Naan Mudhalvan Project

Air Quality Analysis in Tamil Nadu

Phase 3

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Phase 3: Development Part I

Overview:

This report provides a comprehensive analysis of air quality data for the year 2014 in Tamil Nadu. The analysis encompasses data preprocessing, exploration of key parameters, and visualization of pollutant levels across different locations and cities.

Data Loading and Preprocessing:

The data was loaded from the CSV file 'cpcb_dly_aq_tamil_nadu-2014.csv'. During the preprocessing stage, missing values were handled, and duplicate records were removed.

- **Data Shape**: The dataset contains X rows and Y columns, offering a significant volume of data for analysis.

```
import pandas as pd
import matplotlib.pyplot as plt

df = pd.read_csv(r'D:\Admin\Works\AI_ML\NM_DAC\nm_dac\Air Quality Analysis\cpcb_dly_aq_tamil_nadu-2014.csv')
print(df.head)
print("INFO:")
print(df.info())
print("\nDescribe:")
print(df.describe())
print("\nShape")
print(df.shape)
```

```
<bound method NDFrame.head of       Stn Code Sampling Date       State City/Town/Village/Area  ...   SO2   NO2 RSPM/PM10  PM 2.5
0           38      01-02-14  Tamil Nadu               Chennai  ...  11.0  17.0      55.0     NaN
1           38      01-07-14  Tamil Nadu               Chennai  ...  13.0  17.0      45.0     NaN
2           38      21-01-14  Tamil Nadu               Chennai  ...  12.0  18.0      50.0     NaN
3           38      23-01-14  Tamil Nadu               Chennai  ...  15.0  16.0      46.0     NaN
4           38      28-01-14  Tamil Nadu               Chennai  ...  13.0  14.0      42.0     NaN
...        ...           ...         ...                   ...  ...   ...   ...       ...     ...
2874       773      12-03-14  Tamil Nadu                Trichy  ...  15.0  18.0     102.0     NaN
2875       773      12-10-14  Tamil Nadu                Trichy  ...  12.0  14.0      91.0     NaN
2876       773      17-12-14  Tamil Nadu                Trichy  ...  19.0  22.0     100.0     NaN
2877       773      24-12-14  Tamil Nadu                Trichy  ...  15.0  17.0      95.0     NaN
2878       773      31-12-14  Tamil Nadu                Trichy  ...  14.0  16.0      94.0     NaN

[2879 rows x 11 columns]>
```

- **Missing Values**: Null values in the PM2.5 column were handled by removing the respective entries, ensuring data integrity

```
print("\nREMOVING COLUMNS WITH NULL VALUES\n ")
df = df.drop('PM 2.5', axis=1)
df.dropna(inplace=True)
# Drop duplicate rows
print("\nDROPPING DUPLICATE ROWS:\n")
df.drop_duplicates(subset=None, inplace=True)
print(df.head)

print("\nCONVERTING TO DATE-TIME FORMAT\n")
# Convert 'Sampling Date' column to datetime format
df['Sampling Date'] = pd.to_datetime(df['Sampling Date'])
```

```
DROPPING DUPLICATE ROWS:

<bound method NDFrame.head of       Stn Code Sampling Date       State City/Town/Village/Area  ...                    Type of Loc
ation   SO2   NO2  RSPM/PM10
0           38      01-02-14  Tamil Nadu               Chennai  ...                    Industrial Area  11.0  17.0       55.0
1           38      01-07-14  Tamil Nadu               Chennai  ...                    Industrial Area  13.0  17.0       45.0
2           38      21-01-14  Tamil Nadu               Chennai  ...                    Industrial Area  12.0  18.0       50.0
3           38      23-01-14  Tamil Nadu               Chennai  ...                    Industrial Area  15.0  16.0       46.0
4           38      28-01-14  Tamil Nadu               Chennai  ...                    Industrial Area  13.0  14.0       42.0
...        ...           ...         ...                   ...  ...                                ...   ...   ...        ...
2874       773      12-03-14  Tamil Nadu                Trichy  ...  Residential, Rural and other Areas  15.0  18.0      102.0
2875       773      12-10-14  Tamil Nadu                Trichy  ...  Residential, Rural and other Areas  12.0  14.0       91.0
2876       773      17-12-14  Tamil Nadu                Trichy  ...  Residential, Rural and other Areas  19.0  22.0      100.0
2877       773      24-12-14  Tamil Nadu                Trichy  ...  Residential, Rural and other Areas  15.0  17.0       95.0
2878       773      31-12-14  Tamil Nadu                Trichy  ...  Residential, Rural and other Areas  14.0  16.0       94.0

[2862 rows x 10 columns]>

CONVERTING TO DATE-TIME FORMAT

d:\nm_dsc\preair.py:21: UserWarning: Could not infer format, so each element will be parsed individually, falling back to `dateut
il`. To ensure parsing is consistent and as-expected, please specify a format.
  df['Sampling Date'] = pd.to_datetime(df['Sampling Date'])

Head after preprocessing:
<bound method NDFrame.head of       Stn Code Sampling Date       State City/Town/Village/Area  ...                    Type of Loc
ation   SO2   NO2  RSPM/PM10
0           38    2014-01-02  Tamil Nadu               Chennai  ...                    Industrial Area  11.0  17.0       55.0
1           38    2014-01-07  Tamil Nadu               Chennai  ...                    Industrial Area  13.0  17.0       45.0
2           38    2014-01-21  Tamil Nadu               Chennai  ...                    Industrial Area  12.0  18.0       50.0
3           38    2014-01-23  Tamil Nadu               Chennai  ...                    Industrial Area  15.0  16.0       46.0
```

