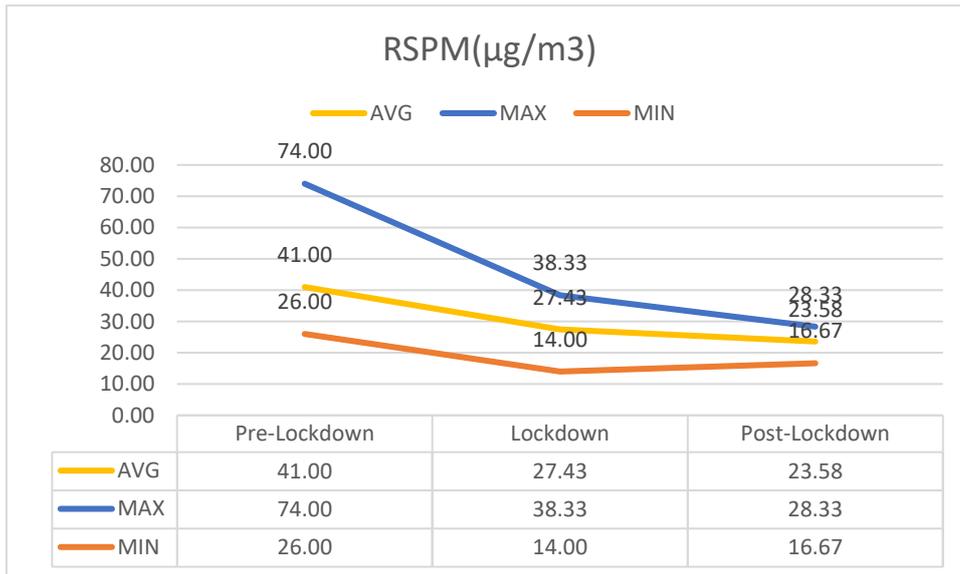


Figure 7.41: RSPM Values at Irumpana Station before, during and after lockdown

Figure 7.41 and 7.42 shows that the average, maximum and minimum values for RSPM and SPM decreased during the lockdown period at Irumpana Station which remained in a decreasing trend even after lifting the lockdown.

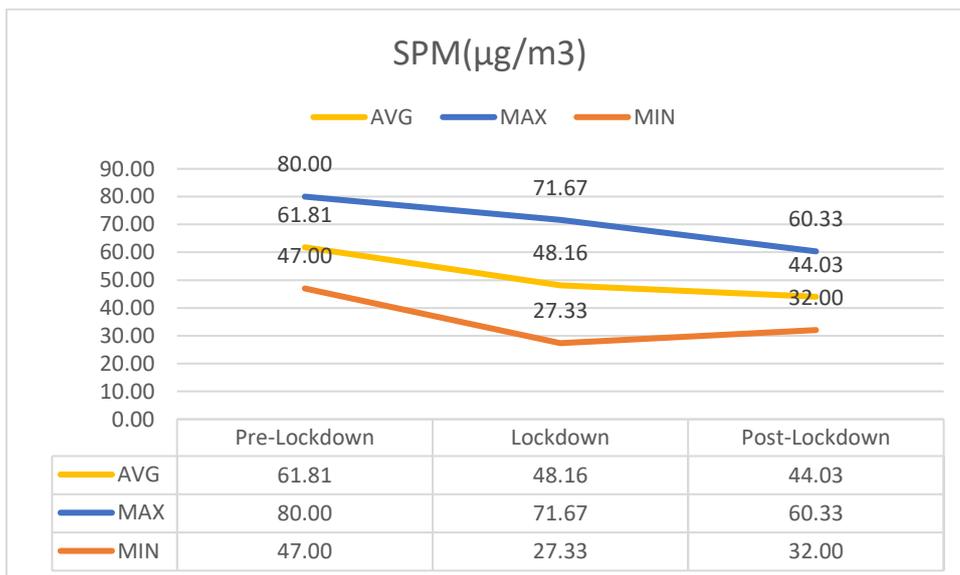


Figure 7.42: SPM Values at Irumpana Station before, during and after lockdown

## 7.6 Kalamaserry (Industrial)- Manual Monitoring Station

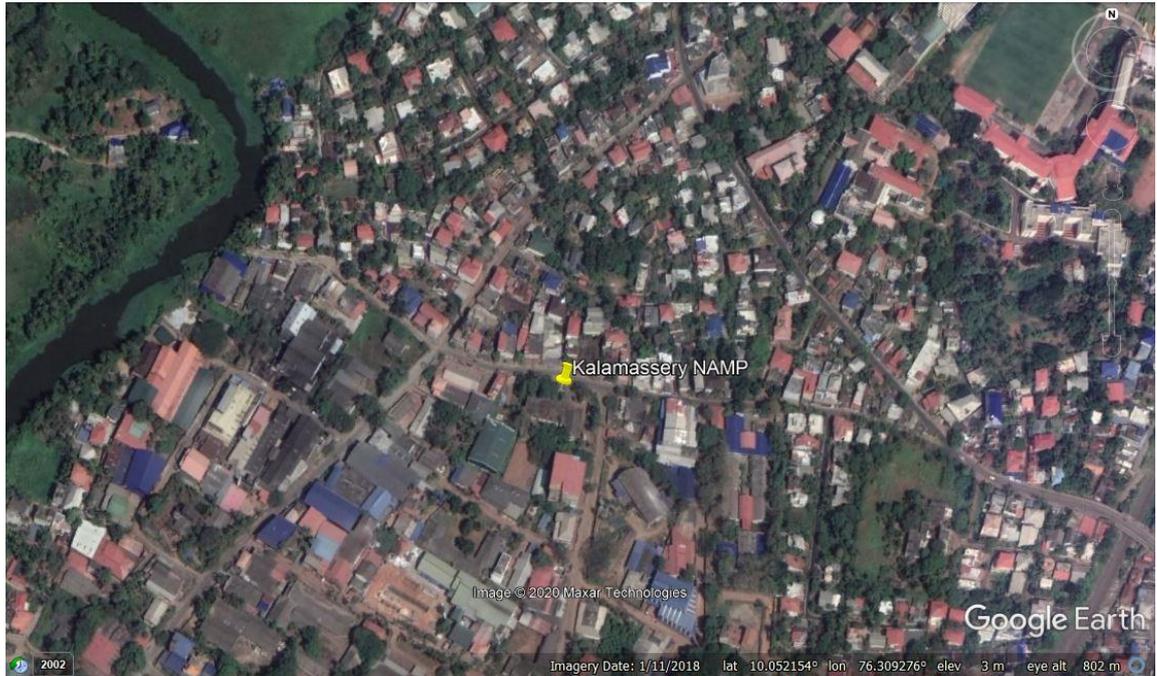


Figure 7.43: Land use pattern at Kalamassery Station

Kalamassery monitoring station is located in a designated industrial area

### 7.6.1 Before Lockdown

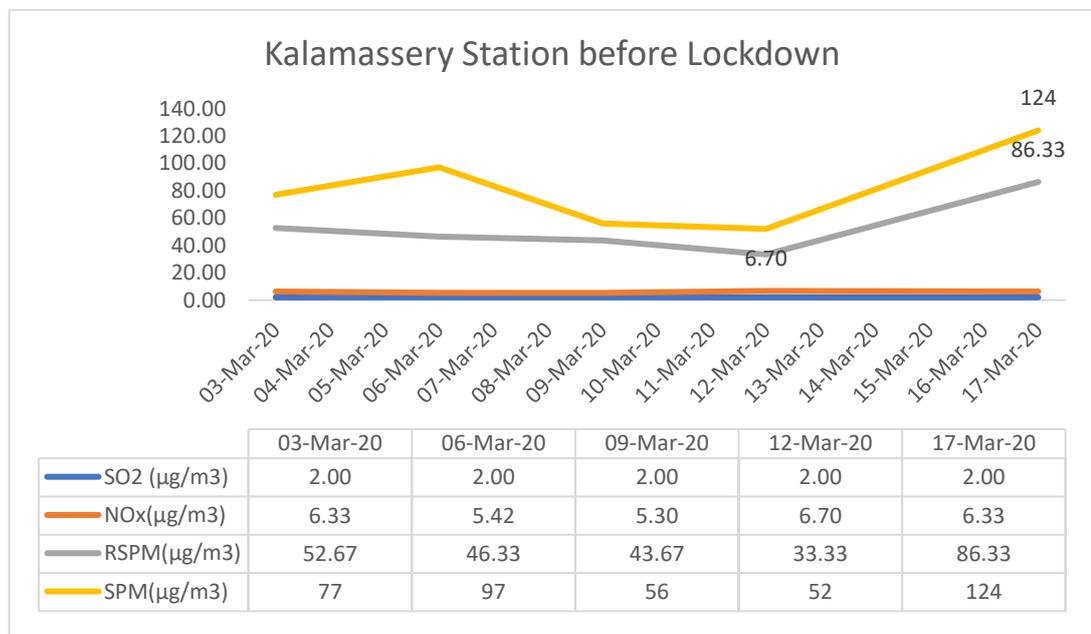


Figure 7.44: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Kalamassery Station before Lockdown

Figure 7.44 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Kalamassery Station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 86.33 µg/m<sup>3</sup> and 124 µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 6.70 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 7.6.2 During Lockdown

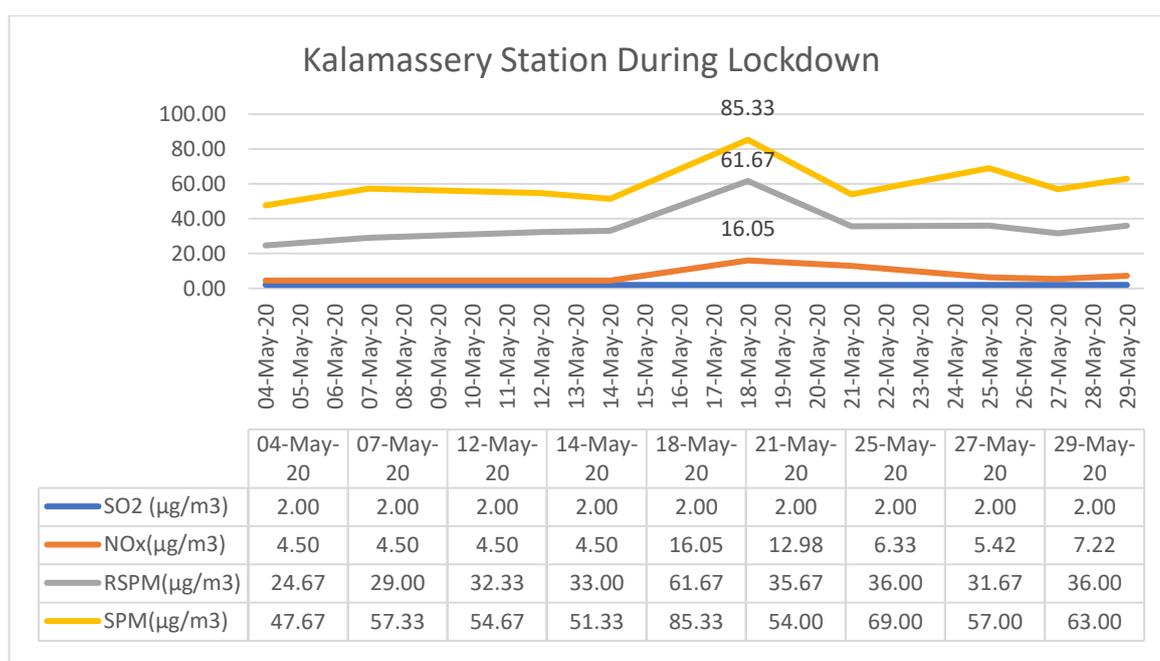
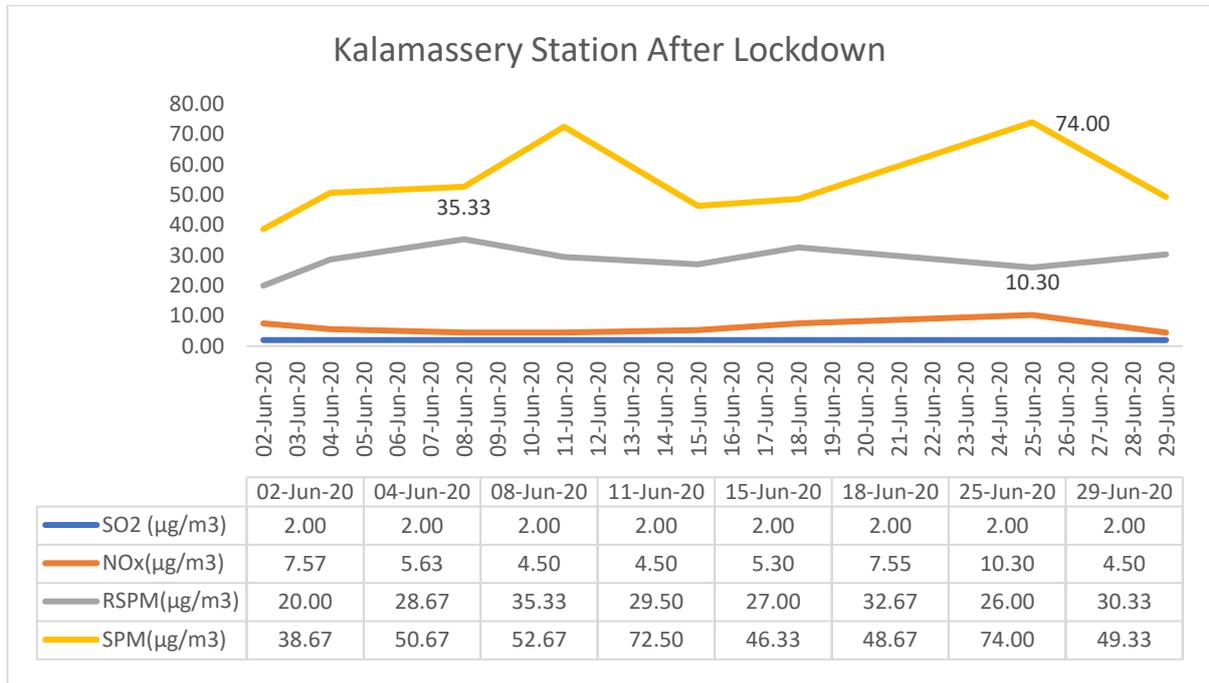


Figure 7.45: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Kalamassery Station during Lockdown

Figure 7.45 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Kalamassery Station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 61.67 µg/m<sup>3</sup> and 85.33 µg/m<sup>3</sup> respectively on 18<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was way below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 16.05 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

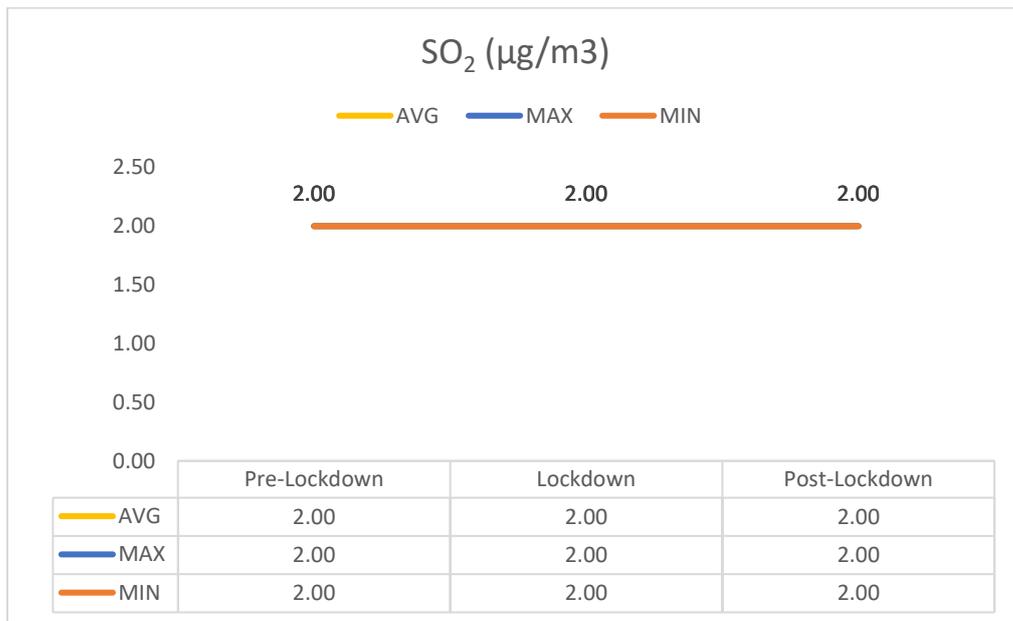
### 7.6.3 After lockdown



**Figure 7.46: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Kalamassery Station after Lockdown**

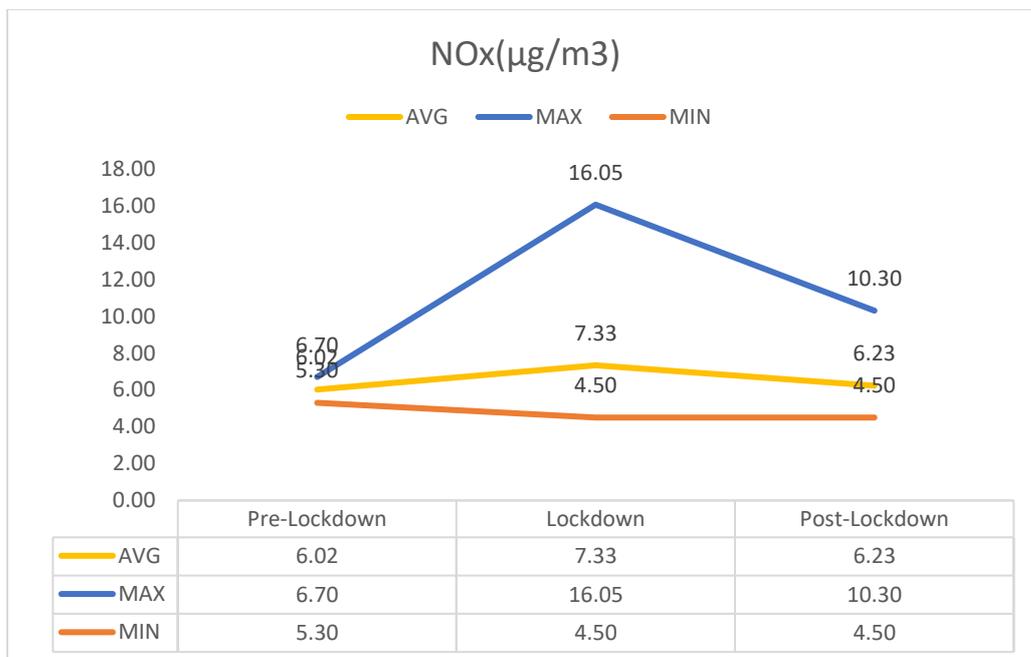
Figure 7.46 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at Kalamassery Station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 35.33 µg/m<sup>3</sup> and 74 µg/m<sup>3</sup> on 8<sup>th</sup> June 2020 and 25<sup>th</sup> June 2020 respectively. The concentration of SO<sub>2</sub> and NO<sub>x</sub> was well within the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 10.30 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

## 7.6.4 Result Analysis



**Figure 7.47: SO<sub>2</sub> Values at Kalamassery Station before, during and after lockdown**

Figure 7.47 shows that the average, maximum and minimum values for SO<sub>2</sub> remained the same before, during and after the lockdown period at Kalamassery Station as it registered a constant minimum value.



**Figure 7.48: NO<sub>x</sub> Values at Kalamassery Station before, during and after lockdown**

Figure 7.48 shows that the average and maximum values for NOx registered an increase during lockdown which showed a relative decrease after lifting the lockdown.

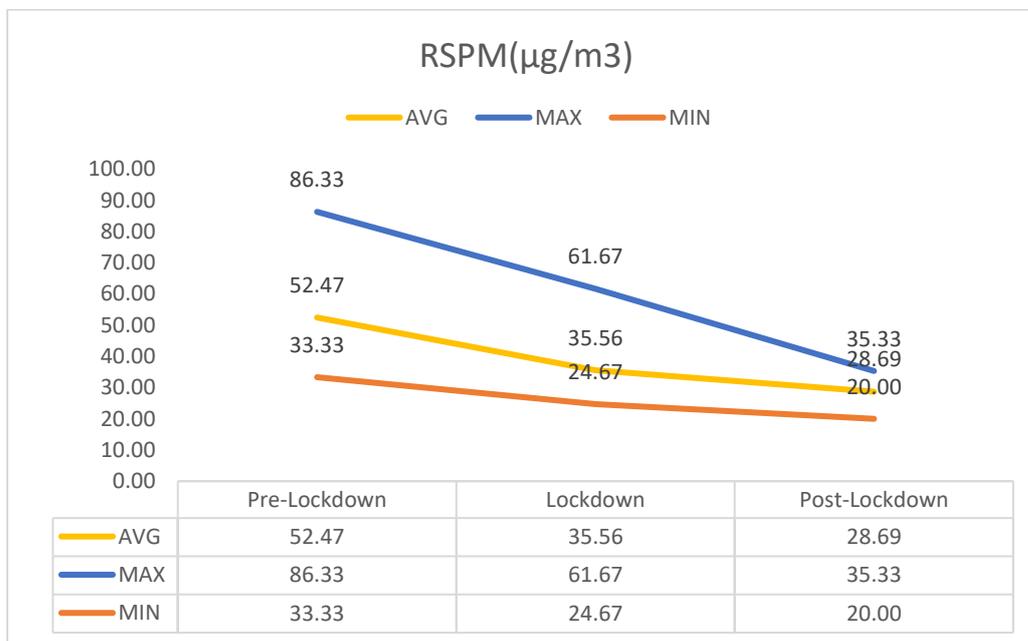


Figure 7.49: RSPM Values at Kalamassery Station before, during and after lockdown

Figure 7.49 and 7.50 shows that the average, maximum and minimum values for RSPM and SPM decreased during the lockdown period at Kalamassery Station which remained in a decreasing trend even after lifting the lockdown.

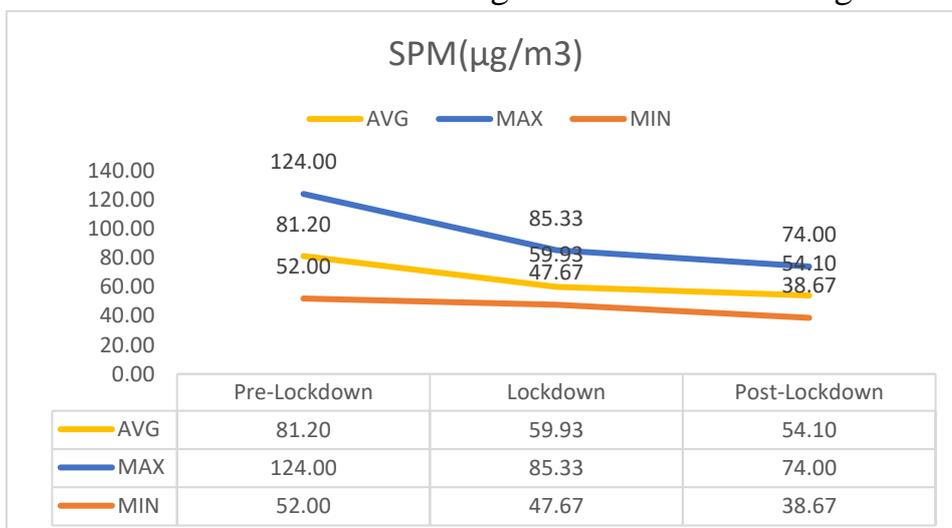


Figure 7.50: SPM Values at Kalamassery Station before, during and after lockdown

## 7.7 MG-Road(Residential) Manual Monitoring Station

MG Road station is located in a residential area with a lot of commercial establishments

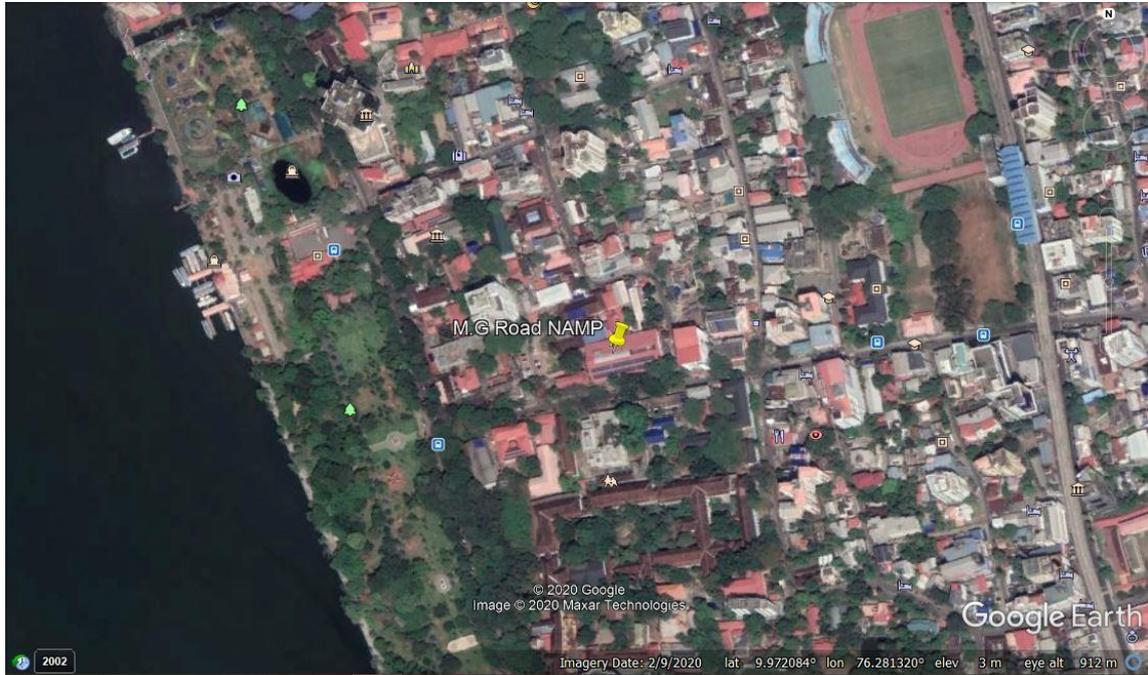


Figure 7.51: Land use Pattern at MG Road Station

### 7.7.1 Before Lockdown

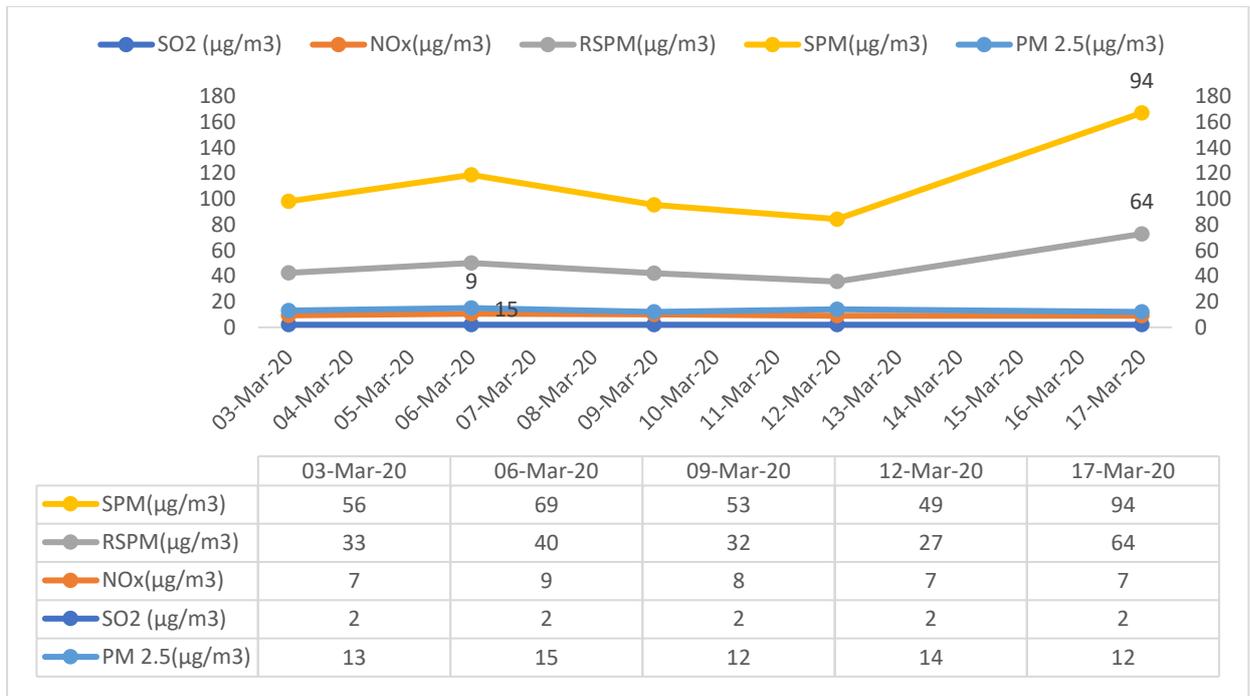


Figure 7.52: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at M.G Road Station before Lockdown

Figure 7.52 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at M.G Road station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 94 µg/m<sup>3</sup> and 64 µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 9.0 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 15 µg/m<sup>3</sup> on 6<sup>th</sup> March 2020.

### 7.7.2 During Lockdown

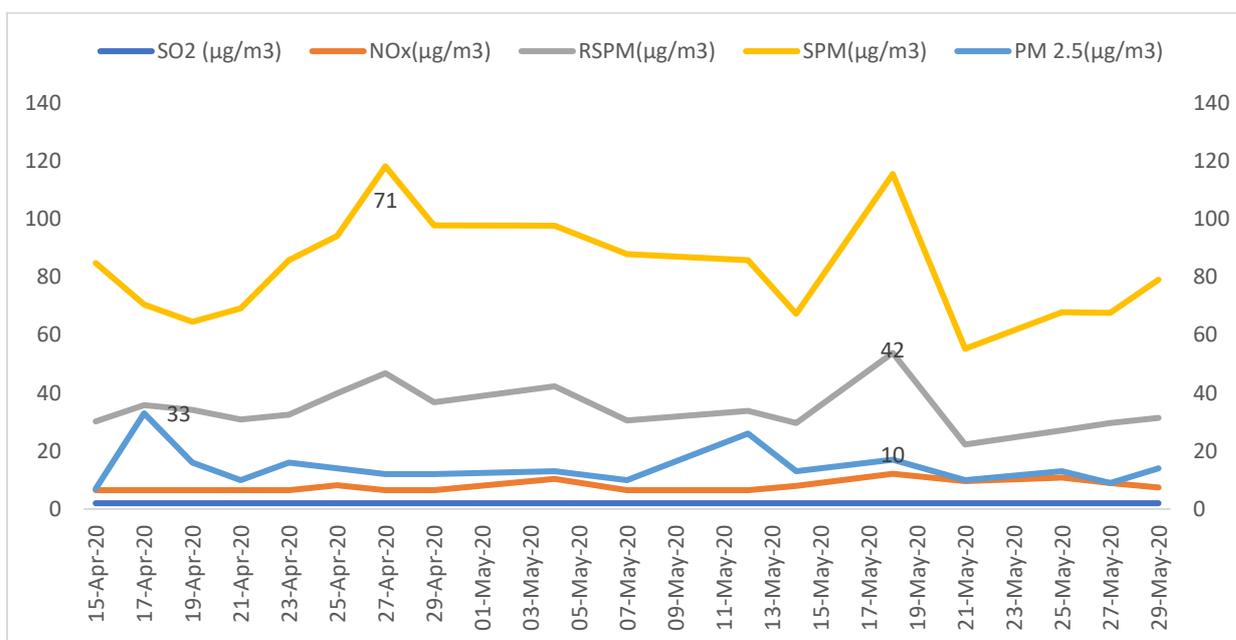


Figure 7.53: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at M.G Road Station during Lockdown

Figure 7.53 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at M.G Road station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 42µg/m<sup>3</sup> and 71µg/m<sup>3</sup> respectively on 18<sup>th</sup> May 2020 and 27<sup>th</sup> April 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 10.0 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 33 µg/m<sup>3</sup> on 17<sup>th</sup> April 2020.

### 7.7.3 After Lockdown

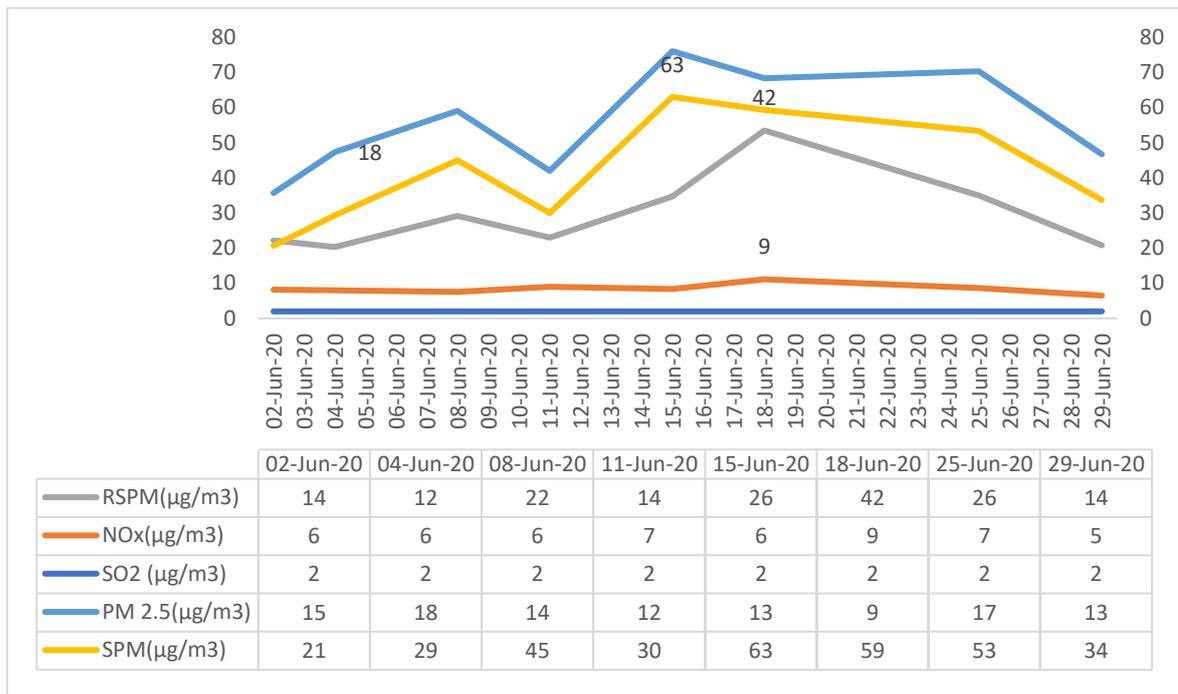


Figure 7.54: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, and SPM measured at M.G Road Station after Lockdown

Figure 7.54 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at M.G Road station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100  $\mu\text{g}/\text{m}^3$ . The highest RSPM and SPM value were recorded as 42 $\mu\text{g}/\text{m}^3$  and 63 $\mu\text{g}/\text{m}^3$  respectively on 18<sup>th</sup> June 2020 and 15<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80  $\mu\text{g}/\text{m}^3$ . The highest values registered are 2.0  $\mu\text{g}/\text{m}^3$  and 9.0  $\mu\text{g}/\text{m}^3$  respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 63  $\mu\text{g}/\text{m}^3$  on 15<sup>th</sup> June 2020.

### 7.7.4 Result Analysis

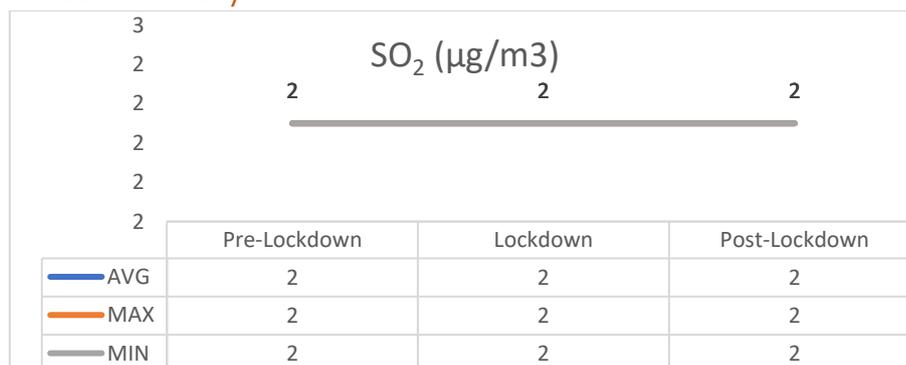


Figure 7.55: SO<sub>2</sub> Values at MG Road Station before, during and after lockdown

Figure 7.55 shows that the average, maximum and minimum values for SO<sub>2</sub> remained the same before, during and after the lockdown period at MG Road Station as it registered a constant minimum value.

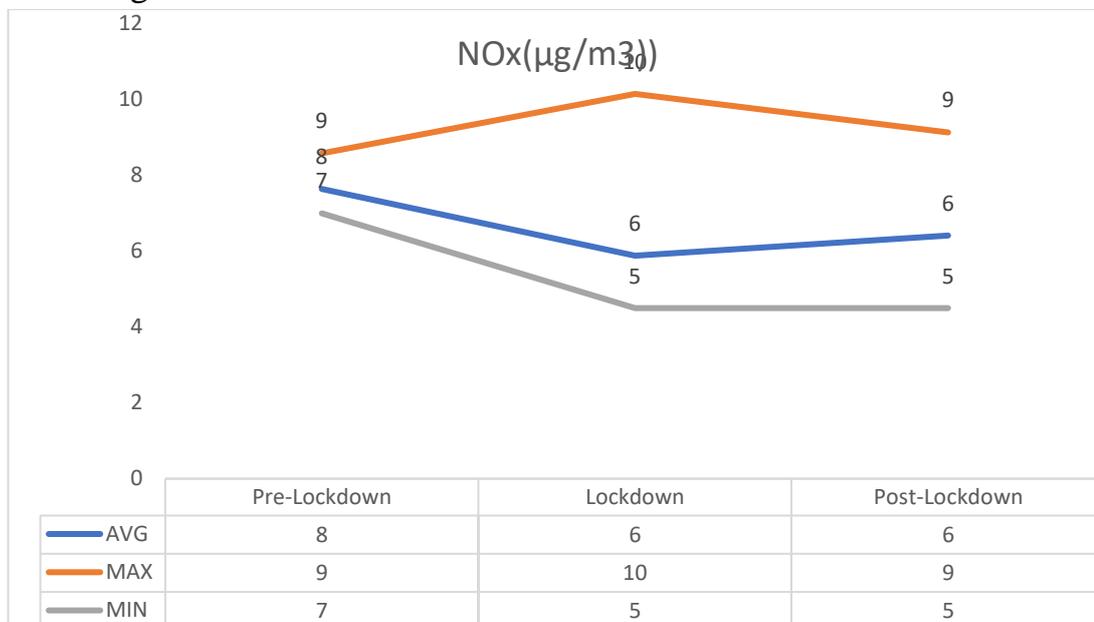


Figure 7.56: NOx Values at MG Road Station before, during and after lockdown

Figure 7.56 shows that the average and minimum values for NOx registered a decrease during the lockdown.

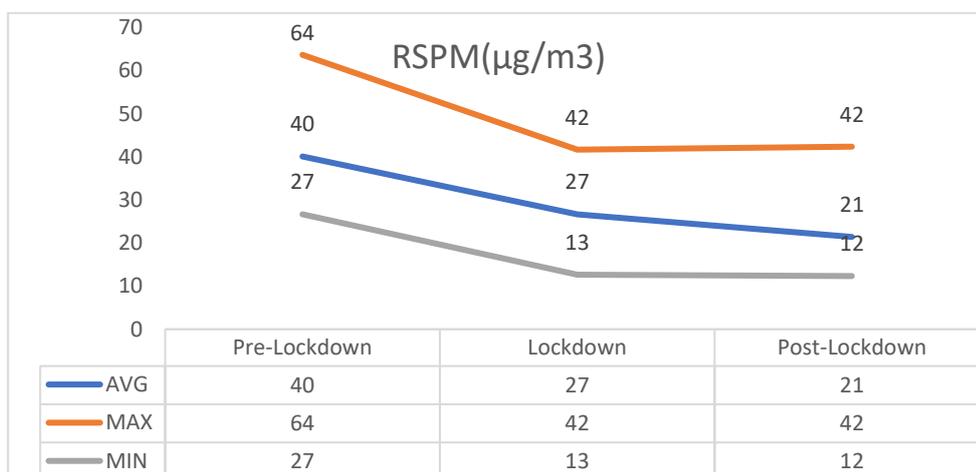


Figure 7.57: RSPM Values at MG Road Station before, during and after lockdown

Figure 7.57 and 7.58 shows that the average, maximum and minimum values for RSPM and SPM decreased during the lockdown period at M.G Road Station which remained in a decreasing trend even after lifting the lockdown.

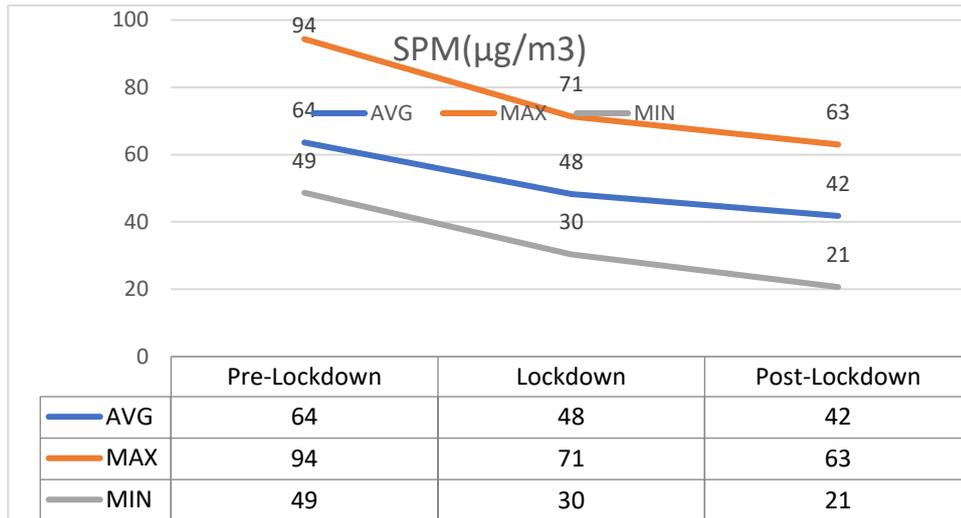


Figure 7.58: SPM Values at MG Road Station before, during and after lockdown

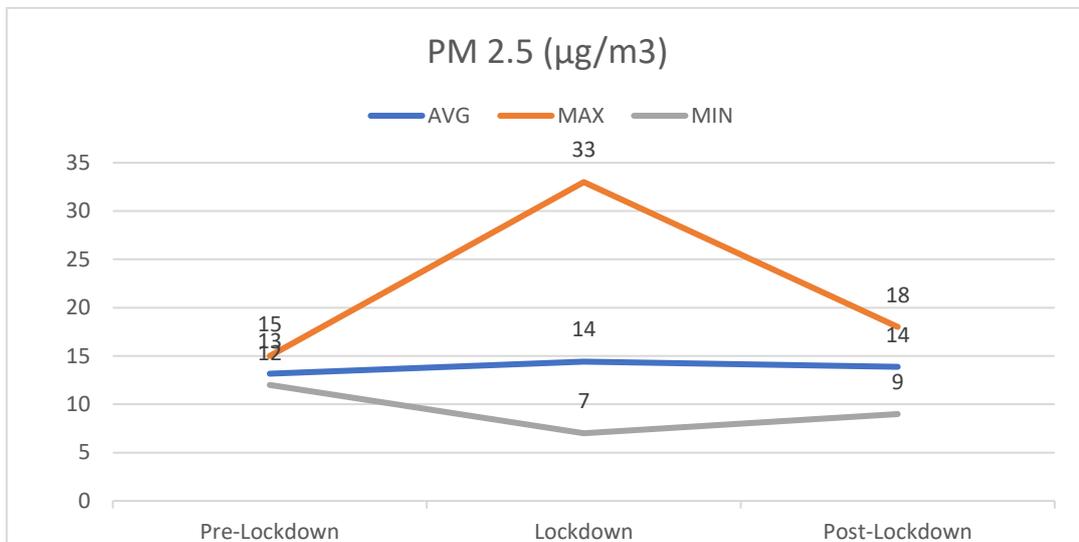


Figure 7.59: PM<sub>2.5</sub> Values at MG Road Station before, during and after lockdown

From figure 7.59, it can be noted that the average and maximum values of PM<sub>2.5</sub> showed an increase during the lockdown at MG Road Station whereas the minimum value registered a decrease during the lockdown which showed a comeback after the lockdown.

