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Assessment of Air Quality in Eastern University, Sri Lanka

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Abstract

Air pollution is a growing environmental concern due to increasing urbanization, transportation activities, and anthropogenic emissions, which negatively affect environmental quality and human health. This study assessed the spatial and temporal variation of air quality in the premises of Eastern University, Sri Lanka, using a portable air quality gas analyzer integrated with GIS-based mapping techniques. Key pollutants monitored included particulate matter (PM_1, $PM_{2.5}$, and PM_{10}), Total Volatile Organic Compounds (TVOC), and Formaldehyde (HCHO). Air quality data were collected from seven sampling locations representing different environmental and human activity conditions within the study area. Pollutant concentrations were measured using a portable gas analyzer, while GPS coordinates were recorded using mobile devices for accurate spatial analysis. The collected data were analyzed using Microsoft Excel and ArcGIS software, and spatial distribution maps were generated using Inverse Distance Weighting (IDW) interpolation techniques. The results showed clear spatial and temporal variations in pollutant concentrations across all monitored sampling locations during the study period. Specifically, PM_{10} concentrations ranged from approximately 25.25 µg/m³ at the agriculture faculty zone to 44.25 µg/m³ near the main road. The highest AQI (44.25) was recorded at the main road area, while the lowest (25.25) was observed in the agriculture zone. Higher pollutant levels were observed in traffic-dominated and highly active areas, particularly near the main road and railway crossing, while lower levels were recorded in greener and less populated areas such as the agriculture faculty zone. All AQI values remained within the "Good" category throughout the study period (ranging from 25.25 to 44.25), indicating generally acceptable air quality conditions. The findings highlight the influence of land use, transportation, and meteorological conditions on local air quality patterns in the study area. This study demonstrates that integrating portable monitoring with GIS techniques effectively identifies pollution hotspots and supports evidence-based environmental management in university settings.

Keywords: *Air quality monitoring; Ambient air pollution; Air Quality Index (AQI); Portable gas analyzer; GIS-based mapping*

INTRODUCTION

Air is one of the most essential natural resources for sustaining life on Earth, and maintaining good air quality is critical for environmental and human health. However, air pollution has become a major global environmental concern due to rapid urbanization, industrialization, transportation activities, and other anthropogenic emissions (Seinfeld and Pandis, 2016). According to the World Health Organization (WHO), air pollution refers to the contamination of the atmosphere by harmful substances such as particulate matter, smoke, dust, and toxic gases that alter the natural composition of air. Recent estimates indicate that nearly 99% of the global population breathes air that exceeds recommended safety limits, contributing significantly to morbidity and mortality worldwide (WHO, 2022).

Air pollution is widely recognized as a major environmental risk factor associated with several health problems, particularly noncommunicable diseases. Exposure to pollutants such as particulate matter ($PM_{2.5}$ and PM_{10}) can cause serious health issues, including respiratory diseases, asthma, lung cancer, cardiovascular diseases, and other chronic conditions, especially among children, the elderly, and vulnerable populations (Brook *et al.*, 2010). Beyond human health, air pollution also affects ecosystems, agricultural productivity, climate conditions, and visibility (Brunekreef and Holgate, 2002).

Therefore, continuous air quality monitoring is essential for identifying pollution levels, understanding exposure risks, and supporting environmental management and policy decisions.

Recent advancements in air quality monitoring technologies have improved the ability to detect and measure pollutants with greater accuracy and efficiency. Portable air quality sensors have become increasingly useful for real-time monitoring in different environments (Snyder *et al.*, 2013). In addition, Geographic Information System (GIS) technology provides valuable tools for analyzing and visualizing spatial environmental data, enabling researchers to identify pollution hotspots and understand spatial distribution patterns more effectively (Burrough and McDonnell, 1998).

Eastern University, Sri Lanka, represents a semi-urban academic environment where increasing transportation activities, construction, population movement, and other anthropogenic factors may contribute to air pollution. Despite these concerns, detailed and systematic air quality monitoring has not been conducted within the university premises. Furthermore, previous studies have largely focused on common pollutants such as $PM_{2.5}$ and PM_{10}, while pollutants including PM_1, Total Volatile Organic Compounds (TVOC), and Formaldehyde (HCHO) remain less explored. Limited studies have also integrated air quality monitoring with GIS-based spatial analysis to evaluate spatial variations in pollutant concentrations.

The objectives are:

1) to assess air quality variation in the premises of Eastern University, Sri Lanka;
2) to measure the key pollutants (PM_1, $PM_{2.5}$, PM_{10}, TVOC, and HCHO);
3) to calculate the Air Quality Index (AQI);
4) to analyze the pollution patterns;
5) to identify the possible pollution sources and provide recommendations for improving air quality management; and
6) to provide evidence-based recommendations for improving air quality management within the university premises.

