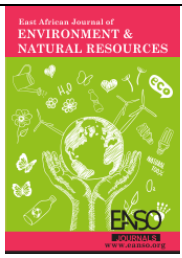


East African Journal of Environment and Natural Resources
eajenr.eanso.org
Volume 8, Issue 1, 2025
Print ISSN: 2707-4234 | Online ISSN: 2707-4242
Title DOI: https://doi.org/10.37284/2707-4242

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Impact of Meteorological Factors on the Interaction between Green Vegetation, Urban Features and Air Quality Over Time in Kampala-Uganda

Jorum Ddumba[1], Ali Anahita[1], Sonal Katyal[1] & Kato Stonewall Shaban[2]*

[1] James Lind Institute, Faculty of Transformational Economics, Rue de la Cité 11204 Genève, Switzerland.
[2] Gulu University, P. O. Box 166, Gulu, Uganda.
[*] Correspondence Email: ddumbajorum5@gmail.com

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

Date Published:

18 March 2025

Keywords:

Biogenic Volatile Organic Compounds, Volatile Organic Compounds, Urban Heat Island Effects, Photochemical Reaction, Impervious Surfaces.

ABSTRACT

The study aimed to analyze the influence of meteorological factors on the interaction between green vegetated areas, urban features, and air quality over time within Kampala city. Six (6) streets were sampled: - Nasser Lane, 6th Street, Namirembe Road, Owino Kafumbe- Mukasa, Makindu Close, and Nakasero Lane. From each street, samples were taken 3 times a day (Morning, Midday and Afternoon) for 7 days. The sampling frequency of every spot was thus 21 times. Makindu Close and Nakasero Lane are known for green vegetation, 6th Street is known for buildings and industrial zones, while Namirembe Road and Owino Kafumbe- Mukasa are known for car parks. A negative coefficient for humidity indicated that higher humidity levels are associated with low $PM_{2.5}$ concentrations. The relationship between temperature and $PM_{2.5}$ in the morning showed a slight positive trend, suggesting that PM2.5 levels may increase slightly as temperatures rise. Significant negative impact for several sites indicated that compared to the reference site (6th Street Industrial Area), other sites had lower $PM_{2.5}$ levels. Both $PM_{2.5}$ and PM_{10} levels had broader distributions in the morning and evening, indicating more significant variability in particulate matter concentrations during these times. CO levels were variable in the evening, with several sites showing higher concentrations. NO_2 levels showed variability across different times, with the highest spread in the evening, indicating increased variability of nitrogen dioxide concentrations during that period. Makindu Close Kololo showed relatively stable levels across the day compared to other sites justifying the importance of green vegetated areas in improving air quality by absorbing pollutants.

APA CITATION

Ddumba, J., Anahita, A., Katyal, S. & Shaban, K. S. (2025). Impact of Meteorological Factors on the Interaction between Green Vegetation, Urban Features and Air Quality Over Time in Kampala-Uganda. *East African Journal of Environment and Natural Resources*, *8*(1), 121-133. https://doi.org/10.37284/eajenr.8.1.2783.

CHICAGO CITATION

Ddumba, Jorum, Ali Anahita, Sonal Katyal and Kato Stonewall Shaban. 2025. "Impact of Meteorological Factors on the Interaction between Green Vegetation, Urban Features and Air Quality Over Time in Kampala-Uganda". *East African Journal of Environment and Natural Resources* 8 (1), 121-133. https://doi.org/10.37284/eajenr.8.1.2783

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

HARVARD CITATION

Ddumba, J., Anahita, A., Katyal, S. & Shaban, K. S. (2025) "Impact of Meteorological Factors on the Interaction between Green Vegetation, Urban Features and Air Quality Over Time in Kampala-Uganda", *East African Journal of Environment and Natural Resources*, 8 (1), pp. 121-133. doi: 10.37284/eajenr.8.1.2783.

IEEE CITATION

J., Ddumba, A., Anahita, S., Katyal & K. S., Shaban "Impact of Meteorological Factors on the Interaction between Green Vegetation, Urban Features and Air Quality Over Time in Kampala-Uganda", *EAJENR*, vol. 8, no. 1, pp. 121-133, Mar. 2025. doi: 10.37284/eajenr.8.1.2783

MLA CITATION

Ddumba, Jorum, Ali Anahita, Sonal Katyal & Kato Stonewall Shaban. "Impact of Meteorological Factors on the Interaction between Green Vegetation, Urban Features and Air Quality Over Time in Kampala-Uganda". *East African Journal of Environment and Natural Resources*, Vol. 8, no. 1, Mar 2025, pp. 121-133, doi:10.37284/eajenr.8.1.2783.

INTRODUCTION

According to the United Nations Report 2018, Today, more than 55% of people on the planet live in cities, which has soared due to rapid urbanisation over the past 20 years. Unfortunately, this swift growth has often led to alarming increases in air pollution caused by transportation, industry, and construction activities (Wang, 2018). However, introducing green spaces such as city parks and tree-lined streets offers a promising solution to mitigate this problem (Nowak et al., 2013). In East Africa, urban air quality has markedly declined (Singh et al., 2020). The United Nations Environment Programme (UNEP) has reported escalating levels of particulate matter (PM2.5 and PM10) in major cities like Nairobi, Kampala, and Addis Ababa, primarily due to vehicle emissions, biomass burning, and industrial processes. Despite these formidable challenges, cities prioritising green spaces have improved air quality (Hirabayashi et al., 2011). When discussing Uganda's air quality, and Kampala in particular, the transportation industry is frequently included in public discourse (Galiwango *et al.*, 2023). However, it's essential to recognize that many environmental elements contribute to air pollution compared to non-urban locations, as cities are more likely to have poor air quality (Fuchs & Kasirye,2020). High population density, building of infrastructure, burning of solid waste, open fuel, automobile and industry exhaust pollution are all blamed for this (Ninsiima *et al.*, no date).

