Detailed Air Quality Monitoring Report for Jaffna – January to March, 2025

By Central Environmental Authority, Sri Lanka

Report No : CEA/ARM/20/2025/AQ

Date : 2025-04-27

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மத்திய சுற்றாடல் அதிகாரசபை
Central Environmental Authority

Contents

Air Quality Monitoring in Jaffna – 2025 January

Report Number / Reference Number	:	CEA/ARM/20/2025/AQ
Report Type	:	Air Quality Monitoring
Geographical Area of Interest	:	Jaffna District / Peninsula
Number of Sites	:	16
Duration	:	2025 Q1 (January to March, 3 months)
Parameters	:	$PM_{2.5}$ (Particulate Matter 2.5 / Fine Particles)
Related Standards	:	The 24-hour national standard for $PM_{2.5}$ and the Interim Target 2 and AQG of WHO Global Air Quality Guidelines.
Monitoring & Analysis by	:	Central Environmental Authority (CEA), Sri Lanka

1. Scope & Approach

To comprehensively assess the ambient air quality in the Jaffna District, a combination of newly deployed and existing monitoring equipment was utilized. Multiple devices were strategically positioned across the region to ensure broad spatial coverage and data reliability. Simultaneously, data from pre-installed monitoring devices in Jaffna were integrated into the analysis.

For comparative analysis, corresponding datasets were obtained from similar monitoring instruments operating in other parts of the country. This facilitated the identification of regional pollution trends and contextualized the findings within the national air quality framework. All collected data were analyzed and presented through a series of graphs, tables, and spatial visualizations to highlight both temporal patterns and geographic variability.

Given the study's focus on understanding localized pollution patterns, certain data points that may typically be excluded during standard quality assurance protocols — such as brief spikes or outlier readings — were intentionally retained to preserve the full picture of local conditions. These values, while potentially influenced by short-term anomalies, can offer valuable insights into episodic pollution events that affect public exposure.

1.1. Monitoring Period

This assessment covers the first quarter of 2025, with monitoring conducted from January through March. It is important to note that additional monitoring devices were installed during the third week of January, resulting in limited data availability from those sites for the initial weeks of the month. As a result, while the full three-month period was used to show temporal trends, only data from February and March were used for spatial comparisons across different locations, ensuring consistency and data completeness.

1.2. Site Selection

This study utilized data from 16 air quality monitoring sensors, selected to ensure both localized insights within the Jaffna District and meaningful comparisons with other regions across the country. Of these, 8 sensors were located within the Jaffna District, with 3 situated inside Jaffna City limits, capturing data from core urban areas. The remaining 5 sensors were positioned in locations outside Jaffna City (yet in the Jaffna District), covering other population centres and urban/suburban zones within the district.

The additional 8 sensors were located outside the Jaffna District. Among these, 3 were situated elsewhere within the Northern Province, enabling intra-provincial comparisons if necessary. The remaining 5 sensors were located across other provinces, such as the Western, North Western, and Sabaragamuwa Provinces, supporting inter-regional assessment and trend analysis. This spatial arrangement allowed for a well-rounded evaluation of both local pollution dynamics and broader regional air quality patterns across varying urban and geographic contexts.

Site selection was carried out based on data accessibility and spatial coverage requirements. Within the Jaffna District, all sensors to which the CEA had data access were included, and several additional sensors were installed to enhance spatial representation. For comparison purposes, all available sensors located outside Jaffna — with valid data during the analysis period and accessible to CEA — were included in the study. Data access was defined as instances where the device was owned by CEA, where CEA was directly involved in the monitoring activity, or where the data was publicly available.

It is also essential to recognize that air quality measurements obtained from individual sensors are highly site-specific. They reflect conditions at the precise location of deployment and may not represent wider geographic areas. To address this, sensor placement was carefully designed to capture broadly representative environmental conditions, avoiding atypical or extreme settings. This approach aligns with internationally accepted practices in decentralized air quality monitoring. While it may not provide perfect spatial generalization, it remains one of the most effective and practical strategies for capturing meaningful air quality insights, particularly in resource-limited or complex field settings.

1.3. Data Presentation Structure

The analysis was structured in several stages for clarity and depth. *Microsoft Excel* and *R Statistical Software* were used. First, detailed graphical outputs were generated for each monitoring location individually, allowing for an in-depth understanding of site-specific air quality patterns and temporal variability. Following this, a comparative analysis was conducted, incorporating cross-location comparisons and visualizations to identify broader trends, spatial disparities, and potential regional influences across the monitoring network.

2. Monitoring Locations

2.1. Sites Details

Table 1: Site Details

Site ID	Region	Location Name	Device Type	Deployed By	GPS coordinates (DD)
S01	Jaffna District	Jaffna City - Old Park / Children's Park	IQAir AirVisual	CEA	9.659917°N, 80.028558°E
S02		Jaffna City - Kacheri (District Secretariat)	TSI BlueSky PM	University of Peradeniya	9.660671°N, 80.028762°E
S03		Jaffna City - Athiyady	Clarity Node S	(Public Device. CC0. Courtesy: OpenAQ)	9.668310°N, 80.022990°E
S04		Karaveddy DS Vadamarachchi SW	IQAir AirVisual	CEA	9.798697°N, 80.189163°E
S05		Kodikamam Pradeshiya Sabha, Chavakachcheri	IQAir AirVisual	CEA	9.681840°N, 80.024634°E
S06		Maruthankerni DS Vadamarachchi East	IQAir AirVisual	CEA	9.623302°N, 80.396837°E
S07		Vaddukoddai - Private Property (House)	IQAir AirVisual	CEA	9.734225°N, 79.952043°E
S08		Point Pedro - Divisional Secretariat	TSI BlueSky PM	University of Peradeniya	9.820317°N, 80.236062°E
S09	Outside Jaffna District	Kilinochchi District Secretariat	IQAir AirVisual	CEA	9.391753°N, 80.405712°E
S10		Manthai West Divisional Sectariat, Mannar	IQAir AirVisual	CEA	8.943462°N, 79.994797°E
S11		Maritimepattu PS sub office, Mulliyawalai, Mullaitivu	IQAir AirVisual	CEA	9.224824°N, 80.775306°E
S12		Chilaw Divisional Secretariat	IQAir AirVisual	CEA	7.572222°N, 79.801601°E
S13		Ratnapura Regional Archaeological Office	IQAir AirVisual	CEA	6.682721°N, 80.398273°E
S14		Colombo Fort	TSI BlueSky PM	University of Peradeniya	6.933864°N, 79.850470°E
S15		Battaramulla CEA Head Office IQA	IQAir AirVisual	CEA	6.901016°N, 79.926511°E
S16		Battaramulla CEA Head Office AQMS	ACOEM/MetOne Ecotech Spirant BAM	CEA	6.901019°N, 79.926519°E

2.2. Locations - Satellite View

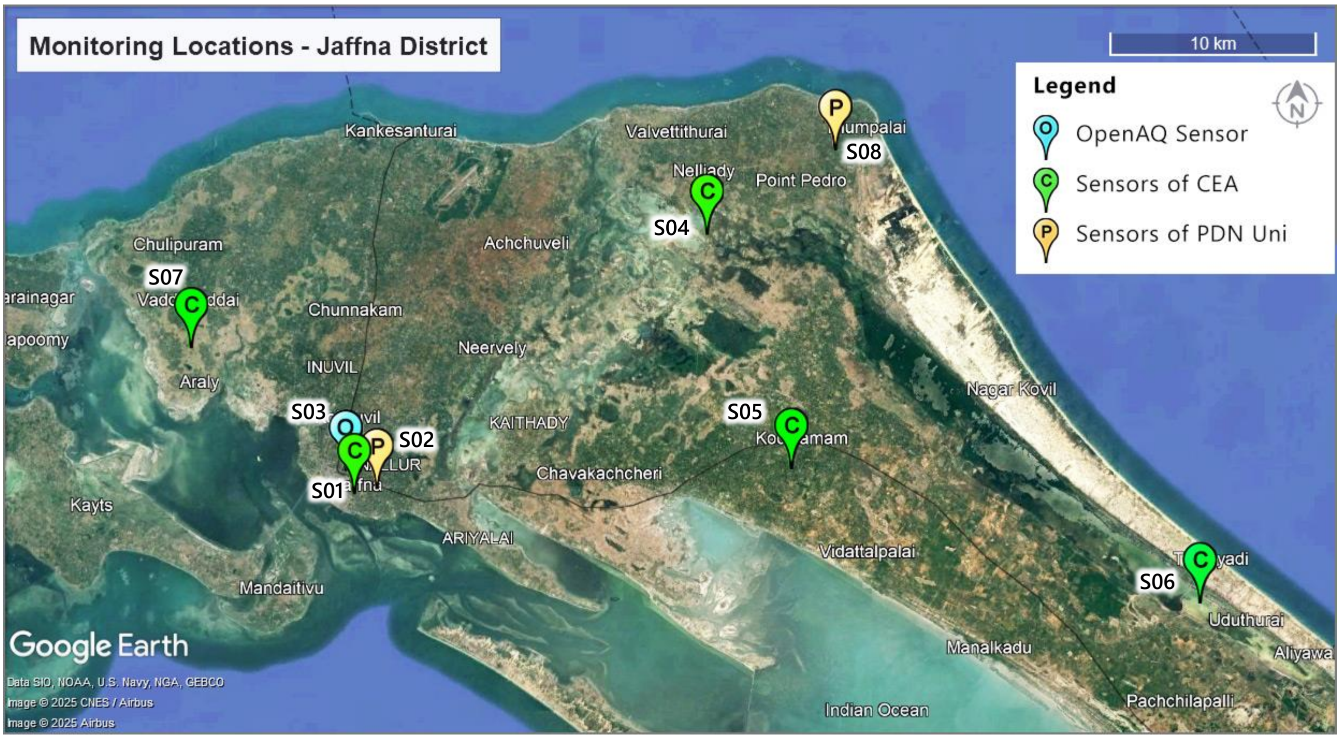


Figure 1: Sites - Satellite View

3. Measurement Results - Pollution Levels

Average $PM_{2.5}$ concentration in Jaffna District (Feb–Mar 2025): **33 µg/m^3**
(Based on data from 8 monitoring stations located within the district)

Average $PM_{2.5}$ concentration in other regions (Feb–Mar 2025): **34 µg/m^3**
(Based on data from 8 monitoring stations situated outside the Jaffna district)

Averaging Method: Combined (Spatial + Temporal).

When averaging air quality data collected across multiple locations and days, two primary methods are commonly used: calculating the Spatial Mean and the Temporal Mean. To obtain a single representative value, the mean of the Spatial Mean and the Temporal Mean were calculated.

Jaffna: Spatial Mean = 32.52, Temporal Mean = 33.00. Mean = 32.76 ~ 33.

Other: Spatial Mean = 33.80, Temporal Mean = 33.91. Mean = 33.86 ~ 34.

Spatial Mean (Average of Location Averages)

First, the average air quality is calculated for each monitoring location across all available days. Then, these location-specific averages are averaged together to obtain the final value, giving equal weight to each location.

Temporal Mean (Average of Daily Averages)

Explanation: Initially, the average air quality is computed for each day across all reporting locations. Subsequently, these daily averages are averaged to yield the final value, ensuring each day contributes equally to the overall average.

Table 2: Averages for each region

<table>
<tr><th colspan="2">Average of the Site</th><th colspan="4">Average of the Sub Region</th><th colspan="2">Average of the Province</th><th colspan="2">Average of the Region</th></tr>
<tr><th>Site</th><th>Mean</th><th>Sub Region</th><th>Mean (Spatial)</th><th>Mean (Temporal)</th><th>Mean (Combo)</th><th>Province</th><th>Mean</th><th>Region</th><th>Mean</th></tr>
<tr><td>S01</td><td>36.4</td><td rowspan="3">Jaffna City Area</td><td rowspan="3">33.59</td><td rowspan="3">33.84</td><td rowspan="3">33.72</td><td rowspan="11">Northern</td><td rowspan="11">31.85</td><td rowspan="8">Jaffna District</td><td rowspan="8">32.76</td></tr>
<tr><td>S02</td><td>32.0</td></tr>
<tr><td>S03</td><td>32.3</td></tr>
<tr><td>S04</td><td>31.2</td><td rowspan="5">Jaffna, Outside the Main City</td><td rowspan="5">31.88</td><td rowspan="5">32.37</td><td rowspan="5">32.14</td></tr>
<tr><td>S05</td><td>31.5</td></tr>
<tr><td>S06</td><td>25.2</td></tr>
<tr><td>S07</td><td>42.6</td></tr>
<tr><td>S08</td><td>28.9</td></tr>
<tr><td>S09</td><td>35.7</td><td rowspan="3">Northern Province</td><td rowspan="3">29.52</td><td rowspan="3">29.55</td><td rowspan="3">29.54</td><td rowspan="8">Other Districts</td><td rowspan="8">33.86</td></tr>
<tr><td>S10</td><td>24.1</td></tr>
<tr><td>S11</td><td>28.7</td></tr>
<tr><td>S12</td><td>34.3</td><td rowspan="5">Outside Northern Province</td><td rowspan="5">36.36</td><td rowspan="5">36.74</td><td rowspan="5">36.55</td><td rowspan="5">Other Provinces</td><td rowspan="5">36.55</td></tr>
<tr><td>S13</td><td>34.1</td></tr>
<tr><td>S14</td><td>38.9</td></tr>
<tr><td>S15</td><td>39.0</td></tr>
<tr><td>S16</td><td>35.6</td></tr>
</table>

4. Pollution Patterns

Presented here are the patterns and pollution levels of PM2.5 (µg/m^3) observed across various locations over a 3-month period, spanning January, February, and March. Four distinct visualizations are given.

Daily PM2.5 Levels: The daily average concentration (calculated over a 24-hour period) is depicted, illustrating its variation throughout the monitoring duration.

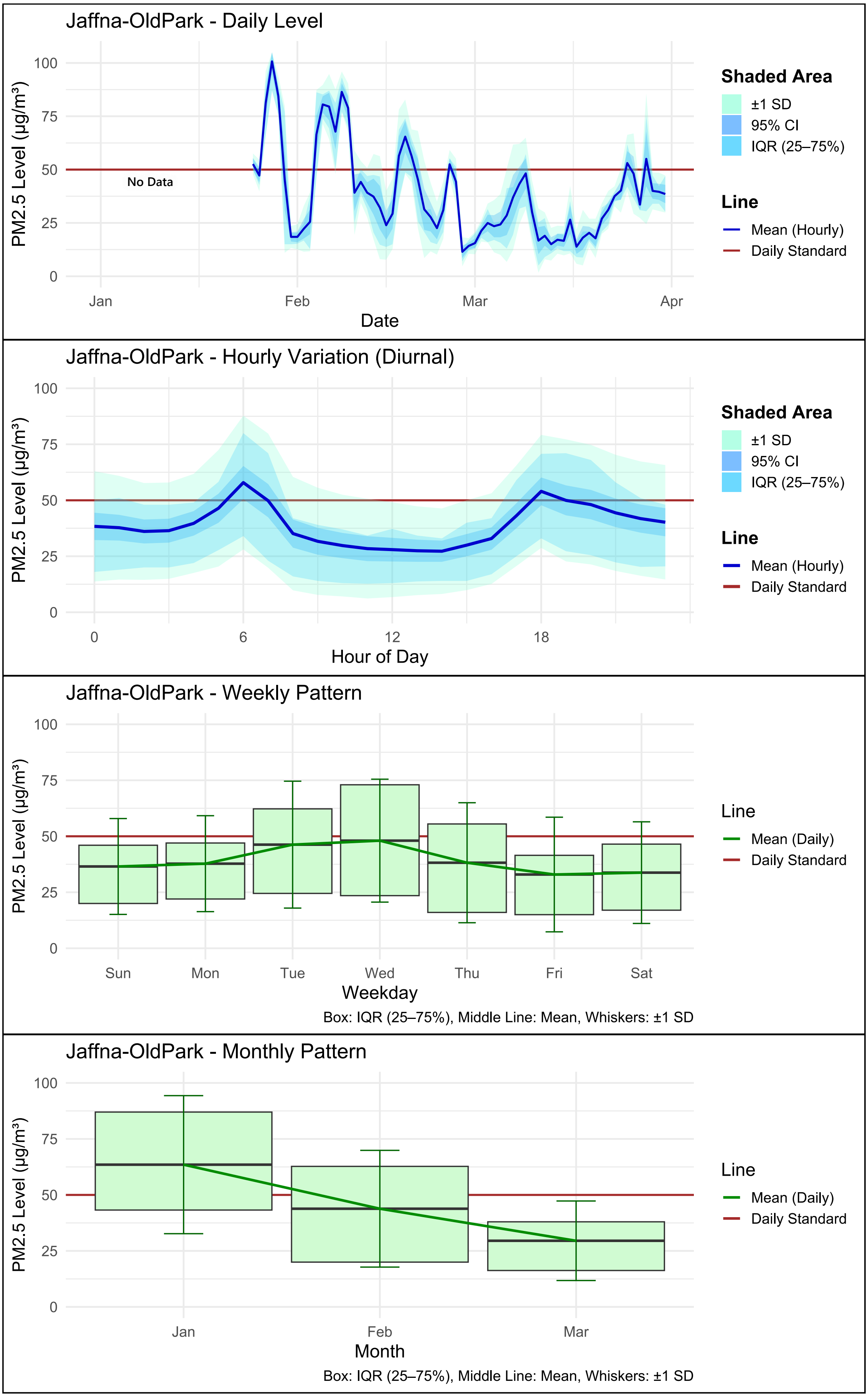
Hourly Variation (Diurnal): Hourly changes in PM2.5 levels are presented in a diurnal plot, revealing how concentrations fluctuate throughout the day. Potential recurring peaks, such as those associated with traffic, may be identified.

Weekly Pattern: The variation in pollution levels across different days of the week, differentiating between weekdays and weekends, is shown.

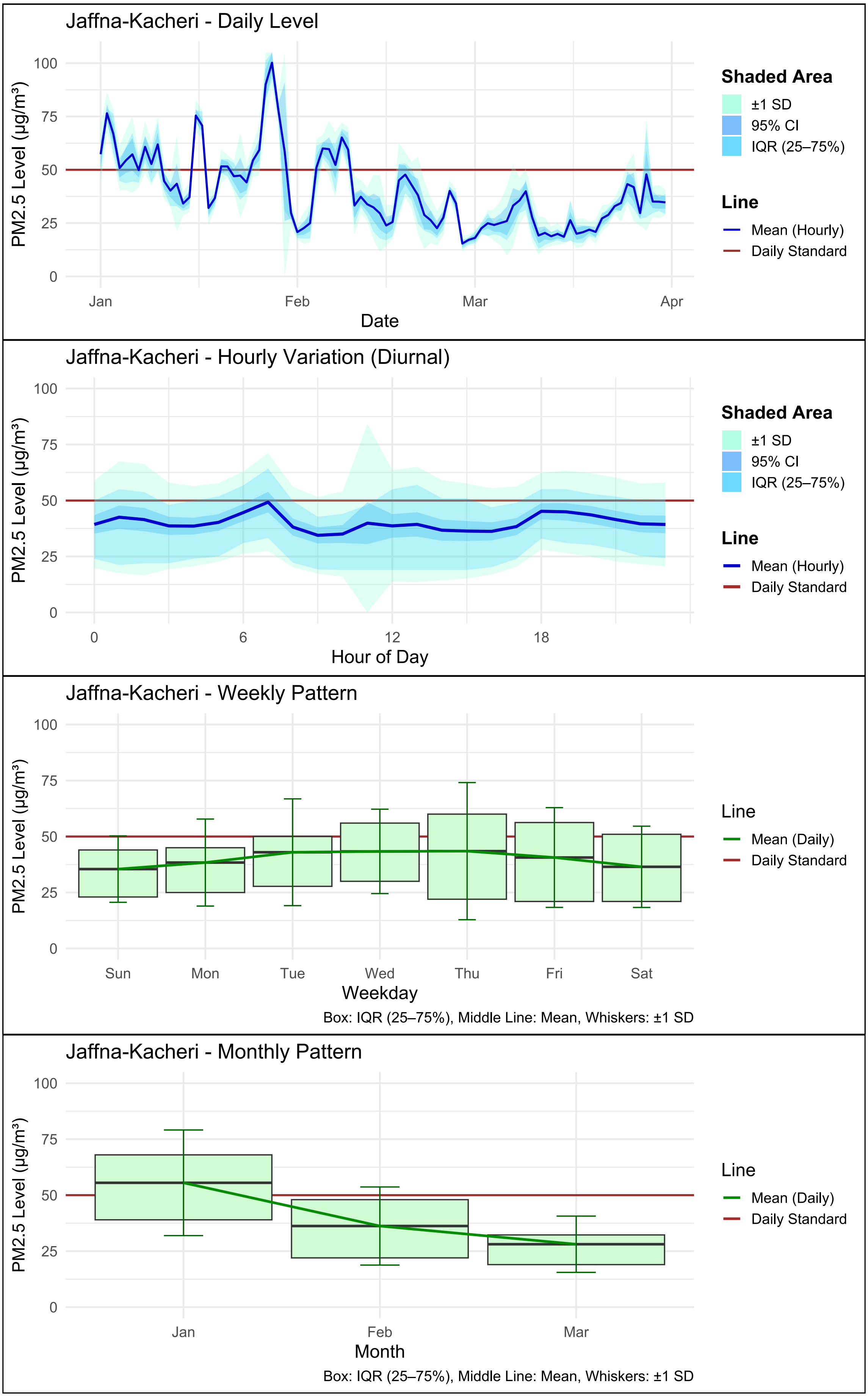
Monthly Pattern: The average pollution level for each month within the three-month period is illustrated.