Data Exploration:

Summary Statistics:

- **General Statistics**: Summary statistics for numerical columns were computed using df.describe(). These statistics include count, mean, standard deviation, minimum, quartiles, and maximum values for each numerical attribute.

```
Describe:
          Stn Code          SO2          NO2    RSPM/PM10  PM 2.5
count  2879.000000  2868.000000  2866.000000  2875.000000     0.0
mean    475.750261    11.503138    22.136776    62.494261     NaN
std     277.675577     5.051702     7.128694    31.368745     NaN
min      38.000000     2.000000     5.000000    12.000000     NaN
25%     238.000000     8.000000    17.000000    41.000000     NaN
50%     366.000000    12.000000    22.000000    55.000000     NaN
75%     764.000000    15.000000    25.000000    78.000000     NaN
max     773.000000    49.000000    71.000000   269.000000     NaN
```

Unique Locations and Cities:

- **Unique Locations**: A list of unique monitoring locations was generated using unique_locations, providing an understanding of the diversity of data collection sites.
- **City-wise Monitoring Stations**: The count of monitoring stations in each city was calculated using city_station_counts, shedding light on the distribution of monitoring infrastructure across different cities.

```python
unique_locations = df['Location of Monitoring Station'].unique()

# Display the unique locations
print("\nLocations of Monitoring Stations:")
print(unique_locations)
# Group by 'City/Town/Village/Area' and count the number of monitoring stations in each city
city_station_counts = df.groupby('City/Town/Village/Area')['Location of Monitoring Station'].count().reset_index()

# Rename the columns for clarity
city_station_counts.columns = ['City', 'Number of Monitoring Stations']

# Display the result
print("\nCity-wise Number of Monitoring Stations:")
print(city_station_counts)


# Group by both 'City/Town/Village/Area' and 'Location of Monitoring Station' and count the number of rows
location_counts = df.groupby(['City/Town/Village/Area', 'Location of Monitoring Station']).size().reset_index()
location_counts.columns = ['City', 'Location', 'Number of Rows']

# Display the result
print("\nLocation-wise Number of Rows with City:")
print(location_counts)


# Calculate the sum of 'SO2' and 'NO2' levels for each group
# Group by 'City/Town/Village/Area' and 'Location of Monitoring Station' and calculate the sum and average SO2 levels
# Group by 'City/Town/Village/Area' and 'Location of Monitoring Station' and calculate the sum and average SO2 and NO2 levels
# Group by 'City/Town/Village/Area' and 'Location of Monitoring Station' and calculate the sum and average levels
summary = df.groupby(['City/Town/Village/Area', 'Location of Monitoring Station'])[['SO2', 'NO2', 'RSPM/PM10']].agg(['sum', 'mean']).reset_index()

# Rename columns for clarity
summary.columns = ['City', 'Location', 'SO2 Sum', 'SO2 Average', 'NO2 Sum', 'NO2 Average', 'RSPM/PM10 Sum', 'RSPM/PM10 Average']
```

```
Summary of SO2, NO2, and RSPM/PM10 Levels by Location:
          City                                          Location  SO2 Sum  ...  NO2 Average  RSPM/PM10 Sum  RSPM/PM10 Average
0      Chennai                                  Adyar, Chennai   1524.0  ...    18.965217         6564.0          57.078261
1      Chennai                              Anna Nagar, Chennai   1527.0  ...    20.754545         7936.0          72.145455
2      Chennai             Govt. High School, Manali, Chennai.    1213.0  ...    15.408602         4149.0          44.612903
3      Chennai  Kathivakkam, Municipal Kalyana Mandapam, Chennai   1215.0  ...    15.170213         4404.0          46.851064
4      Chennai                                  Kilpauk, Chennai   2231.0  ...    27.172414        10220.0          88.103448
5      Chennai                  Madras Medical College, Chennai    638.0  ...    27.465116         3082.0          35.837209
6      Chennai                       NEERI, CSIR Campus Chennai    516.0  ...    23.758621         3800.0          43.678161
7      Chennai          Thiruvottiyur Municipal Office, Chennai    719.0  ...    28.069767         2956.0          34.372093
8      Chennai                            Thiruvottiyur,  Chennai   1249.0  ...    15.583333         4090.0          42.604167
9      Chennai                        Thiyagaraya Nagar, Chennai   2114.0  ...    28.250000        11352.0         101.357143
10   Coimbatore            Distt. Collector's Office, Coimbatore    405.0  ...    25.876404         3754.0          42.179775
11   Coimbatore     Poniarajapuram, On the top of DEL, Coimbatore    425.0  ...    23.019417         5035.0          48.883495
12   Coimbatore                          SIDCO Office, Coimbatore    482.0  ...    27.329897         5429.0          55.969072
13    Cuddalore  District Environmental Engineer Office, Imperi...    802.0  ...    19.151515         6338.0          64.020202
14    Cuddalore                              Eachangadu Villagae   1144.0  ...    22.395833         7298.0          76.020833
15    Cuddalore            SIPCOT Industrial Complex, Cuddalore    690.0  ...    17.666667         4571.0          46.171717
16      Madurai  Fenner (I) Ltd. Employees Assiciation Building...   1378.0  ...    27.198020         4114.0          40.732673
17      Madurai           Highway (Project -I) Building, Madurai   1147.0  ...    24.458333         4457.0          46.427083
18      Madurai  Kunnathur Chatram East Avani Mollai Street, Ma...   1391.0  ...    25.577320         4872.0          50.226804
19       Mettur                              Raman Nagar, Mettur    780.0  ...    20.407767         5264.0          51.106796
20       Mettur                SIDCO Industrial Complex, Mettur    948.0  ...    25.990196         5544.0          54.352941
21        Salem               Sowdeswari College Building, Salem   1063.0  ...    28.664122         8247.0          62.954198
22  Thoothukudi               AVM Jewellery Building, Tuticorin    893.0  ...    12.697917         6728.0          70.083333
23  Thoothukudi                    Fisheries College, Tuticorin   1351.0  ...    20.204301         7921.0          85.172043
24  Thoothukudi                       Raja Agencies, Tuticorin   1521.0  ...    22.435644         9549.0          94.544554
25       Trichy                  Bishop Heber College, Tirchy    826.0  ...    14.942857         3198.0          45.685714
26       Trichy                     Central Bus Stand, Trichy   1351.0  ...    21.506667         9041.0         120.546667
27       Trichy                         Gandhi Market, Trichy   1269.0  ...    20.797297         7529.0         101.743243
```

