

# **Spatiotemporal impact of COVID-19 on Taiwan air quality in the absence of a lockdown: Influence of urban public transportation use and meteorological conditions**

## **ABSTRACT**

The unprecedented outbreak of COVID-19 significantly improved the atmospheric environment for lockdown-imposed regions; however, scant evidence exists on its impacts on regions without lockdown. A novel research framework is proposed to evaluate the long-term monthly spatiotemporal impact of COVID-19 on Taiwan air quality through different statistical analyses, including geostatistical analysis, change detection analysis and identification of nonattainment pollutant occurrence between the average mean air pollutant concentrations from 2018–2019 and 2020, considering both meteorological and public transportation impacts. Contrary to lockdown-imposed regions, insignificant or worsened air quality conditions were observed at the beginning of COVID-19, but a delayed improvement occurred after April in Taiwan. The annual mean concentrations of PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, CO and O<sub>3</sub> in 2020 were reduced by 24%, 18%, 15%, 9.6%, 7.4% and 1.3%, respectively (relative to 2018–2019), and the overall occurrence frequency of nonattainment air pollutants declined by over 30%. Backward stepwise regression models for each air pollutant were successfully constructed utilizing 12 meteorological parameters ( $R^2 > 0.8$  except for SO<sub>2</sub>) to simulate the meteorological normalized business-as-usual concentration. The hybrid single-particle Lagrangian integrated trajectory (HYSPLIT) model simulated the fate of air pollutants (e.g., local emissions or transboundary pollution) for anomalous months. The changes in different public transportation usage volumes (e.g., roadway, railway, air, and waterway) moderately reduced air pollution, particularly CO and NO<sub>2</sub>. Reduced public transportation use had a more significant impact than meteorology on air quality improvement in Taiwan, highlighting the importance of proper public transportation management for air pollution control and paving a new path for sustainable air quality management even in the absence of a lockdown.