## 7.8 Eloor-CAAQM Station

The Land-use pattern at Eloor CAAQM Station include Industries, Residential, Commercial Establishment

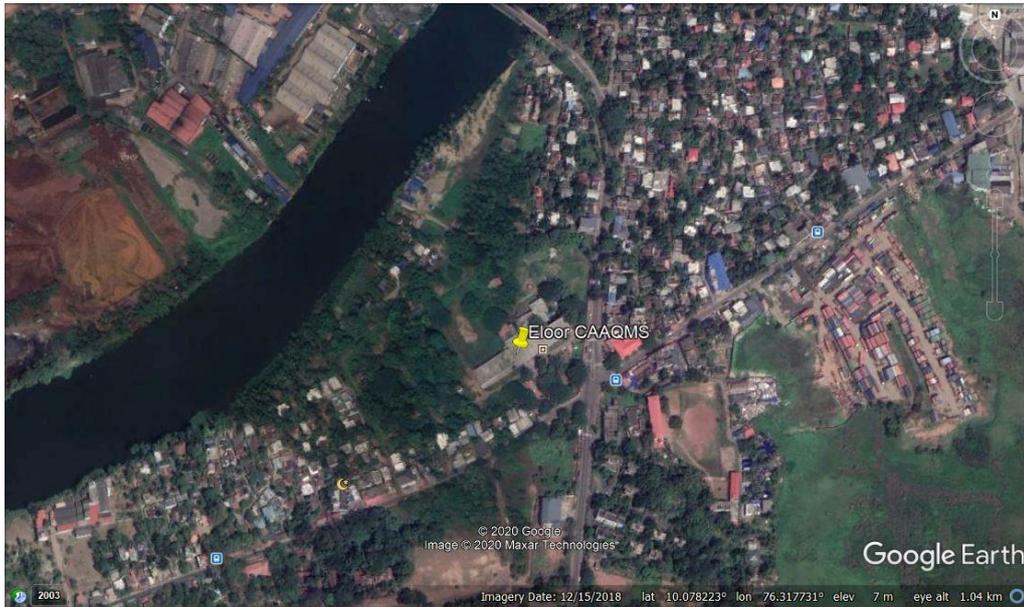


Figure 7.60: Land Use pattern at Eloor CAAQMS

### 7.8.1 Before LockDown

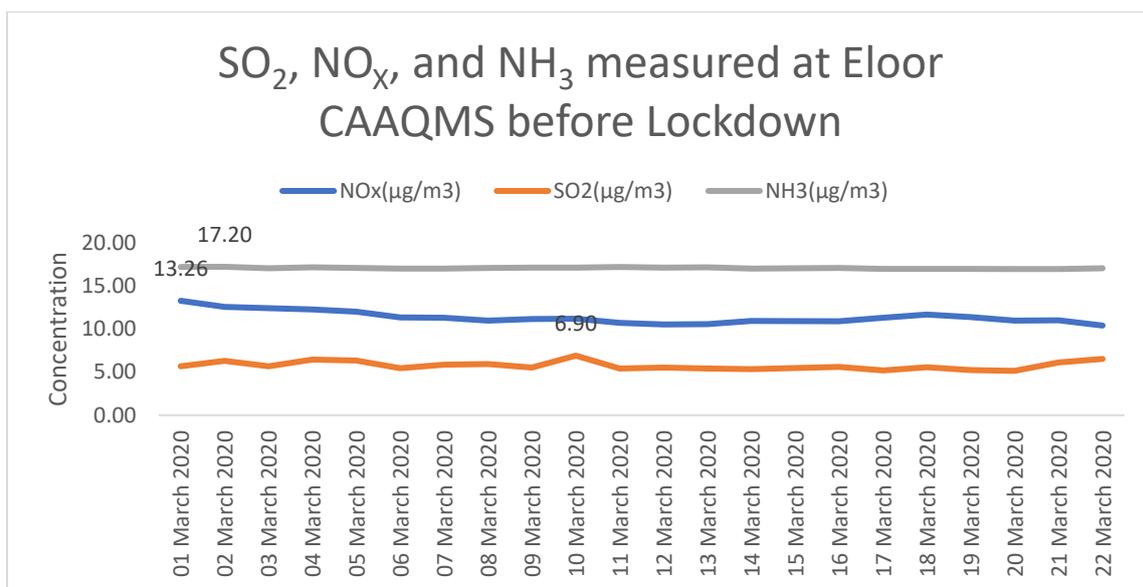


Figure 7.61: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Eloor CAAQMS before Lockdown

Figure 7.61 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Eloor CAAQMS before lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> values were well below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 6.90 µg/m<sup>3</sup> and 13.26 µg/m<sup>3</sup>

respectively on 10<sup>th</sup> March 2020 and 1<sup>st</sup> March 2020. The concentration of NH<sub>3</sub> is well within the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 17.20 µg/m<sup>3</sup> on 2<sup>nd</sup> March 2020.

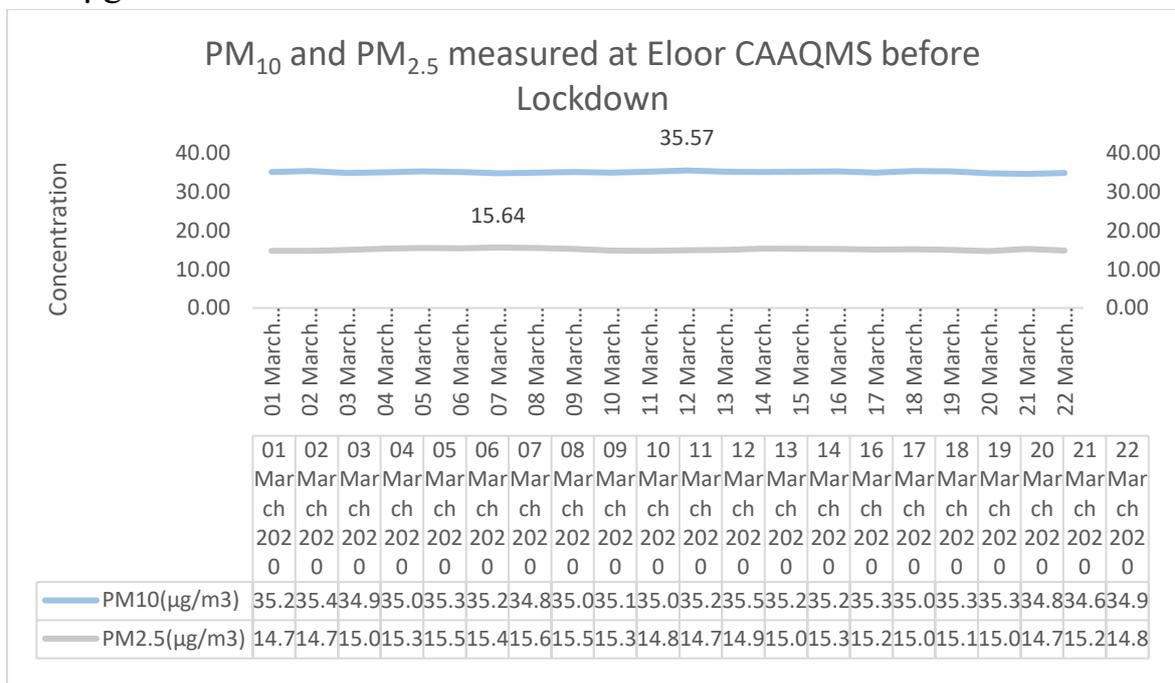


Figure 7.62: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Eloor CAAQMS before Lockdown

Figure 7.62 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Eloor CAAQMS before lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> values were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 35.57 µg/m<sup>3</sup> and 15.64 µg/m<sup>3</sup> respectively on 12<sup>th</sup> March 2020 and 7<sup>th</sup> March 2020.

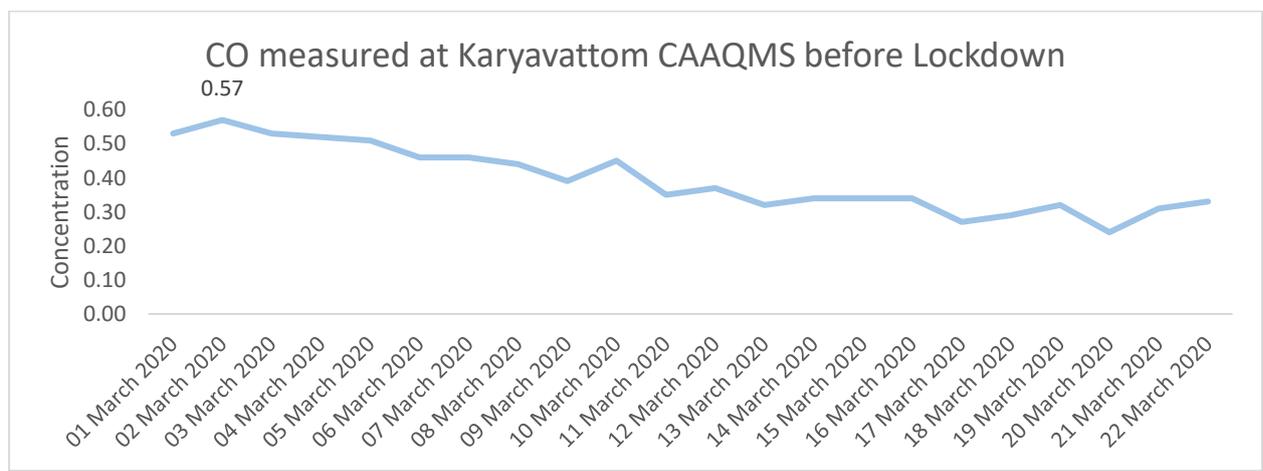


Figure 7.63: CO measured at Eloor CAAQMS before Lockdown

Figure 7.63 shows the 24-hr average values for CO measured at Eloor before lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 0.57 mg/m<sup>3</sup> on 2nd March 2020.

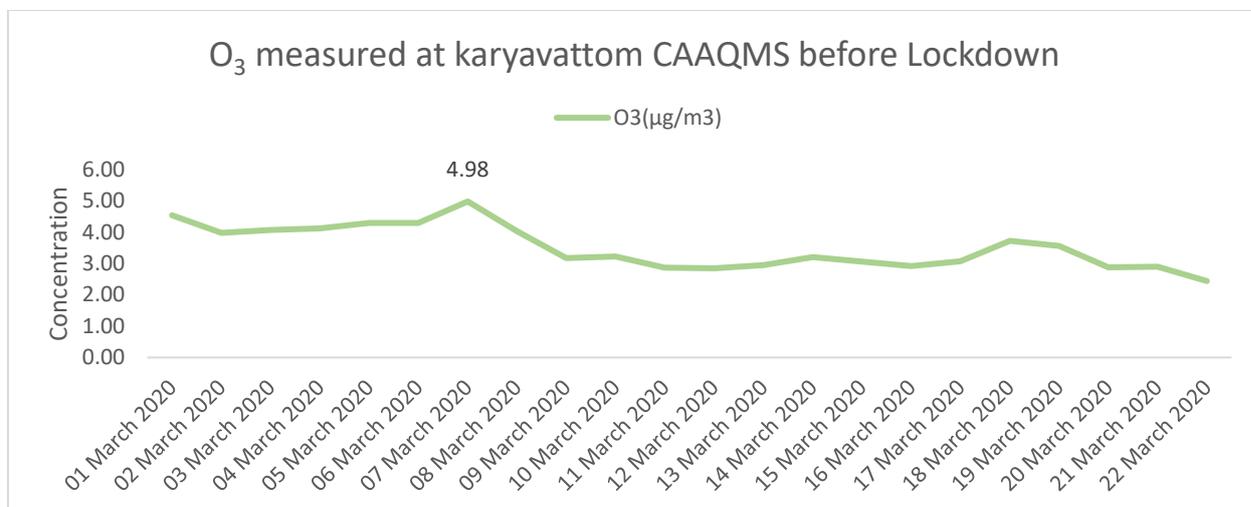


Figure 7.64: O<sub>3</sub> measured at Eloor CAAQMS before Lockdown

Figure 7.64 shows the 24-hr average values for O<sub>3</sub> measured at Eloor station before lockdown. The data analysis indicated that the O<sub>3</sub> was always within the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 4.98 µg/m<sup>3</sup> on 7th March 2020.

### 7.8.2 During Lockdown

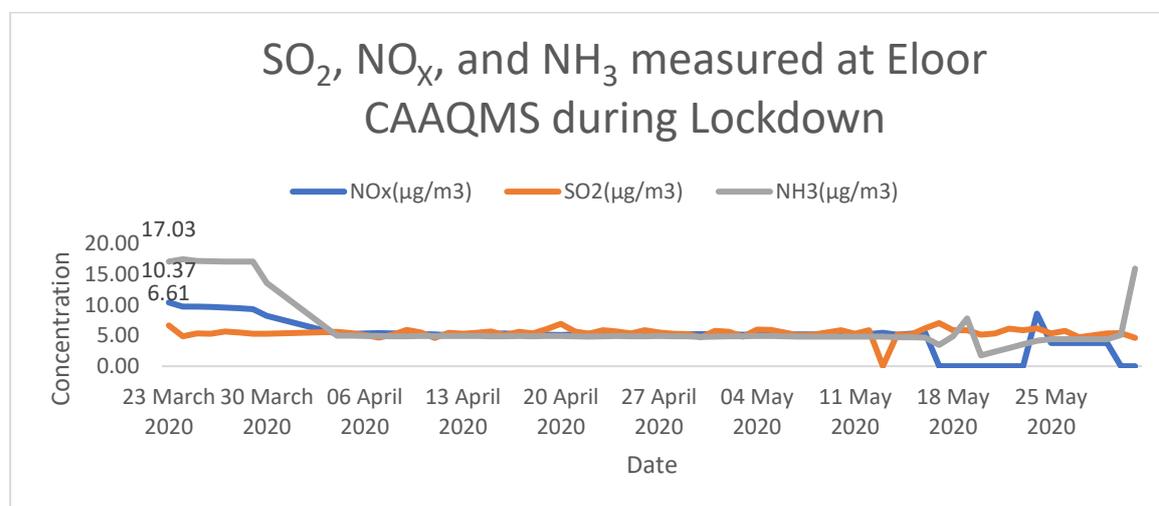


Figure 7.65: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Eloor CAAQMS during Lockdown

Figure 7.65 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Eloor CAAQMS during the lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> values were well below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 6.61 µg/m<sup>3</sup> and 10.37 µg/m<sup>3</sup> respectively on 23rd March 2020. The concentration of NH<sub>3</sub> is well within the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 17.03 µg/m<sup>3</sup> on 23rd March 2020.

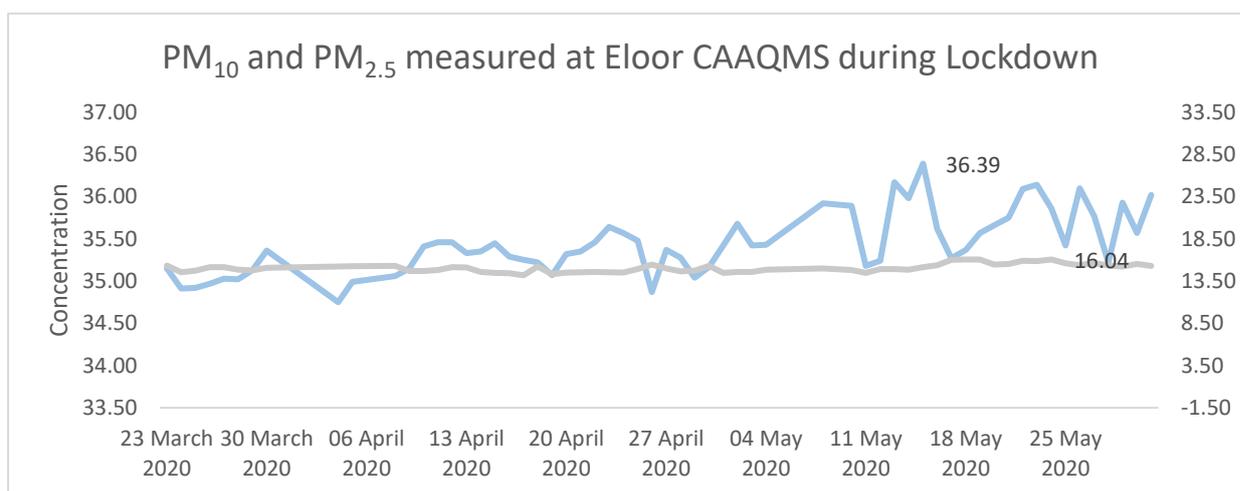


Figure 7.66: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Eloor CAAQMS during Lockdown

Figure 7.66 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Eloor CAAQMS during the lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> values were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 36.39 µg/m<sup>3</sup> and 16.04 µg/m<sup>3</sup> respectively on 15<sup>th</sup> May 2020 and 24<sup>th</sup> May 2020.

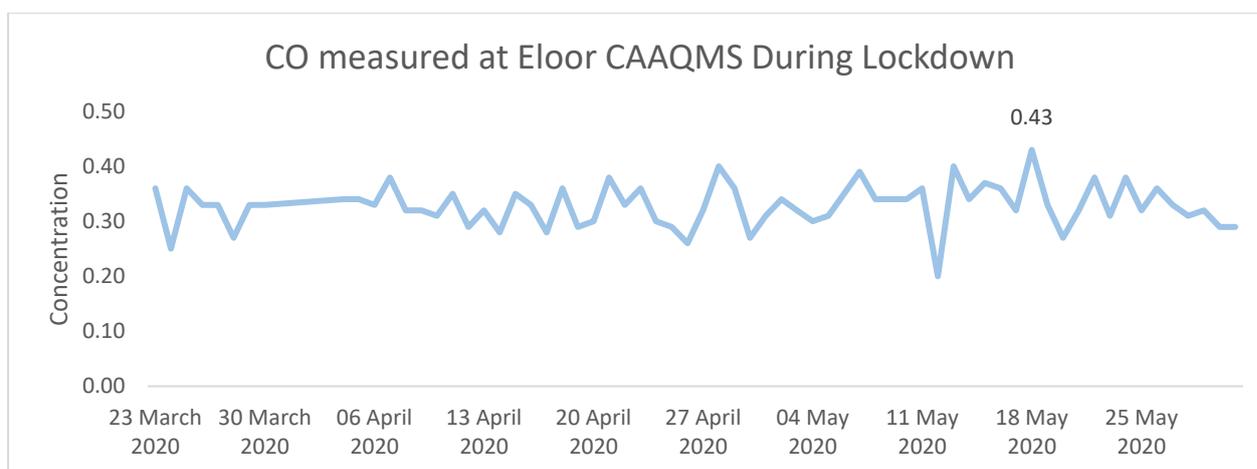


Figure 7.67: CO measured at Eloor CAAQMS during Lockdown

Figure 7.67 shows the 24-hr average values for CO measured at Eloor during the lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 0.43 mg/m<sup>3</sup> on 2<sup>nd</sup> March 2020.

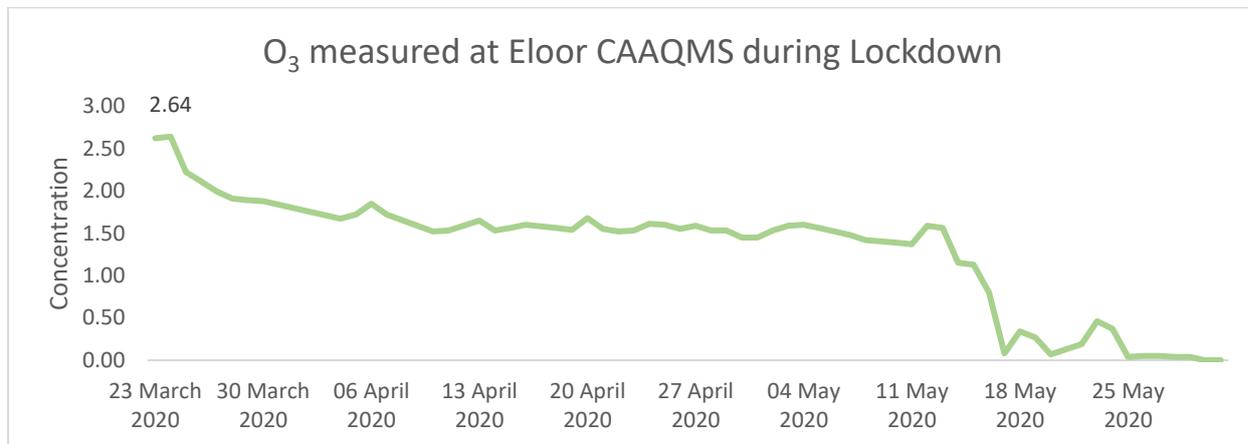


Figure 7.68: O<sub>3</sub> measured at Eloor CAAQMS during Lockdown

Figure 7.68 shows the 24-hr average values for O<sub>3</sub> measured at Eloor station during the lockdown. The data analysis indicated that the O<sub>3</sub> was always within the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 2.64 µg/m<sup>3</sup> on 24<sup>th</sup> March 2020.

### 7.8.3 After Lockdown

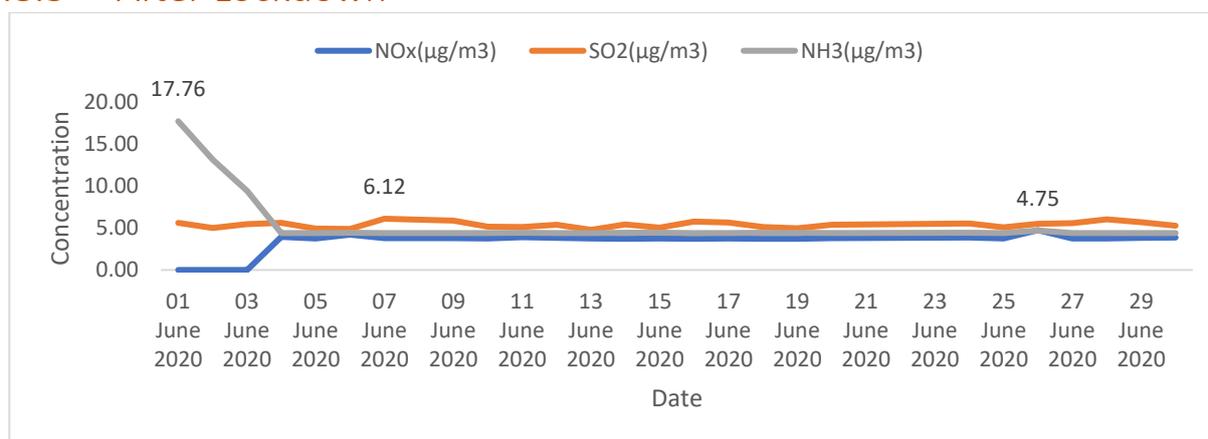


Figure 7.69: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Eloor CAAQMS after Lockdown

Figure 7.69 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Eloor CAAQMS after lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> values were well below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 6.12 µg/m<sup>3</sup> and 4.75 µg/m<sup>3</sup>

respectively on 7<sup>th</sup> June 2020 and 26<sup>th</sup> June. The concentration of NH<sub>3</sub> is well within the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 17.76 µg/m<sup>3</sup> on 23<sup>rd</sup> March 2020.

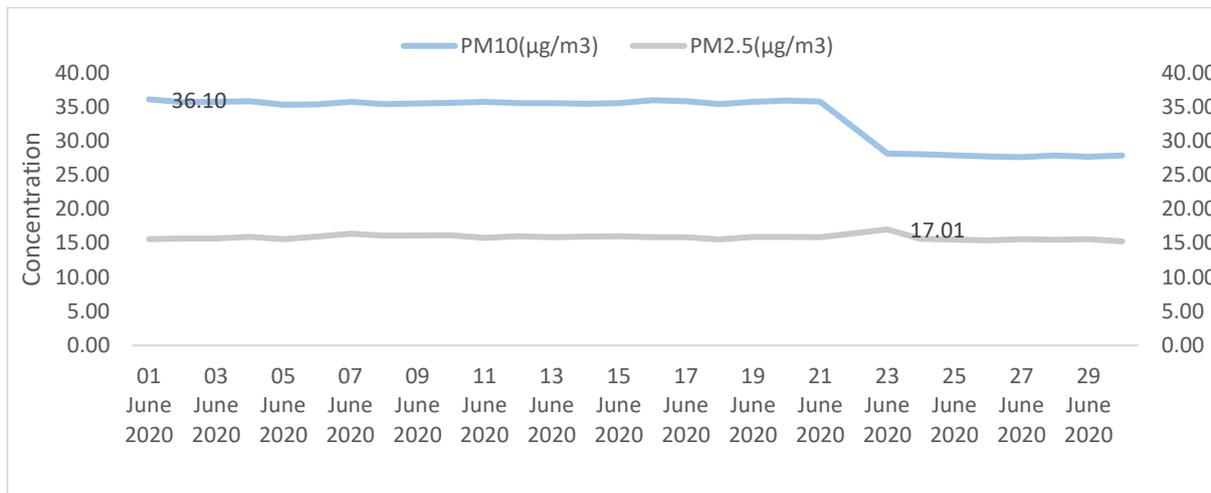


Figure 7.70: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Eloor CAAQMS after Lockdown

Figure 7.70 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Eloor CAAQMS after lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> values were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 36.10 µg/m<sup>3</sup> and 17.01 µg/m<sup>3</sup> respectively on 1<sup>st</sup> June 2020 and 23<sup>rd</sup> June 2020.

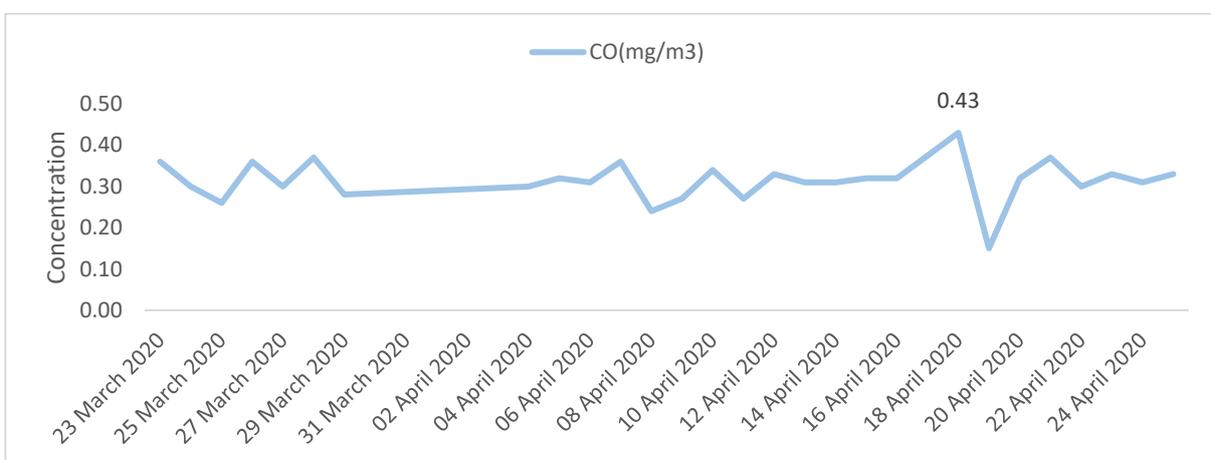


Figure 7.71: CO measured at Eloor CAAQMS after Lockdown

Figure 7.71 shows the 24-hr average values for CO measured at Eloor after lockdown. The data analysis indicated that the CO was always below the 8 hour

standard of 2 mg/m<sup>3</sup>. The highest value was found to be 0.43 mg/m<sup>3</sup> on 18<sup>th</sup> April 2020.

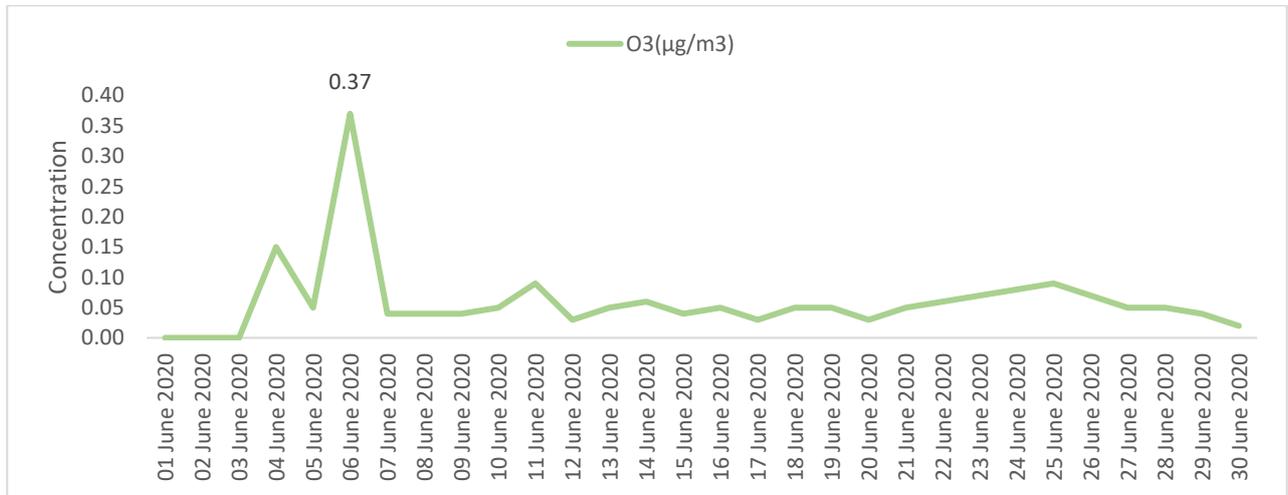


Figure 7.72: O<sub>3</sub> measured at Eloor CAAQMS after Lockdown

Figure 7.72 shows the 24-hr average values for O<sub>3</sub> measured at Eloor station before lockdown. The data analysis indicated that the O<sub>3</sub> was always within the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 0.37 µg/m<sup>3</sup> on 6<sup>th</sup> June 2020.

#### 7.8.4 Result Analysis

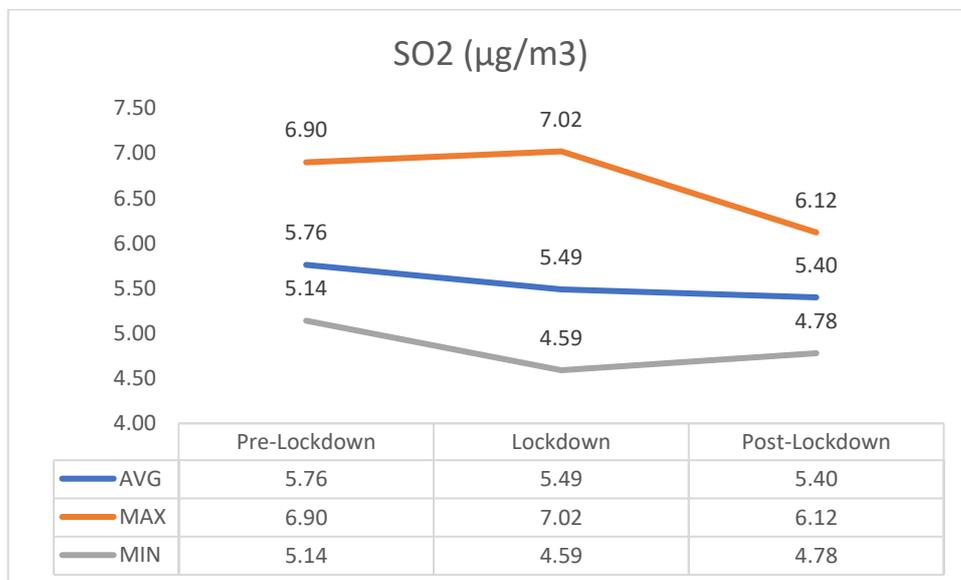


Figure 7.73: SO<sub>2</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.73 shows that average, m values for SO<sub>2</sub> registered a slight decrease during the lockdown period and thereafter. The Peak value thought slightly increase during the lockdown late came down to that value before the lockdown which later decreased as the lockdown was lifted.

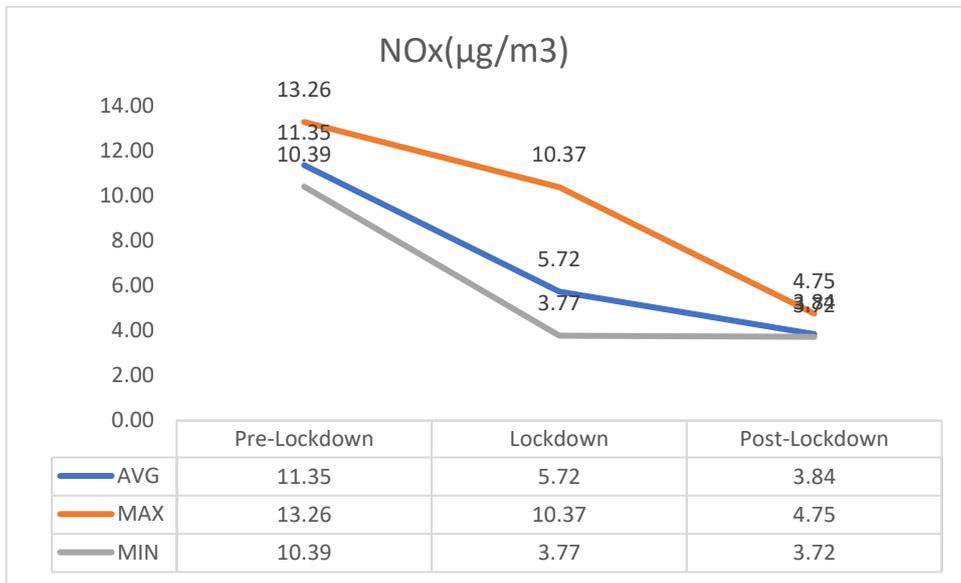


Figure 7.74: NO<sub>x</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.74 shows that average, maximum and minimum values for NO<sub>x</sub> registered a decreasing trend during the lockdown period and thereafter.

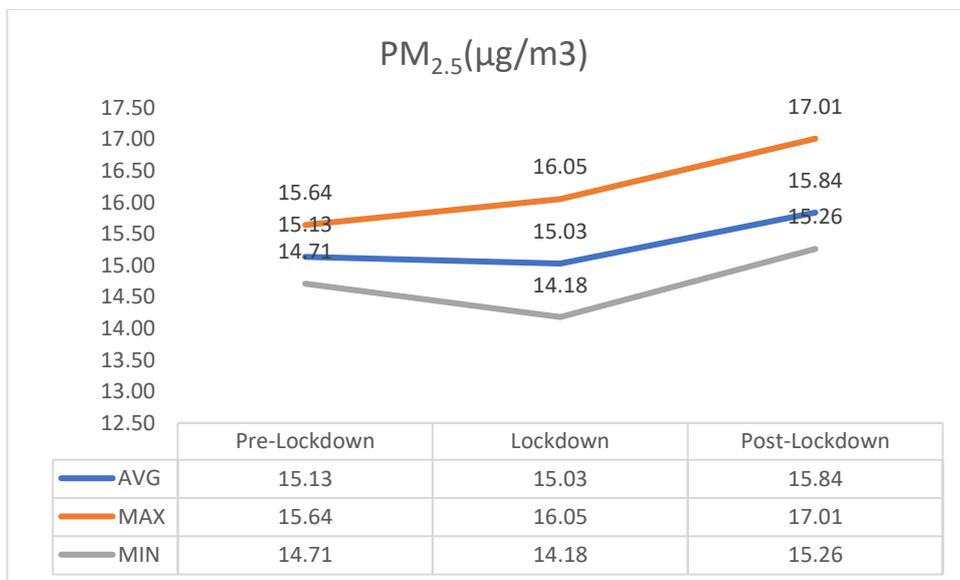


Figure 7.75: PM<sub>2.5</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.75 shows that average, minimum and maximum values for PM<sub>2.5</sub> showed an increasing trend during the lockdown period and thereafter.

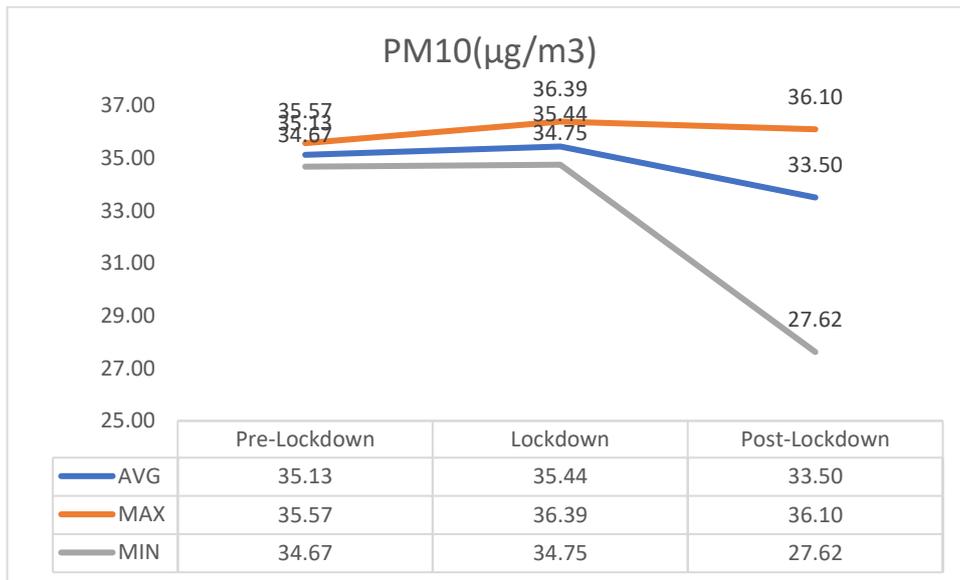


Figure 7.76: PM<sub>10</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.76 shows that average, and minimum values for PM<sub>10</sub> Continued on a decreasing trend after the lockdown despite the relative increase showcased during the lockdown.

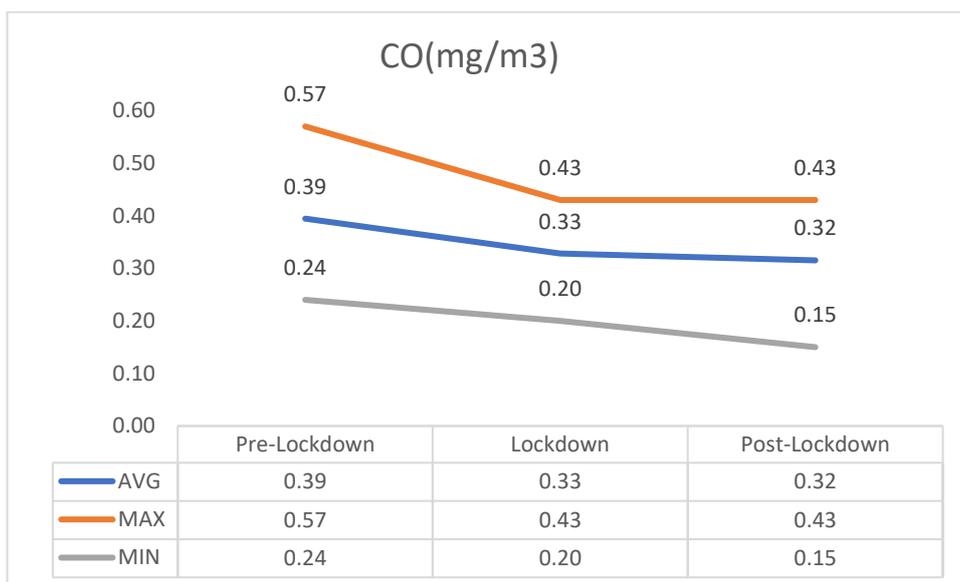


Figure 7.77: CO Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.77 showed that the average, minimum and maximum values of CO started to decline during the lockdown period relative to that of the pre-lockdown time. It later continued in this path even after lifting of the lockdown

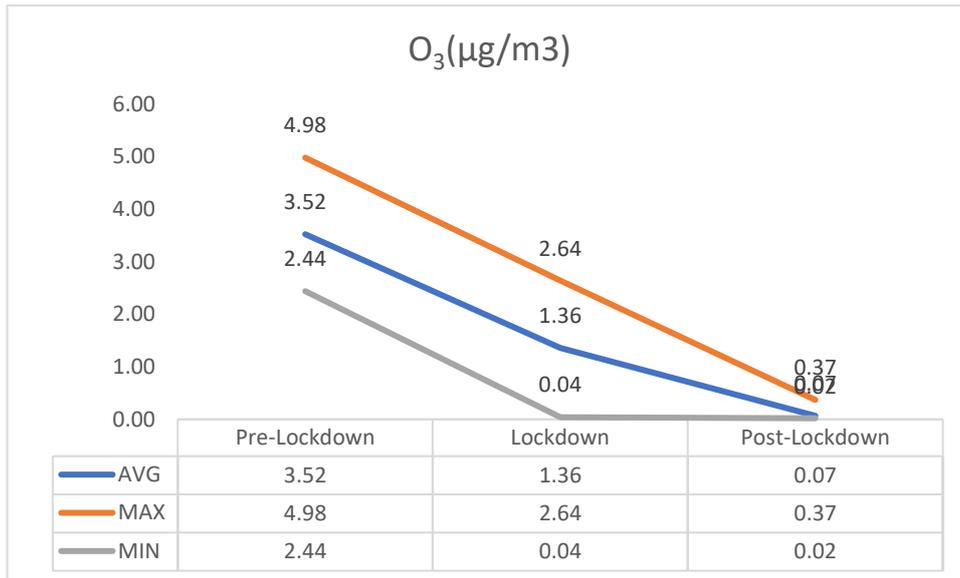


Figure 7.78: O<sub>3</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.78 showed that the average, minimum and maximum values of O<sub>3</sub> started to decline during the lockdown period relative to that of the pre-lockdown time. It later continued in this path even after lifting of the lockdown

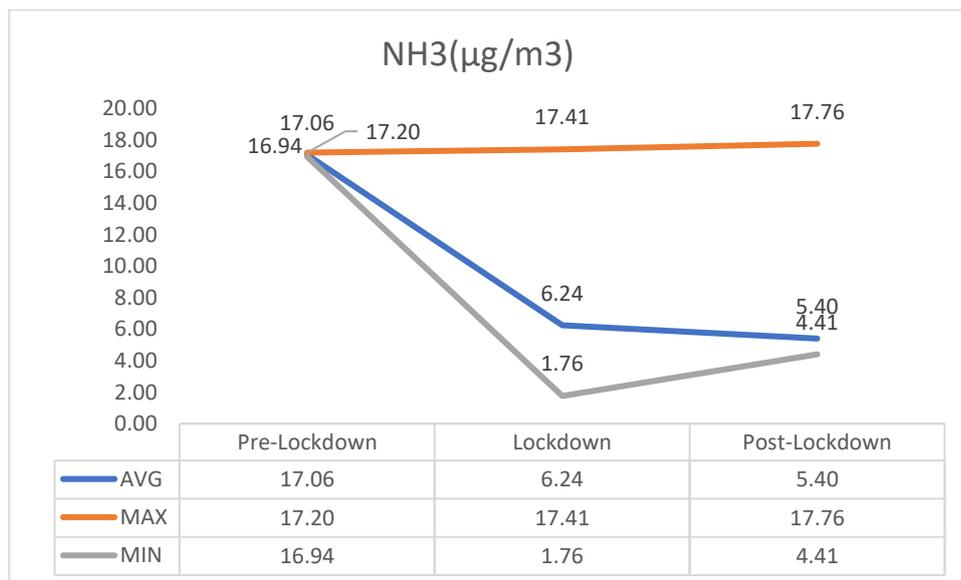


Figure 7.79: NH<sub>3</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.79 showed that the average, minimum and maximum values of NH<sub>3</sub> started to decline during the lockdown period relative to that of the pre-lockdown time. It later continued in this path even after lifting of the lockdown

## 7.9 Vytila CAAQM Station

The Land-use pattern at the station include residential, commercial, major and minor roads with a transport hub

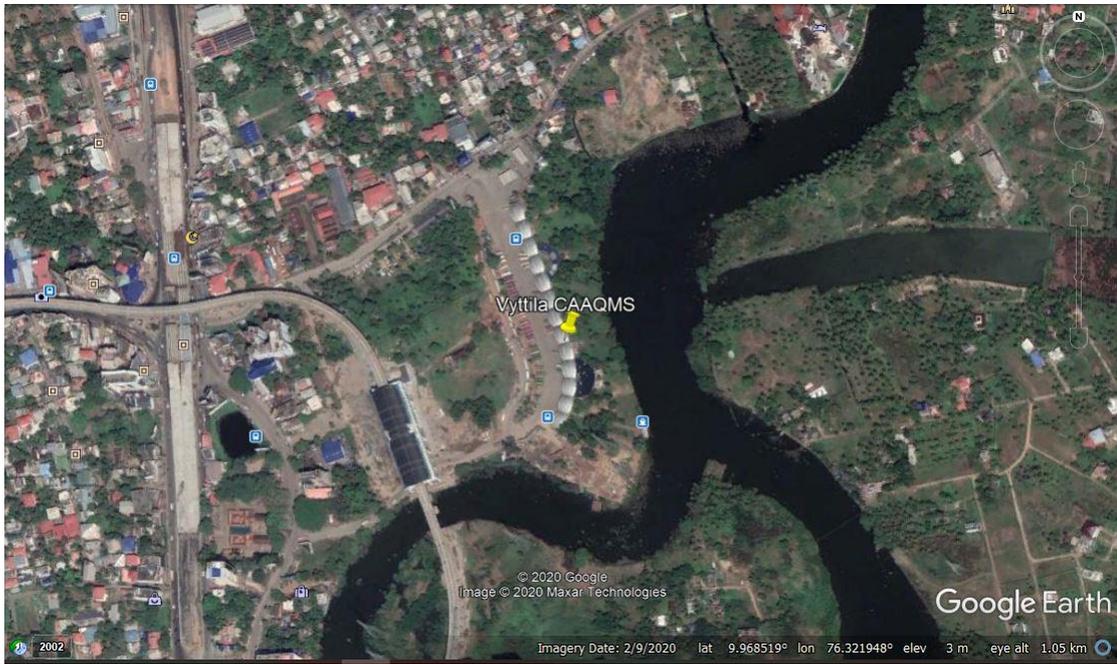


Figure 7.80: Land use pattern at Vytila CAAQMS

### 7.9.1 Before Lockdown

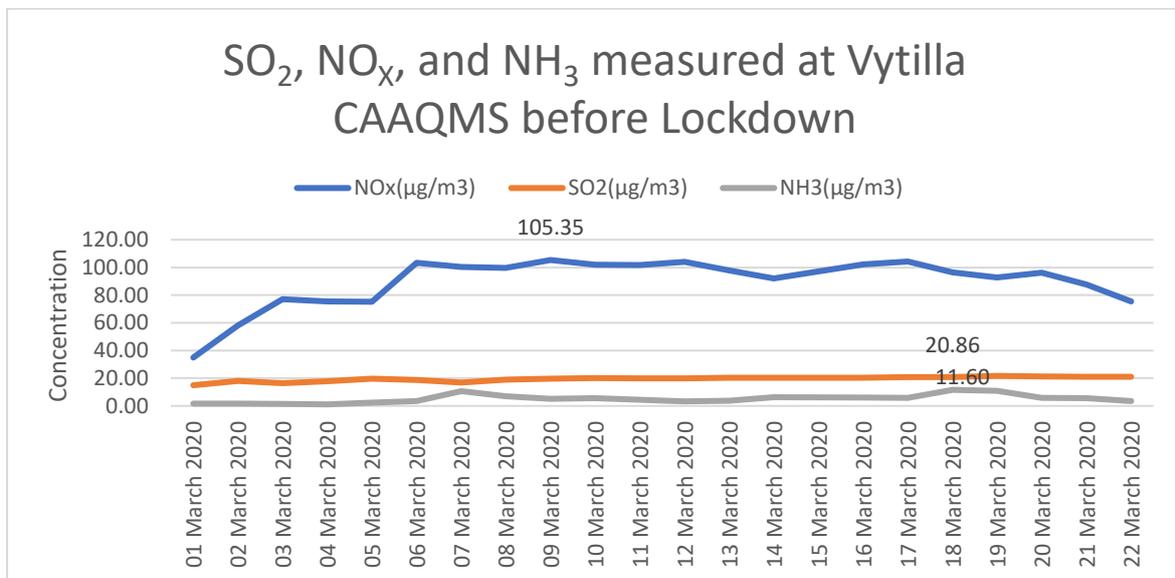


Figure 7.81: O<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Vytila CAAQM Station before Lockdown.

Figure 7.81 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Vytilla CAAQM Station before lockdown. The data analysis indicated that at times the SO<sub>2</sub> values were above the 24-hour standard of 80 µg/m<sup>3</sup> and the highest value registered is 20.86 µg/m<sup>3</sup> on 18<sup>th</sup> March 2020. The NO<sub>x</sub> values were at times above the 24-hour standard of 80 µg/m<sup>3</sup> limit. The highest SO<sub>2</sub> values were found to be and 105.35 µg/m<sup>3</sup> respectively on 9<sup>th</sup> March 2020. The concentration of NH<sub>3</sub> is well within the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 11.60 µg/m<sup>3</sup> on 18<sup>th</sup> March 2020.