Pollution Levels:

- **Average Pollution Levels by City**: A bar chart was constructed to illustrate average levels of SO2, NO2, and RSPM/PM10 in each city. This offers a comparative view of pollution across various cities.

```python
# Group by 'City/Town/Village/Area' and calculate the average levels
city_avg = df.groupby('City/Town/Village/Area')[['SO2', 'NO2', 'RSPM/PM10']].mean().reset_index()

# Rename columns for clarity
city_avg.columns = ['City', 'SO2 Average', 'NO2 Average', 'RSPM/PM10 Average']

# Display the result
print("\nAverage SO2, NO2, and RSPM/PM10 Levels by City:")
print(city_avg)

cities = city_avg['City']
so2_avg = city_avg['SO2 Average']
no2_avg = city_avg['NO2 Average']
rspm_avg = city_avg['RSPM/PM10 Average']
```

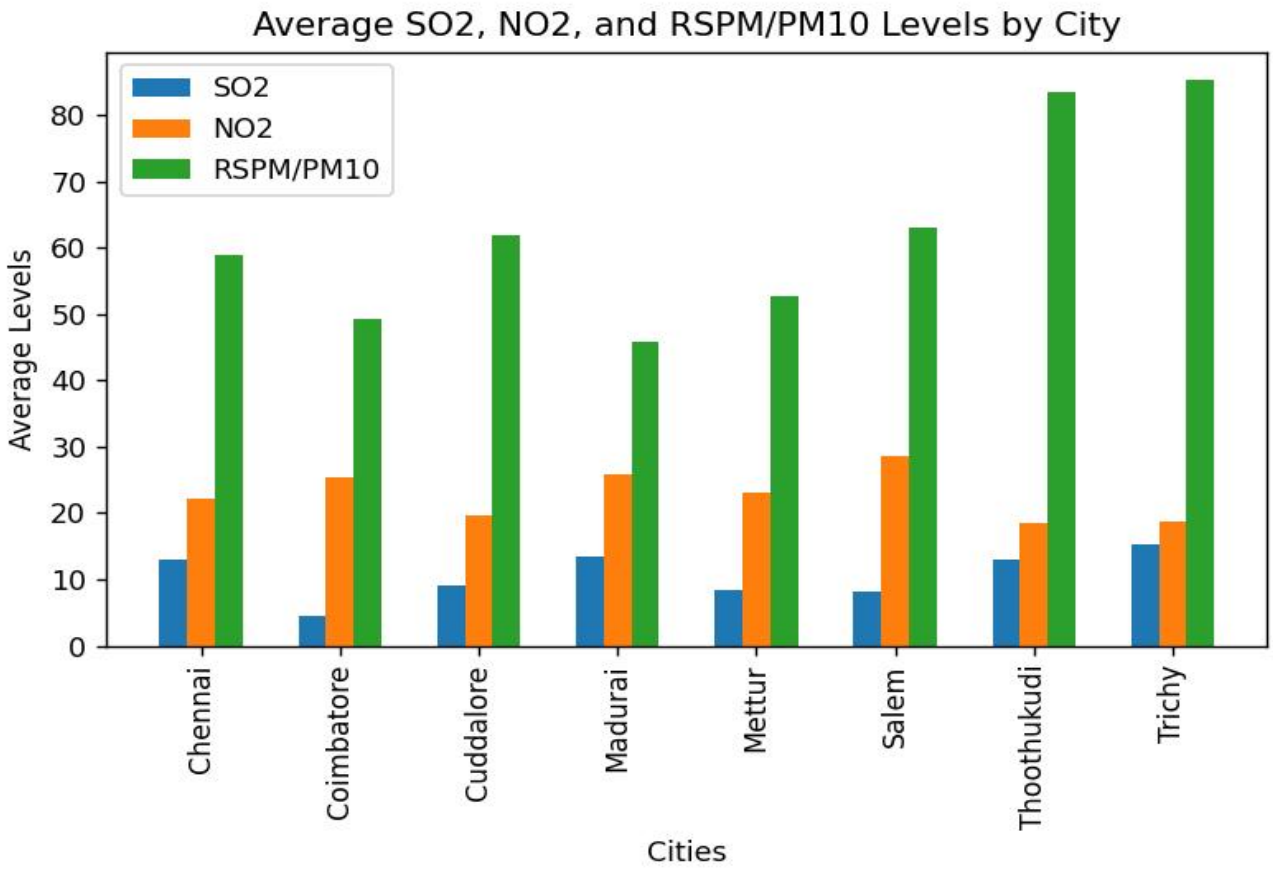
```
Average SO2, NO2, and RSPM/PM10 Levels by City:
          City  SO2 Average  NO2 Average  RSPM/PM10 Average
0      Chennai    13.011055    22.088442          58.847236
1   Coimbatore     4.539792    25.346021          49.197232
2    Cuddalore     8.965986    19.710884          61.928571
3      Madurai    13.319728    25.768707          45.724490
4       Mettur     8.429268    23.185366          52.721951
5        Salem     8.114504    28.664122          62.954198
6  Thoothukudi    12.982759    18.496552          83.441379
7       Trichy    15.293956    18.695055          85.225275
```