MATERIALS AND METHODS

Study Area

The study was conducted in the area of Eastern University, Sri Lanka, in the Eastern Province of Sri Lanka (Fig. 1). The study area covers the academic buildings, residential area of students, road network, vegetation cover, and human activity zones in the vicinity (Fig. 2).

There are increasing transportation activities, population movement, and construction-related activities in the area that could have an effect on local air quality conditions. Several sampling locations were selected inside and around the university premises to cover areas with different environmental characteristics and pollution levels.

Fig. 1: Location map of the Eastern University Sri Lanka.

Fig. 2: Study area map showing the seven sampling locations within Eastern University, Sri Lanka.

Some sites were close to roads and transportation activity with more vehicle emissions, while others were in greener or less populated areas with less exposure to pollution. This allowed comparison of air quality variation within different environments of the study area.

Climate Characteristics of the Study Area

The study area has a tropical climate with warm weather throughout most of the year. During the data collection period, ambient temperatures ranged from 28°C to 33°C in the morning and occasionally reached 38°C in the afternoon. Weather conditions were mostly hot and sunny, with some cloudy, windy, and rainy days during the one-month study period.

Relative humidity ranged between 60% and 80% due to the coastal environment. Climatic factors such as temperature, humidity, wind speed, and rainfall influenced pollutant concentration and movement. Greener and less crowded areas showed lower pollution levels than areas near roads and human activities.

Materials Used in This Study

Air Quality Monitoring Device

For this study, air quality measurements were performed using the IP67 Sky8000 portable gas analyzer with Built-in Pump. This is a portable multi-gas detection equipment that has been developed for the real-time monitoring of ambient air pollutants in the field. The built-in sampling pump of the instrument is used for continuous and active air suction to stabilize and improve the accuracy of the instrument in outdoor measurements. The device was used to measure and log the concentrations of important air contaminants such as PM (PM_1, $PM_{2.5}$, and PM_{10}) and gaseous pollutants such as TVOC and HCHO. The device was calibrated using standard reference gases before each sampling day to ensure measurement accuracy and consistency. Its waterproof and dustproof IP67 rating meant it was suitable for outdoor environmental monitoring, particularly when weather and field conditions were changeable.

GPS Enabled Device

A GPS-enabled mobile device was used in this study to accurately record the geographic coordinates of each air quality sampling location. The device's Global Positioning System (GPS) functionality allowed the collection of precise latitude and longitude values during field surveys. The spatial coordinates were needed for the mapping of the distribution of air pollutants and their spatial analysis with the use of GIS software.

Each sampling point was geotagged right after measurements were taken using the air quality analyzer so that all air quality data could be correctly associated with its respective location.

Data Collection Methods

Air quality data were collected through systematic field sampling at seven selected locations within the premises of Eastern University, Sri Lanka. The sampling sites were chosen based on land-use characteristics, traffic density, population activity, and environmental conditions to ensure proper spatial representation of different emission sources. The selected locations included animal farming sections (L1 and L6), the main auditorium (L2), the main road (L3), the canteen area (L4), the railway crossing (L5), and the Faculty of Agriculture area (L7), as shown in Fig. 2, each representing distinct anthropogenic and natural environmental influences.

Monitoring was carried out over a one-month period from 30 March 2026 to 30 April 2026. The selection of multiple sampling days allowed the capture of temporal variations in air quality influenced by meteorological conditions such as temperature, humidity, wind speed, and rainfall, as well as human activities occurring within the study area.

Air pollutant concentrations, including PM_1, $PM_{2.5}$, PM_{10}, Total Volatile Organic Compounds (TVOC), and Formaldehyde (HCHO), were measured using a portable gas analyzer. Before each measurement, the instrument was switched on and allowed to stabilize to ensure accurate and consistent readings. At each site, measurements were taken at a uniform height of 1.5 meters above ground level and for a fixed sampling duration of five minutes to minimize variations caused by local airflow differences and short-term emission fluctuations.

To improve data reliability, multiple readings were taken at each location, and the average values were used for analysis. Geographic coordinates of each sampling point were recorded using a GPS-enabled mobile device to enable spatial mapping and GIS-based analysis of air quality distribution across the study area.

Data Analysis

The collected air quality data were systematically organized in Microsoft Excel for each sampling location (L1–L7) across the full monitoring period. Data preprocessing involved careful structuring and validation of recorded values to ensure accuracy, consistency, and efficient data handling for subsequent analysis.