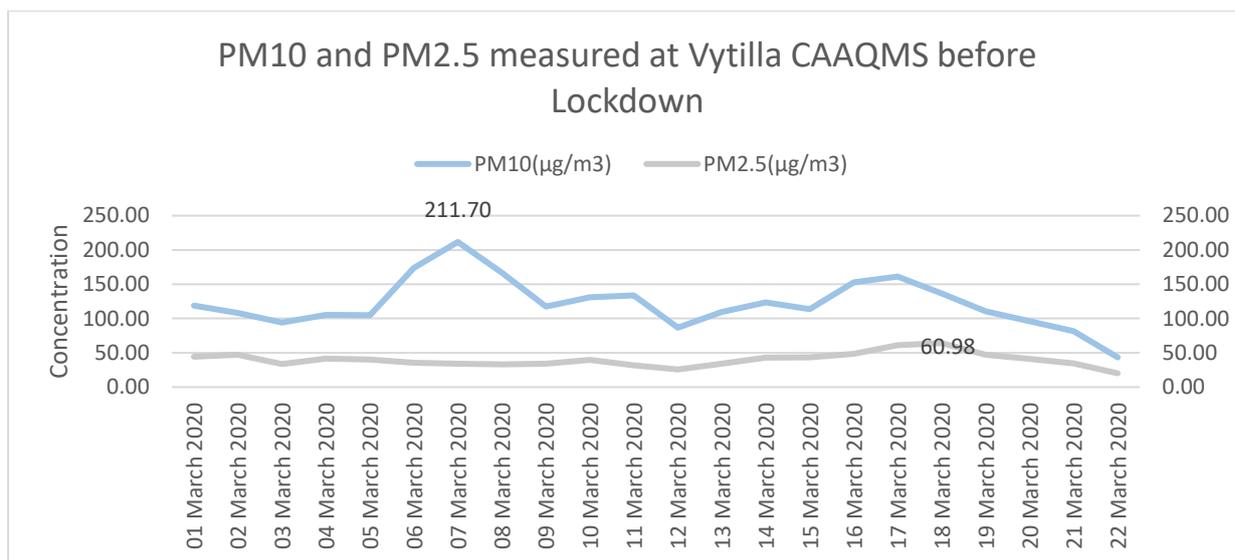


Figure 7.82: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Vytilla CAAQM Station before Lockdown

Figure 7.82 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Vytilla CAAQMS before lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> values were generally below the 24-hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively except for some spikes in the case of PM<sub>10</sub>. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 211.70 µg/m<sup>3</sup> and 60.98 µg/m<sup>3</sup> respectively on 7<sup>th</sup> March 2020 and 17<sup>th</sup> March 2020.

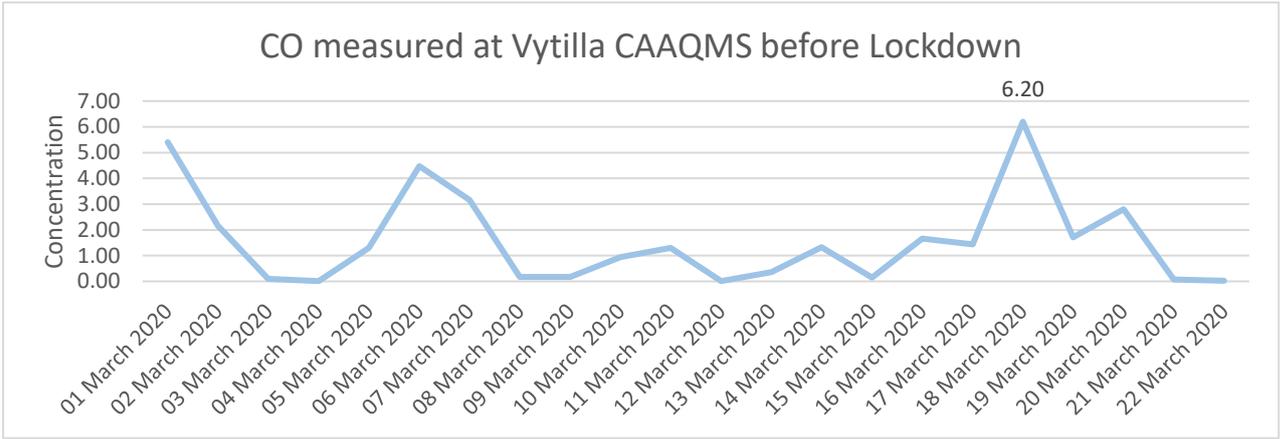


Figure 7.83: CO measured at Vytilla CAAQMS before Lockdown

Figure 7.83 shows the 24-hr average values for CO measured at Vytilla before lockdown. The data analysis indicated that the CO was generally below the 8 hour standard of 2 mg/m<sup>3</sup> except for some occasional spikes. The highest value was found to be 6.20 mg/m<sup>3</sup> on 18<sup>th</sup> March 2020.

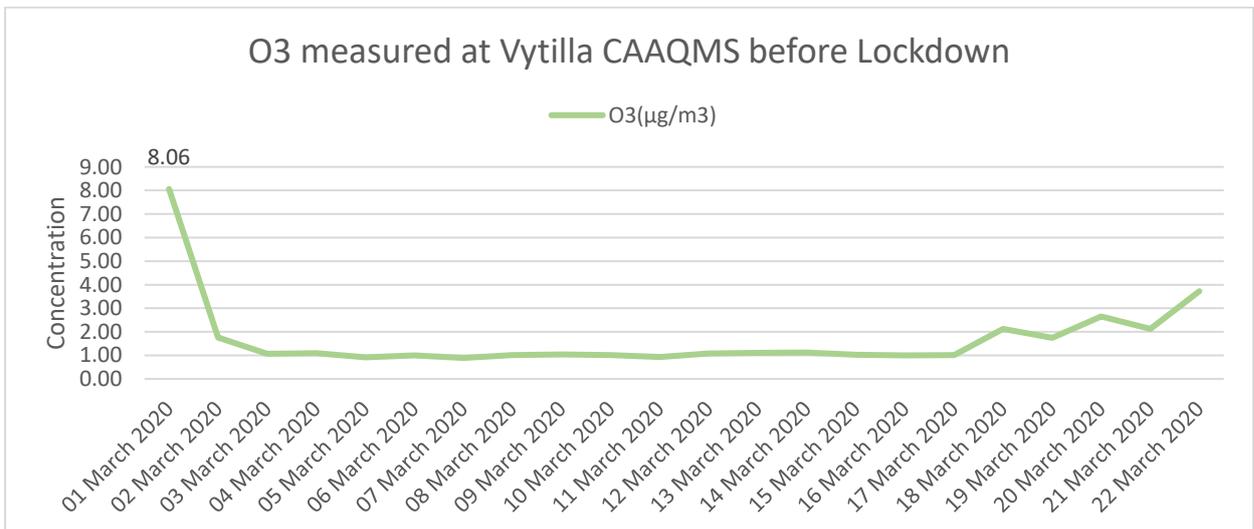
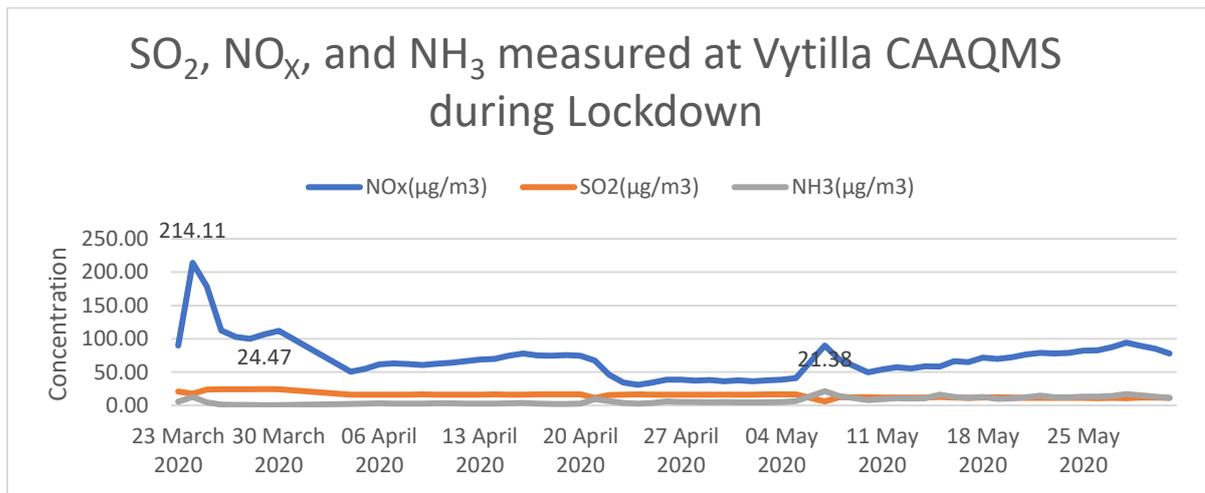


Figure 7.84: O<sub>3</sub> measured at Vytilla CAAQMS before Lockdown

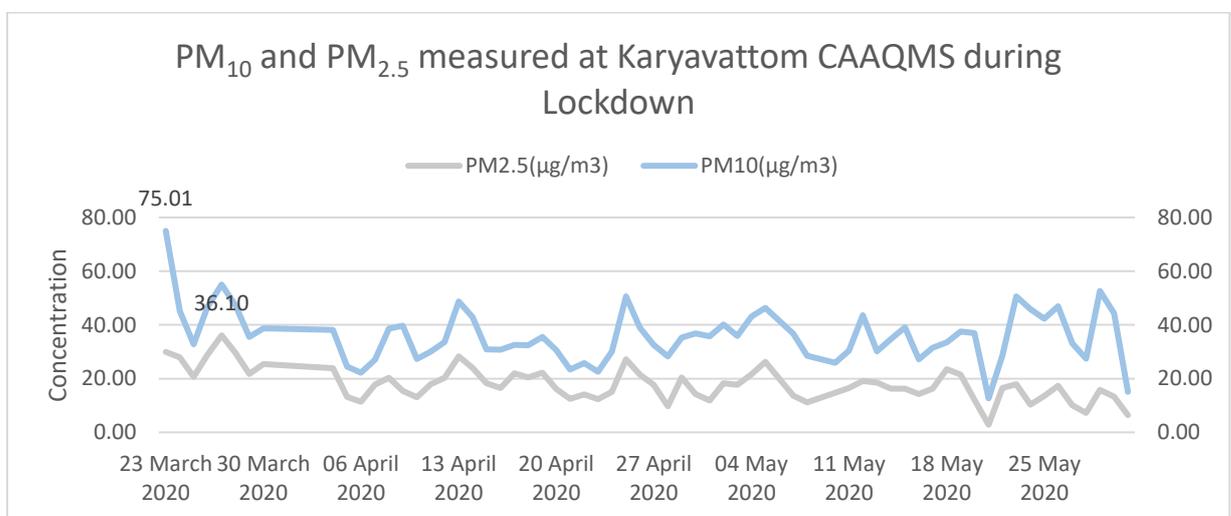
Figure 7.84 shows the 24-hr average values for O<sub>3</sub> measured at Eloor station before lockdown. The data analysis indicated that the O<sub>3</sub> was always within the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 8.06 µg/m<sup>3</sup> on 1<sup>st</sup> March 2020.

## 7.9.2 During Lockdown



**Figure 7.85: O<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Vytilla CAAQMS during Lockdown**

Figure 7.85 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Vytilla CAAQM Station during the lockdown. The data analysis indicated that at times the SO<sub>2</sub> values were above the 24-hour standard of 80 µg/m<sup>3</sup> and the highest value registered is 24.47 µg/m<sup>3</sup> on 29<sup>th</sup> March 2020. The NO<sub>x</sub> values were at times above the 24-hour standard of 80 µg/m<sup>3</sup> limit. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be and 214.11 µg/m<sup>3</sup> respectively on 24<sup>th</sup> March 2020. The concentration of NH<sub>3</sub> is well within the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 21.83 µg/m<sup>3</sup> on 7<sup>th</sup> May 2020.



**Figure 7.86: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Vytilla CAAQM Station during Lockdown**

Figure 7.86 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Vytilla CAAQMS during the lockdown. The data analysis indicated that the PM<sub>10</sub>

and PM<sub>2.5</sub> values were generally below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 75.01 µg/m<sup>3</sup> and 36.01 µg/m<sup>3</sup> respectively on 23<sup>rd</sup> March 2020 and 27<sup>th</sup> March 2020.

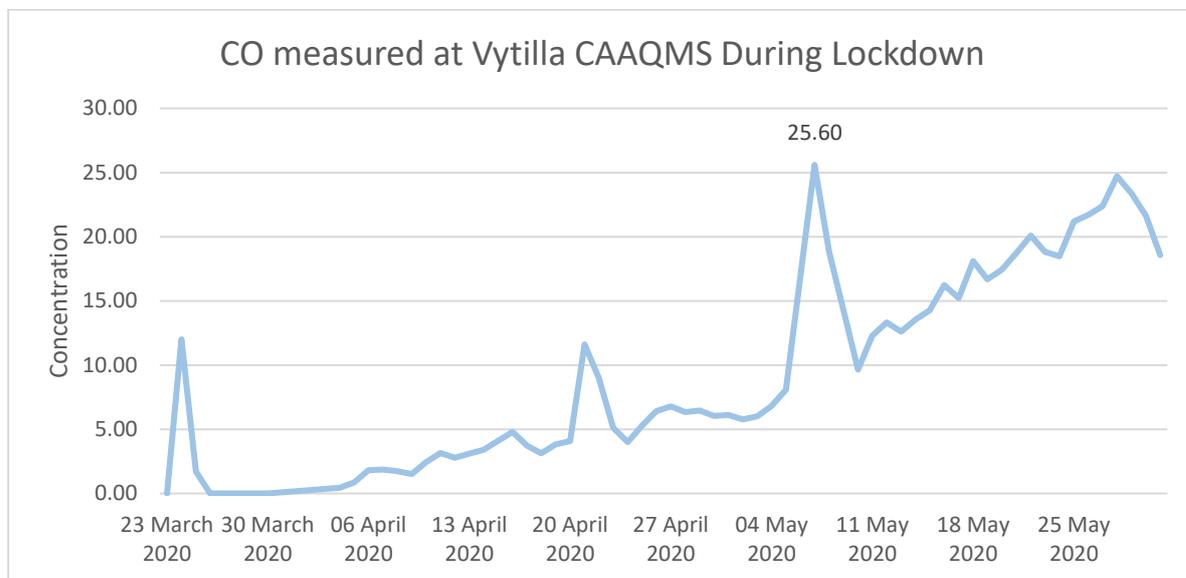


Figure 7.87: CO measured at vytilla CAAQMS during Lockdown

Figure 7.87 shows the 24-hr average values for CO measured at vytilla during the lockdown. The data analysis indicated that the CO was generally below the 8 hour standard of 2 mg/m<sup>3</sup> except for some occasional spikes. The highest value was found to be 25.60 mg/m<sup>3</sup> on 7<sup>th</sup> May 2020.

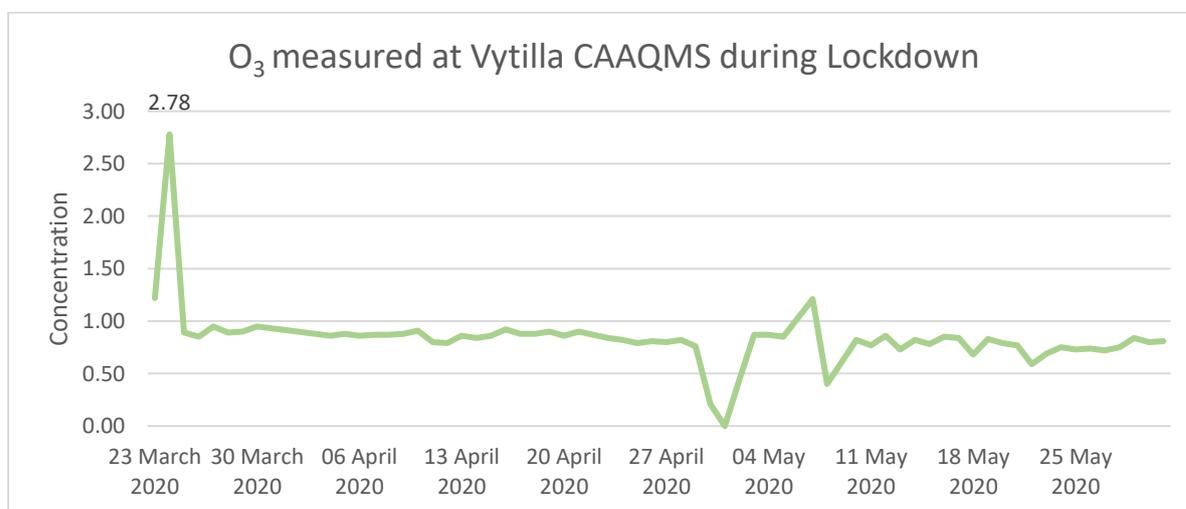


Figure 7.88: O<sub>3</sub> measured at Vytilla CAAQMS before Lockdown

Figure 7.88 shows the 24-hr average values for O<sub>3</sub> measured at Eloor station before lockdown. The data analysis indicated that the O<sub>3</sub> was always within the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 2.78 µg/m<sup>3</sup> on 24<sup>th</sup> March 2020.

### 7.9.3 After Lockdown

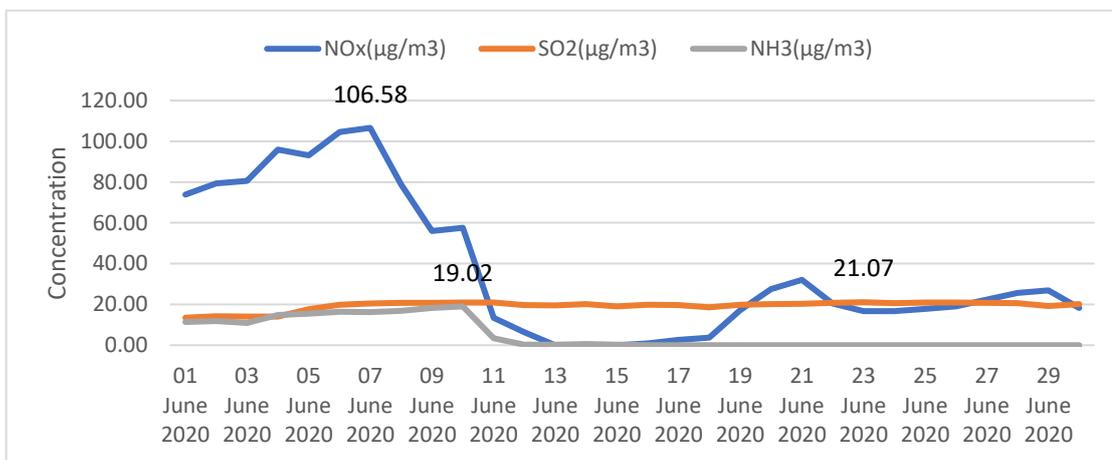
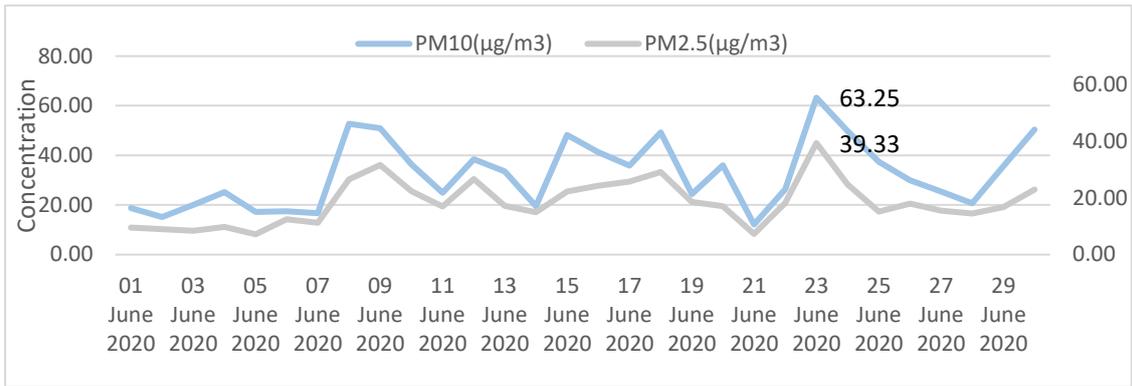


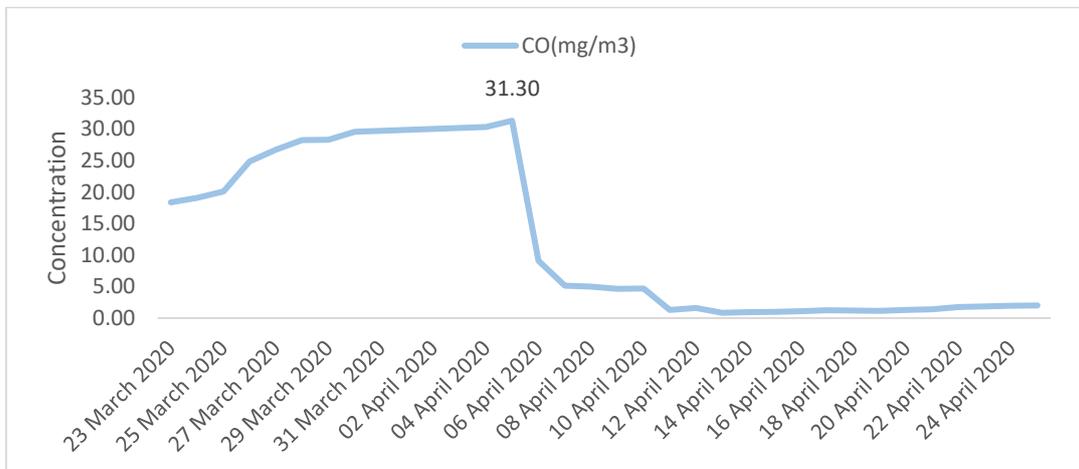
Figure 7.89: O<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Vytilla CAAQMS after Lockdown

Figure 7.89 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Vytilla CAAQM Station after lockdown. The data analysis indicated that at times the NO<sub>x</sub> values were above the 24-hour standard of 80 µg/m<sup>3</sup> and the highest value registered is 106.58 µg/m<sup>3</sup> on 7<sup>th</sup> June 2020. The SO<sub>2</sub> values were always within the 24-hour standard of 80 µg/m<sup>3</sup> limit. The highest SO<sub>2</sub> value was found to be and 21.07 µg/m<sup>3</sup> on 23<sup>rd</sup> June 2020. The concentration of NH<sub>3</sub> is well within the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 19.02 µg/m<sup>3</sup> on 10<sup>th</sup> June 2020.



**Figure 7.90: PM10 and PM<sub>2.5</sub> measured at Vytilla CAAQM Station after Lockdown**

Figure 7.90 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Eloor CAAQMS during the lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> values were generally below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 63.25 µg/m<sup>3</sup> and 39.33 µg/m<sup>3</sup> respectively on 23<sup>rd</sup> June 2020.



**Figure 7.91: CO measured at Vytilla CAAQMS during Lockdown**

Figure 7.91 shows the 24-hr average values for CO measured at Vytilla during the lockdown. The data analysis indicated that the CO was generally below the 8 hour standard of 2 mg/m<sup>3</sup> except for some occasional spikes. The highest value was found to be 31.30 mg/m<sup>3</sup> on 5<sup>th</sup> April 2020.

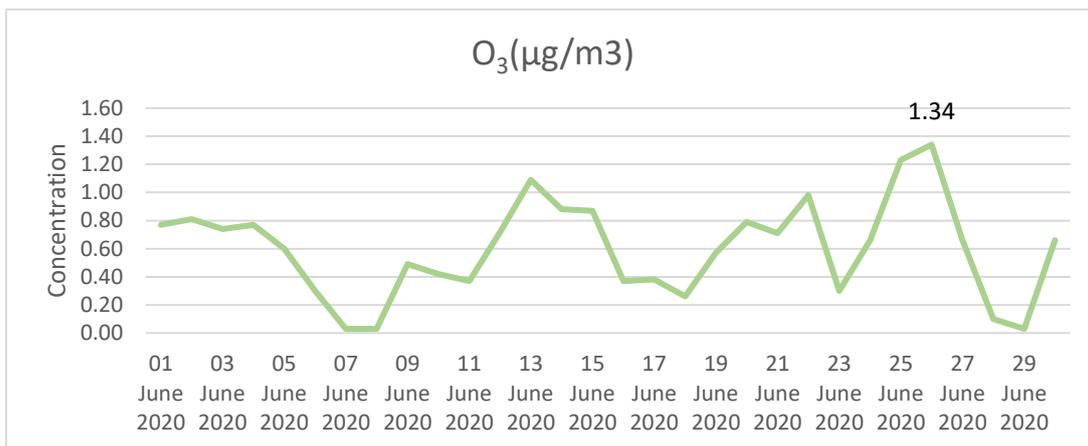


Figure 7.92: O<sub>3</sub> measured at Vytilla CAAQMS before Lockdown

Figure 7.92 shows the 24-hr average values for O<sub>3</sub> measured at Vytilla station before lockdown. The data analysis indicated that the O<sub>3</sub> was always within the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 1.34 µg/m<sup>3</sup> on 26<sup>th</sup> June 2020.

#### 7.9.4 Result Analysis

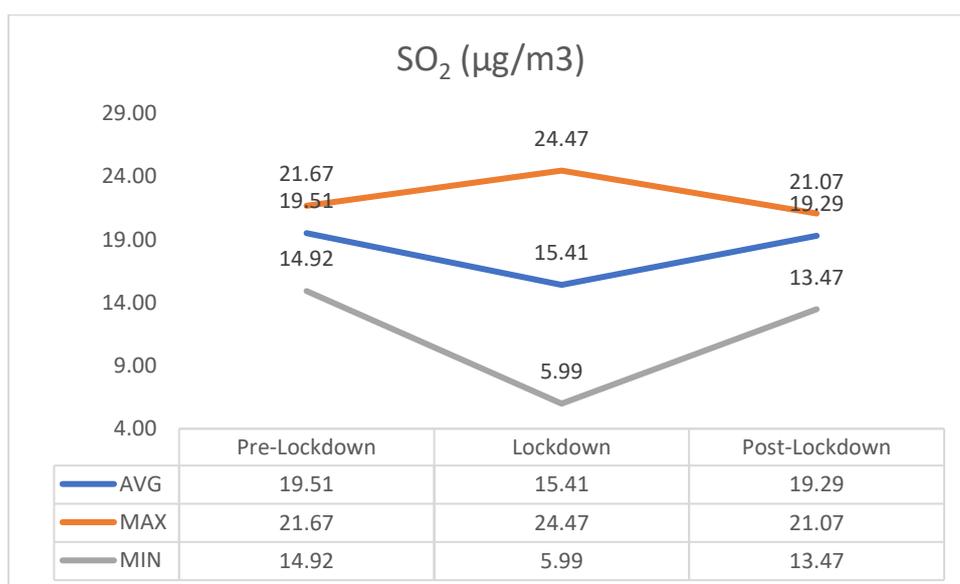


Figure 7.93: SO<sub>2</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.93 shows that average and minimum values for SO<sub>2</sub> registered a slight decrease during the lockdown period which relapsed as the restrictions were lifted. The Peak value thought slightly increase during the lockdown late came

down to that value before the lockdown which later decreased as the lockdown was lifted.

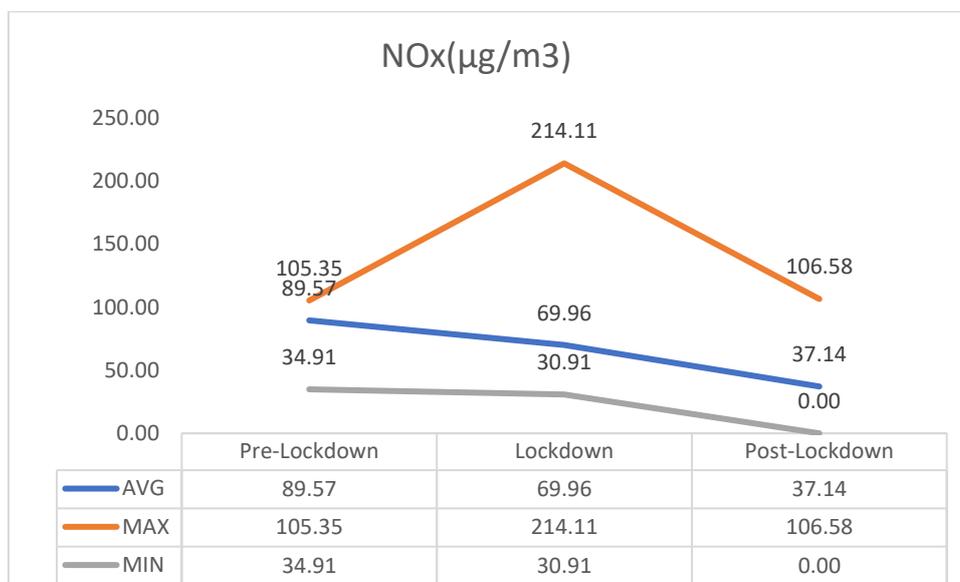


Figure 7.94: NOx Values of Vytilla CAAQMS station before, during and after lockdown.

Figure 7.94 shows that average, maximum and minimum values for NOx registered a decreasing trend during the lockdown period and thereafter. The peak value observed a hike during the lockdown.

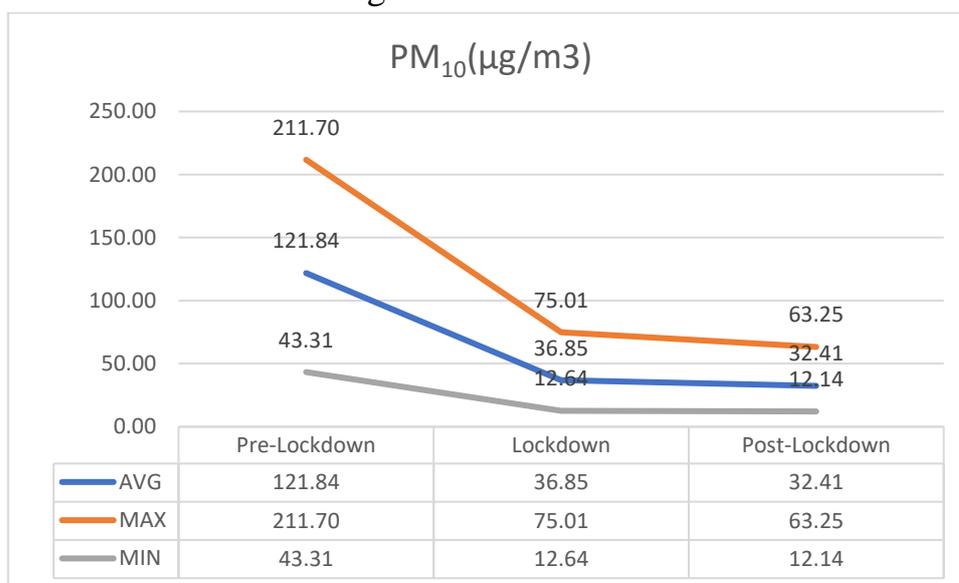


Figure 7.95: PM<sub>10</sub> Values of Vytilla CAAQMS station before, during and after lockdown.

Figure 7.95 shows that average, maximum and minimum values for NOx registered a decreasing trend during the lockdown period and thereafter.

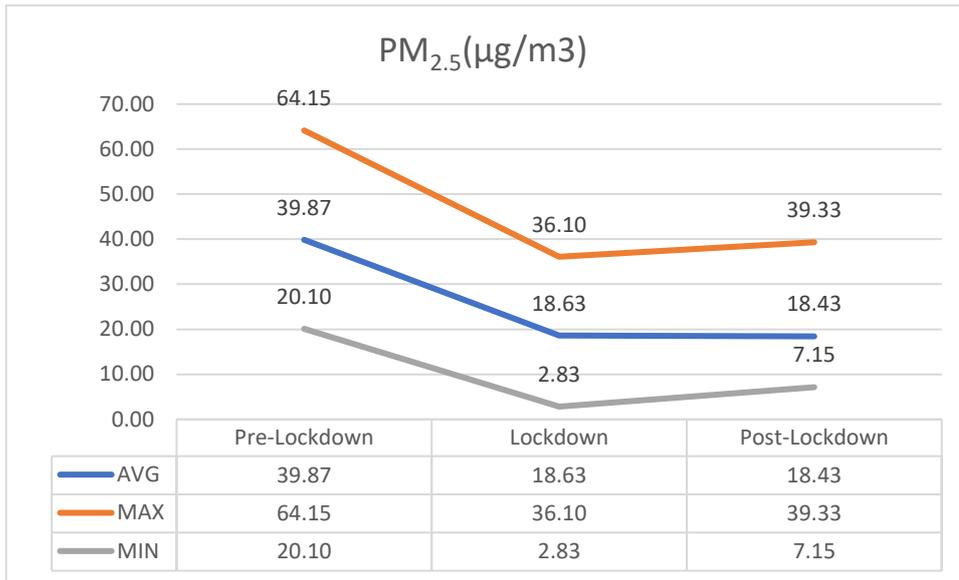


Figure 7.96: PM<sub>2.5</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.96 shows that average, minimum and maximum values for PM<sub>2.5</sub> showed a decreasing trend during the lockdown period and relapsed as the lockdown was lifted.

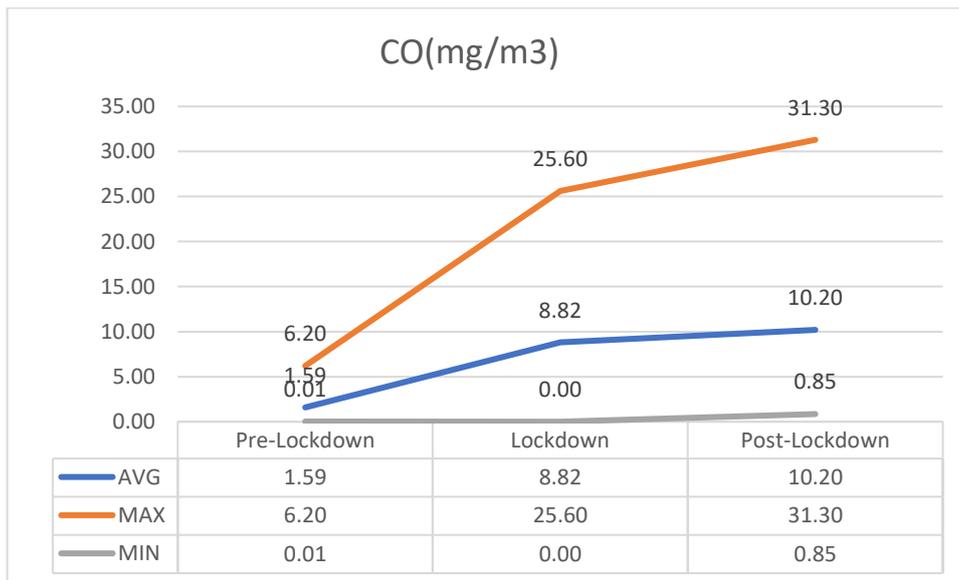


Figure 7.97: CO Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.97 showed that the average, minimum and maximum values of CO started to increase during the lockdown period which increased even further. It later continued in this path even after lifting of the lockdown



Figure 7.98: O<sub>3</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.98 showed that the average, minimum and maximum values of O<sub>3</sub> started to decline during the lockdown period relative to that of the pre-lockdown time. It later continued in this path even after lifting of the lockdown

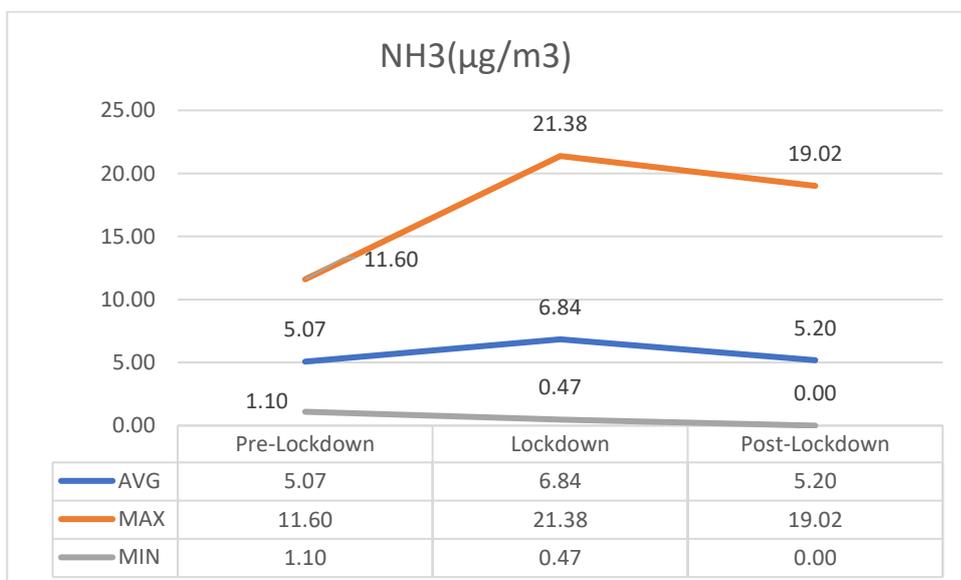


Figure 7.99: NH<sub>3</sub> Values of Eloor CAAQMS station before, during and after lockdown.

Figure 7.99 showed that the average and maximum values of  $\text{NH}_3$  started to increase during the lockdown period which later reduced once the lockdown was lifted.

## 7.10 M.G Road CAAQM Station

M.G Road manual monitoring station is located in that part of the city where the land use pattern includes both residential and commercial establishments

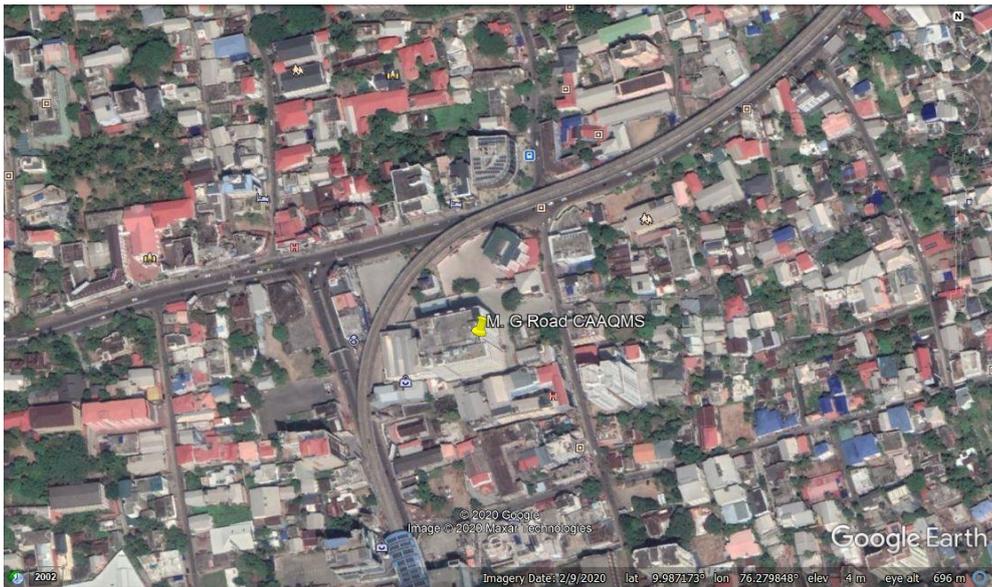


Figure 7.100: Land use pattern at M.G Road Station

### 7.10.1 Before Lockdown

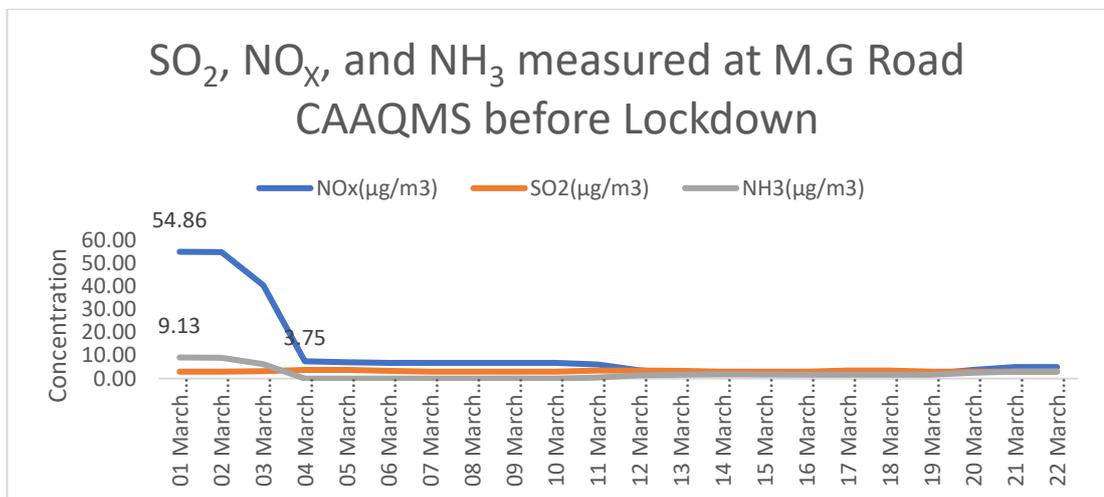


Figure 7.101: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at MG Road station before Lockdown

Figure 7.101 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at MG Road CAAQMS before lockdown. The data analysis indicated that the SO<sub>2</sub> and NO<sub>x</sub> values were well below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 3.75 µg/m<sup>3</sup> and 54.86 µg/m<sup>3</sup> respectively on 4<sup>th</sup> March 2020 and 1<sup>st</sup> March 2020. The concentration of NH<sub>3</sub> is well within the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 9.05 µg/m<sup>3</sup> on 2<sup>nd</sup> March 2020.

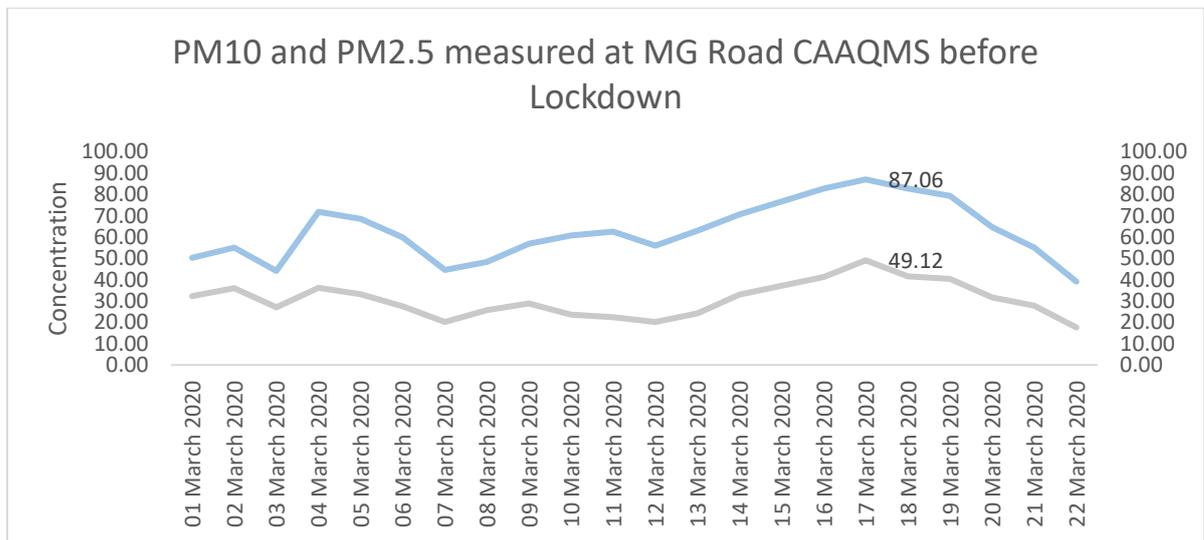


Figure 7.102: PM<sub>10</sub> & PM<sub>2.5</sub> measured at M.G Road station before lockdown

Figure 7.102 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at MG Road Station before lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 87.06 µg/m<sup>3</sup> and 49.12 µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020.

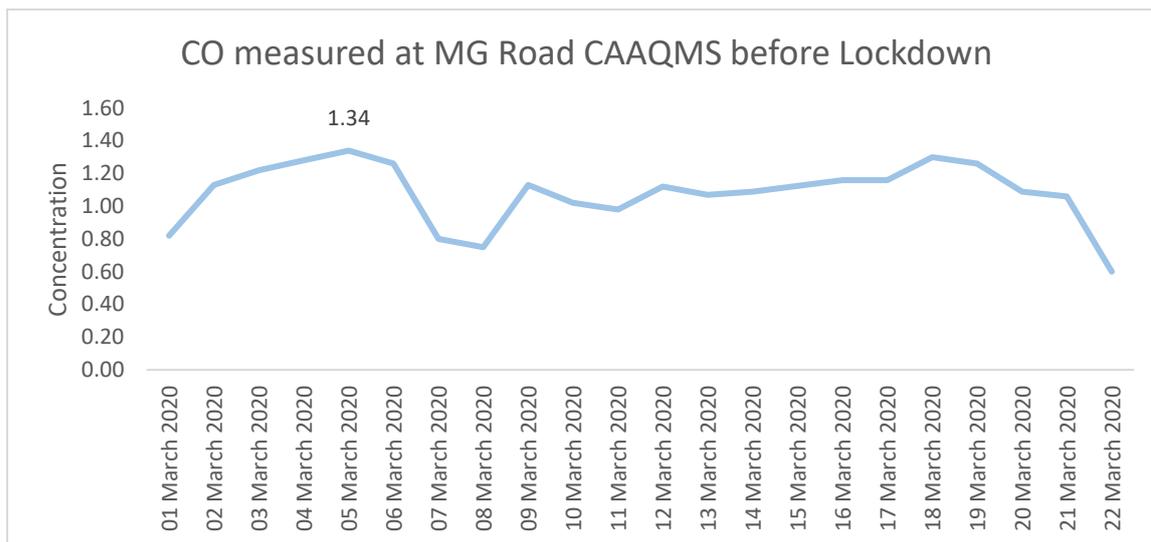


Figure 7.103: CO measured at M.G Road station before lockdown

Figure 7.103 shows the 24-hr average values for CO measured at M.G Road station before the lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 µg/m³. The highest value was found to be 1.34 µg/m³ on 5<sup>th</sup> March 2020.

