$PM_{2.5}$ SPATIO-TEMPORAL DISTRIBUTION USING MOBILE MONITORING BASED ON LOW-COST SENSOR IN INDONESIAN URBAN ENVIRONMENT

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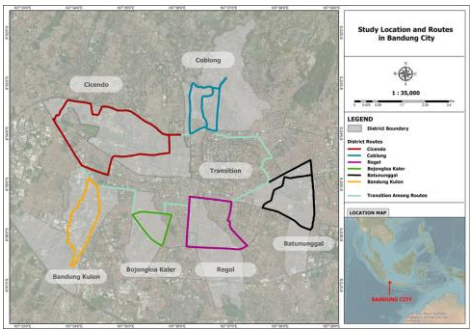
Abstract

This pilot study employed low-cost mobile monitoring (AS-LUNG-P) to assess spatiotemporal $PM_{2.5}$ variability and commuter exposure across approximately 50 km of urban routes in Bandung City. The mean PM2.5 concentration was 40 μg/m^3, with higher levels in traffic-intensive areas (53.5 μg/m^3) than residential districts (32 μg/m^3). Concentrations peaked during morning and nighttime periods, while localized hotspots covered approximately 5% of the monitored area. Inhalation dose estimates indicated greater exposure during peak commuting hours, particularly among children on a body-mass basis. These findings highlight the value of mobile monitoring for identifying pollution hotspots and complementing fixed monitoring networks.

Keyword: High pollution zone, Low-cost sensor, Mobile monitoring

Introduction

This study characterizes the spatiotemporal variability of $PM_{2.5}$ concentrations in Bandung City using a mobile monitoring approach. By integrating high-resolution monitoring, meteorological analysis, and exposure assessment, this study improves understanding of $PM_{2.5}$ dynamics in data-limited urban areas and supports targeted air quality mitigation and health risk reduction.



Picture 1. Mobile monitoring routes



Picture 2. Mobile monitoring setup

Research Method

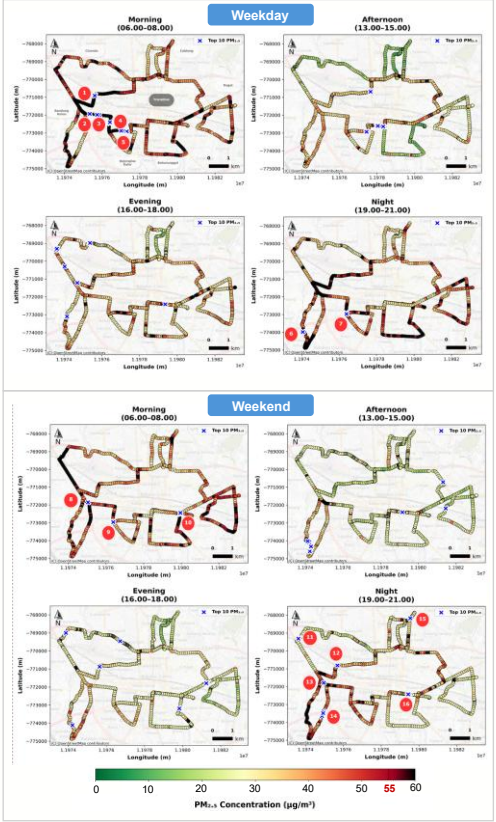
The study covers seven routes in total, comprising six district-based routes which are Regol, Batununggal, Cicendo, Coblong, Bojongloa Kaler, Bandung Kulon, and one transitional route, with a combined length of 69.6 km.

≤30 km/h (Munir et al., 2022

GMT+7 | Morning, Afternoon, Evening, Night

Discussion & Result

Spatio-temporal Distribution



Picture 3. Spatio-temporal distribution of $PM_{2.5}$

High-concentration points (>60 μg m^{-3}) were most frequent in the morning. Hotspots identified from the spatial mapping were concentrated in the western districts and transitional areas, corresponding to eight primary road corridors.

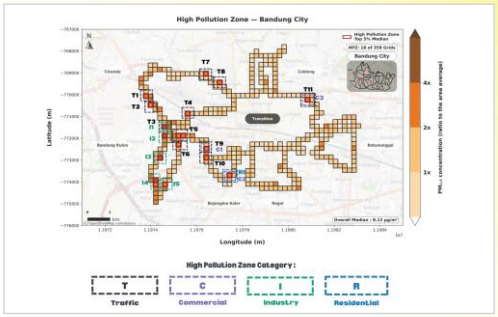
Meteorological Factor

Table 1. Correlation coefficient ($PM_{2.5}$ conc. and temperatures)

Time Range	p Temperature	P-value
06.00-08.00	-0.24	0.33
13.00-15.00	-0.28	0.25
16.00-18.00	-0.33	0.18
19.00-21.00	-0.60	0.009

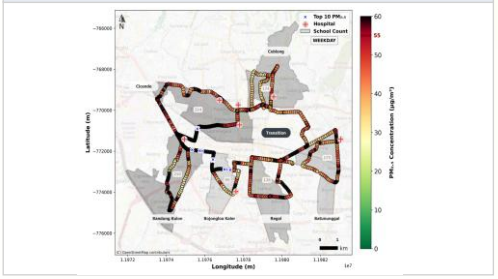
A moderate and statistically significant negative correlation was observed at night, indicating lower temperatures are associated with higher $PM_{2.5}$ due to atmospheric stability.

High Pollution Zone



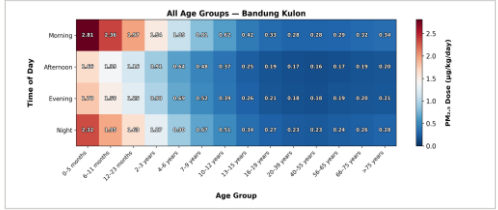
Picture 4. High pollution zone map across route

Sensitive Facilities in High Exposure Areas



Picture 5. Sensitive facilities overlaid to $PM_{2.5}$ distribution

Inhaled Dose



Picture 6. $PM_{2.5}$ inhaled dose to all age groups

Children under 6 years of age represent the most vulnerable group, with estimated inhalation doses ranging from 1.1 to 1.95 μg kg^{-1} day^{-1}, approximately 3.7–6.5 times higher than those of adults.

In the high-concentration zone of Bandung Kulon (morning average $PM_{2.5}$ 69.5 μg m^{-3}), the estimated adult (>20 years) inhalation dose reaches 0.30 μg kg^{-1} day^{-1}, exceeding prior estimates from Bandung (0.22 μg kg^{-1} day^{-1}; Munir et al., 2022) and Makassar (0.11 μg kg^{-1} day^{-1}; Patel et al., 2016).

Conclusion

This study successfully captured localized $PM_{2.5}$ hotspots and peak concentration events across the study area using practical and scalable approach of mobile monitoring. The analysis identified priority locations for targeted interventions, emphasizing place-based air quality management. Future studies should expand spatial coverage and use reference-grade instruments to improve accuracy and reliability.

References

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