The role of green vegetated areas in mitigating air pollution has gained attention in recent research. Green vegetated areas, including parks, green belts, and street trees, have been recognized for their capacity to enhance air quality through various mechanisms (Yousofpour et al., 2024). Vegetation is a natural sink for air pollutants, capturing and filtering particulate matter (Nowak et al., 2014). Trees and plants also play a crucial role in the removal of gaseous pollutants, contributing to the reduction of nitrogen dioxide and ozone concentrations (Dzierzanowski et al., 2011).

The spatial distribution of green vegetated areas within urban environments is a critical factor influencing their effectiveness in improving air quality (Ottosen & Kumar, 2020). The arrangement and density of green spaces can impact the dispersion of pollutants, creating microclimates that influence local air quality conditions(Nowak et al., 2013). Understanding how the spatial distribution of green vegetated areas interacts with urban features, such as roads, buildings, and industrial zones, is essential for developing targeted strategies to enhance air quality in urban settings (Zhao et al., 2023). Research has shown that the proximity of green spaces to significant sources of pollution, such as traffic corridors or industrial zones, can significantly influence their ability to act as "green buffers" that mitigate the impact of pollutants (Greg McPherson *et al.*, 2005). However, the effectiveness of green spaces can also be influenced by various urban features, including the design and layout of streets, impervious surfaces, and overall land use patterns (Hirabayashi et al., 2011).

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

In this context, a comprehensive analysis of the role of the spatial distribution of green vegetated areas and urban features on air quality is essential. This research aims to contribute to the understanding of how the design and planning of urban environments can maximize the benefits of green infrastructure in the context of air quality improvement.

Urban areas are increasingly impacted by poor air quality, which poses significant health and environmental risks (Ninsiima *et al.*, 2022). While green vegetated areas are known to improve air quality by absorbing pollutants, the effectiveness of these green spaces can vary due to a range of meteorological factors (such as temperature, humidity, wind speed, and solar radiation) and urban features (like buildings and infrastructure) (Ottosen and Kumar, 2020). Furthermore, the relationship between green spaces and air quality is not static; it changes over time, influenced by the varying meteorological conditions throughout the day (Meili et al., 2021).

The Objective of the Study

- To conduct a temporal analysis to understand how the correlation between green vegetated areas and air quality changes over different times of the day
- To analyze the mediating role of metrological factors on green vegetated areas and urban features on air quality

LITERATURE REVIEW

Influence of Metrological Factors on Air Quality

Temperature and wind patterns affect the dispersion and dilution of air pollutants (M. Wu et al., 2022). Urban heat island effects can lead to temperature differentials between urban areas and surrounding vegetated regions, influencing wind patterns and pollutant dispersion (Di Sabatino *et al.*, 2020). Vegetated areas can moderate temperatures through shading and evapotranspiration, altering local wind patterns and air movement and influencing pollutant transport and distribution (Arnfield, 2003). Atmospheric stability, characterised by temperature gradients and vertical air movements, affects the vertical mixing of pollutants in the atmosphere (Zoras et al., 2006). Stable atmospheric conditions, such as temperature inversions, can hold contaminants close to the ground, increasing their concentrations in cities. (Nejad *et al.*, 2023). Vegetated areas can influence atmospheric stability through their effects on surface temperatures and evapotranspiration rates, potentially mitigating the impact of stable atmospheric conditions on air quality (Byun & Ching, 1999)

Precipitation events can remove atmospheric pollutants through wet deposition, effectively cleansing the air (Yamamoto, 2023). Vegetated areas play a role in the hydrological cycle by intercepting and absorbing precipitation, which can influence pollutant washout processes (Coenders-Gerrits, 2010). Urban features such as impervious surfaces and stormwater runoff systems can affect the hydrological response to precipitation events, influencing the transport of pollutants into water bodies and potentially affecting air quality through secondary processes such as aerosol formation (Zhang et al., 2020). Solar radiation drives photochemical reactions in the atmosphere, creating secondary pollutants like particle matter and ozone (Ojha et al., 2022). Vegetated areas can modify local radiation budgets through shading effects and surface albedo, influencing photochemical reaction intensity and spatial distribution (Luo et al., 2023). Urban features such as buildings and surfaces can modify radiation absorption and reflection patterns, affecting the local microclimate and atmospheric chemistry (Meili *et al.*, 2021)

Relative humidity influences the rates of physical and chemical atmospheric reactions, including creating and modifying air pollutants (Yamamoto, 2023). Vegetated areas can modify local humidity levels through transpiration and evapotranspiration, influencing atmospheric moisture content and stability (Coenders-Gerrits, 2010). Urban features such as impervious surfaces and artificial structures

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

can alter local humidity gradients and moisture exchange processes, affecting air quality dynamics (Nowak & Crane, 2000).

Addressing air pollution in Kampala requires coordinated efforts from government authorities, policymakers, industries, urban planners, and the community. Some strategies to reduce air pollution are implementing car emission standards, promoting cleaner transportation technologies, improving industrial pollution control methods, expanding green areas, improving waste management techniques, and promoting cleaner heating and cooking solutions. Initiatives to raise public awareness and engage stakeholders are also necessary to promote Kampala's sustainable development and environmental stewardship culture.

Green Vegetated Areas and Air Quality Change Over Different Times of the Day

Vegetation, particularly trees and shrubs with dense foliage, can act as natural filters, capturing airborne particulate matter such as dust, pollen, and pollutants (Sillars-Powell, Tallis and Fowler, 2020). Studies have shown that vegetation can effectively trap PM, especially during periods of low wind activity when particles are less likely to be dispersed (Nowak et al., 2013). Through photosynthesis, green vegetated areas absorb CO2 and release oxygen (O2) into the atmosphere during daylight hours (Yahia, 2018). This process helps reduce atmospheric CO2 concentrations and increase oxygen levels, improving air quality (McPherson, 1997). Green vegetation can help to mitigate ground-level ozone concentrations through a process known as dry deposition. Plant leaves take up ozone molecules, broken down or digested through biological reactions. Ozone levels may decrease as a result, especially during the day when photosynthesis is taking place. (Gielen et al., 2015).