### 7.10.2 During Lockdown

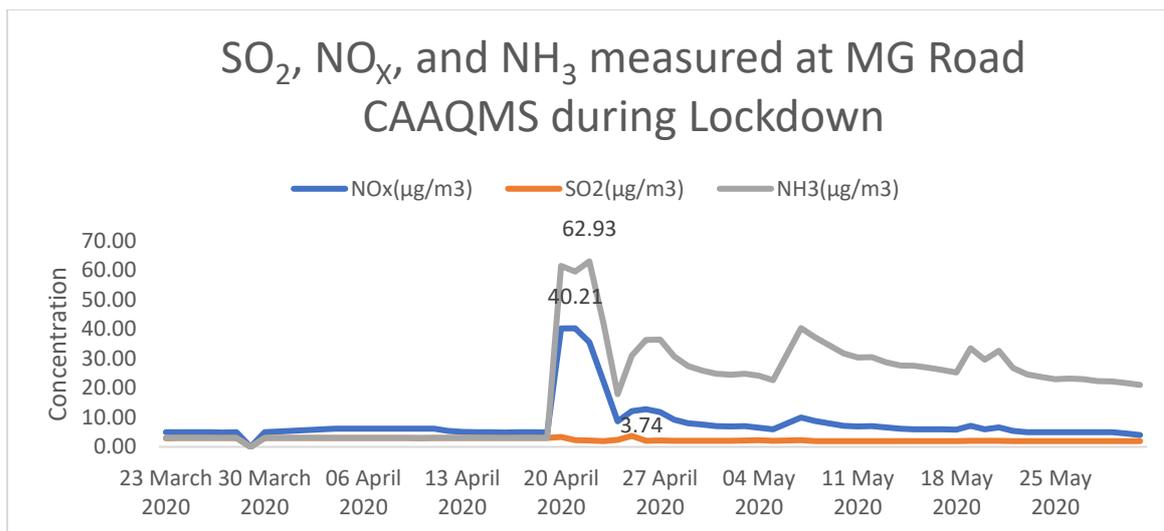


Figure 7.104: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at MG Road station before Lockdown

Figure 7.104 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at M.G Road station during a Lockdown. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m³. The highest values registered are 3.74 µg/m³ on 25<sup>th</sup> April and 40.21 on 21<sup>st</sup> April µg/m³ respectively for SO<sub>2</sub> and NO<sub>x</sub>. The concentration of NH<sub>3</sub> is well within the

NAAQS standards of  $400 \mu\text{g}/\text{m}^3$ . The highest value registered is  $62.93 \mu\text{g}/\text{m}^3$  on 22<sup>nd</sup> April 2020.

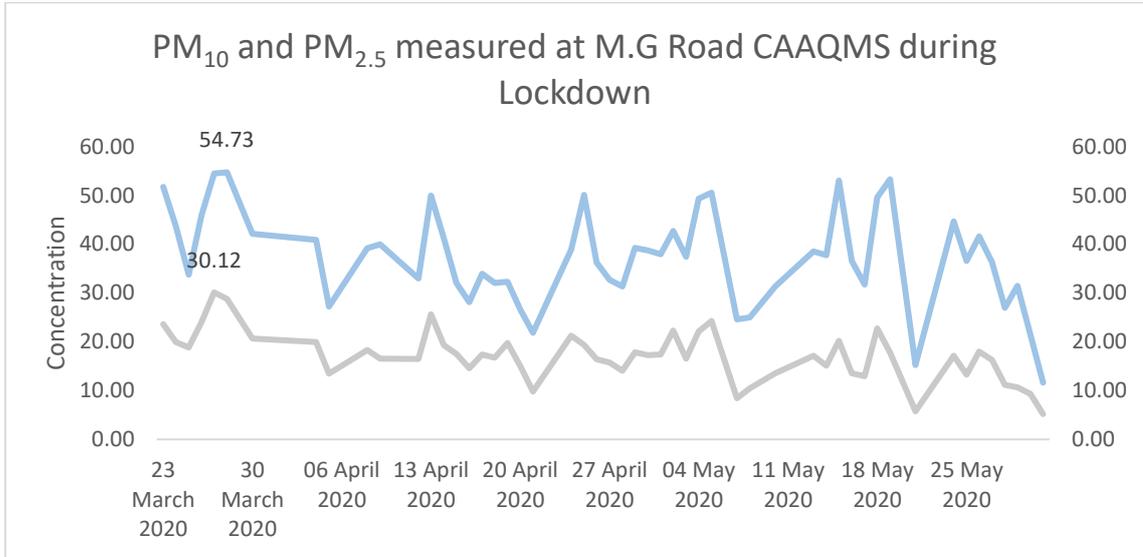


Figure 7.105: PM<sub>10</sub> & PM<sub>2.5</sub> measured at M.G Road station during the lockdown

Figure 7.105 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at M.G Road station during the lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of  $100 \mu\text{g}/\text{m}^3$  and  $60 \mu\text{g}/\text{m}^3$  respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be  $54.73 \mu\text{g}/\text{m}^3$  and  $30.12 \mu\text{g}/\text{m}^3$  respectively on 28<sup>th</sup> March 2020 and 27<sup>th</sup> March 2020.

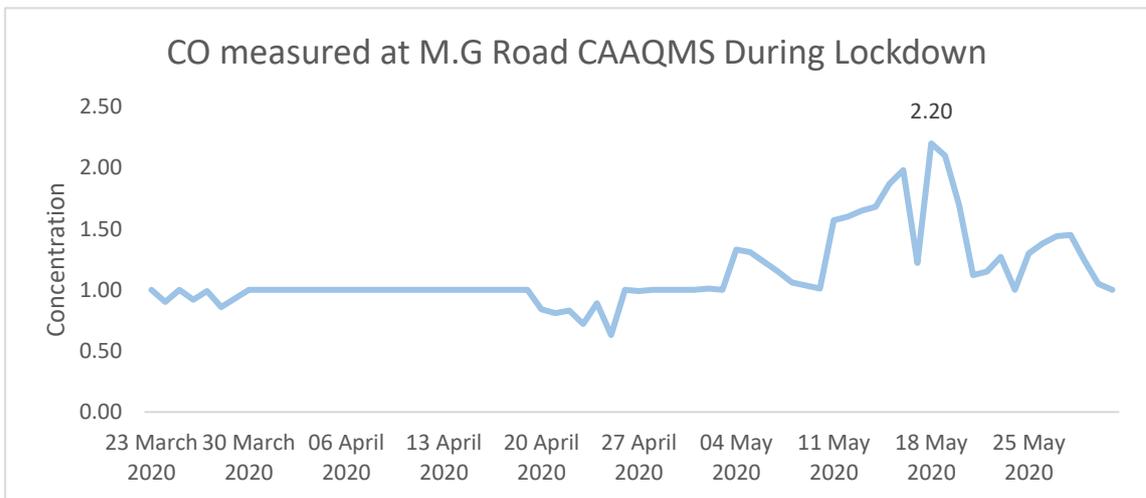
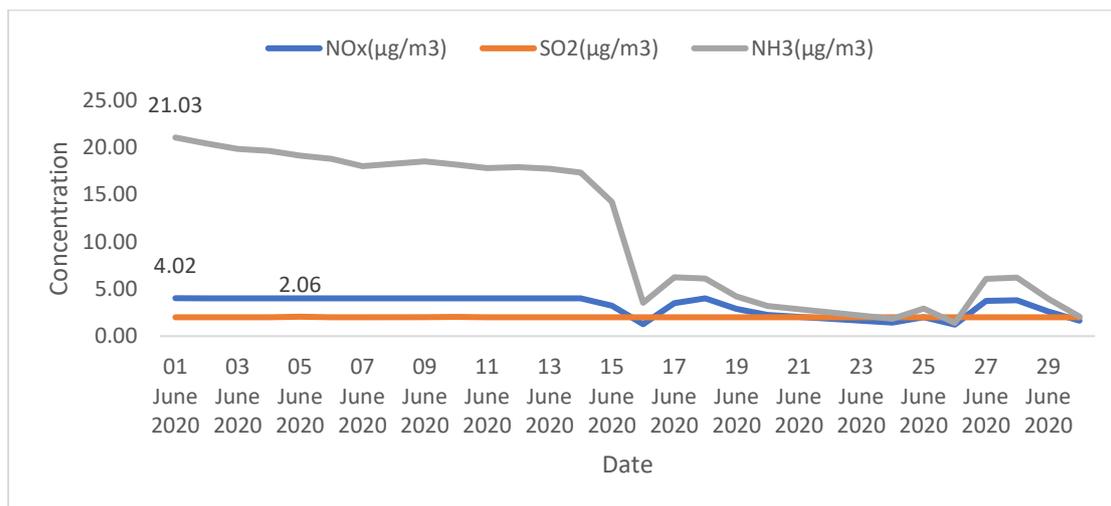


Figure 7.106: CO Measured at MG Road station during the lockdown

Figure 7.106 shows the 24-hr average values for CO measured at MG Road station during a lockdown. The data analysis indicated that the CO was above the 8 hour standard of 2  $\mu\text{g}/\text{m}^3$ . The highest value was found to be 2.20  $\mu\text{g}/\text{m}^3$  on 18<sup>th</sup> May 2020.

### 7.10.3 After Lockdown



**Figure 7.107: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at MG Road station before Lockdown**

Figure 7.107 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at M.G Road station after the lockdown. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80  $\mu\text{g}/\text{m}^3$ . The highest values registered are 2.0  $\mu\text{g}/\text{m}^3$  and 4.02  $\mu\text{g}/\text{m}^3$  respectively for SO<sub>2</sub> and NO<sub>x</sub>. The concentration of NH<sub>3</sub> is well within the NAAQS standards of 400  $\mu\text{g}/\text{m}^3$ . The highest value registered is 21.03  $\mu\text{g}/\text{m}^3$  on 1<sup>st</sup> June 2020.

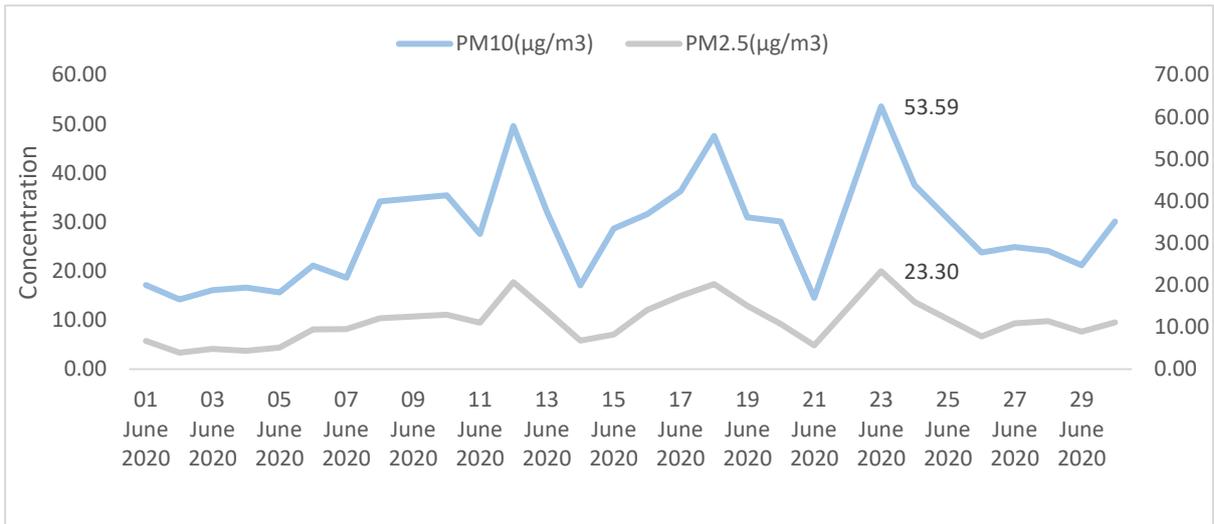


Figure 7.108: PM<sub>10</sub> & PM<sub>2.5</sub> measured at M.G Road station after the lockdown

Figure 7.108 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at MG Road station after lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 53.59 µg/m<sup>3</sup> and 23.20 µg/m<sup>3</sup> respectively on 23<sup>rd</sup> June 2020.

#### 7.10.4 Result Analysis

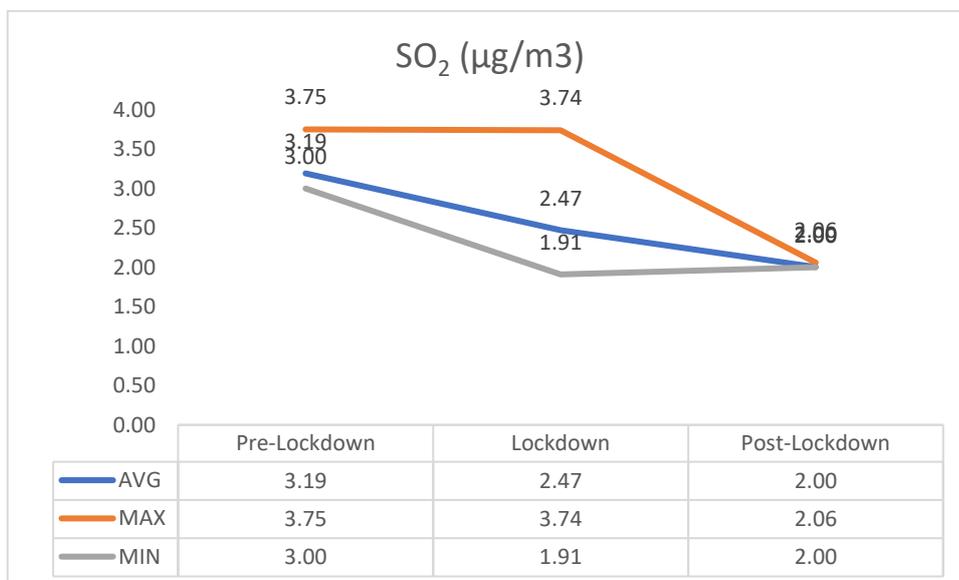


Figure 7.109: SO<sub>2</sub> Values of MG Road station before, during and after lockdown.

Figure 7.109 shows that the average, maximum and minimum values for SO<sub>2</sub> showed a slight decrease during lockdown and post lockdown period at MG Road Station.

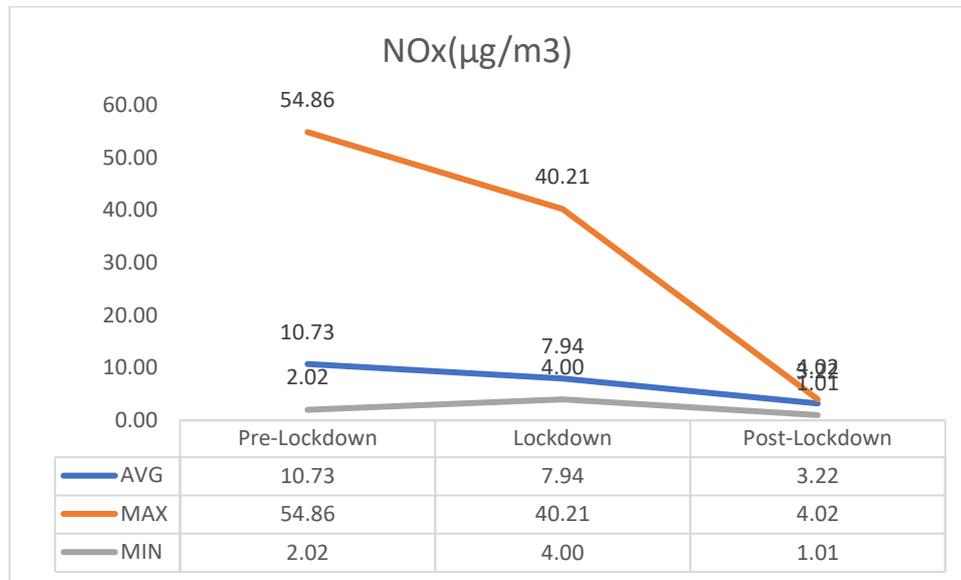


Figure 7.110: NO<sub>x</sub> Values of MG Road station before, during and after lockdown.

Figure 7.110 shows that the average and maximum values for NO<sub>x</sub> registered a decrease during the lockdown.

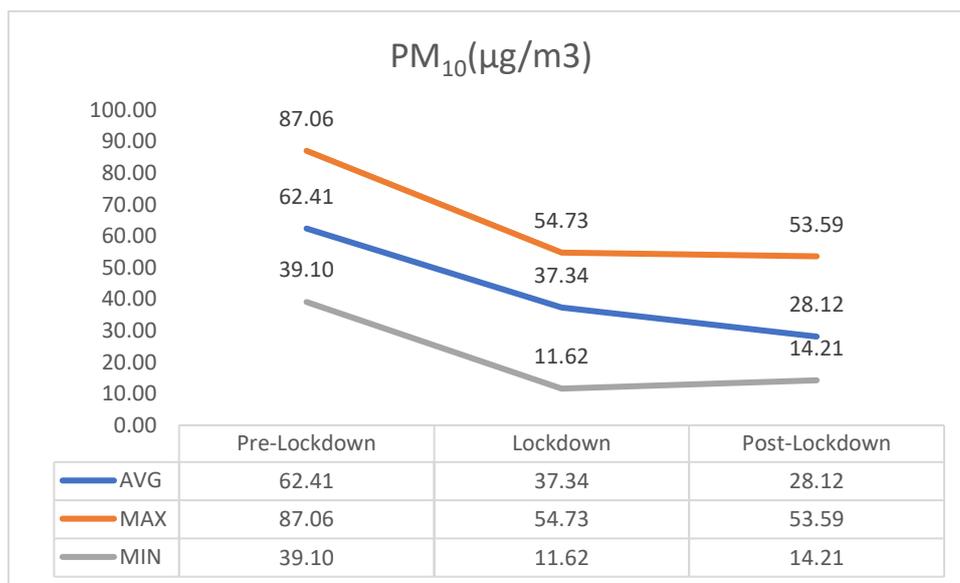


Figure 7.111: PM<sub>10</sub> Values of MG Road station before, during and after lockdown.

Figure 7.111 and 7.112 shows that the average, maximum and minimum values for PM<sub>10</sub> and PM<sub>2.5</sub> decreased during the lockdown period at M.G Road Station which remained in a decreasing trend even after lifting the lockdown.

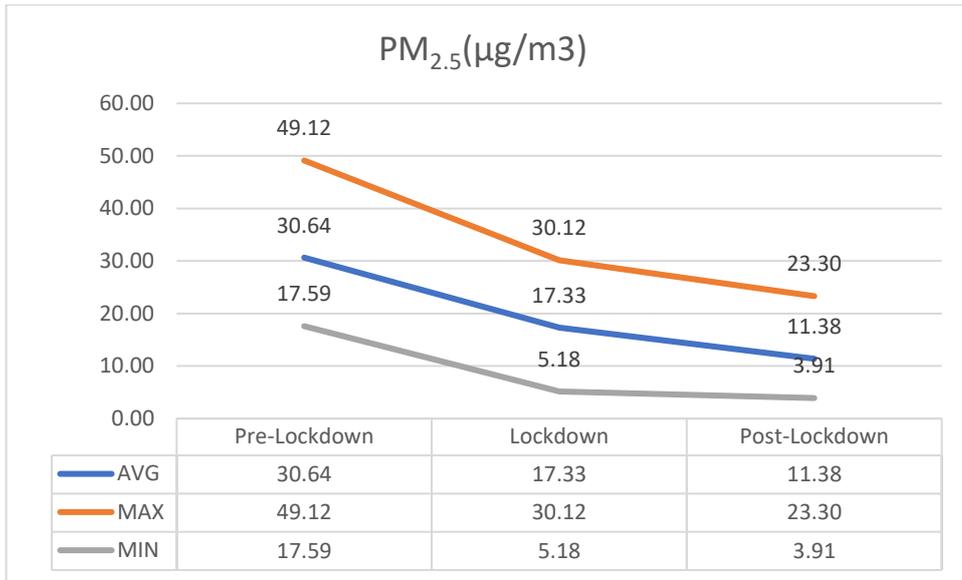


Figure 7.112: PM<sub>2.5</sub> Values of MG Road station before, during and after lockdown.

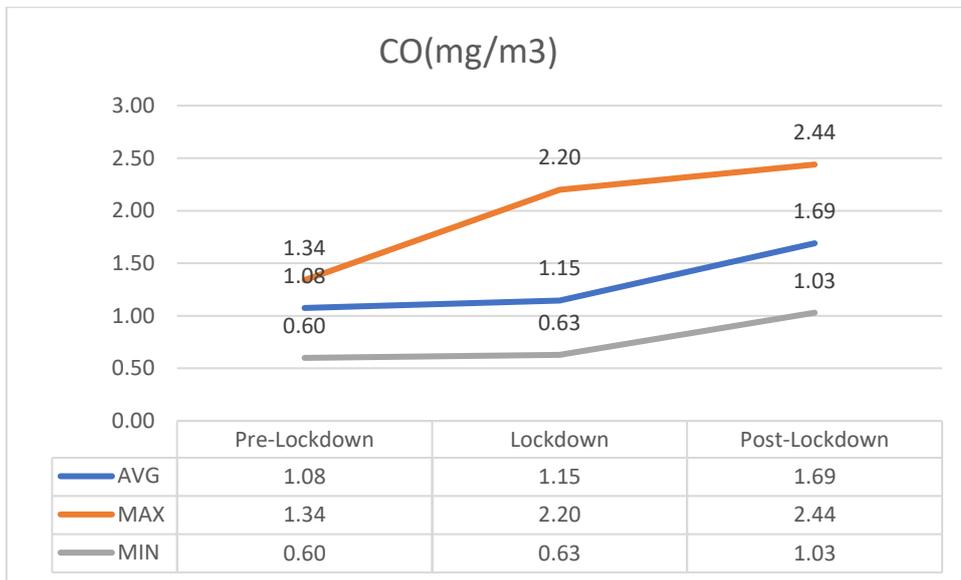
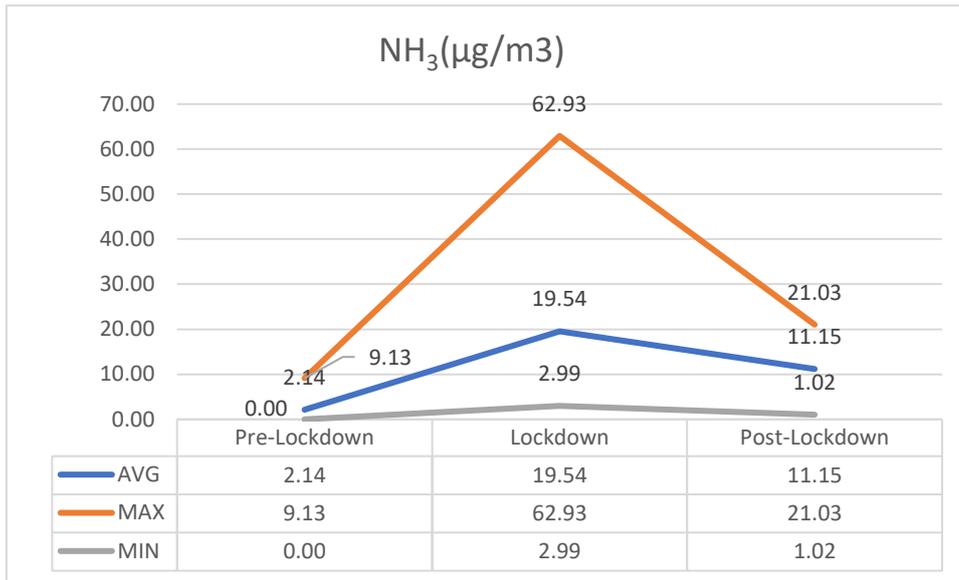


Figure 7.113: CO Values of MG Road station before, during and after lockdown.

Figure 7.113 shows that the average, maximum and minimum values for CO increased during the lockdown period at M.G Road Station which remained in an increasing trend even after lifting the lockdown



**Figure 7.114: NH<sub>3</sub> Values of MG Road station before, during and after lockdown.**

Figure 7.114 shows that the average, minimum and maximum values for NH<sub>3</sub> registered a notable increase during the lockdown period, these values continued on an increasing trend even after lifting of the lockdown

## 8 Thrissur

The list of Monitoring stations in the city is tabulated in Table 8.1. The land use pattern at these stations is also depicted.

Table 8.1: List of monitoring stations in Thrissur

Site	Co-ordinates	Scheme	Type	Land Use Pattern
<b>Poonkunnam</b>	10.52219242363413 76.22573453933	NAMP	Residential	Commercial Buildings, Major road, college, hospital, church
<b>Peringadoor</b>	10.61791731457101 5	NAMP	Industrial	Industrial area

Table 8.2 gives the growth of vehicles in the district of Thrissur, it has shown steady growth.

Table 8.2: Vehicular Count in Thrissur

Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
<b>No of vehicles</b>	895730	987444	1059370	1149999	1248317	1361561

### 8.1 Poonkunnam (Residential & Others)-Manual Monitoring Station

Poonkunnam (East fort ) station is located in that part of the Thrissur city that has land utilisation as residential & commercial with major roads and transport terminal.

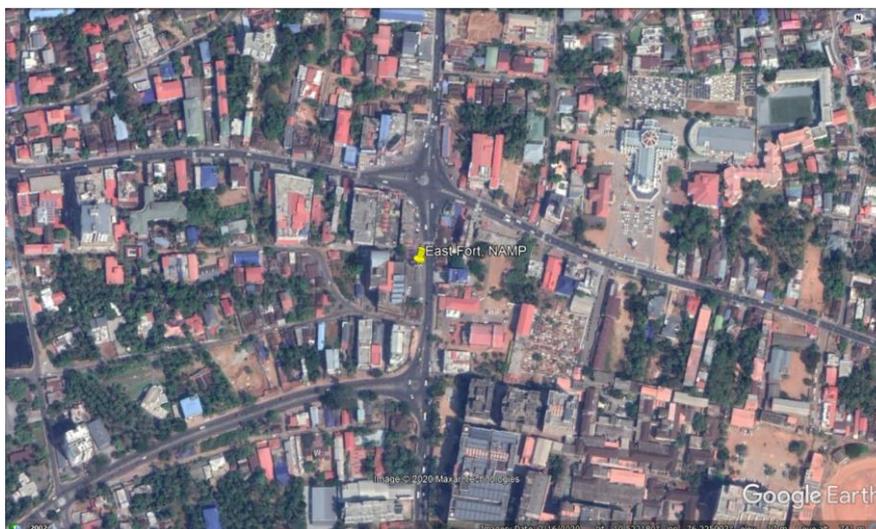


Figure 8.1: Land Use pattern at Poonkunnam station (East Fort)

### 8.1.1 Before Lockdown

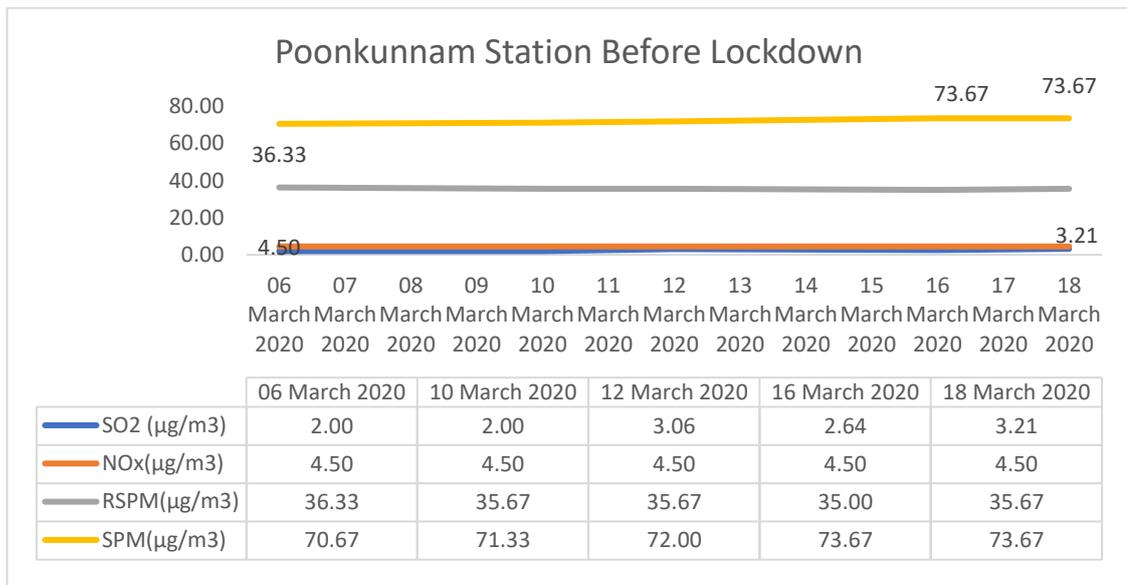


Figure 8.2: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Poonkunnam station before Lockdown

Figure 8.2 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Poonkunnam station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 36.33µg/m<sup>3</sup> and 73.67µg/m<sup>3</sup> respectively on 6<sup>th</sup> March 2020 and 18<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 3.21 µg/m<sup>3</sup> and 4.5 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 8.1.2 During Lockdown

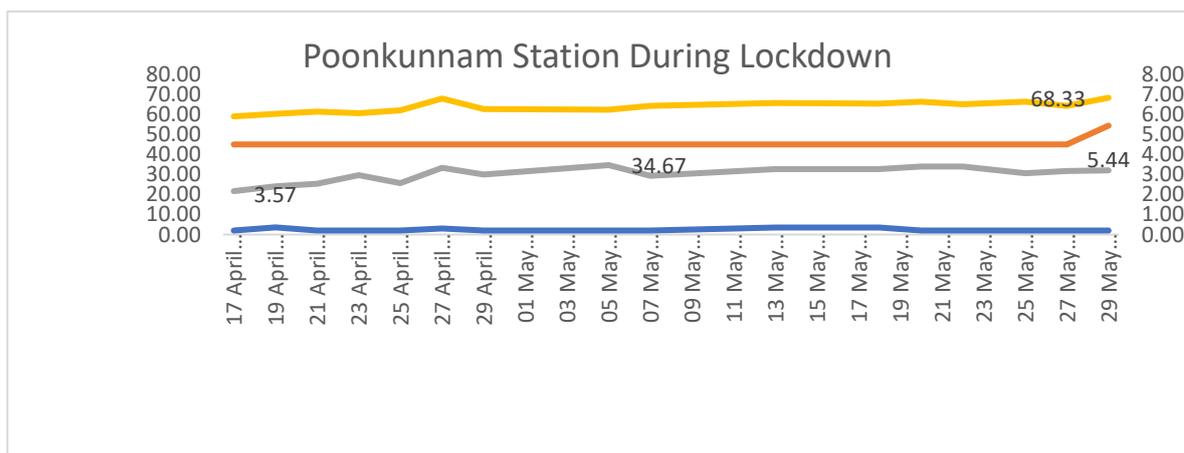


Figure 8.3: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Poonkunnam station during Lockdown

Figure 8.3 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Poonkunnam station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 34.67µg/m<sup>3</sup> and 68.33µg/m<sup>3</sup> respectively on 5<sup>th</sup> May 2020 and 29<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 3.57 µg/m<sup>3</sup> and 5.44µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 8.1.3 After Lockdown

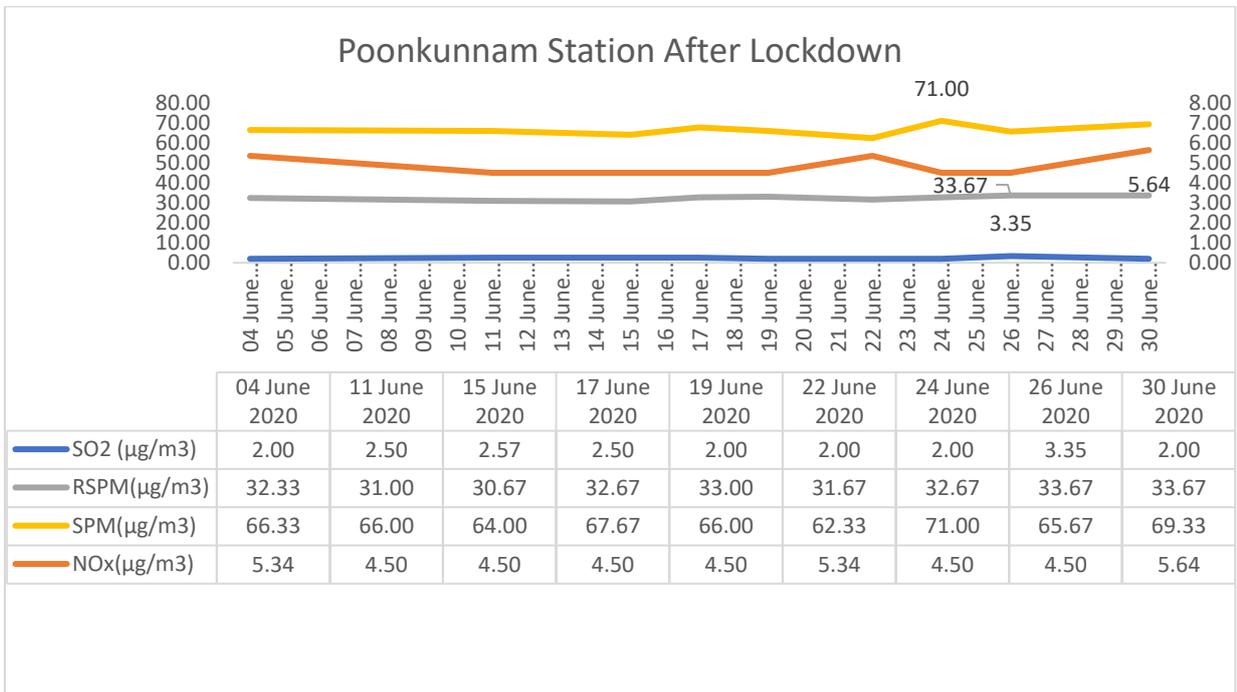


Figure 8.4: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Poonkunnam station after Lockdown

Figure 8.4 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Poonkunnam station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 33.67µg/m<sup>3</sup> and 71.00µg/m<sup>3</sup> respectively on 26<sup>th</sup> June 2020 and 24<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 3.35 µg/m<sup>3</sup> and 5.64µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 8.1.4 Result Analysis

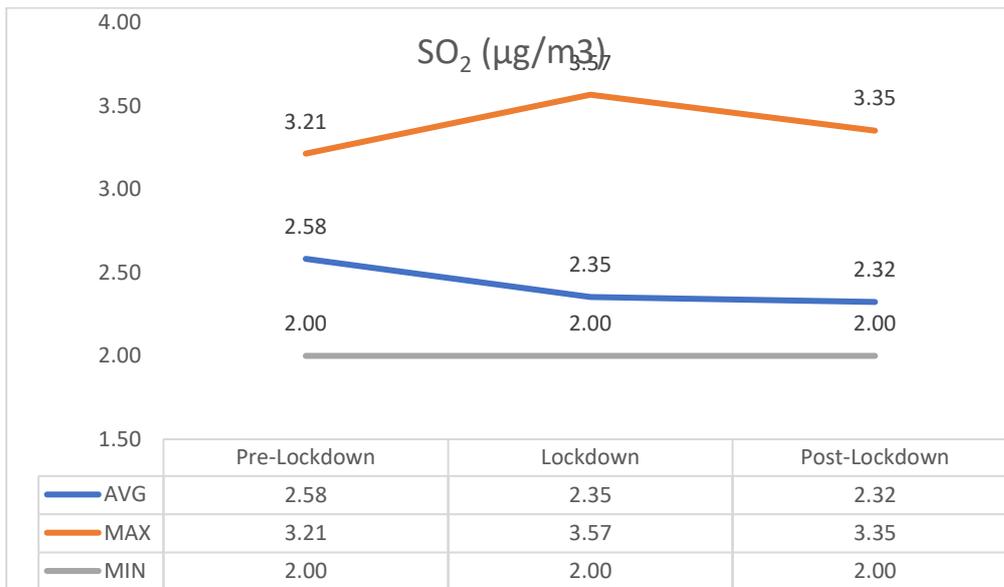


Figure 8.5: SO<sub>2</sub> Values of Poonkunnam station before, during and after lockdown.

Figure 8.5 shows that the average, maximum and minimum values for SO<sub>2</sub> remained nearly the same during pre-lockdown, lockdown and post lockdown period at Poonkunnam Station.

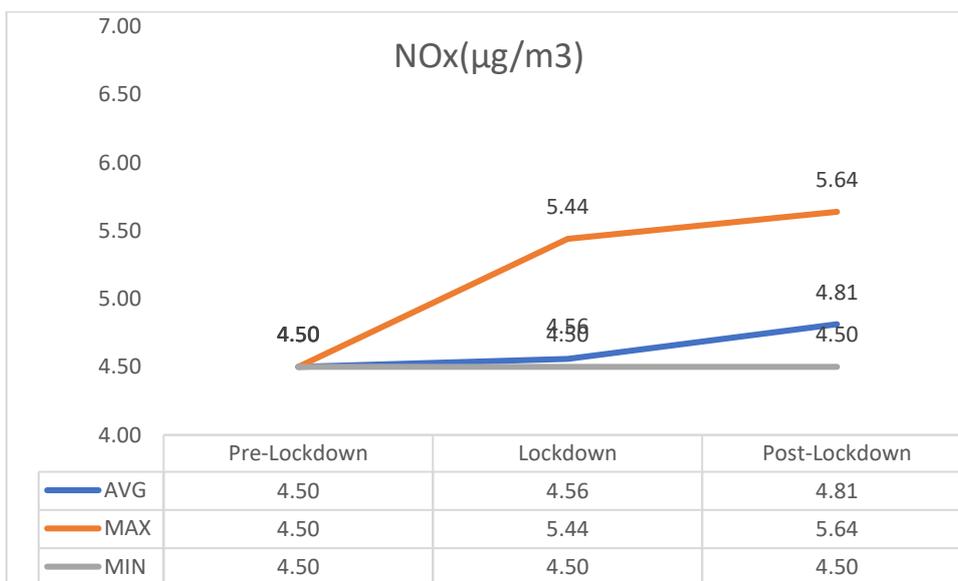


Figure 8.6: NO<sub>x</sub> Values of Poonkunnam station before, during and after lockdown.

Figure 8.6 shows that the average and maximum values for NO<sub>x</sub> registered an increase during the lockdown and thereafter. The minimum value remained

constant during pre-lockdown, lockdown and post lockdown period at Poonkunnam Station.

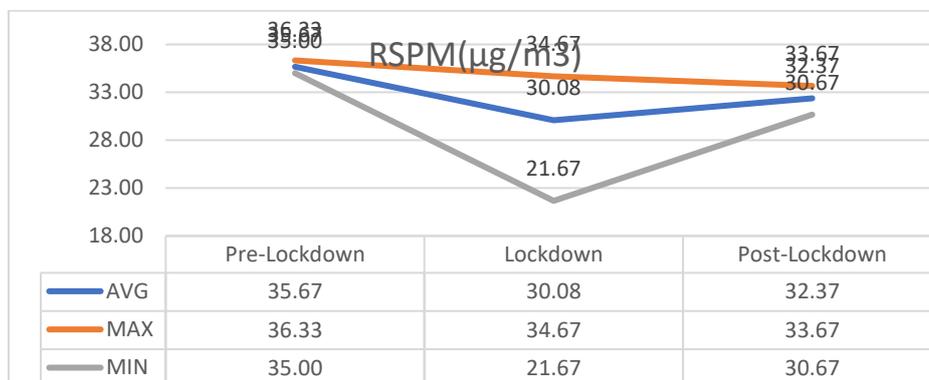


Figure 8.7: RSPM Values of Poonkunnam station before, during and after lockdown.

Figure 8.7 shows that the average, maximum and minimum values for RSPM decreased during the lockdown period at Poonkunnam Station which relapsed except for the peak value, which remained in a decreasing trend even after lifting the lockdown.

## 8.2 Peringadoor(Industrial)-Manual Monitoring Station

Peringadoor manual air quality monitoring station is located in a designated industrial area.



Figure 8.8: Land Use Pattern at Peringadoor Station

### 8.2.1 Before Lockdown

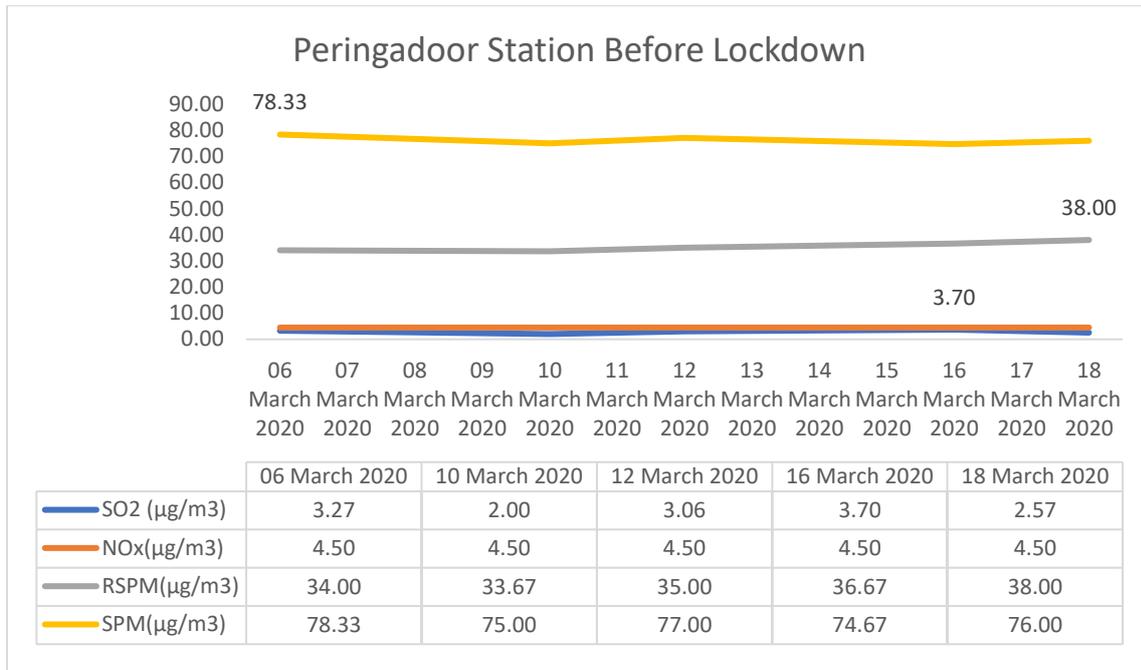


Figure 8.9: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Peringadoor station before Lockdown

Figure 8.9 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Peringadoor station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 38µg/m<sup>3</sup> and 78.33µg/m<sup>3</sup> respectively on 18<sup>th</sup> March 2020 and 6<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 3.70µg/m<sup>3</sup> and 2.0 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 8.2.2 During Lockdown

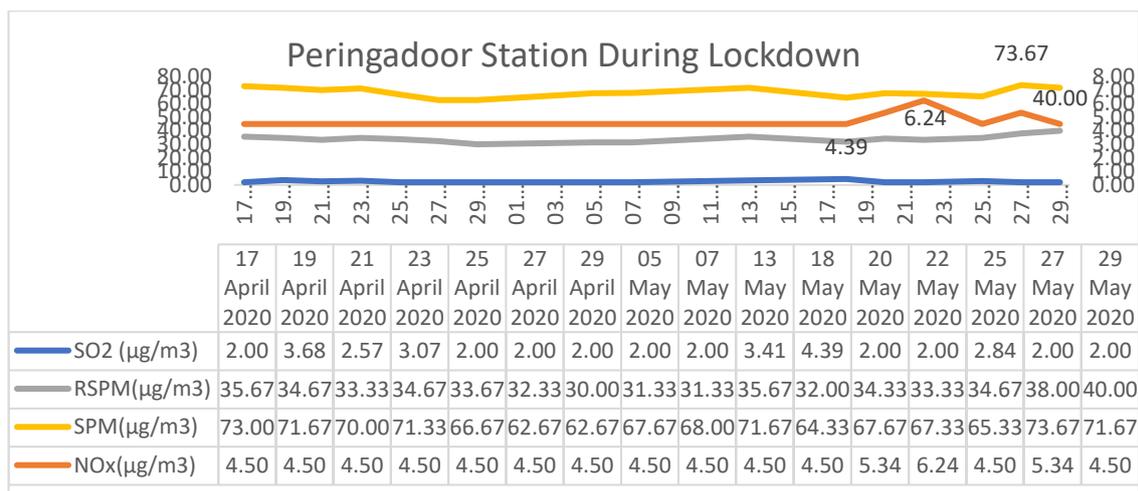


Figure 8.10: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Peringadoor station during Lockdown

Figure 8.10 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Peringadoor station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 40µg/m<sup>3</sup> and 73.67µg/m<sup>3</sup> respectively on 29<sup>th</sup> May 2020 and 27<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 4.39µg/m<sup>3</sup> and 6.24 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 8.2.3 After Lockdown

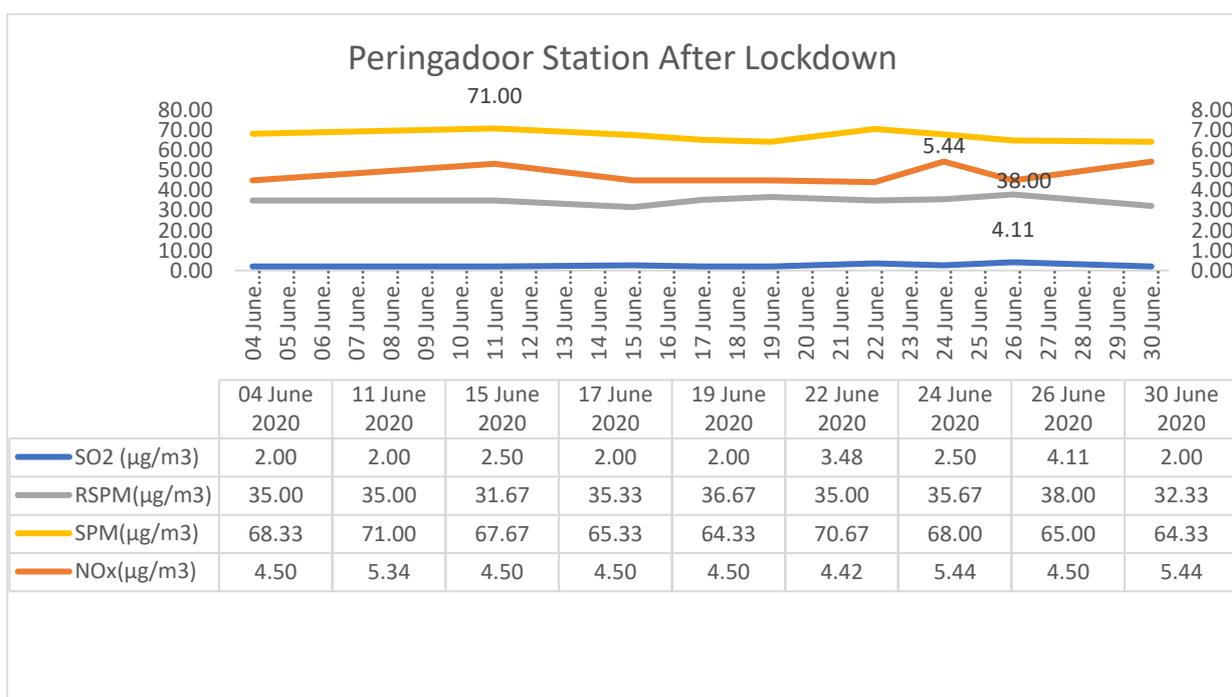


Figure 8.11: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Peringadoor station after Lockdown

Figure 8.11 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Peringadoor station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 38µg/m<sup>3</sup> and 71µg/m<sup>3</sup> respectively on 26<sup>th</sup> June 2020 and 11<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 4.11µg/m<sup>3</sup> and 5.54 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

## 8.2.4 Result Analysis



Figure 8.12: SO<sub>2</sub> Values of Peringadoor station before, during and after lockdown.