It is important to note that these plots are generated using available data. Consequently, the inherent uncertainty in the visualizations may be higher at times and locations where data completeness is lower. While a data completeness threshold of two-thirds was applied during the calculation of daily averages from hourly values, this threshold was not consistently applied in the generation of the other plots presented.

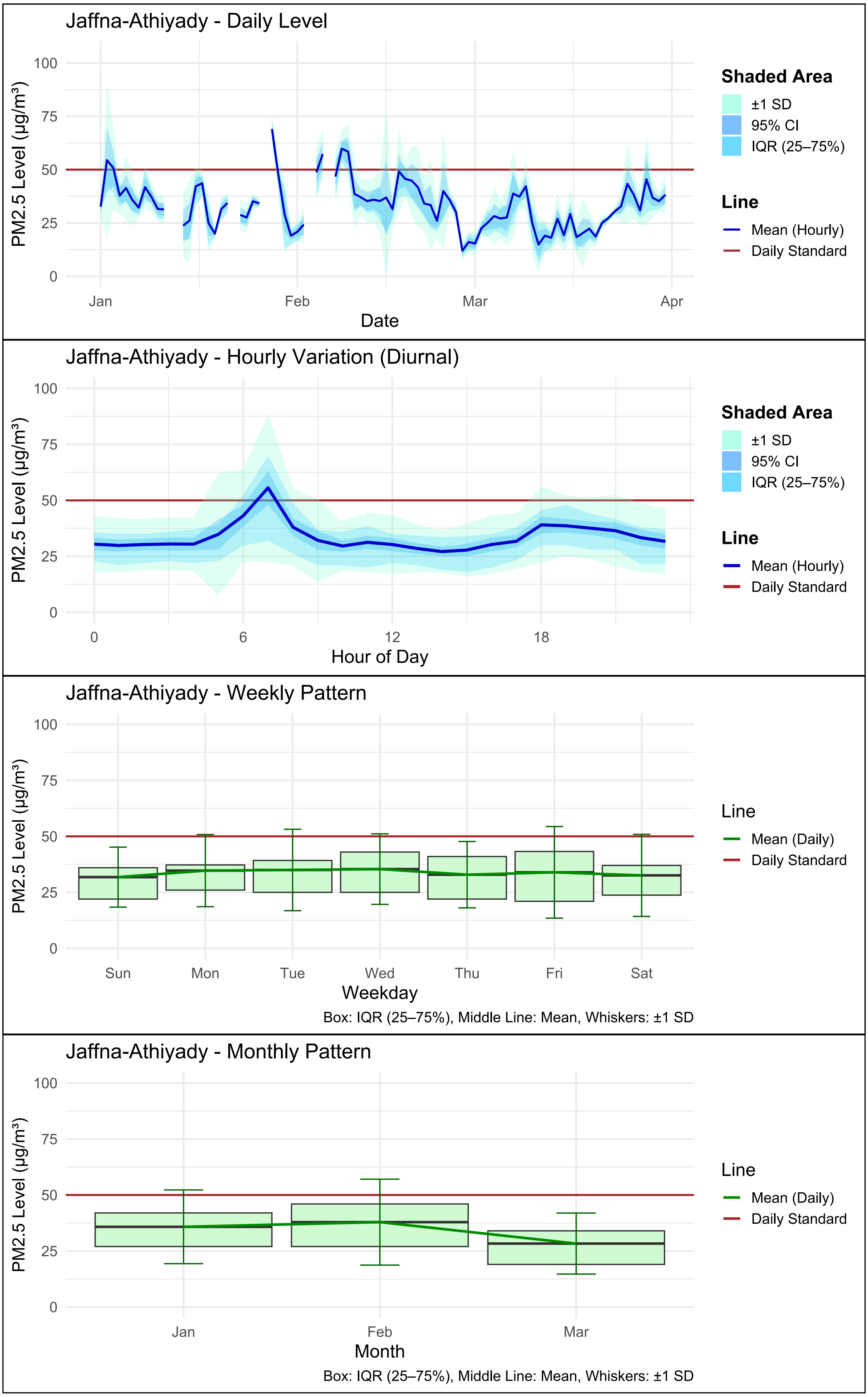
4.1. Patterns - Jaffna District



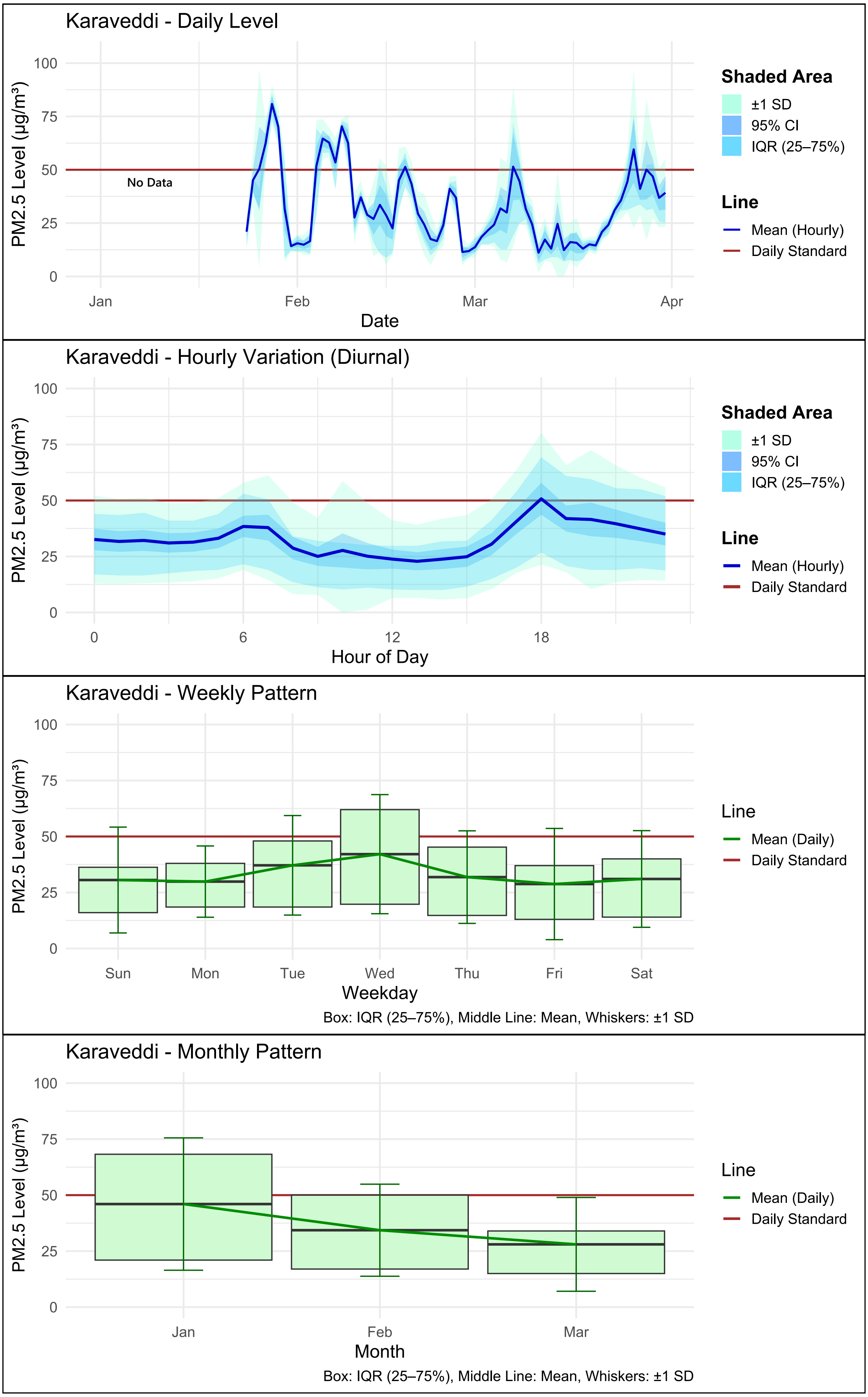
Graph 1: S01


Jaffna-Kacheri - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Jaffna-Kacheri - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
100
75
50
25
0
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Jaffna-Kacheri - Weekly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Line
Mean (Daily)
Daily Standard
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Jaffna-Kacheri - Monthly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Month
Line
Mean (Daily)
Daily Standard
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD

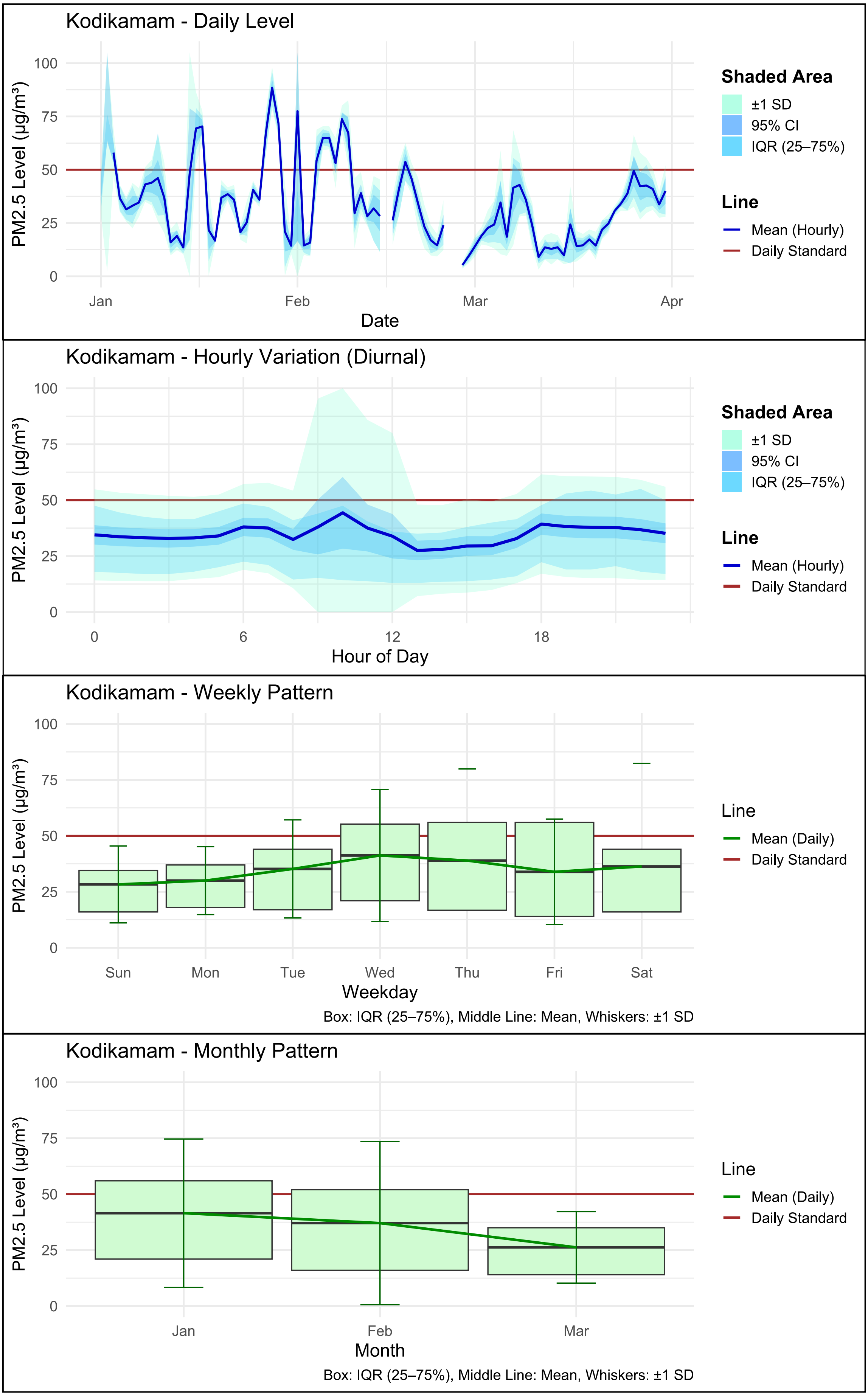
Graph 2: S02


Jaffna-Athiyady - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Jaffna-Athiyady - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
100
75
50
25
0
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Jaffna-Athiyady - Weekly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
Jaffna-Athiyady - Monthly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

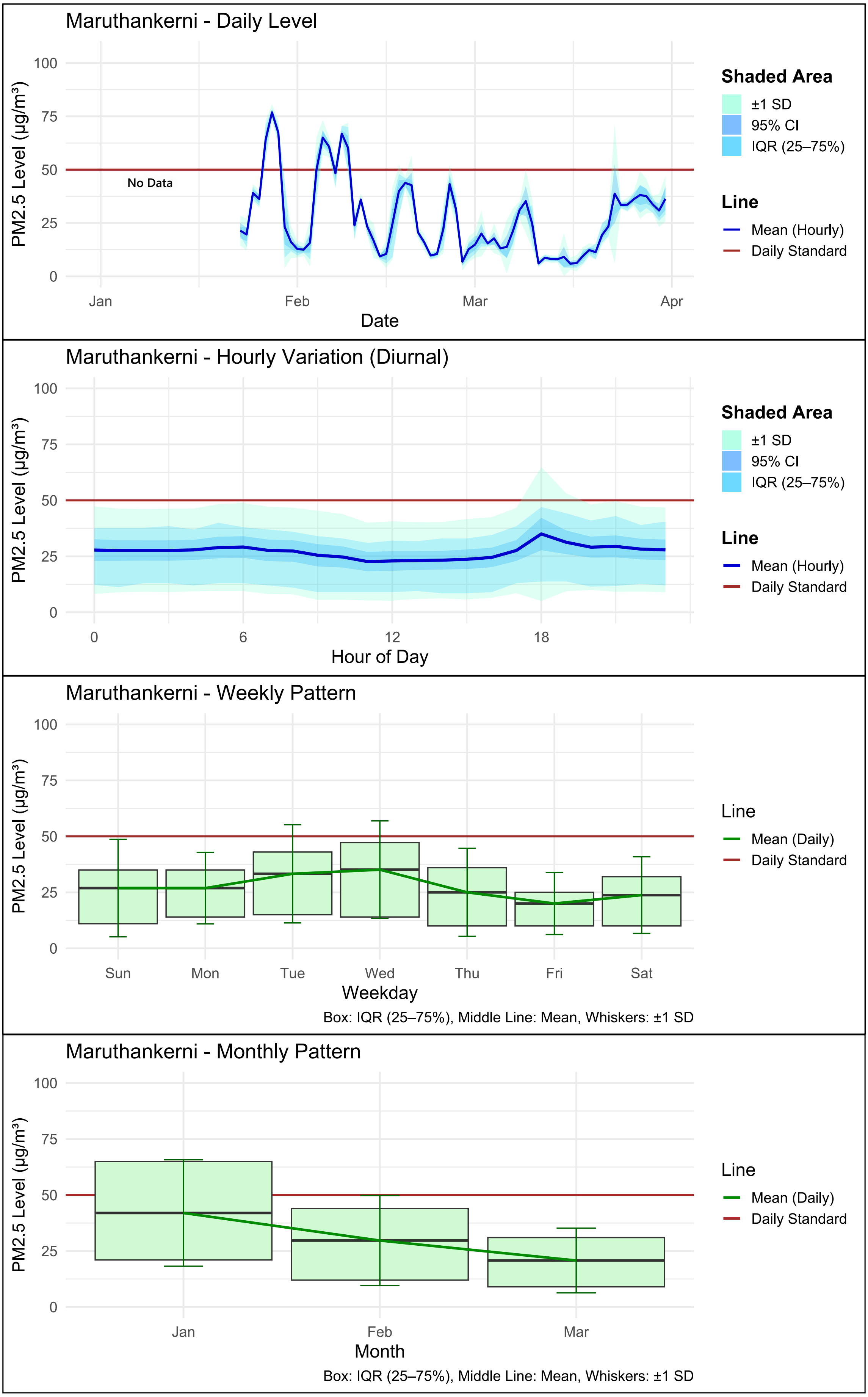
Graph 3: S03


Karaveddi - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
No Data
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Karaveddi - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
100
75
50
25
0
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Karaveddi - Weekly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
Karaveddi - Monthly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

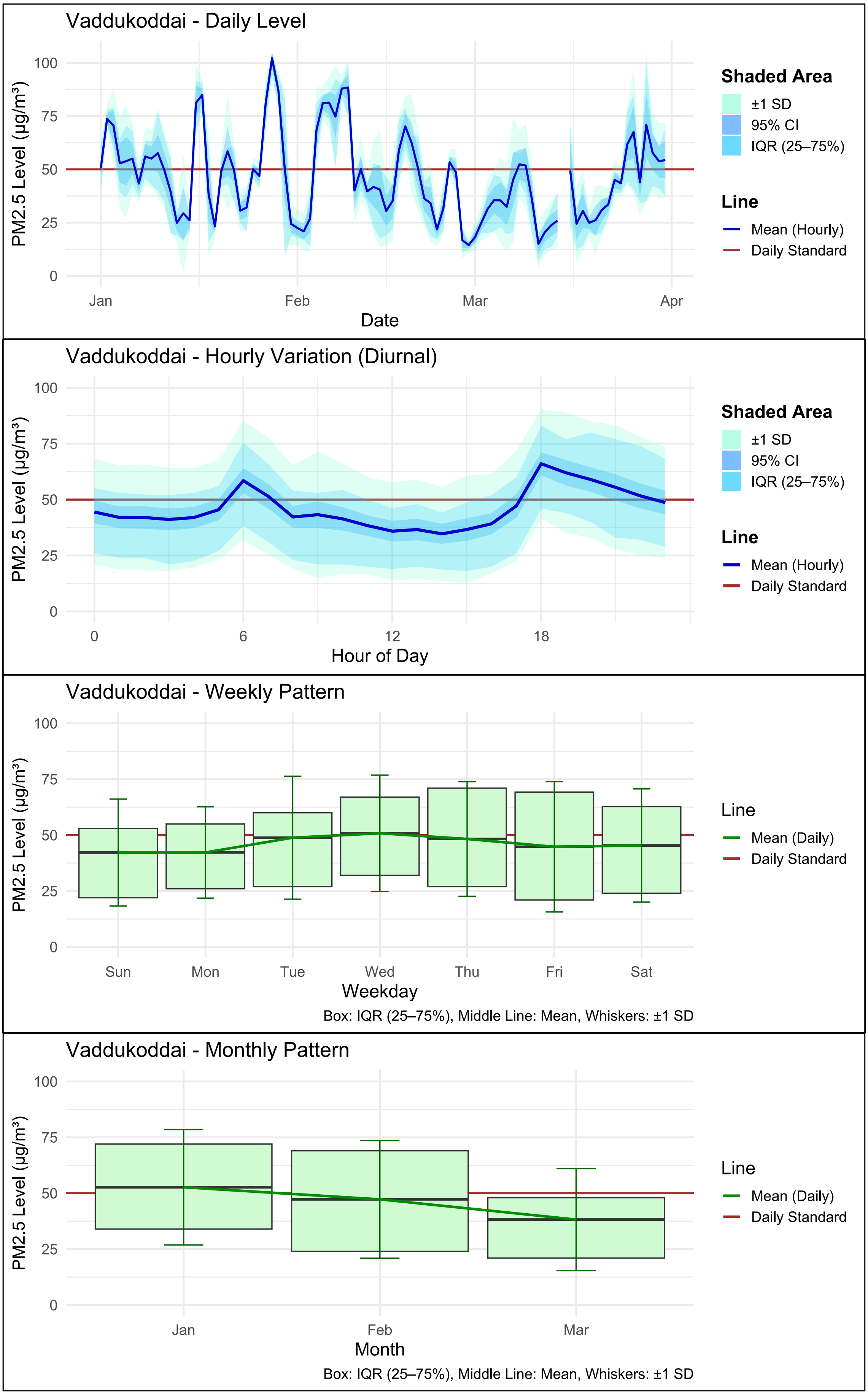
Graph 4: S04


Kodikamam - Daily Level
100
75
50
25
0
PM2.5 Level (µg/m³)
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Kodikamam - Hourly Variation (Diurnal)
100
75
50
25
0
PM2.5 Level (µg/m³)
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Kodikamam - Weekly Pattern
100
75
50
25
0
PM2.5 Level (µg/m³)
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
Kodikamam - Monthly Pattern
100
75
50
25
0
PM2.5 Level (µg/m³)
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

