CEST 2025

19th International Conference on Environmental Science and Technology

Kos, Greece, 3 to 6 September 2025

Factors Influencing Particulate Matter Variability in an Urban Street in Chios

KOTRIKLA A.M.[1*], SALAVERI S.[1], MAROULIS CH.[1]

[1]Department of Shipping, Trade and Transport, University of the Aegean, Chios, 82132, Greece

*Corresponding author:
e-mail: akotr@aegean.gr

Abstract. This study examines how traffic flow, suburban $PM_{2.5}$ concentrations, noise and meteorological factors influence particulate matter levels in an urban street. Spearman's correlation analysis reveals that urban PM_{10} concentrations are moderately and significantly correlated with traffic flow (ρ=0.574, p<0.001), highlighting vehicular non-exhaust emissions as an important source of coarse particles. Traffic flow also shows a weaker but positive relationship with urban PM_1 (ρ=0.312, p=0.05), indicating more complex sources for finer particles. The correlation between urban PM fractions and suburban $PM_{2.5}$ varies by particle size and source: Urban PM_1 strongly correlates due to regional combustion sources; urban $PM_{2.5}$ shows a moderate correlation; urban PM_{10} shows no significant correlation. Meteorological variables further modulate urban PM levels: wind direction moderately correlates with PM concentrations ($\rho \approx 0.400$), reflecting directional pollutant transport patterns; wind speed negatively predicts PM levels (ρ between -0.415 and -0.455), consistent with dispersion effects; and relative humidity positively influences PM concentrations (ρ=0.420–0.495), likely due to hygroscopic growth and secondary aerosol formation. These findings underscore the combined influence of traffic, regional pollution, and weather on urban particulate matter variability.

Keywords: Urban Air Pollution, PM sources, Particulate Matter, meteorological parameters, traffic flow

1. Introduction

Air quality in urban environments is significantly affected by various atmospheric pollutants, with particulate matter (PM) posing a major public health concern. Elevated PM levels in cities result from multiple sources, including vehicle emissions, residential heating, industrial and commercial activities, construction and natural sources. At the street level, vehicles contribute to PM through exhaust emissions, primarily producing fine particles, while non-exhaust sources—such as tire-road friction, brake wear, and road dust resuspension—mainly generate coarser particles (Matthaios et al., 2022).

This study aims to monitor particulate matter (PM) levels at an urban street site and investigate their correlations with traffic flow, meteorological conditions, noise levels, and background pollution measured at a suburban station.

2. Methodology

PM_1, $PM_{2.5}$ and PM_{10} concentrations were monitored in a commercial street in the centre of Chios city, Greece (Figure 1a), utilizing two mobile PM sensors (Alphasense, OPC-N3). The street experiences increased traffic flow during rush hours. Over a period spanning from June 2023 to August 2024, forty data collection campaigns were carried out, encompassing all seasons (Figure 1b) and various times of the day, each campaign lasting around one hour. In addition, $PM_{2.5}$ concentrations were measured with a Purpleair – PA II monitor at a suburban station (Figure 1), where road traffic is a less significant source of PM pollution, with other sources such as domestic heating, agriculture and natural phenomena to contribute, allowing these measurements to serve as background levels. Street noise levels were measured using a smartphone application (DecibelX). Meteorological conditions were obtained from the Hellenic National Meteorological Service site. Correlation analysis using the Spearman rank-order correlation coefficient was employed to evaluate the strength and direction of the monotonic relationship between two variables using SPSS Version 28.0.1.0.

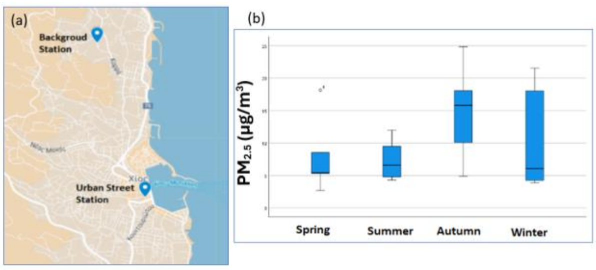

Figure 1. (a) The measurement points (urban and background - suburban) at Chios city and (b) Boxplots of the seasonal variation of urban $PM_{2.5}$ concentrations

3. Results and discussion

The normality of the data set was tested with the Shapiro-Wilk Test which showed that data for PM_1, $PM_{2.5}$, PM_{10}, noise levels and wind speed are not normally distributed indicating that only non-parametric processes will be further used. The analysis (Table 1) shows a moderate and statistically significant correlation between traffic flow and street PM_{10} concentrations (Spearman's ρ = 0.574, p < 0.001), suggesting that increased vehicular activity leads to higher PM_{10} levels, likely due to direct contributions from non-exhaust emissions such as road dust resuspension and wear particles (Matthaios et al., 2022). In contrast, the weaker and marginally significant correlation with PM_1 (Spearman's $\rho = 0.312$, $p = 0.05$) indicates that while traffic flow does influence PM_1 levels to some extent, other factors—such as combustion efficiency, vehicle type, atmospheric transformation, and meteorological dispersion—play a more dominant role in determining PM_1 concentrations in the urban environment.