Figure 8.12 shows that the average and minimum values for SO<sub>2</sub> remained almost constant during pre lockdown, lockdown and post lockdown period at Peringadoor Station. The maximum value showed a slight increase during the lockdown which later showed a relative decrease.

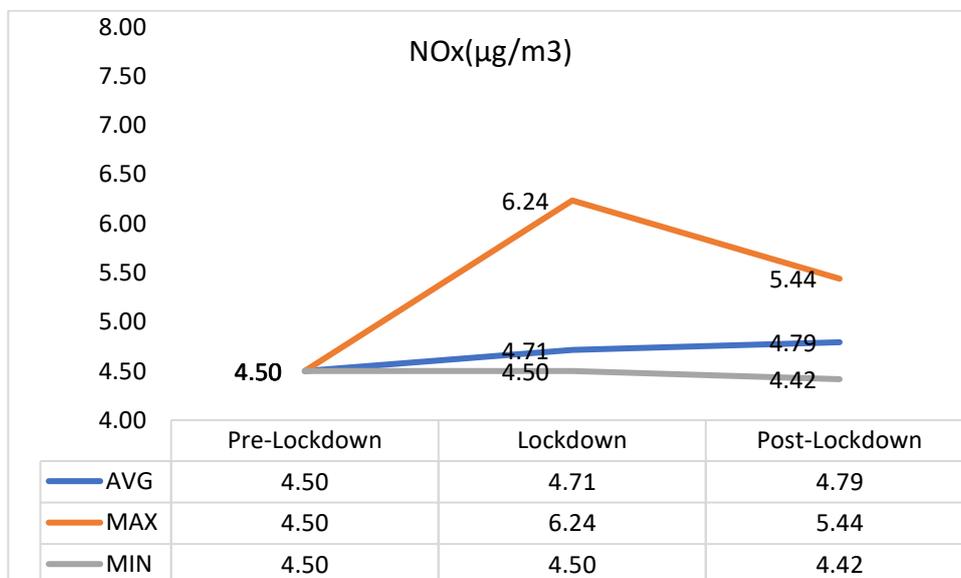


Figure 8.13: NO<sub>x</sub> Values of Peringadoor station before, during and after lockdown.

Figure 8.13 shows that the average and maximum values for NOx registered an increase during the lockdown which remained nearly the same afterwards.

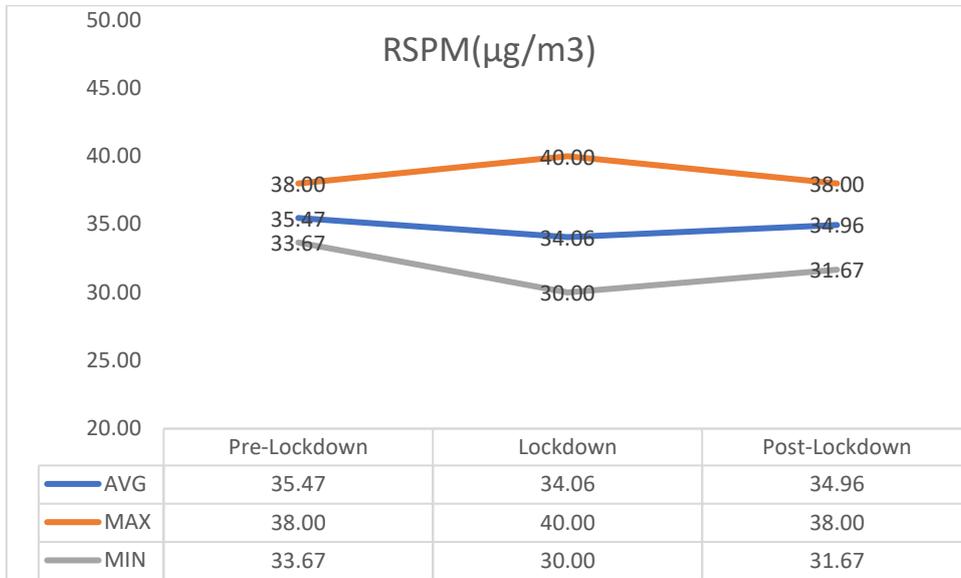


Figure 8.14: RSPM Values of Peringadoor station before, during and after lockdown.

Figure 8.14 shows that the average, maximum and minimum values for RSPM decreased during the lockdown period at Peringadoor Station which remained almost the same thereafter.

## 9 Kozhikkode

The list of Monitoring stations in the city is tabulated in Table 9.1. The land use pattern at these stations is also depicted

Table 9.1: List of monitoring stations in Kozhikkode

Site	Co-ordinates	Scheme	Type	Land Use Pattern
Kozhikkode city	11°14'56.6"N 75°47'02.4"E	NAMP	Residential & Rural locations	Hospital, major roads, commercial establishment/commercial area
Palayam	11.249077, 75.784371	CAAQMS	Residential	Transportation hub
Nallalam	11.2050062, 75.8071121	NAMP	Industrial	Industries, Diesel power plants

Table 9.2 gives the growth of vehicles in the district of Kozhikkode, it has shown steady growth.

Table 9.2: Vehicular Count in Kozhikkode

Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
No of vehicles	757103	834769	927388	1016328	1114491	1227317

### 9.1 Palayam (Residential, Rural & Others)-Manual Monitoring Station.

Palayam station is located in the heart of the Kozhikkode city with diverse land use pattern. These include Residential, commercial as well as an established transportation network (Major roads).



Figure 9.1: Land use pattern at palayam manual monitoring station

### 9.1.1 Before Lockdown

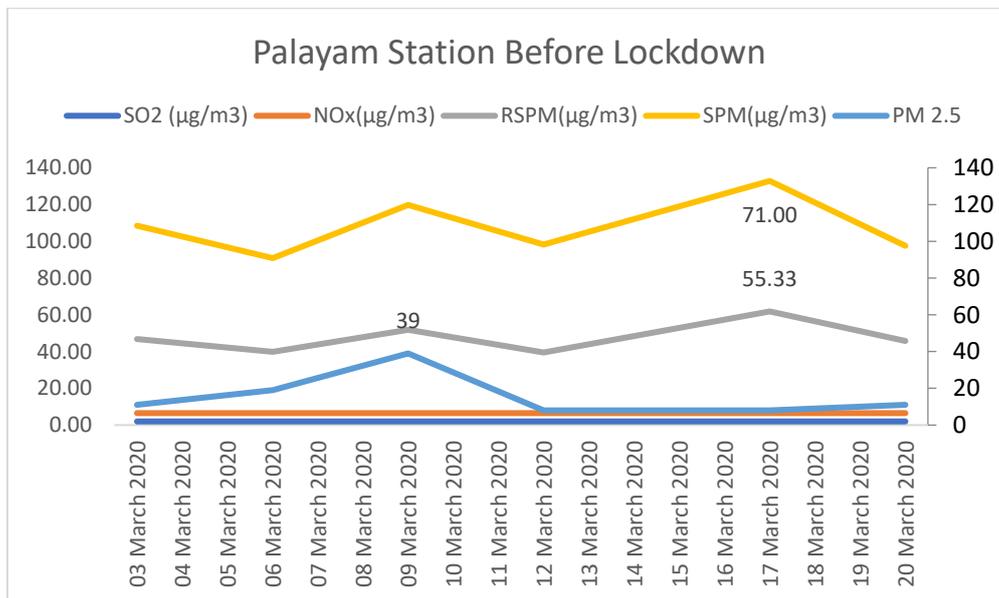


Figure 9.2: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Palayam station before Lockdown

Figure 9.2 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Palayam station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 55.33µg/m<sup>3</sup> and 71µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. SO<sub>2</sub> and NO<sub>x</sub> have registered a constant value

of  $2.0 \mu\text{g}/\text{m}^3$  and  $4.50 \mu\text{g}/\text{m}^3$  respectively. The peak value of  $\text{PM}_{2.5}$  was observed as  $39 \mu\text{g}/\text{m}^3$  on 9<sup>th</sup> March 2020.

### 9.1.2 During Lockdown

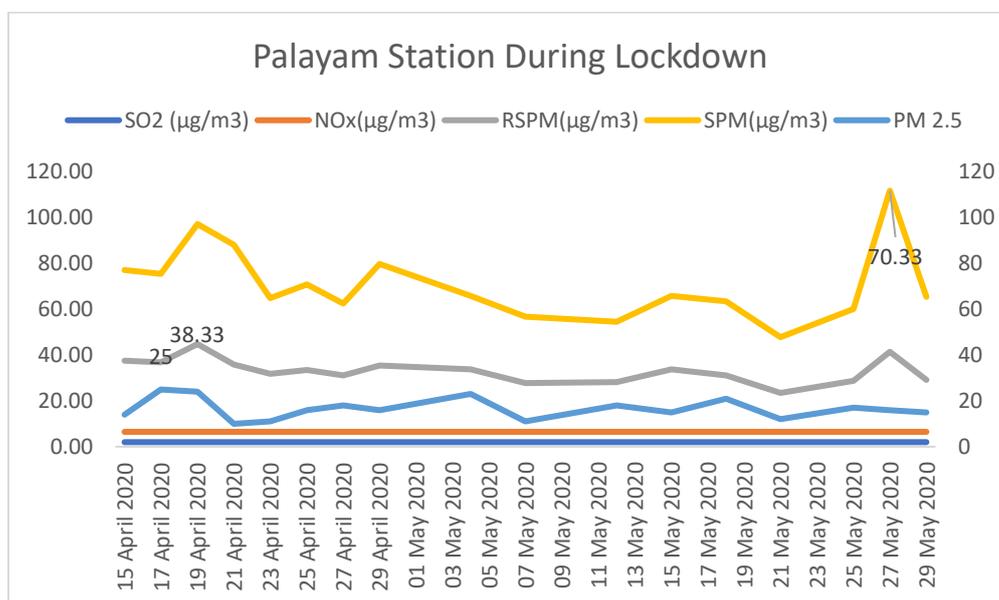


Figure 9.3: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Palayam station during Lockdown

Figure 9.3 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Palayam station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of  $100 \mu\text{g}/\text{m}^3$ . The highest RSPM and SPM value were recorded as  $38.33 \mu\text{g}/\text{m}^3$  and  $70.33 \mu\text{g}/\text{m}^3$  respectively on 19<sup>th</sup> April and 27<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of  $80 \mu\text{g}/\text{m}^3$ . The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of  $80 \mu\text{g}/\text{m}^3$ . SO<sub>2</sub> and NO<sub>x</sub> have registered a constant value of  $2.0 \mu\text{g}/\text{m}^3$  and  $4.50 \mu\text{g}/\text{m}^3$  respectively. The peak value of  $\text{PM}_{2.5}$  was observed as  $25 \mu\text{g}/\text{m}^3$  on 17<sup>th</sup> April 2020.

### 9.1.3 After Lockdown

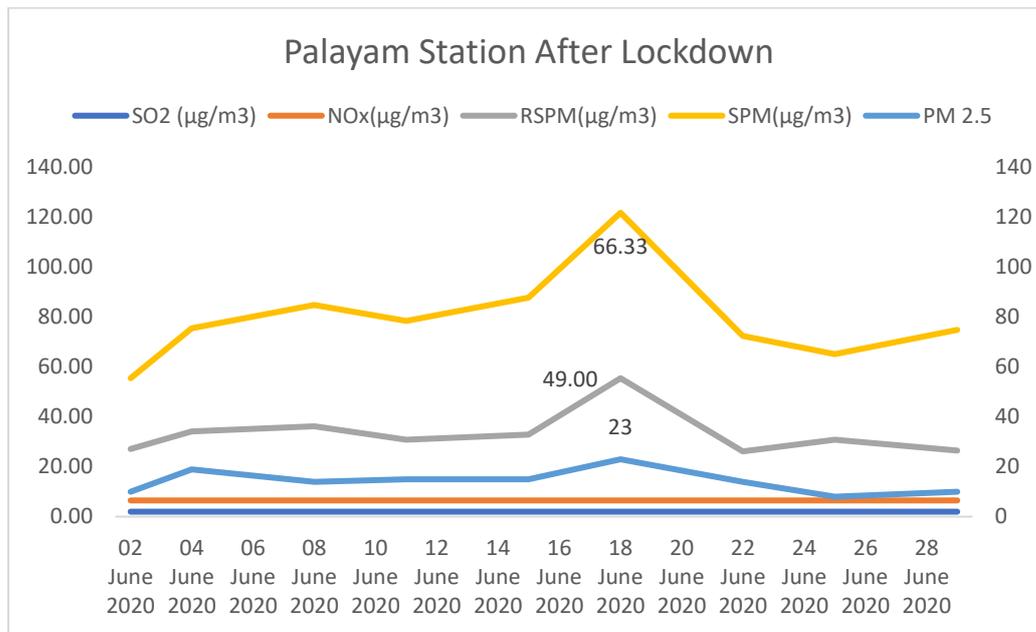


Figure 9.4: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Palayam station after Lockdown

Figure 9.4 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Palayam station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 49µg/m<sup>3</sup> and 66.33µg/m<sup>3</sup> respectively on 18<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. SO<sub>2</sub> and NO<sub>x</sub> have registered a constant value of 2.0 µg/m<sup>3</sup> and 4.50 µg/m<sup>3</sup> respectively. The peak value of PM<sub>2.5</sub> was observed as 23µg/m<sup>3</sup> on 18<sup>th</sup> June 2020.

### 9.1.4 Result Analysis

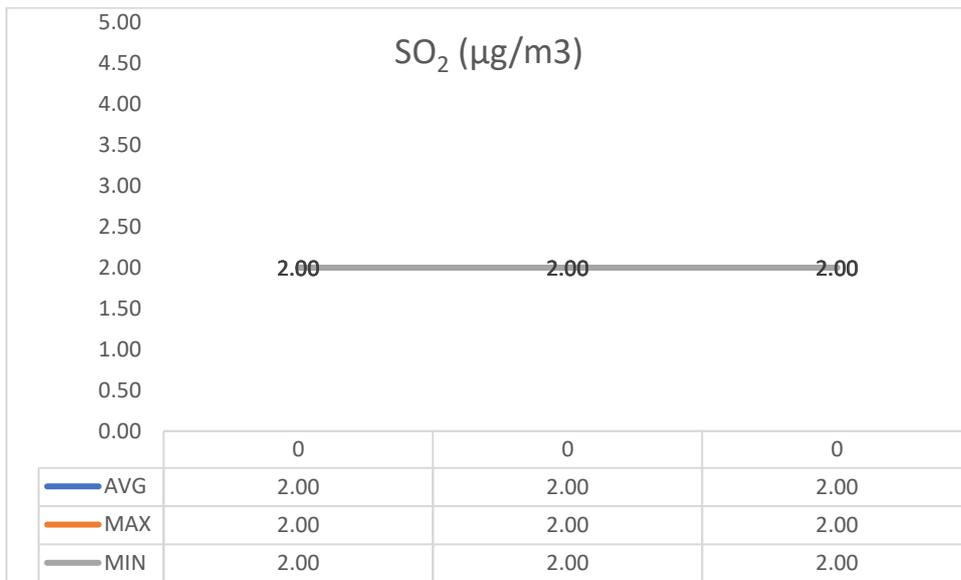


Figure 9.5: SO<sub>2</sub> Values of Palayam station before, during and after lockdown.

Figure 9.5 shows that the average, maximum and minimum values for SO<sub>2</sub> remained constant during pre lockdown, lockdown and post lockdown period at Palayam Station.

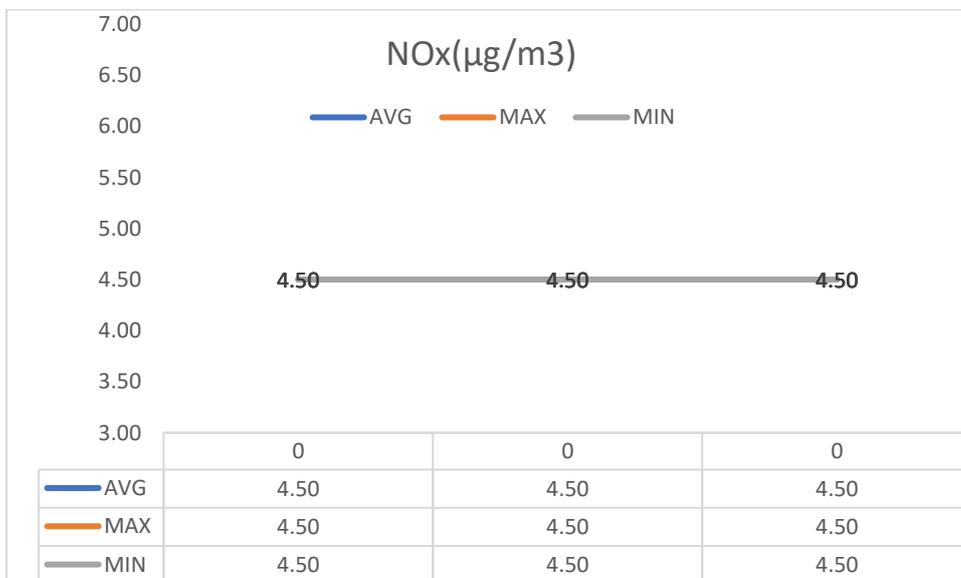


Figure 9.6: Nox Values of Palayam station before, during and after lockdown.

Figure 9.6 shows that the average, maximum and minimum values for NO<sub>x</sub> remained constant during pre lockdown, lockdown and post lockdown period at Palayam Station.

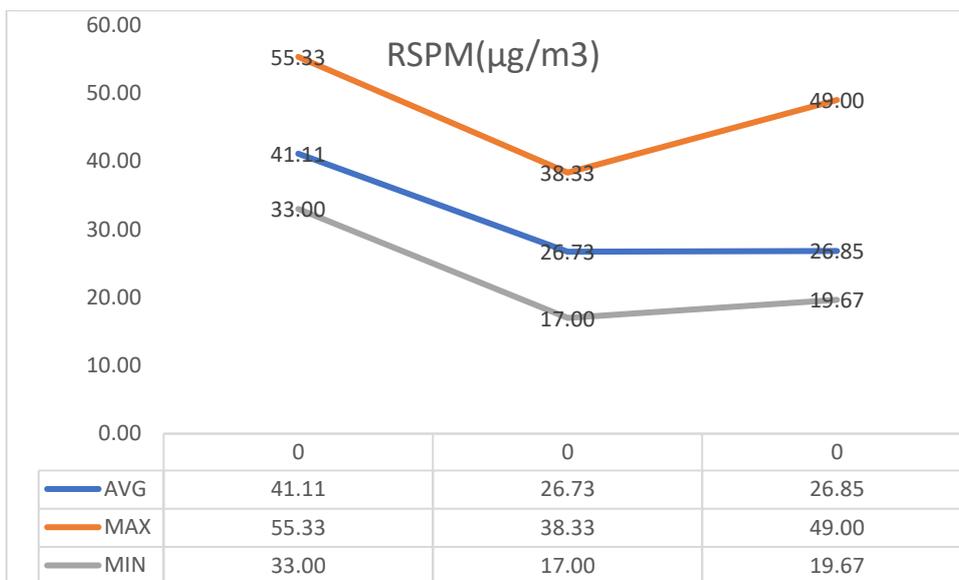


Figure 9.7: RSPM Values of Palayam station before, during and after lockdown.

Figure 9.7 and 9.8 shows that the average, maximum and minimum values for RSPM and SPM decreased during the lockdown period at Palayam station which relapsed as the lockdown was lifted.

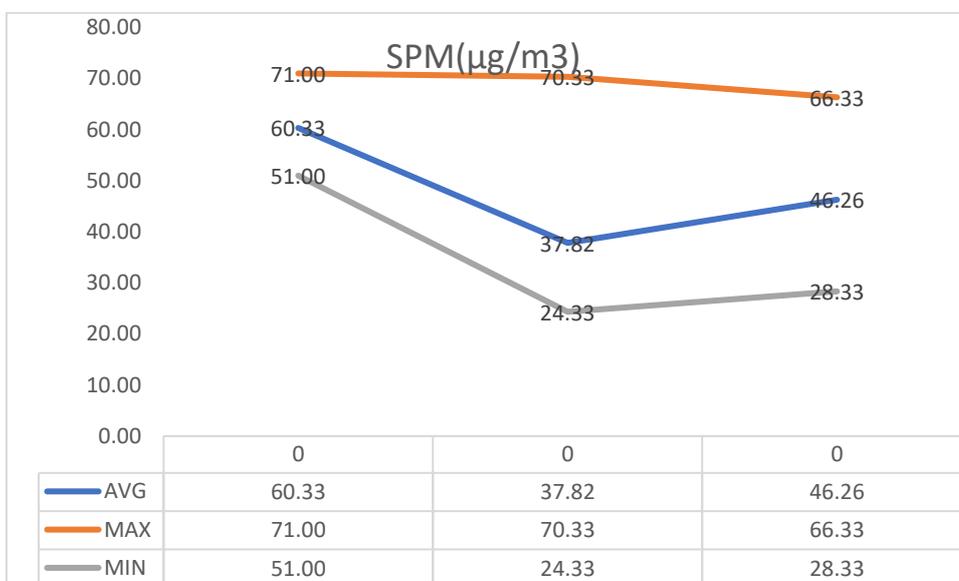


Figure 9.8: SPM Values of Palayam station before, during and after lockdown.

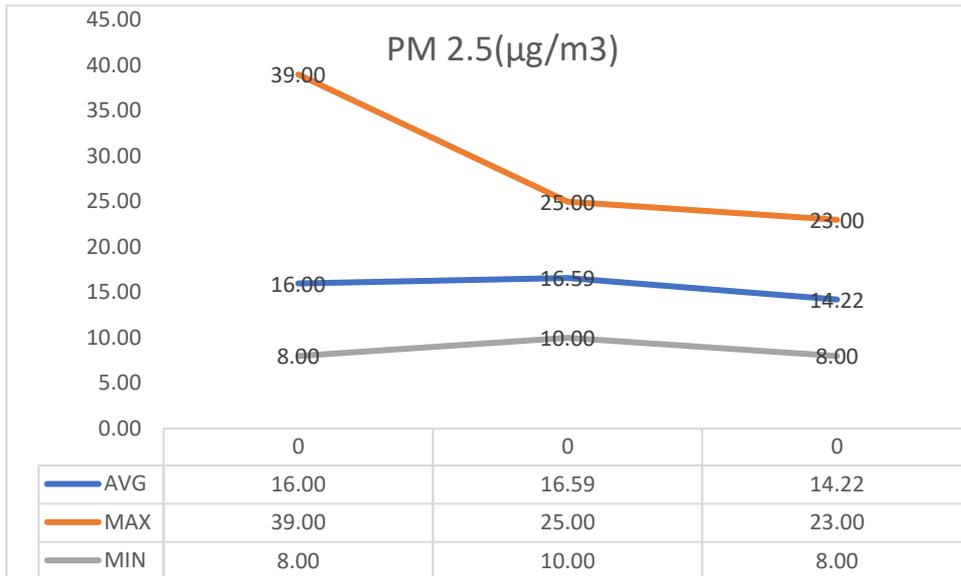


Figure 9.9: PM<sub>2.5</sub> Values of Palayam station before, during and after lockdown.

Figure 9.9 shows that the average and minimum values for PM<sub>2.5</sub> showed a slight increase during the lockdown period whereas the maximum value decreased during the lockdown period at Palayam station.

## 9.2 Nallalam (Industrial)- Manual Monitoring Station

Nallalam is located in an industrial area. The only diesel-powered power generation plant is located here



Figure 9.10: Land use Pattern at Nallalam Station

### 9.2.1 Before Lockdown

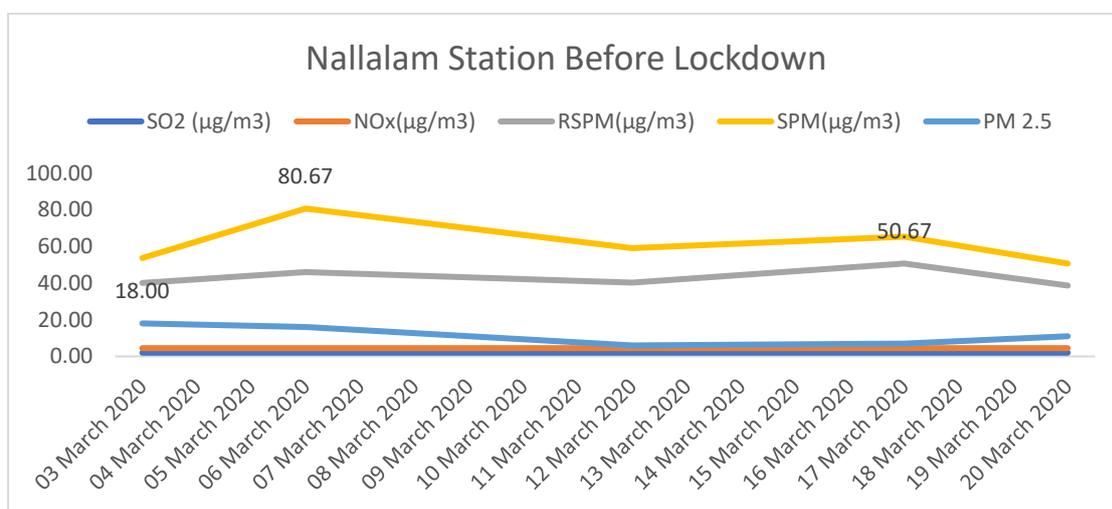


Figure 9.11: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM SPM and PM<sub>2.5</sub> measured at Nallalam station before Lockdown

Figure 9.11 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Nallalam station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 50.67µg/m<sup>3</sup> and 80.67µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020 and 6<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. SO<sub>2</sub> and NO<sub>x</sub> have registered a constant value of 2.0 µg/m<sup>3</sup> and 4.50 µg/m<sup>3</sup> respectively. The peak value of PM<sub>2.5</sub> was observed as 18 µg/m<sup>3</sup> on 3<sup>rd</sup> March 2020

### 9.2.2 During Lockdown

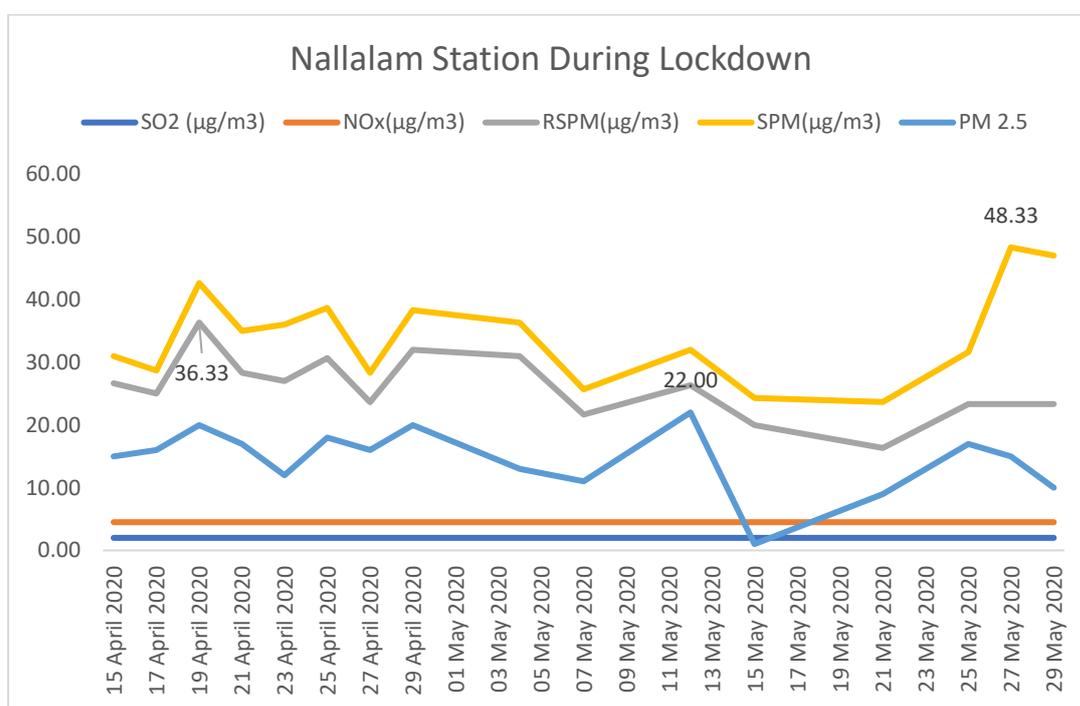


Figure 9.12: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM SPM and PM<sub>2.5</sub> measured at Nallalam station during Lockdown

Figure 9.12 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM SPM and PM<sub>2.5</sub> measured at Nallalam station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 36.33µg/m<sup>3</sup> and 48.33µg/m<sup>3</sup> respectively on 19<sup>th</sup> April 2020 and 27<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>.

SO<sub>2</sub> and NO<sub>x</sub> have registered a constant value of 2.0 µg/m<sup>3</sup> and 4.50 µg/m<sup>3</sup> respectively. The peak value of PM<sub>2.5</sub> was observed as 22 µg/m<sup>3</sup> on 12<sup>th</sup> May 2020.

### 9.2.3 After Lockdown

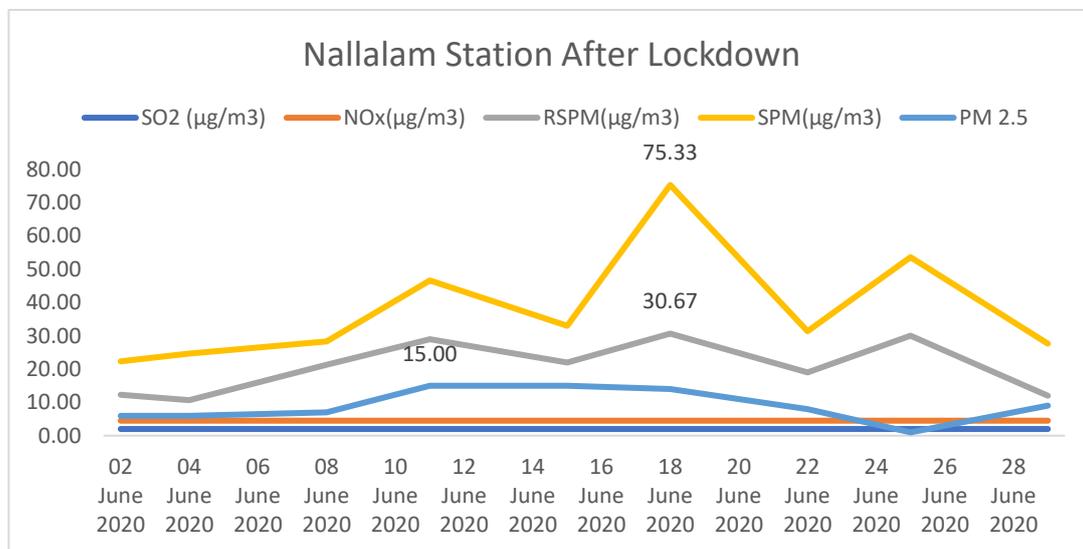


Figure 9.13: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM, SPM and PM<sub>2.5</sub> measured at Nallalam station after Lockdown

Figure 9.13 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Nallalam station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 30.67µg/m<sup>3</sup> and 75.33µg/m<sup>3</sup> respectively on 18<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. SO<sub>2</sub> and NO<sub>x</sub> have registered a constant value of 2.0 µg/m<sup>3</sup> and 4.50 µg/m<sup>3</sup> respectively. The peak value of PM<sub>2.5</sub> was observed as 15 µg/m<sup>3</sup> on 11<sup>th</sup> June 2020.

### 9.2.4 Result Analysis



Figure 9.14: SO2 Values of Nallalam station before, during and after lockdown.

Figure 9.14 shows that the average, maximum and minimum values for SO2 remained constant during pre lockdown, lockdown and post lockdown period at Nallalam Station.

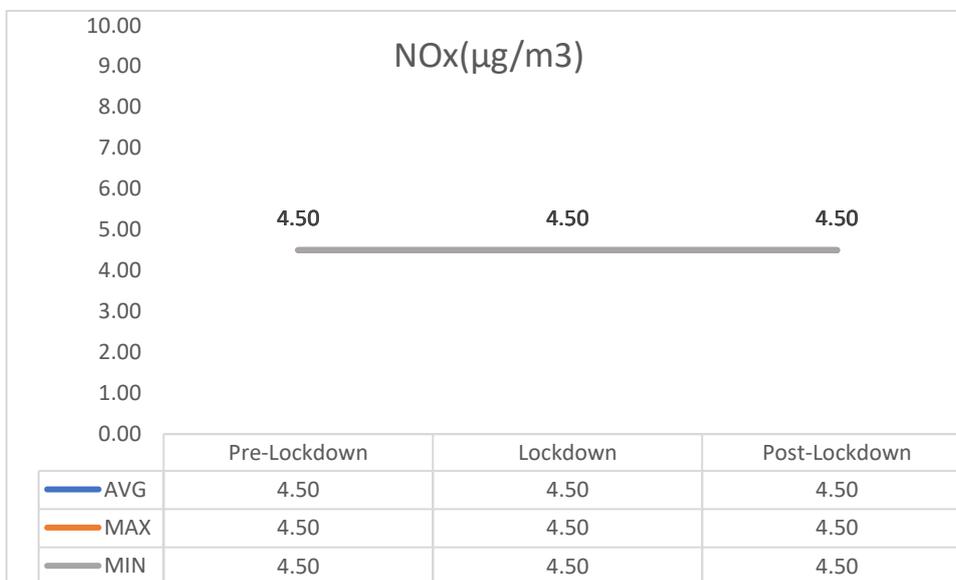


Figure 9.15: NOX Values of Nallalam station before, during and after lockdown

Figure 9.15 shows that the average, maximum and minimum values for NOx remained constant during pre lockdown, lockdown and post lockdown period at Nallalam Station.

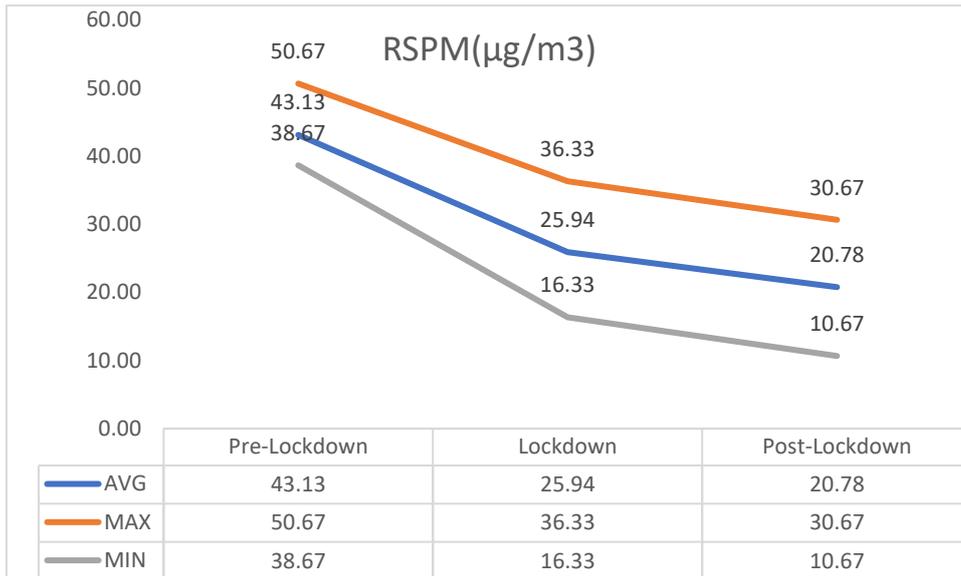


Figure 9.16: RSPM Values of Nallalam station before, during and after lockdown

Figure 9.16 and 9.17 shows that the average, maximum and minimum values for RSPM and SPM decreased during the lockdown period at Nallalam station which later decreased in the case of RSPM whereas in the case of SPM it remained steady.

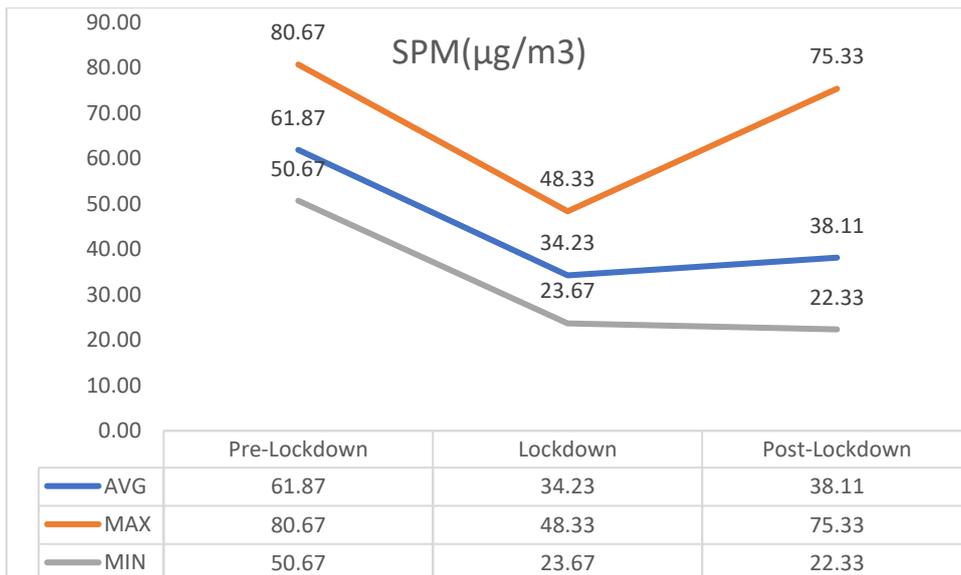


Figure 9.17: SPM Values of Nallalam station before, during and after lockdown

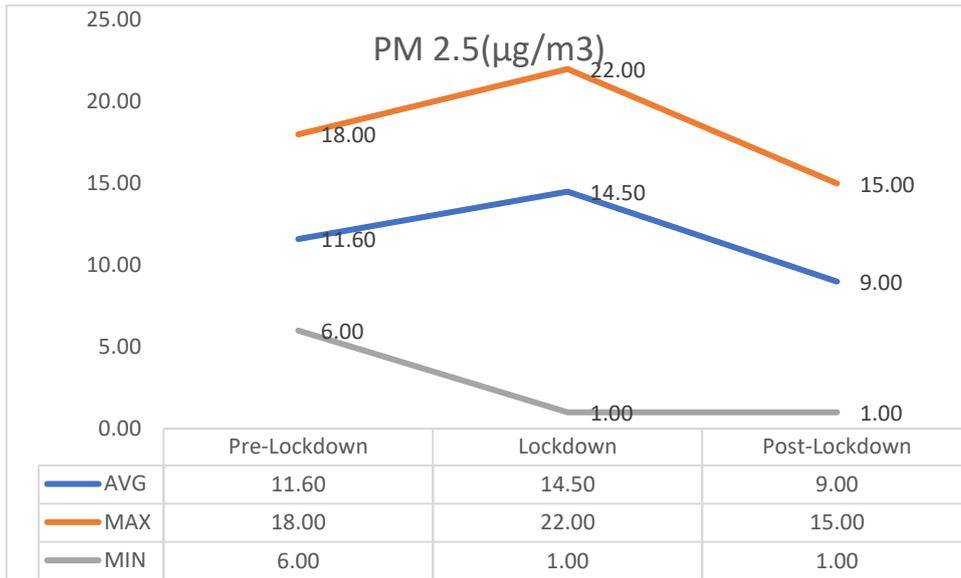


Figure 9.18: PM2.5 Values of Nallalam station before, during and after lockdown

Figure 9.18 shows that the average and maximum values for PM2.5 increased during the lockdown period whereas the minimum value decreased during the lockdown period at Nallalam station.

### 9.3 Palayam CAAQM Station

Palayam station is located in the heart of the Kozhikode city with diverse land use pattern. These include Residential, commercial as well as an established transportation network (Major roads).

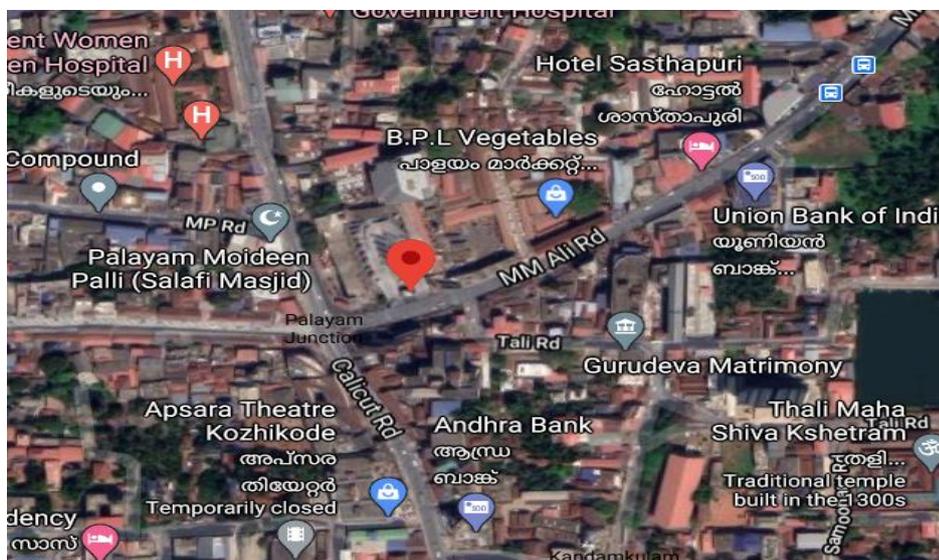


Figure 9.19: Land Use pattern at Palayam CAAQM

### 9.3.1 Before Lockdown

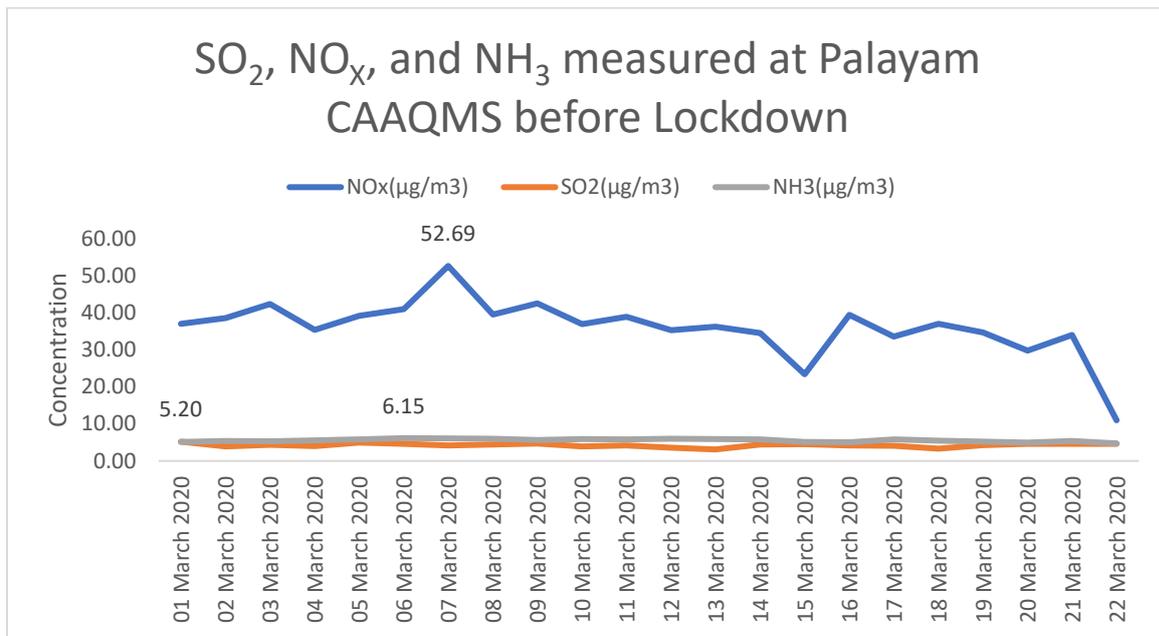


Figure 9.20: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Palayam CAAQMS before Lockdown

Figure 9.20 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Palayam CAAQM station before lockdown. The data analysis indicates that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 5.20 µg/m<sup>3</sup> and 52.69 µg/m<sup>3</sup> respectively on 1<sup>st</sup> March 2020 and 7<sup>th</sup> march 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 12.25 µg/m<sup>3</sup> on 6<sup>th</sup> March 2020 for NH<sub>3</sub>.

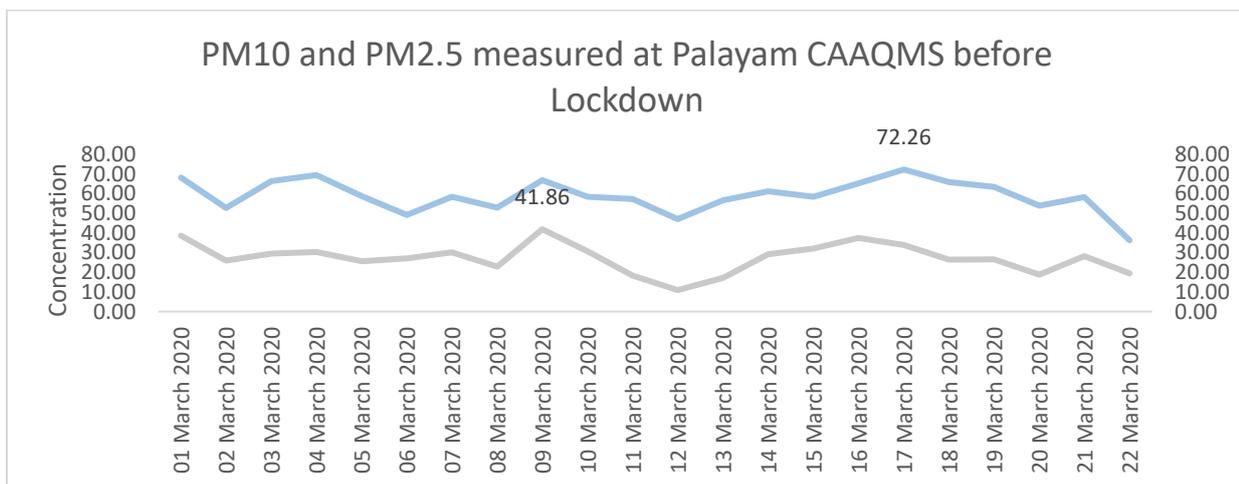


Figure 9.21: PM10 and PM2.5 measured at Palayam CAAQMS before Lockdown

Figure 9.21 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Palayam CAAQM station before lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 72.26 µg/m<sup>3</sup> and 14.86 µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020 and 9<sup>th</sup> March 2020.