Following data organization, the mean concentrations of each pollutant, PM_1, $PM_{2.5}$, PM_{10}, TVOC, and HCHO, were computed for each sampling location. These averaged values were used to minimize the influence of short-term fluctuations and to provide a more representative indication of ambient air quality conditions at each site.

The calculated mean pollutant concentrations were subsequently used to derive the AQI for each location. This conversion enabled the transformation of complex multi-pollutant data into a standardized index, facilitating easier interpretation and comparison of air quality levels across the study area.

Finally, the processed dataset was exported in CSV format by Microsoft Excel and imported into ArcGIS software (ArcMap 10.8 version) for spatial analysis and mapping. This enabled the visualization of spatial distribution patterns of air pollutants and AQI across the study area, supporting the identification of pollution gradients and spatial hotspots.

AQI calculation

The AQI was calculated to turn the different pollutant measurements into one simple value that shows the overall air quality at each location. This helps to make the results easier to understand and allows direct comparison of air pollution levels between different sampling sites.

Each pollutant sub-index was then calculated using the standard linear interpolation method, expressed as:

$$AQI = \frac{I_{high} - I_{low}}{C_{high} - C_{low}} \times (C - C_{low}) + I_{low} \quad (1)$$

Where:

AQI = The resulting index value

C = Pollution concentration

C_{high} = upper breakpoint concentration

C_{low} = lower breakpoint concentration

AQI_{low} = AQI value corresponding to C low

AQI_{high} = AQI value corresponding to C high

The overall AQI for each location was determined as the maximum value among all pollutant sub-indices, following the dominant pollutant approach. This ensures that the most critical pollutant represents the final AQI value, reflecting the worst air quality condition at each site. AQI simplifies air quality interpretation by converting pollutant data into a single numerical value with corresponding categories and color codes.

It is generally classified into six levels ranging from "Good" to "Hazardous," indicating increasing health risks. The color-coded system enables easy interpretation of air quality, helping users quickly understand whether conditions are safe for outdoor activities or pose risks to sensitive populations.

Preparation of Maps Using GIS Techniques

After converting the dataset into CSV format, the file was imported into Google Earth Pro to visualize and verify the spatial locations of all air quality sampling points. The latitude and longitude values recorded during fieldwork were used to accurately plot each sampling site, ensuring correct geographic positioning and improving data reliability for further spatial analysis.

Spatial analysis was then carried out using ArcMap (ArcGIS 10.8) with the Inverse Distance Weighting (IDW) interpolation technique to estimate the spatial distribution of air pollutants across the study area (Ameen *et al.*, 2021; Kumar and Deswal, 2025). IDW is a deterministic interpolation method based on the assumption that locations closer to each other have more similar values than those farther apart. Accordingly, nearby sampling points exert greater influence on estimated values than distant points. This method was selected due to its simplicity, efficiency, and suitability for environmental studies with limited and scattered sampling locations. Following spatial analysis, thematic maps were prepared using ArcMap layout tools to clearly present the spatial distribution of air pollutants. Each map was carefully designed with standardized cartographic elements, including a legend, north arrow, scale bar, title, and coordinate system, to enhance clarity and interpretation. Separate maps were produced for each air quality parameter to provide detailed spatial insights and support the identification of pollution patterns across the study area.

Identification of Pollution Sources, Factors Affecting Air Quality, and Impacts

The identification of pollution sources in this study was based on field observations, land-use characteristics, and spatial distribution patterns of measured air pollutants. Sampling locations were analyzed with respect to nearby activities such as traffic flow, residential areas, agricultural practices, and small-scale combustion or industrial activities to identify potential emission sources contributing to air pollution.

Factors affecting air quality were assessed by examining variations in pollutant concentrations, including PM_1, $PM_{2.5}$, PM_{10}, TVOC, and HCHO, across different sampling locations. The influence of surrounding land use, traffic intensity, human activities, and combustion-related sources was considered in the analysis. Locations with higher traffic density and intense human activities generally exhibited elevated pollutant levels, indicating a strong relationship between land-use patterns and air quality variation within the study area.

The impacts of air pollution were interpreted in terms of potential environmental and health effects. Increased concentrations of particulate matter and gaseous pollutants indicate possible risks to human health, vegetation, and overall environmental quality. Exposure to particulate matter may contribute to respiratory and cardiovascular diseases, while elevated levels of TVOC and HCHO may cause irritation and other adverse health effects. These impacts were evaluated based on established air quality guidelines and existing literature, providing a general understanding of pollution implications in the study area.

