

## **Spatial Temporal Analysis of Nitrogen Dioxide (NO<sub>2</sub>) Concentration in Urban Environments**

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### **Structured Abstract**

**Background:** Air pollution is rapidly becoming a critical challenge in Malaysia as cities keep expanding. Nitrogen dioxide (NO<sub>2</sub>), one of the main culprits, mainly comes from cars and industrial operations and is linked to serious lung diseases and damage to ecosystems (DOE, 2023; WHO, 2021). When inhaled, NO<sub>2</sub> doesn't just threaten health directly; it can also trigger the formation of ground-level ozone, a secondary pollutant that further strains urban communities (Latif et al., 2022). This research determines how NO<sub>2</sub> levels change over time and space in two Penang urban areas, Seberang Jaya and Balik Pulau, by comparing measurements taken in 2022 and 2023.

**Method:** The hourly data of NO<sub>2</sub> concentration for 2022 and 2023 were employed in this research, which were gathered from the Department of Environment (DOE) Malaysia. The data were analyzed using XLSTAT software in order to observe spatiotemporal trends. Descriptive statistics, boxplots, time-series plots, and comparison of means were performed to ascertain temporal and spatial disparities. The study also referred to the Air Pollutant Index (API) and likened the findings with the Malaysian Ambient Air Quality Standard (MAAQS) (DOE, 2023; Ab Malik et al., 2021).

**Results:** The findings revealed that Seberang Jaya consistently had higher NO<sub>2</sub> concentrations than Balik Pulau, particularly on weekdays and during the dry season. Although there were monthly variations, all of the concentrations were below the acceptable limit of MAAQS. There was also a minimal increase in the average NO<sub>2</sub> concentration in the year 2023, which might be due to increased post-pandemic human activity and traffic congestion. The spatial analysis revealed that there was a high correlation between NO<sub>2</sub> levels and the level of urbanisation density.

**Conclusion:** In short, the temporal and spatial variation of Penang's NO<sub>2</sub> concentrations reflect the dominant impact of urbanization on air quality. Such implications necessitate continuous monitoring and local area-based air quality regulations in order to restrict pollution risks and provide public health security.

**Keywords:** NO<sub>2</sub>, Spatiotemporal analysis, Seberang Jaya, Balik Pulau, Urban Air Pollution

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