**Comparative Time Series Analysis of Air Quality Across All Stations (MER, TLA, BJU, PED)**

This document presents a consolidated time series analysis of air quality across four monitoring stations: MER, TLA, BJU, and PED.

It follows a structured approach to compare AQI trends, seasonal variations, pollutant distributions, and weather effects, highlighting key similarities and differences among the stations.

The insights derived from this analysis provide a comprehensive understanding of regional pollution patterns and suggest targeted interventions for improving air quality.

**1. Overall Trends in AQI**

**Similarities:**

* All four stations exhibit seasonal patterns, with AQI levels peaking during winter months (December–February) and dropping during summer (June–August).
* High daily fluctuations in AQI at all stations suggest that air quality is strongly influenced by short-term factors such as weather, pollution events, and human activity.
* The general trend across stations indicates improving air quality mid-2022, followed by a gradual decline towards late 2023.

**Differences:**

* **Absolute AQI Values:** MER consistently records the highest AQI, followed by PED. BJU and TLA have relatively lower AQI values, suggesting better air quality.
* **Magnitude of Fluctuations:** MER and PED stations experience larger AQI swings compared to BJU and TLA, indicating higher sensitivity to pollution events.
* **Specific Peaks and Dips:** Unique local factors influence air quality at each station. The PED station saw a sharp increase in AQI in early 2024, while BJU recorded an unusual peak in January 2023.

**2. Smoothed AQI (30-Day Rolling Average)**

**Similarities:**

* The rolling average for all stations shows a steady improvement in AQI in mid-2022, followed by a gradual worsening in 2023.
* Winter months consistently have higher AQI across all locations, indicating a common seasonal impact on pollution levels.

**Differences:**

* MER and PED show more pronounced peaks and dips in the rolling average compared to TLA and BJU.
* The rate of AQI increase in late 2023 is steeper at PED compared to the other stations.
* BJU station’s rolling average is smoother, indicating a more stable pollution pattern compared to the higher variability seen at MER and PED.

**3. 365-Day Rolling Average of AQI**

* The 365-day analysis confirms that AQI trends observed over shorter periods are not anomalies but long-term patterns.
* MER and PED stations exhibit the highest long-term AQI levels, while TLA and BJU show relatively lower pollution levels.

**4. Decomposing Time Series**

**Trend Direction and Magnitude:**

* All stations display an increasing AQI trend from 2021 to 2023, with a temporary decline in mid-2022.
* The magnitude of this trend is most pronounced in PED and MER, while BJU and TLA show smaller variations.

**Seasonality Strength:**

* Seasonal effects are strongest in TLA and BJU, showing clear cyclical peaks and troughs.
* MER and PED exhibit more irregular seasonal patterns, possibly influenced by local pollution sources such as industrial activity.

**Magnitude of Residuals:**

* MER and PED have larger residuals, suggesting a higher impact of short-term, unpredictable pollution events.
* BJU and TLA have lower residual fluctuations, indicating more stable air quality trends.

**5. Effect of Weather on AQI**

**Temperature:**

* Higher AQI during colder months suggests an inverse relationship between temperature and pollution levels.
* AQI is lowest during summer across all stations, aligning with increased atmospheric dispersion.

**Humidity:**

* No clear correlation between humidity and AQI was observed.
* However, BJU and PED show instances where high humidity correlates with lower AQI, likely due to pollutant washout by precipitation.

**Wind Speed:**

* Higher wind speeds are associated with lower AQI values, indicating pollutant dispersion.
* Wind speeds at MER and PED stations are generally lower, potentially contributing to their higher AQI levels.

**6. Air Quality Distribution by Season**

**Similarities:**

* All stations experience their highest AQI levels in winter and lowest in summer.
* PM10 and PM2.5 concentrations peak in winter, likely due to temperature inversions trapping pollutants.
* Ozone (O3) reaches its highest levels in spring and early summer across all locations.

**Differences:**

* MER and PED have stronger seasonal variations compared to BJU and TLA.
* NO2 levels are more elevated at PED and BJU during colder months, possibly due to higher traffic emissions.
* TLA sees a more even pollutant distribution throughout the year.

**7. Average Contribution of Pollutants to AQI**

**Similarities:**

* PM10 is the dominant pollutant at all stations, contributing the most to AQI levels.
* Ozone and PM2.5 show moderate contributions across locations.

**Differences:**

* The contribution of PM10 is significantly higher at PED compared to the other stations.
* BJU shows a higher contribution from ozone compared to MER, TLA, and PED.
* NO2 and SO2 show more seasonal dependency at PED and BJU, peaking in winter.

**8. Conclusion**

* **Regional Trends:** All stations exhibit similar seasonal AQI fluctuations, influenced by winter temperature inversions and summer pollutant dispersion.
* **Station-Specific Insights:** MER and PED experience consistently higher AQI, while BJU and TLA generally have better air quality.
* **Key Pollutants:** PM10 remains the primary contributor to AQI across all locations, with O3 and PM2.5 also playing significant roles.
* **Future Considerations:** To improve air quality, targeted interventions should focus on winter pollution control measures and emission reductions in high-risk areas like MER and PED.