RESULTS AND DISCUSSION

Variations of Air Pollutants

PM

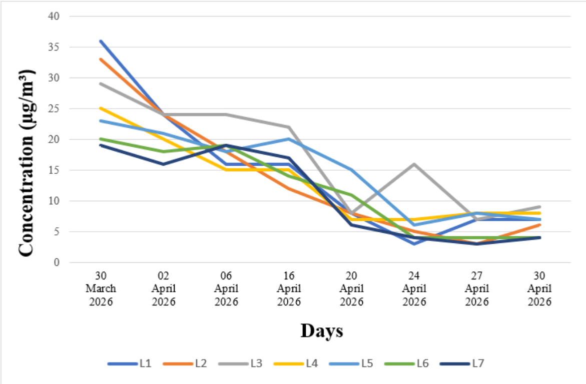
The temporal variation and spatial distribution of PM (PM_1, $PM_{2.5}$, and PM_{10}) are presented in Fig. 3 and Fig. 4, respectively. The spatial distribution of PM (PM_1, $PM_{2.5}$, and PM_{10}) showed similar patterns across all monitoring locations. Higher particulate matter concentrations were consistently observed near the main road, mainly due to heavy traffic flow and vehicle emissions. Main roads are typically associated with increased pollution levels caused by vehicle congestion and combustion processes.

Relatively elevated PM levels were also recorded at the railway crossing, likely due to transportation-related emissions. Road transport is a major source of particulate matter in urban environments, where emissions mainly originate from fuel combustion and consist of carbon and partially burned organic compounds. Elevated concentrations were also observed in the canteen and auditorium areas, influenced by human activities and movement. In contrast, lower PM levels were recorded in the agriculture faculty and animal farm areas, indicating cleaner conditions with reduced traffic and anthropogenic influence.

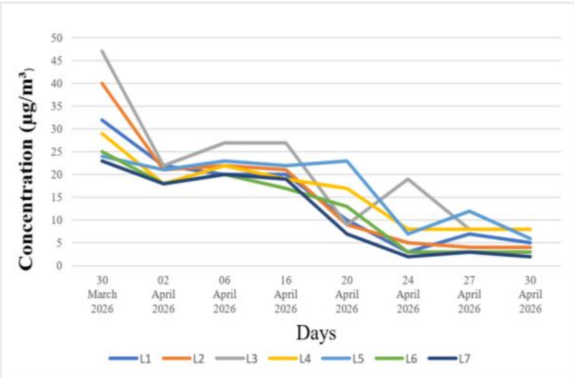
TVOC

The temporal variation and spatial distribution of TVOC are presented in Fig. 5 and Fig. 6, respectively. The TVOC concentrations recorded during the monitoring period showed noticeable spatial variations across the study area. Among all monitoring locations, the highest average TVOC concentration was observed at the main road area (0.35 ppm), while the lowest average concentration was recorded at the agriculture faculty area (0.08 ppm). Relatively higher TVOC levels were also identified at the auditorium area and animal farm area. In contrast, comparatively lower concentrations were observed at the canteen area, railway cross area, and agriculture faculty animal farm area.

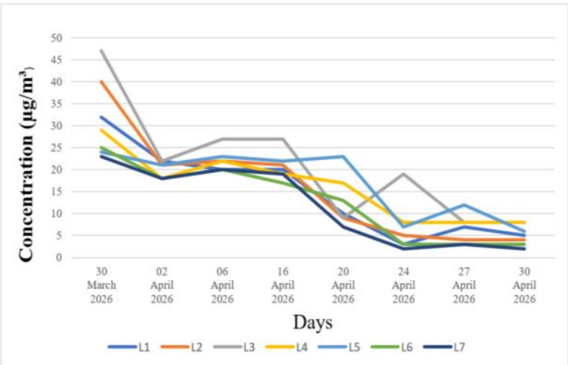
The daily observations indicated fluctuations in TVOC concentrations throughout the monitoring period across all monitoring locations. These spatial variations are commonly associated with differences in traffic density, human activities, and surrounding land-use characteristics, where roadside and highly populated areas generally exhibit



(a): PM_1 concentration.



(b): $PM_{2.5}$ concentration.



(c): PM_{10} concentration.

Fig. 3: Temporal variation of PM concentration.

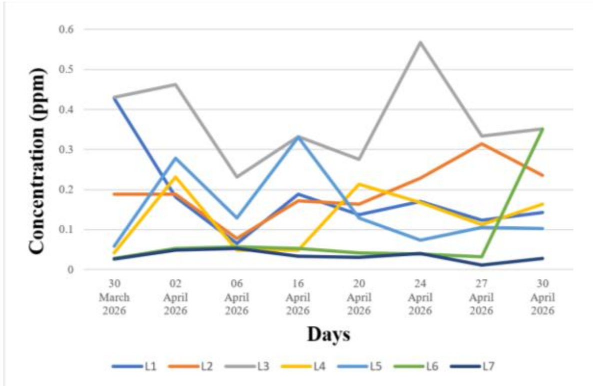


Fig. 5: Temporal variation of TVOC concentration.