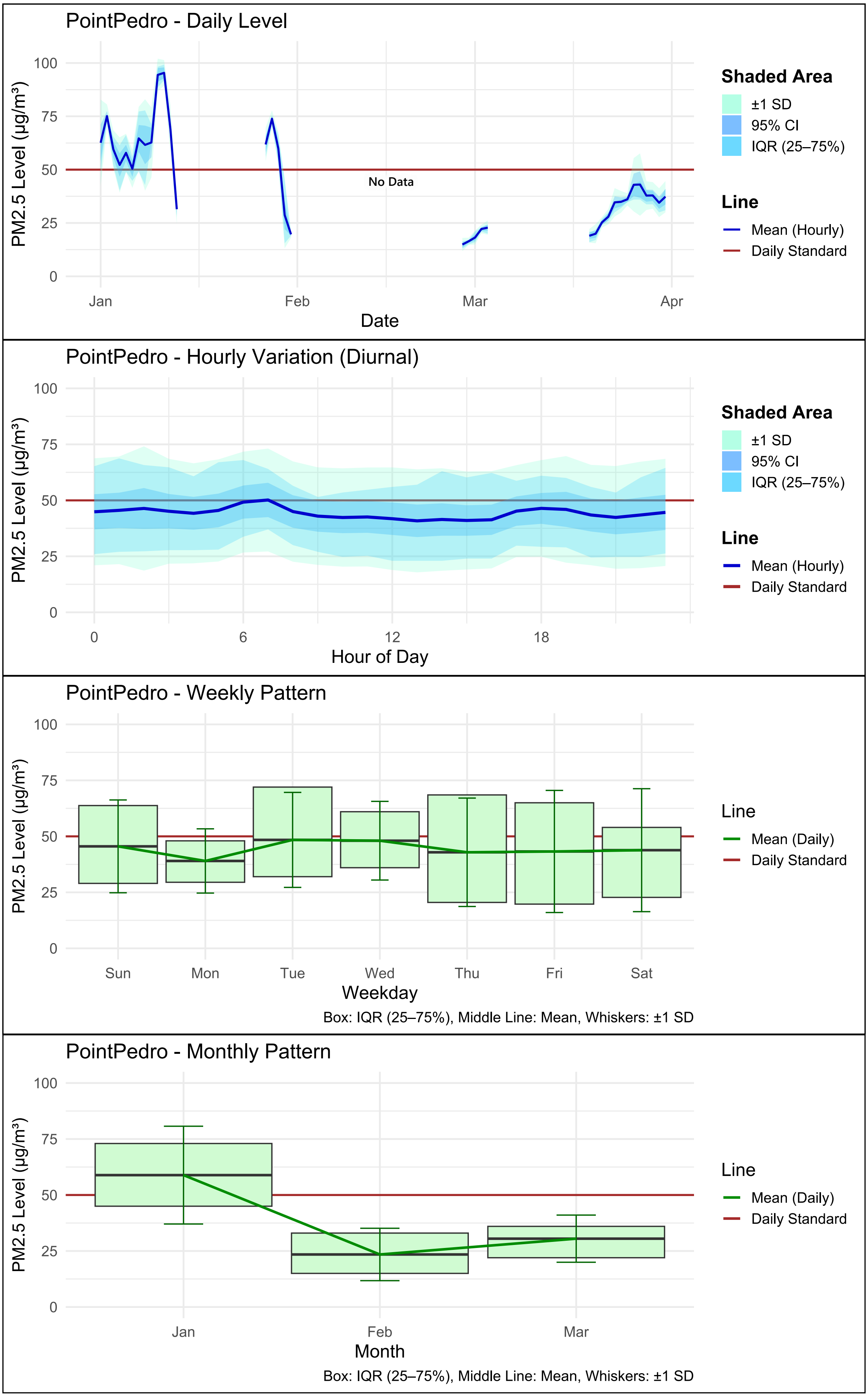
Graph 5: S05


Maruthankerni - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
No Data
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Maruthankerni - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
100
75
50
25
0
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Maruthankerni - Weekly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
Maruthankerni - Monthly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

Graph 6: S06

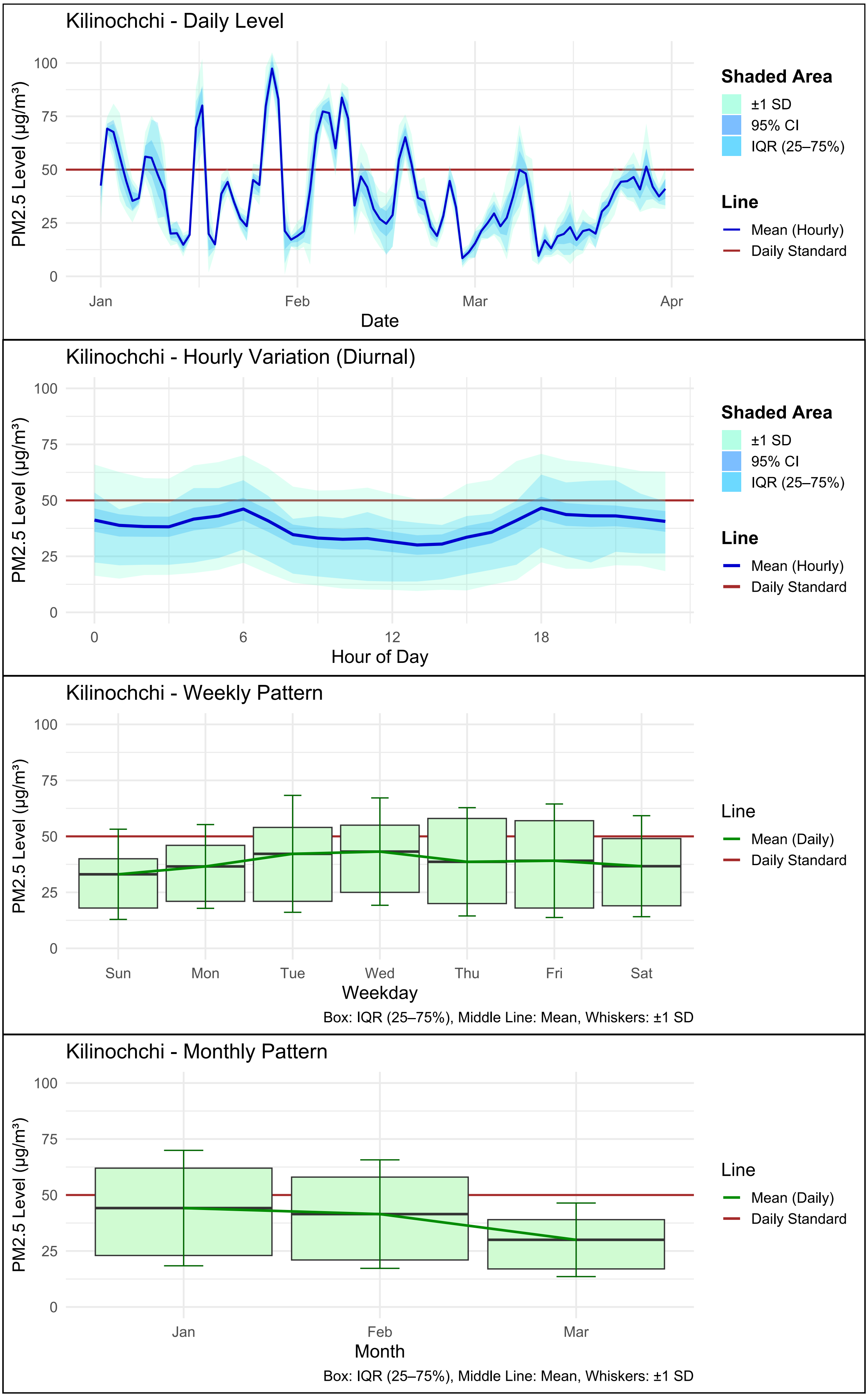

Vaddukoddai - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Vaddukoddai - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Vaddukoddai - Weekly Pattern
PM2.5 Level (µg/m³)
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
Vaddukoddai - Monthly Pattern
PM2.5 Level (µg/m³)
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

Graph 7: S07

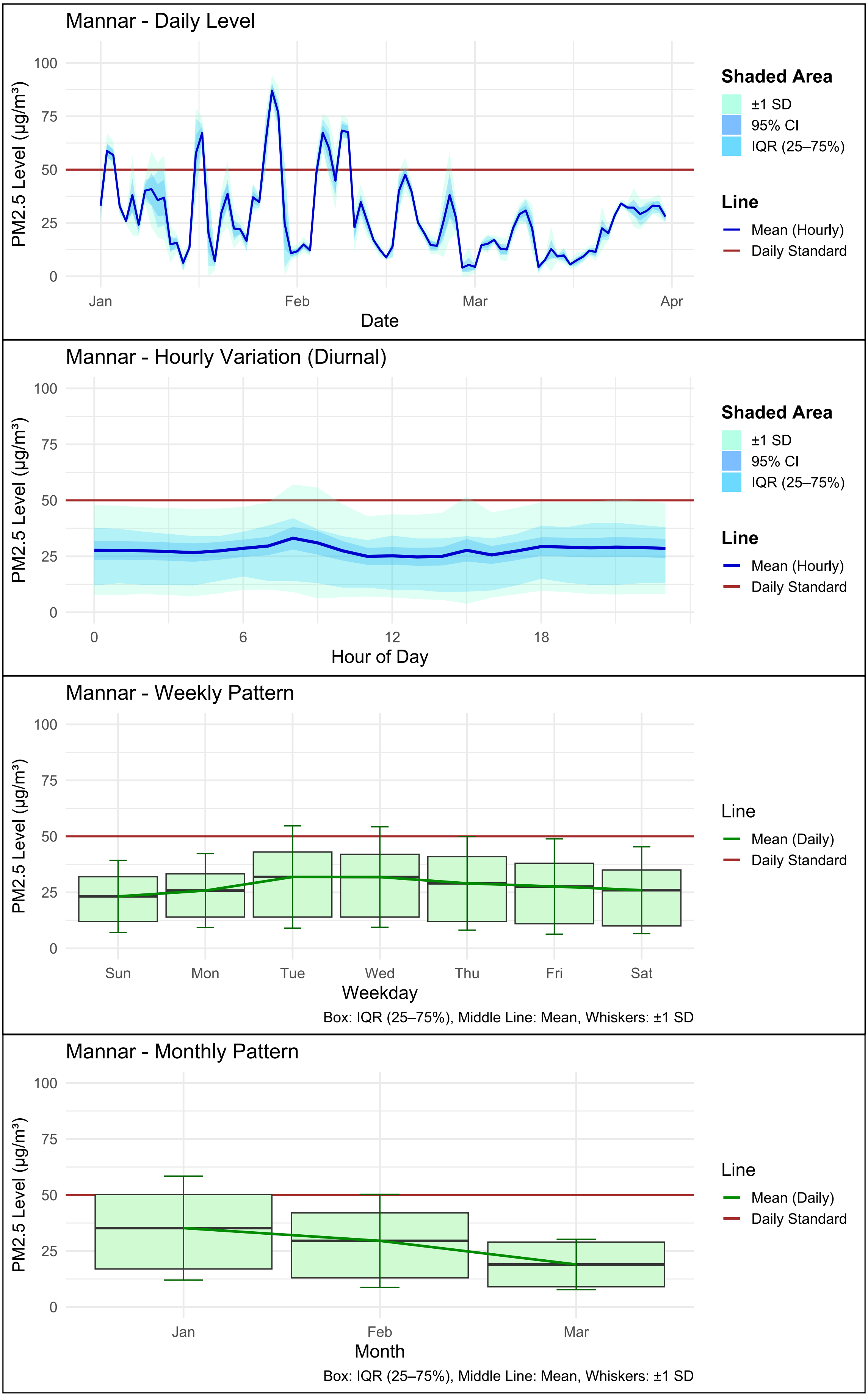

PointPedro - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
No Data
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
PointPedro - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
100
75
50
25
0
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
PointPedro - Weekly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
PointPedro - Monthly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

Graph 8: S08

4.2. Patterns – Outside Jaffna District

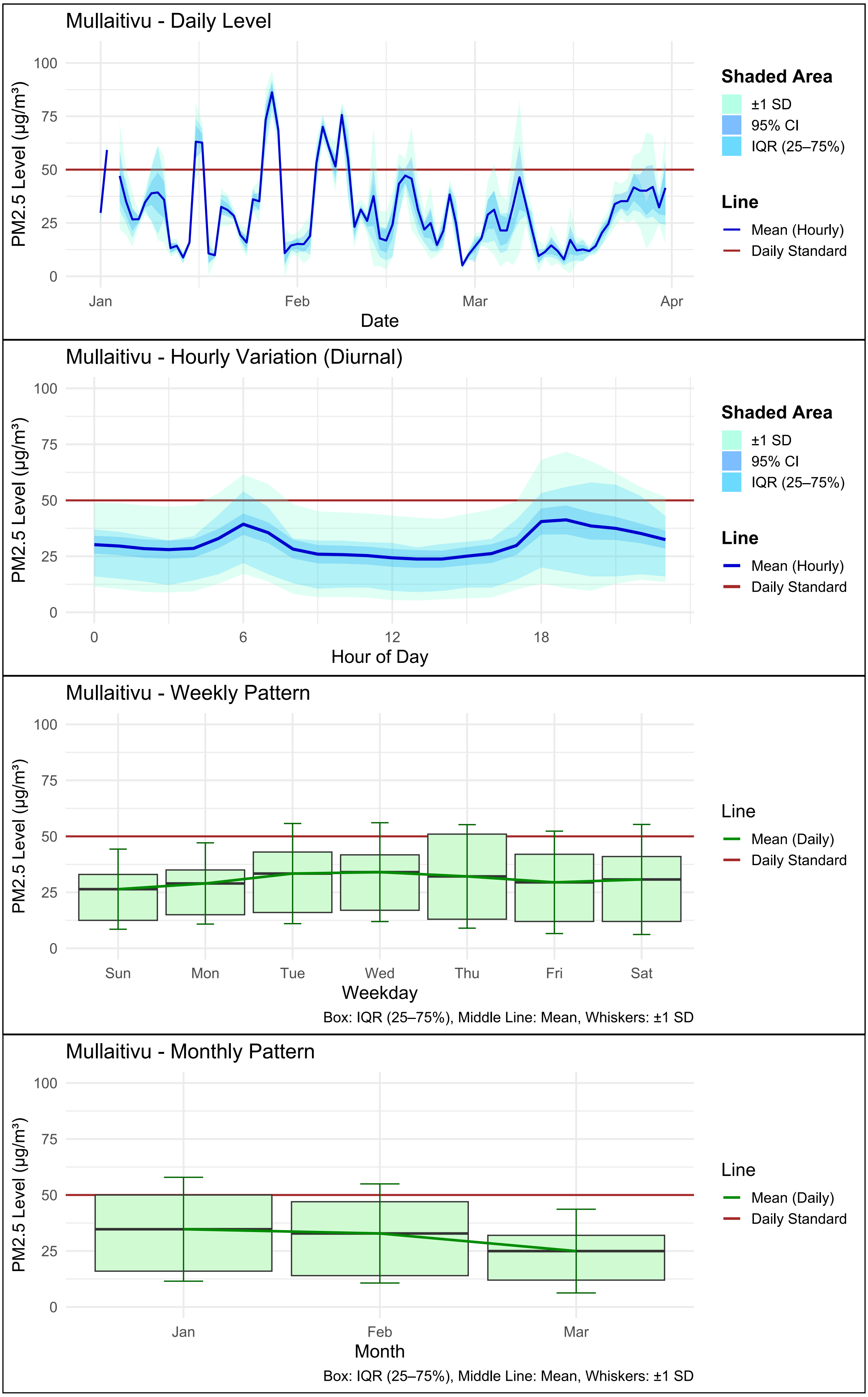


Graph 9: S09

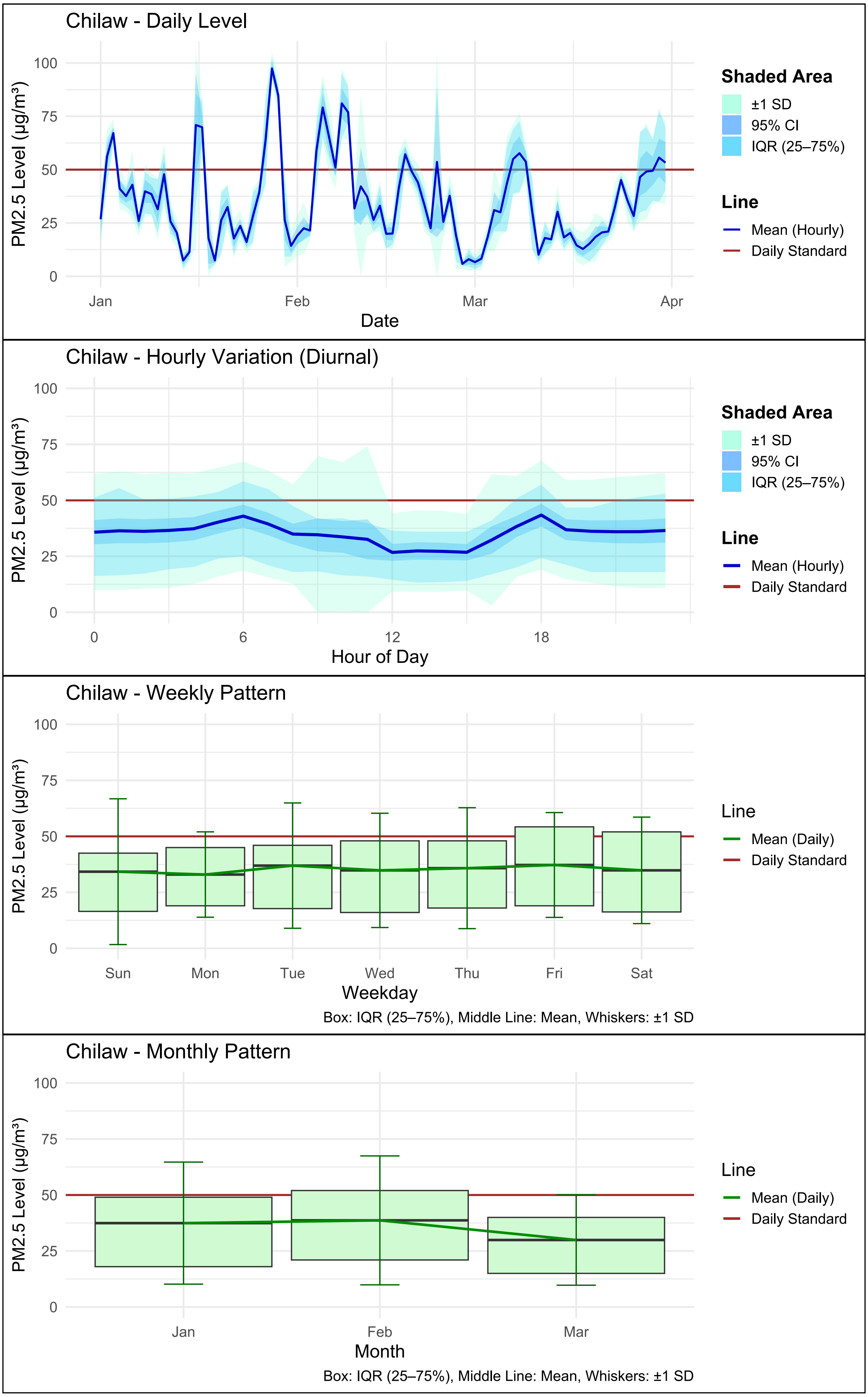


Mannar - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Mannar - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Mannar - Weekly Pattern
PM2.5 Level (µg/m³)
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
Mannar - Monthly Pattern
PM2.5 Level (µg/m³)
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

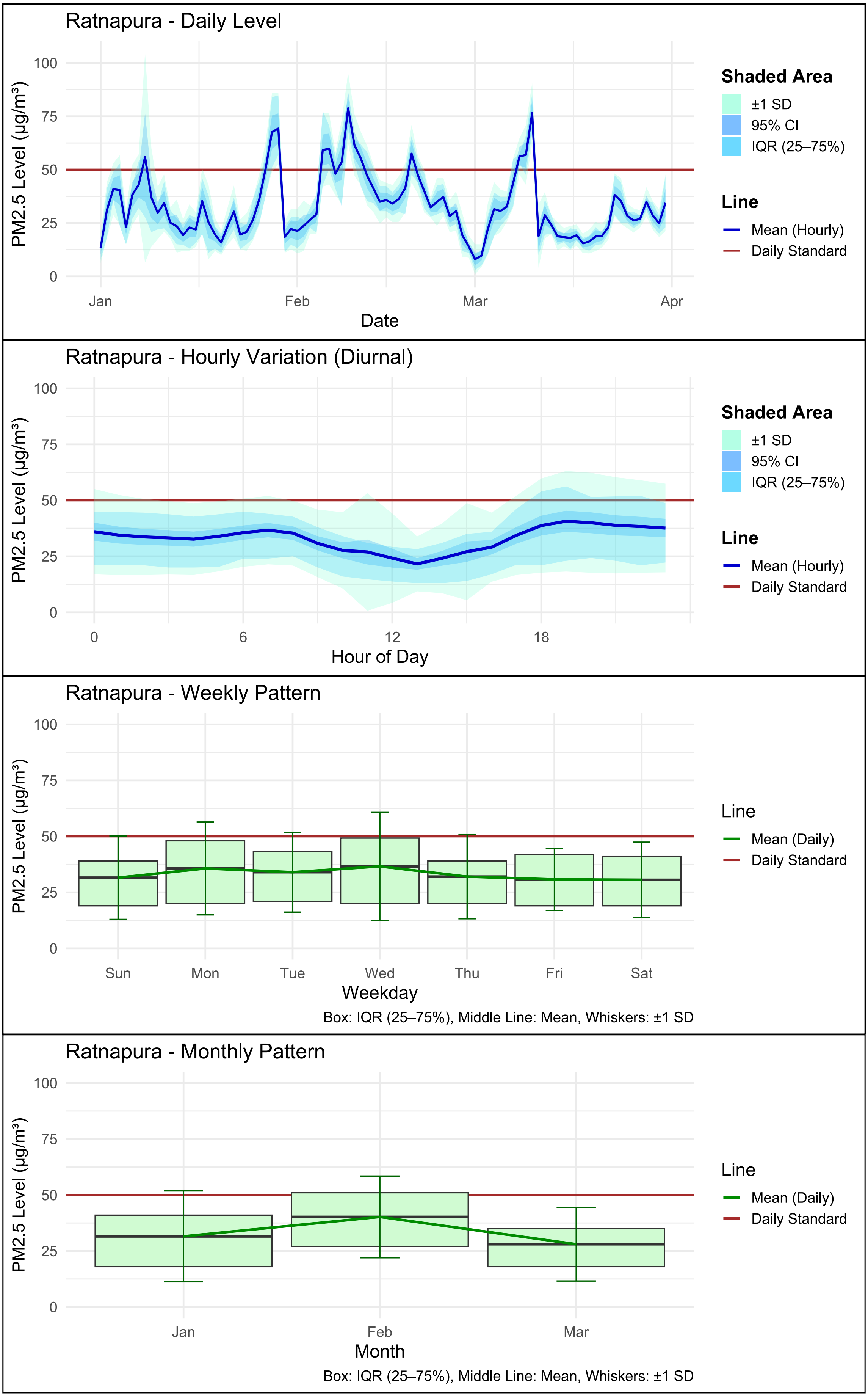
Graph 10: S10


Mullaitivu - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Mullaitivu - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
100
75
50
25
0
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Mullaitivu - Weekly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Line
Mean (Daily)
Daily Standard
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Mullaitivu - Monthly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Month
Line
Mean (Daily)
Daily Standard
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD

