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A Comparative Trend Analysis of Air Quality and Meteorological Parameters at Selected Urban Stations in Malaysia (2018-2023)

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KEYWORDS

Air Quality, Trend Analysis, Meteorological Parameters, Air Pollution, COVID-19 MCO

ABSTRACT

In this paper, the investigation of long-term environmental trends was conducted across key urban monitoring stations in Malaysia. The primary objective is to analyze and contrast the annual average data for meteorological and air quality parameters from 2018 to 2023, a period covering pre-pandemic, pandemic, and endemic phases. To achieve this, a secondary data analysis methodology was applied to visualize and interpret trends for parameters including temperature, humidity, PM2.5 and PM10. From the analysis, two distinct patterns were understood: a general improvement in air quality at most stations during the 2020-2021 Movement Control Order (MCO) period, particularly for traffic-related pollutants and notable anomalies, such as the PM2.5 concentrations at the Cheras station spiking to over 60 µg/m³ in 2020. From these results, it can be concluded that while large-scale activity reductions like the MCO can improve regional air quality, highly localized emission events can create severe, overriding pollution episodes, which carry direct and significant implications for public health data and localized healthcare demand.

1. INTRODUCTION

Urban air quality is a critical environmental issue directly impacting public health. In Malaysia, urban centers are exposed to a complex mix of pollutants from sources like vehicular traffic, industrial emissions, and transboundary haze. This study provides a six-year (2018-2023) retrospective analysis of key air quality indicators and meteorological parameters. This timeframe is uniquely significant as it encompasses the pre-pandemic normalcy, the unprecedented socioeconomic shutdown during the COVID-19 Movement Control Order (MCO) from 2020, and the subsequent transition to an endemic phase (Abdullah, Samat&Chan,2020). By analyzing pollutants such as Particulate Matter (PM2.5) and Nitrogen Dioxide (NO_2), this research aims to quantify the environmental impact of these distinct periods and identify both widespread trends and localized anomalies.

2. EXPERIMENTAL PROCEDURE

This study is based on a quantitative analysis of secondary data sourced from continuous air quality monitoring stations (CAQMS) (Department of Environment Malaysia,2003). The dataset consists of annual average values for the years 2018 through 2023 for ten stations: Alor Setar, Balik Pulau, Cheras, Kota Bharu, Larkin, Melaka, Perak, Putrajaya, Seberang Perai, and Seremban.

The following parameters were analyzed:

- Particulate Matter: Mean PM10 and PM2.5 concentrations (µg/m³)
- Meteorological Parameters: Mean Temperature (°C), Mean Humidity (%)

A comparative analysis was conducted by plotting time-series data for each parameter. To better capture temporal and spatial variations, rolled-mean calculations were applied to reduce short-term variability and emphasize overall trend patterns.

3. RESULTS AND DISCUSSION

The analysis revealed distinct trends across air pollutant and meteorological parameters, with the 2020-2021 period often serving as a point of inflection.

3.1 Air Pollutant Trends

The trends for air pollutants showed significant variation, strongly suggesting the influence of the MCO and other localized factors.

This analysis places a primary focus on PM2.5 due to its more significant adverse health impacts, as its smaller size allows for deeper penetration into the respiratory and cardiovascular systems (Department of Environment Malaysia,2003). The PM2.5 data shows a majority of stations recorded a noticeable dip in concentrations in 2020, aligning with the expected reduction in economic and traffic activities during the MCO (Abdullah, Samat&Chan,2020). In stark contrast, the Cheras station exhibited a severe PM2.5 anomalies, with its level surging from ~43 µg/m³ in 2019 to over 60 µg/m³ in 2020. A similar, though less pronounced, trend was observed in the PM10 data, with most stations also recording a decrease in 2020, which corroborates the MCO's impact.

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However, the PM10 data also revealed different local anomalies, such as a distinct spike in Cheras in 2019, suggesting complex and varied local emission sources affecting particles of different sizes.