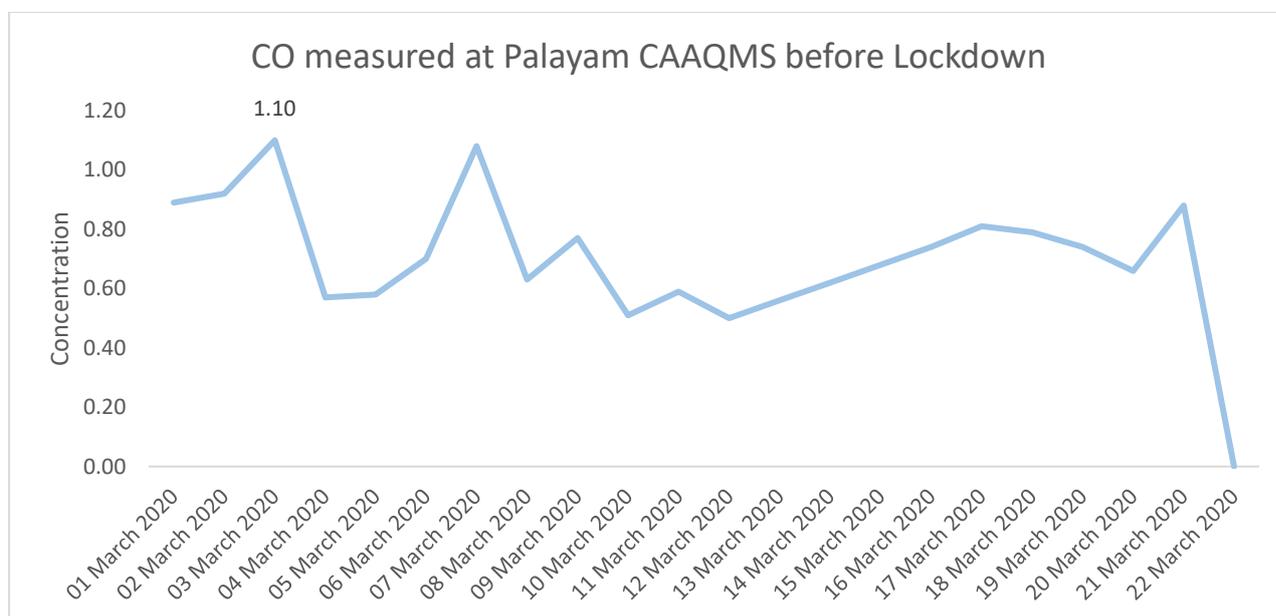


Figure 9.22: CO measured at Palayam CAAQMS before Lockdown

Figure 9.22 shows the 24-hr average values for CO measured at Palayam CAAQM station before lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 µg/m<sup>3</sup>. The highest value was found to be 1.10 µg/m<sup>3</sup> on 3<sup>rd</sup> March 2020.

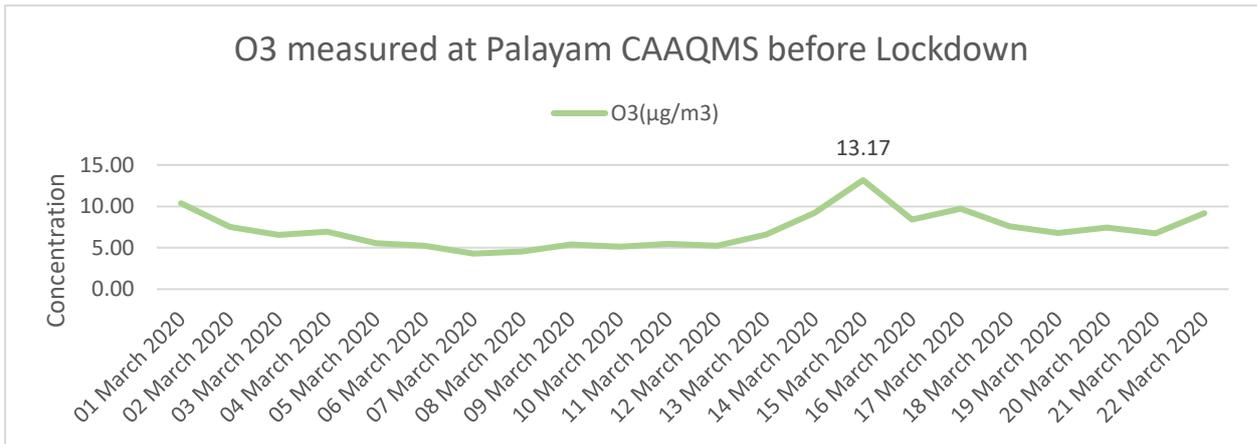


Figure 9.23: O<sub>3</sub> measured at Palayam CAAQMS before Lockdown

Figure 9.23 shows the 24-hr average values for O<sub>3</sub> measured at Palayam CAAQM station before lockdown. The data analysis indicated that the O<sub>3</sub> was mostly below the 8 hour standard of 100 µg/m<sup>3</sup>. However, the highest value was found to be 13.17 µg/m<sup>3</sup> on 15<sup>th</sup> March 2020.

### 9.3.2 During Lockdown

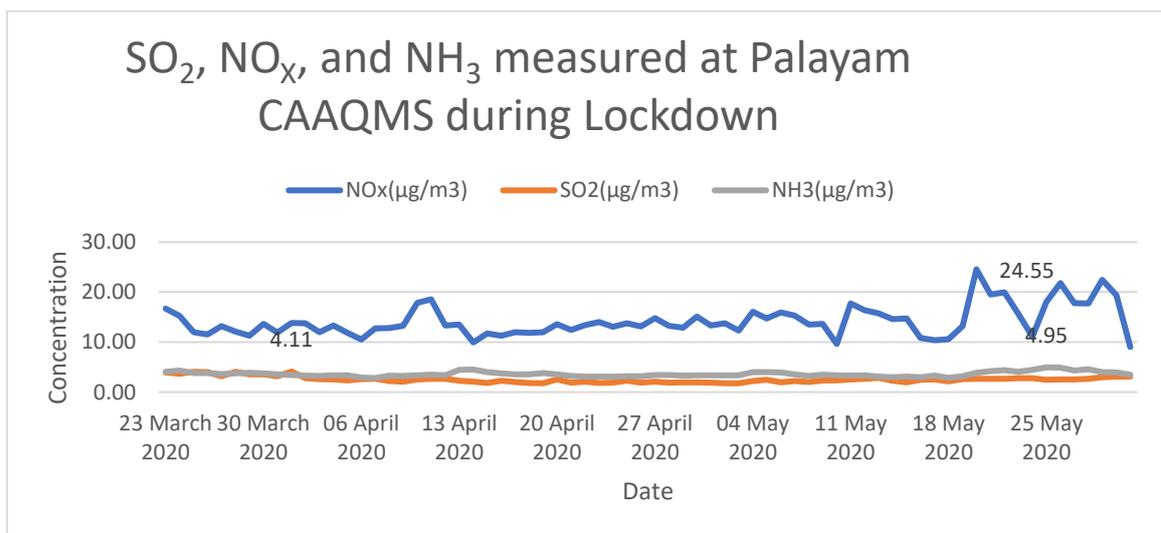


Figure 9.24: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Palayam CAAQMS during Lockdown

Figure 9.24 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Palayam CAAQM station during the lockdown. The data analysis indicates that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 4.11 µg/m<sup>3</sup> and 24.55

$\mu\text{g}/\text{m}^3$  respectively on 1<sup>st</sup> April 2020 and 20<sup>th</sup> May 2020. The concentration of  $\text{NH}_3$  is also below the NAAQS standards of  $400 \mu\text{g}/\text{m}^3$ . The highest value registered is  $4.95 \mu\text{g}/\text{m}^3$  on 25<sup>th</sup> May 2020 for  $\text{NH}_3$ .

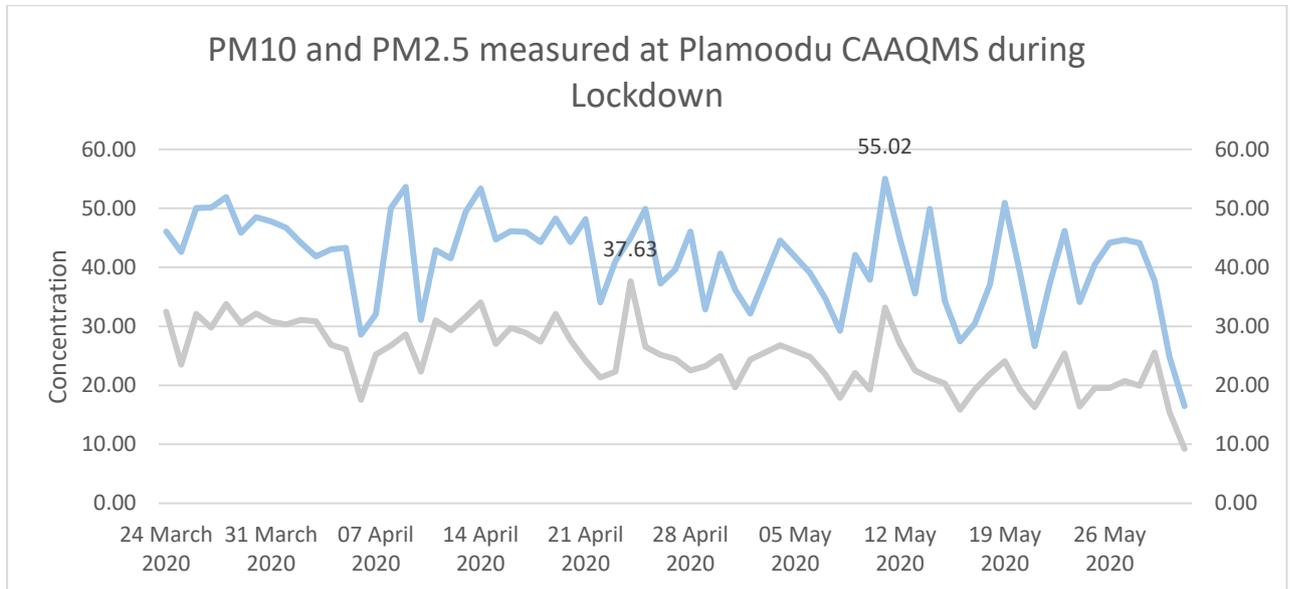


Figure 9.25: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Palayam CAAQMS during Lockdown

Figure 9.25 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Palayam CAAQM station during the lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of  $100 \mu\text{g}/\text{m}^3$  and  $60 \mu\text{g}/\text{m}^3$  respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be  $55.02 \mu\text{g}/\text{m}^3$  and  $37.63 \mu\text{g}/\text{m}^3$  respectively on 11<sup>th</sup> May 2020 and 24<sup>th</sup> April 2020.

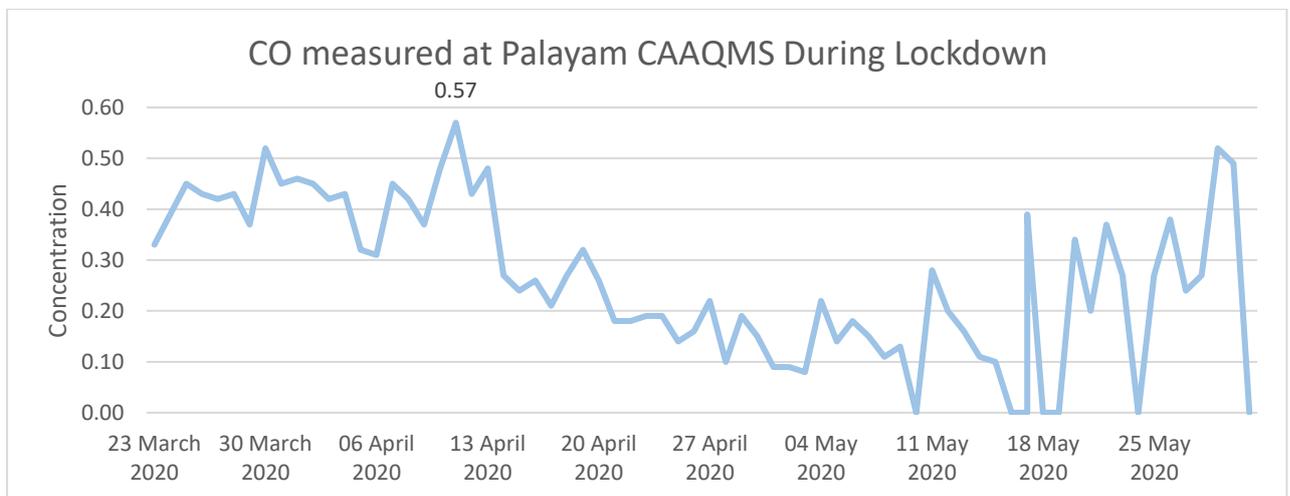


Figure 9.26: CO measured at Palayam CAAQMS during Lockdown

Figure 9.26 shows the 24-hr average values for CO measured at Palayam CAAQM station during the lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2  $\mu\text{g}/\text{m}^3$ . The highest value was found to be 0.57  $\mu\text{g}/\text{m}^3$  on 11<sup>th</sup> April 2020.

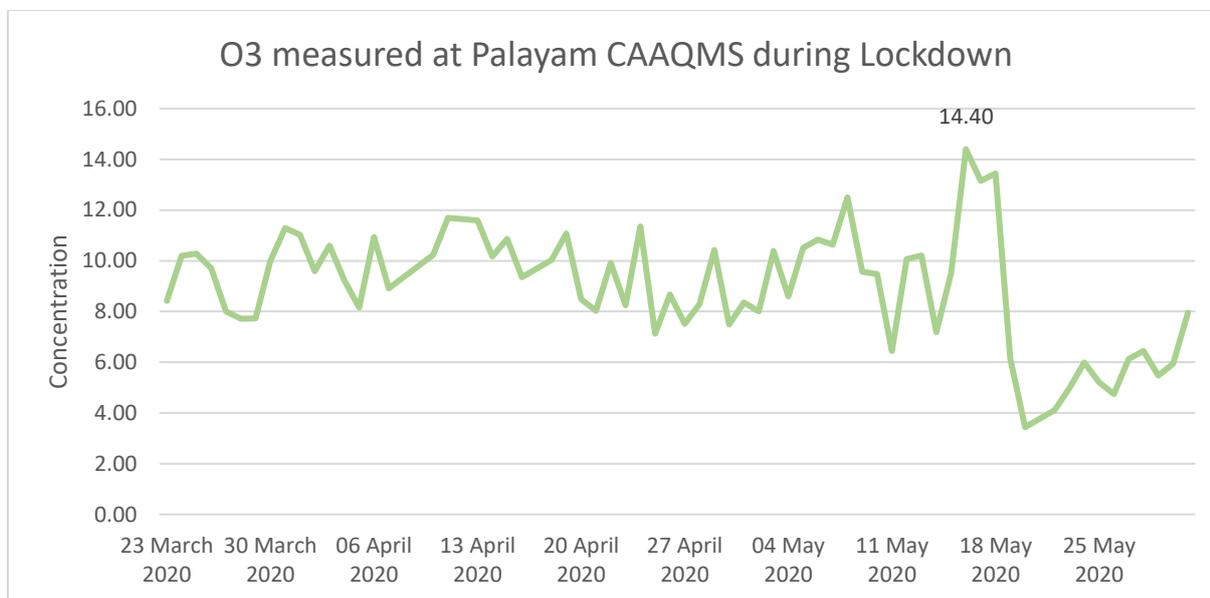


Figure 9.27: O<sub>3</sub> measured at Palayam CAAQMS before Lockdown

Figure 9.27 shows the 24-hr average values for O<sub>3</sub> measured at Palayam CAAQM station during the lockdown. The data analysis indicated that the O<sub>3</sub> was mostly below the 8 hour standard of 100  $\mu\text{g}/\text{m}^3$ . However, the highest value was found to be 14.40  $\mu\text{g}/\text{m}^3$  on 16<sup>th</sup> May 2020.

### 9.3.3 After Lockdown

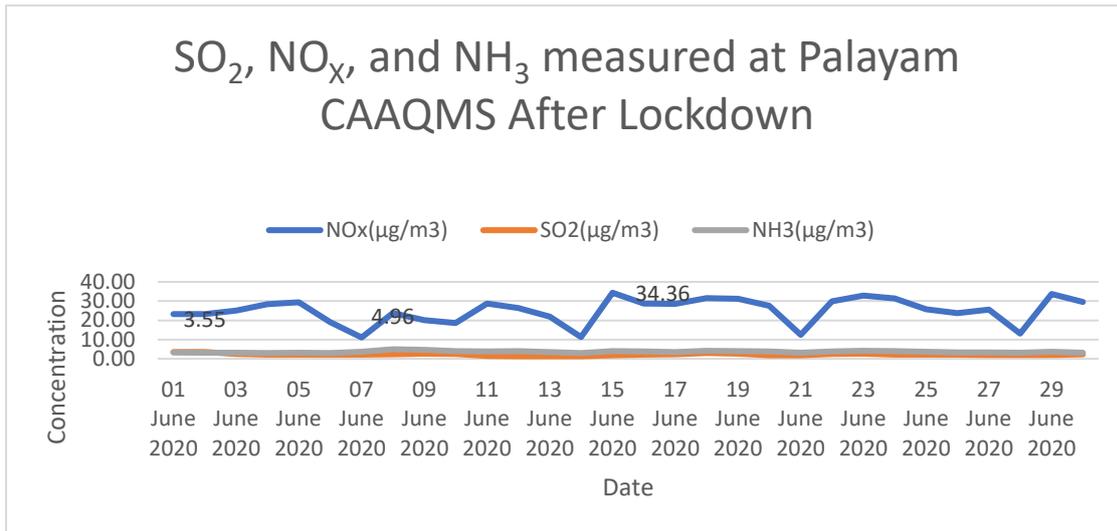


Figure 9.28: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Palayam CAAQMS after Lockdown

Figure 9.28 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Palayam CAAQM station during the lockdown. The data analysis indicates that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 3.55 µg/m<sup>3</sup> and 34.36 µg/m<sup>3</sup> respectively on 2<sup>nd</sup> June 2020 and 15<sup>th</sup> June 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 4.96 µg/m<sup>3</sup> on 8<sup>th</sup> June 2020 for NH<sub>3</sub>.

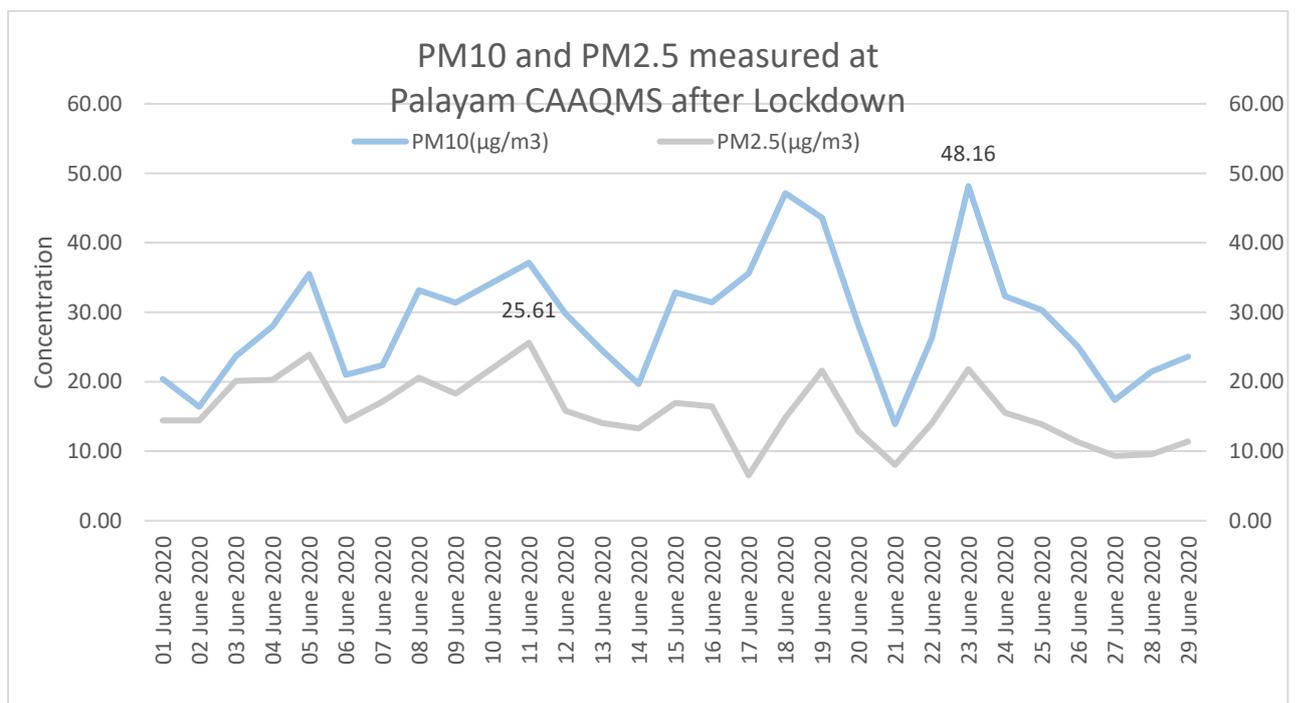


Figure 9.29: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Palayam CAAQMS after Lockdown

Figure 9.29 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Palayam CAAQM station after lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 48.16 µg/m<sup>3</sup> and 25.61 µg/m<sup>3</sup> respectively on 23<sup>rd</sup> June 2020 and 11<sup>th</sup> June 2020.

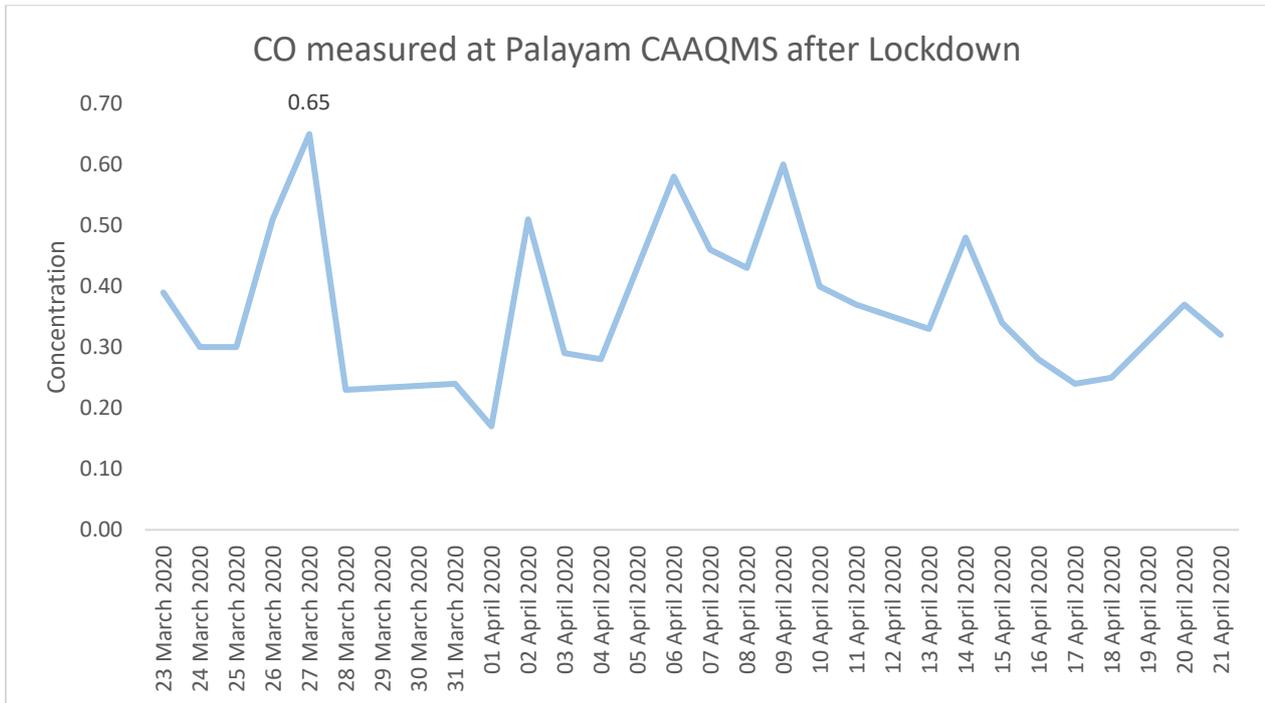


Figure 9.30: CO measured at Palayam CAAQMS after Lockdown

Figure 9.30 shows the 24-hr average values for CO measured at Palayam CAAQM station after lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 µg/m<sup>3</sup>. The highest value was found to be 0.65 µg/m<sup>3</sup> on 27<sup>th</sup> March 2020.

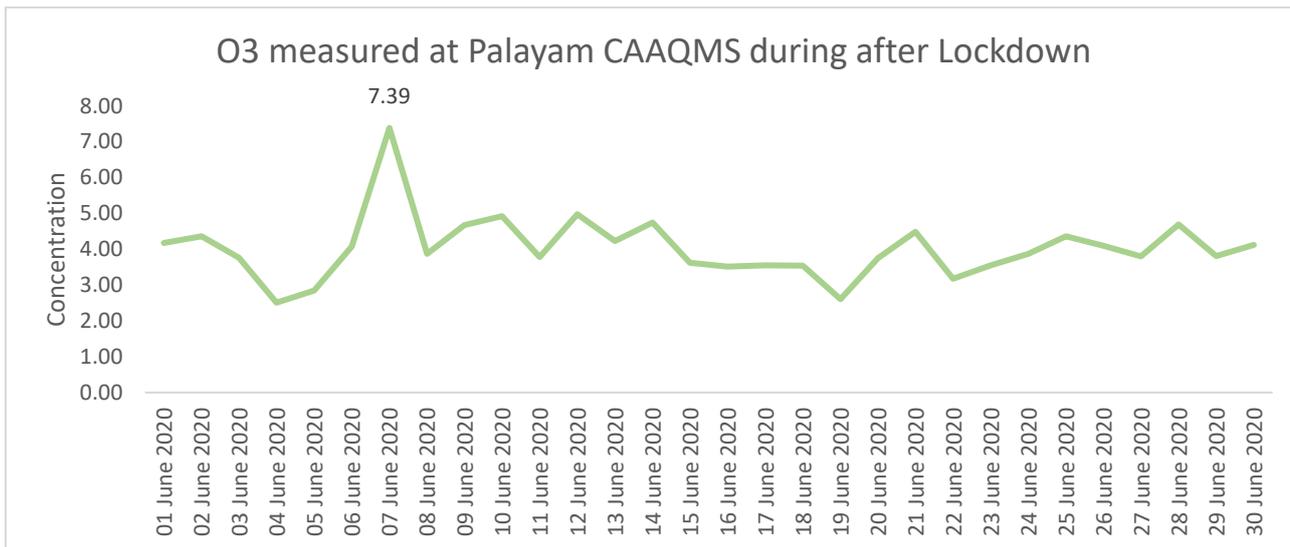


Figure 9.31: O<sub>3</sub> measured at Palayam CAAQMS before Lockdown

Figure 9.31 shows the 24-hr average values for O<sub>3</sub> measured at Palayam CAAQM station after lockdown. The data analysis indicated that the O<sub>3</sub> was always below the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 7.39 µg/m<sup>3</sup> on 07<sup>th</sup> June 2020.

### 9.3.4 Result Analysis

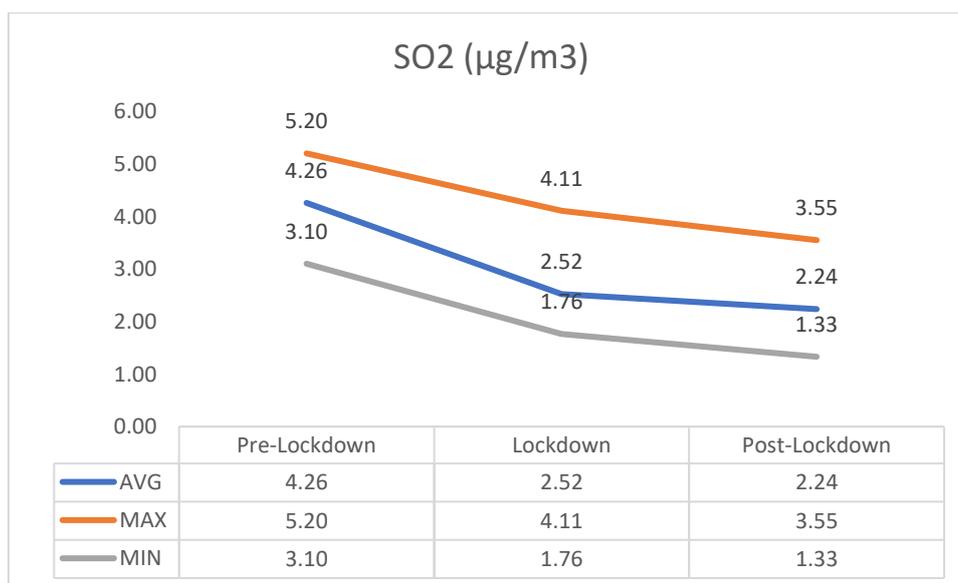
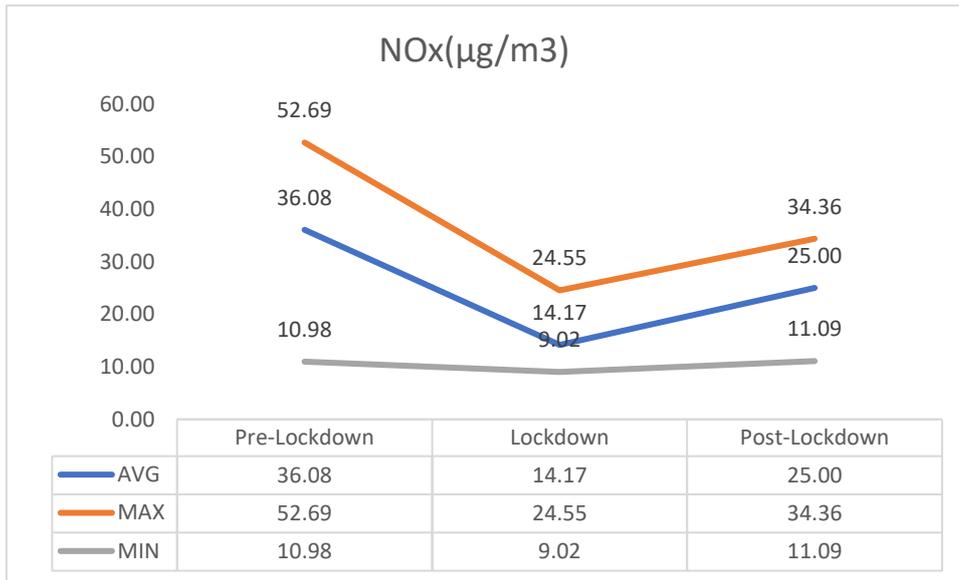


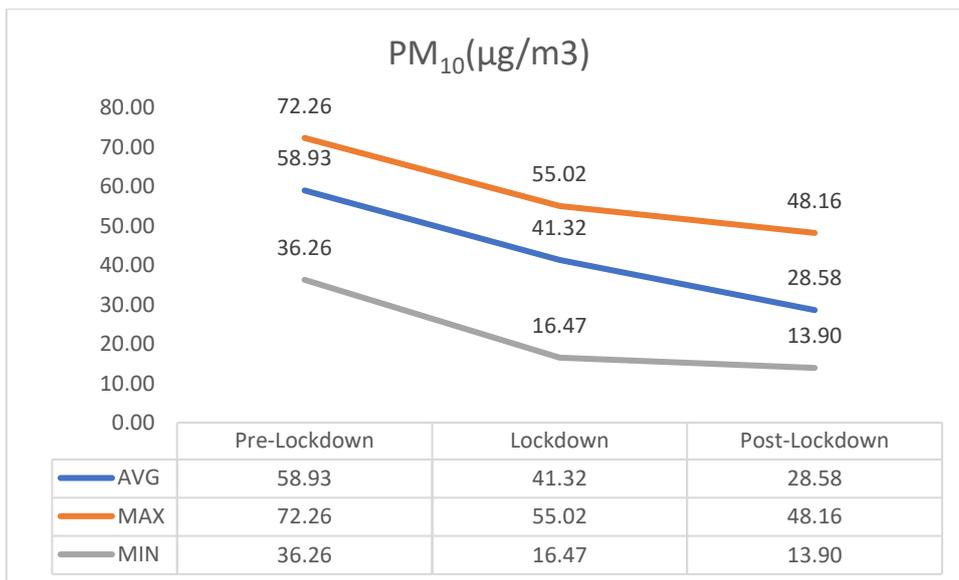
Figure 9.32: SO<sub>2</sub> Values of Palayam CAAQM station before, during and after lockdown.

Figure 9.32 shows that average, maximum and minimum values for SO<sub>2</sub> registered a slight decrease during the lockdown period and showed a decreasing trend even after the lockdown was lifted.



**Figure 9.33: NO<sub>x</sub> Values of Palayam CAAQM station before, during and after lockdown.**

Figure 9.33 shows that average, maximum and minimum values for NO<sub>x</sub> registered a decrease during the lockdown period at Palayam CAAQMS and relapsed after the lockdown was lifted.



**Figure 9.34: PM<sub>10</sub> Values of Palayam CAAQM station before, during and after lockdown.**

Figure 9.34 shows that average, maximum and minimum values for PM<sub>10</sub> registered a notable decrease during the lockdown period which later decreased further as the lockdown was lifted.

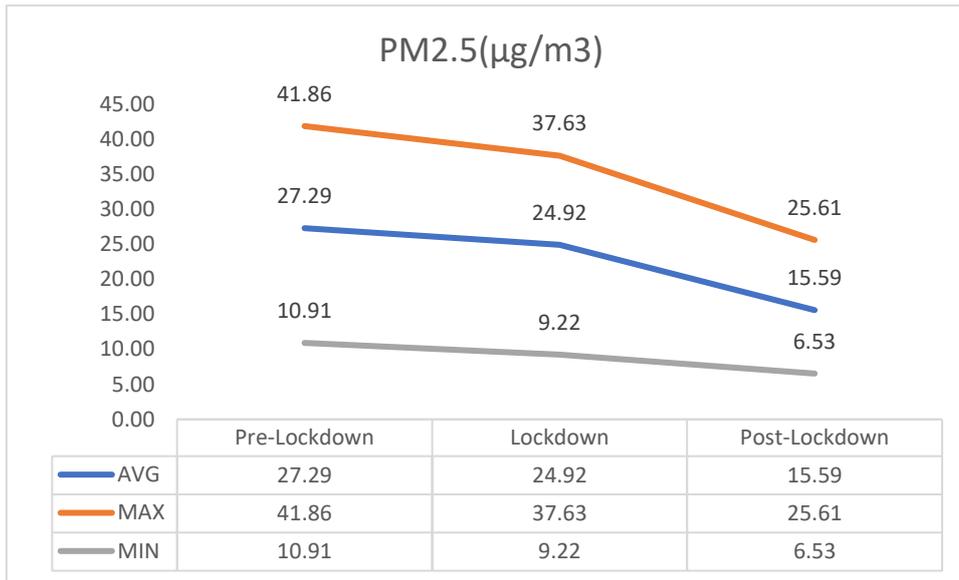


Figure 9.35: PM<sub>2.5</sub> Values of Palayam CAAQM station before, during and after lockdown.

Figure 9.35 shows that average, maximum, and minimum values for PM<sub>10</sub> registered a notable decrease during the lockdown period which further reduced slightly as the lockdown was lifted.

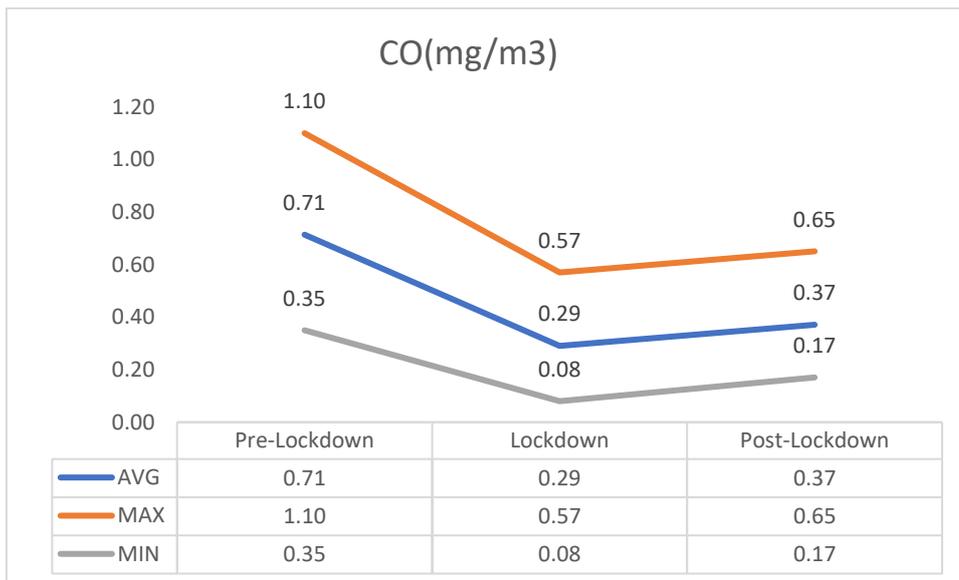


Figure 9.36: CO Values of Palayam CAAQM station before, during and after lockdown.

Figure 9.36 shows that average, maximum and minimum values for CO registered a decrease during the lockdown period which registered a slight increase with lifting of the lockdown.

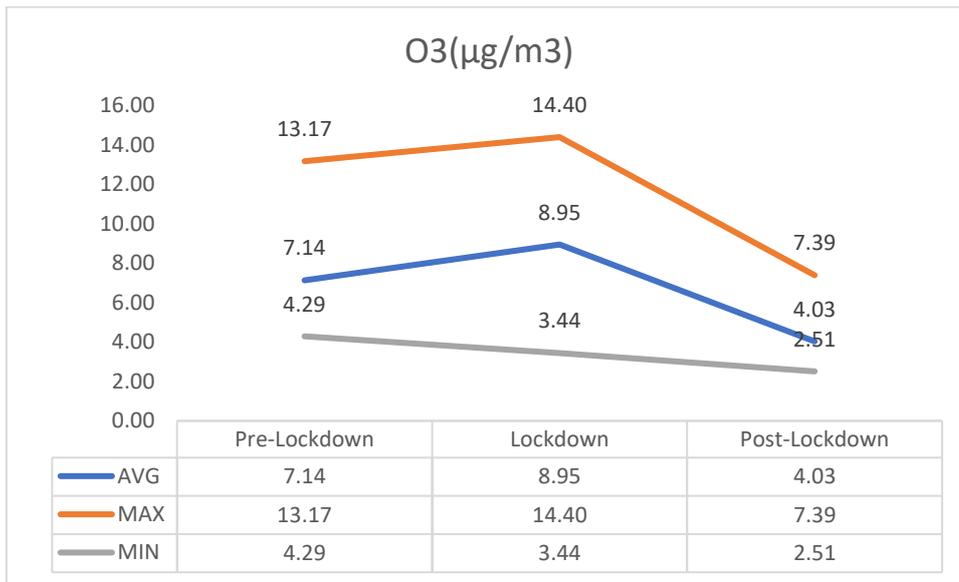


Figure 9.37: O<sub>3</sub> Values of Palayam CAAQM station before, during and after lockdown.

Figure 9.37 shows that average, maximum and minimum values for O<sub>3</sub> registered a notable decrease during the lockdown period. These values relapsed as the lockdown was lifted.

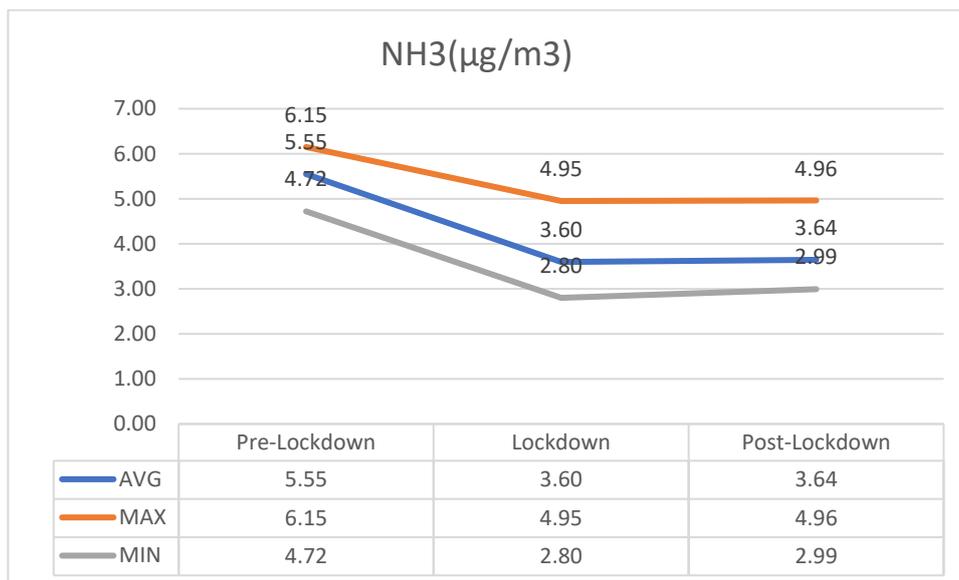


Figure 9.38: NH<sub>3</sub> Values of Palayam CAAQM station before, during and after lockdown.

Figure 9.38 shows that average, maximum and minimum values for NH<sub>3</sub> registered a notable decrease during the lockdown period. These values continued to show a decreasing trend which later relapsed as the lockdown was lifted.

## 10 Kannur

The list of Monitoring stations in the city is tabulated in Table 10.1. The land use pattern at these stations is also depicted

Table 10.1: List of monitoring stations in Kannur

Site	Co-ordinates	Scheme	Type	Land Use Pattern
Thavakkara	11.875000, 75.373200	CAAQMS	Commercial	Commercial Establishments
Mangattuparambu	11.986566, 75.381995	SAMP	Residential,Rural &others	Industries, Major and Minor industries

Table 10.2 gives the growth of vehicles in the district of Kannur, it has shown steady growth.

Table 10.2: Vehicular Count in Kannur

Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
No of vehicles	464885	512320	601790	666523	739595	826010

### 10.1 Mangattuparamba (Residential, Rural & Others) -Manual Monitoring Station



Figure 10.1: Land use pattern at mangattuparamba

### 10.1.1 Before Lockdown

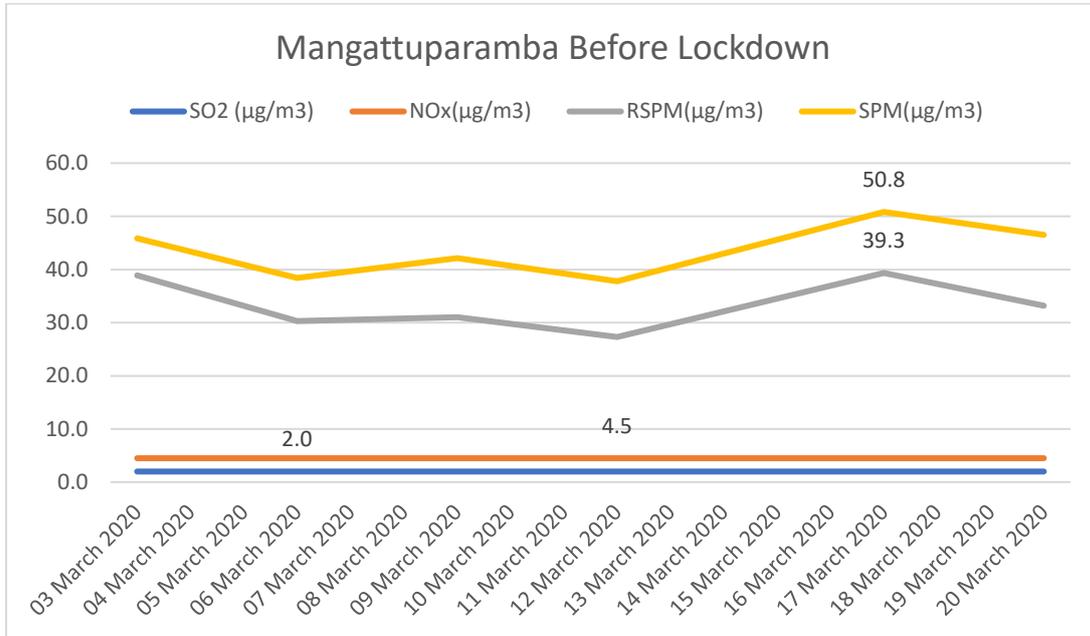


Figure 10.2: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Mangattuparamba station before Lockdown

Figure 10.2 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Mangattuparamba station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup> except for some instances of the spike in the value of SPM. The highest RSPM and SPM value were recorded as 39.3µg/m<sup>3</sup> and 50.8µg/m<sup>3</sup> respectively on 17<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 4.5 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 10.1.2 During Lockdown

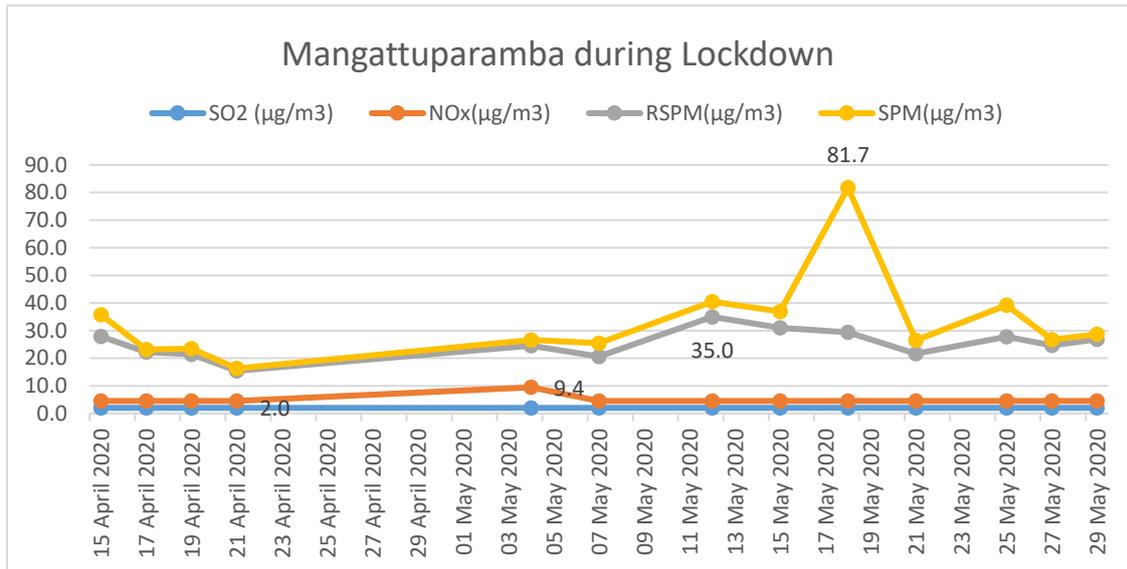


Figure 10.3: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Mangattuparamba station during Lockdown

Figure 10.3 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Mangattuparamba station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup> except for some instances of the spike in the value of SPM. The highest RSPM and SPM value were recorded as 35.0µg/m<sup>3</sup> and 81.7µg/m<sup>3</sup> respectively on 12<sup>th</sup> May 2020 and 18<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 9.4 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 10.1.3 After Lockdown

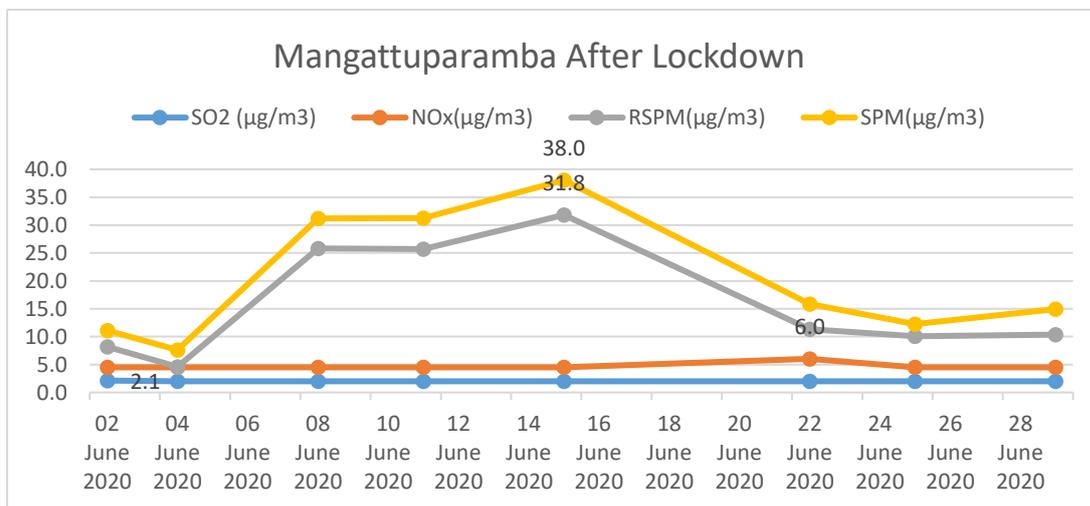


Figure 10.4: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Mangattuparamba station after Lockdown

Figure 10.4 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Mangattuparamb station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 31.8µg/m<sup>3</sup> and 38.0µg/m<sup>3</sup> respectively on 15<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.1 µg/m<sup>3</sup> and 6.0 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>. The peak value of PM<sub>2.5</sub> was observed as 35.8 µg/m<sup>3</sup> on 2<sup>nd</sup> June 2020.