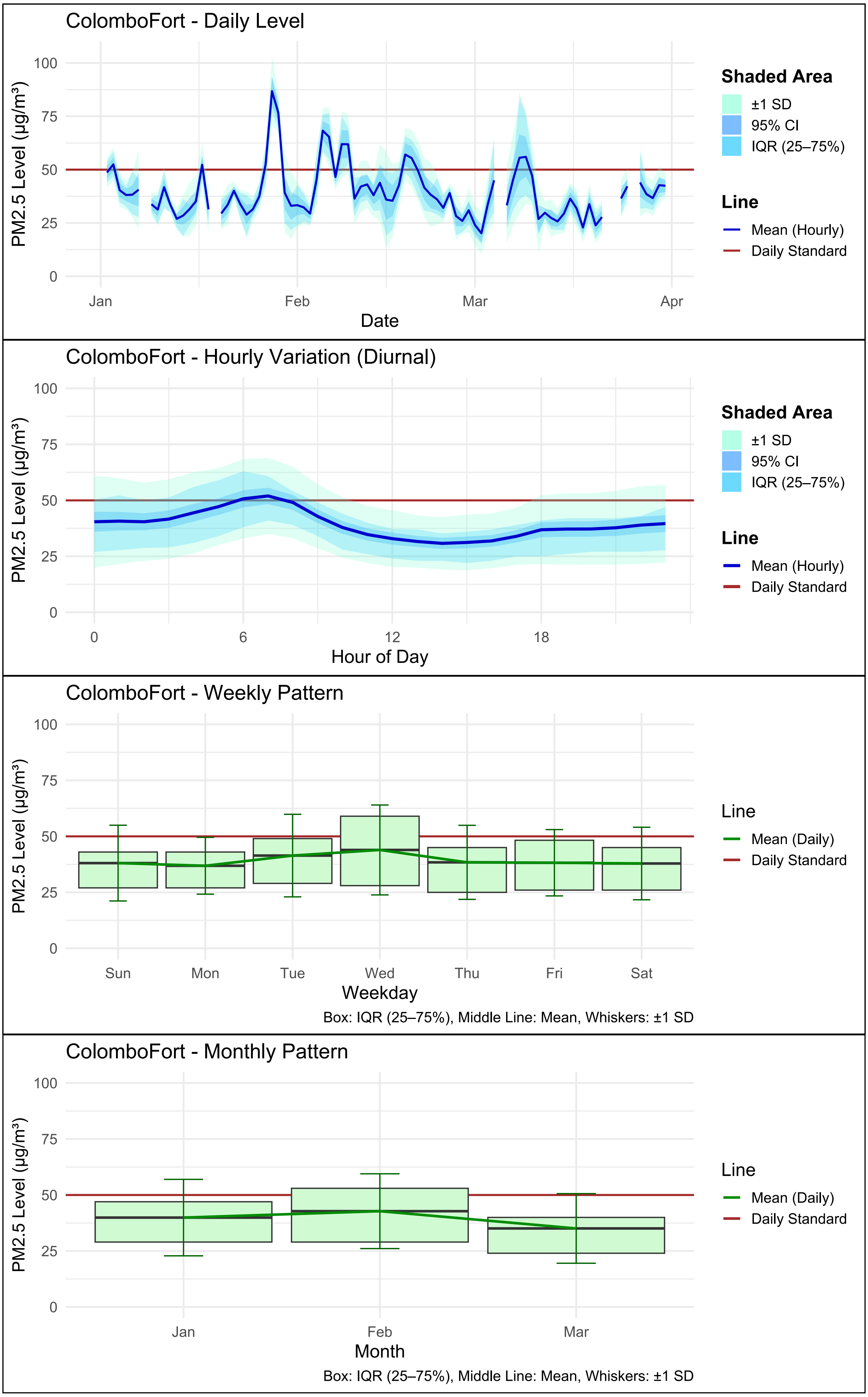
Graph 11: S11


Chilaw - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Chilaw - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
100
75
50
25
0
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Chilaw - Weekly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
Chilaw - Monthly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

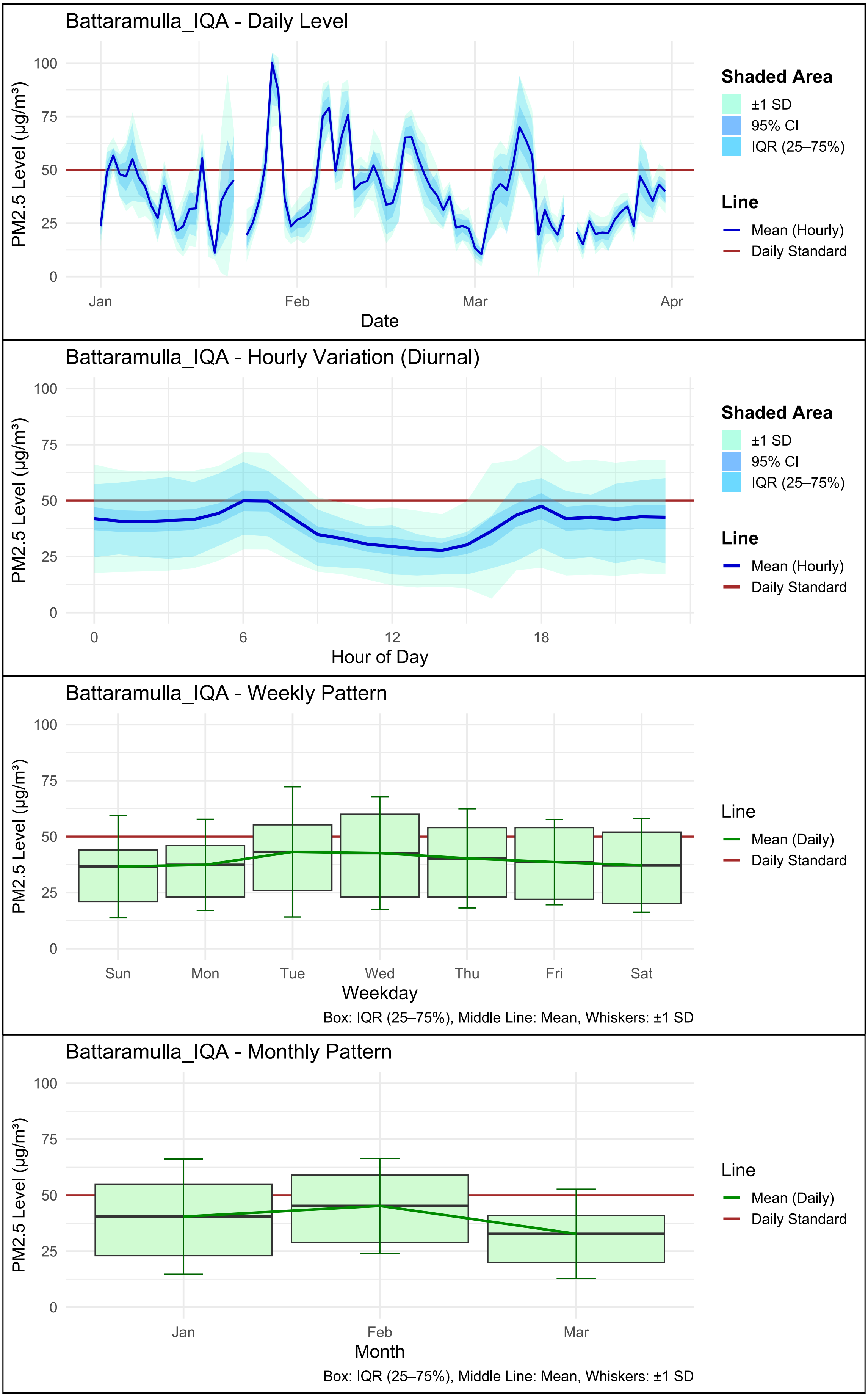
Graph 12: S12


Ratnapura - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Ratnapura - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Ratnapura - Weekly Pattern
PM2.5 Level (µg/m³)
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
Ratnapura - Monthly Pattern
PM2.5 Level (µg/m³)
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

Graph 13: S13

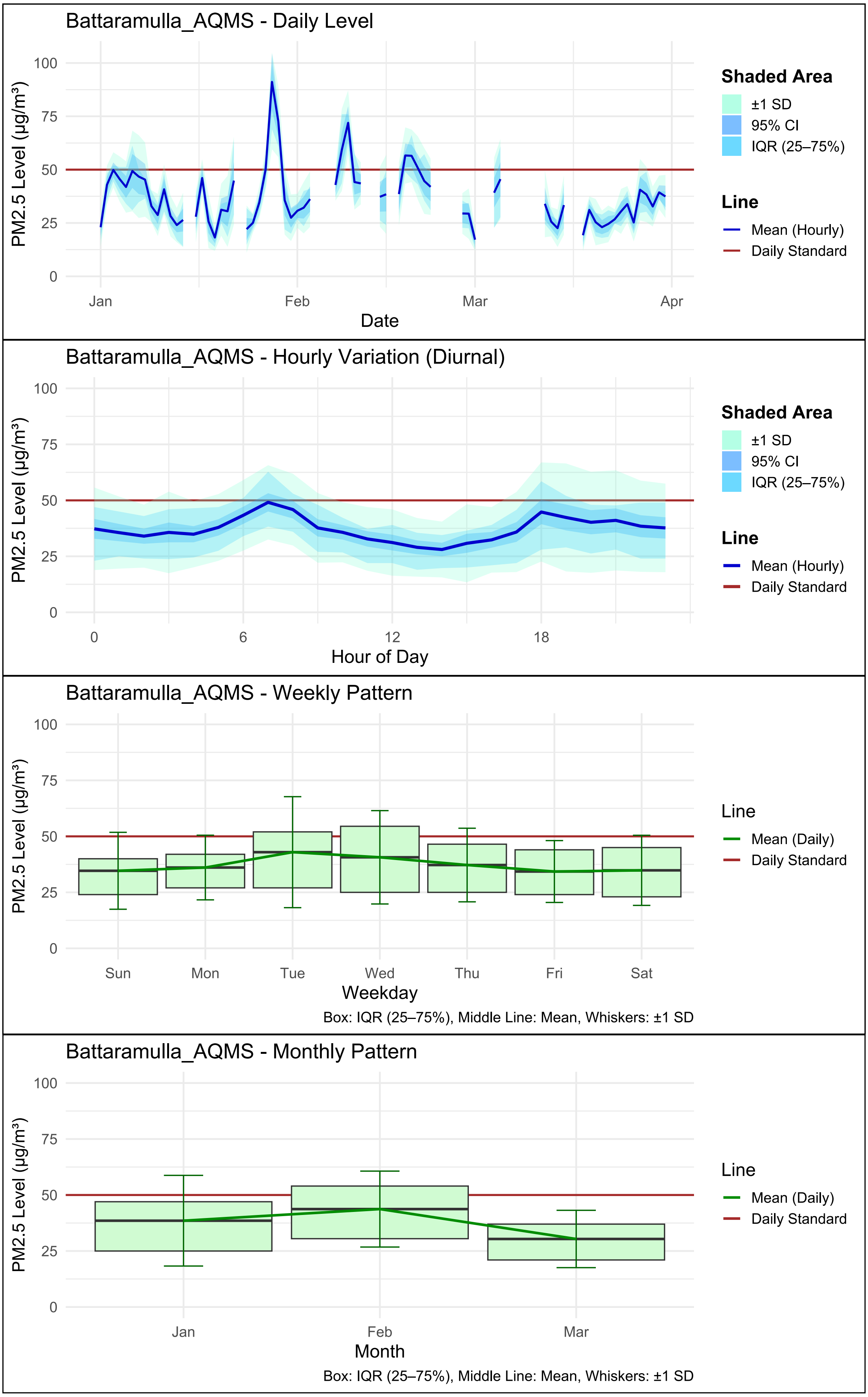

ColomboFort - Daily Level
PM2.5 Level (µg/m³)
Date
Jan
Feb
Mar
Apr
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
ColomboFort - Hourly Variation (Diurnal)
Hour of Day
ColomboFort - Weekly Pattern
Weekday
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Mean (Daily)
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
ColomboFort - Monthly Pattern
Month

Graph 14: S14



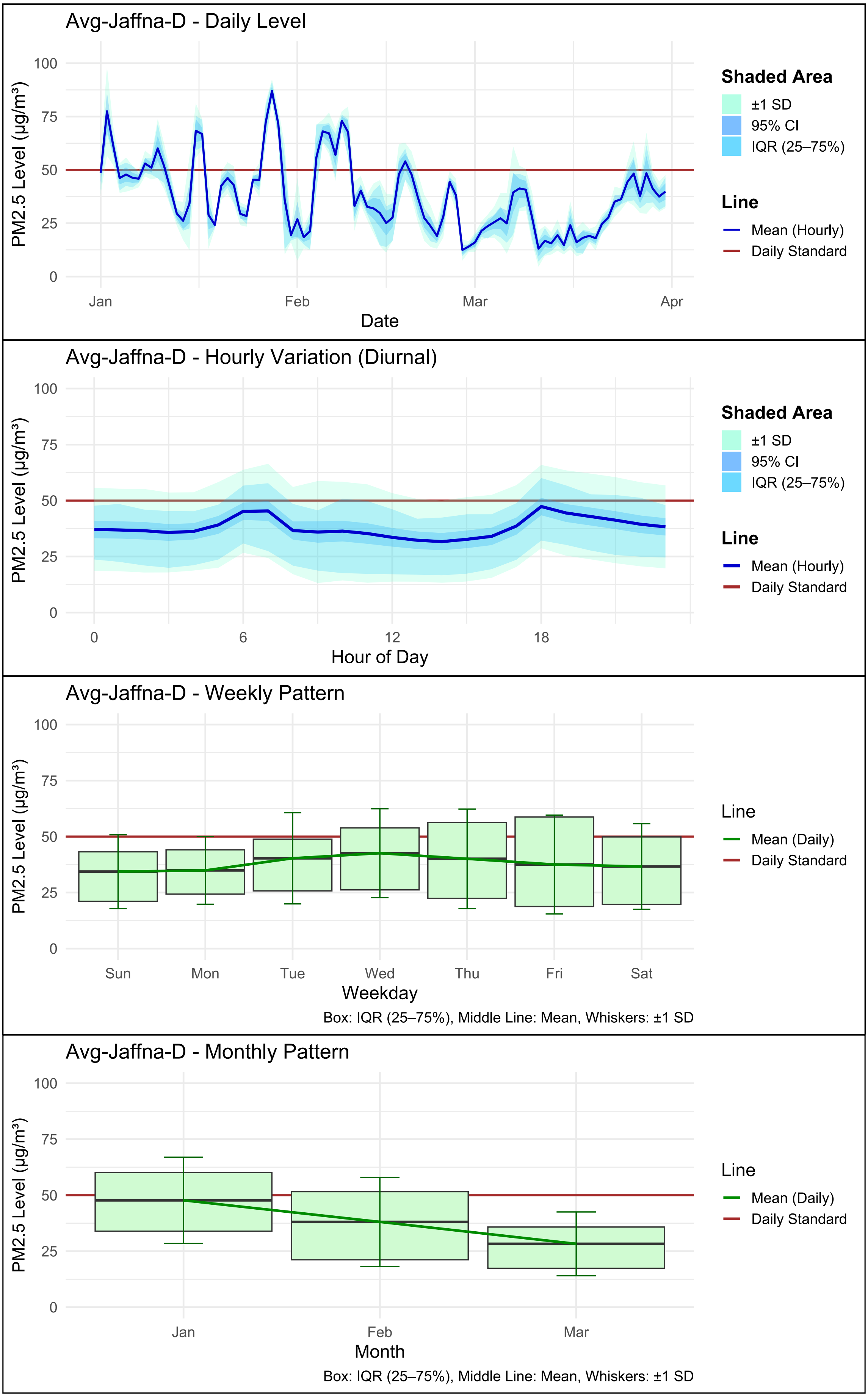
Battaramulla_IQA - Daily Level
PM2.5 Level (µg/m³)
Date
Jan
Feb
Mar
Apr
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Battaramulla_IQA - Hourly Variation (Diurnal)
Hour of Day
Battaramulla_IQA - Weekly Pattern
Weekday
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Mean (Daily)
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Battaramulla_IQA - Monthly Pattern
Month

Graph 15: S15

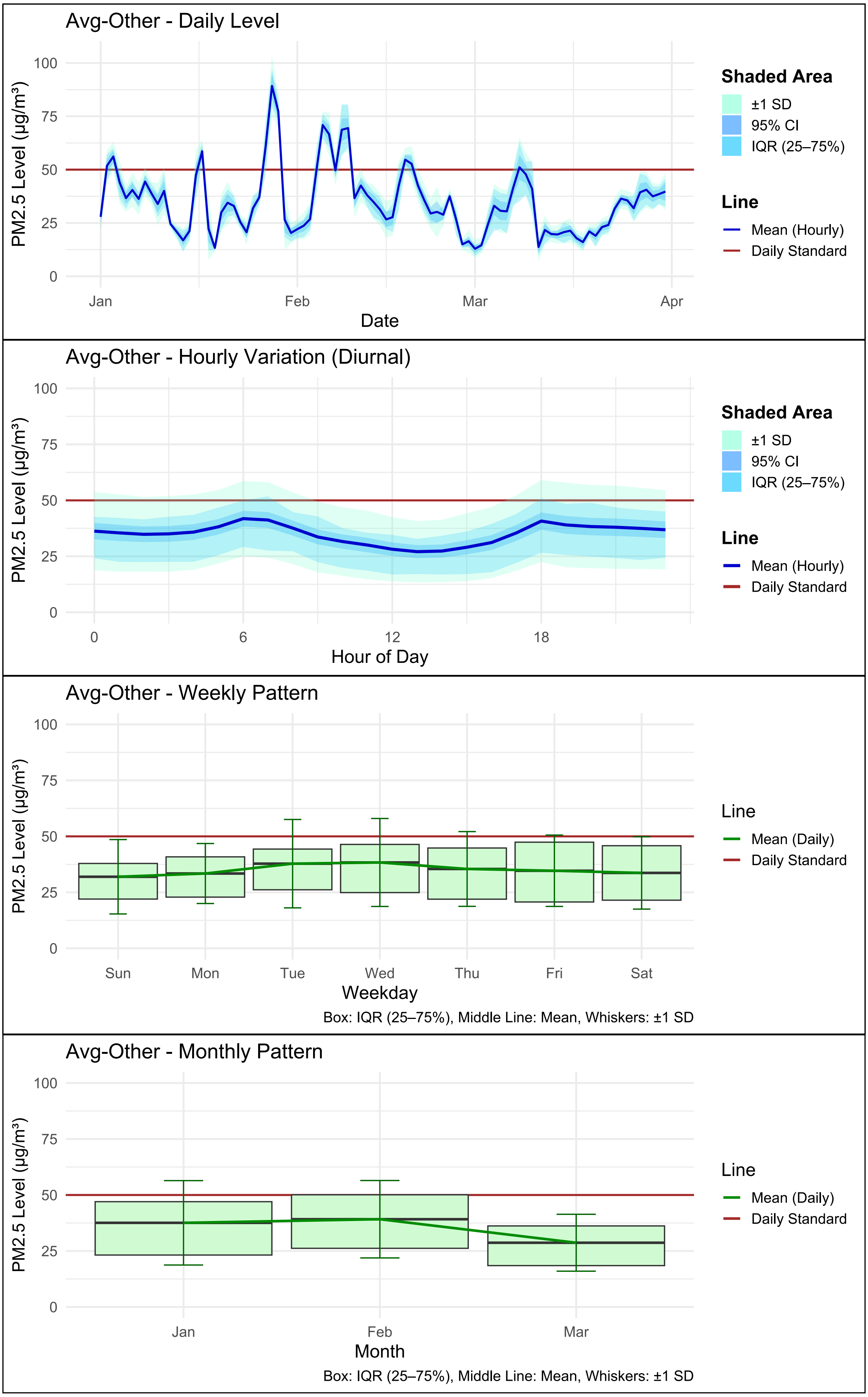

Battaramulla_AQMS - Daily Level
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Apr
Date
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Battaramulla_AQMS - Hourly Variation (Diurnal)
PM2.5 Level (µg/m³)
100
75
50
25
0
0
6
12
18
Hour of Day
Shaded Area
±1 SD
95% CI
IQR (25–75%)
Line
Mean (Hourly)
Daily Standard
Battaramulla_AQMS - Weekly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Weekday
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard
Battaramulla_AQMS - Monthly Pattern
PM2.5 Level (µg/m³)
100
75
50
25
0
Jan
Feb
Mar
Month
Box: IQR (25–75%), Middle Line: Mean, Whiskers: ±1 SD
Line
Mean (Daily)
Daily Standard

