APPENDIX 3

Graphs

The data required to forecast the air pollutants are collected from NAMP. In case of Mumbai there are six stations of NAMP to monitor air quality viz. at Bandra, Sion and Mulund. Out of which three stations are operated and managed by NEERI. In case of Navi Mumbai, three AAQM stations are covered under NAMP. Navi Mumbai Municipal Corporation has set up two more CAAQM stations. The monitoring stations are at Vashi, Airoli, Nerul, Rabale, Airoli and Mahape.

The data used in this research are daily ambient minimum and maximum air temperature, relative humidity, wind speed and wind direction, atmospheric pressures at station level and mean sea level, and daily concentration of NO$_x$, SO$_2$ and RSPM at three locations in Mumbai and five locations in Navi Mumbai for a period of 3 years from 2009 to 2011.

This data was provided by the regional center of Meteorology Department situated at Santacruz and the Maharashtra Pollution Control Board portal respectively (www.mpcb.in). Further, the month and date information was also provided as input. The distribution of the data set obtained from the MPCB for the parameters of SO$_2$, NO$_x$ and RSPM at the seven stations mentioned above are as follows as shown in the Figure A3.1 for Mumbai locations and Figure A3.2 for Navi Mumbai Locations.
Figure A3.1: Distribution of data Acquired from MCPB Mumbai Locations
Figure A3.2: Distribution of data Acquired from MPCB for Navi Mumbai Locations
The distribution of the data set obtained from the meteorological department for the parameters of relative humidity, wind speed, wind direction, rainfall, maximum and minimum temperatures, pressure at the station level and the mean sea level are as shown in the Figure A3.3.

Figure A3.3: Distribution of data Acquired from Meteorological Department
Data Transformation

In statistics, **Data Transformation** refers to the application of a deterministic mathematical function to each point in a data set, each data point $z_i$ is replaced with the transformed value

$$y_i = f(z_i)$$ \hspace{1cm} (1)

where $f_i$ is a function. Transformations are usually applied so that the data appear to more closely meet the assumptions of a statistical inference procedure that is to be applied, or to improve the interpreting or appearance of graphs.

As suggested by Tabachnick and Fidell (2007) and Howell (2007), the following guidelines should be used when transforming data.

<table>
<thead>
<tr>
<th>Data Distribution</th>
<th>Data Transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse J Shaped</td>
<td>Inverse transformation $\text{NEWX} = 1/(X)$</td>
</tr>
<tr>
<td>Moderately positive skewness</td>
<td>Square-Root $\text{NEWX} = \text{SQRT}(X)$</td>
</tr>
<tr>
<td>Substantially positive skewness</td>
<td>Logarithmic (Log 10) $\text{NEWX} = \text{LG10}(X)$</td>
</tr>
<tr>
<td>Moderately negative skewness</td>
<td>Square-Root $\text{NEWX} = -1/\sqrt{X}$</td>
</tr>
<tr>
<td>Substantially negative skewness</td>
<td>Logarithmic (Log 10) $\text{NEWX} = -1/\text{LG10}(X)$</td>
</tr>
<tr>
<td>J Shaped</td>
<td>Inverse transformation $\text{NEWX} = -1/(X)$</td>
</tr>
</tbody>
</table>

**Bandra Monitoring Station Air Pollutant SO$_2$**

The descriptive statistical analysis for the air pollutant SO$_2$ monitored at Bandra is shown in Figure A3.4
Figure A3.4: Statistical Summary of Bandra SO$_2$

Bandra Monitoring Station Air Pollutant NO$_x$

The descriptive statistical the air pollutant NO$_x$ monitored at Bandra is shown in Figure A3.5

Figure A3.5: Statistical Summary of Bandra NO$_x$
Bandra Monitoring Station Air Pollutant RSPM

The descriptive statistical analysis for the air pollutant RSPM monitored at Bandra is shown in Figure A3.6.