### 10.1.4 Result Analysis

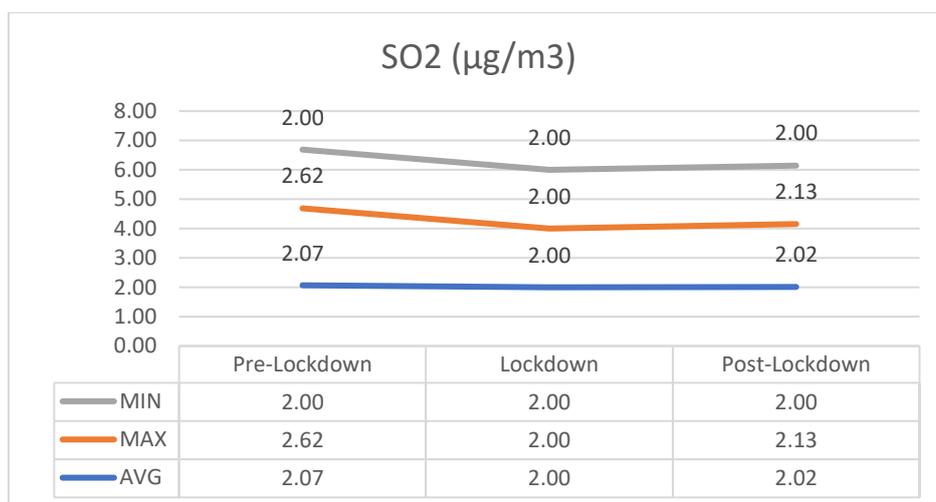


Figure 10.5: SO<sub>2</sub> Values of Mangattuparamba station before, during and after lockdown

Figure 10.5 shows that the average, maximum and minimum values for SO<sub>2</sub> showed a slight decrease during the lockdown period at Mangattuparamb Station.

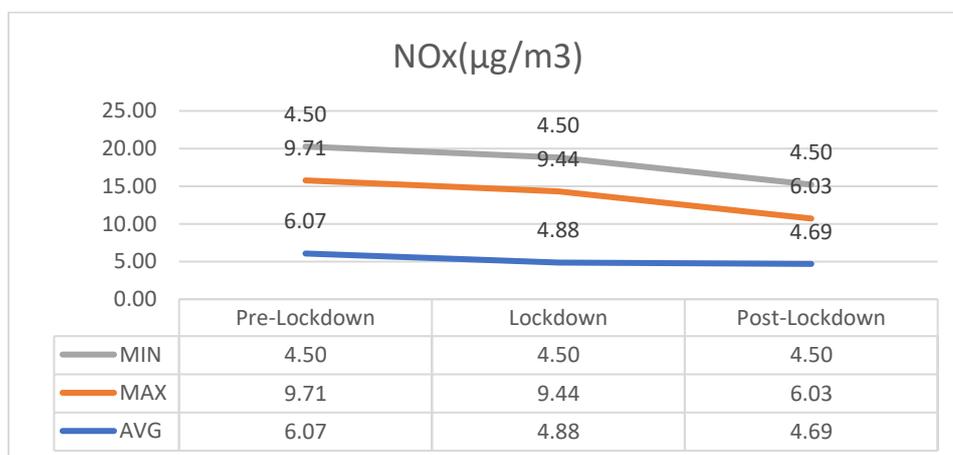


Figure 10.6: NO<sub>x</sub> Values of Mangattuparamba station before, during and after lockdown

Figure 10.6 shows that the average and maximum values for NOx showed a slight decrease during the lockdown period at Mangattuparamba Station.

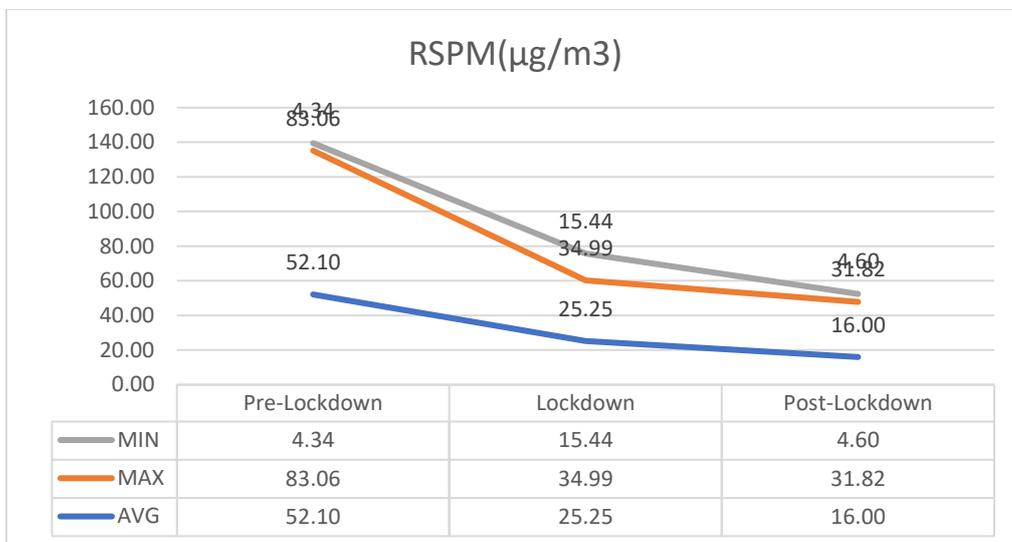


Figure 10.7: RSPM Values of Mangattuparamb station before, during and after lockdown

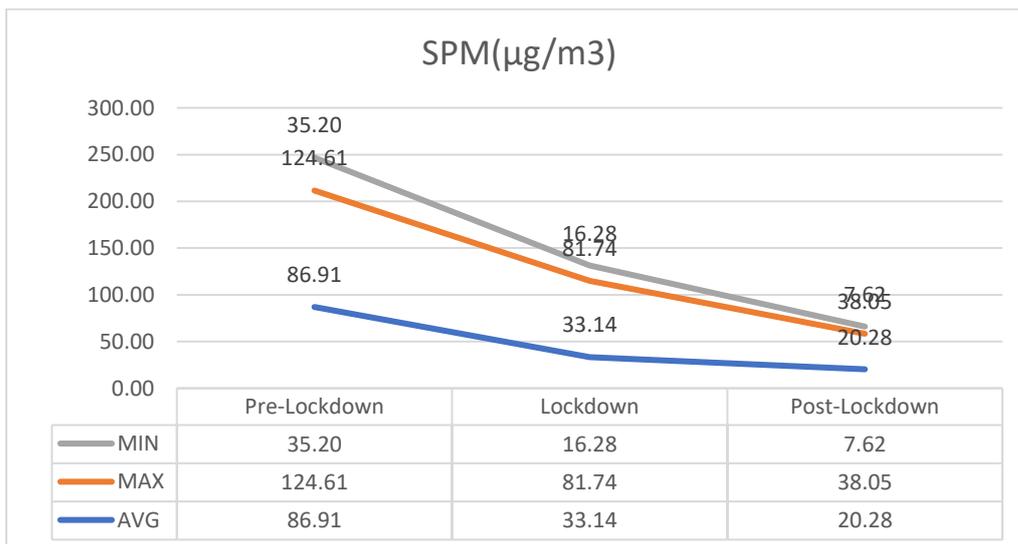
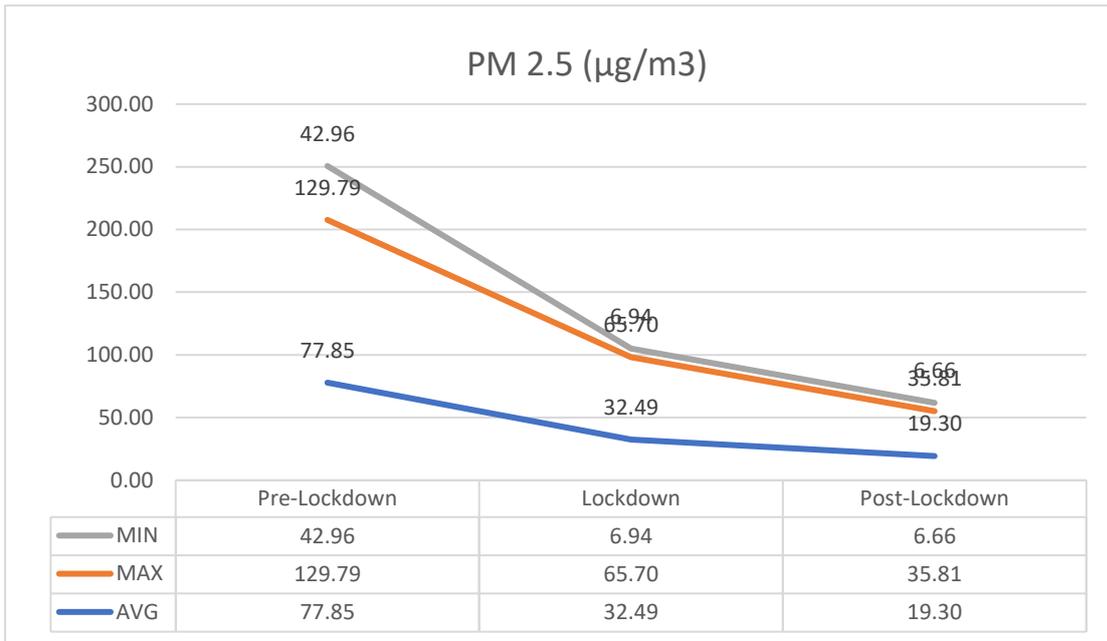


Figure 10.8: SPM Values of Mangattuparamb station before, during and after lockdown

Figure 10.7 and 10.8 shows that the average, maximum and minimum values for RSPM and SPM decreased during the lockdown period and showed decreasing trend even after lifting lockdown at Mangattuparamb Station.



**Figure 10.9: PM 2.5 Values of Mangattuparamb station before, during and after lockdown**

Figure 10.9 shows that the average, minimum, maximum values for PM<sub>2.5</sub> decreased during the lockdown period at Mangattuparamb station which remained in a decreasing trend even after lifting the lockdown.

## 10.2 Kannur CAAQM Station

The CAAQMS station in the district of thavakkara



Figure 10.10: Land Use pattern at Kannur CAAQM Station

### 10.2.1 Before Lockdown

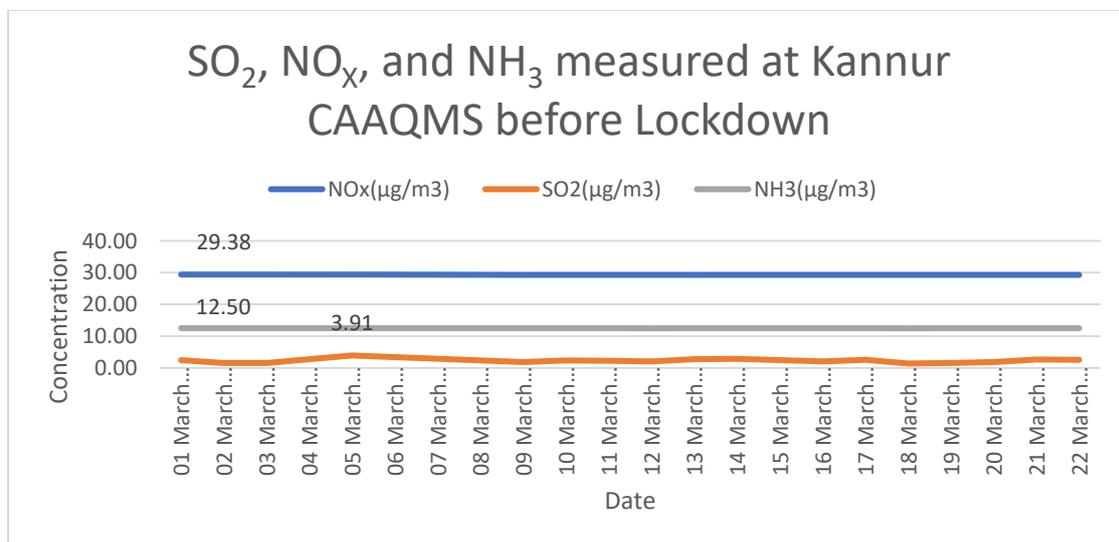


Figure 10.11: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Kannur CAAQMS before Lockdown

Figure 10.11 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Kannur CAAQM station before lockdown. The data analysis indicates that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 3.91 µg/m<sup>3</sup> and 29.38 µg/m<sup>3</sup> respectively on 5<sup>th</sup> March 2020 and 2<sup>nd</sup> March 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 12.50 µg/m<sup>3</sup> on 1<sup>st</sup> March 2020 for NH<sub>3</sub>.

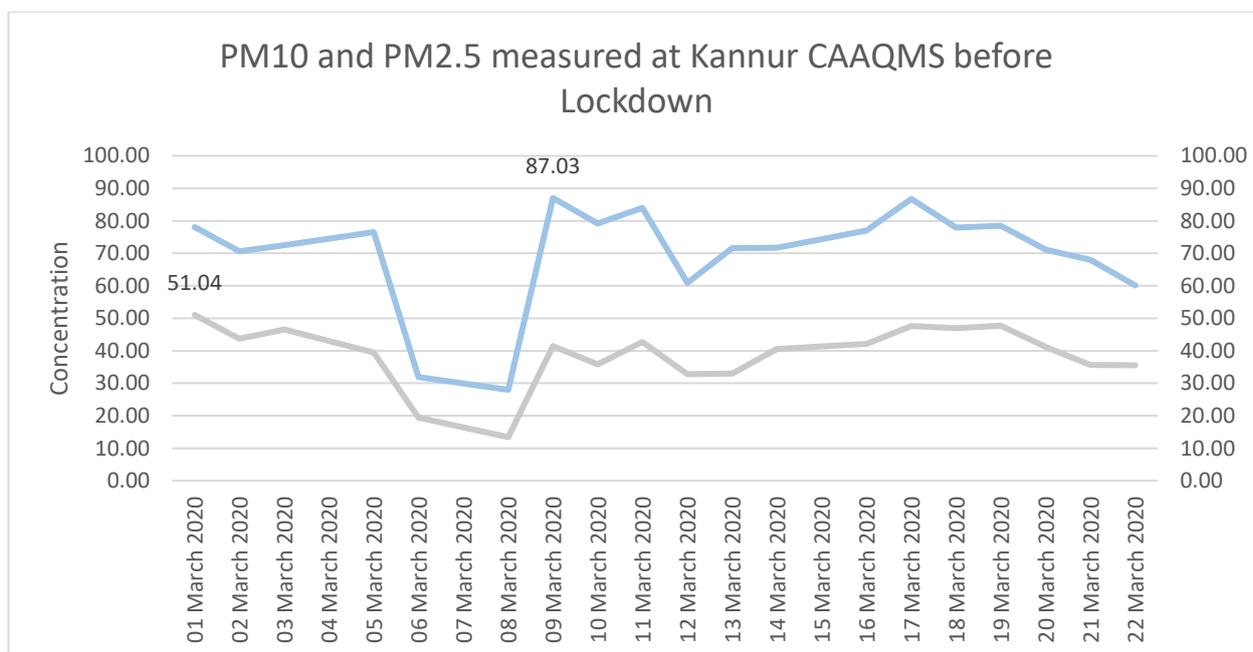


Figure 10.12: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Kannur CAAQMS before Lockdown

Figure 10.12 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Kannur CAAQM station before lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 87.03 µg/m<sup>3</sup> and 51.04 µg/m<sup>3</sup> respectively on 9<sup>th</sup> March 2020 and 1<sup>st</sup> March 2020.

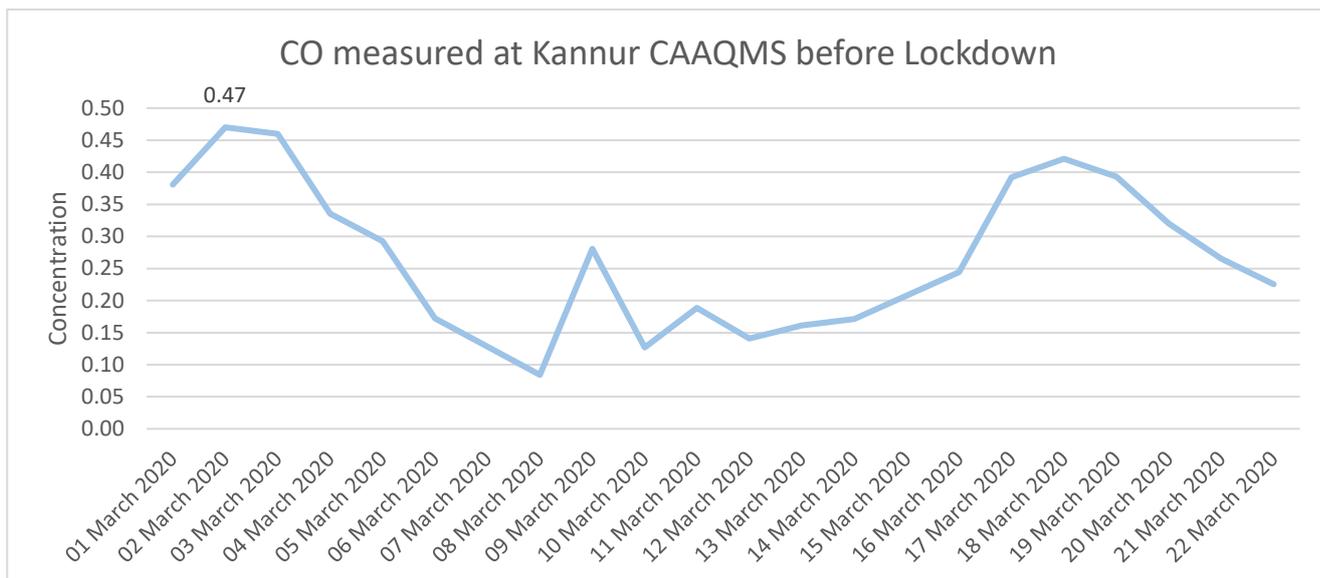


Figure 10.13: CO measured at Kannur CAAQMS before Lockdown

Figure 10.13 shows the 24-hr average values for CO measured at Kannur CAAQM station before lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 0.47 mg/m<sup>3</sup> on 2<sup>nd</sup> March 2020.

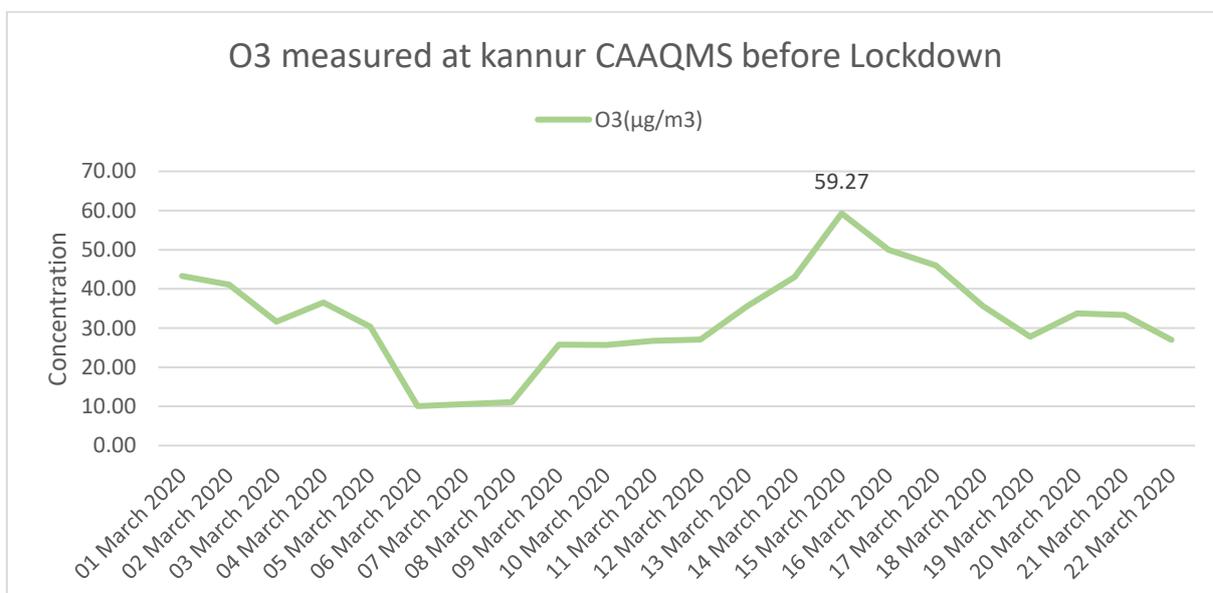


Figure 10.14: O<sub>3</sub> measured at Kannur CAAQMS before Lockdown

Figure 10.14 shows the 24-hr average values for O<sub>3</sub> measured at Kannur CAAQM station before lockdown. The data analysis indicated that the O<sub>3</sub> was

always below the 8 hour standard of 100  $\mu\text{g}/\text{m}^3$ . The highest value was found to be 59.27  $\mu\text{g}/\text{m}^3$  on 15<sup>th</sup> March 2020.

### 10.2.2 During Lockdown

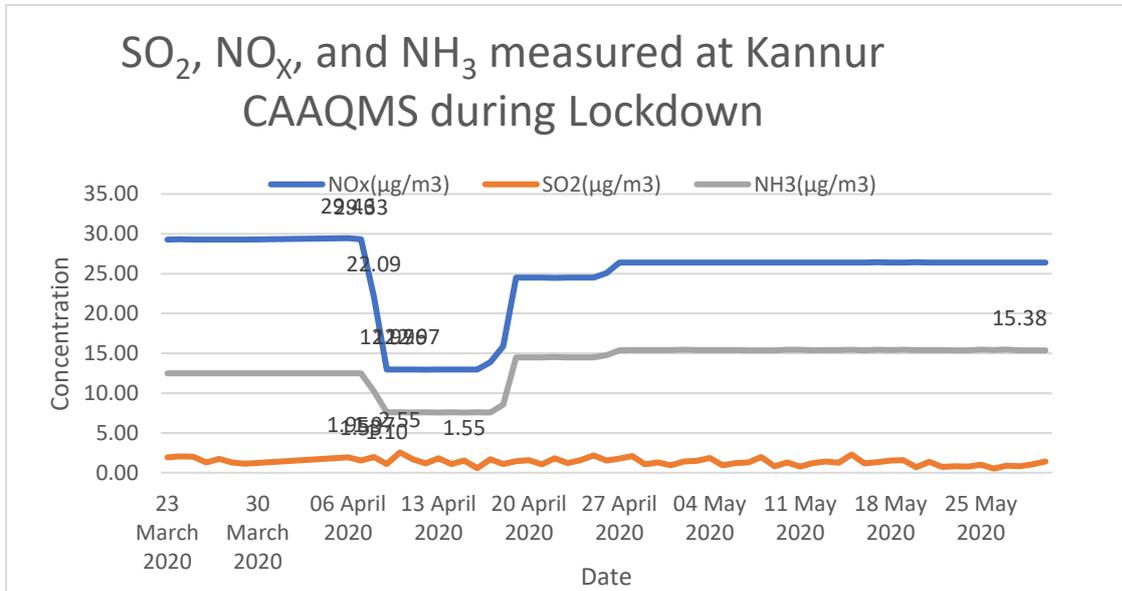


Figure 10.15: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Kannur CAAQMS during Lockdown

Figure 10.15 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Kannur CAAQM station during the lockdown. The data analysis indicates that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80  $\mu\text{g}/\text{m}^3$ . The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 2.55  $\mu\text{g}/\text{m}^3$  and 29.46  $\mu\text{g}/\text{m}^3$  respectively on 10<sup>th</sup> April 2020 and 6<sup>th</sup> April 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400  $\mu\text{g}/\text{m}^3$ . The highest value registered is 15.37  $\mu\text{g}/\text{m}^3$  on 23<sup>rd</sup> May 2020 for NH<sub>3</sub>.

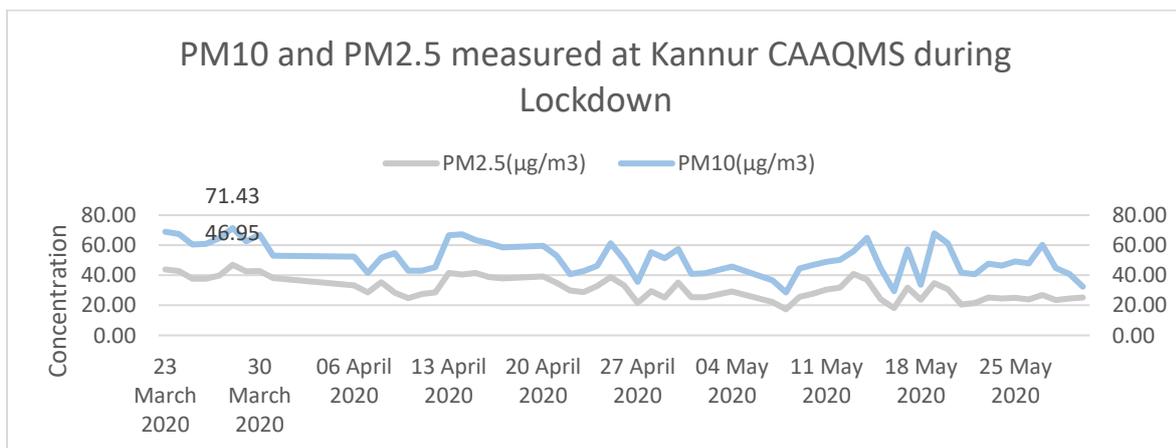


Figure 10.16: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Kannur CAAQMS during Lockdown

Figure 10.18 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Kannur CAAQM station before lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 71.43 µg/m<sup>3</sup> and 46.95 µg/m<sup>3</sup> respectively on 28<sup>th</sup> March 2020.

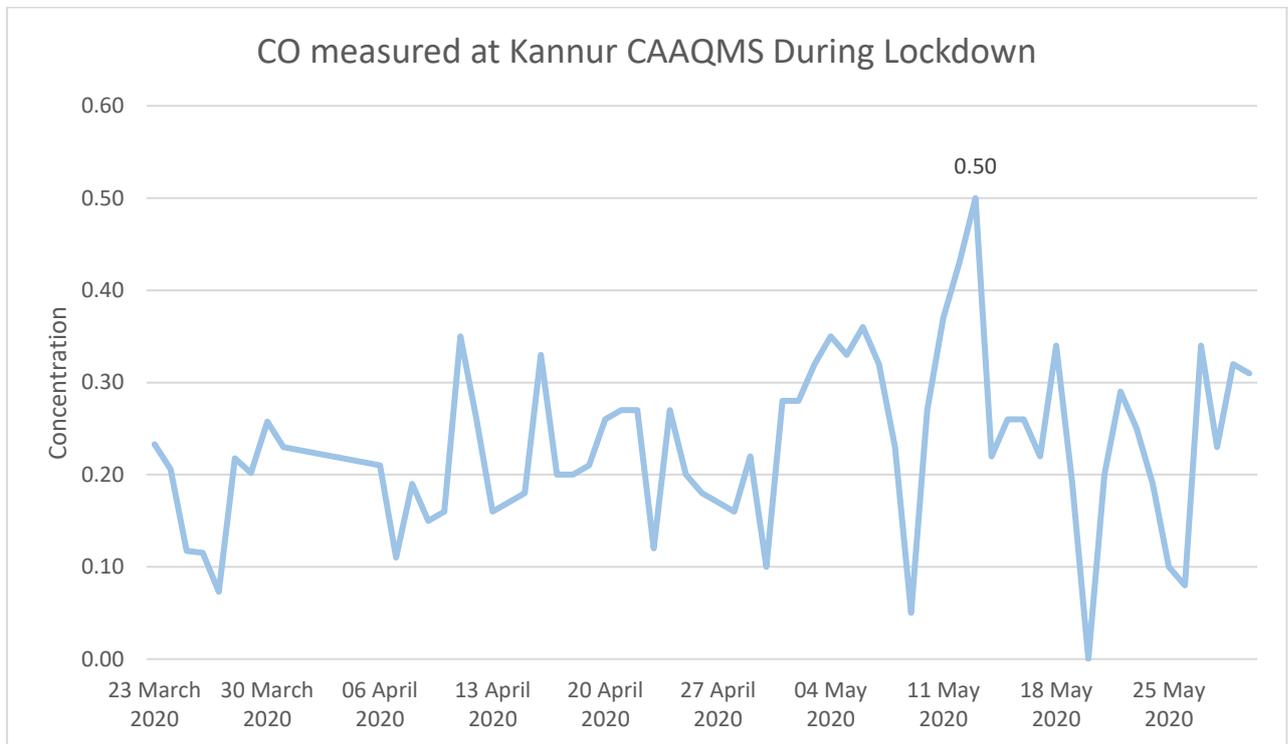


Figure 10.17: CO measured at Kannur CAAQMS during Lockdown

Figure 10.19 shows the 24-hr average values for CO measured at Kannur CAAQM station during the lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 0.50 mg/m<sup>3</sup> on 13<sup>th</sup> May 2020.

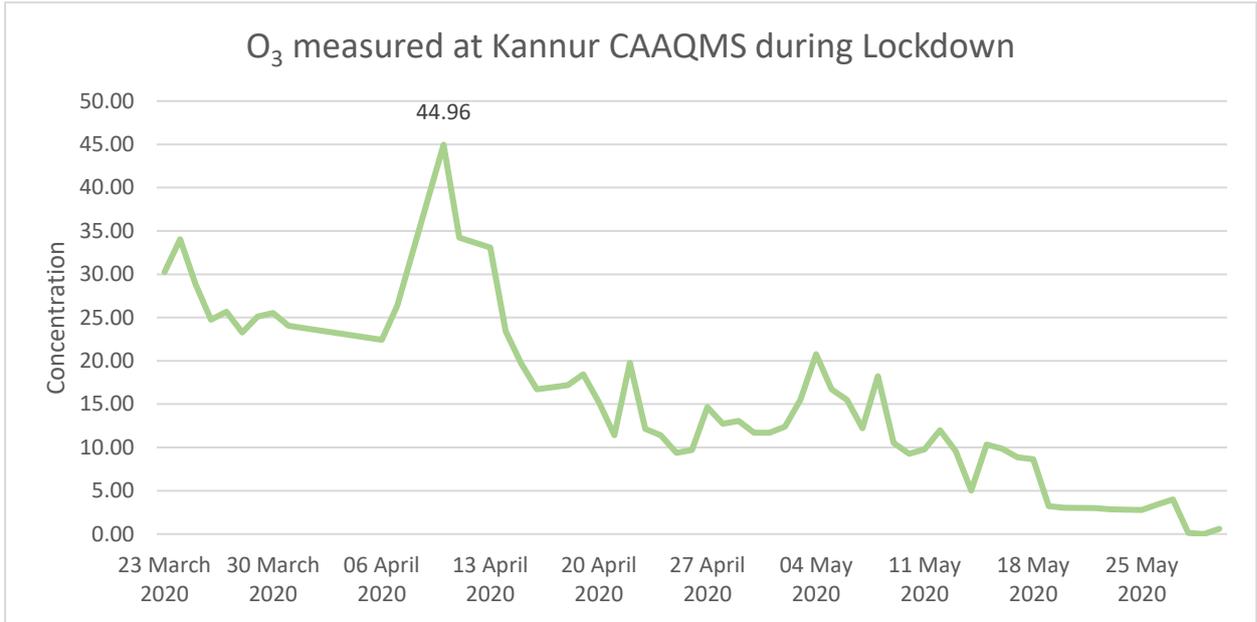


Figure 10.18: O<sub>3</sub> measured at Kannur CAAQMS before Lockdown

Figure 10.18 shows the 24-hr average values for O<sub>3</sub> measured at Kannur CAAQM station during the lockdown. The data analysis indicated that the O<sub>3</sub> was always below the 8 hour standard of 100 µg/m<sup>3</sup>. The highest value was found to be 44.96 µg/m<sup>3</sup> on 10<sup>th</sup> April 2020.

### 10.2.3 After Lockdown

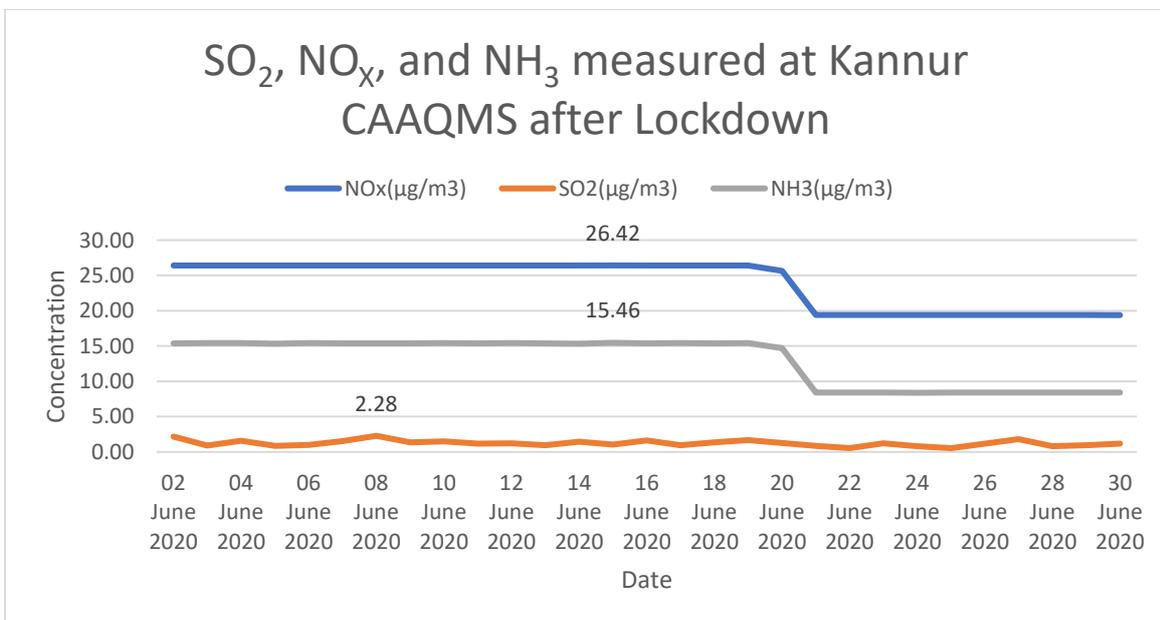


Figure 10.19: SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Kannur CAAQMS after Lockdown

Figure shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, and NH<sub>3</sub> measured at Kannur CAAQM station after lockdown. The data analysis indicates that the SO<sub>2</sub> and NO<sub>x</sub> were always below the 24 hour standard of 80 µg/m<sup>3</sup>. The highest SO<sub>2</sub> and NO<sub>x</sub> values were found to be 2.28 µg/m<sup>3</sup> and 26.42 µg/m<sup>3</sup> respectively on 8<sup>th</sup> June 2020 and 15<sup>th</sup> June 2020. The concentration of NH<sub>3</sub> is also below the NAAQS standards of 400 µg/m<sup>3</sup>. The highest value registered is 15.46 µg/m<sup>3</sup> on 15<sup>th</sup> June 2020 for NH<sub>3</sub>.

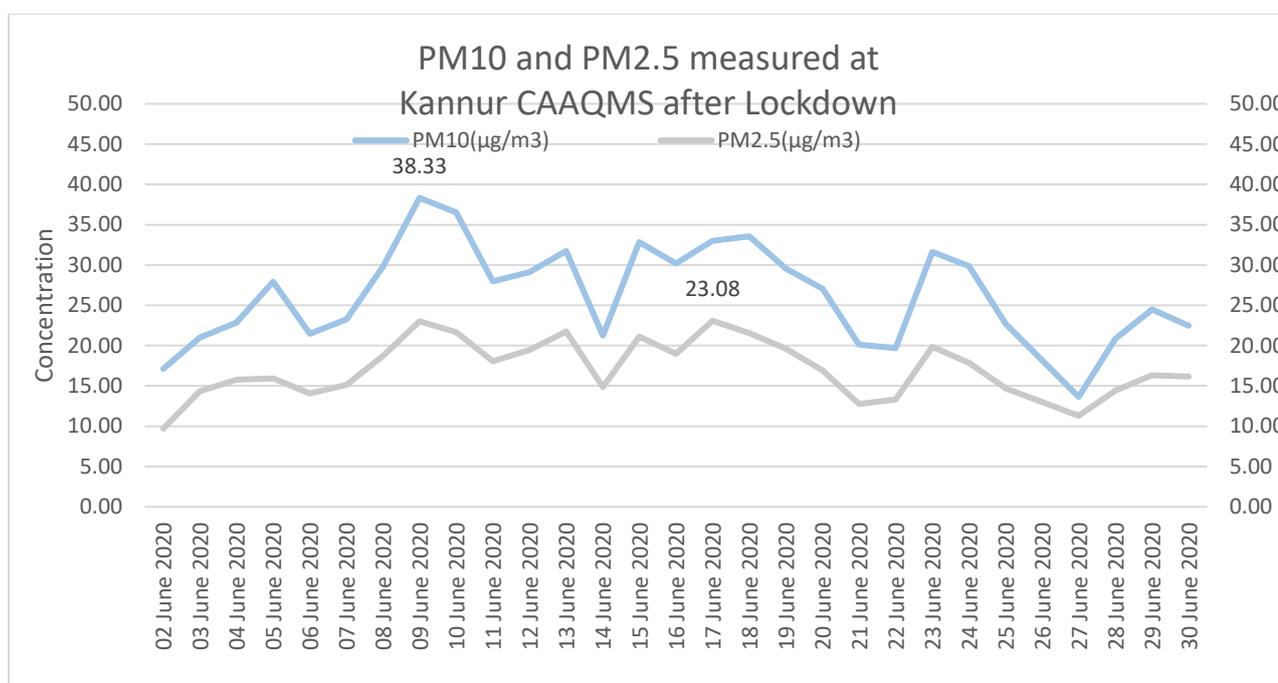


Figure 10.20: PM<sub>10</sub> and PM<sub>2.5</sub> measured at Kannur CAAQMS after Lockdown

Figure 10.20 shows the 24-hr average values for PM<sub>10</sub> and PM<sub>2.5</sub> measured at Kannur CAAQM station after lockdown. The data analysis indicated that the PM<sub>10</sub> and PM<sub>2.5</sub> were always below the 24 hour standard of 100 µg/m<sup>3</sup> and 60 µg/m<sup>3</sup> respectively. The highest PM<sub>10</sub> and PM<sub>2.5</sub> values were found to be 38.33 µg/m<sup>3</sup> and 23.08 µg/m<sup>3</sup> respectively on 9<sup>th</sup> June 2020 and 17<sup>th</sup> June 2020.

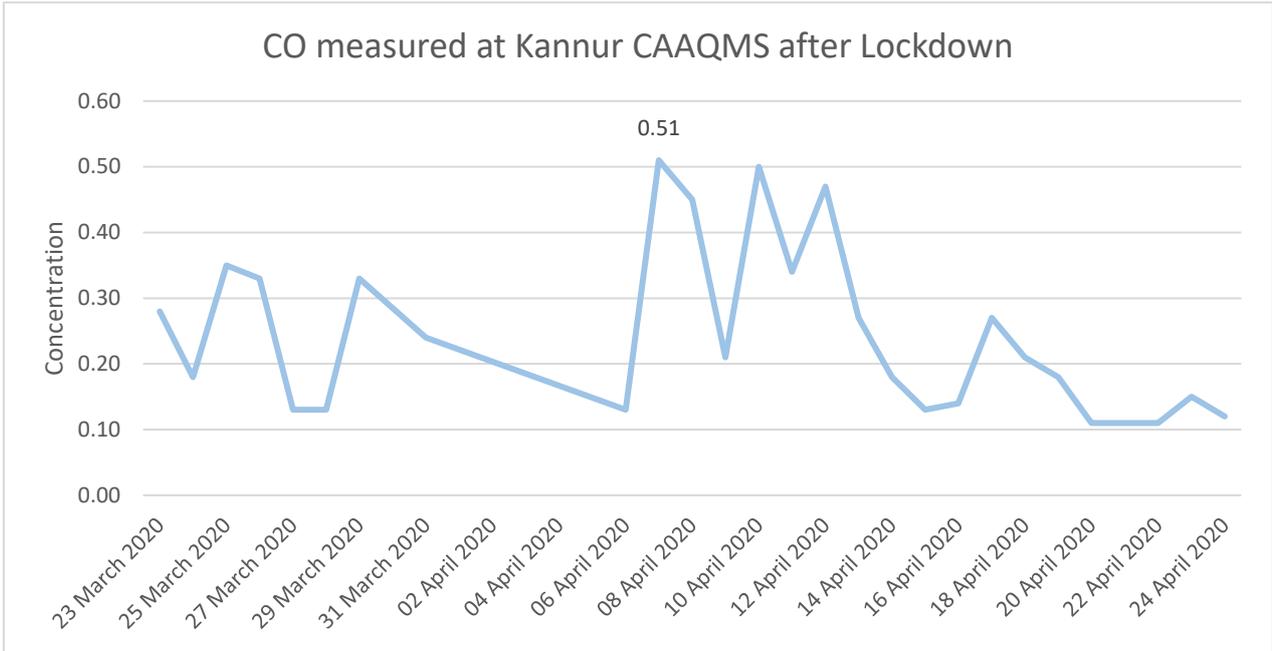


Figure 10.21: CO measured at Kannur CAAQMS after Lockdown

Figure 10.21 shows the 24-hr average values for CO measured at Kannur CAAQM station after lockdown. The data analysis indicated that the CO was always below the 8 hour standard of 2 mg/m<sup>3</sup>. The highest value was found to be 0.51 mg/m<sup>3</sup> on 7<sup>th</sup> April 2020.

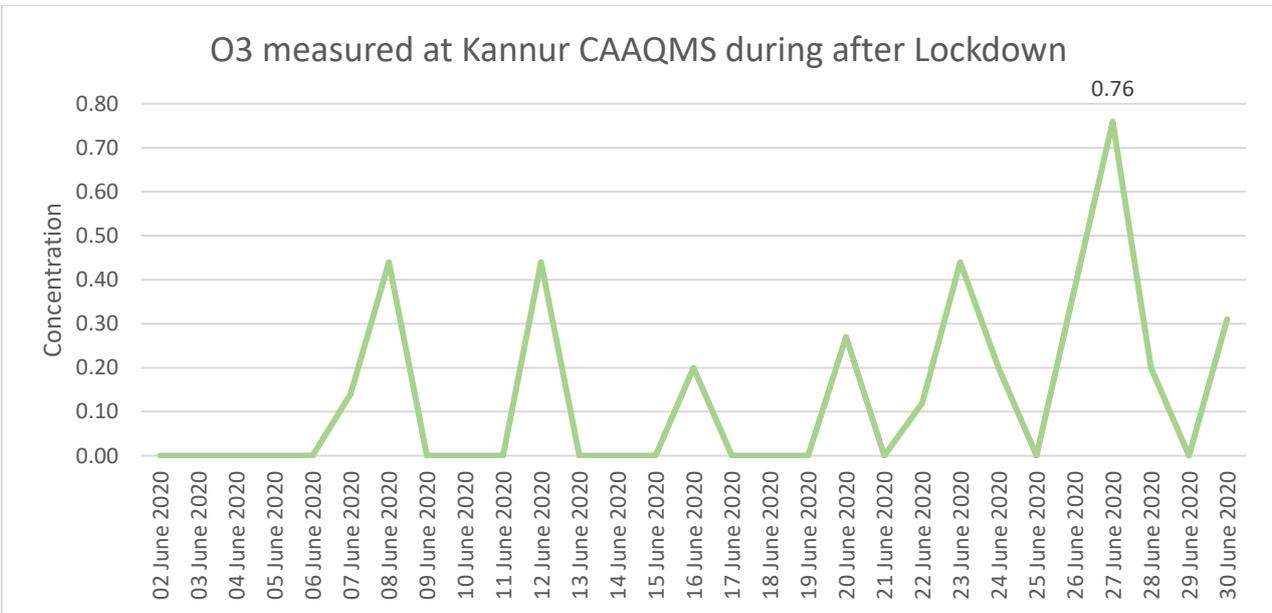


Figure 10.22: O<sub>3</sub> measured at Kannur CAAQMS after Lockdown

Figure 10.22 shows the 24-hr average values for O<sub>3</sub> measured at Kannur CAAQM station during the lockdown. The data analysis indicated that the O<sub>3</sub> was always below the 8 hour standard of 100 µg/m<sup>3</sup>. However, the highest value was found to be 0.76 µg/m<sup>3</sup> on 10<sup>th</sup> April 2020.