Graph 16: S16

4.3. Patterns – Averages of Jaffna District and Other Regions

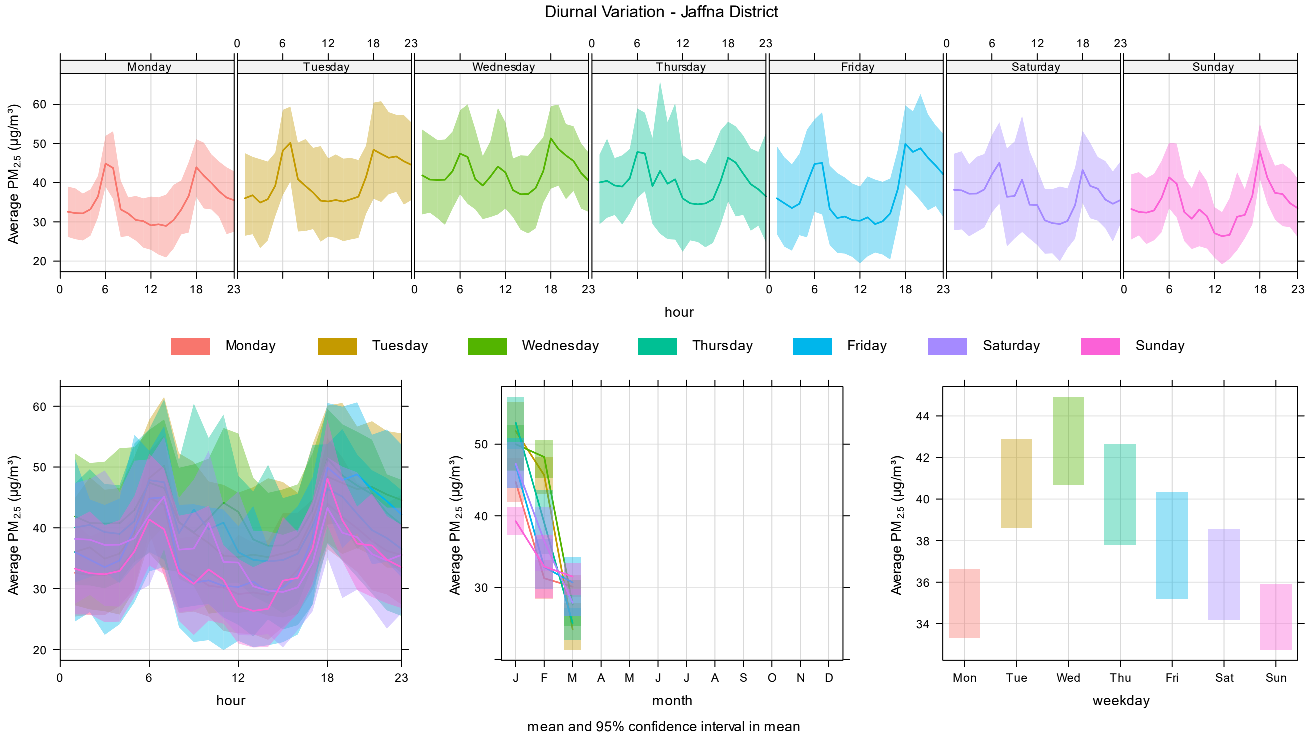


Graph 17: Average of Jaffna District (Avg S01-S08)

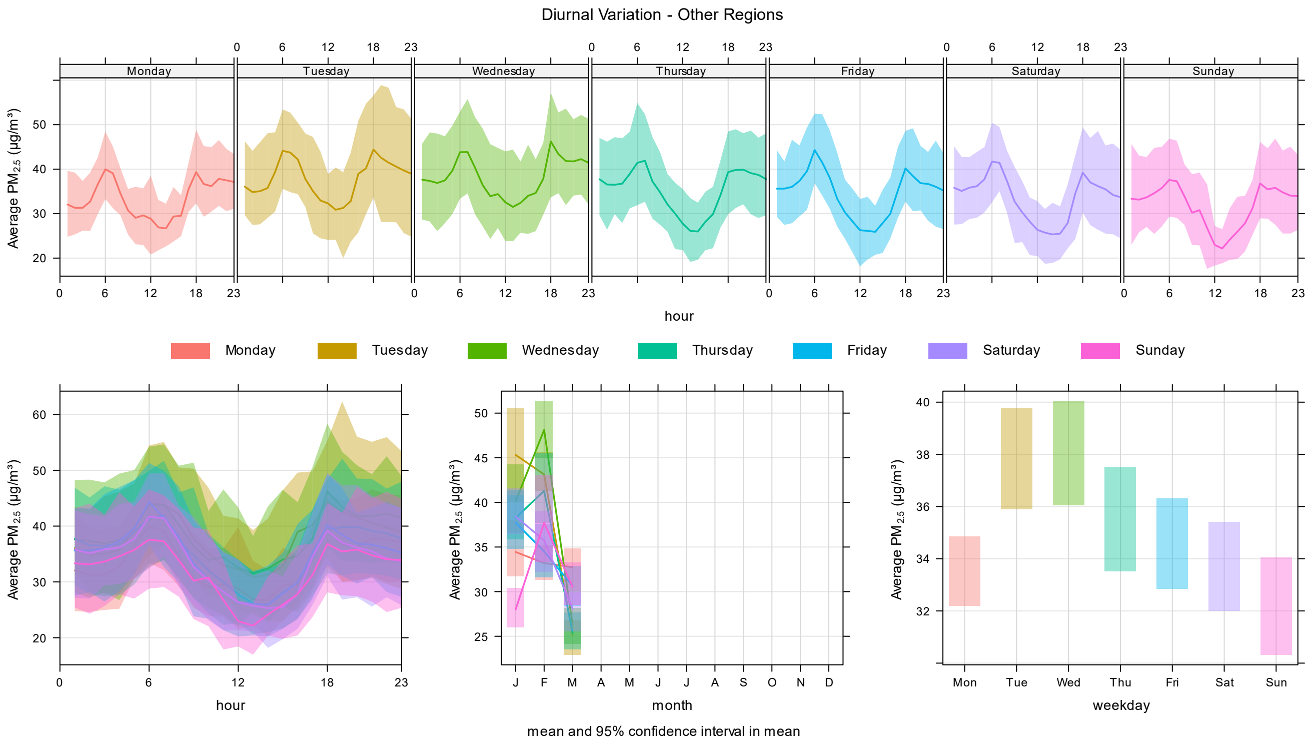


Graph 18: Average of Other Regions (Avg S09-S16)

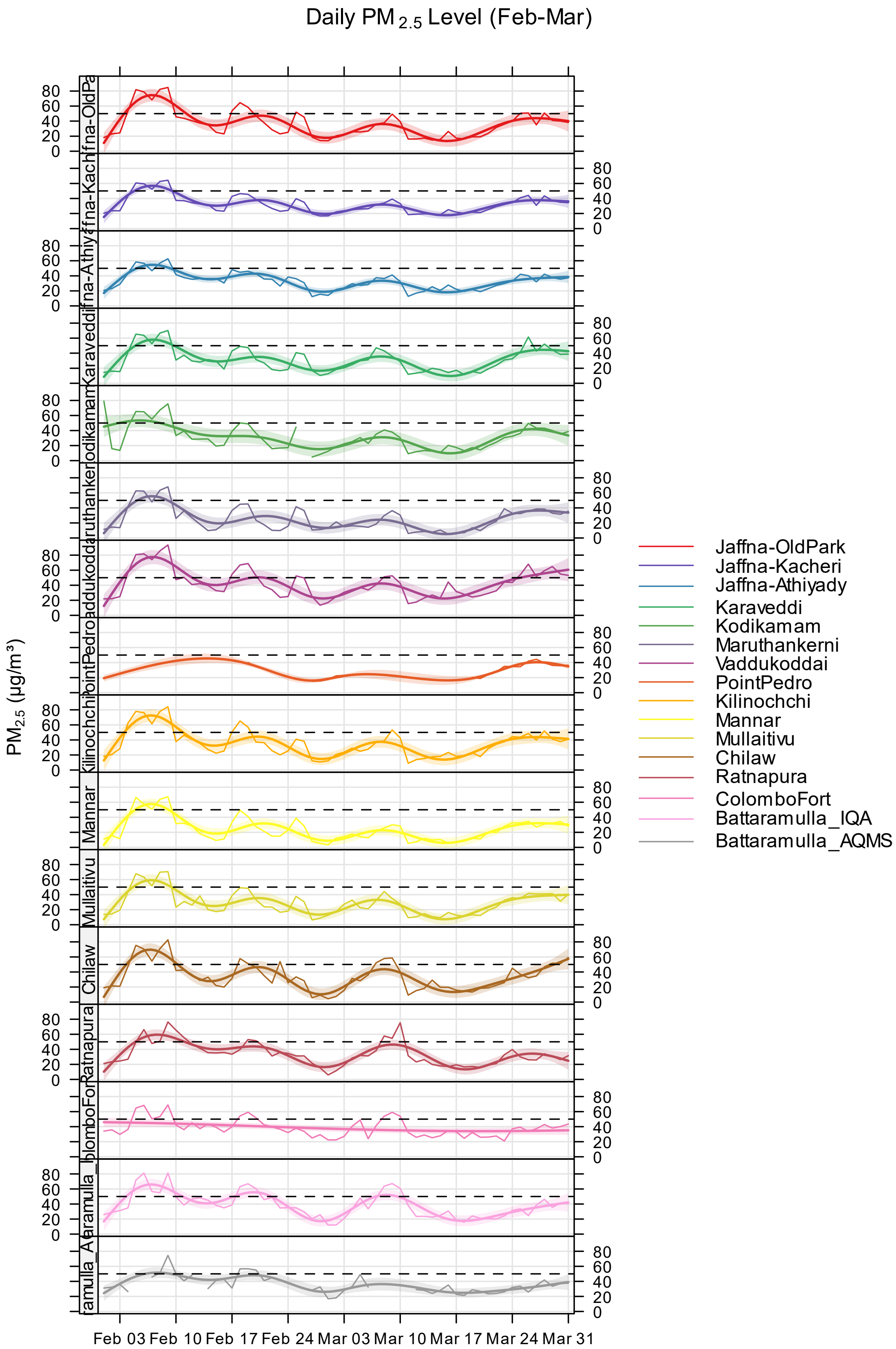
4.4. Patterns – Combined



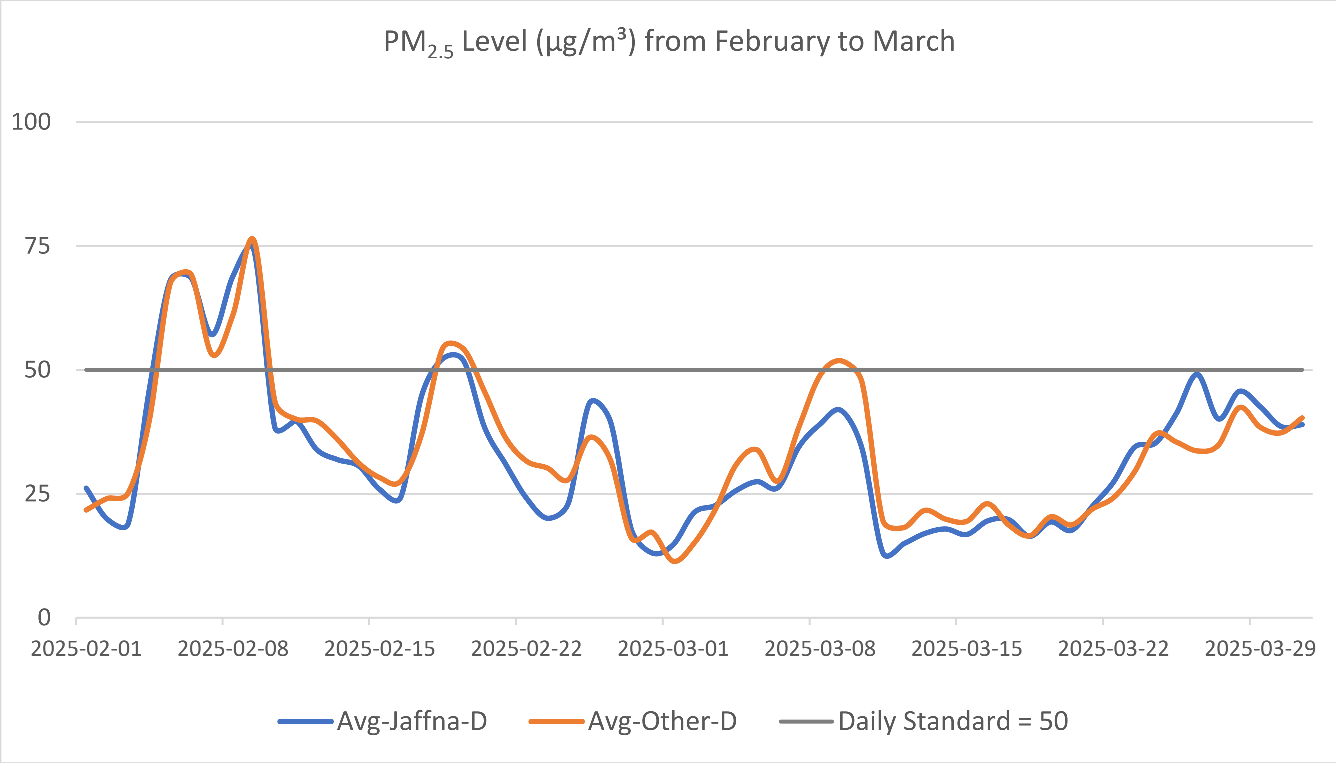
Graph 19: Patterns in Jaffna



Graph 20: Patterns in Other Regions



Graph 21: Pattern - Daily PM2.5 Level (Diurnal) in all 16 sites



Graph 22: Average of Jaffna District & Other Regions

4.5. Interpretation of Pollution Patterns

Graphs 1 through 22 illustrate the variations and commonalities in air quality across individual monitoring sites and present regional average trends. Notably, as highlighted in Graph 22, the temporal trend of PM2.5 levels in the Jaffna District exhibits a considerable similarity to the trends observed in other regions included in this analysis.

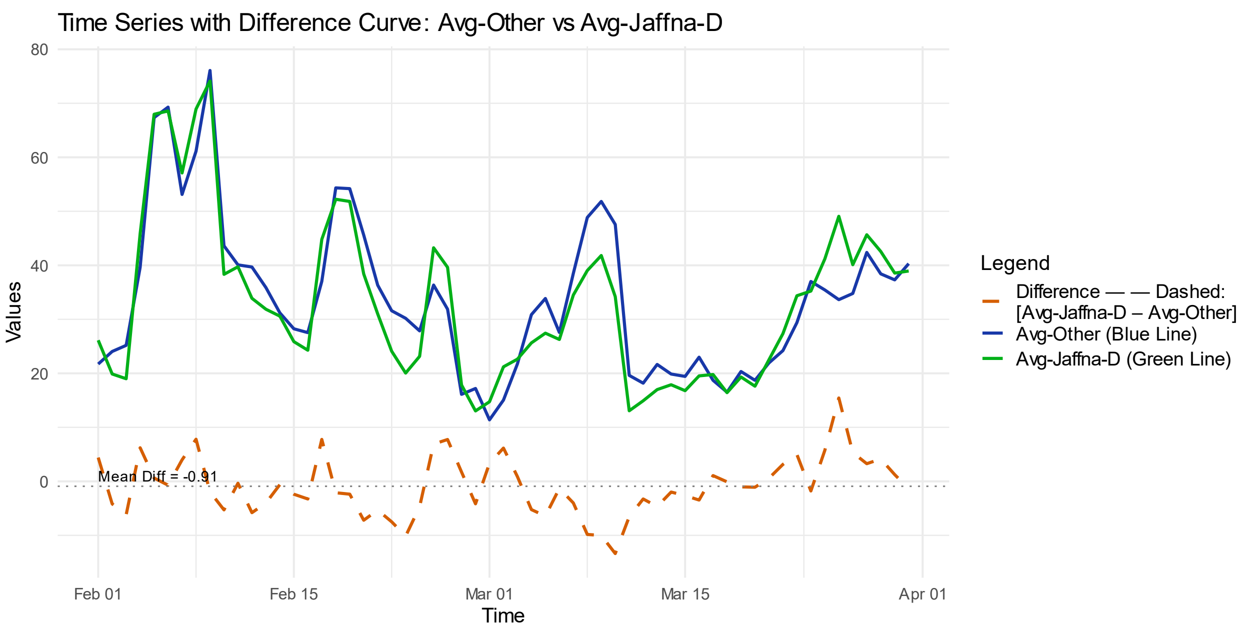
5. Comparison

5.1. Comparison Analysis – Jaffna District vs Other Regions

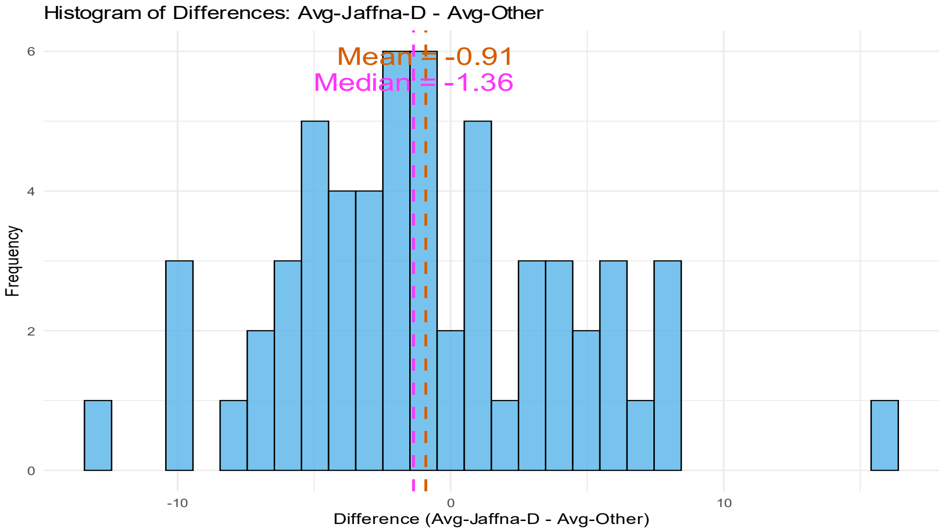
To assess differences in ambient $PM_{2.5}$ levels between the Jaffna District and locations outside the district, a detailed statistical comparison was conducted. Specifically, the average $PM_{2.5}$ concentrations for all monitoring sites within Jaffna District were compared against the average values from sites located outside the district. Data from 16 monitoring devices were used in the analysis. However, since some devices were installed in late January, only data from February and March were used for comparisons, as those were the months during which all devices recorded measurements consistently. The analysis included a suite of visual and quantitative methods:

- Time series plot with difference curve to visualize temporal divergence.
- Histograms and Density Plots to compare the distribution of values between regions.
- Bland–Altman plot / analysis to assess the agreement between the two datasets in terms of distributional differences and bias.
- Scatter plots and regression analysis to assess correlation and linear agreement. (Both unconstrained and constrained linear regression models were employed in order to account for observed limitations in the dataset — particularly the lack of lower-bound (near-zero) values that could affect the stability of unconstrained intercept estimation).

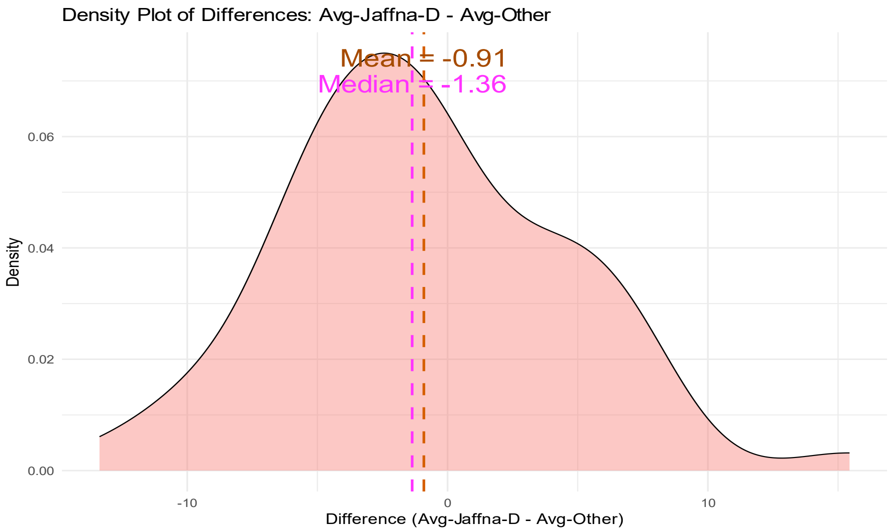
These methods, combined with key statistical indicators, provided a comprehensive picture of how air quality conditions in Jaffna align with or differ from broader regional patterns.