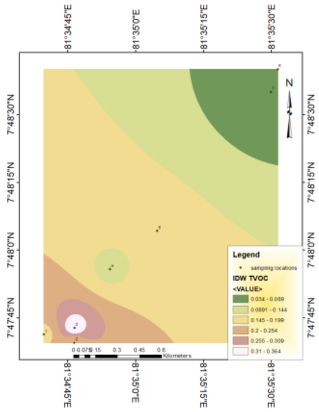
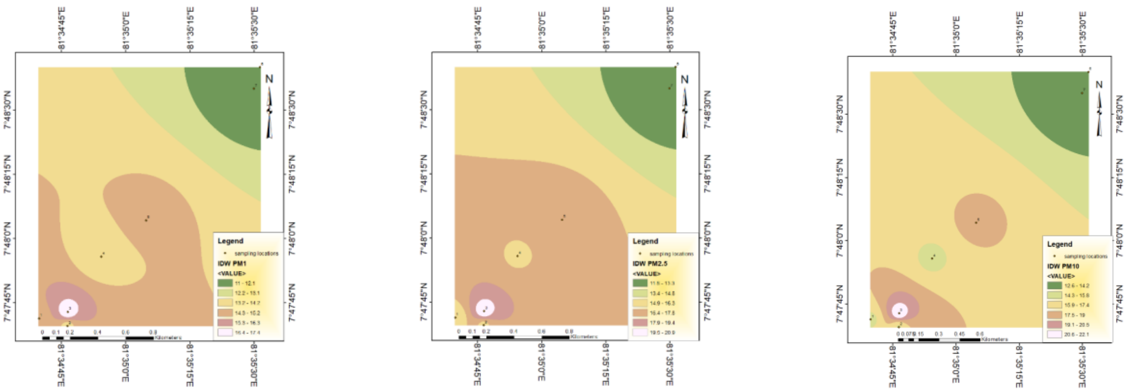


Fig. 6: Spatial distribution of TVOC concentration.

elevated TVOC concentrations compared to less disturbed environments (Monod *et al.*, 2001; Kumar *et al.*, 2018).

HCHO

The temporal variation and spatial distribution of HCHO are presented in Fig. 7 and Fig. 8, respectively. The HCHO concentrations recorded during the monitoring period showed spatial variations across the study area. The highest average concentration was observed at the main road area (0.18 ppm), while the lowest was recorded at the agriculture faculty ~~animal farm~~ area (0.04). Relatively higher levels were also identified at the railway crossing and auditorium area, whereas lower concentrations were observed at the canteen and agriculture faculty areas. These variations are associated



(a): PM_1 **(b):** $PM_{2.5}$ **(c):** PM_{10}

Fig. 4: Spatial distribution of PM concentration.

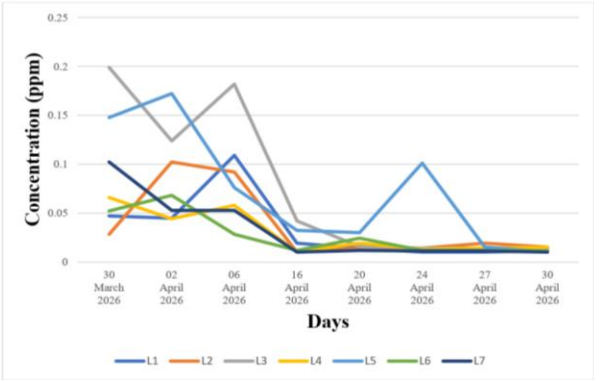


Fig. 7: Temporal variation of HCHO concentration.

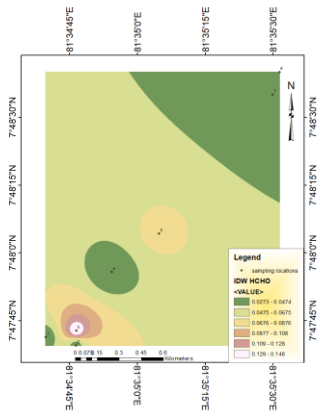


Fig. 8: Spatial distribution of HCHO concentration.

with traffic density, human activities, and land-use characteristics. Similar patterns have been reported in previous studies linking HCHO levels to vehicular emissions and urban activities (da Rocha *et al.*, 2023; Liu *et al.*, 2025; Salthammer *et al.*, 2010).