Sion Monitoring Station Air Pollutant SO₂

The descriptive statistical analysis for the air pollutant SO₂ monitored at Sion is shown in Figure A3.7.
Sion Monitoring Station Air Pollutant NO$_x$

The descriptive statistical analysis for the air pollutant NO$_x$ monitored at Sion is shown in Figure A3.8

Figure A3.8: Statistical Summary of Sion NO$_x$

Sion Monitoring Station Air Pollutant RSPM

The descriptive statistical analysis for the air pollutant RSPM monitored at Sion is as shown in Figure A3.9

Figure A3.9: Statistical Summary of Sion RSPM
Mulund Monitoring Station Air Pollutant $SO_2$

The descriptive statistical analysis for the air pollutant $SO_2$ monitored at Mulund is shown in Figure A3.10

![Figure A3.10: Statistical Summary of Mulund $SO_2$](image)

**Mulund Monitoring Station Air Pollutant NOx**

The descriptive statistical analysis for the air pollutant NOx monitored at Mulund is shown in Figure A3.11

![Figure A3.11: Statistical Summary of Mulund NOx](image)

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Mulund Monitoring Station Air Pollutant RSPM

The descriptive statistical analysis for the air pollutant RSPM monitored at Sion is shown in Figure A3.12

![Figure A3.12: Statistical Summary of Mulund RSPM](image)

Vashi Monitoring Station Air Pollutant SO$_2$

The descriptive statistical analysis for the air pollutant SO$_2$ monitored at Vashi is shown in Figure A3.13

![Figure A3.13: Statistical Summary of Vashi SO$_2$](image)
Vashi Monitoring Station Air Pollutant NO\textsubscript{x}

The descriptive statistical analysis for the air pollutant NO\textsubscript{x} monitored at Vashi is shown in Figure A3.14

Figure A3.14: Statistical Summary of Vashi NO\textsubscript{x}

Vashi Monitoring Station Air Pollutant RSPM

The descriptive statistical analysis for the air pollutant RSPM monitored at Vashi is shown in Figure A3.15

Figure A3.15: Statistical Summary of Vashi RSPM
Airoli Monitoring Station Air Pollutant $\text{SO}_2$

The descriptive statistical analysis for the air pollutant $\text{SO}_2$ monitored at Airoli is shown in Figure A3.16

![Figure A3.16: Statistical Summary of Airoli $\text{SO}_2$](Image)

Airoli Monitoring Station Air Pollutant $\text{NO}_x$

The descriptive statistical analysis for the air pollutant $\text{NO}_x$ monitored at Airoli is shown in Figure A3.17

![Figure A3.17: Statistical Summary of Airoli $\text{NO}_x$](Image)
Airoli Monitoring Station Air Pollutant RSPM
The descriptive statistical analysis for the air pollutant RSPM monitored at Airoli is shown in Figure A3.18

![Figure A3.18: Statistical Summary of Airoli RSPM](image)

Nerul Monitoring Station Air Pollutant SO$_2$
The descriptive statistical analysis for the air pollutant SO$_2$ monitored at Nerul is shown in Figure A3.19

![Figure A3.19: Statistical Summary of Nerul SO$_2$](image)
Nerul Monitoring Station Air Pollutant NO$_x$

The descriptive statistical analysis for the air pollutant NO$_x$ monitored at Nerul is shown in Figure A3.20

![Figure A3.20: Statistical Summary of Nerul NO$_2$](image)

Nerul Monitoring Station Air Pollutant RSPM

The descriptive statistical analysis for the air pollutant RSPM monitored at Nerul is shown in Figure A3.21

![Figure A3.21: Statistical Summary of Nerul RSPM](image)

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Mahape Monitoring Station Air Pollutant SO$_2$

The descriptive statistics analysis for the air pollutant SO$_2$ monitored at Mahape is shown in Figure A3.22

![Figure A3.22: Statistical Summary of Mahape SO$_2$](image)

Mahape Monitoring Station Air Pollutant NO$_x$

The descriptive statistical analysis for the air pollutant NO$_x$ monitored at Mahape is shown in Figure A3.23