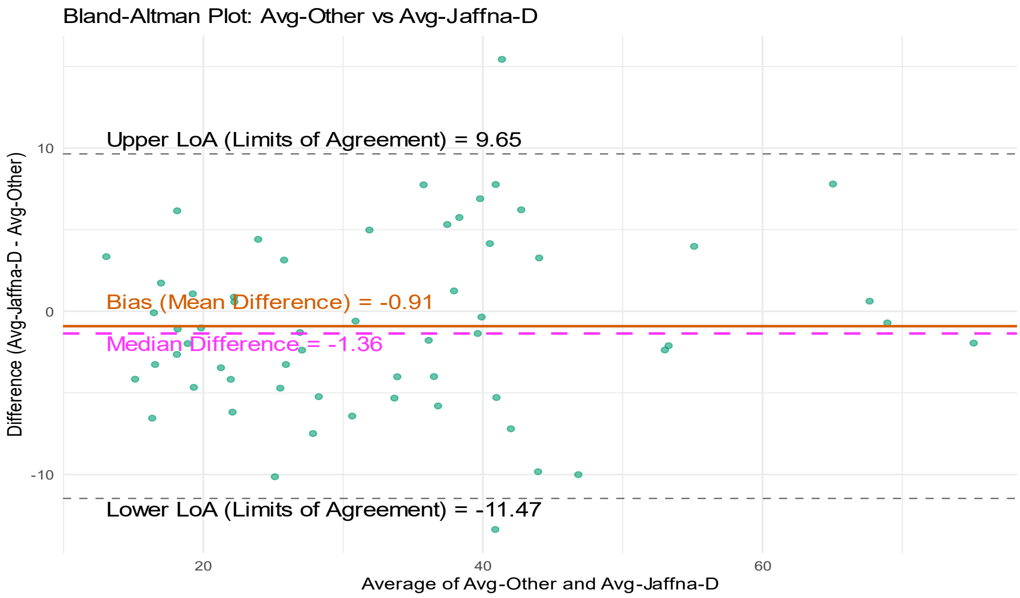
Graph 23



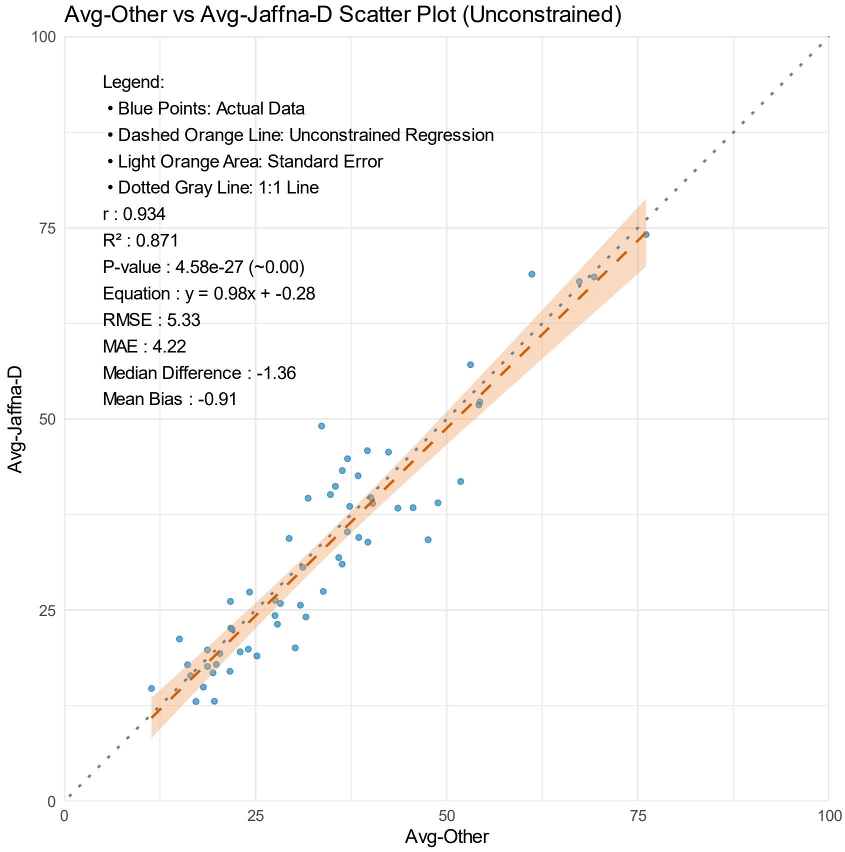
Graph 24



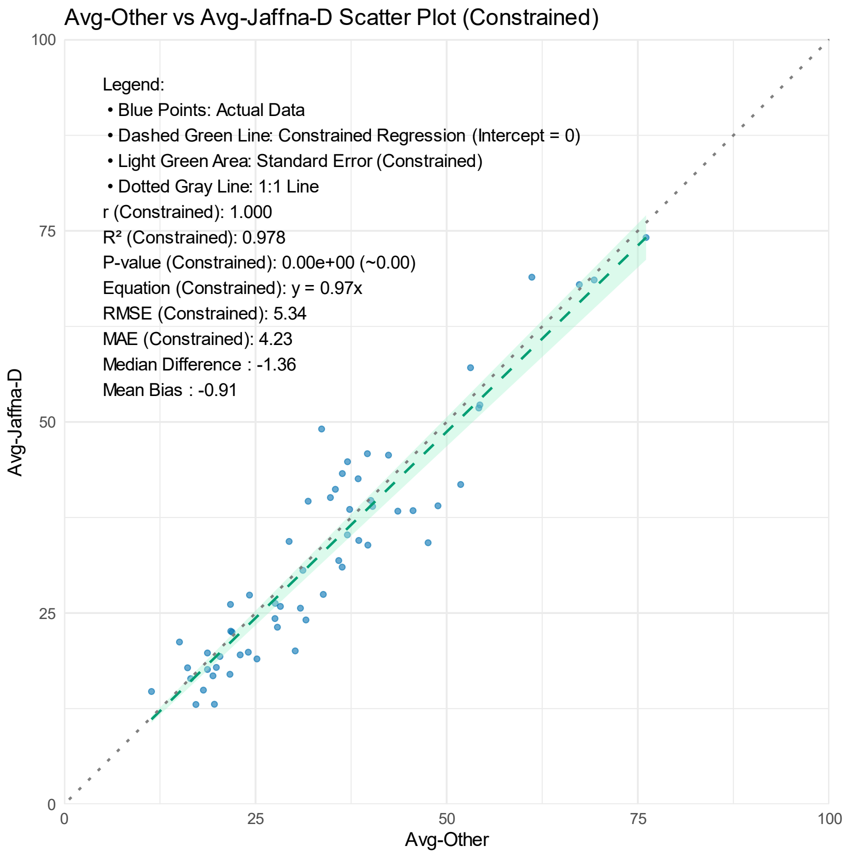
Graph 25



Graph 26



Graph 27



Graph 28

5.2. Results and Interpretation

Bland–Altman Analysis +

- **Mean difference (bias): -0.91 μg/m³ and Median difference: -1.36 μg/m³**

  Indicates that, on average, $PM_{2.5}$ levels in Jaffna were about 0.91 μg/m³ lower than those outside the district. The median difference of -1.36 μg/m³ indicates that the middle value of $PM_{2.5}$ levels in Jaffna was 1.36 μg/m³ lower than the middle value of $PM_{2.5}$ levels in the regions outside Jaffna, when considering all paired measurements. The relatively small magnitudes (close to 0) of these differences, especially when considered alongside potential data variability and uncertainty, suggest that they might not be of strong practical significance.

- **Standard deviation of differences: 5.39 μg/m³**

  The standard deviation quantifies the spread or dispersion of these differences. A value of 5.39 μg/m³ suggests that the daily differences between Jaffna and external $PM_{2.5}$ levels varied by a typical amount of around 5.39 μg/m³ around the mean difference. This value indicates a moderate degree of inconsistency in how much higher or lower Jaffna's $PM_{2.5}$ levels were compared to the external regions on any given day.

- **Limits of agreement (LoA):**

  Lower limit: −11.47 μg/m³

  Upper limit: 9.65 μg/m³

  These limits of agreement indicate that most (95%) of the observed daily differences in $PM_{2.5}$ levels (calculated as Jaffna District minus Outside Jaffna District) are expected to fall within the range of -11.47 μg/m³ to 9.65 μg/m³. The width of the range suggests the variability in how the $PM_{2.5}$ levels in Jaffna compare to those outside the district on any given day. Occasional deviations beyond these limits likely reflect unique, localized factors influencing air quality.

Unconstrained regression (With Bias Term):

- **Pearson correlation coefficient (r): 0.93**

  The Pearson correlation coefficient of 0.93 indicates a strong positive linear relationship between $PM_{2.5}$ levels in the regions outside of Jaffna (x-axis) and $PM_{2.5}$ levels in Jaffna (y-axis) based on the historical data. This means that when $PM_{2.5}$ levels historically tended to increase in the areas outside Jaffna, there was a strong tendency for $PM_{2.5}$ levels in Jaffna to also increase, and vice versa. The positive value signifies that the relationship is direct – both tend to move in the same direction.

- **R-squared (R^2): 0.87**

  Approximately 87% of the variability observed in historical $PM_{2.5}$ levels within Jaffna can be statistically explained by the variability in historical $PM_{2.5}$ levels outside of Jaffna. This indicates a substantial portion of the changes in $PM_{2.5}$ in Jaffna can be associated with changes in $PM_{2.5}$ in the regions outside of Jaffna, based on the historical data. While still a strong relationship, it suggests that about 13% of the variation in Jaffna's $PM_{2.5}$ levels is influenced by other factors not included in this simple linear relationship with the outside regions.

- **P-value: 4.58×10^{-27} (<0.0000)**

  Indicates that the correlation is statistically significant.

- **Regression slope: 0.98**

  Suggests that increases in external $PM_{2.5}$ levels are closely mirrored by increases in Jaffna, but at a slightly lower rate.

- **Regression intercept: -0.28**

  The intercept being close to zero suggests that when pollution outside Jaffna was low, pollution in Jaffna was also generally low. However, this value may carry considerable uncertainty due to the limited availability of data at very low (near 0) concentration levels.

- **RMSE (Root Mean Square Error): 5.33**

  Represents a typical magnitude of prediction error of 5.33.

- **MAE (Mean Absolute Error): 4.22**

  Represents an average absolute difference of 4.22 between Jaffna and external values.

Constrained Regression (Without Bias Term. Intercept set to 0):

- **Pearson correlation coefficient (r): 1.0**

  Shows a strong linear relationship between $PM_{2.5}$ levels in Jaffna and those in external regions.

- **R-squared (R^2): 0.98**

  Approximately 98% of the variation in Jaffna's historical air quality levels can be statistically explained by the variation outside Jaffna, indicating a very strong association between their trends.

- **P-value: 0.00×10^{0} (<0.0000)**

  This extremely low p-value indicates a statistically significant correlation between air quality levels inside and outside Jaffna. This strong relationship is highly unlikely due to chance, suggesting a genuine historical tendency for their levels to change concurrently.

- **Regression slope: 0.97**

  Suggests that increases in $PM_{2.5}$ levels in Jaffna are closely mirrored by increases in external regions, at a slightly higher rate.

- **RMSE (Root Mean Square Error): 5.34**

  Represents a typical magnitude of prediction error of 5.34.

- **MAE (Mean Absolute Error): 4.23**

  Represents an average absolute difference of 4.23 between Jaffna and external values.

5.3. Summary

- During the study period, Jaffna generally recorded slightly lower $PM_{2.5}$ levels compared to other regions. However, statistical analysis indicates that this difference was not significant.
- This difference, while consistently observed, was relatively small. It is unlikely to be of major practical concern and may not be statistically significant without further analysis.
- The data showed a strong correlation between Jaffna and external locations. When pollution levels increased or decreased in other areas, Jaffna showed similar changes. This suggests that the regions are affected by common factors, such as seasonal patterns or shared air movements.
- These similarities were supported by both types of regression models used in the study. They confirmed that the overall behaviour of air quality in Jaffna closely matched that of the other regions.
- While Jaffna exhibited slightly lower $PM_{2.5}$ levels, the overall trend remained consistent with that of surrounding regions. Minor differences may be influenced by local factors, but there is no strong indication of a distinct or significantly different pollution pattern.
- It is also important to recognize the inherent uncertainty in air quality measurements. Variations in sensor calibration, gradual equipment wear, weather fluctuations, isolated events, and site-specific conditions can all affect readings — particularly when observed differences are small, and the number of monitoring locations or the study duration is limited.
- In summary, Jaffna's air quality followed patterns similar to those observed in nearby regions. The slight but consistent elevation seen in Jaffna should be understood in the context of normal measurement variation and regional influences.

6. Compliance with Standards

Here, the levels are compared with the Local & International Standards.

Local:

Standards given in National Environmental (Ambient Air Quality) Regulations of Sri Lanka. (Year 2008).

"SCHEDULE

Pollutant	*Averaging Time**	*Maximum Permissible Level*	
		μgm^{-3}	*ppm*
1. Particulate Matter - Aerodynamic diameter is less than 10 μm in size (PM_{10})	Annual	50	—
	24 hrs.	100	—
2. Particulate Matter - Aerodynamic diameter is less than 2.5 μm in size ($PM_{2.5}$)	Annual	25	—
	24 hrs.	50	—

Figure 2: National Standards

International:

Standards given in WHO global air quality guidelines. (Year 2021).

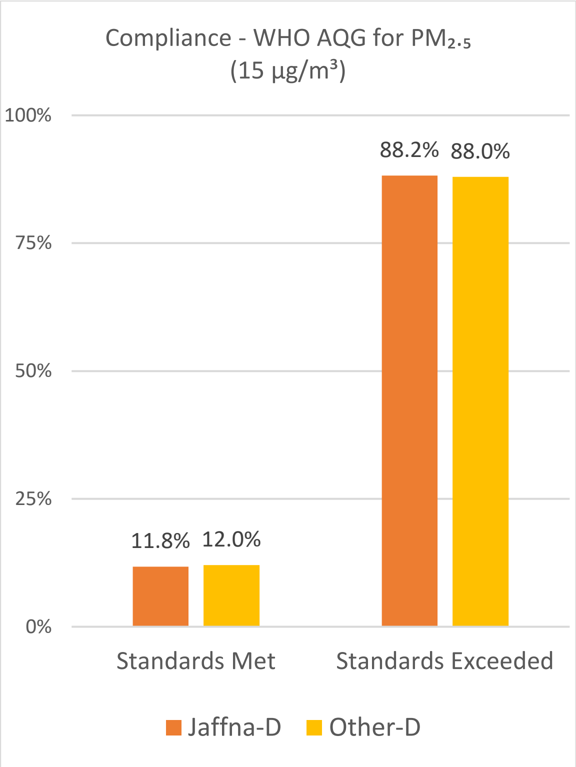
Table 3.24. Summary of recommended long- and short-term AQG levels and interim targets

Pollutant	Averaging time	Interim target				AQG level
		1	2	3	4	
$PM_{2.5}$, µg/m³	Annual	35	25	15	10	5
	24-hour[a]	75	50	37.5	25	15

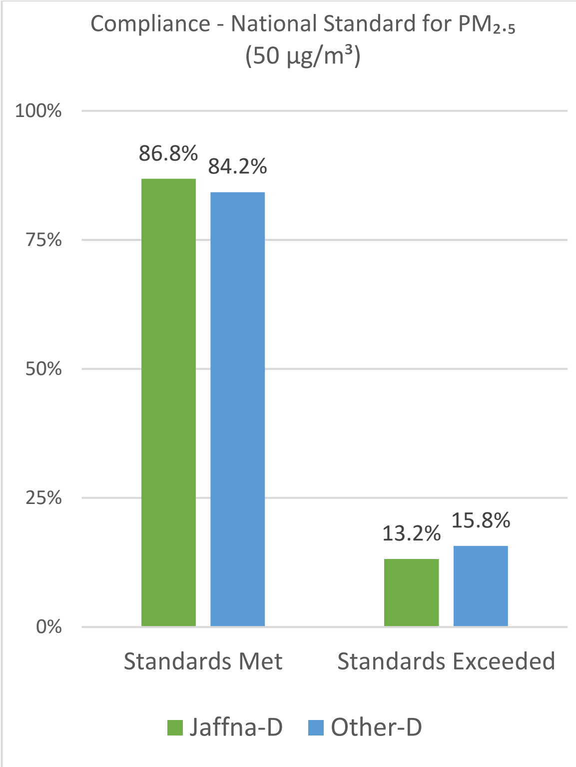
Figure 3: WHO global air quality guidelines

The national standard for $PM_{2.5}$ aligns with the Interim Target 2 (**IT2**) value set by the World Health Organization (WHO) guideline. These Interim Targets were established specifically for developing countries, recognizing that achieving the ultimate Air Quality Guideline (**AQG**) level might be challenging in the context of ongoing national development. Consequently, a series of progressive targets have been introduced to guide developing nations toward improved air quality in a step-by-step manner.

The 24-hour national standard for PM2.5 is 50 µg/m^3, which equals the Interim Target 2 of the WHO Global Air Quality Guidelines. The respective AQG value is 15 µg/m^3.



Graph 29: Compliance - WHO AQG



Graph 30: Compliance - National Standards

This shows that regionwide, air quality patterns are similar between Jaffna and Other Regions. Both areas frequently exceeded the WHO Air Quality Guidelines for most of the time, whereas exceedances of the National Standards were very low.

Below is another dimension of air quality compliance is examining **AQI** categories, reflecting the level of environmental quality and/or health risk associated with pollution category levels.

7. Air Quality Index (AQI)

The Air Quality Index (AQI) simplifies air pollutant levels into a single scale, ranging from 0 to 500, to help the general public understand air quality and its impacts. Pollutant concentrations are typically measured in units like µg/m³ or ppb, but AQI translates these into an easy-to-understand scale with color-coded categories. Different countries use customized air quality indices based on local standards and conditions. Sri Lanka uses the AQI-SL (Air Quality Index for Sri Lanka), inspired by the US EPA's AQI, with breakpoints largely based on Sri Lanka's National Ambient Air Quality Standards, which align with WHO guidelines. The goal of AQI-SL is to reflect both international best practices and local regulatory requirements.

Since National Standards vary somewhat between countries, AQI classifications can also differ accordingly.

AQI-SL is published and found in CEA website under publications.