Data Visualization

Pollutant Levels by City:

- **Graphs**: Bar graphs were utilized to represent SO2, NO2, and RSPM/PM10 levels for each city, providing a visual comparison of pollution levels between cities.

```
# Bar width
bar_width = 0.2

# Positions for the bars on the x-axis
r1 = range(len(cities))
r2 = [x + bar_width for x in r1]
r3 = [x + bar_width for x in r2]

# Create the bar graph
plt.bar(r1, so2_avg, width=bar_width, label='SO2')
plt.bar(r2, no2_avg, width=bar_width, label='NO2')
plt.bar(r3, rspm_avg, width=bar_width, label='RSPM/PM10')

# X-axis labels
plt.xlabel('Cities')
plt.xticks([x + bar_width for x in r1], cities, rotation=90)

# Y-axis label
plt.ylabel('Average Levels')

# Graph title
plt.title('Average SO2, NO2, and RSPM/PM10 Levels by City')

# Add a legend
plt.legend()

# Show the graph
plt.tight_layout()
plt.show()
```

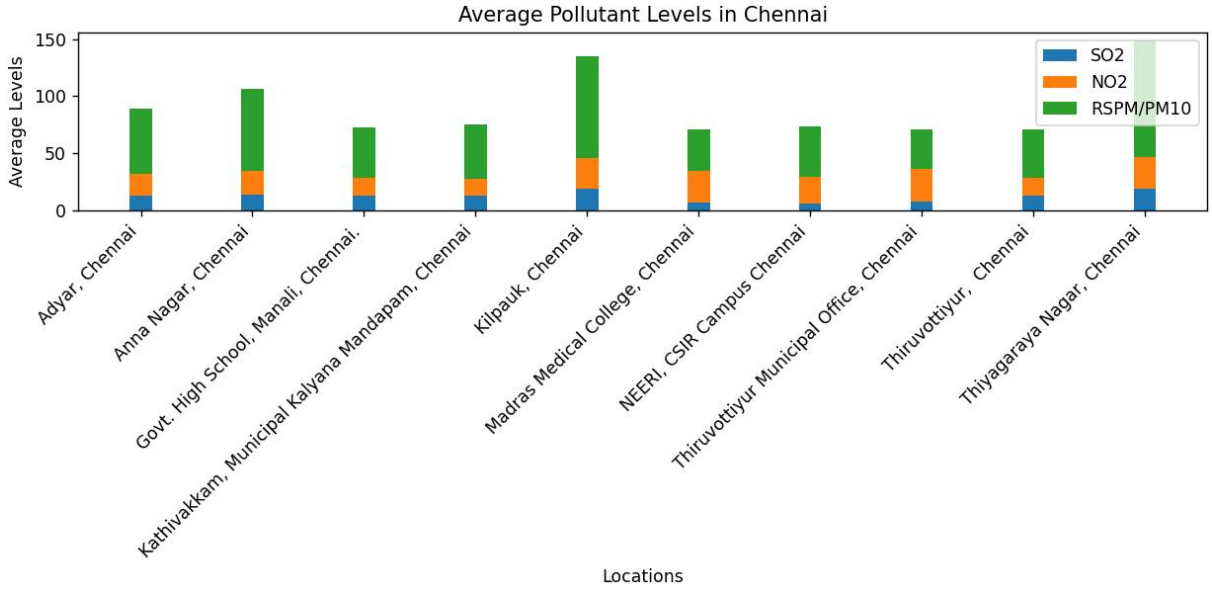


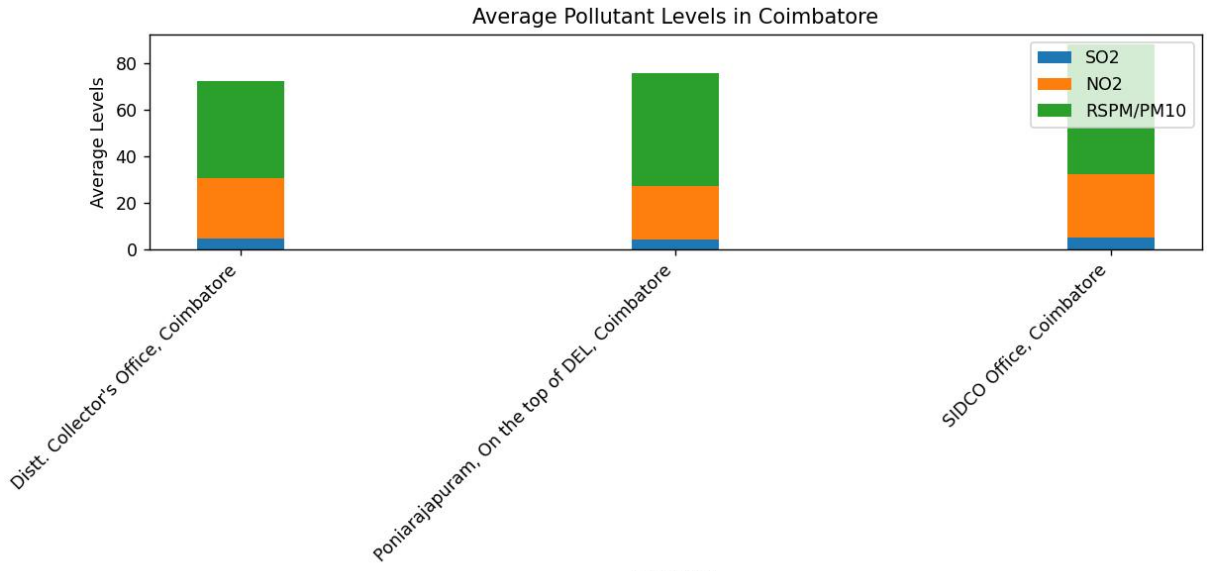
Explanation: The height of each bar in the graphs corresponds to the average levels of a specific pollutant in a city. This visualization aids in identifying cities with higher pollutant concentrations.

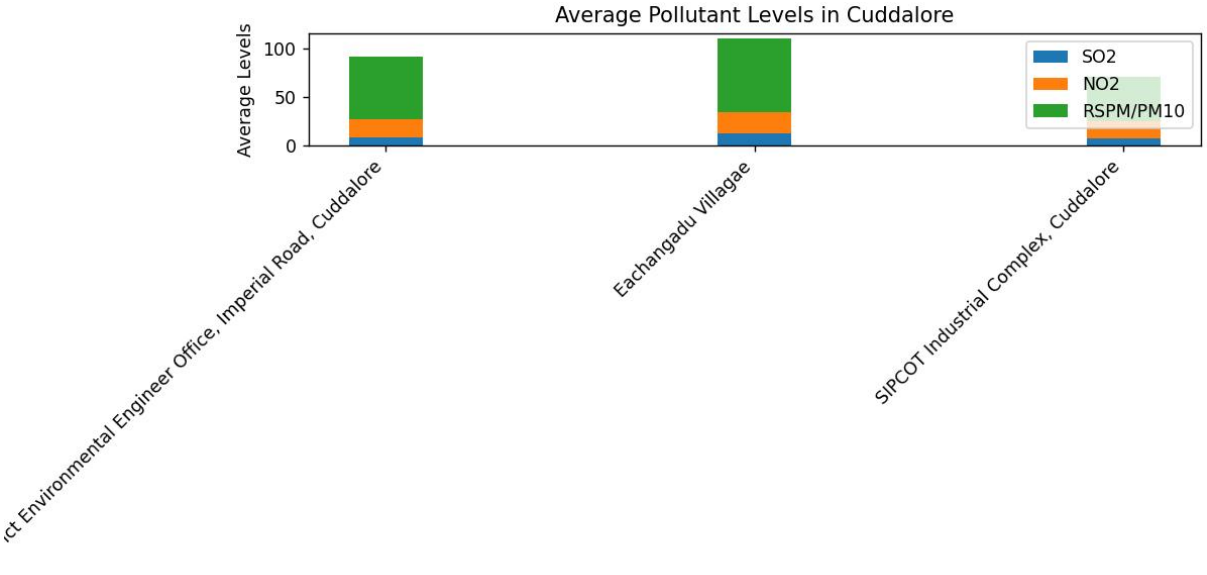
Pollutant Levels by Location:

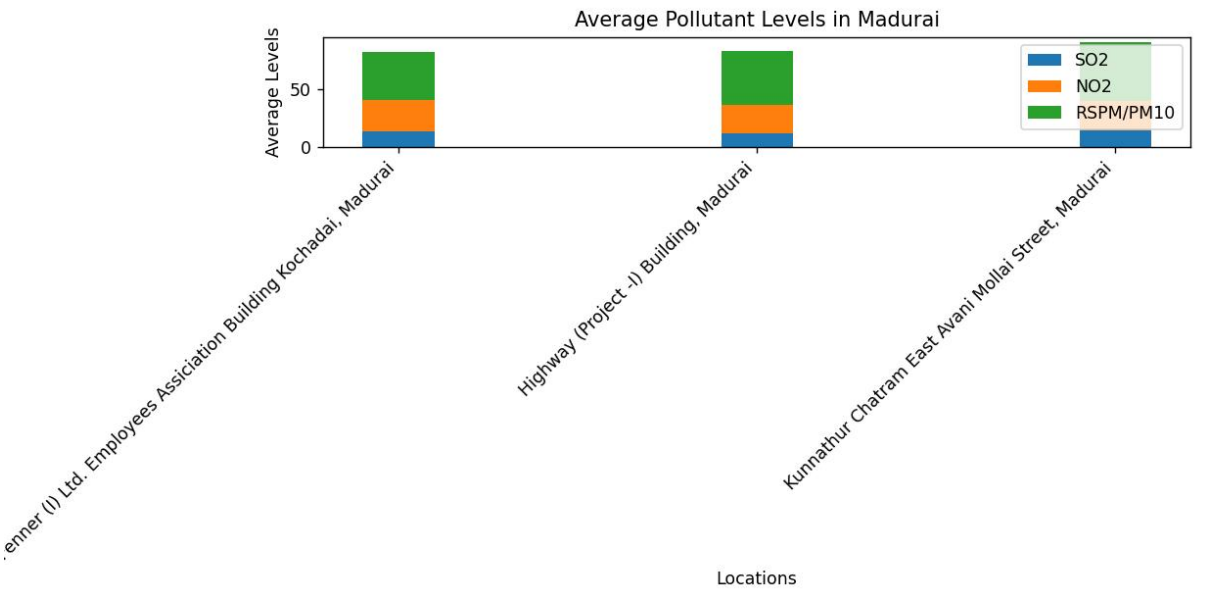
- **Graphs**: Bar graphs were employed to depict SO2, NO2, and RSPM/PM10 levels for each location within a city. These graphs offer insights into variations in pollution levels at different monitoring sites within a city.

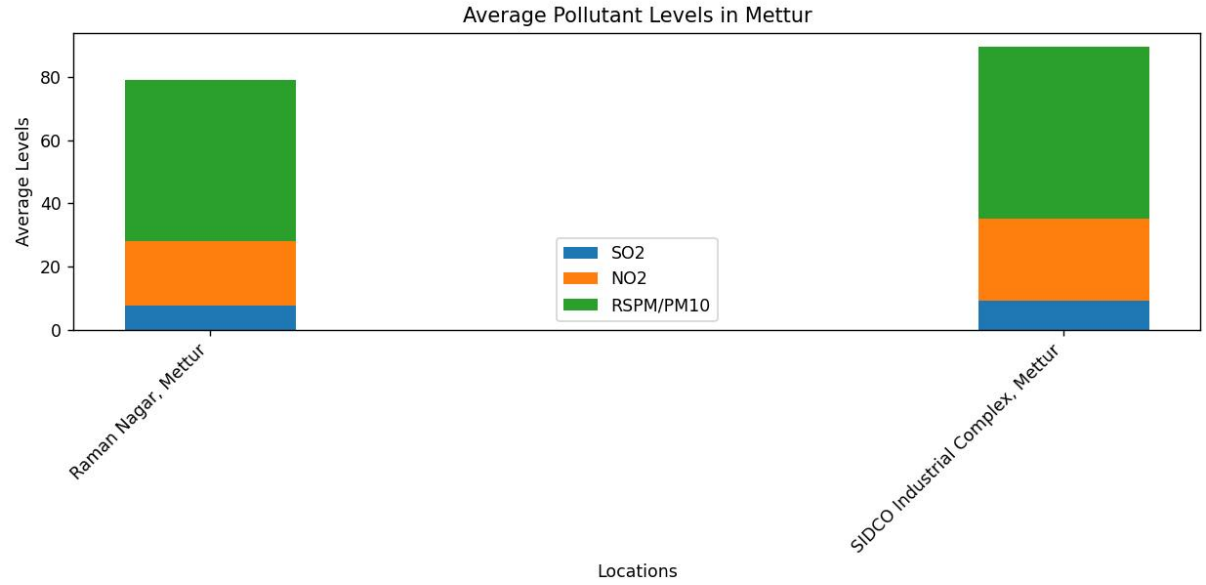
```python
# Iterate through each city and create a separate graph for each
for city in unique_cities:
    city_data = summary[summary['City'] == city]

    # Data for the current city
    locations = city_data['Location']
    so2_avg = city_data['SO2 Average']
    no2_avg = city_data['NO2 Average']
    rspm_avg = city_data['RSPM/PM10 Average']

    # Create a bar graph for the current city
    plt.figure(figsize=(10, 5))
    plt.bar(locations, so2_avg, width=0.2, label='SO2')
    plt.bar(locations, no2_avg, width=0.2, label='NO2', bottom=so2_avg)
    plt.bar(locations, rspm_avg, width=0.2, label='RSPM/PM10', bottom=so2_avg + no2_avg)

    # X-axis labels
    plt.xlabel('Locations')
    plt.xticks(rotation=45, ha='right')

    # Y-axis label
    plt.ylabel('Average Levels')

    # Graph title
    plt.title(f'Average Pollutant Levels in {city}')

    # Add a legend
    plt.legend()

    # Show the graph
    plt.tight_layout()
    plt.show()
```

