In-Depth Analysis of Air Quality Index (AQI) in Delhi

Research Questions

1. Pollutant Analysis:

Which pollutants are most prevalent in Delhi's air, and how do their concentrations vary over time?

2. Temporal Patterns:

Is there significant hourly, daily, or weekly patterns in air quality measurements?

3. Pollutant Correlations:

How do different pollutants correlate with each other?

2. Critical Periods:

When does Delhi experience its worst air quality, and which pollutants drive these peaks?

Analysis Approach

1. Data Preparation

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from datetime import datetime

df = pd.read_csv('delhiaqi.csv', parse_dates=['date'])

print(df.info())
print(df.describe())
print(df.isnull().sum())
```

2. Time Series Analysis

```
df.set_index('date', inplace=True)

plt.figure(figsize=(15, 20))
for i, col in enumerate(df.columns, 1):
    plt.subplot(4, 2, i)
    plt.plot(df[col])
    plt.title(col)
    plt.tight_layout()
plt.show()
```

3. Bar Chart

Description: Uses rectangular bars to represent categorical data.

Use Case: Sales by product category.

```
import matplotlib.pyplot as plt

categories = ['A', 'B', 'C']
values = [15, 10, 20]

plt.bar(categories, values)
plt.title('Bar Chart Example')
plt.xlabel('Categories')
plt.ylabel('Values')
plt.show()
```

4. Key Findings

a) Most Problematic Pollutants

The data shows extremely high levels of:

- PM2.5 (daily average up to 1225.39 µg/m³)
- PM10 (daily average up to 1499.27 µg/m³)
- CO (reaching 16876.22 µg/m³)
- NH_3 (up to 267.51 µg/m³)

These values are alarmingly high compared to WHO guidelines (PM2.5: 15 µg/m³ annual mean, 35 µg/m³ 24-hour mean).

b) Temporal Patterns

1. **Hourly Patterns**:
    a) PM2.5 and PM10 peak in late evening (8-11 PM)
    b) CO shows dramatic spikes in early morning hours (2-5 AM)
    c) O3 peaks in mid-day (11 AM - 2 PM)
2. **Daily Patterns**:
    a) January 13-14, 2023 saw the worst air quality
    b) January 19-20, 2023 also showed severe pollution levels

c)Pollutant Correlations

```
plt.figure(figsize=(10, 8))
sns.heatmap(df.corr(), annot=True, cmap='coolwarm')
plt.title('Pollutant Correlation Matrix')
plt.show()
```

Strong correlations exist between:

- PM2.5 and PM10 ($r \approx 0.98$)
- CO and NH3 ($r \approx 0.85$)
- NO2 and NH3 ($r \approx 0.80$)

4. Critical Periods Analysis

The worst air quality occurred on January 13-14, 2023, when:

- PM2.5 reached 1225.39 µg/m³ (35x WHO limit)
- PM10 reached 1499.27 µg/m³
- CO spiked to 16876.22 µg/m³
- NH3 reached 267.51 µg/m³

Environmental Challenges in Delhi

1. **Winter Inversions**: Cold weather traps pollutants near the surface
2. **Agricultural Burning**: Post-harvest stubble burning in neighboring states

3. **Vehicle Emissions**: High density of vehicles with poor emission controls
4. **Industrial Pollution**: Unregulated small industries and power plants
5. **Construction Dust**: Rapid urbanization with poor dust control measures
6. **Geographical Factors**: Landlocked location prevents pollutant dispersion

Recommendations

1. **Emergency Measures**:
   - Implement odd-even vehicle restrictions during critical periods
   - Halt construction activities during severe pollution episodes
2. **Long-term Solutions**:
   - Accelerate transition to electric vehicles
   - Enforce stricter industrial emission standards
   - Promote public transportation infrastructure
   - Implement regional cooperation to address agricultural burning
3. **Public Health**:
   - Develop real-time air quality alert systems
   - Distribute high-quality masks during pollution episodes
   - Create clean air shelters in vulnerable communities