Air Quality Index Analysis of PM

The PM–based AQI values recorded across the study locations ranged from 25.25 to 44.25 (Table 1), indicating overall good air quality conditions throughout the monitoring period. The highest AQI value was observed at the main road area with an AQI of 44.25 (PM_{10}), followed by the railway cross area with an AQI of 35.75 (PM_{10}), auditorium area with an AQI of 31.25 ($PM_{2.5}$), animal farm area with an AQI of 30.75 (PM_{10}), and canteen area with an AQI of 30.75 ($PM_{2.5}$). Lower AQI values were recorded at the agriculture faculty animal farm area with an AQI of 28 (PM_{10}) and the agriculture faculty area with an AQI of 25.25 (PM_{10}). All measured AQI values remained within the good category, indicating that particulate matter concentrations across all sampling locations were within acceptable air quality limits during the study period.

Comparison with standard AQI Levels

The AQI is represented using color codes to indicate air pollution levels and associated health effects (Table 2). Green represents "Good" air quality with minimal health risk, while yellow indicates "Moderate" air quality where sensitive individuals may experience minor effects. Orange represents "Unhealthy for Sensitive Groups," and red indicates

Table 1: AQI concentration at various locations.

Location	AQI	Dominant Pollutant
L1 (Animal Farm 1)	30.75	PM_{10}
L2 (Auditorium)	31.25	$PM_{2.5}$
L3 (Main Road)	44.25	PM_{10}
L4 (Canteen)	30.75	$PM_{2.5}$
L5 (Railway Crossing)	35.75	PM_{10}
L6 (Animal Farm 2)	28.00	PM_{10}
L7 (Agriculture Faculty)	25.25	PM_{10}

Table 2: Category and breakpoint table for PM.

AQI Colour	Level of Concern	Index	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)
Green	Good	0-50	0-25	0-50
Yellow	Moderate	50-100	25-50	50-100
Orange	Slightly Unhealthy	100-150	50-75	100-150
Red	Unhealthy	150-200	75-150	150-275
Purple	Very Unhealthy	200-300	150-250	275-450
Maroon	Hazardous	300-500	250-400	450-650

Source: AQI classification chart adapted from airveda (based on US EPA air quality index standards).

"Unhealthy" conditions that may affect the general population. Purple and maroon represent "Very Unhealthy" and "Hazardous" conditions, respectively, indicating serious health risks. These categories help communicate pollution levels and health concerns effectively.

AQI analysis of particulate matter (Table 2) showed that overall air quality across all study locations remained within the "Good" category, indicating minimal short-term health risks associated with ambient particulate pollution. The computed AQI values for $PM_{2.5}$ and PM_{10} were consistently below 50, corresponding to clean air conditions under standard AQI classification systems. These low values indicate that particulate concentrations remained within acceptable ambient air quality limits during the monitoring period.

For gaseous pollutants, HCHO and TVOC concentrations (Table 3) were evaluated using WHO indoor air quality guidelines. The observed concentrations remained within acceptable limits, indicating no significant risk of acute exposure during the study period. Results suggest that particulate matter primarily governed AQI interpretation, while gaseous pollutants remained within safe exposure thresholds. This pattern is consistent with previous studies showing that particulate pollution is often the dominant factor influencing ambient AQI in semi-urban environments, particularly in areas affected by traffic and human activities.

Variation of Pollutants with Ambient Temperature and Relative Humidity

The variation of ambient temperature and relative humidity during the study period showed a clear diurnal pattern,

Table 3: Category and breakpoint table for TVOC.

Level	Hygienic Rating	Recommendation	Exposure Limit	TVOC (PPM)
Unhealthy	Situation not acceptable	Use only if unavoidable / Intense ventilation necessary	hours	2.2 – 5.5
Poor	Major objections	Intensified ventilation / airing necessary. Search for sources	< 1 month	0.66 – 2.2
Moderate	Some objections	Intensified ventilation / airing recommended. Search for sources	< 12 months	0.22 – 0.66
Good	No relevant objections	Ventilation / airing recommended	No limit	0.065 – 0.22
Excellent	No objections	Target value	No limit	0 – 0.065

Source: Adapted from ATMO Team (2024), based on German federal environmental agency and WHO indoor air quality guidelines.

Table 4: Average ambient temperature and relative humidity.

TIME	Average Ambient Temperature (°C)	Relative Humidity (%)
9.00 am	30	76
10.00 am	32	69
11.00 am	35	65
12.00pm	37	59

characterized by increasing temperature and decreasing relative humidity throughout the day (Table 4). These meteorological changes directly influenced the dispersion and concentration of air pollutants across the study area. During the morning hours, ambient temperature remained moderate at around 30°C, while relative humidity was relatively high at approximately 80%, indicating cooler and moisture-rich atmospheric conditions.