Vegetation provides shade and reduces surface temperatures through evapotranspiration, which can help moderate local microclimates (Meili et al., 2021). Lower temperatures can reduce the formation of certain pollutants, such as ozone, and mitigate the impact of heat-related air quality issues (Akbari et al., 2001). While vegetation primarily acts as a sink for atmospheric pollutants, certain plant species emit biogenic volatile organic compounds (BVOCs) into the atmosphere (Calfapietra *et al.*, 2013). These BVOCs can react photochemically, which helps create secondary pollutants, including ozone and fragile particle matter. (Ciccioli et al., 2014). The emission rates of BVOCs may vary over different times of the day, influencing pollutant concentrations accordingly (Guenther, 1995).

METHODOLOGY

Study Area

The study focused on Kampala, the Capital City of Uganda, from which 6 streets were sampled and included: - Nasser Lane, 6th Street, Namirembe Road, Owino Kafumbe- Mukasa, Makindu Close and Nakasero Lane.

	Division	Parish	Village	Street
1	Central	Civic centre	Nkrumah	Nasser Lane
2	Central	Industrial Area	6th Street	6th Street
3	Central	Kisenyi I	Buwanika	Namirembe Road
4	Central	Kisenyi II	School View	Owino Kafumbe- Mukasa
5	Central	Kololo	Makindu Close	Makindu Close
6	Central	Nakasero	Nakasero Lane	Nakasero Lane

Makindu Close and Nakasero Lane are known for green vegetation, 6th Street is known for buildings and industrial zones, and Namirembe Road and Owino Kafumbe—Mukasa are known for car parks.

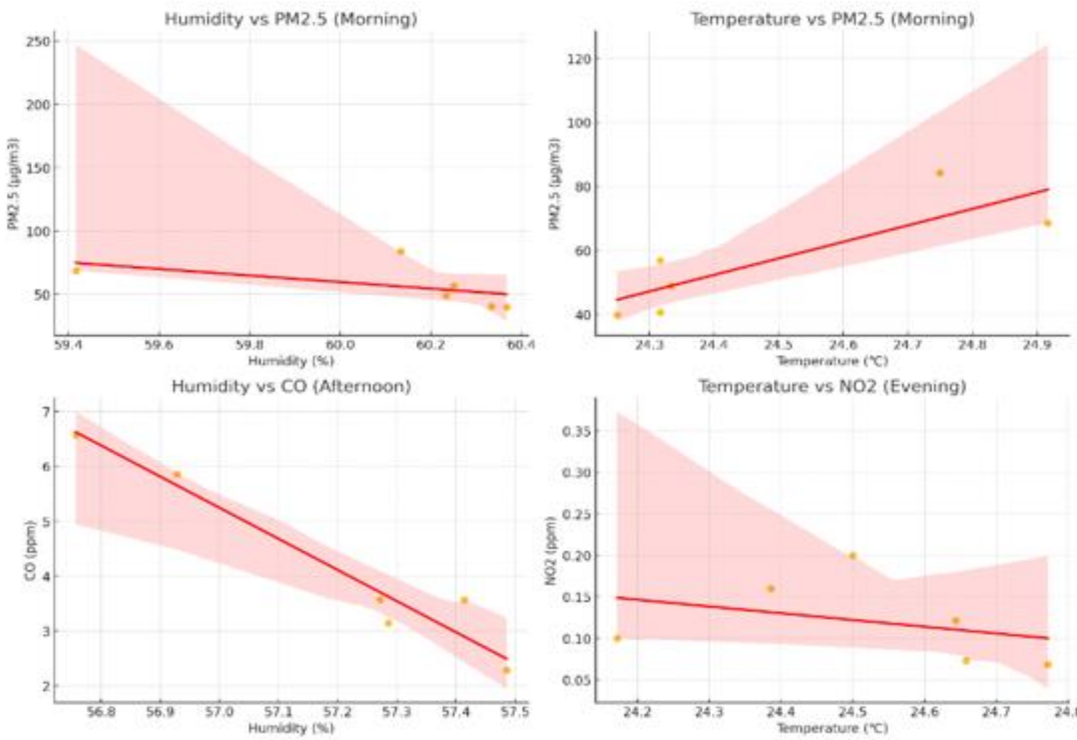
Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

Methodology

The survey entailed cross-sectional studies; quantitative approaches were used during sampling, data collection, quality control, and analysis. At the data collection stage, the quantitative design involved Air quality monitors. This study used descriptive statistics to describe and summarize the main features of a data set collected. In contrast, inferential statistics was used to make predictions, draw inferences, or test hypotheses about a population based on a sample.

FINDINGS AND DISCUSSION

The relationships between green vegetated areas, urban features, metrological factors (humidity and temperature), and the air quality parameters (Particulate matter (PM), Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2) and Carbon monoxide (CO)) were analyzed to ascertain if there is any correlation.



The scatter plots with regression lines illustrate the effects of humidity and temperature on various pollutants across different times of the day at different sites:

Humidity vs. $PM_{2.5}$ (Morning):

A negative correlation indicates that higher humidity levels in the morning are associated with lower concentrations of $PM_{2.5}$. This suggests that moisture in the air may help settle particulate matter, reducing its concentration.

Temperature vs. $PM_{2.5}$ (Morning):

The relationship between temperature and $PM_{2.5}$ in the morning shows a slight positive trend, suggesting that PM2.5 levels may increase slightly as temperatures rise. This could be due to increased atmospheric mixing or other factors affecting particulate matter dispersion.