![Figure A3.23: Statistical Summary of Mahape NO$_x$](image)
Mahape Monitoring Station Air Pollutant RSPM

The descriptive statistical analysis for the air pollutant RSPM monitored at Mahape is shown in Figure A3.24

![Summary for Mahape RSPM μg/m³]

Figure A3.24: Statistical Summary of Mahape RSPM

Rabale Monitoring Station Air Pollutant SO₂

The descriptive statistical analysis for the air pollutant SO₂ monitored at Rabale is shown in Figure A3.25

![Summary for Rabale SO₂ μg/m³]

Figure A3.25: Statistical Summary of Rabale SO₂

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Rabale Monitoring Station Air Pollutant NO\textsubscript{x}

The descriptive statistical analysis for the air pollutant NO\textsubscript{x} monitored at Rabale is shown in Figure A3.26

![Image of statistical summary for NO\textsubscript{x}](image)

Figure A3.26: Statistical Summary of Rabale NO\textsubscript{x}

Rabale Monitoring Station Air Pollutant RSPM

The descriptive statistical analysis for the air pollutant RSPM monitored at Rabale is shown in Figure A3.27

![Image of statistical summary for RSPM](image)

Figure A3.27: Statistical Summary of Rabale RSPM

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Relative humidity

The descriptive statistical analysis for the meteorological parameter relative humidity is shown in Figure A3.28

![Figure A3.28: Statistical Summary of Relative Humidity](image)

Wind Direction

The descriptive statistical analysis for the meteorological parameter wind direction is shown in Figure A3.29

![Figure A3.29: Statistical Summary of Wind Direction](image)
Wind Speed

The descriptive statistical analysis for the meteorological parameter wind speed is shown in Figure A3.30.

![Figure A3.30: Statistical Summary of Wind Speed](image)

After the transformation the skewness is -0.424 and is more uniformly distributed than the non-transformed values with respect to wind speed the transformed values are used for the further processing as shown in Figure A3.31.

![Figure A3.31: Statistical Summary of Transformed Wind Speed](image)
Cloud Octa - % percentage of the sky covered by clouds

The descriptive statistical analysis for the meteorological parameter cloud octa - % percentage of the sky covered by clouds as shown in Figure A3.32.

Rainfall

The descriptive statistical analysis for the meteorological parameter rainfall measured in mm is as shown in Figure A3.33.
The average rainfall measured in mm 62.96 mm with a standard deviation of 33617.35 mm. After observing skewness 3.82 and kurtic 15.30 values of the parameter rainfall it is concluded that it is substantially skewed to the right and leptokurtic. Hence the researcher has transformed the data using positive logarithmic transformation and tested for improvement in $R^2$ value in the regression model as shown in Figure 3.34.

![Figure A3.34: Statistical Summary of Transformed Rainfall](image)

After the transformation the skewness is -0.424 and is more uniformly distributed than the non-transformed values with respect to rainfall the transformed values are used for the further processing.
Maximum Temperature

The descriptive statistical analysis for the meteorological parameter maximum temperature measured in degree Celsius is as shown in Figure A3.35.

![Figure A3.35: Statistical Summary of Maximum Temperature](image)

Minimum Temperature

The descriptive statistical analysis for the meteorological parameter minimum temperature measured in degree Celsius is as shown in Figure A3.36.

![Figure A3.36: Statistical Summary of Minimum Temperature](image)
Pressure in Mb - Station level

The descriptive statistical analysis for the meteorological parameter Pressure measured in Mb at Station level is as shown in Figure A3.37.

![Figure A3.37: Statistical Summary of Pressure in Mb - Station level](image)

Pressure in Mb - Mean Sea Level

The descriptive statistical analysis for the meteorological parameter Pressure measured in Mb at Mean Sea level is as shown in Figure A3.38.

![Figure A3.38: Statistical Summary of Pressure in Mb - Mean Sea Level](image)