AQI-SL

Table 3: AQI-SL

AQI Color	Level of Concern	Index
Green	**Good**	**0 - 50**
Yellow	**Moderate**	**51 -100**
Orange	**Slightly Unhealthy**	**101 - 150**
Red	**Unhealthy**	**151 - 200**
Purple	**Very Unhealthy**	**201 - 300**
Maroon	**Hazardous**	**301 - 500**

Category	Color	Index	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	O_3 (ppb)	CO (ppb)	NO_2 (ppb)	SO_2 (ppb)
		0	0	0	0	0	0	0
Good	Green							
		50	25	50	50	2,250	65	15
Moderate	Yellow							
		100	50	100	100	4,500	130	30
Slightly Unhealthy	Orange							
		150	75	150	200	9,000	350	80
Unhealthy	Red							
		200	150	275	300	15,000	650	250
Very Unhealthy	Purple							
		300	250	450	400	30,000	1,250	600
Hazardous	Maroon							
		500	400	650	600	50,000	2,000	1,000

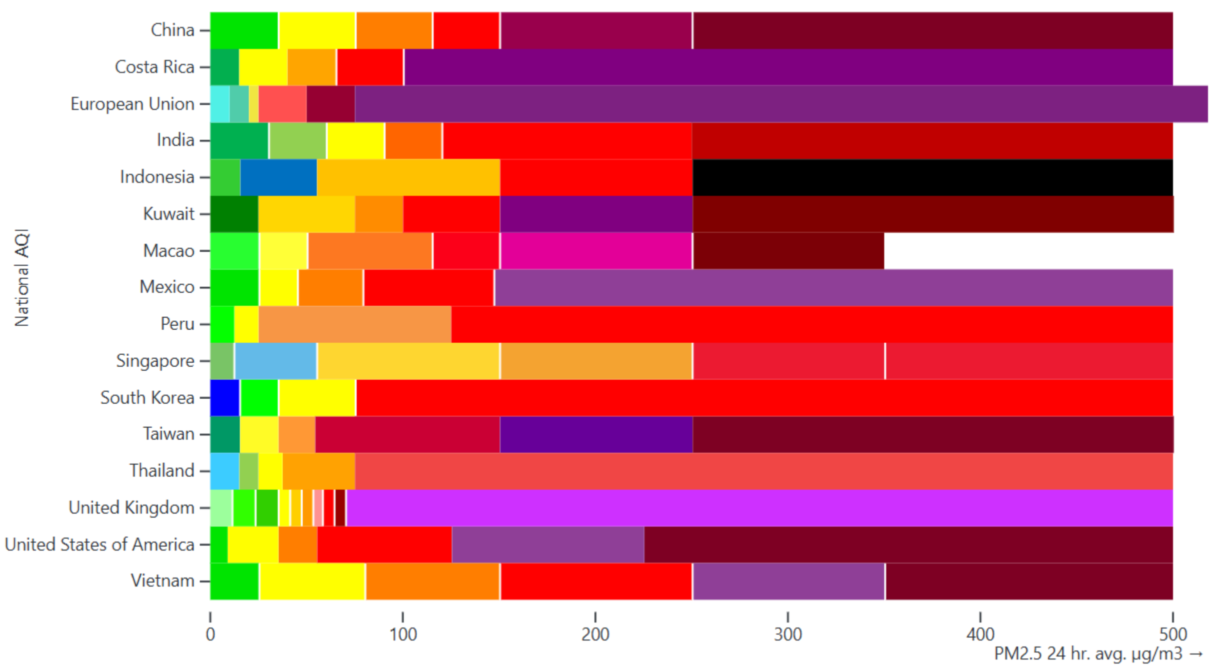


Figure 4: Different AQI Schemes (Courtesy: AQIHub.info)

7.1. Daily AQI

Table 4: Daily AQI of 16 Sites, Feb-Mar 2025 (Heatmap)

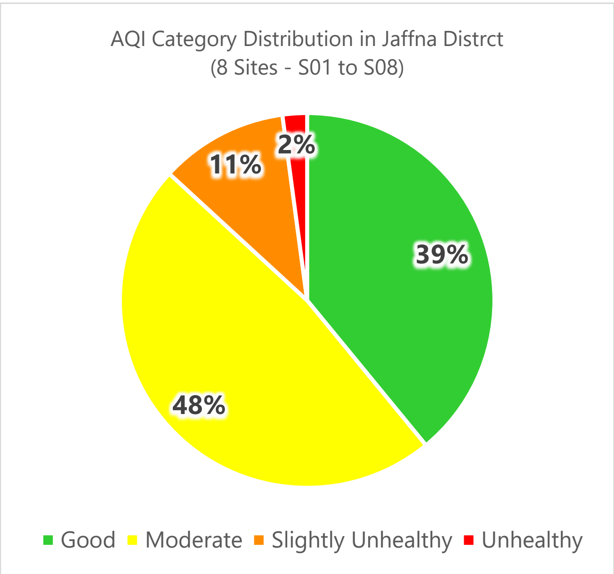
Date (2025-mm-dd)	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16
02-01	36	41	41	29	151	23	43		36	22	27	38	43	68	51	61
02-02	46	47	46	33	32	29	45		41	31	29	43	47	71	58	64
02-03	48	47		31	27	27	49		56	23	38	42	49	60	63	72
02-04	104	85		80	88	81	112		130	77	85	92	54	72	69	55
02-05	155	122	117	132	131	125	154		152	132	135	150	98	130	141	
02-06	153	119		127	129	126	154		151	115	127	142	134	137	154	
02-07	138	105	94	106	111	97	148		125	103	104	110	96	105	116	92
02-08	155	125	114	132	133	126	157		152	126	138	140	102	106	109	102
02-09	157	128	125	141	150	136	162		156	135	142	156	151	139	154	150
02-10	94	76	84	64	69	54	97		77	66	48	87	132	85	100	102
02-11	86	73	74	74	78	71	99		91	63	61	84	111	72	77	82
02-12	81	69	71	60	58	54	82		81	58	52	72	95	90	94	93
02-13	74	65	72	56	57	37	84		73	37	76	58	85	77	97	
02-14	70	64	73	62	60	20	79		55	28	41	65	73	86	91	61
02-15	50	48	73	61	42	22	68		45	19	35	45	71	78	77	83
02-16	46	46	61	40		36	63		51	22	37	39	72	65	69	85
02-17	106	84	95	85	77	73	107		100	65	77	62	67	82	77	62
02-18	128	92	89	98	100	90	134		130	99	99	116	80	108	126	113
02-19	118	91	92	97	99	90	138		115	83	97	103	105	118	134	113
02-20	93	77	85	63	74	48	105	69	76	56	67	93	105	103	120	110
02-21	76	64	72	54	53	35	79		74	43	48	71	88	85	91	82
02-22	57	53	70	36	32	21	68		52	30	47	50	63	78	96	89
02-23	46	46	53	33	34	20	49		41	30	34	105	72	73	69	
02-24	50	48	75	36	34	31	49		50	45	36	51	69	66	72	
02-25	102	78	72	81		83	103		81	76	75	66	64	76	70	
02-26	91	71	62	78		74	100		78	57		58	62	68	60	
02-27	40	41	27	36		23	52	31	26	17	14	12	43	49	40	57
02-28	28	33	31	21	16	22	26	31	21	11	17	18	31	59	52	66
03-01	28	34	28	26	25	27	34	35	25	7	25	9	12	45	25	35
03-02	41	44	44	37	37	43	49	45	42	24	35	15	23	45	24	33
03-03	45	48	48	41	44	30	61	46	47	29	54	31	37	53	41	56
03-04	53	51	60	50	50	32	68	47	58	36	65	62	57	82	67	67
03-05	51	52	55	60	60	31	76		52	29	47	56	64	98	98	99
03-06	53	52	56	63	48	28	67		55	25	42	71	62	48	69	69
03-07	70	62	73	92	69	36	80		72	42	64	106	77	82	98	
03-08	75	67	72	88	83	60	102		77	51	87	117	116	106	130	
03-09	98	78	82	73	77	73	105		110	60	70	120	109	119	138	
03-10	80	67	66	58	61	61	86		86	58	55	81	150	112	124	
03-11	33	37	26	24	19	13	32		19	11	19	18	67	65	76	
03-12	33	39	36	27	23	16	35		27	14	21	30	45	51	45	58
03-13	36	40	39	32	27	17	46		32	24	29	37	54	58	53	61
03-14	29	38	50	39	25	15	53		35	20	22	57	41	51	45	48
03-15	31	37	41	36	22	21	47		37	21	19	40	36	55	49	55
03-16	52	50	54	28	40	10			46	12	32	39	34	71	62	72
03-17	36	44	45	35	36	14	67		39	15	25	32	39	66		46
03-18	33	40	38	23	27	14	55		38	16	23	28	34	50	33	43
03-19	38	44	43	32	35	27	50	40	47	24	27	26	34	64	47	57
03-20	38	42	37	27	29	20	52	38	36	22	24	37	32	52	42	54
03-21	47	50	45	38	40	34	58	48	57	40	38	38	39	51	41	47
03-22	63	58	55	48	49	45	65	55	68	39	47	45	43	56	41	48
03-23	72	63	59	61	61	77	88	69	75	55	64	51	65		48	52
03-24	79	68	65	65	65	65	87	69	87	65	71	90	80	74	63	63
03-25	100	81	83	82	73	65	107	69	87	65	70	75	59	78	67	67
03-26	102	89	81	123	99	72	136	83	98	69	83	65	52	71	49	52
03-27	71	62	64	87	88	77	105	88	81	54	82	68	52	74	76	69
03-28	100	86	83	103	86	77	117	79	104	62	82	96	68	89	94	85
03-29	86	78	78	88	81	66	133	72	83	64	82	106	61	76	74	69
03-30	80	70	71	78	71	64	110	72	76	69	63	104	52	79	81	73
03-31	77	69	74	77	77	71	106	73	82	56	81	121	62	87	81	75

Table 5: No of Days at each AQI Category

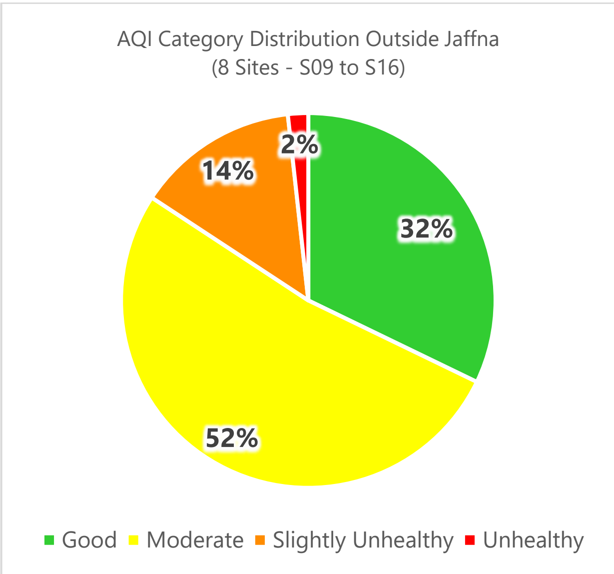
AQI Category	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16
Good	**22**	**23**	**17**	**25**	**24**	**33**	**13**	**9**	**20**	**32**	**29**	**22**	**18**	**5**	**14**	**7**
Moderate	**26**	**31**	**36**	**27**	**25**	**22**	**25**	**11**	**29**	**22**	**24**	**23**	**31**	**42**	**33**	**34**
Slightly Unhealthy	**7**	**5**	**3**	**7**	**5**	**4**	**16**	0	**6**	**5**	**5**	**13**	**9**	**11**	**9**	**6**
Unhealthy	**4**	0	0	0	**1**	0	**4**	0	**4**	0	0	**1**	**1**	0	**2**	0
Very Unhealthy & Hazardous	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	59	59	56	59	55	59	58	20	59	59	58	59	59	58	58	47

Table 6: No of Days at Each AQI Category, as a Percentage

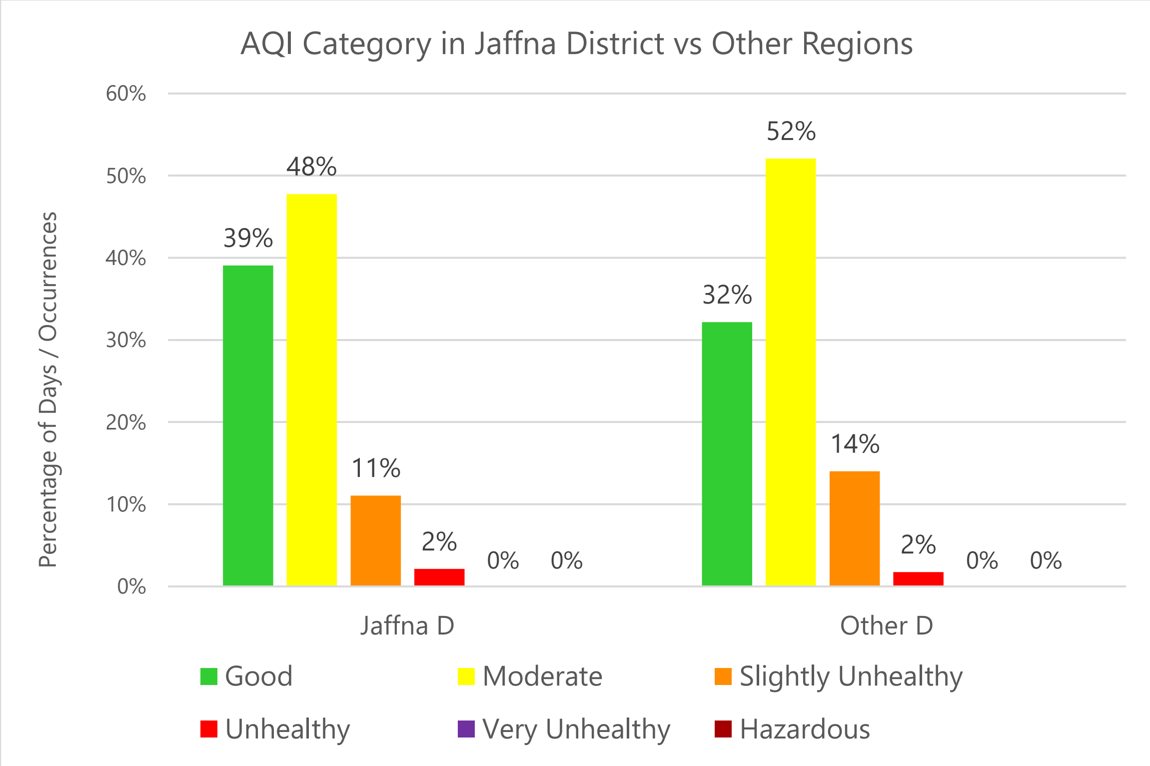
AQI Category	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16
Good	37%	39%	30%	42%	44%	56%	22%	45%	34%	54%	50%	37%	31%	9%	24%	15%
Moderate	44%	53%	64%	46%	45%	37%	43%	55%	49%	37%	41%	39%	53%	72%	57%	72%
Slightly Unhealthy	12%	8%	5%	12%	9%	7%	28%	0%	10%	8%	9%	22%	15%	19%	16%	13%
Unhealthy	7%	0%	0%	0%	2%	0%	7%	0%	7%	0%	0%	2%	2%	0%	3%	0%
Very Unhealthy & Hazardous	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%



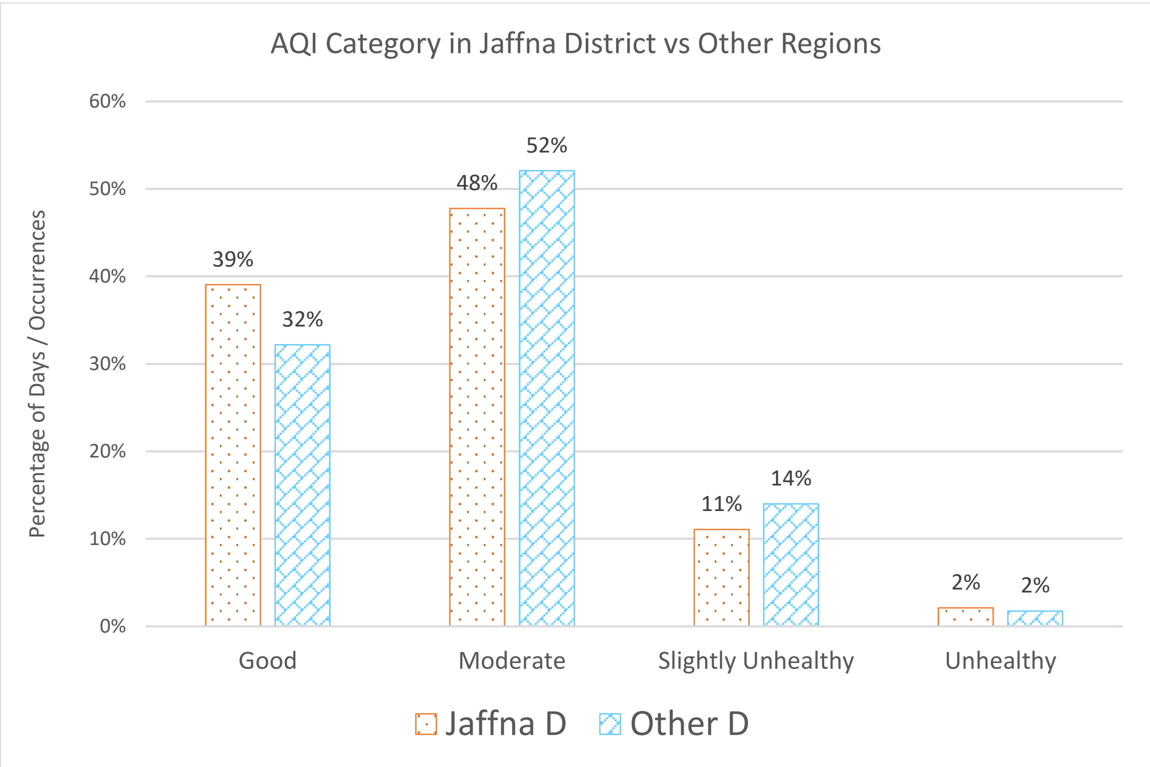
Graph 31: AQI categories of 8 sites in Jaffna District, February to March 2025



Graph 32: AQI categories of 8 sites outside Jaffna District, February to March 2025



Graph 33



Graph 34

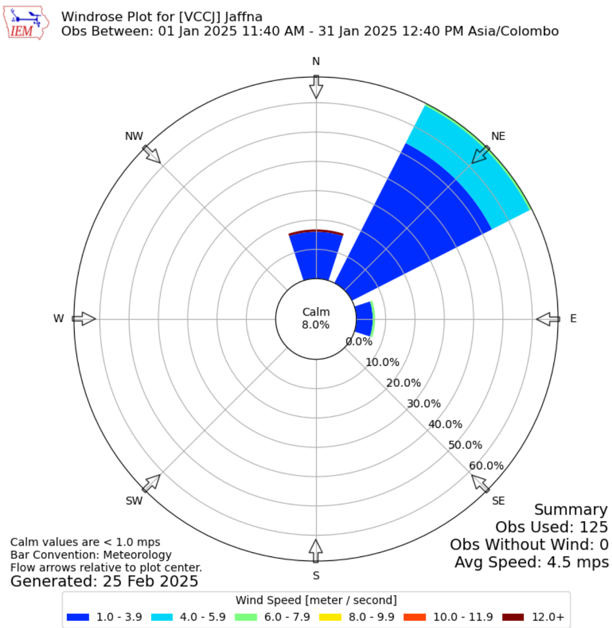
These graphs (Graph 31, 32, 33 & 34) reveal that even though there are some differences, it level of difference is minimum and it is safe to consider there is no significant difference.

8. Wind Direction & Speed

Throughout the monitoring period, the NorthEastern Monsoon remained active, resulting in predominantly NorthEasterly wind patterns. Historical observations indicate that air pollution levels in this region are typically elevated during this season—particularly in January—and tend to gradually decline as March approaches.

Wind-rose diagrams and back-trajectory analyses confirm the dominance of NorthEasterly winds in January and February. By March, however, the prevailing wind direction shifts more toward the East.

8.1. WindRose

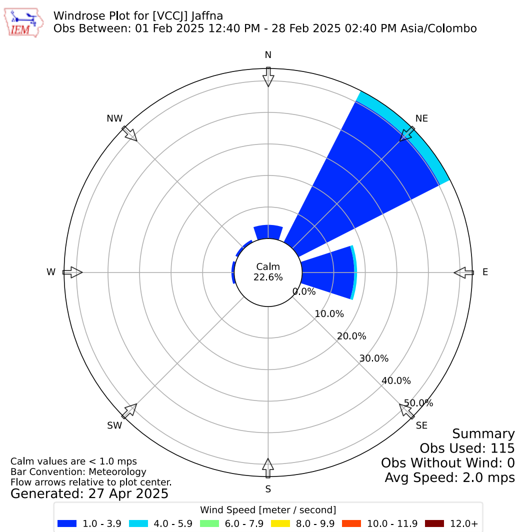


The data for January indicates that the prevailing wind direction during the monitoring period was from the North-East (NE), accounting for approximately 70% of observations.

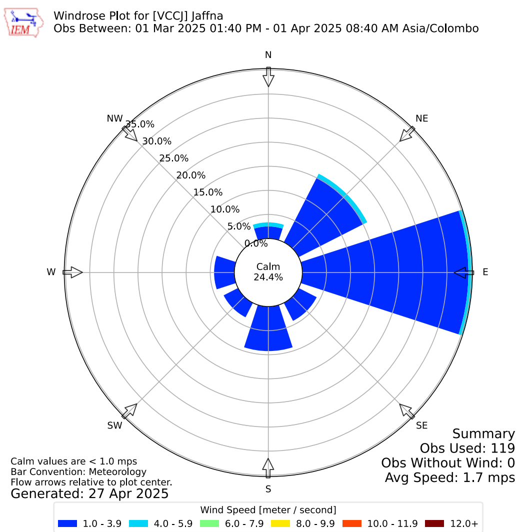
For February about 55% NE.

For March about 35% E, 17% NE.