Humidity vs. CO (Afternoon):

A strong negative correlation is observed between humidity and CO levels in the afternoon. Higher humidity appears to be associated with lower CO

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

levels, possibly due to the dilution effect of moisture or changes in local activities like traffic.

Temperature vs. NO_2 (Evening):

The plot shows a slight negative correlation between temperature and NO_2 levels in the evening, suggesting that higher temperatures may help disperse NO_2, potentially reducing its concentration in the air.

The Impact of Humidity and Temperature Across Different Sites

6th Street Industrial Area:

High Pollution Levels: This site consistently shows higher levels of pollutants ($PM_{2.5}$, PM_{10}, CO, and NO_2), likely due to industrial activities and heavy traffic.

Humidity's Impact: The strong negative correlation between moisture and pollutants, such as CO and $PM_{2.5}$, suggests that higher humidity helps reduce pollutant concentrations. However, the reduction may not be as pronounced due to ongoing emissions from industrial activities.

Temperature's Impact: A slight positive correlation between temperature and $PM_{2.5}$ suggests that warmer temperatures might increase particulate dispersion or secondary particulate formation from industrial emissions.

Makindu Close Kololo:

Lower Pollution Levels: This site shows generally lower levels of all pollutants, suggesting fewer local sources of pollution, like less traffic or fewer industrial activities.

Humidity's Impact: The negative correlation between moisture and pollutants is more evident here, indicating that even small increases in humidity can help clear the air due to fewer ongoing emissions.

Temperature's Impact: Lower temperatures might correlate with lower pollutant concentrations, as cooler conditions can reduce the photochemical reactions that produce secondary pollutants.

Nkrumah-Nasser Lane:

Moderate Pollution Levels: This site shows moderate pollution levels across all parameters.

Humidity's Impact: The negative correlation between moisture and pollutants like $PM_{2.5}$ and CO indicates that higher humidity helps reduce pollution. This may be due to the settling of particulate matter in more humid air or the dilution effect of moisture.

Temperature's Impact: A less pronounced correlation with temperature suggests that other factors, such as local traffic patterns or microclimates, might play a role in determining pollutant levels.

Buwanika-Namirembe Road:

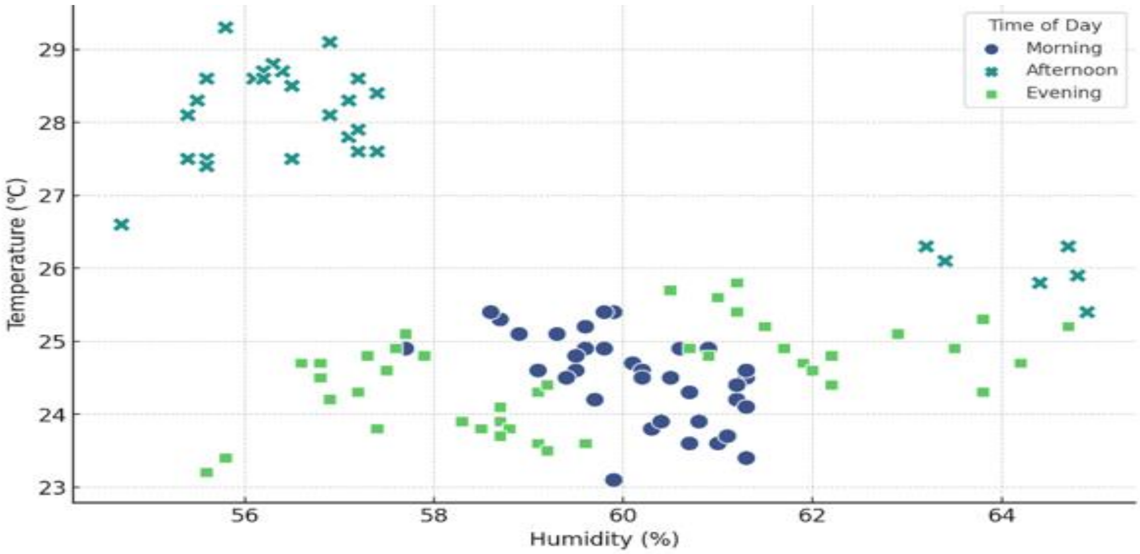
Moderate to High Pollution Levels: This site also shows moderate to high levels of pollutants, particularly in the morning and evening.

Humidity's Impact: Similar to other sites, higher humidity correlates with lower pollutant levels, which suggests that increased moisture helps to settle particles or disperse gases.

Temperature's Impact: Higher temperatures could increase pollutant levels due to more significant atmospheric mixing or enhanced chemical reactions.

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

Humidity Vs Temperature Trends Across Different Times of Day



The scatter plot illustrates the relationship between humidity and temperature across different times (morning, afternoon, and evening).

Morning: The data points for the morning period show a clustering where humidity tends to be slightly higher and temperature varies moderately.

Afternoon: Humidity generally decreases in the afternoon while temperatures remain relatively higher.

Evening: There is a trend toward increasing humidity with slightly cooler temperatures in the evening.

These trends suggest a typical diurnal pattern in which temperatures peak in the afternoon and humidity levels fluctuate inversely with temperature changes throughout the day.

	Humidity (%)	Temperature (°C)	PM2.5 (µg/m^3)	PM10 (µg/m^3)	CO (ppm)	SO2 (ppm)	NO2 (ppm)
Humidity (%)	1	-0.56	0.48	0.459	0.47	0.06	0.48
Temperature (°C)	-0.56	1	-0.27	-0.265	-0.55	-0.19	-0.43
PM2.5 (µg/m^3)	0.48	-0.27	1	0.997	0.4	0.23	0.42
PM10 (µg/m^3)	0.46	-0.26	1	1	0.39	0.25	0.4
CO (ppm)	0.47	-0.55	0.4	0.389	1	0.36	0.73
SO2 (ppm)	0.06	-0.19	0.23	0.255	0.36	1	0.41
NO2 (ppm)	0.48	-0.43	0.42	0.402	0.73	0.41	1

Correlation Coefficients between Meteorological Factors and Pollutant Concentration

Key Significant Associations:

Humidity: Positive correlation with $PM_{2.5}$ (0.48), PM_{10} (0.46), CO (0.47), and NO_2 (0.48). Indicates that higher humidity levels are associated with increased pollutant concentrations.

