

Article

Spatial Analysis of Air Pollutants in an Industrial City Using GIS-Based Techniques: A Case Study of Pavlodar, Kazakhstan

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Abstract: The given research employs high-resolution air quality monitoring and contemporary statistical methods to address gaps in understanding the urban air pollution in Pavlodar, a city with a significant industrial presence and promising touristic potential. Using mobile air quality sensors for detailed spatial data collection, the research aims to quantify concentrations of particulate matter (PM_{2.5}, PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), and ground-level ozone (O₃); assess their distribution; and identify key influencing factors. In this study, we employed Geographic Information Systems (GISs) for spatial analysis, integrating multi-level B-spline interpolation to model spatial variability. Correlation analysis and structural equation modeling were utilized to explore the relationships between variables, while regression analysis was conducted to quantify these relationships. These techniques were crucial for accurately mapping and interpreting spatial patterns and their underlying factors. The study identifies PM_{2.5} and NO₂ as the primary contributors to air pollution in Pavlodar, with NO₂ exceeding the 24 h threshold in 87.38% of locations and PM_{2.5} showing the highest individual air quality index (AQI) in 75.7% of cases. Correlation analysis reveals a positive association between PM_{2.5} and AQI and a negative correlation between NO₂ and AQI, likely due to the dominant influence of PM_{2.5} in AQI calculations. Structural equation modeling (SEM) further underscores PM_{2.5} as the most significant impactor on AQI, while NO₂ shows no significant direct impact. Humidity is positively correlated with AQI, though this relationship is context-specific to seasonal patterns observed in May. The sectoral analysis of landscape indices reveals weak correlations between the green space ratio (GSR) and air quality, indicating that while vegetation reduces pollutants, its impact is minimal due to urban planting density. The road ratio (RR) lacks sufficient statistical evidence to draw conclusions about its effect on air quality, possibly due to the methodology used. Spatial variability in pollutant concentrations is evident, with increasing PM_{2.5}, PM₁₀, and AQI towards the east-northeast, likely influenced by industrial activities and prevailing wind patterns. In contrast, NO₂ pollution does not show a clear geographic pattern, indicating vehicular emissions as its primary source. Spatial interpolation highlights pollution hotspots near industrial zones, posing health risks to vulnerable populations. While the city's overall AQI is considered "moderate", the study highlights the necessity of implementing measures to improve air quality in Pavlodar. This will not only enhance the city's attractiveness to tourists but also support its sustainable development as an industrial center.

Keywords: air pollution; air quality index (AQI); particulate matter (PM_{2.5}; PM₁₀); green space ratios; road ratio; Pavlodar, Kazakhstan



Citation: Safarov, R.; Shomanova, Z.; Nossenko, Y.; Kopishev, E.; Bexseitova, Z.; Kamatov, R. Spatial Analysis of Air Pollutants in an Industrial City Using GIS-Based Techniques: A Case Study of Pavlodar, Kazakhstan. *Sustainability* **2024**, *16*, 7834. <https://doi.org/10.3390/su16177834>

Academic Editors: Jan A. Weert, Kuliyash Kaimuddinova and Zhasen Benderov

Received: 11 August 2024

Revised: 4 September 2024

Accepted: 4 September 2024

Published: 9 September 2024



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The Analysis Of Air Pollutants

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