As the day progressed, continuous solar radiation caused ambient temperature to rise and relative humidity to decrease to around 50%, reflecting enhanced evaporation and reduced atmospheric moisture. These changes influenced the concentrations of PM_1, $PM_{2.5}$, PM_{10}, TVOC, and HCHO across the monitoring locations. Under cooler and more humid morning conditions, pollutant dispersion was limited due to weaker thermal mixing, allowing particulate and gaseous pollutants to remain concentrated near emission sources. This contributed to higher localized exposure, particularly in traffic-dominated and active areas.

As temperature increased during the daytime, stronger thermal convection and atmospheric mixing enhanced vertical pollutant dispersion, reducing near-ground concentrations in some locations. Lower humidity also favored the resuspension of dust particles, contributing to increased PM_{10} levels in exposed and traffic-influenced areas. In contrast, higher humidity during morning hours promoted particle agglomeration and deposition, slightly reducing airborne concentrations.

The observed relationship between meteorological conditions and pollutant levels indicates that ambient air quality within the study area is influenced by both emission intensity and atmospheric dynamics. Ambient temperature and relative humidity play important roles in controlling pollutant dispersion, accumulation, and temporal variation. Lower temperatures and higher humidity during early morning hours may enhance atmospheric stability and reduce vertical mixing, leading to temporary pollutant accumulation near the surface.

Identification of Pollution Hotspots and Factors Affecting Air Quality

The variation in air quality across the study area, based on PM_1, $PM_{2.5}$, PM_{10}, TVOC, and HCHO measurements, was strongly influenced by anthropogenic activities, land-use characteristics, and local dispersion conditions. The highest pollutant concentrations were consistently recorded at the main road area, identifying it as the primary pollution hotspot within the study area. This is mainly due to high vehicular traffic, frequent acceleration and deceleration, and incomplete fuel combustion, all of which significantly contribute to particulate and gaseous pollutant emissions. In addition, vehicle-induced resuspension of road dust further increases $PM_{2.5}$ and PM_{10} concentrations, making traffic activity a major driver of localized air pollution.

The railway crossing also exhibited elevated pollution levels due to the combined influence of railway operations and traffic congestion. Diesel-powered trains release particulate and gaseous pollutants through combustion processes, while frequent stopping and idling of vehicles near the crossing promote the accumulation of exhaust emissions. Repeated braking and acceleration also increase dust resuspension, particularly affecting PM_{10} concentrations. These factors identify the railway crossing as a secondary pollution hotspot.

The auditorium and canteen areas showed moderate pollution levels influenced by human activities. Periodic gatherings and increased transport activity near the auditorium contribute to localized pollutant accumulation. Similarly, the canteen area experiences emissions from cooking activities, waste handling, and continuous student movement, contributing to elevated particulate matter and volatile organic compound concentrations.

The animal farm area showed intermediate pollution levels due to both natural and anthropogenic sources. Emissions from animal waste decomposition may contribute to gaseous pollutants, while dust from exposed soil surfaces increases particulate matter under dry conditions. However, the absence of heavy traffic limits pollution levels compared to major hotspots.

The lowest pollutant concentrations were recorded at the agriculture faculty animal farm area and agriculture faculty area. These locations benefit from favorable land-use characteristics, including open spaces and vegetation cover, which enhance pollutant dispersion and deposition. Vegetation acts as a natural sink for particulate matter, while lower traffic density and the absence of continuous combustion sources contribute to cleaner air conditions. Overall, traffic intensity, land use, and local environmental conditions were key factors influencing air quality variations across the study area.

Environmental and Health Implications

Environmental Implications

The presence of airborne pollutants in the atmosphere exerts wide-ranging impacts on interconnected environmental components, including vegetation, soil systems, and atmospheric quality. One of the most immediate effects is observed in vegetation, where particulate matter deposition on leaf surfaces forms a physical layer that reduces light interception and obstructs stomatal openings.

This interferes with essential physiological processes such as photosynthesis, transpiration, and gas exchange, leading to reduced plant growth, lower biomass accumulation, and decreased overall productivity. Continuous exposure to elevated pollutant concentrations can cause visible foliar injury, chlorosis, necrosis, and premature leaf senescence, ultimately weakening plant health and reducing ecosystem resilience (WHO, 2006; Deswal and Deswal, 2017; FAO, 2018).

Fine particulate matter and volatile organic compounds (VOCs) undergo complex photochemical reactions in the lower atmosphere, particularly under conditions of intense solar radiation and stagnant air masses. These reactions lead to the formation of secondary pollutants such as ozone and secondary organic aerosols, which significantly contribute to regional haze and photochemical smog formation.