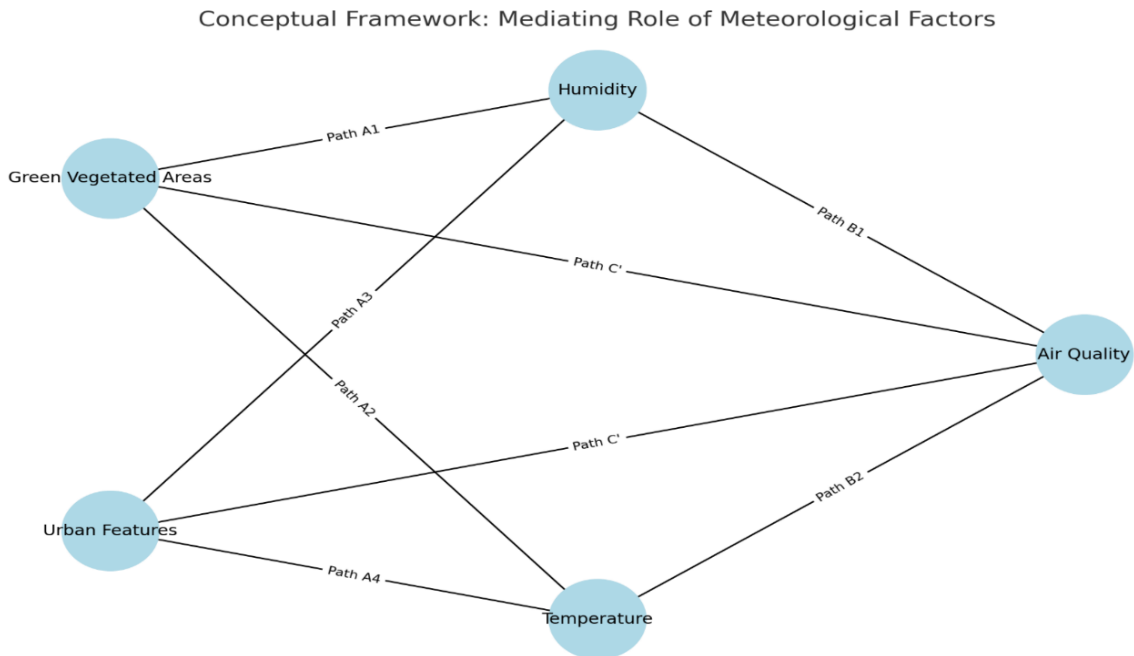
Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

Temperature: Negative correlation with CO (-0.55) and NO_2 (-0.43). Suggesting higher temperatures reduce these pollutants.

Pollutants: $PM_{2.5}$ and PM_{10} are highly correlated (0.99), reflecting their shared sources and similar dispersion mechanisms.

CO Strongly Correlates with NO_2 (0.73), Indicating Potential Co-emissions or Interactions in Atmospheric Chemistry

Conceptual Framework Mediating Role of Meteorological Factors.



Green Vegetated Areas and Urban Features Impact Humidity and Temperature (Path A):

Results show that:

Green Vegetated Areas significantly increase humidity and reduce temperature, likely due to evapotranspiration and shading effects.

Urban Features (such as., car parks, buildings and industrial areas) reduce humidity and increase temperature due to heat island effects and lack of vegetation.

This is consistent with Path A1, A2, A3, and A4 in the framework.

Meteorological Factors Influence Air Quality (Path B):

Results indicate:

Humidity often improves air quality by reducing particulate matter (e.g., PM2.5, PM10) through particle deposition.

Temperature has a mixed effect, sometimes exacerbating air pollution due to chemical reactions (e.g., ozone formation) or heat-induced pollutant buildup.

These observations match Path B1 and B2 in the framework.

 |

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

Direct Effects of Green Vegetation and Urban Features on Air Quality (Path C'):