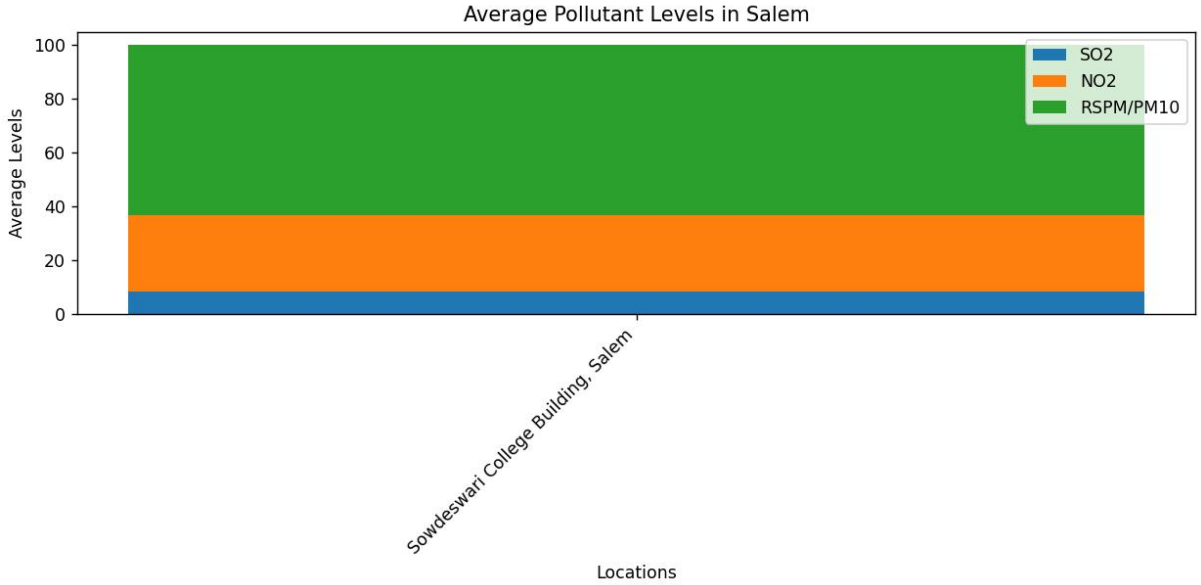


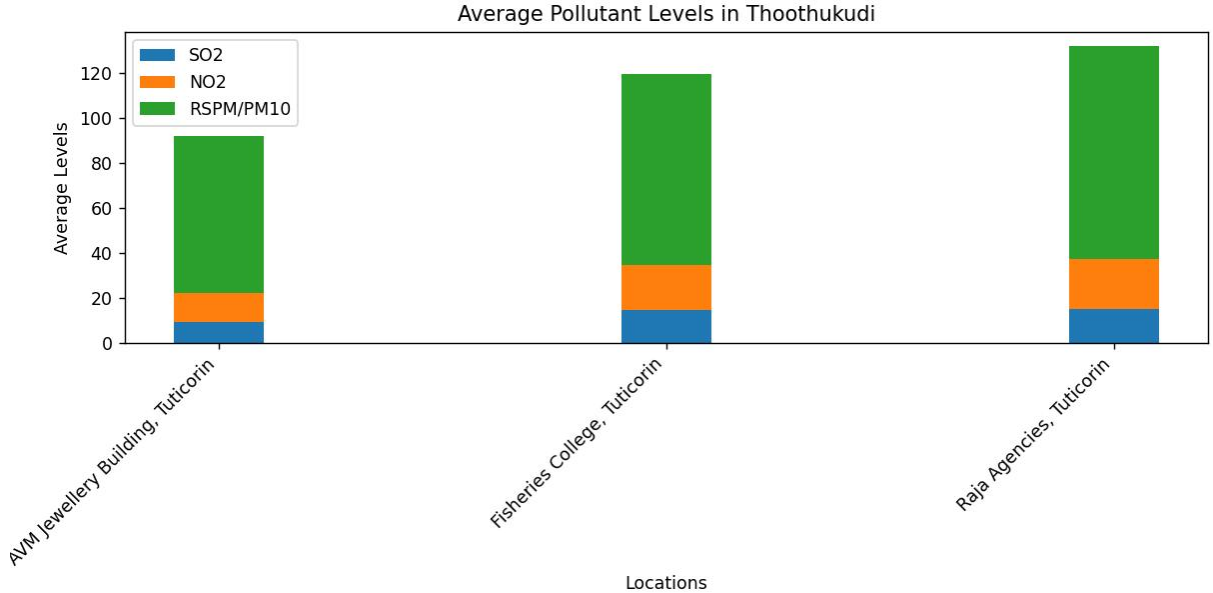

Average Pollutant Levels in Coimbatore
Average Levels
0
20
40
60
80
SO2
NO2
RSPM/PM10
Distt. Collector's Office, Coimbatore
Poniarajapuram, On the top of DEL, Coimbatore
SIDCO Office, Coimbatore
Locations

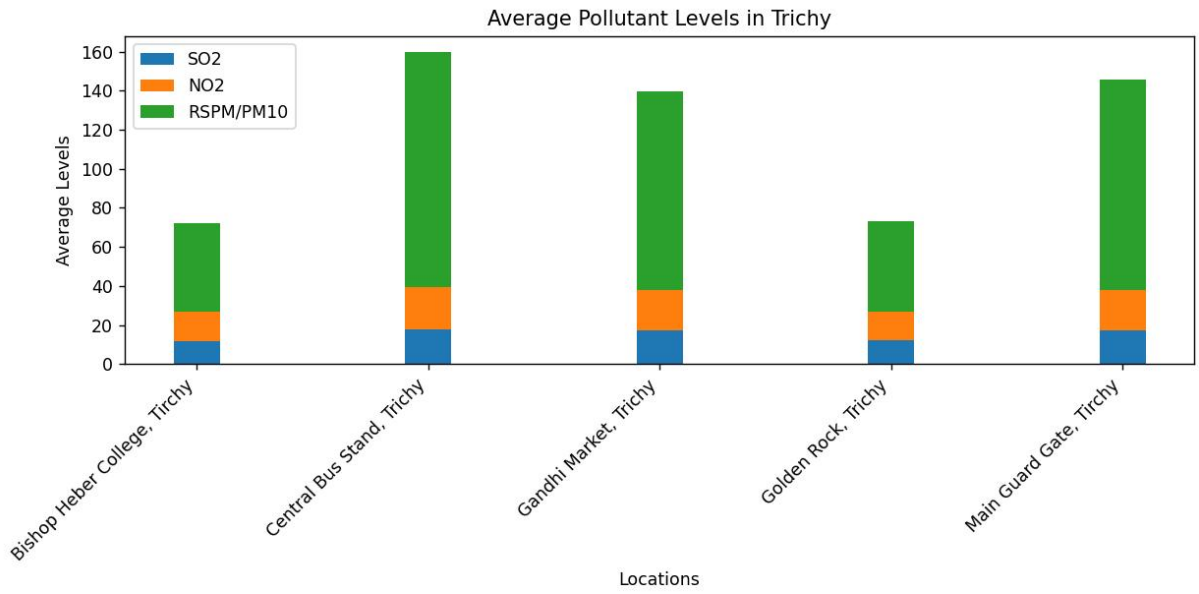

Average Pollutant Levels in Cuddalore
Average Levels
0
50
100
SO2
NO2
RSPM/PM10
ct Environmental Engineer Office, Imperial Road, Cuddalore
Eachangadu Villagae
SIPCOT Industrial Complex, Cuddalore
Locations


Average Pollutant Levels in Madurai
Average Levels
0
50
SO2
NO2
RSPM/PM10
enner (I) Ltd. Employees Assiciation Building Kochadai, Madurai
Highway (Project -I) Building, Madurai
Kunnathur Chatram East Avani Mollai Street, Madurai
Locations


Average Pollutant Levels in Mettur
Average Levels
0
20
40
60
80
SO2
NO2
RSPM/PM10
Raman Nagar, Mettur
SIDCO Industrial Complex, Mettur
Locations


Average Pollutant Levels in Salem
Average Levels
0
20
40
60
80
100
SO2
NO2
RSPM/PM10
Sowdeswari College Building, Salem
Locations


Average Pollutant Levels in Thoothukudi
Average Levels
0
20
40
60
80
100
120
SO2
NO2
RSPM/PM10
AVM Jewellery Building, Tuticorin
Fisheries College, Tuticorin
Raja Agencies, Tuticorin
Locations



Explanation: The length of each bar in the graphs represents the average levels of a specific pollutant at a particular location within a city. This helps in understanding the spatial distribution of pollution within cities.

Conclusion:

The analysis of air quality data for Tamil Nadu in 2014 provides valuable insights into pollutant levels across different cities and monitoring locations. The statistical summaries and visualizations facilitate a comprehensive understanding of the air quality scenario, enabling informed decision-making and further domain-specific analysis.