*Graph 35: Windrose. **January** 2025 (Courtesy: mesonet.agron.iastate.edu)*



*Graph 36: Windrose. **February** 2025 (Courtesy: mesonet.agron.iastate.edu)*



*Graph 37: Windrose. **March** 2025 (Courtesy: mesonet.agron.iastate.edu*

8.2. Backward Trajectories

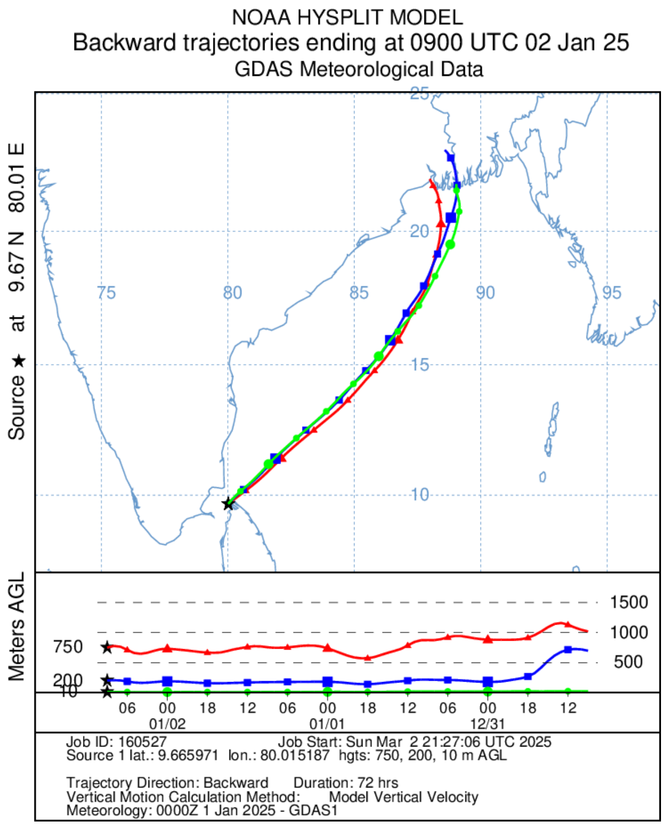


Figure 5: Backward Trajectory, Jan 02

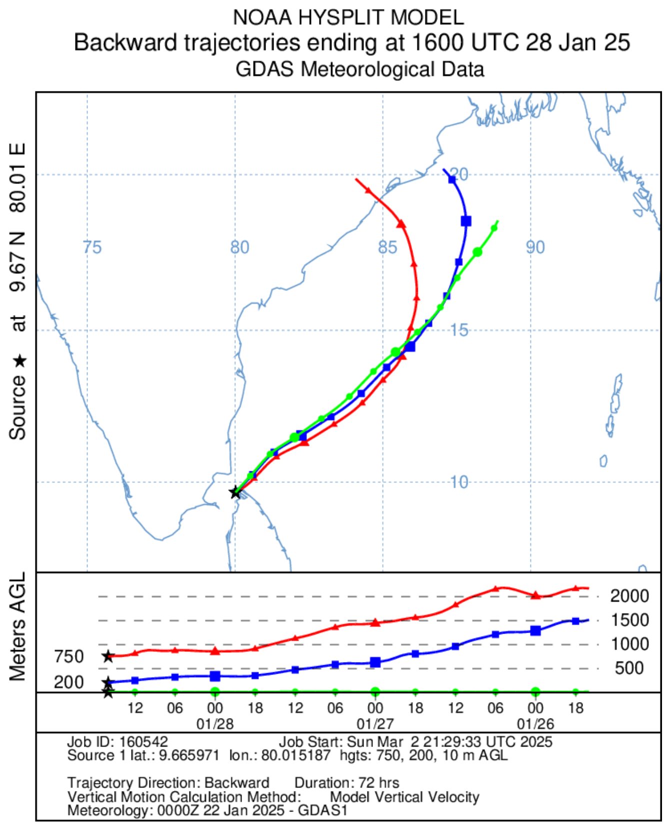


Figure 6: Backward Trajectory, Jan 28

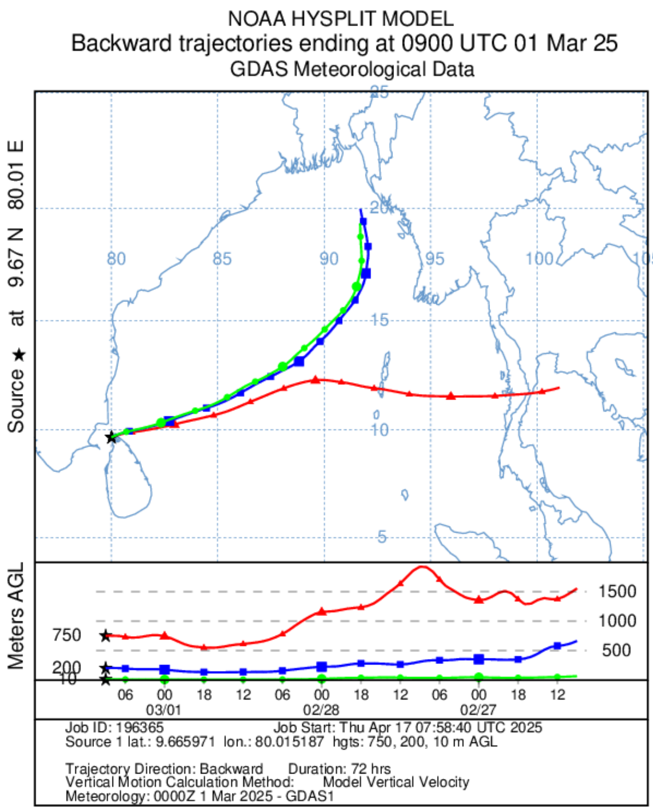


Figure 7: Backward Trajectory, Mar 01

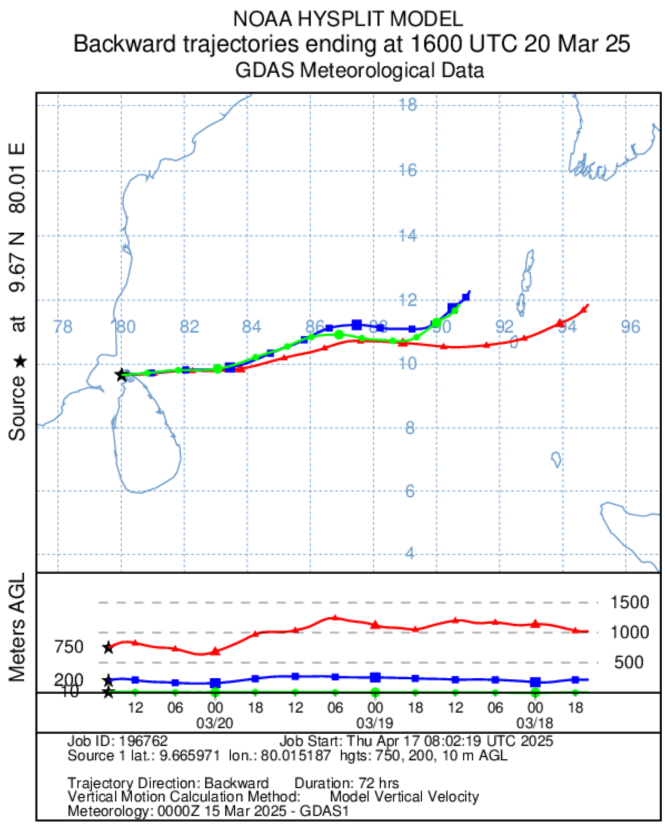


Figure 8: Backward Trajectory, Mar 20

- Backward Trajectories were generated using the **NOAA HYSPLIT** model to identify pollution transport pathways on January 2 and 28, when high pollution levels were observed.
- A height of 10 meters was chosen as it closely matches the sampling height and represents the Surface Layer (10–100 m AGL), which is relevant for ground-level pollution transport. 750 meters was selected to represent the Boundary Layer (500–1500 m AGL), where regional pollutant transport occurs within the Planetary Boundary Layer (PBL). 200 meters was included as an intermediate level between these two layers to provide additional insight into pollutant dispersion.

8.3. Comparison with Other Regions

Wind Direction and Backward Trajectory patterns remained kind of same for all the regions during the whole period.

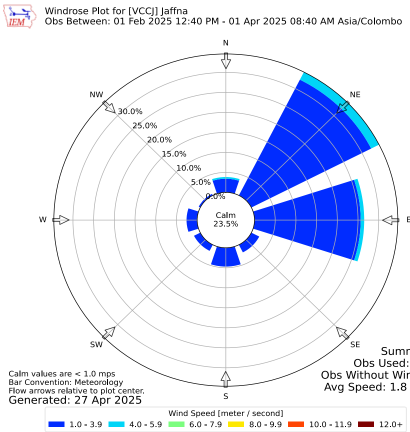


Figure 9: Jaffna (Feb-Mar) WindRose

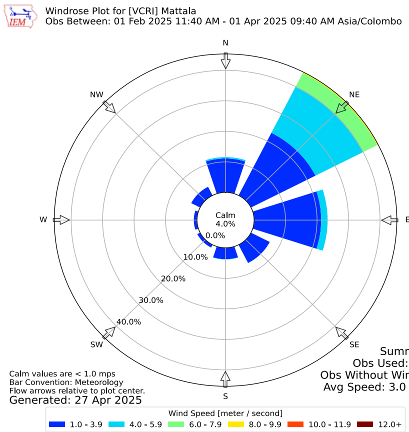


Figure 10: Mattala (Feb-Mar) WindRose

WindRose Jaffna vs Mattala (This compares northern and southern parts of the country.).

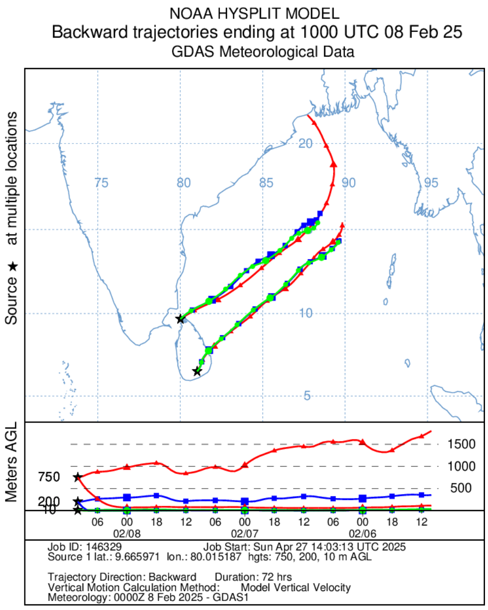


Figure 11: February 8, Back Trajectory (Jaffna vs Mattala)

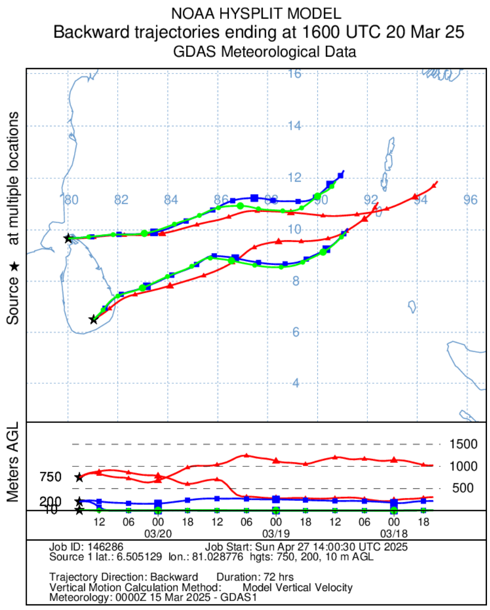


Figure 12: March 20, Back Trajectory (Jaffna vs Mattala)

Back Trajectories: Jaffna vs Mattala. (This compares northern and southern parts of the country.).

9. Measurement Equipment

This air quality monitoring study utilized a network of sixteen monitoring sites, each equipped with a dedicated instrument. The instrumentation comprised 4 distinct device types (3 microsensor types, 1 reference-grade regulatory monitor).

Prior to the monitoring campaign, the microsensor units underwent a validation and calibration process against reference-grade Beta Attenuation Monitors (BAM) located at the Battaramulla, Kandy and/or Mobile Ambient Air Quality Monitoring Stations (AAQMS). This step was crucial to ensure the accuracy and reliability of the data collected by the microsensors. Additionally, some device manufacturers employ real-time, cloud-based validation procedures based on their proprietary air quality models, further contributing to data quality assurance.

The monitoring network included both pre-existing sensors (deployed before January 1, 2025) and a new set of microsensors recently deployed through a collaborative effort between the Central Environmental Authority (CEA) and the National Building Research Organization (NBRO). Furthermore, NBRO also deployed its reference/regulatory grade Mobile Ambient Air Quality Monitoring Station (Mobile-AAQMS). It is important to note that the data originating from devices owned and operated by NBRO are excluded from this particular report and will be presented in a separate publication.

Particulate Matter (PM) concentration is measured in micrograms per cubic meter ($\mu g/m^3$). The original method involved determining the weight of collected particles from a known air volume using filter papers. For greater accuracy, higher air volumes were sampled. The High-Volume Sampling (HVS) is the **reference** method for PM measurements. However, HVS is difficult to automate and does not provide immediate results. With advancements in technology, automated methods were introduced. Some, such as the Beta Attenuation Monitor (BAM), provide high accuracy and are classified as **equivalent** methods to reference methods. Others, like light scattering low-cost **microsensors**, have lower accuracy but offer convenience, reliability, affordability and ease of use.

1. Gravimetric High-Volume Samplers (HVS):

Gravimetric High-Volume Samplers (HVS) are widely regarded as a reference method for measuring particulate matter (PM). These devices collect PM on a filter over a specified sampling period, typically 24 hours, after which the filter is weighed to determine the mass concentration of PM. While HVS provides highly accurate and reliable data, it is not suitable for capturing rapid changes in air quality due to its long sampling duration. This makes it less effective for real-time monitoring or identifying short-term fluctuations in PM levels.

2. Beta Attenuation Monitor (BAM):

(S16 - Battaramulla CEA Head Office AQMS consists of a BAM. Model/Vendor: Ecotech Spirant BAM - ACOEM/MetOne).

The Beta Attenuation Monitor (BAM) is a real-time PM measurement technology that uses beta-ray attenuation to measure the mass of particles collected on a filter tape. BAM is capable of providing hourly average PM concentrations, making it suitable for detecting relatively quick changes in air quality. However, it is not ideal for capturing instantaneous changes within shorter timeframes, such as 5-minute intervals. Despite this limitation, BAM is considered a robust and reliable tool for regulatory-grade monitoring. High Maintenance.

3. Low-Cost Light Scattering MicroSensors:

(S01 to S15 - MicroSensors in this study fall into this category. Model(s)/Vendor(s): IQAir AirVisual, TSI BlueSky PM, Clarity Node-S).

Low-cost light scattering sensors measure PM concentrations by detecting the intensity of light scattered by particles in the air. These devices are highly responsive and capable of capturing rapid changes in PM levels, even at minute intervals. While their accuracy may degrade over longer periods due to factors like humidity and particle composition, they excel in identifying sudden spikes or drops in PM concentrations. When paired with and calibrated against reference-grade instruments like HVS or BAM, these sensors provide valuable insights into short-term air quality dynamics, making them a practical choice for real-time monitoring applications. (Note that there are light scattering devices with higher accuracies, which are considered as Equivalent Reference devices as well).

Reference-grade monitors, such as High-Volume Samplers (HVS) and Beta Attenuation Monitors (BAM), are also known as regulatory devices due to their established use in regulatory air quality monitoring across the world for decades. According to National Environmental (Ambient Air Quality) Regulations, published in 2008, regulatory work requires an HVS or BAM. While a relatively recent advancement in air quality monitoring with evolving capabilities, light-scattering microsensor technology is not yet widely established for regulatory applications. However, recognizing their potential, current trends favor their integration into air quality monitoring frameworks, often employing co-location studies with reference-grade instruments for rigorous performance evaluation. Despite their limited establishment in regulatory applications, low-cost microsensors are widely being used, and have been used for a considerable time globally, in air quality awareness initiatives, research endeavors, and emergency response efforts. Their accuracy and reliability are continually enhanced through ongoing technological advancements. It is crucial to acknowledge that each microsensor device type possesses its own inherent advantages and limitations, which influence data interpretation.

Summary of Suitability:

HVS : Not suitable for quick air quality changes due to long sampling periods and manual work. Excellent for higher accuracy for longer period sampling.

BAM : Effective for hourly changes but not for sub-hourly or instantaneous variations. Good for high accuracy and medium period sampling. High Maintenance.

Low Cost **MicroSensors**: Ideal for rapid changes, though less accurate over extended periods; best used when calibrated with reference devices as it gives lower accuracy otherwise. Cost effective. Low Maintenance.

10. High Pollution Episodes

To face high pollution episodes, CEA published an Emergency Plan for Such situations called **Contingency Response Action Plan for Deterioration of Air Quality in Sri Lanka (CRAP-DAQ-SL).** It is based on National Standards and the Air Quality Index for Sri Lanka (**AQI-SL**). If the AQI exceeds 150, it will be activated and implemented to address the elevated air pollution levels effectively.

It has several stages. Alert (Stage I) Episode, Warning (Stage II) Episode, Emergency (Stage III) Episode. (Colored Red, Purple & Maroon accordingly. Sof fat as per our monitoring, we have seen the Red Stage, which is about Alerting the Public. Since CRAP-DAQ-SL introduced recently, the implementation of it is an initial stage. With increased monitoring & forecasting facilities, the effectiveness will be higher.

11. Pollution Sources

Methods to Determine Pollution Source Contributions are as follows.

- **Theoretical:**
  Relies on literature, knowledge, logical reasoning, historical data, common sense & assumptions.
- **Modelling:**
  Simulations, Computational tools
- **Remote Sensing:**
  Uses satellite or aerial data to track pollutant distribution.
- **Sampling and Analysis:**
  Direct measurement of pollutants via instruments and chemical testing.

Potential Air Pollution Sources (Theoretically)

- **Transboundary Pollution**
- **Industrial Emissions**
- **Vehicular Emissions**
- **Domestic Activities**

Assessing the specific level of contribution and impact of each pollution source is complex and requires sustained, interdisciplinary research. This complexity arises due to dynamic interactions & overlapping, variable emission patterns, data integration challenges & long-term trends. Therefore, it is often safer, affordable and more practical to choose solutions that are broadly applicable and widely beneficial.

12. Future of Air Pollution Control in Sri Lanka

As a developing country, Sri Lanka faces significant challenges in air quality monitoring and implementing effective measures to combat air pollution. Systematic monitoring provides critical data to assess air quality trends, while targeted control measures are essential for achieving tangible improvements in environmental and public health outcomes. However, despite the existence of rules, regulations, and standards, enforcement is significantly hindered by a critical shortage of human resources, along with financial constraints and technological limitations. The lack of skilled personnel remains a primary challenge, as it directly impacts the effective implementation, coordination, and monitoring of air quality management efforts.

To address these challenges in general and specifically those related to air quality issues in Jaffna, a multi-stakeholder committee is planned to be established to ensure progress. This committee will include experts from environmental science, public health, urban planning, academia, and representatives from local authorities, research institutions, and universities. By pooling resources, expertise, and innovative solutions, this collaborative effort aims to develop sustainable, evidence-based strategies to tackle air pollution comprehensively.

In the near future, advancements in air quality monitoring technologies and data analysis are expected to provide more valuable insights and updates about air pollution in Sri Lanka. These developments will enhance the understanding of air pollution trends, address existing barriers, and enable better-informed actions to safeguard public health and the environment. Together, these initiatives aim to build a stronger foundation for effective air pollution control in the country.

Glossary

AQI:	Air Quality Index
AQI-SL:	Air Quality Index for Sri Lanka
AQG:	Air Quality Guideline (by WHO)5
Ambient Air Quality:	The air quality in the outdoor atmosphere (as opposed to indoor air).
AAQMS:	Ambient Air Quality Monitoring Station.
BAM:	Beta Attenuation Monitor.
Bias Term:	The intercept in regression analysis representing systematic error or offset.
Bland-Altman Analysis:	A statistical method used to assess the agreement between two sets of measurements.
Backward Trajectory:	A modeled path showing where air parcels came from before arriving at the monitoring site — used to trace pollution sources.
CEA:	Central Environmental Authority. The government body responsible for environmental monitoring and regulation in Sri Lanka.
Constrained Regression:	A regression model with the intercept fixed at zero, used to model relationships that pass through the origin.
CRAP-DAQ-SL:	Contingency Response Action Plan for Deterioration of Air Quality – Sri Lanka. Emergency protocol activated when air pollution levels exceed specific thresholds.
Diurnal:	Relating to changes that occur during a 24-hour period; daily cycles. (And the term also used with weekly, monthy, patterns as well)
DS:	Divisional Secretariat. (Or, Sometimes, a District Secratariat). An administrative subdivision in Sri Lanka where monitoring sites were located.
Gravimetric Method:	A method that directly involves/measures weight (of pollutants) to determine concentration.
GPS:	Global Positioning System.
HVS:	High-Volume Sampler
Interim Target:	A progressive benchmark (In this case, set by the WHO) to help developing countries gradually improve air quality.
Kacheri:	Refers to the District Secretariat office in the context of Jaffna.
LoA:	Limits of Agreement. A statistical range (typically 95%) within which the differences between two measurements are expected to fall.
MAE:	Mean Absolute Error. The average of the absolute differences between predicted and actual values.
Mean Difference (Bias):	The average difference between two sets of measurements, indicating a tendency to over- or underestimate.
Median Difference:	The midpoint value of the differences between two sets of measurements.
Microsensor:	A small, typically low-cost air quality sensor that detect and report real-time pollution levels.
NBRO:	National Building Research Organisation.
NOAA HYSPLIT:	Hybrid Single-Particle Lagrangian Integrated Trajectory of National Oceanic and Atmospheric Administration (of USA). A model used to simulate the movement of air parcels for tracing pollutant sources.
OpenAQ:	Open Air Quality. A public platform that shares air quality data globally under an open-access license.
Outlier:	A data point that significantly deviates from other observations and may indicate anomalies or measurement errors.
PBL:	Planetary Boundary Layer. The lowest part of the atmosphere that directly interacts with the Earth's surface and affects pollution dispersion.

PM2.5:	Particulate Matter 2.5. Fine inhalable particles with diameters of 2.5 micrometers or less, capable of penetrating deep into the lungs.
PS:	Pradeshiya Sabha. A local government body responsible for municipal-level administration in Sri Lanka.
R Statistical Software:	An open-source programming language used for statistical analysis and data visualization.
R^2:	R-squared. Coefficient of Determination. A statistical measure that indicates how much variance in one variable is explained by another in a regression model.
Regression Intercept:	The point where a regression line crosses the y-axis, indicating the expected value when all predictors are zero.
Regression Slope:	The rate of change between two variables in regression, showing how much the dependent variable increases with the independent one.
RMSE:	Root Mean Square Error. A measure of the average magnitude of prediction errors in a model.
Satellite View:	A map or image based on satellite data, used to visualize the geographic layout of monitoring locations.
Spatial Mean:	An average calculated across multiple locations, each contributing equally regardless of size or population.
P-value:	Statistical Significance. Indicates the likelihood that an observed effect is due to chance; a p-value < 0.05 (< 05%) is typically considered significant.
Temporal Mean:	An average calculated over time, treating each day (or time unit) equally.
TSI BlueSky PM:	A brand of low-cost particulate matter sensors used in the study.
$\mu g/m^3$:	Micrograms per Cubic Meter. The unit used to express the concentration of air pollutants in a given volume of air.
WHO:	World Health Organization. The United Nations agency responsible for international public health and setting global air quality guidelines.
WindRose:	A circular diagram showing the frequency and direction of wind patterns at a location.

- (End of the Report) -