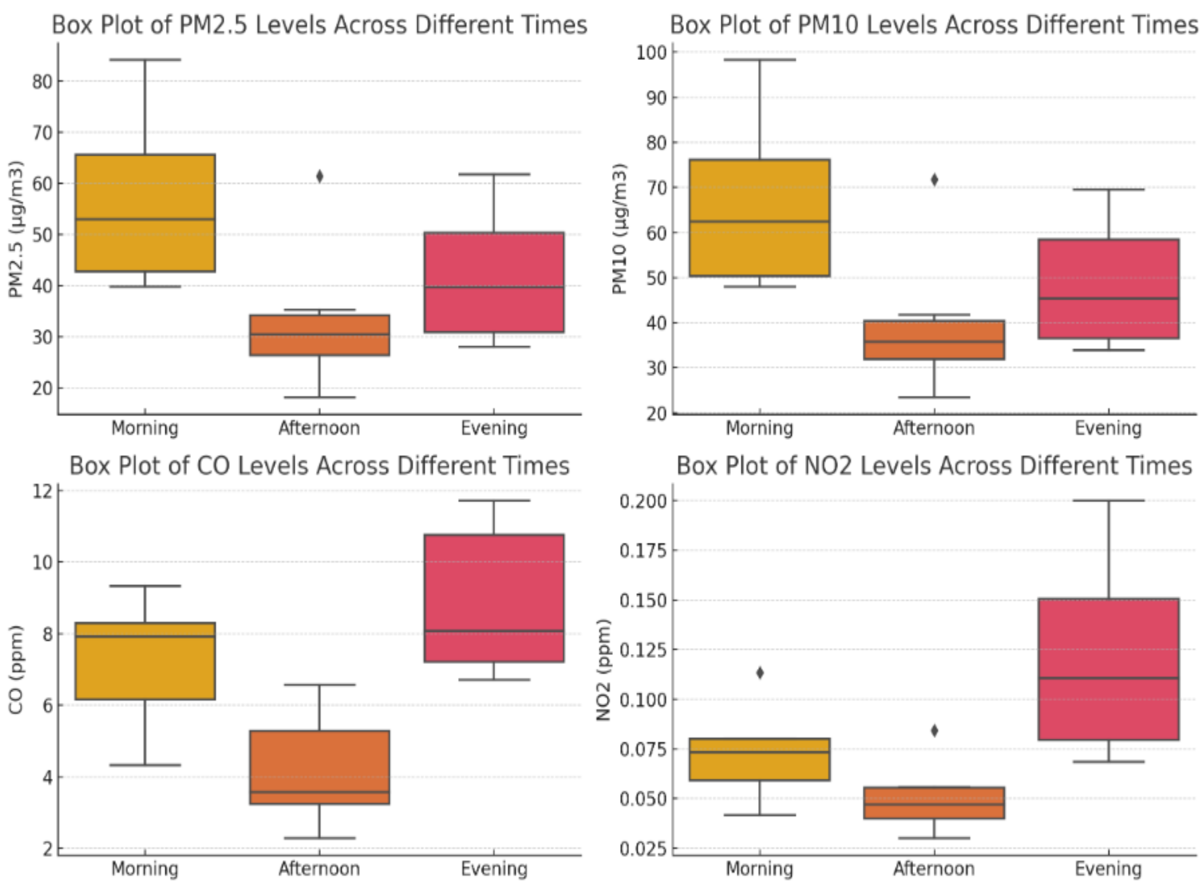
The results show:

Green Vegetated Areas directly reduce air pollutants like PM2.5 and PM10, likely due to pollutant filtration by trees and vegetation.

Urban Features contribute to higher pollutant levels due to emissions from vehicles, industries, and dense construction.

These findings are consistent with Path C' in the framework.

Distribution of Air Quality Parameters ($PM_{2.5}$, PM_{10}, CO, and NO_2) Across Different Times of the Day (Morning, Afternoon, and Evening).



Key Observations from the Box Plots:

$PM_{2.5}$ and PM_{10} Levels:

$PM_{2.5}$ and PM_{10} levels tend to have broader distributions in the morning and evening, indicating more significant variability in particulate matter concentrations.

The afternoon shows a narrower range, suggesting more consistent particulate matter levels.

CO Levels:

CO levels are more variable in the evening, with several sites showing higher concentrations, as reflected by the spread of the box plot.

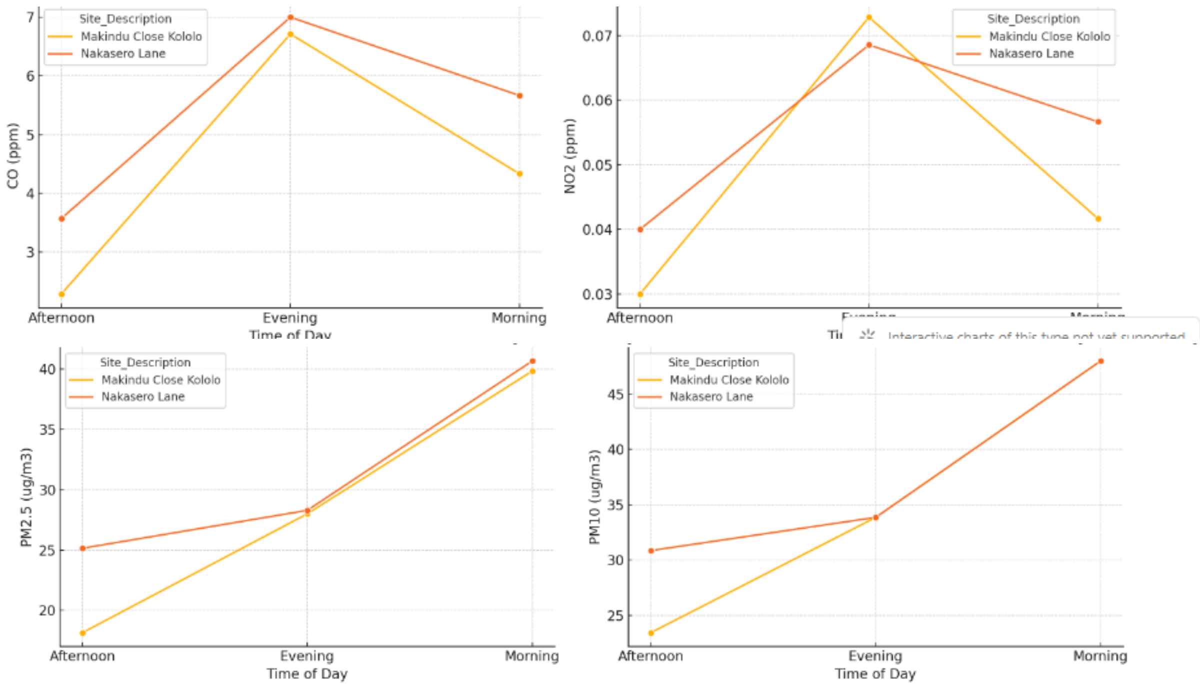
The morning and afternoon CO levels are relatively more consistent but vary across different sites.

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

NO2 Levels:

NO2 levels also show variability across different times, with the highest spread in the evening, indicating increased variability of nitrogen dioxide concentrations during that period.

CO, NO_2, $PM_{2.5}$ and PM_{10} levels at Makindu Close Kololo and Nakasero Lane by Time of Day.