In addition, the correlation between urban PM fractions and suburban $PM_{2.5}$ has different strengths reflecting the differences in particle size, origin, and atmospheric behavior. Urban PM_1 shows a strong correlation with suburban $PM_{2.5}$ (Spearman's $\rho = 0.687$, $p < 0.001$) due to the dominance of regional, combustion-related sources and the long atmospheric residence time of fine particles, allowing for spatial transport. Urban $PM_{2.5}$ shows a moderate correlation (Spearman's $\rho = 0.440$, $p=0.006$) , balancing both regional and local influences. In contrast, urban PM_{10}, driven primarily by local mechanical sources such as traffic-related dust and wear particles, shows no significant correlation with suburban $PM_{2.5}$ (Spearman's $\rho = 0.156$, $p=0.349$), highlighting its limited dispersion and localized nature.

Table 1. Spearman's rho correlation coefficient (ρ) (and its significance level) of the urban street PM concentrations with various predictors

	Correlation coefficient (Sig.)		
	PM_1 ($\mu g/m^3$)	**$PM_{2.5}$** ($\mu g/m^3$)	**PM_{10}** ($\mu g/m^3$)
Traffic flow (vehicles/h)	0.312 (0.050)	0.402* (0.010)	0.574** (<0.001)
Leq (dB)	-0.050 (0.767)	0.081 (0.627)	0.165 (0.321)
Temperature (°C)	-0.147 (0.364)	-0.172 (0.288)	-0.092 (0.574)
RH (%)	0.495** (0.001)	0.486** (0.001)	0.420** (0.007)
Wind speed (Bft)	-0.434** (0.005)	-0.455** (0.003)	-0.415** (0.008)
Wind direction (°)	0.399* (0.024)	0.479** (0.006)	0.356* (0.045)
$PM_{2.5}$ ($\mu g/m^3$) (suburban)	0.687** (<0.001)	0.440* (0.006)	0.156 (0.349)

**Significant correlation 0.01 level (2 tailed)
*Significant correlation 0.05 level (2 tailed)

The observed moderate negative correlation (ρ between -0.415 and -0.455) between wind speed and particulate matter concentrations indicates that stronger winds are generally associated with lower PM levels reflecting the role of wind speed in enhancing atmospheric dispersion and reducing pollutant accumulation (Zeb et al, 2024). A moderate Spearman's rho correlation (~0.400) between wind direction and particulate matter concentrations suggests that certain wind directions are associated with consistently higher or lower pollutant levels in the street environment.

The moderate positive correlations between relative humidity and concentrations of PM_1 ($\rho = 0.495$), $PM_{2.5}$ ($\rho = 0.486$), and PM_{10} ($\rho = 0.420$) suggest that higher moisture levels in the air are associated with elevated particulate matter levels (Zeb et al, 2024). This relationship can be attributed to the hygroscopic growth of fine particles, which absorb water and increase in mass under humid conditions, thereby increasing measured PM concentrations (Wang et al, 2019). Additionally, high relative humidity promotes the formation of secondary aerosols through aqueous-phase reactions and often coincides with meteorological conditions that limit dispersion (e.g., low wind, stable air masses), further contributing to PM accumulation. These combined effects explain the consistent, moderate correlations across particle size ranges.

The very low, statistically insignificant correlation between temperature and PM concentrations (Spearman's ρ≈-0.147 to -0.092) indicates that temperature does not have a clear monotonic influence on particulate matter levels in this urban street environment. Noise levels and PM concentrations correlation is also low possibly due to different sources, the influence of meteorological and urban design factors, differing temporal behaviors or complex or non-linear relationships.

4. Conclusions

Traffic flow exhibits a significant positive correlation with urban PM_{10} and a weaker association with $PM_{2.5}$ levels, reflecting the predominance of non-exhaust local emissions for coarse particles and mixed sources for finer fractions. Urban PM_1 strongly correlates with suburban $PM_{2.5}$, indicating regional transport, while PM_{10} remains localized. Meteorological variables modulate PM levels through dispersion and hygroscopic growth. Noise and temperature show no significant monotonic relationship with urban PM concentrations.

References

Matthaios, V. N., Lawrence, J., Martins, M. A., Ferguson, S. T., Wolfson, J. M., Harrison, R. M., & Koutrakis, P. (2022). Quantifying factors affecting contributions of roadway exhaust and non-exhaust emissions to ambient $PM_{10-2.5}$ and $PM_{2.5-0.2}$ particles. *Science of the Total Environment*, 835, 155368.

Wang, X., Zhang, R., & Yu, W. (2019). The effects of $PM_{2.5}$ concentrations and relative humidity on atmospheric visibility in Beijing. *Journal of Geophysical Research: Atmospheres*, *124*(4), 2235-2259.

Zeb, B., Ditta, A., Alam, K., Sorooshian, A., Din, B. U., Iqbal, R., ... & Elshikh, M. S. (2024). Wintertime investigation of PM_{10} concentrations, sources, and relationship with different meteorological parameters. *Scientific Reports*, *14*(1), 154.