These processes not only reduce visibility but also influence radiative balance and local microclimatic conditions, including near-surface temperature and humidity patterns. Atmospheric chemistry studies indicate that such secondary pollutant formation mechanisms can prolong pollution episodes even after primary emissions have declined (Seinfeld and Pandis, 2016; Jacob, 1999).

Long-term deposition of airborne contaminants also contributes to gradual soil degradation. Pollutants settle onto the ground through dry and wet deposition processes, altering soil pH, disrupting nutrient cycling, and reducing microbial diversity and activity.

These changes negatively affect soil fertility and may impair agricultural productivity, particularly in ecosystems exposed to continuous anthropogenic emissions. Heavy particulate deposition may also introduce toxic compounds such as polycyclic aromatic hydrocarbons (PAHs) and trace metals into the soil, further increasing ecological and environmental risks (FAO, 2018).

Health Implications

The measured concentrations of PM and gaseous pollutants indicate potential adverse health implications associated with both acute and chronic exposure. Fine particulate matter poses the highest risk due to its ability to penetrate deep into the respiratory system and enter the bloodstream, contributing to respiratory and cardiovascular diseases, while PM_{10} primarily affects the upper respiratory tract, causing irritation and aggravating pre-existing conditions (WHO, 2006; Pope and Dockery, 2006).

TVOC and formaldehyde exposure are associated with acute symptoms such as headache and respiratory irritation, with formaldehyde recognized as a potential human carcinogen under long-term exposure (WHO, 2010).

LIMITATIONS OF THE STUDY

While this study provides valuable baseline data on air quality within the university premises, several limitations should be acknowledged.

First, the monitoring period was limited to one month (March–April 2026), which may not capture seasonal variations in air quality influenced by the northeast and southwest monsoons prevalent in Sri Lanka. Second, measurements were taken only during daytime hours (between 9:00 AM and 12:00 PM), potentially missing significant diurnal patterns such as nighttime pollutant accumulation or early morning peaks. Third, the study relied on a single portable gas analyzer; while calibrated, the use of multiple instruments or reference-grade monitors would have improved data robustness. Fourth, the number of sampling locations (n=7) may not fully represent the spatial heterogeneity of air quality across the entire university premises, particularly in microenvironments such as indoor spaces or isolated residential blocks. Fifth, the study focused on PM and gaseous pollutants (TVOC, HCHO) but did not monitor other critical pollutants such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), or ground-level ozone (O_3), which could provide a more comprehensive air quality profile.

Future studies should address these limitations by extending the monitoring duration to cover all seasons, conducting 24-hour continuous measurements, increasing the density of sampling points, and incorporating a broader range of pollutants to support more robust air quality management strategies.

CONCLUSION

This study assessed air quality in the premises of Eastern University, Sri Lanka, using a portable air quality gas analyzer integrated with GIS-based mapping techniques. Key pollutants, including PM_1, $PM_{2.5}$, PM_{10}, TVOC, and HCHO, were monitored at selected locations, and the Air Quality Index (AQI) was calculated to evaluate overall air quality conditions.

The results revealed clear spatial variations in pollutant concentrations across the study area. Higher pollutant levels were observed near the main road and railway crossing due to traffic movement, transportation activities, road dust, and human activities. In contrast, lower pollutant concentrations were recorded in greener and less populated areas such as the agriculture faculty zone. Traffic emissions, road dust, and population movement were identified as major factors influencing local air quality.

Although some locations showed relatively higher pollutant concentrations, all AQI values remained within the "Good" category during the study period (25.25 – 44.25), indicating generally acceptable air quality conditions. However, prolonged exposure to particulate and gaseous pollutants may still affect human health and environmental quality over time. The GIS-based spatial analysis effectively identified pollution distribution patterns and hotspot areas.

Based on the findings, the following recommendations are proposed:

- *Traffic management:* Implement traffic calming measures near the main road and railway crossing, such as speed bumps, designated drop-off zones, and restricted vehicle access during peak hours to reduce exhaust emissions.
- *Green infrastructure:* Enhance vegetation buffers and green barriers along roadside areas to act as natural pollutant sinks.
- *Regular monitoring*: Establish a long-term, continuous air quality monitoring network with fixed stations to track pollution trends and evaluate the effectiveness of mitigation measures.
- *Awareness programs:* Conduct awareness campaigns for students and staff on air quality issues and promote sustainable commuting options (e.g., cycling, carpooling).

Overall, the study demonstrated that integrating portable air quality monitoring with GIS techniques is an effective approach for air quality assessment, environmental monitoring, and future management planning within university environments.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy, have been completely observed by the authors.

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