The line plots show the time-specific pollutant trends for Makindu Close Kololo and Nakasero Lane across different times of the day (morning, afternoon, and evening):

Key Observations:

PM2.5 and PM10 Levels:

Both $PM_{2.5}$ and PM_{10} levels fluctuate over the day at both sites.

Makindu Close Kololo shows relatively stable $PM_{2.5}$ levels across the day, while Nakasero Lane shows a noticeable peak in the afternoon.

CO Levels:

CO levels tend to increase in the evening for both sites, with Nakasero Lane showing a higher CO level than Makindu Close Kololo. This suggests more significant traffic or combustion activity in the evening at Nakasero Lane.

NO_2 Levels:

NO_2 levels also tend to peak in the evening at both sites, particularly at Nakasero Lane. This is consistent with increased traffic emissions during the evening rush hour.

INTERPRETATION OF RESULTS

Makindu Close has a denser tree cover and less traffic compared to Nakasero Lane, which explains why the concentration of pollutants along Nakasero Lane was slightly higher. This further confirms Sillars-Powell, Tallis, and Fowler's (2020) findings that Vegetation, particularly trees and shrubs with dense foliage, can act as natural filters, capturing airborne particulate matter such as dust, pollen, and pollutants.

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

The results suggest that humidity partially mediates the relationship between site descriptions and $PM_{2.5}$ levels, as humidity significantly correlates with $PM_{2.5}$ levels. However, the site descriptions do not strongly predict humidity levels, indicating a weak mediation effect.

Temperature does not appear to mediate the relationship significantly, as its effect on $PM_{2.5}$ is insignificant.

The above finding correlates with Zender-Świercz E., 2024 whose research on the effect of temperature and humidity of air on the concentration of particulate matter ($PM_{2.5}$ and PM_{10}) concluded that the concentration of $PM_{2.5}$ and PM_{10} is more strongly dependent on the air humidity than on the temperature.

Examine Traffic-Related Pollutants:

CO (Carbon Monoxide): Primarily emitted from vehicle exhaust, CO levels can directly indicate traffic emissions.

NO_2 (Nitrogen Dioxide): Also, primarily produced by vehicles, especially diesel engines.

$PM_{2.5}$ and PM_{10} (Particulate Matter): Can increase due to road dust, brake wear, and exhaust emissions.

Compare Pollutant Levels During Peak Traffic Times:

Morning (9:00 AM - 12:00 Noon): Represents the post-morning rush period.

Afternoon (1:00 PM - 4:00 PM): Represents off-peak traffic.

Evening (5:00 PM - 7:00 PM): Represents the evening rush period.

CONCLUSION:

The correlation between humidity, temperature, and pollutants varied depending on the site's local environment and pollution sources: High-emission sites (like industrial area) showed weaker effects of humidity and temperature due to continuous pollution. Low-emission sites (like Makindu Close Kololo) showed more substantial impacts of humidity and temperature on air quality due to fewer conflicting factors.

While humidity shows some mediation effects in the relationship between site description and $PM_{2.5}$ levels, temperature did not appear to play a significant mediating role. These findings highlight that local site characteristics, such as emissions and activities, directly affect air quality more than through changes in humidity or temperature.

Targeted Interventions

The data indicates that targeted air quality management interventions are necessary to mitigate high levels of pollutants, especially in areas such as Nkrumah-Nasser Lane and 6th Street Industrial Area. Stricter regulations, community awareness campaigns, and ongoing monitoring are advised to improve air quality throughout these high-risk sites.

REFERENCES

Akbari, H., Pomerantz, M., & Taha, H. (2001). Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. *Solar Energy*, *70*(3), 295–310.

Arnfield, A. J. (2003). Two decades of urban climate research: A review of turbulence, exchanges of energy and water, and the urban heat island. *International Journal of Climatology*, *23*(1), 1–26. https://doi.org/10.1002/joc.859

Byun, D. W., & Ching, J. K. S. (1999). Science algorithms of the epa models-3 community multiscale air quality (cmaq) modeling system.

Calfapietra, C., Fares, S., Manes, F., Morani, A., Sgrigna, G., & Loreto, F. (2013). Role of Biogenic Volatile Organic Compounds (BVOC) emitted by urban trees on ozone concentration in cities: A review. *Environmental Pollution*, *183*, 71–80.

 |

https://doi.org/10.1016/J.ENVPOL.2013.03.012

Ciccioli, P., Centritto, M., & Loreto, F. (2014). Biogenic volatile organic compound emissions from vegetation fires. In *Plant, Cell and Environment* (Vol. 37, Issue 8, pp. 1810–1825). Blackwell Publishing Ltd. https://doi.org/10.1111/pce.12336

Coenders-Gerrits, M. (2010). *The role of interception in the hydrological cycle*. https://www.researchgate.net/publication/45685037

Di Sabatino, S., Barbano, F., Brattich, E., & Pulvirenti, B. (2020). The multiple-scale nature of urban heat island and its footprint on air quality in real urban environment. *Atmosphere*, *11*(11). https://doi.org/10.3390/atmos11111186

Dzierzanowski, K. *et al.* (2011) 'Deposition of particulate matter of different size fractions on leaf surfaces and in waxes of urban forest species', *International Journal of Phytoremediation*, 13(10), pp. 1037–1046. Available at: https://doi.org/10.1080/15226514.2011.552929.

Fuchs Rebecca & Kasirye Verena (2020). *Kampala's Air Quality is Red-Flagged*. Available at: https://aqicn.org/city/uganda/kampala/us-embassy/de/m/.

Galiwango, R. *et al.* (2023). 'Air pollution and mobility patterns in two Ugandan cities during COVID-19 mobility restrictions suggest the validity of air quality data as a measure for human mobility', *Environmental Science and Pollution Research*, 30(12), pp. 34856–34871. Available at: https://doi.org/10.1007/s11356-022-24605-1.