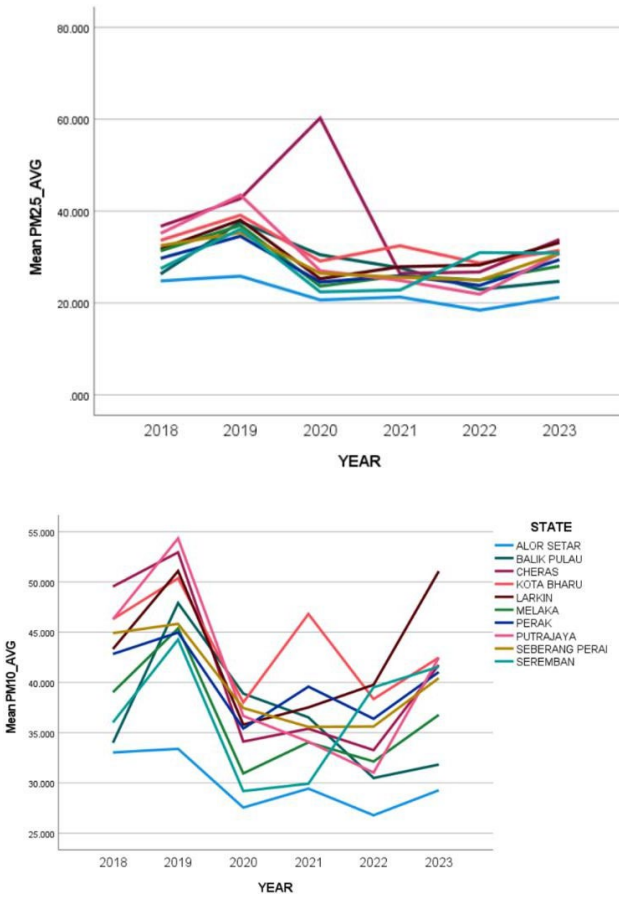

Figure 1&2. Mean PM2.5 and PM10 concentrations, highlighting the anomalous spike in Cheras in 2020.

3.2 Meteorological Trends

Mean annual temperatures across most stations remained relatively stable within the 30°C to 33°C range. However, significant deviations were noted in highly urbanized areas, with Putrajaya peaking at ~38.5°C in 2019 and Cheras reaching ~37.5°C in 2020, likely exacerbated by the urban heat island effect.

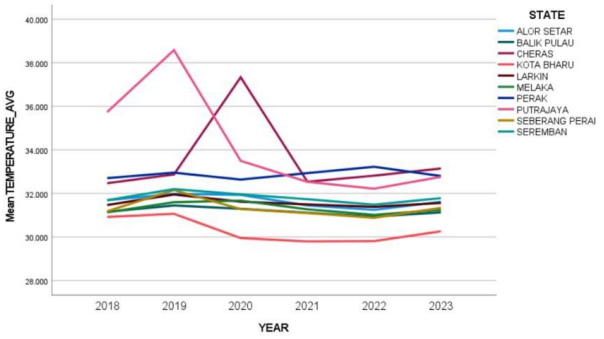

Figure 3. Trend of Mean Annual Temperature (°C) across selected stations (2018-2023).

Mean humidity was consistently high, generally fluctuating between 90% and 95%, which is characteristic of Malaysia's tropical climate.

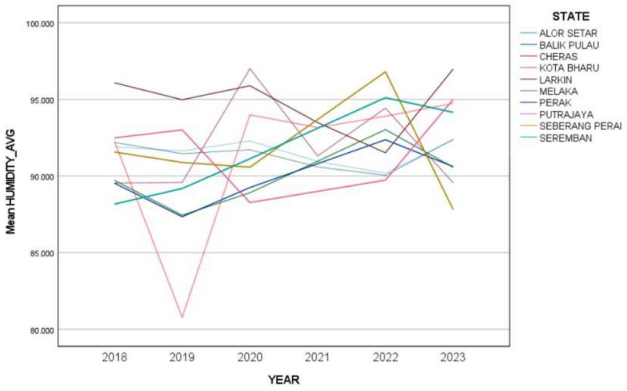

Figure 4. Trend of Mean Annual Humidity (%) showing high stability in the tropical climate.

4. CONCLUSION

This comparative analysis from 2018 to 2023 confirms two key findings which is the COVID-19 MCO period in 2020-2021 corresponded with a general, temporary improvement in air quality across most Malaysian urban centers, evidenced by reduced concentrations of traffic-related pollutants like NO_2 and PM2.5 (Abdullah, Samat&Chan,2020). In addition, Regional trends can be completely overshadowed by intense local emission sources, as demonstrated by the multi-pollutant spike observed at the Cheras station in 2020.

This study not only highlights environmental shifts but also underscores the direct public health implications. The data suggests that reduced emissions correlate with tangible public health benefits, while localized pollution events pose significant, acute health risks that should be reflected in local healthcare data. Future work should involve a correlational study between this environmental data and anonymized health records to quantify the public health impact and should prioritize source apportionment for the anomalous 2020 Cheras pollution event.

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