### 10.2.4 Result Analysis

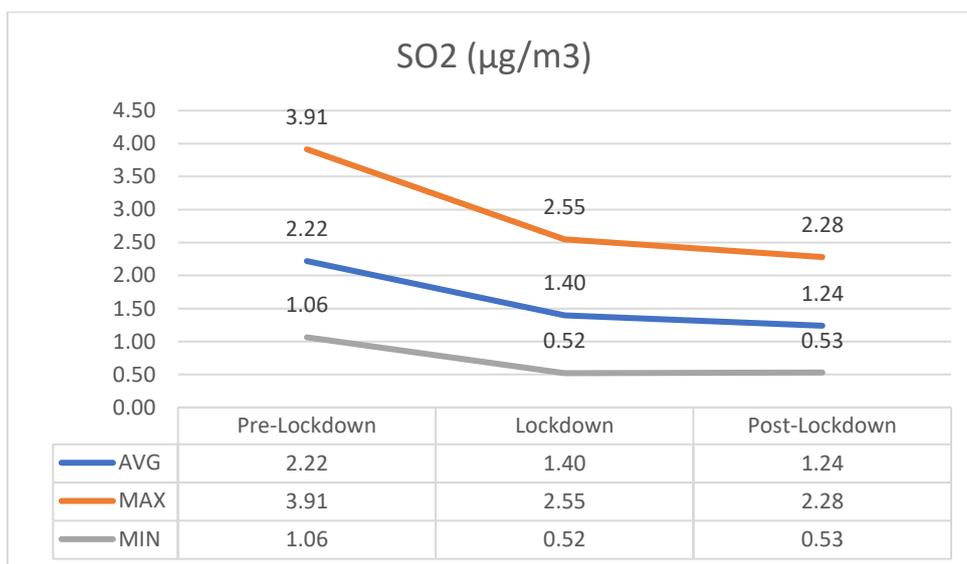


Figure 10.23: SO<sub>2</sub> Values of Kannur CAAQM station before, during and after lockdown.

Figure 10.23 shows that average, maximum and minimum values for SO<sub>2</sub> registered a slight decrease during the lockdown period and showed a decreasing trend even after the lockdown was lifted.

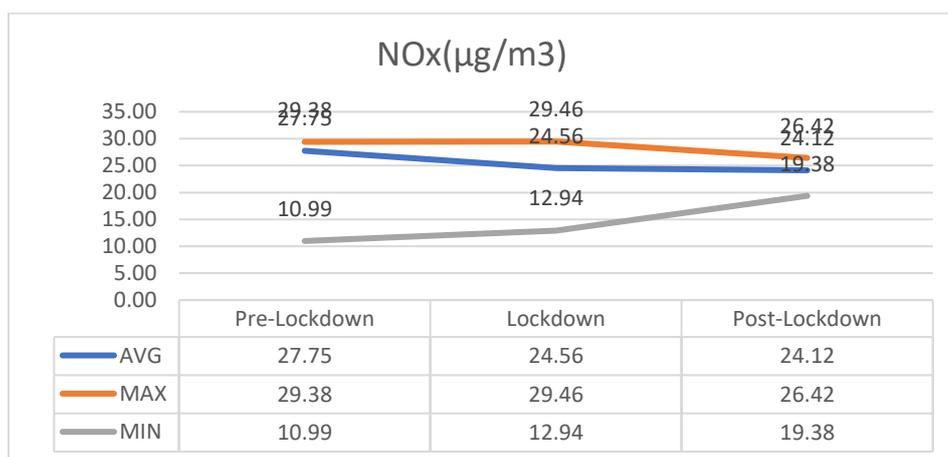


Figure 10.24: NO<sub>x</sub> Values of Kannur CAAQM station before, during and after lockdown.

Figure 10.24 shows that average values for NO<sub>x</sub> registered a slight decrease during the lockdown period and showed a decreasing trend even after the lockdown was lifted.

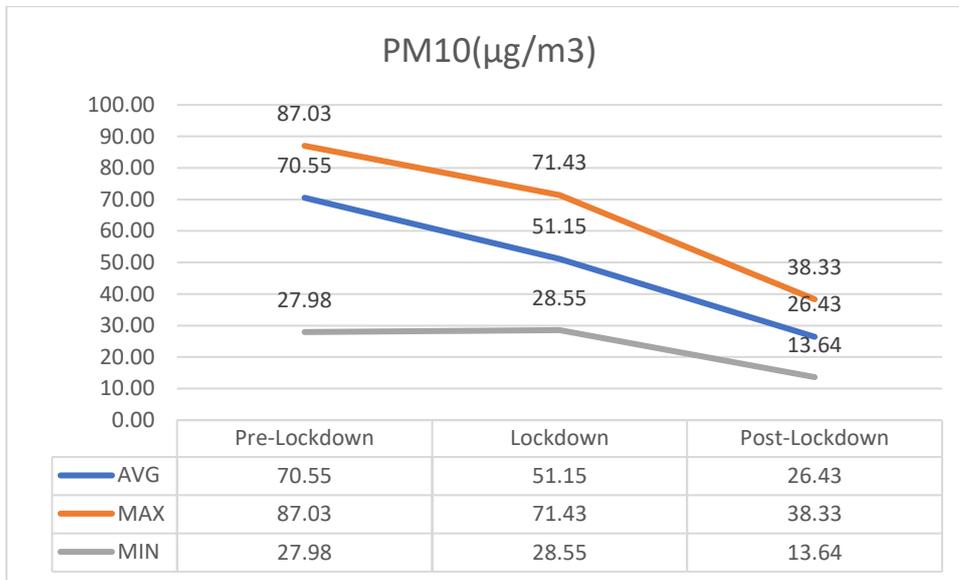


Figure 10.25: PM<sub>10</sub> Values of Kannur CAAQM station before, during and after lockdown.

Figure 10.25 shows that average, maximum and minimum values for PM<sub>10</sub> registered a slight decrease during the lockdown period and showed a decreasing trend even after the lockdown was lifted.

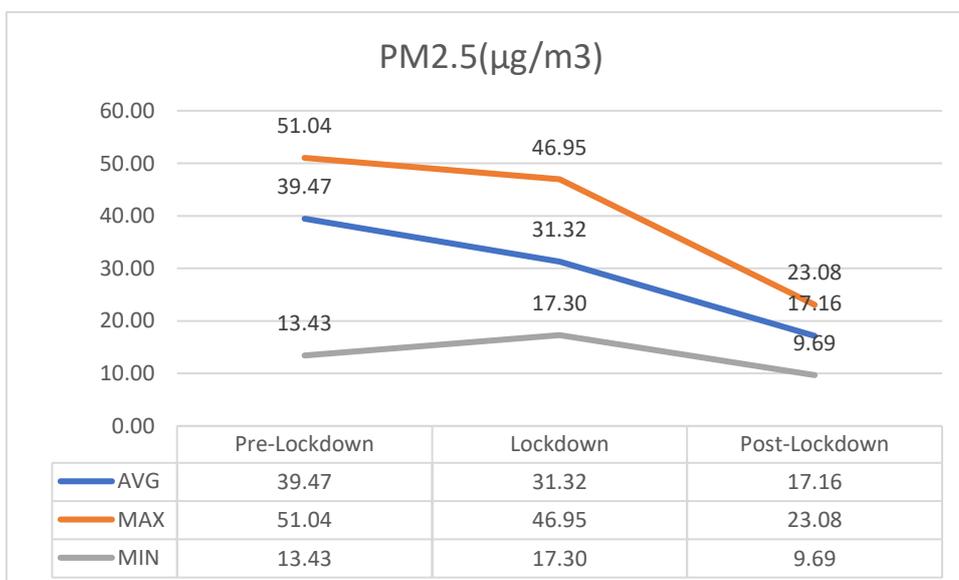


Figure 10.26: PM<sub>2.5</sub> Values of Kannur CAAQM station before, during and after lockdown.

Figure 10.26 shows that average, and maximum values for PM<sub>2.5</sub> registered a slight decrease during the lockdown period and showed a decreasing trend even after the lockdown was lifted.

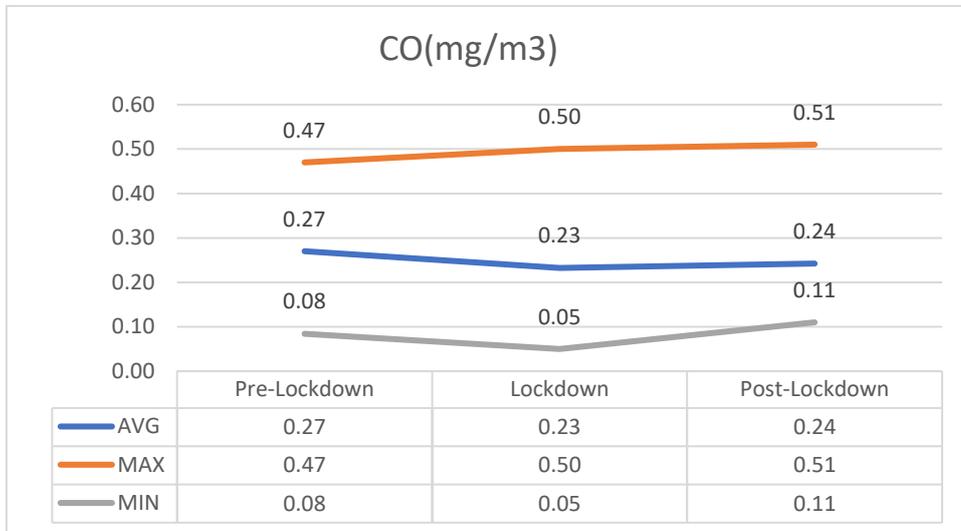


Figure 10.27: CO Values of Kannur CAAQM station before, during and after lockdown.

Figure 10.27 shows that the Value of CO remained almost Unchanged During the Lockdown and afterwards

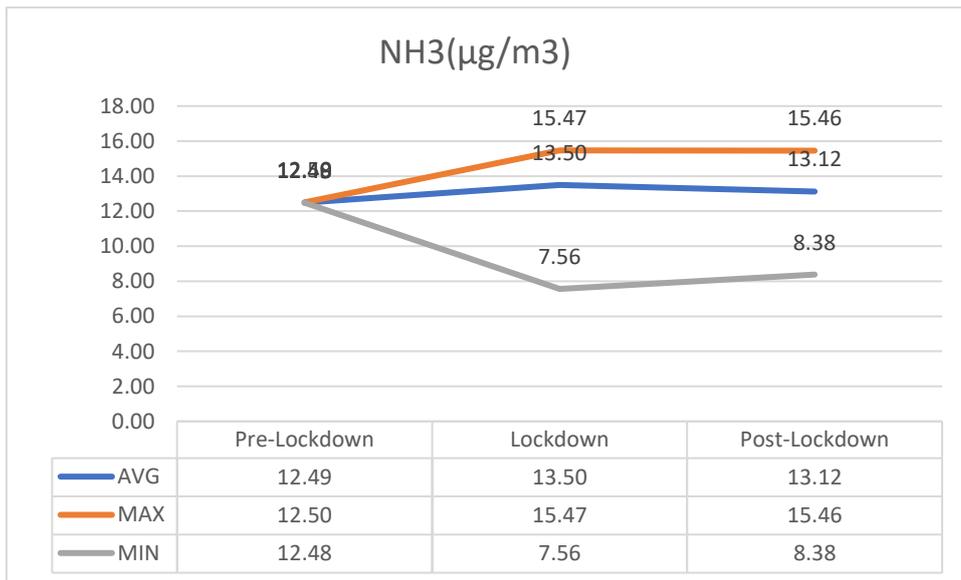
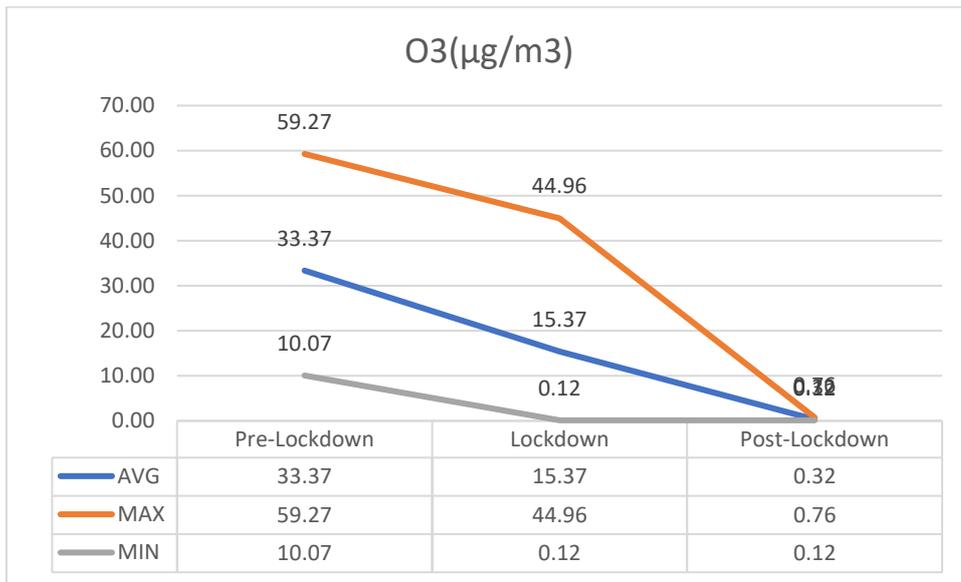


Figure 10.28: CO Values of Kannur CAAQM station before, during and after lockdown.

Figure 10.28 shows that average, maximum and minimum values for NH<sub>3</sub> registered an increase during the lockdown period and showed a decreasing trend after the lockdown was lifted.



**Figure 10.29: O<sub>3</sub> Values of Kannur CAAQM station before, during and after lockdown.**

Figure 10.29 shows that average, maximum and minimum values for O<sub>3</sub> registered a slight decrease during the lockdown period and showed a decreasing trend even after the lockdown was lifted.

# 11 Kasaragod

The list of Monitoring stations in the city is tabulated in Table 11.1. The land use pattern at these stations is also depicted

Table 11.1: List of monitoring stations in Kasaragod

Site	Co-ordinates	Scheme	Type	Land Use Pattern
Kasaragod	12°30'45.0"N 74°59'27.7" E	SAMP	Residential, Rural & others	Commercial Cum Residential
Khanangad	12°19'16.5"N 74°05'01.0" E	SAMP	Residential, Rural & others	Commercial Cum Residential

Table 11.2 gives the growth of vehicles in the district of Kasaragod, it has shown steady growth.

Table 11.2: Vehicular Count in Kasaragod

Year	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
No of vehicles	464885	512320	601790	666523	739595	826010

## 11.1 Kasaragod-1 (Residential Rural And Others)-Manual Monitoring Station

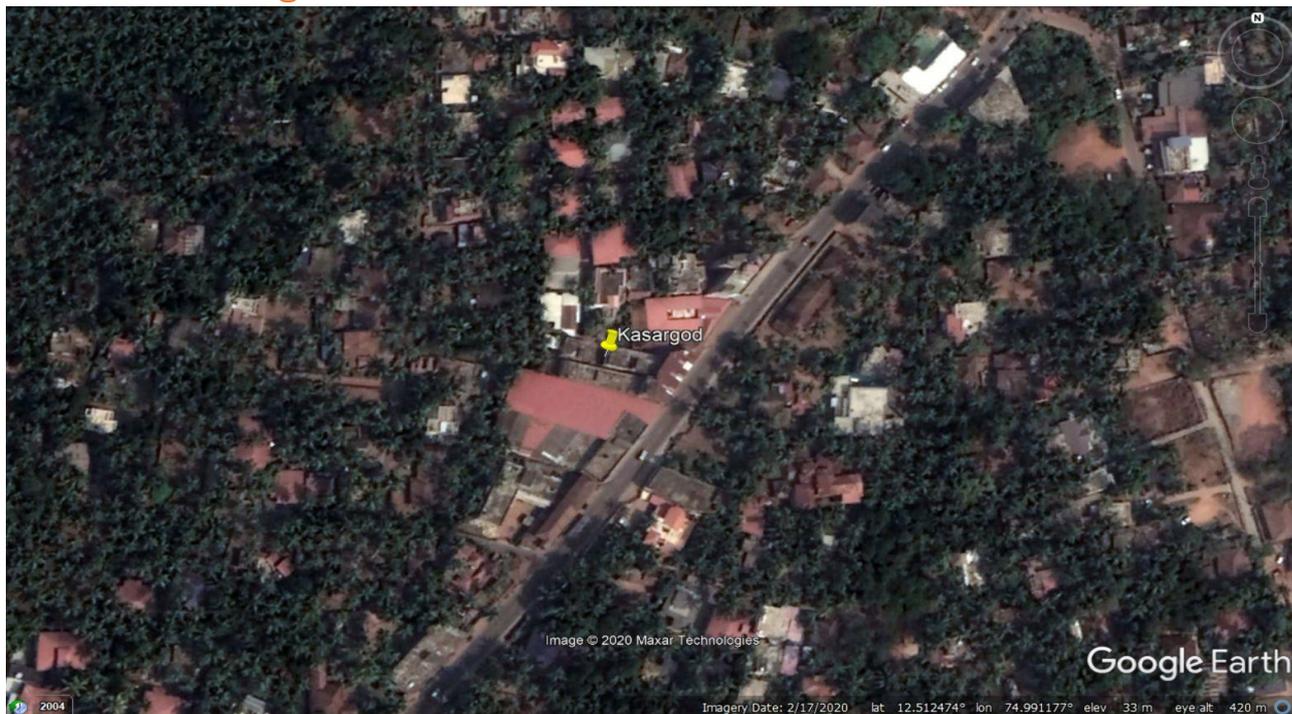


Figure 11.1: Land Use pattern at Kasaragod -1 Station

Land use pattern at the station is Residential as well as commercial

### 11.1.1 Before Lockdown

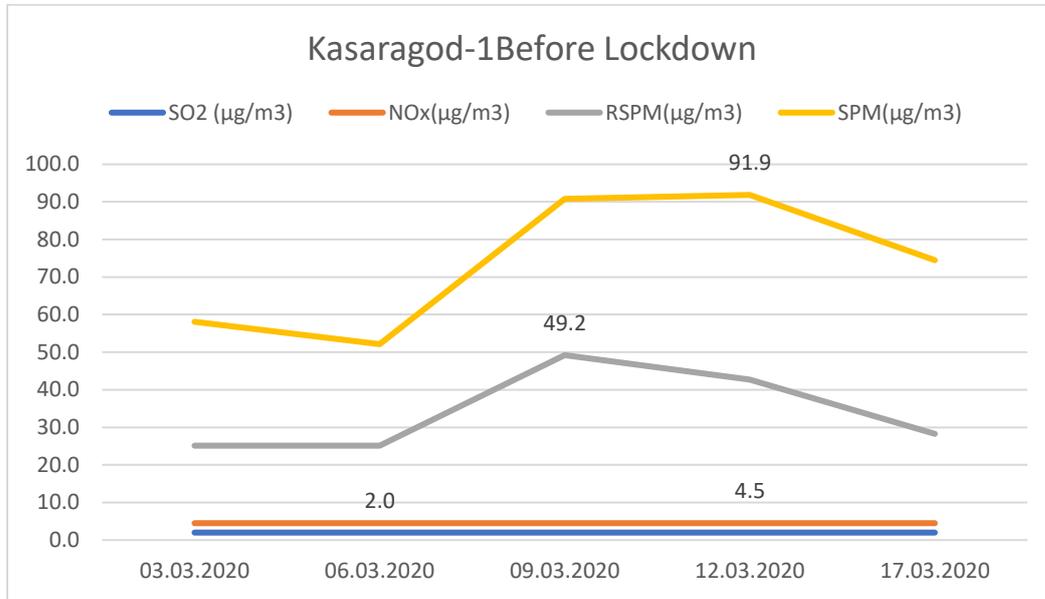


Figure 11.2: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Kasaragod station before Lockdown

Figure 11.2 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Kasaragod station before Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 49.22µg/m<sup>3</sup> and 91.86µg/m<sup>3</sup> respectively on 9<sup>th</sup> March 2020 and 12<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 4.50 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 11.1.2 During Lockdown

Due to the Pandemic Induced triple lockdown monitoring could be carried out in this site during this period

### 11.1.3 After Lockdown

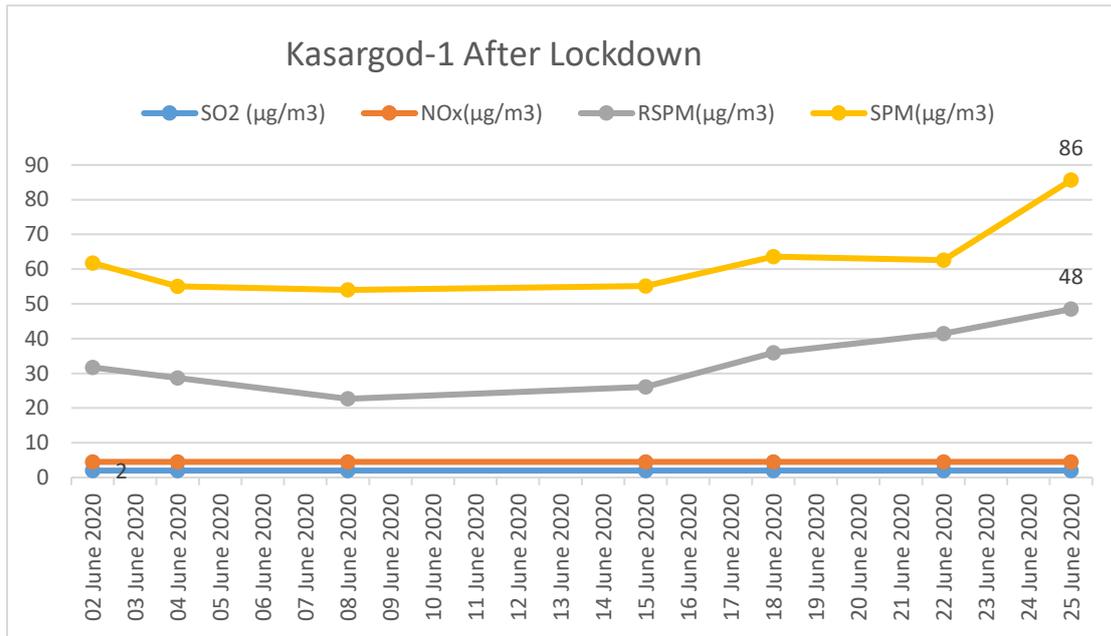


Figure 11.3: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Kasargod station after Lockdown

Figure 11.3 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Kasargod station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 28.07µg/m<sup>3</sup> and 67.40µg/m<sup>3</sup> respectively on 25<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 4.50 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

Unfortunately, data during the lockdowns are not available due to strict triple lockdown in the city

## 11.2 Khanangad(Residential Rural & Others)-Manual Monitoring Station

The land use in the sation include residential area, commercial establishment and minor and major roads

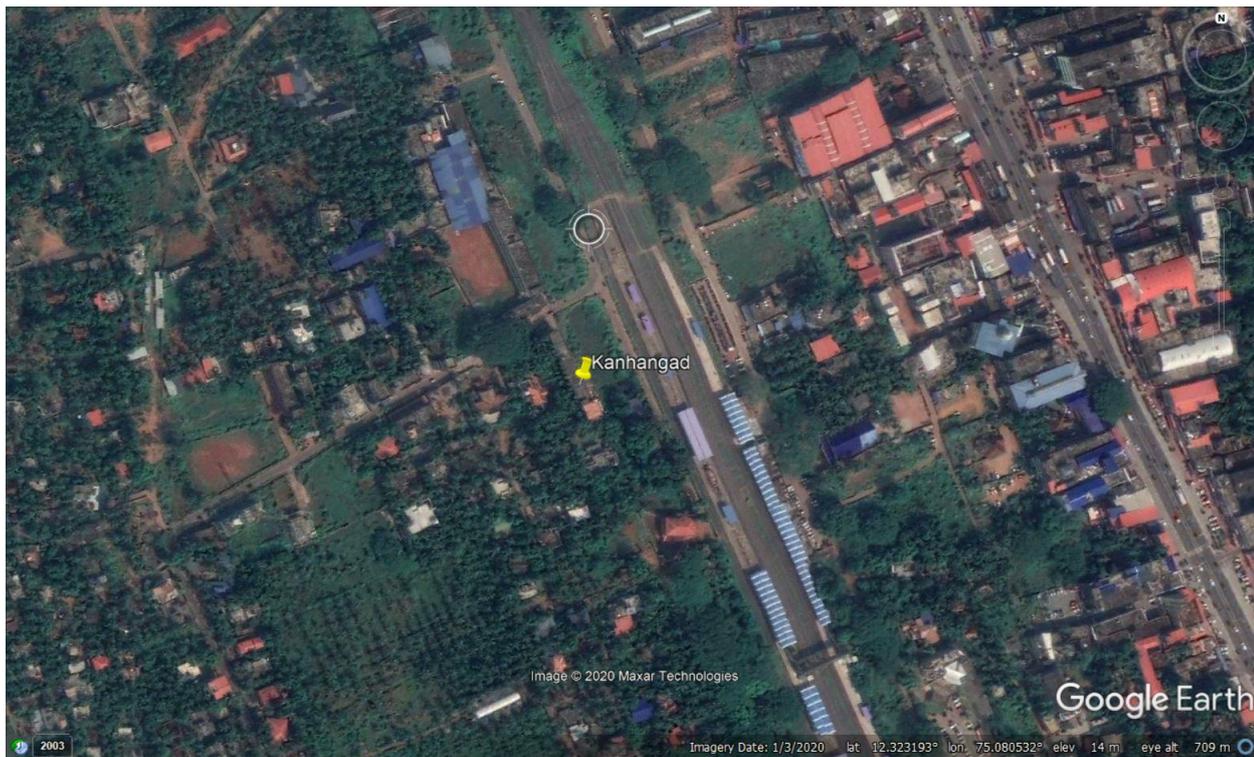


Figure 11.4: Land Use pattern at Khananghad

### 11.2.1 Before Lockdown

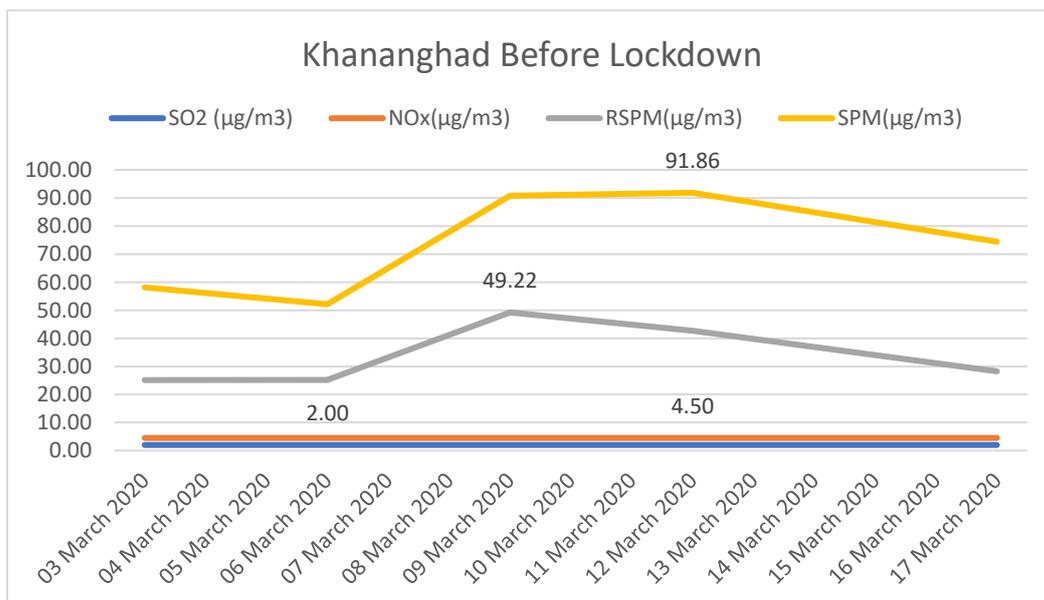


Figure 11.5: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Khananghad station before Lockdown

Figure 11.5 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Khananghad station before Lockdown. The data analysis indicated that

the RSPM and SPM were always below the 24 hr average standard of 100  $\mu\text{g}/\text{m}^3$ . The highest RSPM and SPM value were recorded as 49.22 $\mu\text{g}/\text{m}^3$  and 91.86 $\mu\text{g}/\text{m}^3$  respectively on 9<sup>th</sup> March 2020 and 12<sup>th</sup> March 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80  $\mu\text{g}/\text{m}^3$ . The highest values registered are 2.0  $\mu\text{g}/\text{m}^3$  and 4.50  $\mu\text{g}/\text{m}^3$  respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 11.2.2 During Lockdown

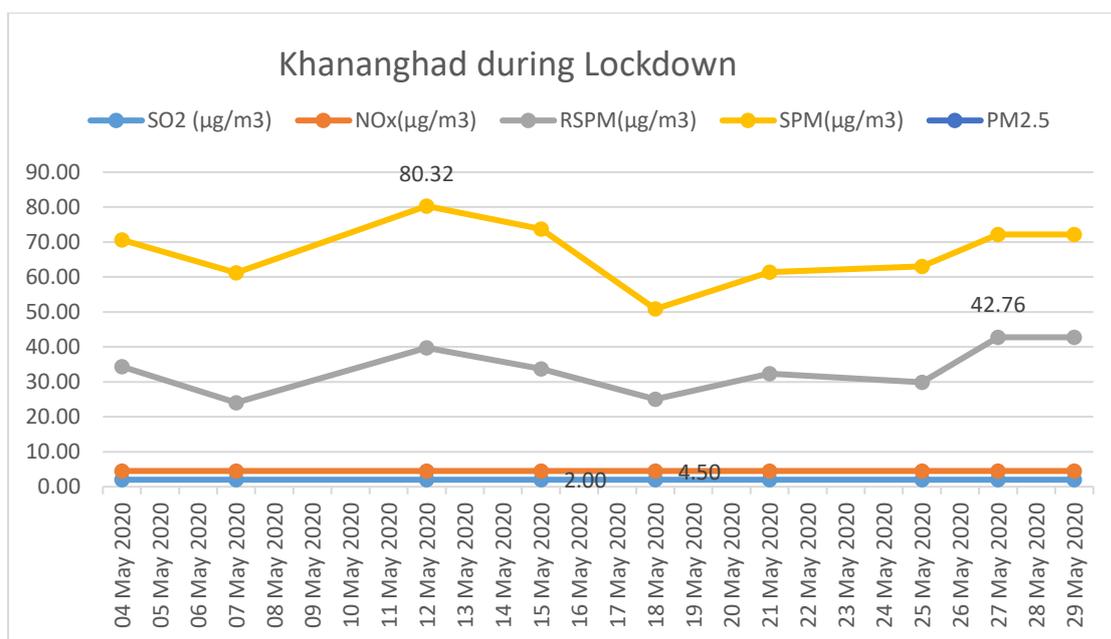


Figure 11.6: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Khanangad station during Lockdown

Figure 11.6 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Khanangad station during Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100  $\mu\text{g}/\text{m}^3$ . The highest RSPM and SPM value were recorded as 42.76 $\mu\text{g}/\text{m}^3$  and 80.32 $\mu\text{g}/\text{m}^3$  respectively on 27<sup>th</sup> May 2020 and 12<sup>th</sup> May 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80  $\mu\text{g}/\text{m}^3$ . The highest values registered are 2.0  $\mu\text{g}/\text{m}^3$  and 4.50  $\mu\text{g}/\text{m}^3$  respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 11.2.3 After Lockdown

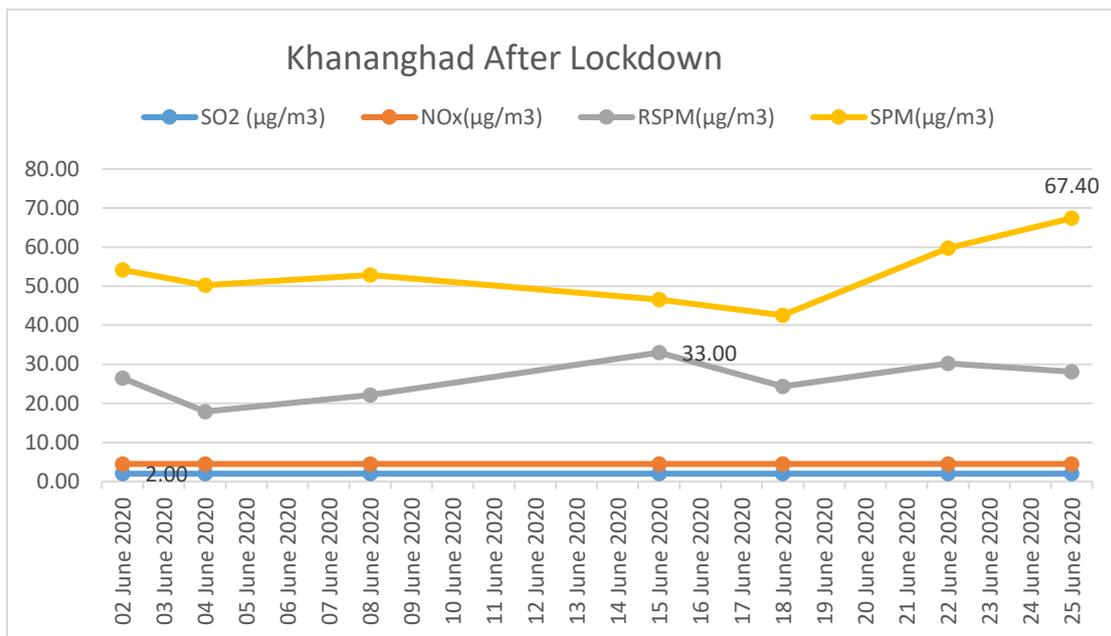


Figure 11.7: 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Khananghad station after Lockdown

Figure 11.7 shows the 24-hr average values for SO<sub>2</sub>, NO<sub>x</sub>, RSPM and SPM measured at Khananghad station after Lockdown. The data analysis indicated that the RSPM and SPM were always below the 24 hr average standard of 100 µg/m<sup>3</sup>. The highest RSPM and SPM value were recorded as 33.00µg/m<sup>3</sup> and 67.40µg/m<sup>3</sup> respectively on 15<sup>th</sup> June 2020 and 25<sup>th</sup> June 2020. The concentration of SO<sub>2</sub> and NO<sub>x</sub> is well below the NAAQS standards of 80 µg/m<sup>3</sup>. The highest values registered are 2.0 µg/m<sup>3</sup> and 4.50 µg/m<sup>3</sup> respectively for SO<sub>2</sub> and NO<sub>x</sub>.

### 11.2.4 Result Analysis

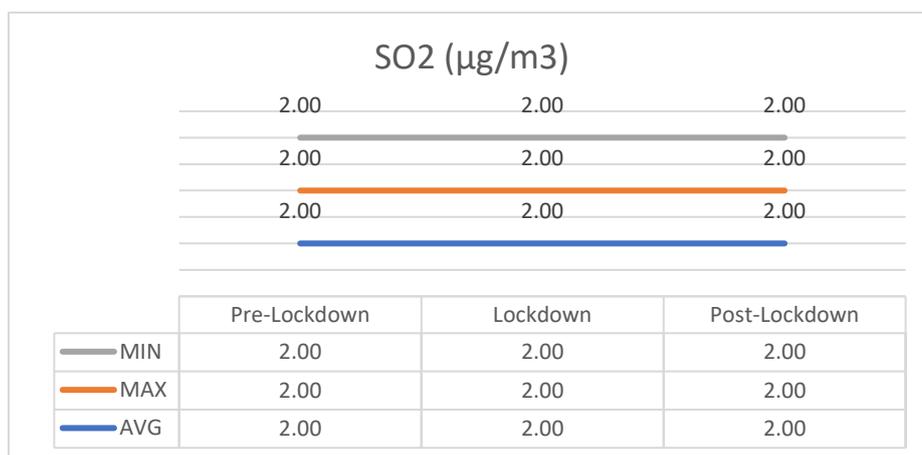


Figure 11.8: SO<sub>2</sub> Values of Khananghad station before, during and after lockdown

Figure 11.8 shows that the average, maximum and minimum values for SO<sub>2</sub> remained constant during pre lockdown, lockdown and post lockdown period at Khanangad Station.

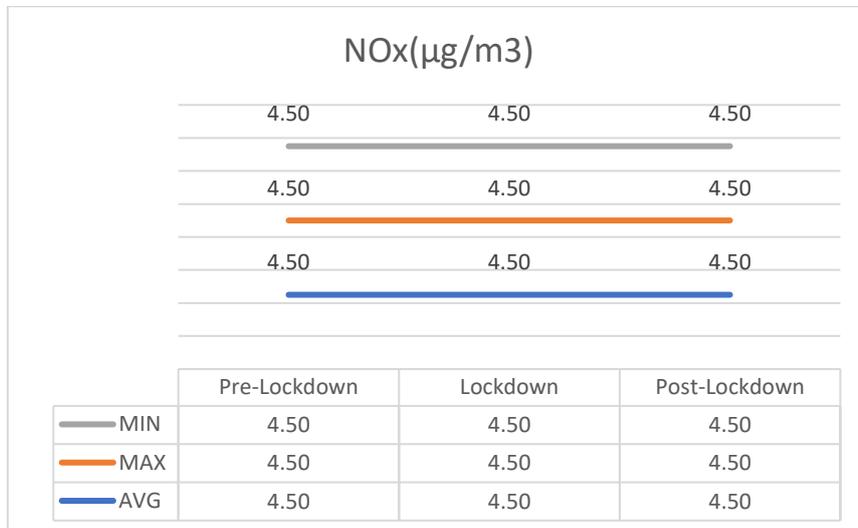


Figure 11.9: NO<sub>x</sub> Values of Khanangad station before, during and after lockdown

Figure 11.9 shows that the average, maximum and minimum values for NO<sub>x</sub> remained constant during pre lockdown, lockdown and post lockdown period at Khanangad Station.

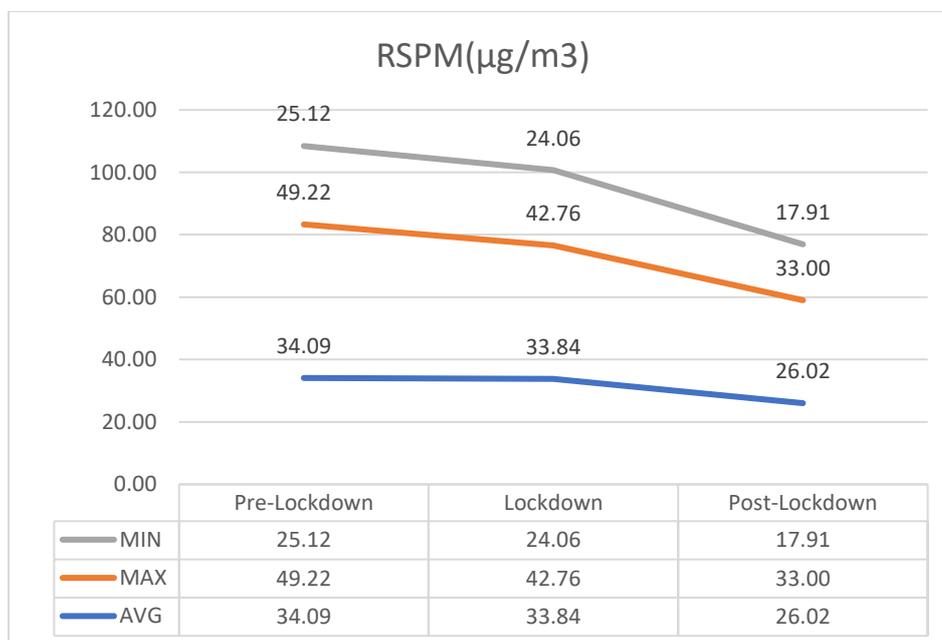


Figure 11.10: RSPM Values of Khanangad station before, during and after lockdown

Figure 11.10 and 11.11 shows that the average, maximum and minimum values for RSPM and SPM decreased during the lockdown period at Khanangad Station.

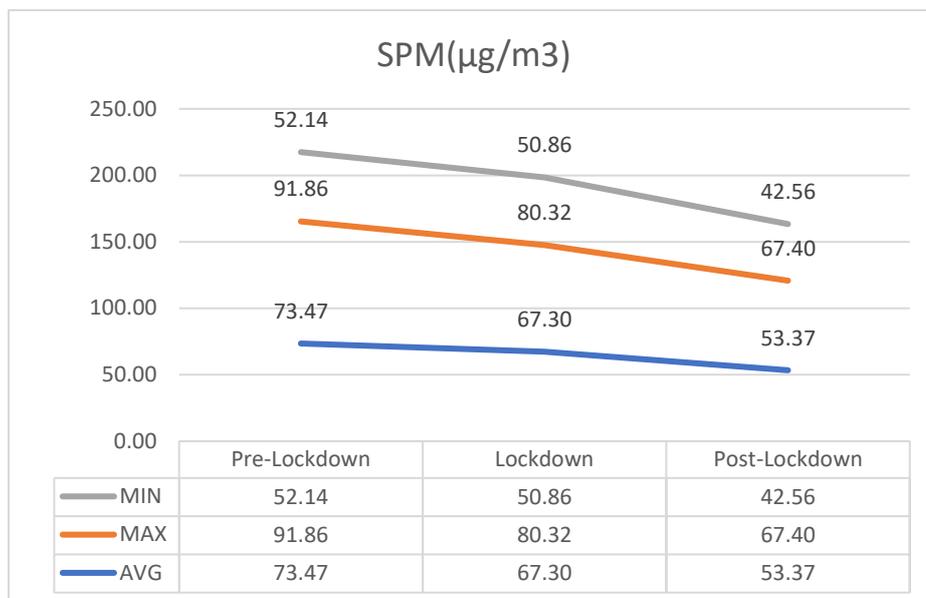


Figure 11.11: SPM Values of Khanangad station before, during and after lockdown

## 12 Summary Of Findings

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Board had established 35 manual air quality monitoring stations and 9 CAAQM Stations across the states. In Trivandrum different parameters SPM, RSPM, SO<sub>2</sub>, NO<sub>x</sub> are being monitored in all manual monitoring stations and PM<sub>2.5</sub> is started in certain stations. In CAAQMS SO<sub>2</sub>, NH<sub>3</sub>, CO, O<sub>3</sub>, PM<sub>10</sub> & PM<sub>2.5</sub> etc are being monitored. In this study air quality data from 22 manual stations and 8 CAAQM Station in the 8 cities ( Thiruvananthapuram, Kollam, Alappuzha, Kochi, Thrissur, Kozhikkode, Kannur & Kasaragod) in Kerala, during pre lockdown( 1<sup>st</sup> March 2020 to 23<sup>rd</sup> March 2020 ), lockdown (23<sup>rd</sup> March 2020 to 31<sup>st</sup> May 2020) and post lockdown (1<sup>st</sup> June 2020 to 30<sup>th</sup> June 2020 )were analysed.

The overall results of the analysis reveal that in all the eight cities the concentration of SO<sub>2</sub> and NO<sub>x</sub> were found to be within 80µg/m<sup>3</sup>, the prescribed standard limit. RSPM & SPM were within the limit of 100µg/m<sup>3</sup> & 60µg/m<sup>3</sup> in all manual monitoring stations. In the case of CAAQM Stations, all parameters are within the prescribed standards except in the case of Vytilla NO<sub>x</sub>, CO & PM parameters showed exceedance for a few days.

The district-wise ambient air quality status as per the study is depicted as below:

- a. In Thiruvananthapuram, the data from two CAAQMS and four manual ambient air quality monitoring stations were analysed. the concentration of SO<sub>2</sub> and NO<sub>x</sub> are found to be below the prescribed standard limit as of 80 µg/m<sup>3</sup>. The 24 hours concentration of RSPM and SPM are found to be within the prescribed standard limit of 100µg/m<sup>3</sup> and 60µg/m<sup>3</sup> respectively in the district.
- b. In Kollam, data from one CAAQMS and two manual ambient air quality monitoring stations were analysed. It is observed that all the measured parameters in the manual and continuous monitoring stations are well within the prescribed limits.

- c. In Alappuzha, data from two manual ambient air quality monitoring stations were analysed and observed that all the parameters are well within the prescribed limits.
- d. In Kochi, data from seven manual ambient air quality monitoring stations and three CAAQMS and have been analysed and parameters are well within prescribed limit for manual ambient air quality monitoring stations. In case of the Vytilla CAAQM Station some exceedance in NO<sub>x</sub>, PM and CO is noticed. Even then monthly average value of NO<sub>x</sub> and PM are within the prescribed limit and only CO exceeded the limit.
- e. In Thrissur, data from two manual ambient air quality monitoring stations have been analysed and observed that all the measured parameters in the manual monitoring stations are well within the prescribed limits.
- f. In Kozhikode (Calicut), data from one CAAQMS and two manual ambient air quality monitoring stations have been analysed and all the measured parameters in the manual and continuous monitoring stations are well within the prescribed limits.
- g. In Kannur, data from one CAAQMS and one manual ambient air quality monitoring stations were analysed and observed that all the measured parameters in the manual and monitoring stations were well within the prescribed limit.
- h. In Kasaragod, data from two manual ambient air quality monitoring stations were analysed and observed that all the parameters are well within the prescribed limits.

## 13 Suggestion&Recommendations

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The primary sources of air pollution in the state are

1. Vehicular Emissions
2. Burning of biomass, crop residues, and Municipal Solid waste
3. Road Dust
4. Construction and Demolition Waste
5. Industrial Emission

The following long term and short term measures suggested based on the above air quality study

### **Short term steps suggested for improving Air Quality**

6. Launching extensive awareness drive against polluting vehicles
7. Ensuring strict action against visibly polluting vehicles
8. Steps to prevent parking of vehicles in non designated areas.
9. Introducing wet/Mechanised vacuum sweeping of roads.
10. Controlling dust pollution at construction sites through by providing appropriate covering system.
11. Ensuring carriage of construction material in closed/covered vessels.

### **Long term steps suggested for improving Air Quality**

1. Retrofitting of diesel vehicles with particulate filters
2. Installation of the vapour recovery system in fuelling stations
3. Promoting battery-operated vehicles.
4. Banning of old diesel vehicles in a phased manner
5. Undertaking Greening of open areas
6. Creation of green buffers along the traffic corridors.

7. Undertaking control measures for fugitive emissions from material handling, conveying, and screening operations through water sprinkling, curtains, barriers, and dust suppression units.
8. Development of a proper system for ensuring garbage/municipal solid waste/biomass/leaves connection and disposal and to avoid open burning.
9. Promoting the use of LPG only and to avoid the use of kerosene/ firewood in restaurants/dhabas/roadside eateries.
10. Introduce water fountains at a major traffic intersection, wherever feasible
11. Take steps for blacktopping/pavement of road shoulders to avoid road dust
12. Prepare an action plan for public transport on CNG mode.
13. Ensure the proper collection of solid waste ( biomass)
14. Ensure strict enforcement of the ban on burning of agriculture waste and crop residues
15. Ensure strict action against industrial units not complying with standards.
16. Ensure DG sects meeting the standards only be allowed to operate
17. Undertake road widening and improvement of infrastructure for decongestion of road

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