Gielen, B., Neirynck, J., Fleck, S., Janssens, I. A., & Ceulemans, R. (2015). Mapping ozone risk for vegetation in complex terrain: the example of the Swiss canton of Ticino. *Environmental Pollution*, *202*, 93–104.

Guenther, A. (1995). A global model of natural volatile organic compound emissions. *Journal of Geophysical Research*, *100*(D5), 8873–8892. https://doi.org/10.1029/94JD02950

Luo, Y., Yang, J., Shi, Q., Xu, Y., Menenti, M., & Wong, M. S. (2023). Seasonal Cooling Effect of Vegetation and Albedo Applied to the LCZ Classification of Three Chinese Megacities. *Remote Sensing*, *15*(23). https://doi.org/10.3390/rs15235478

McPherson, E. G. N. D. J. H. G. M., G. S., S. C. (1997). Quantifying urban forest structure, function, and value. *Urban Ecosystems, 1*, 49–61.

Meili, N., Manoli, G., Burlando, P., Carmeliet, J., Chow, W. T. L., Coutts, A. M., Roth, M., Velasco, E., Vivoni, E. R., & Fatichi, S. (2021). Tree effects on urban microclimate: Diurnal, seasonal, and climatic temperature differences explained by separating radiation, evapotranspiration, and roughness effects. *Urban Forestry and Urban Greening*, *58*. https://doi.org/10.1016/j.ufug.2020.126970

Nejad, M. T., Ghalehteimouri, K. J., Talkhabi, H., & Dolatshahi, Z. (2023). The relationship between atmospheric temperature inversion and urban air pollution characteristics: a case study of Tehran, Iran. *Discover Environment*, *1*(1). https://doi.org/10.1007/s44274-023-00018-w

Ninsiima, M. *et al.* (2022) *Spatio-temporal trends of air quality in Kampala City, 2020-2022*, *Quarterly Epidemiological Bulletin*. Kampala.

Nowak, D. J., & Crane, D. E. (2000). *The Urban Forest Effects (UFORE) Model: Quantifying urban forest structure and functions', in Integrated tools for natural resources inventories in the*. https://www.researchgate.net/publication/285762449

Article DOI: https://doi.org/10.37284/eajenr.8.1.2783

Nowak, D. J., Hirabayashi, S., & Bodine, A. (2013). Modeled PM2.5 removal by trees in Ten U.S. Cities and associated health effects. *Environmental Pollution*, *178*, 395–402.

Ojha, N., Soni, M., Kumar, M., Gunthe, S. S., Chen, Y., & Ansari, T. U. (2022). Mechanisms and Pathways for Coordinated Control of Fine Particulate Matter and Ozone. In *Current Pollution Reports* (Vol. 8, Issue 4, pp. 594–604). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/s40726-022-00229-4

Sillars-Powell, L., Tallis, M. J., & Fowler, M. (2020). Road verge vegetation and the capture of particulate matter air pollution. *Environments - MDPI*, *7*(10), 1–19. https://doi.org/10.3390/environments7100093

Singh, A., Avis, W. R., & Pope, F. D. (2020). Visibility as a proxy for air quality in East Africa. *Environmental Research Letters*, *15*(8). https://doi.org/10.1088/1748-9326/ab8b12

United Nations Report 2018 Department of Economic and Social Affairs. https://www.un.org/uk/desa/68-world-population-projected-live-urban-areas-2050-says-un

Wang, Q. (2018). Urbanization and Global Health: The Role of Air Pollution. In *Iran J Public Health* (Vol. 47, Issue 11). http://ijph.tums.ac.ir

World Health Organization (2016). *Ambient air pollution: A global assessment of exposure and burden of disease*. World Health Organization.

Wu, M., Zhang, G., Wang, L., Liu, X., & Wu, Z. (2022). Influencing Factors on Airflow and Pollutant Dispersion around Buildings under the Combined Effect of Wind and Buoyancy—A Review. In *International Journal of Environmental Research and Public Health* (Vol. 19, Issue 19). MDPI. https://doi.org/10.3390/ijerph191912895

Yahia, E. M. (2018). Postharvest physiology and biochemistry of fruits and vegetables. In *Postharvest Physiology and Biochemistry of Fruits and Vegetables*. Elsevier. https://doi.org/10.1016/C2016-0-04653-3

Yamamoto, N. (2023). Bioaerosols in built and natural environments. *Fundamentals of Bioaerosols Science*, 399– 467. https://doi.org/10.1016/B978-0-12-824411-1.00005-3

Yousofpour, Y. *et al.* (2024) 'Ecosystem services and economic values provided by urban park trees in the air polluted city of Mashhad', *Sustainable Cities and Society*, 101. Available at: https://doi.org/10.1016/j.scs.2023.105110.

Zhang, Y., Zhang, X., & Shen, J. (2020). Interactions between urbanization, vegetation, and air quality from a microscale perspective. *Atmospheric Research*, 104–757.

Zoras, S., Triantafyllou, A. G., & Deligiorgi, D. (2006). Atmospheric stability and PM10 concentrations at far distance from elevated point sources in complex terrain: Worst-case episode study. *Journal of Environmental Management*, *80*(4), 295– 302. https://doi.org/10.1016/J.JENVMAN.2005.09.010

Zhao, H. *et al.* (2023) 'Assessment of Urban Forest Ecological Benefit Based on the i-Tree Eco Model—A Case Study of Changchun Central City', *Forests*, 14(7). Available at: https://doi.org/10.3390/f14071304.

Zender-Świercz E., Galiszewska B., Telejko M, Starzomska M., (2024). The effect of temperature and humidity of air on the concentration of particulate matter - PM2.5 and PM10, Atmospheric Research, Volume 312,2024,107733, ISSN 01698095, https://doi.org/10.1016/j.atmosres.2024.107733.(https://www.sciencedirect.com/science/article/pii/S0169809524005155)

